HEAVY-DUTY ENGINE OIL CLASSIFICATION PANEL
OF
ASTM D02.B0.02
September 26, 2001
Marriott Rivercenter Hotel of San Antonio, TX

ACTION ITEMS

1. Issue round three of exit ballots.	**Jim McGeehan**
2. Complete tiered limits for 1R and M-11 EGR	**Statisticians**

MINUTES

1.0 Call to Order

1.1 The meeting was called to order by Chairman Jim McGeehan at 9:45 a.m. on September 26, 2001, in Salon M of the Marriott Rivercenter Hotel of San Antonio, Texas. A moment of silence was observed in remembrance of the September 11th terrorist victims and their families. There were 14 members present or represented and approximately 30 guests present, one by teleconference. The attendance list is shown as Attachment 2.

2.0 Agenda

2.1 The published agenda (Attachment 1) was reviewed. It was suggested and agreed upon that the IR oxidation discussion be moved to be part of the T-10 discussion.

3.0 Previous Meeting Minutes

3.1 The minutes of the August 15, 2001 meeting were approved as distributed and posted on the TMC website.

4.0 Membership

4.1 There were no changes in membership. See Attachment 2 for the list of members.

5.0 PC-9 Matrix Status

5.1 John Zalar's report on the 1R matrix status and the PC-9 timeline was presented in absentia (Attachment 3). The 1R matrix has been completed and the statistical analysis is done. Earliest API license date for CI-4 is now estimated to be August 15, 2002.

6.0 Caterpillar 1R

6.1 Dwayne Tharp presented an update on the 1R status and suggested limits for the single cylinder tests (Attachment 4). Most of the ensuing discussion was concerned with the proposed oil consumption limits for the 1R.

6.2 Phil Scinto, via teleconference, went over his presentation (Attachment 5) of the statistical analysis for the 1R matrix. Afterward, the group asked Phil to analyze the initial oil consumption, final oil consumption and their ratio. Dwayne showed a sreadsheet with the data he had and suggested a maximum ratio of 1.1 (FOC/IOC) or perhaps an increment of between 1.0 and 1.5 g/h over the initial oil consumption. Most of the matrix tests had lower FOC than IOC.

6.3 Dwayne Tharp moved and Steve Kennedy seconded that the 1R test be accepted as part of PC-9. The motion passed with 14 for, 0 against, 0 abstain. There was no 'official' ACC representation present to speak on 1R registration, but speculation was that registration of tests could start on Monday, October 1, 2001.

6.4 Dwayne Tharp moved and Bill Kleiser seconded that the proposed 1R limits for a one test pass, rounded to whole numbers, be accepted. The two and three test pass limits will be determined statistically. The motion passed with 14 for, 0 against, 0 abstain.

6.5 Sometime after lunch, Phil called back with analysis of the matrix oil consumption data. The following information is all in grams per hour except for the ratios. For IOC he found no stand effects, but possible lab and oil effects. The least squared mean of IOC for Oil A was 8.34; for Oil D was 10.15 and for Oil M was 10.40 with a pooled standard deviation of 1.32. Looking at the ratio (IOC/FOC) removed any lab effect, yet still left a possible oil effect. The LSM was 1.09 for Oil A; 0.97 for Oil D and 1.22 for Oil M with a pooled S. Dev. of 0.16. The 95% confidence interval for Oil M would be 1.1 to 1.4. Looking at the differential (IOC-FOC) again removed any lab effect but still showed some weak oil effect. Oil A had an LSM of 0.4; Oil D, -0.25 and Oil M, 1.87 with a pooled S. Dev. of 1.38.

6.6 Dwayne Tharp proposed to exit ballot an oil consumption limit for the 1R of FOC less than or equal to IOC + 1.2 g/h. Steve Kennedy seconded the motion. Bill Kleiser raised concern that the proposed increment is less than the matrix standard deviation. The motion passed with 12 for, 0 against, 1 abstain.

7.0 Lunch

7.1 The meeting went into recess around 11:30 a.m. for lunch and restarted at 12:45 p.m. with a review of the round two exit ballot results.

8.0 Exit Ballot Review (See Attachment 6 for a summary)

8.1 M-11 EGR

8.11 Lubrizol negative on concern that the TRWL limit of 175 mg is too tight.

8.12 ExxonMobil negative on TRWL for the M-11. They feel the T-10 covers the TRWL need. Steve Kennedy presented a slide (Attachment 7) showing M-11 & T-10 matrix results relative to the proposed limits.

8.13 Infineum negative on concerns about OFDP and the sludge / viscosity differences between labs.

8.14 Chevron negative on concerns with TRWL. Jim McGeehan presented a slide of matrix TRWL results (Attachment 8) and feels the limit should be 190 mg or higher.

8.15 Oronite negative on concerns with OFDP and TRWL. Bill Kleiser presented a slide (Attachment 9), showing filter pleats touching and glued that way.

8.16 Dave Stehouwer responded for Cummins with a presentation shown as Attachment 10. In addition to the matrix Oil E data, they have internal data which support the need to stay below TRWL of 175 mg. He talked about the tests Fleetguard was performing on a sample of 36 filters pulled from the TEI test filter stock and tests they had run on returned used filters.

8.17 Chevron and Lubrizol indicated they would reluctantly agree to a TRWL limit of 175 mg. ExxonMobil would abstain on TRWL if they were the only negative, but they still feel the T-10 and M-11 TRWL are looking at the same thing. Oronite would reconsider after looking at the effect of the adopted outlier criteria for TRWL.

8.18 Cummins volunteered to reduce the sludge limit from 8.0 to 7.8 and asked that it be exit balloted. Statistically derived tiered limits for the M-11 are shown in Attachment 11, except for the revised sludge limit at 7.8.

8.2 T-10

8.21 Infineum negative on concern that three of the pass / fail parameters (EOT lead, Delta lead 250-300, IR oxidation) are highly correlated and thus increase the chances of failing a test just on random variability. Jai Bansal made a presentation (Attachment 12) which suggests eliminating the Delta lead 250-300 and the IR oxidation and accepting the Sequence III-F test at SL limits for oxidation protection.

8.22 Greg Shank showed the statistical tiered limits for the T-10 (Attachment 11) and then put up a slide (Attachment 13) showing lead level versus time in the test for several oils. One of the oils exhibited a significant increase in lead level between 250 and 300 hours. Because of this type of behavior, he is unwilling to give up the Delta lead 250-300 parameter. He would be willing to give up the IR oxidation parameter for the Sequence III-F at SL limits, for oxidation and oil consumption only in that test. Thus, Greg Shank moved and Jai Bansal seconded that the Sequence III-F be accepted as the oxidation test for CI-4 at SL limits for oxidation and oil consumption only.

8.23 Oronite negative over concern for random test failures with the correlated parameters. Bill Kleiser presented a proposed merit system (Attachment 14) they feel would help offset the lack of precision in the test parameters. There was a lot of discussion over the feasibility of implementing a merit system at this late date. Greg Shank agreed to meet with those interested in a merit system, if they could all meet together before the next HDEOCP meeting.

8.24 Greg Shank moved to exit ballot the John Zalar tiered limits for the T-10 (Attachment 11). Dave Stehouwer seconded the motion which passed with 14 for, 0 against, 0 abstain.

8.3 1N

8.31 Dwayne Tharp stated that based on the data presented to Caterpillar, they would stay with the CG-4 limits for the 1N (See Attachment 4). They would however, accept either the 1N at CG-4 limits or the 1K at CH-4 limits for PC-9.

8.32 Rich Lee proposed using the 1K at CH-4 limits as the aluminum piston deposit test for PC-9, with the 1N at CG-4 limits as an acceptable alternative. Lew Williams seconded the motion which passed with 13 for, 0 against, 0 abstain.

8.4 HTHS

8.41 3.5, Non-Critical (See Attachment 15 for John Zalar explanation of D-3244 on “Critical” / “Non-Critical” specifications)

8.411 Pennzoil-Quaker State negative, but would not hold up the category.

8.412 Infineum negative for previously enumerated reasons. They will maintain the negative.

8.413 Equilon negative, will maintain that position.

8.42 3.3, Critical

8.421 Ethyl negative, would abstain.
8.422 Valvoline negative, would favor 3.5, non-critical.
8.423 Infineum negative, would switch to positive.
8.424 Oronite negative
8.425 Pennzoil-Quaker State negative, would prefer 3.3, non-critical, but would abstain if this went forward.
8.426 Jim McGeehan presented some slides on the blending target effects of the critical / non-critical specifications (Attachment 16).
8.427 Greg Shank for EMA commented they feel too much time has been spent on this subject already. Frank Bondarowicz presented Attachment 17 and noted that European oils are already at 3.5 cP, HTHS.
8.428 Greg Shank moved and Ken Chao seconded that 3.5 cP, non-critical, be accepted as the PC-9 HTHS limit. The motion passed with 11 for, 1 against, 1 abstain.

8.5 Used Oil Viscosity

8.51 Dave Stehouwer used some of the slides from Attachment 18 and then proposed a PC-9 MRV limit of 25,000 cP at –20 C on the T-10 75 hour oil sample, for all viscosity grades. Lew Williams seconded the motion which passed with 13 for, 0 against, 1 abstain.

9.0 Backward Compatibility

9.1 Mark Rees presented Lubrizol data (Attachment 19) comparing T-10 versus T-9 results and M-11 EGR versus M-11 HST results. Mark then made a motion that the tests and limits as approved by ASTM D.02.B used to qualify oils for API CI-4 may be used to qualify oils for API CH-4. Dave Stehouwer seconded the motion, which after discussion was tabled because all the CI-4 limits have not yet been defined.

10.0 Elastomers

10.1 Tom Boschert presented a report on the status of elastomer compatibility (Attachment 20) and indicated that a surveillance panel had been formed. That panel plans to meet on September 27, 2001. Tom asked for HDEOCP concurrence with the process proposed. Lew Williams seconded the motion which passed via voice vote with no objections.

11.0 “B” Ballot Preparation

11.1 Since this meeting was in San Antonio, Tom Franklin retreated from retirement long enough to attend, probably, much to his regret. Being the experienced ballot compiler that he is, he was prevailed upon to undertake putting together the “B” ballot for PC-9. In the event that funding is needed to help compensate Tom for this effort, the following organizations have committed to help: Chevron, Infineum, Ethyl, EMA, Lubrizol, TEI, Equilon and Ohio Technologies.

12.0 Next Meeting

12.1 The next meeting is scheduled for October 16, 2001 at the Hyatt Regency O'Hare in Rosemont, IL.

13.0 Adjournment

13.1 This meeting was adjourned at 4:45 p.m. on September 26, 2001.

Submitted by:

Jim Wells
Secretary to the HDEOCP

ATTACHMENT 1

ASTM-HDEOCP

Marriot Rivercenter, San Antonia,
Conference Room Salon M
September 26, 2001
9:30 am –4:00 pm

Chairman/ Secretary: **Jim Mc Geehan/Jim Wells**

Purpose: **PC-9**

Desired Outcomes:
- **Finalize Cat.1R Limits**
- **Resolve all exit criteria ballots**

TOPIC	PROCESS	WHO	TIME
Agenda Review	• Desired Outcomes & Agenda	Group	9:30 – 9:35
Minutes Approval	• August 15th 2001	Group	9:35-9:40
Membership	• Changes • Chairman's comments	Group Jim Mc Geehan	9:40-9:45
Matrix Status	• Cat.1R • Time line for PC-9	John Zalar	9:45 –10:00
Caterpillar 1R	• Statistical Analysis • BOI • Proposed Limits • Exit criteria ballot • Status of Research Report	Dwayne Tharp Phil Scinto Ralph Cherrillo	10:00 – 11:00
Oxidation	• IR oxidation and IIIF • Discussion	Greg Shank Pat Fetterman	11:00-11:30
Lunch	• Collect money for room and Lunch	Group	11:30 – 12:15
Results of Exit Criteria Ballots	• 100% pass on : Mack T-8E/Elastomer/Volatility/Roller Follower /Aeration/High Temp. Corrosion/Shear stability and foam • Mack T-10 • Cummings M11-EGR • Caterpillar 1N • SAE XX-30 –HT/HS • Used oil viscometrics	Jim Mc Geehan Group	12:15 – 3:15
Backward compatible	• Tests • User Language	Jim Mc Geehan Lew Williams	3:15-3:50
Elastomer test	• Severity adjustment	Tom Boschert	3:50-4:00

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Hardy, Bryant Conoco P.O. Box 1267 Ponca City, OK	(580) 767-5601 bryant.j.hardy@usa.conoco.com		
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SECTION D.02.B0.02
HEAVY DUTY ENGINE OIL CLASSIFICATION PANEL

ATTENDANCE LIST

SEPTEMBER 2001

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PREVIOUS GUESTS

	Phone No. Fax No. e-mail add.	INITIAL WHEN PRESENT	ROOM FEE
Klein, Rick Oronite 30150 Telegraph Rd., Suite 416 Bingham Farms, MI 48025	(248) 540-3277 (248) 540-3279 rmkl@chevron.com	RMK	☺
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Lee, Rich Chevron Oronite 100 Chevron Way Richmond, CA 94802	(510) 242-2988 (510) 242-3173 rhle@chevron.com	RAL	☺
Malandro, Dennis Infineum USA, LP 1900 E. Linden Ave. Linden, NJ 07036	(908) 474-3895 (908) 474-2298 dennis.malandro@infineum.com		
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SEPTEMBER 2001

PREVIOUS GUESTS

	Phone No. Fax No. e-mail add.	INITIAL WHEN PRESENT	ROOM FEE
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SEPTEMBER 2001

PREVIOUS GUESTS

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SEPTEMBER 2001

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SEPTEMBER 2001

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SEPTEMBER 2001

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Smith, Leigh L. CITGO Petroleum Corp. 28 Cedar Hill Rd. Newtown, CT 06470	(203) 270-8156 (203) 270-8452 lsmith2@citgo.com		
Smith, Roy (A09) Detroit Diesel Corp. 13400 W. Outer Loop Dr. Detroit, MI 48239-4001	(313) 592-5758 (313) 592-7888 roy.smith@detroitdiesel.com		
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SEPTEMBER 2001

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Sztenderowicz, Mark Chevron Products Co. 100 Chevron Way Richmond, CA 94802-0627	(510) 242-1022 (510) 242-3758 mlsz@chevron.com		
Tarbox, Steven R. 76 Lubricants Company 1920 E. Deere Avenue Santa Ana, CA 92705	(714) 428-7400 (714) 428-7498 starbox@tosco.com		
Tharby, Ron Tharby & Associates 273 Juniper Ave. Burlington, Ontario L7L2TS	(905) 632-1568 (905) 333-8194		
Tucker, Richard Shell International Petroleum Co. P.O. Box 1380 Houston, TX 77251-1380	(281) 544-8354 (281) 544-6196 rftucker@shellus.com		
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Vidal, Andre Total Raffinage Distribution Cedex 47 92069 Paris La Defense, FRANCE	33 (1) 41 35 2482 33 (1) 41 35 8561		
Villena-Denton, Vicky F&L Asia Publications, Inc. POBox 151 Ayala Alabang Village Post Office 1780 Muntinlupa City, Philippines	63 917 531-1736 63 807-54-90 flasia@i-manila.com.ph		
Wakem, Mark Shell Research Ltd. P.O. Box 1 Chester, England CH1 3SH	44 (0) 151 373 5779 44 (0) 151 373 5475 mark.p.wakem@opc.shell.com		
Weber, Ben Southwest Research Institute 6220 Culebra Rd. San Antonio, TX 78238	(210) 522-5911 (210) 684-7530 bweber@swri.edu	BW	☺
Weismiller, Michael Ciba Spec. Chemicals 540 White Plains Rd. Tarrytown, NY 10591	(914) 785-5515 michael.weismiller@cibasc.com		
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___San Antonio, TX 78238___________________________	john.glaser@perkinelmer.com	

Name:____
Company:____
Address:____
____

Name:____
Company:____
Address:____
____

Name:____
Company:____
Address:____
____

Status of PC-9 Matrix Testing

Presented to HDEOCP

September 26, 2001

John L. Zalar

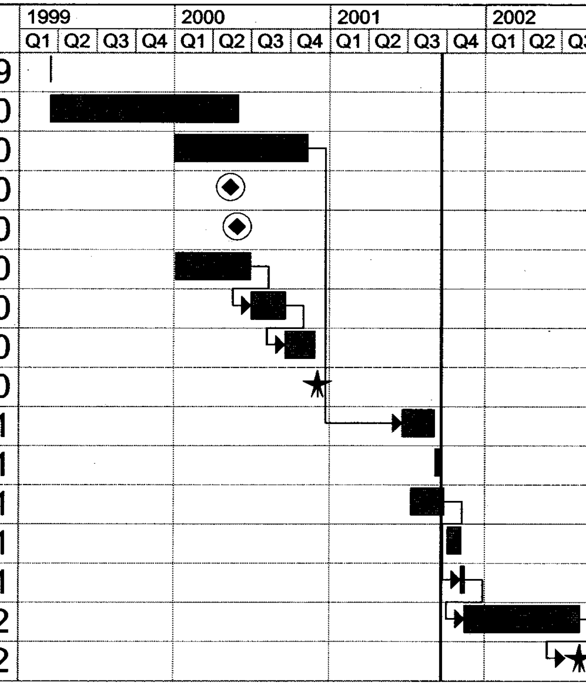
1R

- **Planned Tests: 18**
- **Total Starts: 19**
- **Completed Tests**
  - **Posted on TMC web site: 18**
  - **Aborted/Invalid: 1**
- **Statistical analysis completed and consensus reached by statisticians**

Summary of Events Required for PC-9 Licensing

J. L. Zalar 9/26/01

ID	Task Name	Start	Finish
1	Define PC-9 Performance Parameters	3/16/99	3/16/99
2	Design Precison Matrix	3/17/99	5/31/00
3	PC-9 Funding MOA Signed	1/3/00	11/10/00
4	1Q & M11EGR Adequate for Oil Devel.	5/15/00	5/15/00
5	Finalize Base Oil Selections for Prec. Mtx.	5/31/00	5/31/00
6	Finalize Additive Selections for Prec. Mtx.	1/6/00	6/30/00
7	Base Oils Recd. by Additive Companies	7/3/00	9/20/00
8	Blend Matrix Oils > TMC > Labs	9/21/00	11/27/00
9	Final Acceptance of New Engine Tests	12/5/00	12/5/00
10	PC-9 Matrix Testing*	6/20/01	9/2/01
11	Precision Matrix Data Analysis (1R)	9/6/01	9/14/01
12	HDEOCP Post Matrix Test Acceptance	7/11/01	9/26/01
13	Subcommittee B Ballot	10/5/01	11/5/01
14	Finalize Pass/Fail Criteria (Sub B Mtg)	11/6/01	11/14/01
15	New Product Development	11/15/01	8/14/02
16	API Licensing Allowed	8/15/02	8/15/02



* Last 1R Stand

Caterpillar Piston Deposit Test
Proposed Limits

CATERPILLAR®

ATTACHMENT 4, 1 OF 11

Aluminum Piston Deposit Test

- A wide range of data was evaluated
  - Different companies
  - Different laboratories
  - Different formulations
  - Single and Multi-cylinder




CATERPILLAR®

Aluminum Piston Deposit Test

- Conclusions:
  – No definitive data was put forth to alter 1N limits from CG-4 criteria
    - Raising 1N limits was not supported by the data nor by multi-cylinder testing
    - Raising limits <u>could</u> lead to loss of oil control




Aluminum Piston Deposit Test

- **Proposal:**
  - Use Cat 1N test with CG-4 limits **<u>OR</u>**
  - Use Cat 1K test with CH-4 limits (multi-pass)




CATERPILLAR®

1N Limits

	1 Test Pass	2 Test Pass	3 Test Pass
WDN	286.2	311.7	323.0
TGF	20	23	25
TLHC	3	4	5
Ave OC	0.5	0.5	0.5
Scuffing	None	None	None
Sticking	None	None	None




1K Limits

	1 Test Pass	2 Test Pass	3 Test Pass
WDK	332.0	347.0	353.0
TGF	24	27	29
TLHC	4	5	5
Ave OC	0.50	0.50	0.50
Scuffing	None	None	None
Sticking	None	None	None




CATERPILLAR®

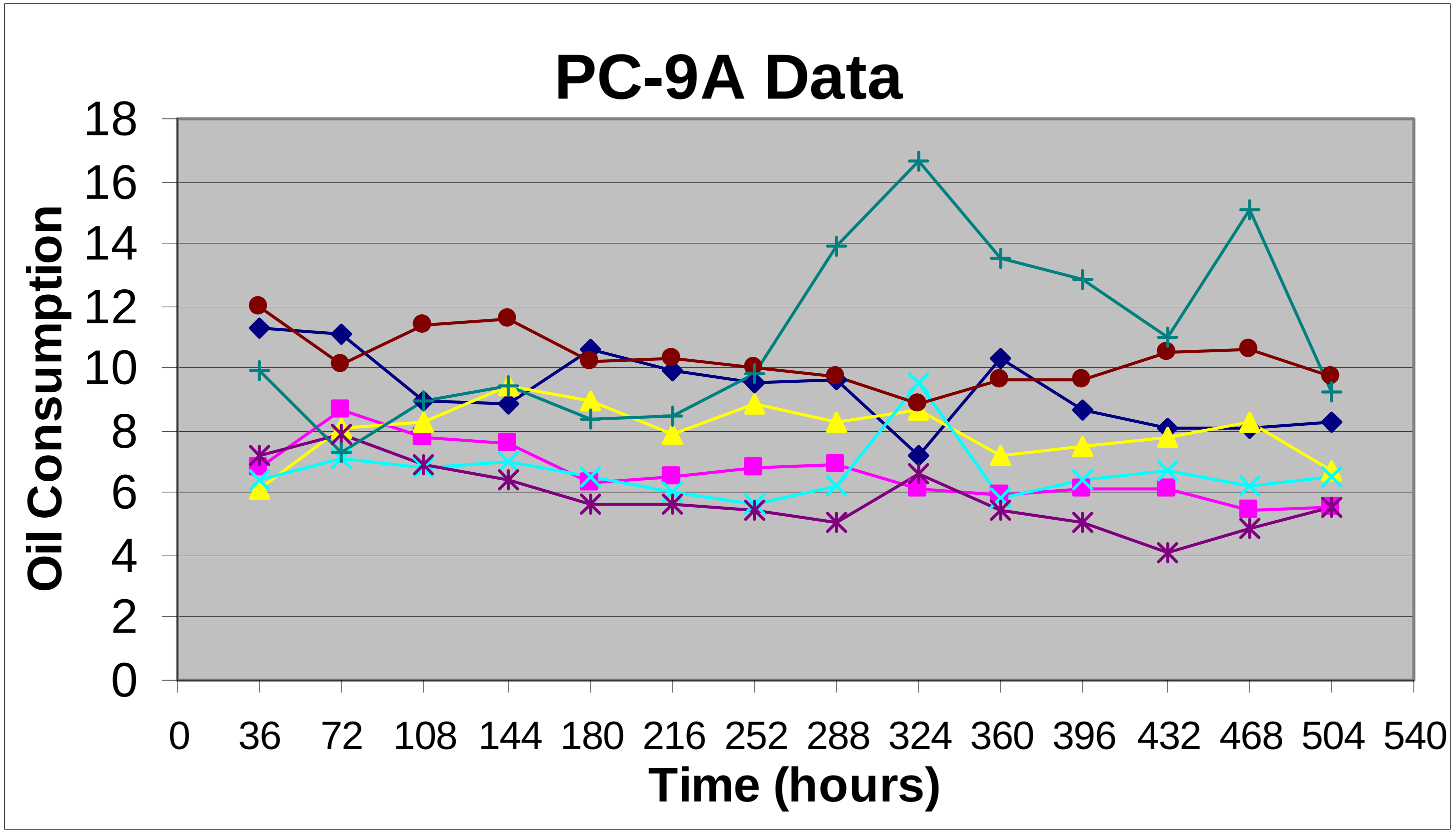
Articulated Steel Piston Deposit Test

- PC-9 test matrix completed
- Statistical analysis completed and verified
- Set Limits based on past experience with similar oils and matrix oils



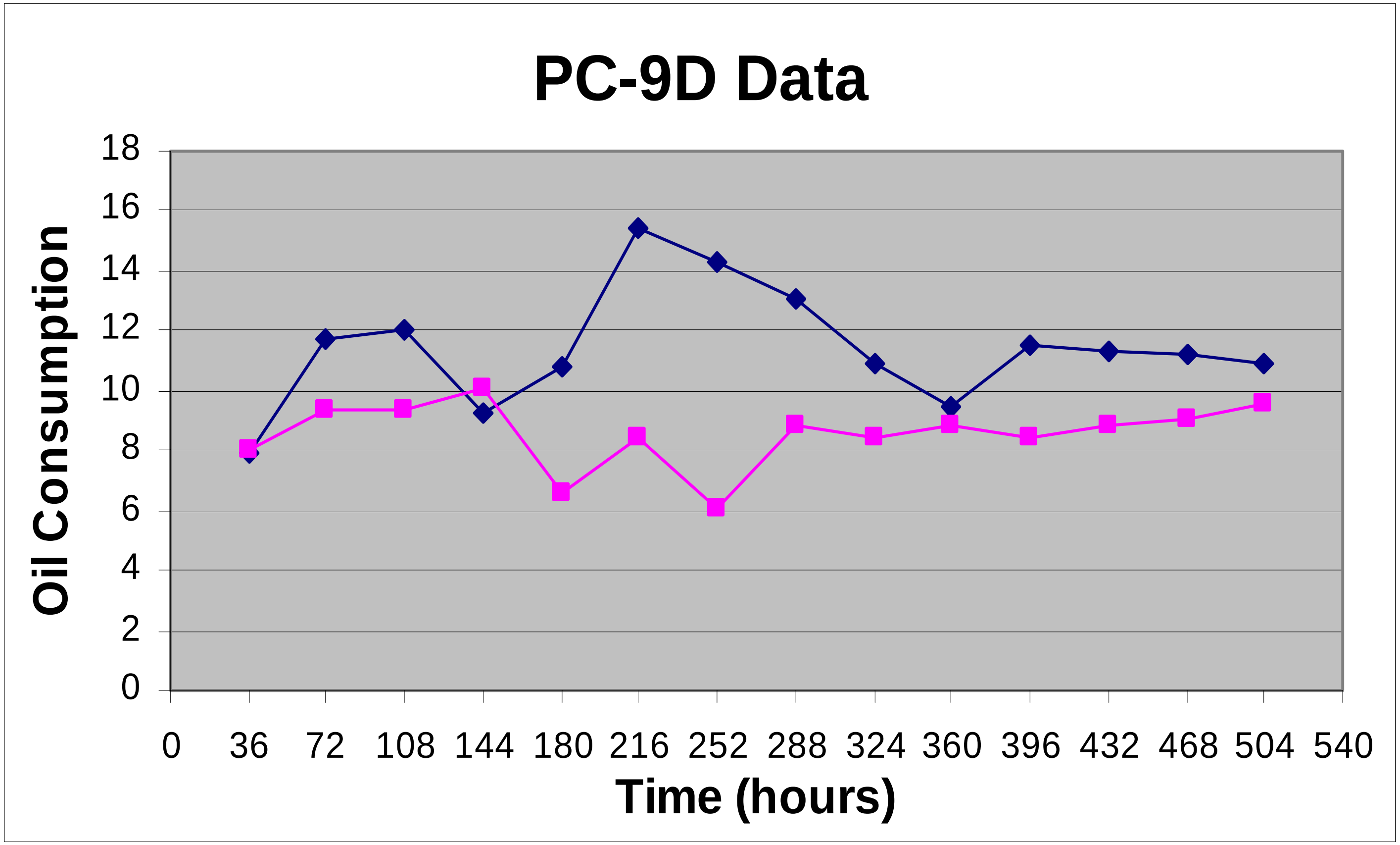

CATERPILLAR®

PC-9A Oil Consumption



ATTACHMENT 4, 8 OF 11

PC-9D Oil Consumption



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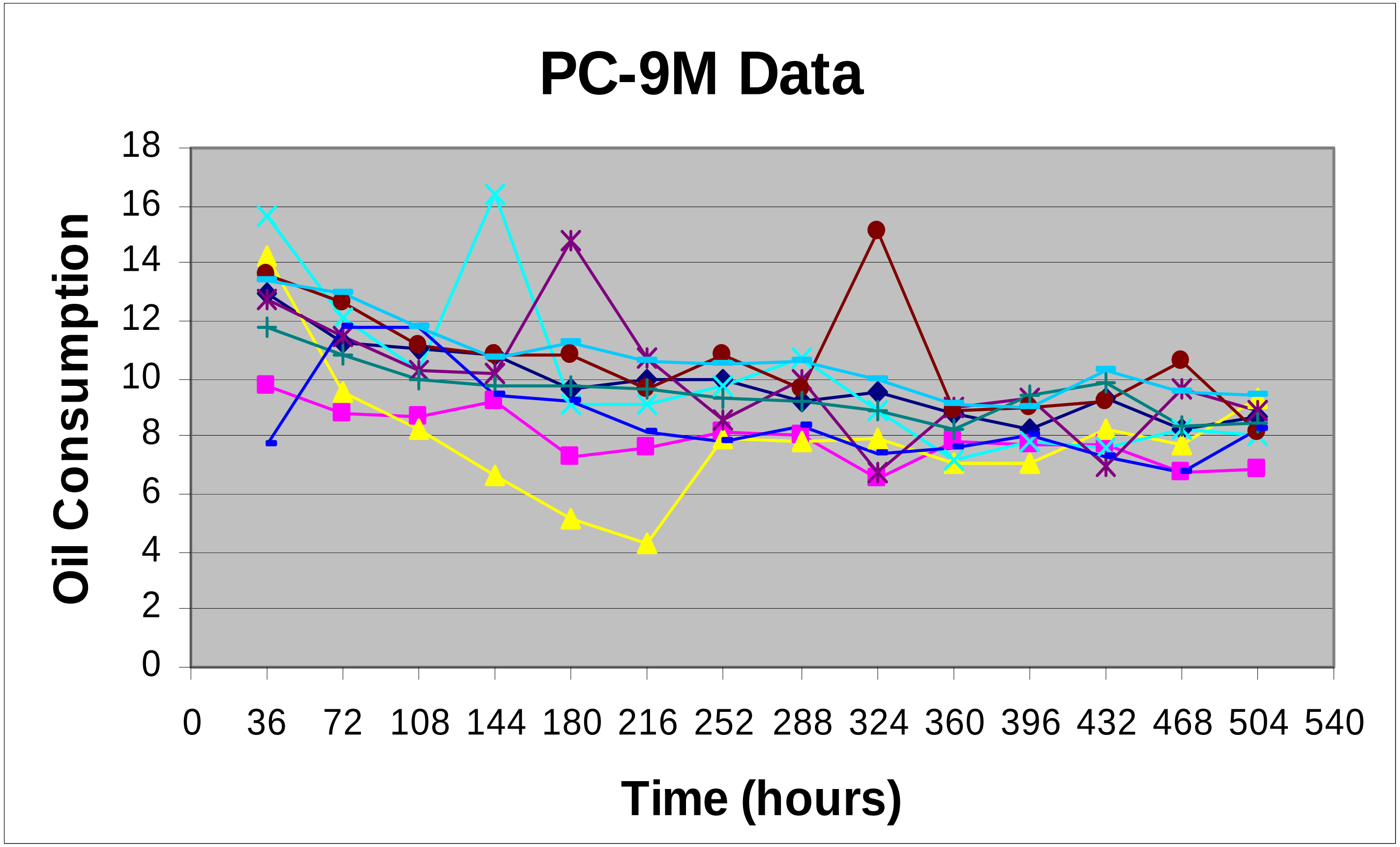
PC-9M Oil Consumption



CATERPILLAR®

1R Test Limit Proposal

- Matrix data was compared to multi-cylinder engine tests
- Proposed limits:

	1 Test Pass	2 Test Pass	3 Test Pass
WDR	382.0	410.5	433.8
TGC	52	63.0	72.3
TLC	31	36.4	41.0
OC/Ratio	13.1/1.0	13.1/1.0	13.1/1.0
Scuffing	None	None	None
Sticking	None	None	None




CATERPILLAR®

REVISED DRAFT of the Statistical Summary of the Caterpillar 1R Precision Matrix

09/25/2001

Caterpillar 1R Matrix Summary

- The 1R matrix is complete.
- Only WD, TGC, TLC, OC, ETOC, TGF, TLHC, UCWD and ALW analyzed to date. Is there more?
- Three oils (A, D, M) are in the matrix. There is some weak evidence of oil discrimination in Weighted Demerits and Average Oil Consumption and evidence of oil discrimination in End of Test Oil Consumption.
- No transformations necessary among the major parameters. TLHC needs a transformation.

Caterpillar 1R Matrix Summary

- High Copper may affect UCWD, but does not seem to affect other parameters. An unusually high UCWD result of 22 occurred in CMIR 41536 (Lab A, Oil M), but had High Copper early in the test.
- There are Lab effects in OC, ETOC and Liner Wear.
- CMIR 41547 (Lab B, Oil A) had unusually high test results in WD, TLC and TLHC.
- There are positive correlations among the parameters especially TGF/TGC and OC/ETOC.
- There are Lab and Stand differences in Torque & Blowby

Caterpillar 1R Matrix Summary

- Average humidity for CMIR 41543 (Lab D, Oil M) of 18.2 was different from all other tests which ran at 17.8 or 17.9.
- Average coolant flow of 63 L/m in CMIRs 41535, 41536 and 41537 (all Lab A) did not meet the 75 L/m specification. After investigation, the 1R Task Force concluded that the matrix test results were unaffected by the Coolant Flow difference.
- The Average Liner Wear of 0.03 for CMIR 41537 is a mistake in the database. The result should be 0.003 mm.
- The End of Test Oil Consumption of 9.4 for CMIR 41760 is a mistake in the database. The result should be 11.1.

Caterpillar 1R Matrix Summary

- Reference Oil targets for Oils A and M may be based on the analysis of the entire matrix, or the summary statistics for each individual reference oil.

Caterpillar 1R Matrix

Lab A			Lab B	Lab G			Lab D	Lab F
Stand 1	Stand 2	Stand 3	Stand 1	Stand 1	Stand 2	Stand 3	Stand 1	Stand 7
M	M	A	M	M	M	A	A	M
A	D	M	A	A	D	M	M	A

Caterpillar 1R Correlations

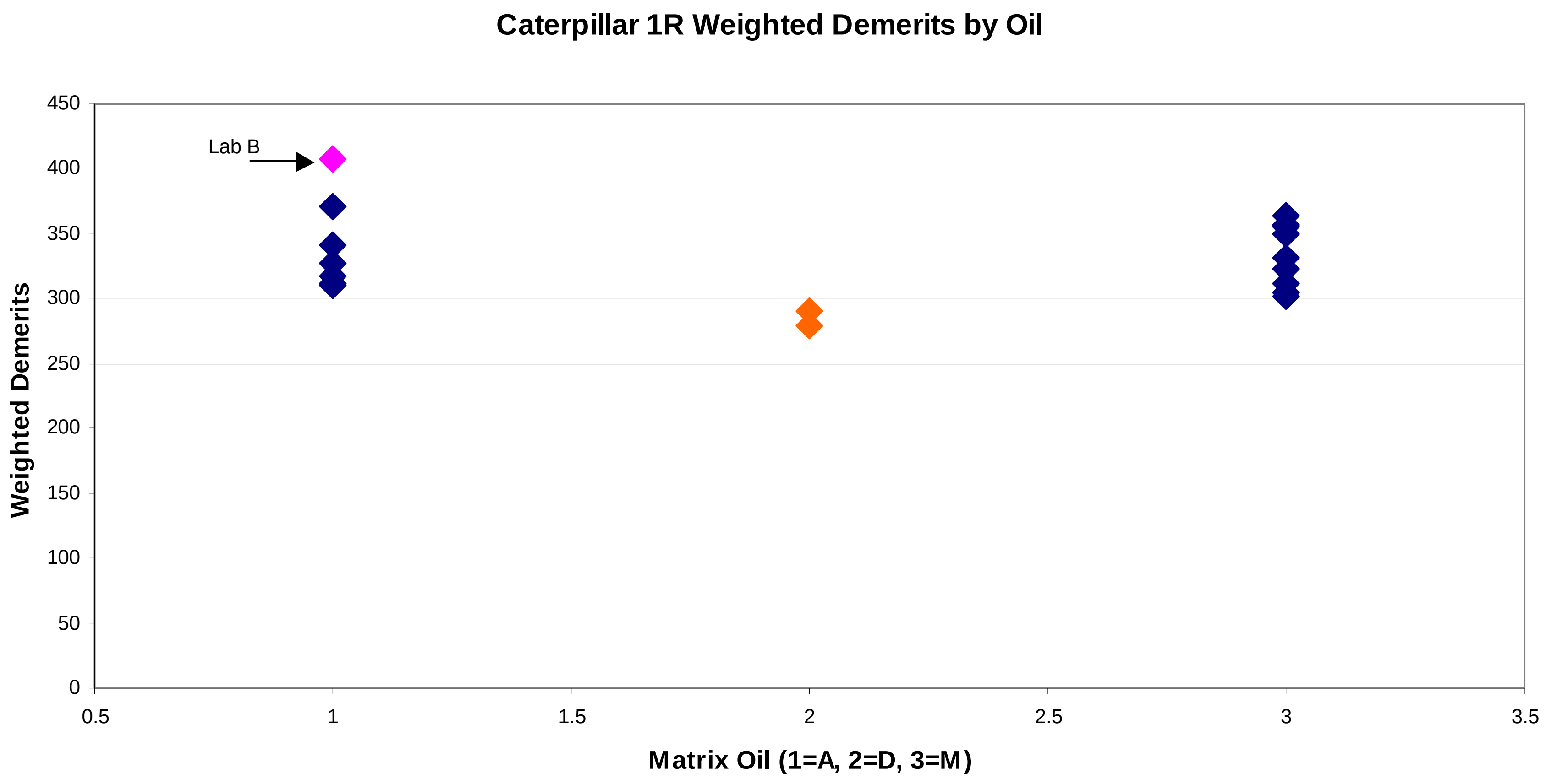
WD	0.66	0.64	0.07	0.16	0.69	0.48	0.17	-0.01
0.57	TGC	0.64	0.25	0.25	**0.95**	0.58	-0.12	-0.28
0.50	0.57	TLC	0.30	0.42	0.66	0.75	-0.19	0.06
0.35	0.28	0.49	OC	**0.89**	0.24	0.35	-0.01	0.03
0.55	0.31	0.66	0.89	ETOC	0.27	0.41	-0.09	-0.03
0.71	**0.95**	0.63	0.18	0.31	TGF	0.34	-0.03	-0.09
0.31	0.48	0.79	0.39	0.47	0.53	TLHC*	-0.04	-0.24
0.27	-0.31	-0.08	-0.33	-0.23	-0.09	-0.09	UCWD	-0.14
0.13	-0.37	-0.22	-0.48	-0.38	-0.21	-0.27	0.69	ALW

Raw Data Correlations on Upper Triangle; Partial Correlations on Lower Triangle

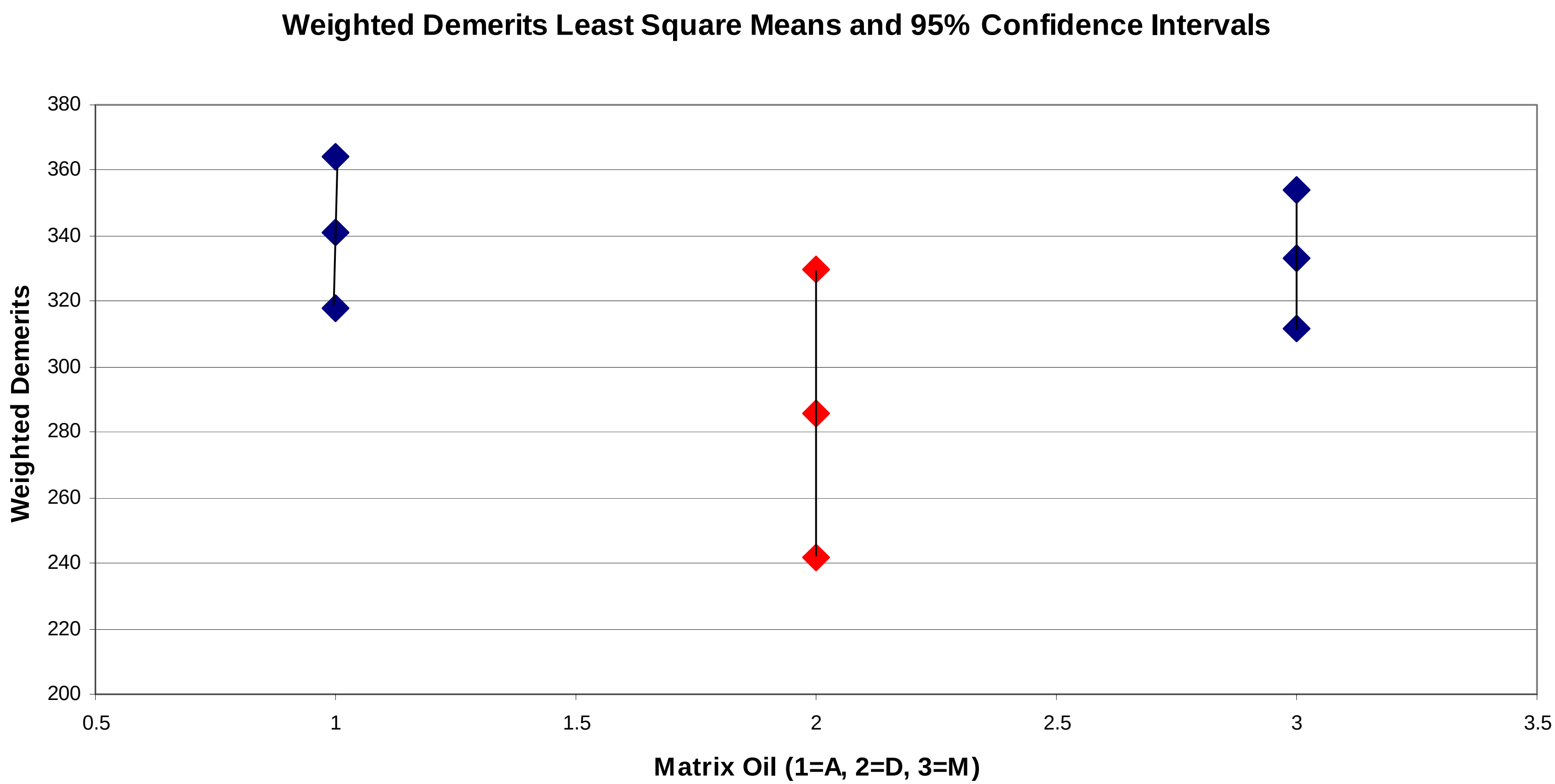
Weighted Deposits (WD)

- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- Some evidence that Oil D is Lower than Oils A and M
  - Root MSE = 29.03 (15 df – Oil Model)
  - $R^2 = 0.28$
  - CMIR 41547 (Lab B, Oil A) had a large Studentized residual

p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.08	0.85	341.2
Oil D	0.08		0.13	285.9
Oil M	0.85	0.13		333.3



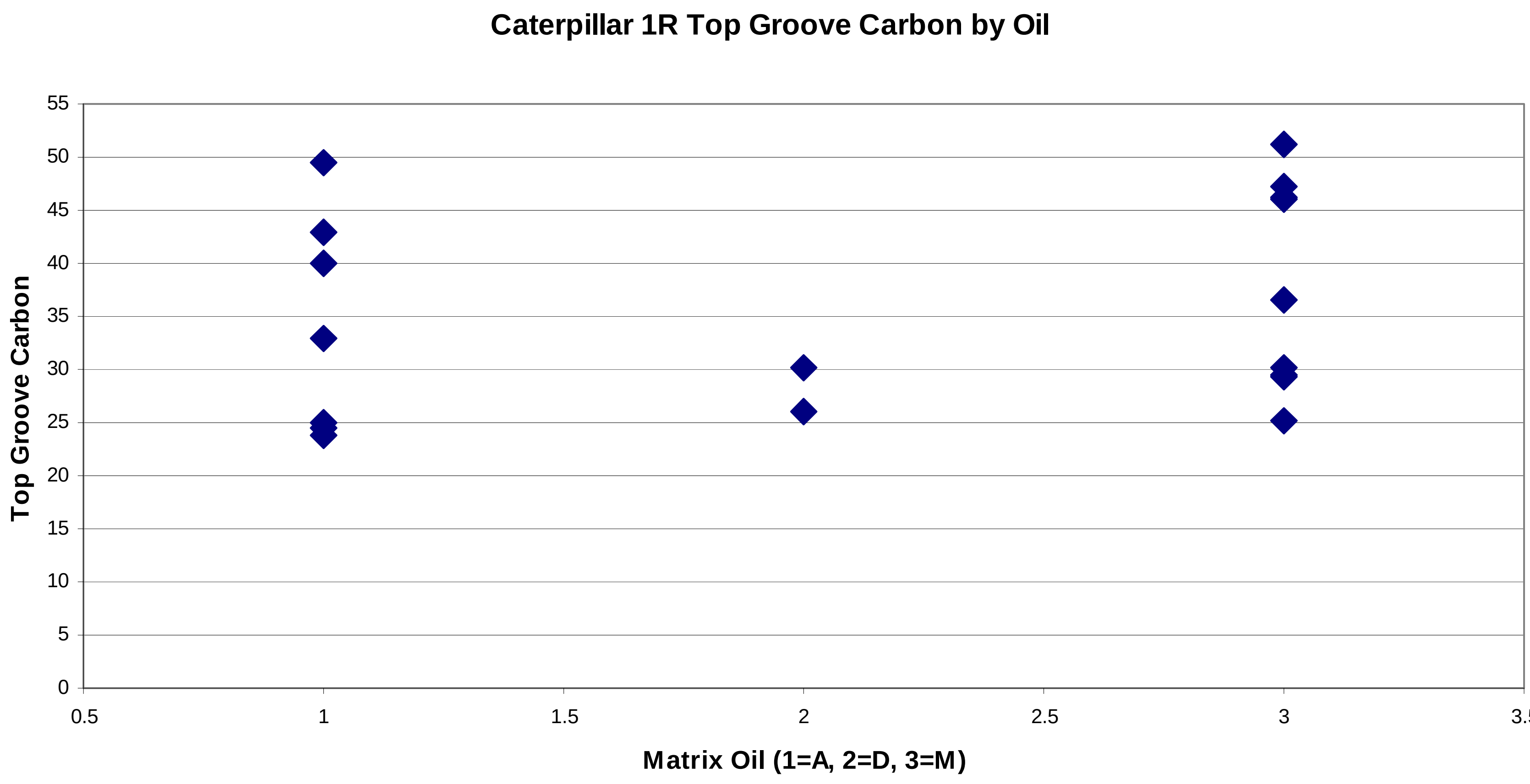
Caterpillar 1R Weighted Demerits by Oil
Lab B
Weighted Demerits
450
400
350
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)


Weighted Demerits Least Square Means and 95% Confidence Intervals
Weighted Demerits
380
360
340
320
300
280
260
240
220
200
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

Top Groove Carbon (TGC)

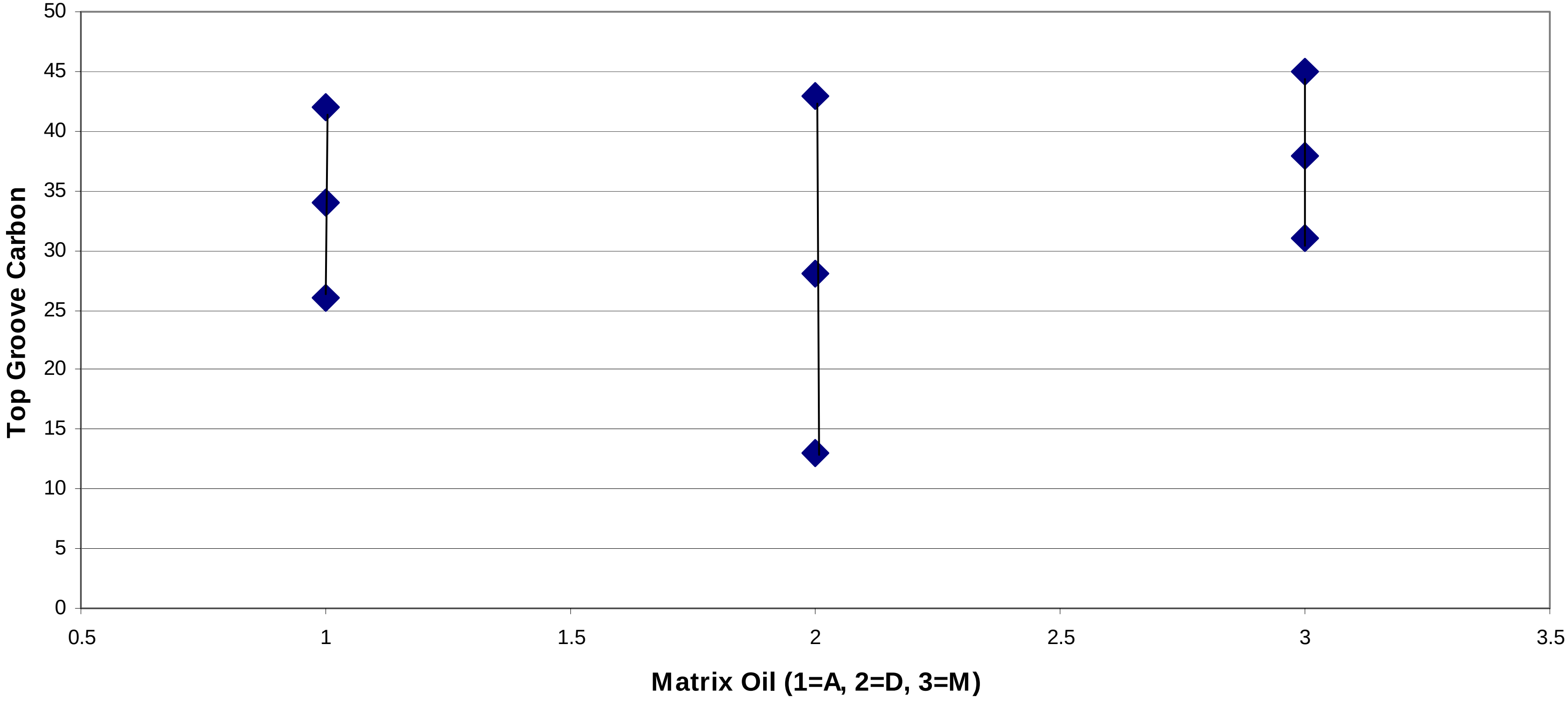
- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- No evidence of any effects
  - Root MSE = 9.70 (15 df – Oil Model)
  - $R^2 = 0.11$
  - No observations had large Studentized residuals

p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.73	0.72	34.1
Oil D	0.73		0.42	28.1
Oil M	0.72	0.42		37.9



Caterpillar 1R Top Groove Carbon by Oil
Top Groove Carbon
0
5
10
15
20
25
30
35
40
45
50
55
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

Top Groove Carbon Least Square Means and 95% Confidence Intervals

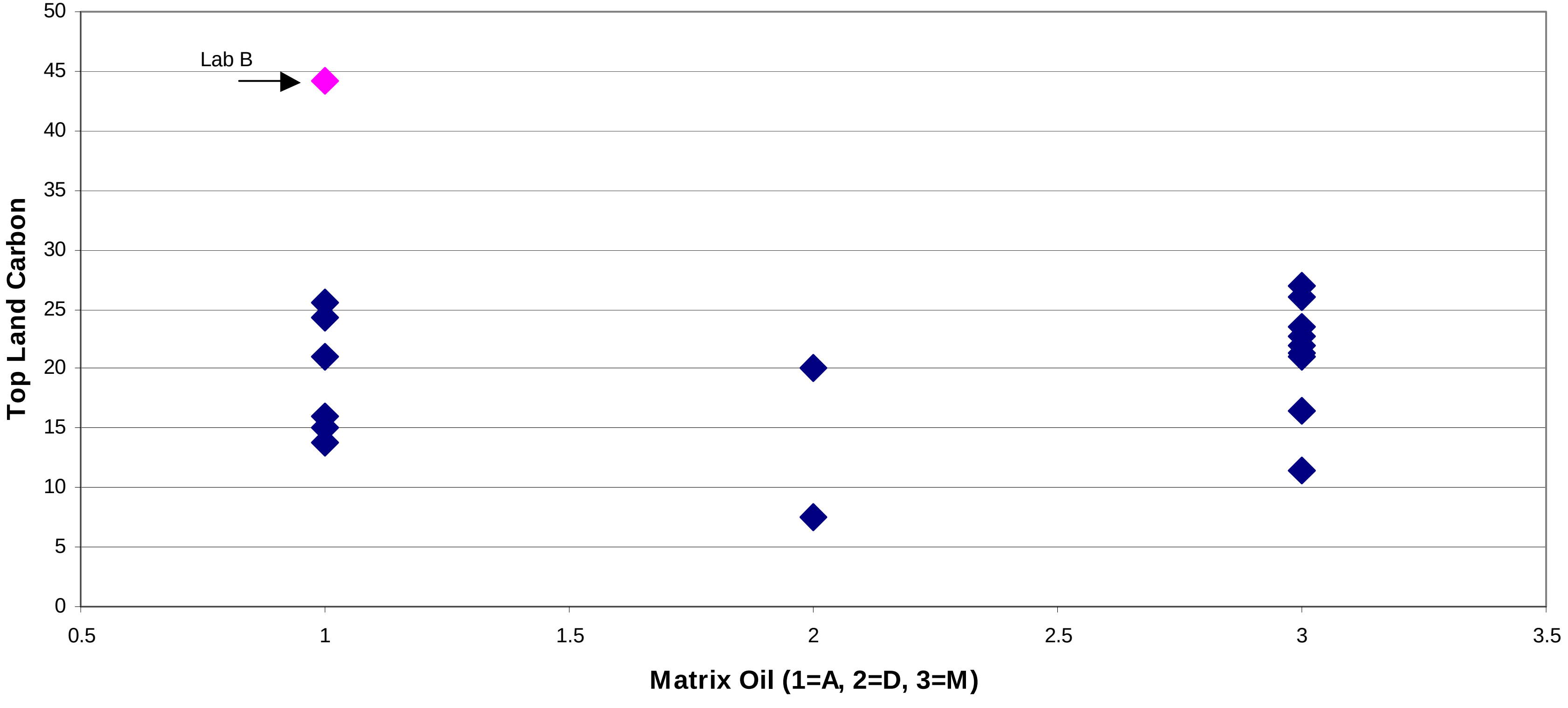


Top Land Carbon (TLC)

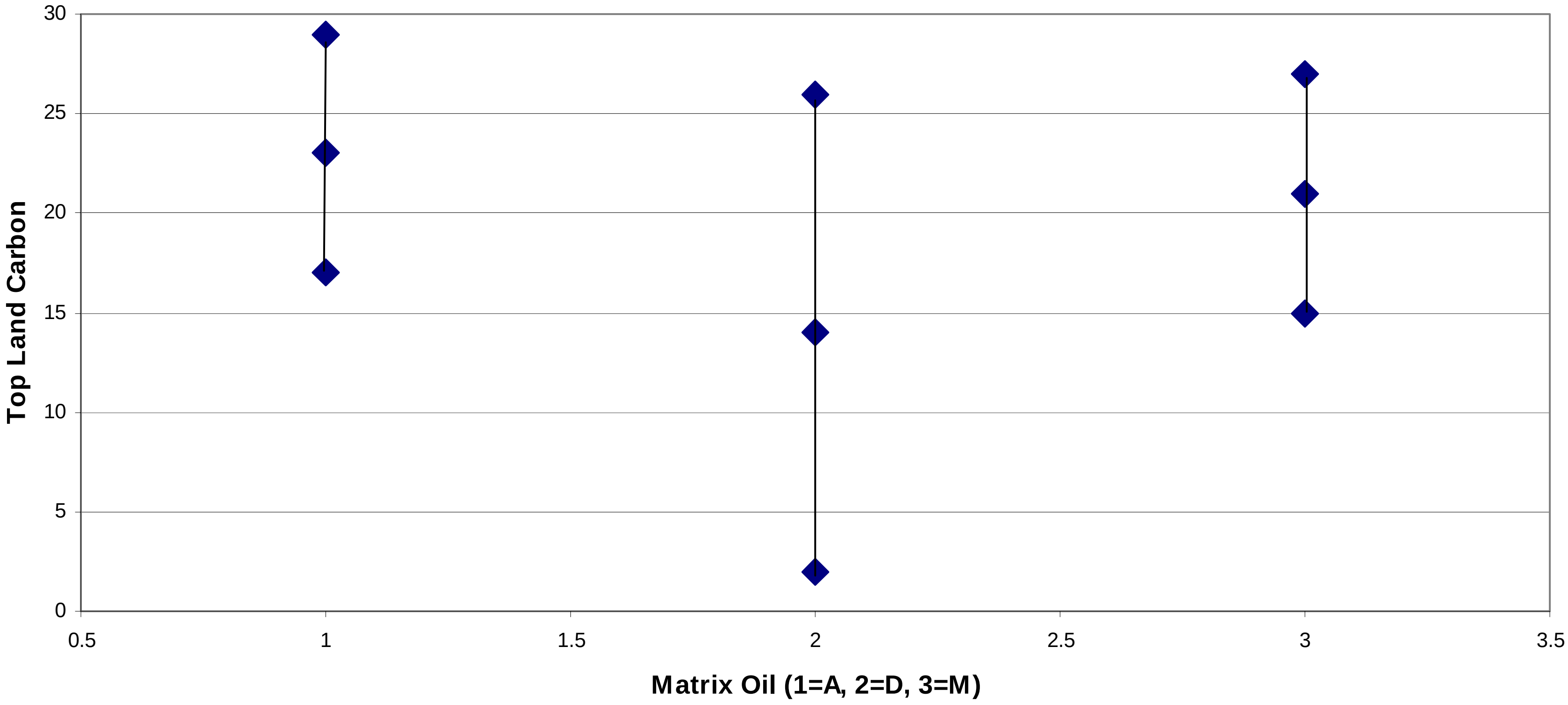
- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- No evidence of any effects
  - Root MSE = 7.84 (15 df – Oil Model)
  - $R^2 = 0.12$
  - CMIR 41547 (Lab B, Oil A) had a large Studentized residual

p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.34	0.92	22.8
Oil D	0.34		0.45	13.8
Oil M	0.92	0.45		21.3

Caterpillar 1R Top Land Carbon by Oil



Top Land Carbon Least Square Means and 95% Confidence Intervals



Average Oil Consumption (OC)

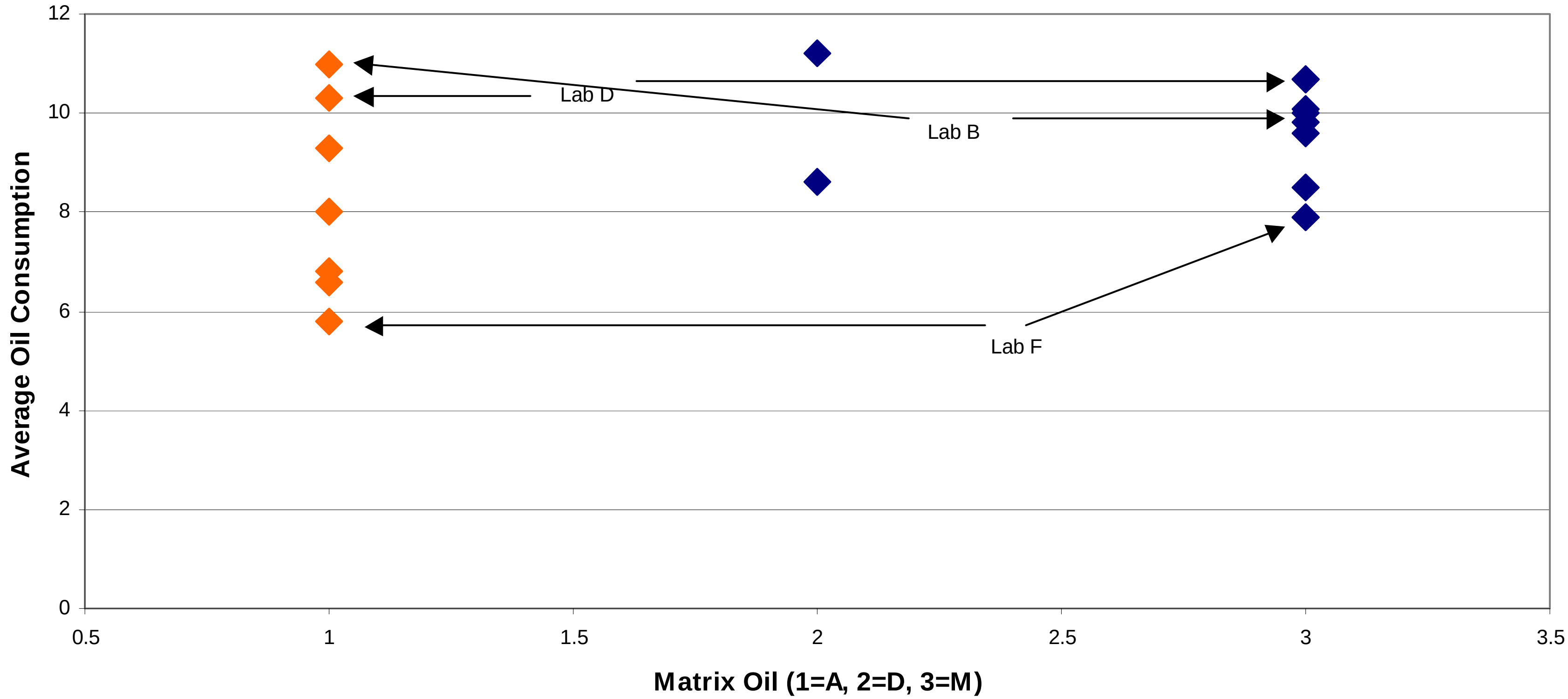
- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- Some evidence that Lab F is Lower than Labs B and D and some weak evidence that Oil A is Lower than Oils D & M
  - Root MSE = 1.19 (11 df – Lab and Oil Model)
  - $R^2 = 0.65$
  - No observations had large Studentized residuals

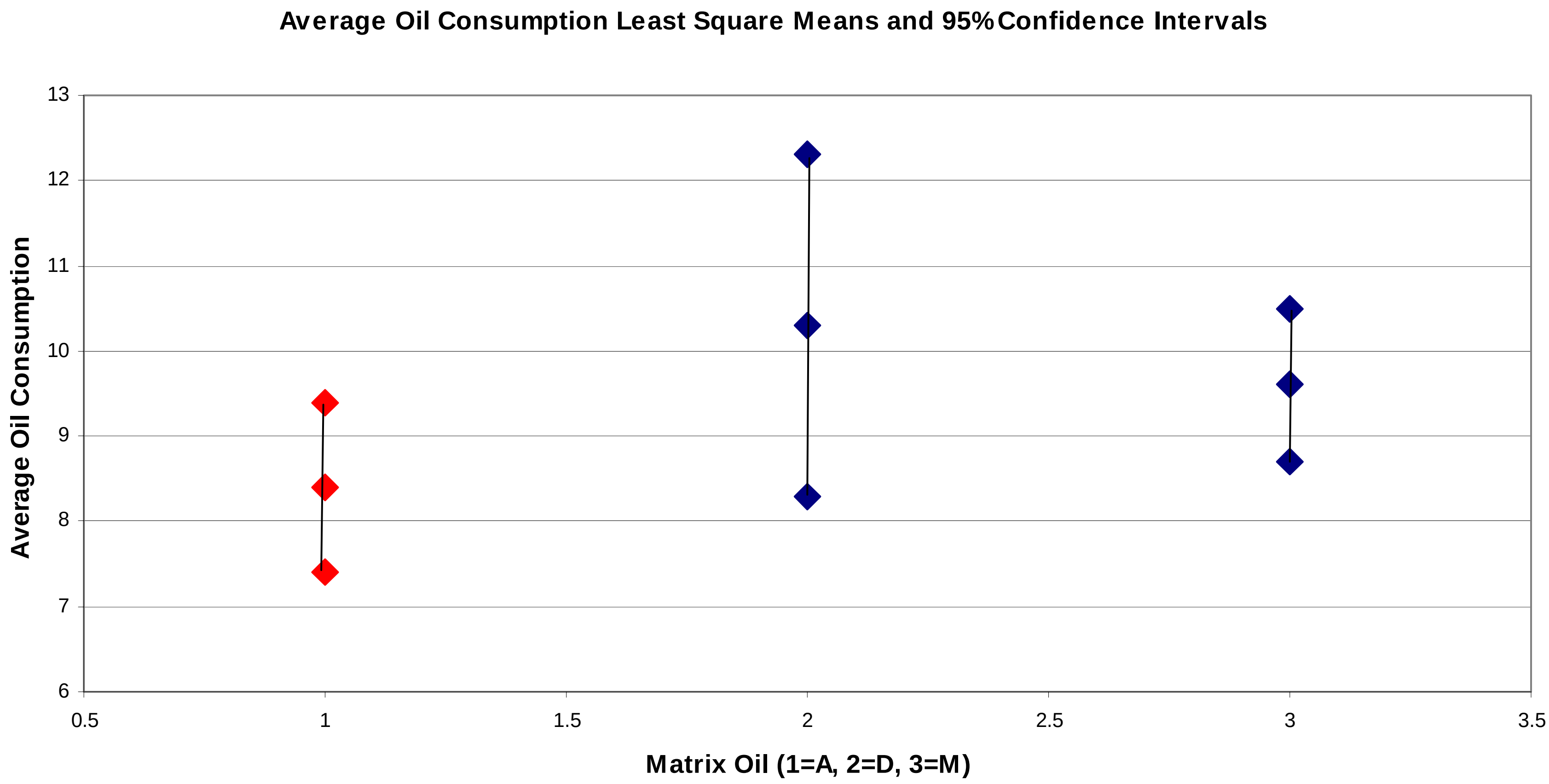
p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.17	0.13	8.37
Oil D	0.17		0.77	10.31
Oil M	0.13	0.77		9.65

Average Oil Consumption (OC)

p-values in Hypothesis Test of No Difference						Least Square Mean
	Lab A	Lab B	Lab D	Lab F	Lab G	
Lab A		0.56	0.56	0.27	0.81	9.41
Lab B	0.56		1.00	0.07	0.22	10.93
Lab D	0.56	1.00		0.07	0.22	10.93
Lab F	0.27	0.07	0.07		0.64	7.28
Lab G	0.81	0.22	0.22	0.64		8.66

Caterpillar 1R Average Oil Consumption by Oil




Average Oil Consumption Least Square Means and 95% Confidence Intervals
Average Oil Consumption
13
12
11
10
9
8
7
6
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

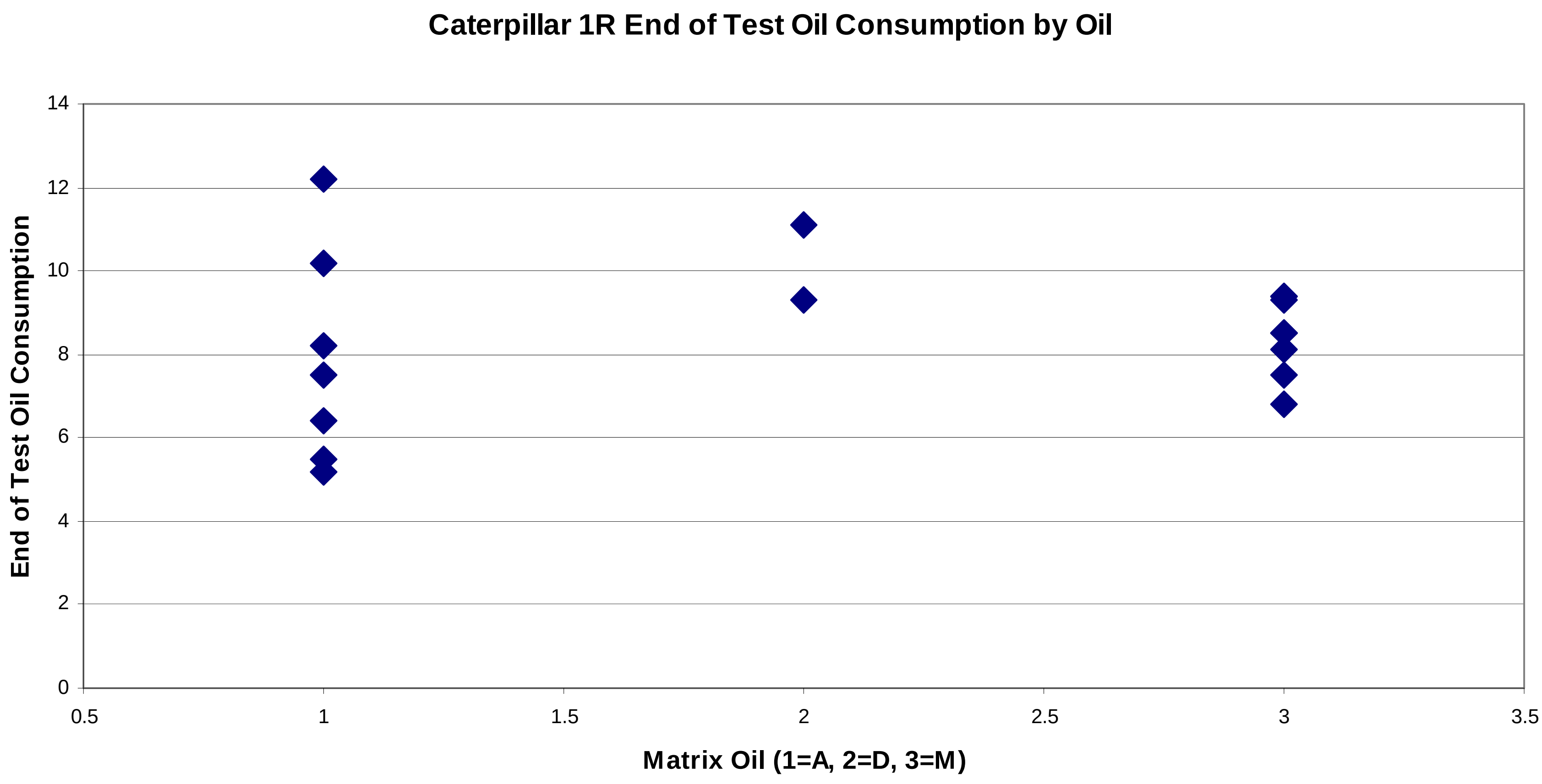
End of Test Oil Consumption (ETOC)

- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- Evidence that Oil D is Higher than Oil A and some evidence that it is Higher than Oil M
- Evidence that Lab B is Higher than Lab G and some evidence that it is Higher than Lab F
  - Root MSE = 1.35 (11 df – Lab and Oil Model)
  - R^2 = 0.64
  - No observations had large Studentized residuals

p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.05	0.57	8.15
Oil D	0.05		0.13	11.14
Oil M	0.57	0.13		8.86

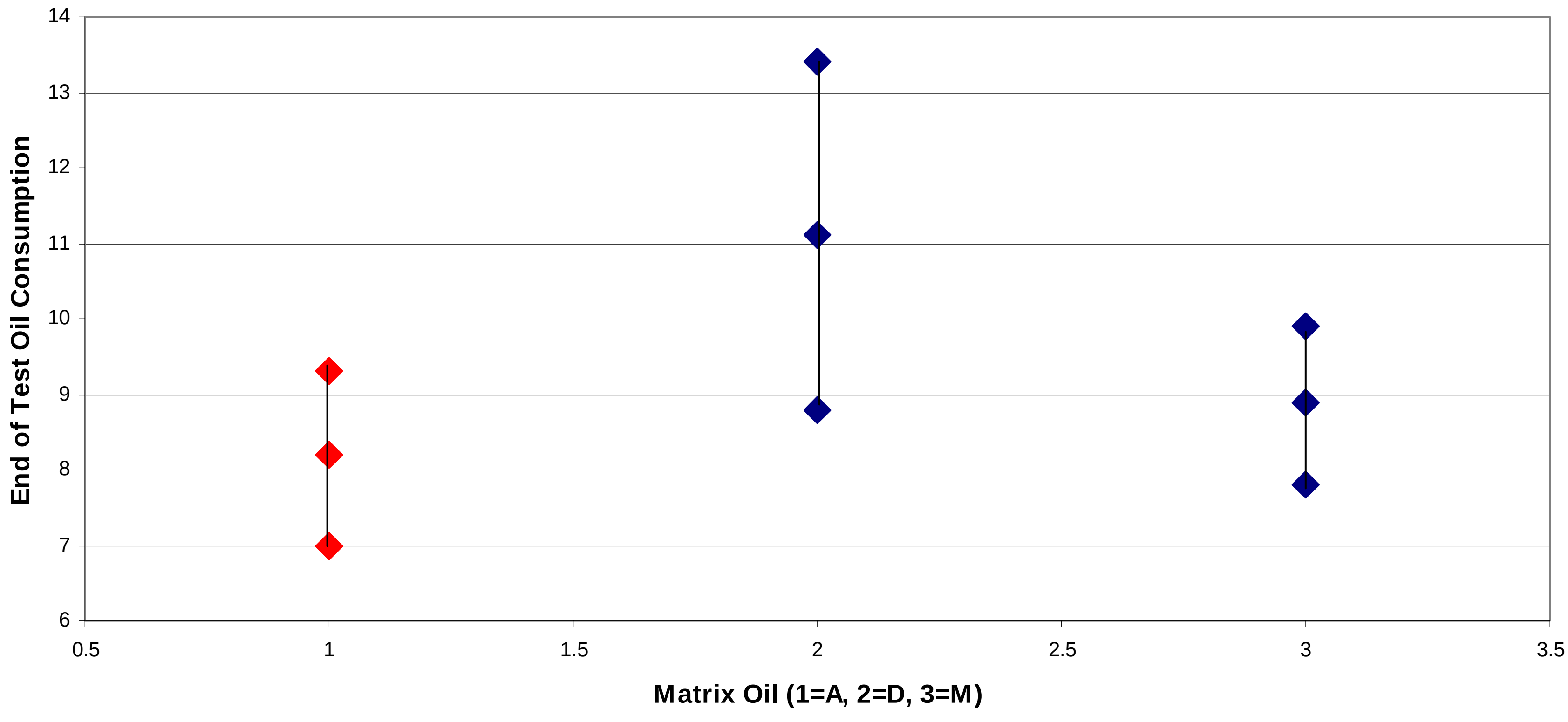
End of Test Oil Consumption (ETOC)

p-values in Hypothesis Test of No Difference						Least Square Mean
	Lab A	Lab B	Lab D	Lab F	Lab G	
Lab A		0.16	0.49	0.86	0.87	8.81
Lab B	0.16		0.95	0.09	0.05	11.63
Lab D	0.49	0.95		0.25	0.21	10.68
Lab F	0.86	0.09	0.25		1.00	7.73
Lab G	0.87	0.05	0.21	1.00		8.08



Caterpillar 1R End of Test Oil Consumption by Oil
End of Test Oil Consumption
0
2
4
6
8
10
12
14
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

End of Test Oil Consumption Least Square Means and 95% Confidence Intervals



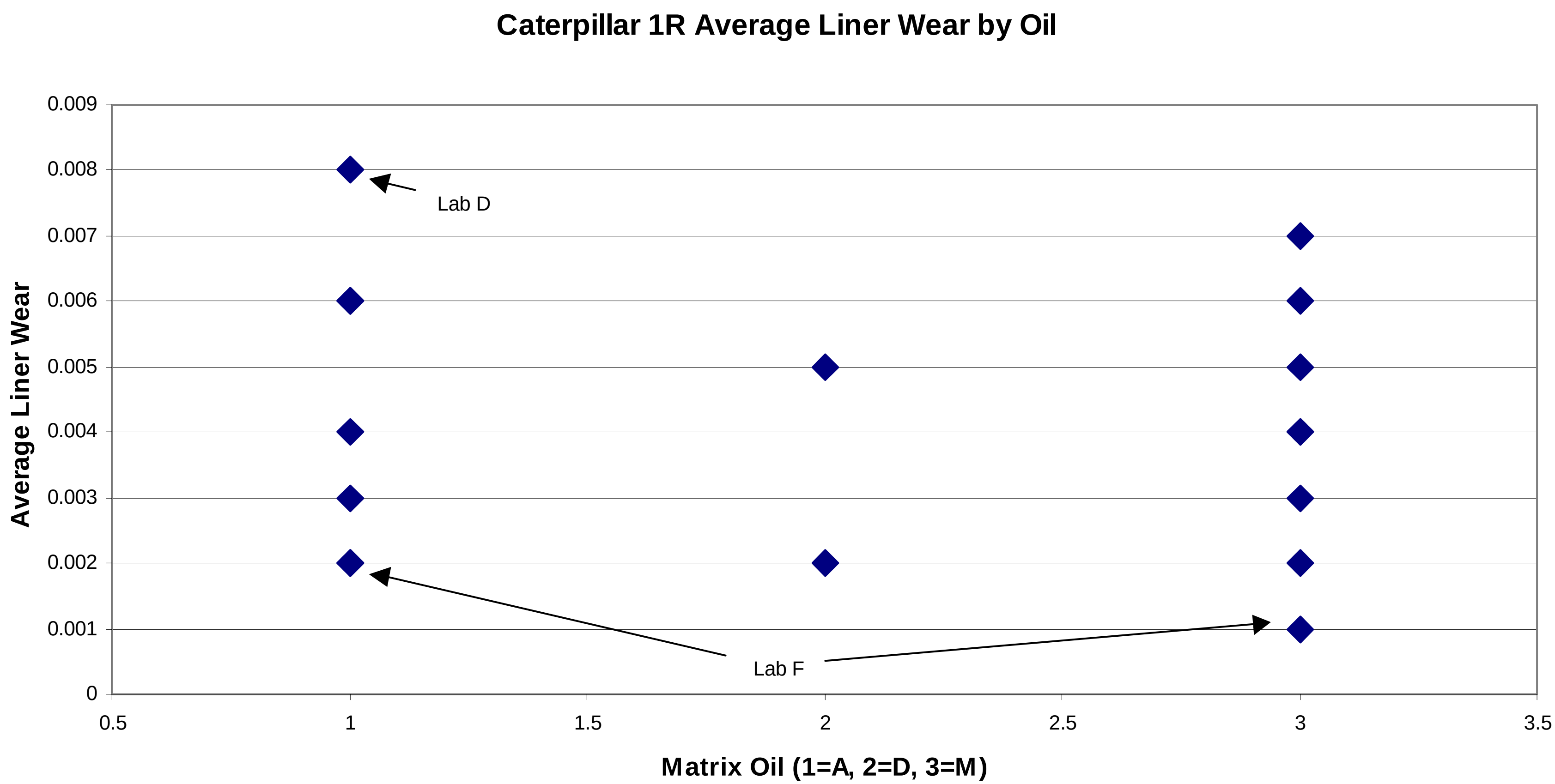
Average Liner Wear (ALW)

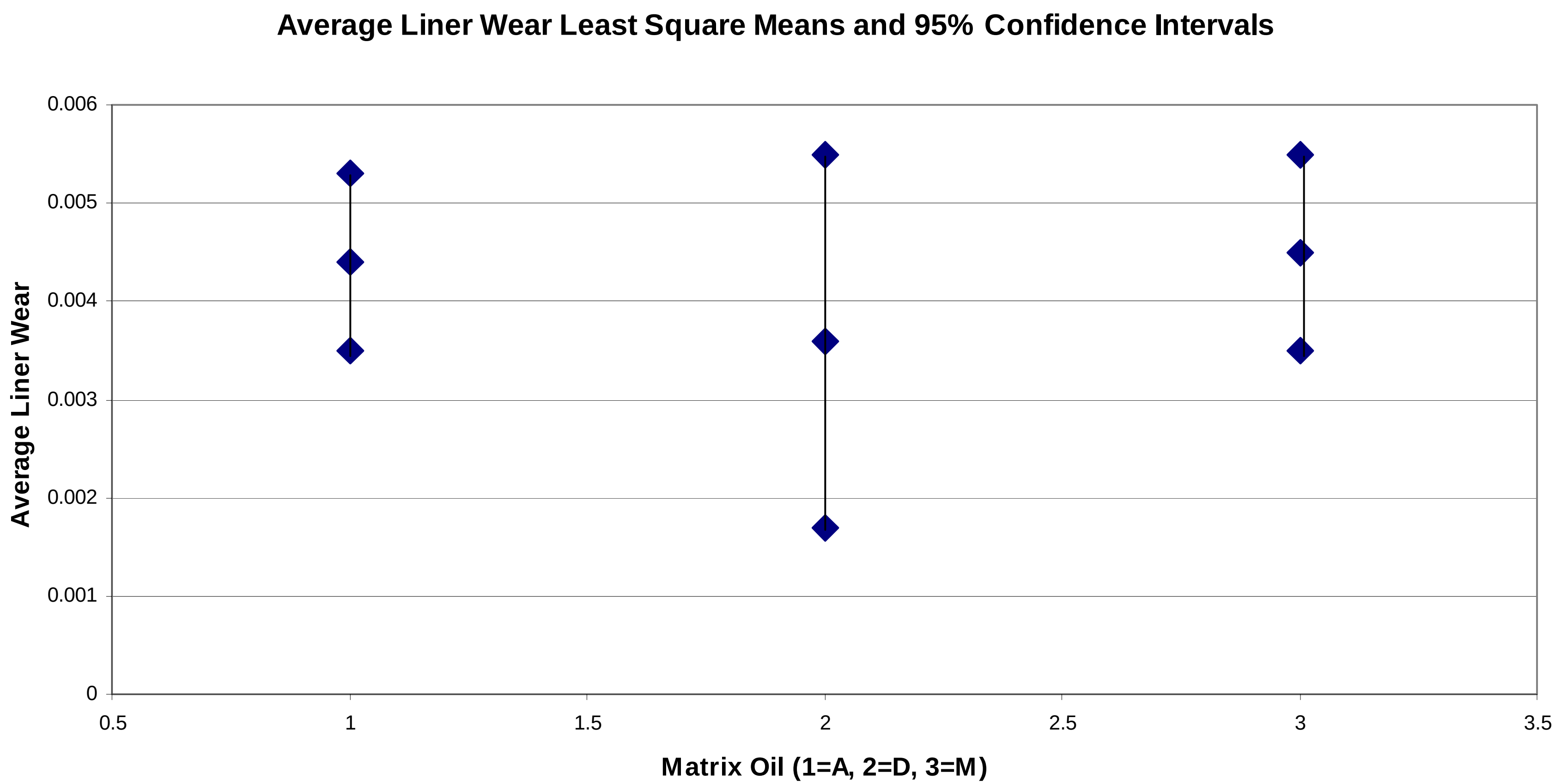
- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- Evidence that Labs differ ($p<0.05$)
  - Root MSE = 0.001064 (10 df – Lab and Oil Model)
  - $R^2 = 0.83$
  - No observations had large Studentized residuals
  - ALW for CMIR 41543 (Lab D, Oil M) is missing

p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.60	0.99	0.0044
Oil D	0.60		0.56	0.0036
Oil M	0.99	0.56		0.0045

Average Liner Wear (ALW)

p-values in Hypothesis Test of No Difference						Least Square Mean
	Lab A	Lab B	Lab D	Lab F	Lab G	
Lab A		0.77	0.01	0.49	0.01	0.0027
Lab B	0.77		0.08	0.21	0.31	0.0037
Lab D	0.01	0.08		0.00	0.41	0.0077
Lab F	0.49	0.21	0.00		0.00	0.0012
Lab G	0.01	0.31	0.41	0.00		0.0055


Caterpillar 1R Average Liner Wear by Oil
Average Liner Wear
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)
Lab D
Lab F

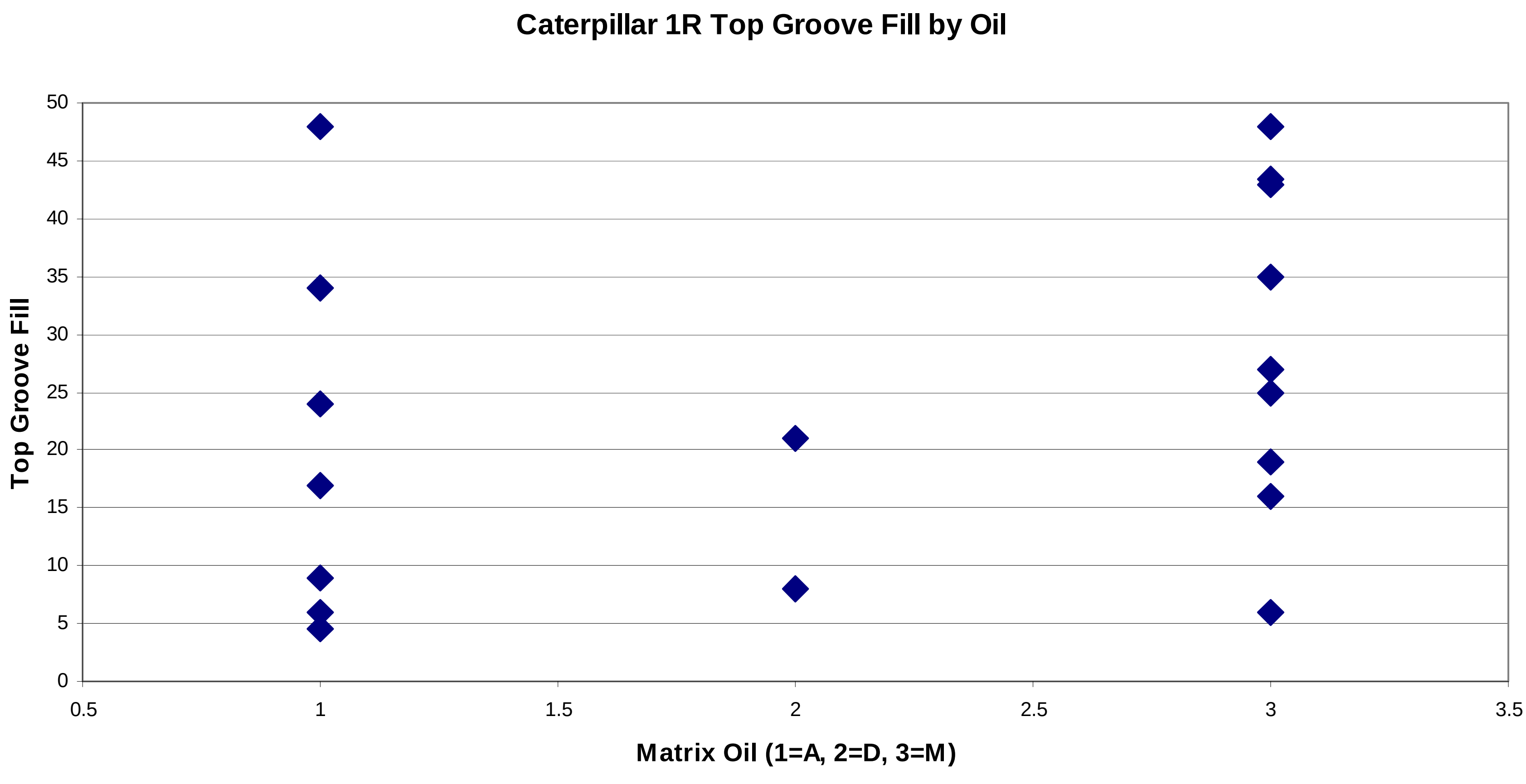


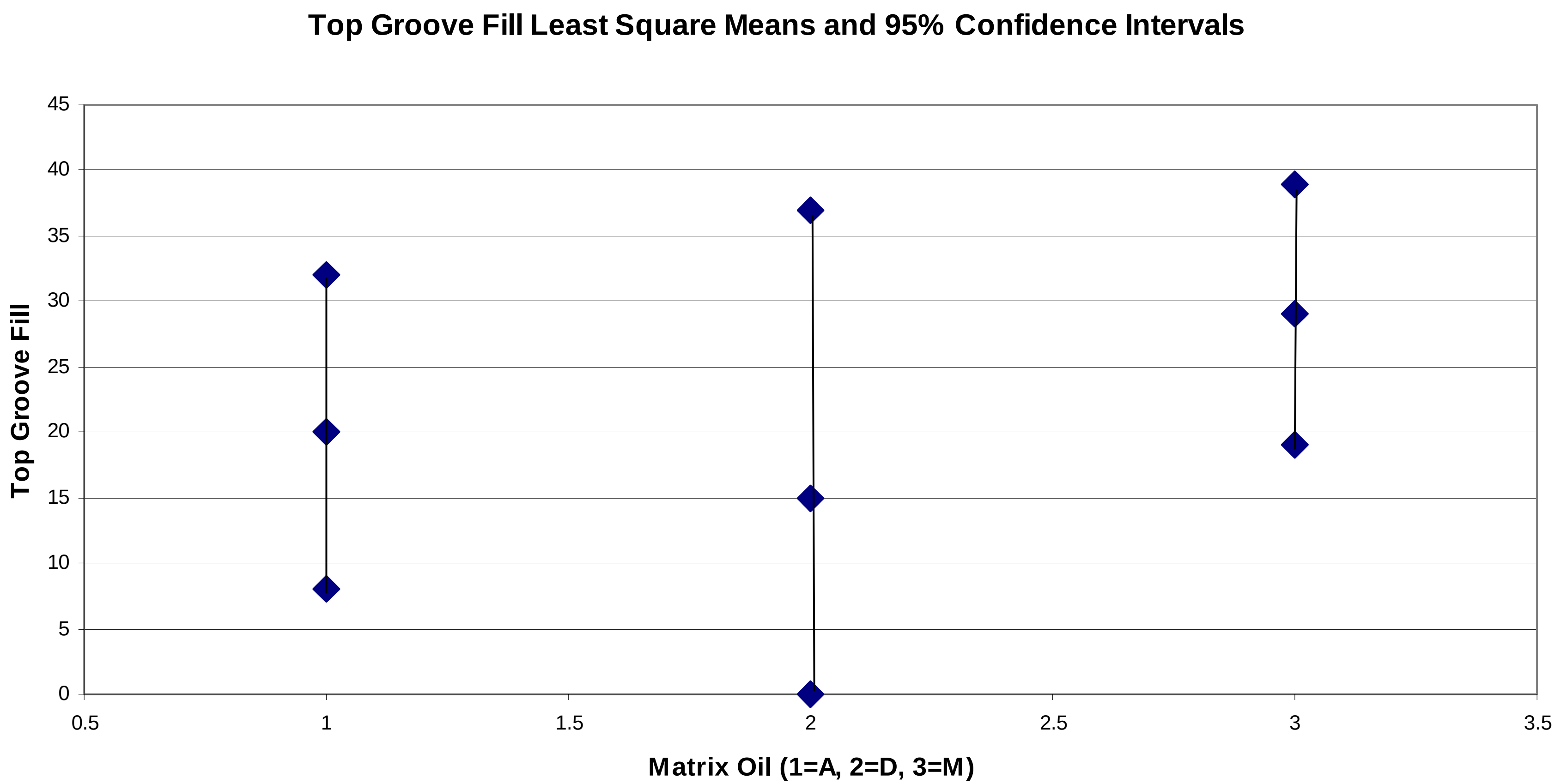
Average Liner Wear Least Square Means and 95% Confidence Intervals
Average Liner Wear
0.006
0.005
0.004
0.003
0.002
0.001
0
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

Top Groove Fill (TGF)

- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- No evidence of any effects
  - Root MSE = 14.75 (15 df – Oil Model)
  - $R^2 = 0.14$
  - No observations had large Studentized residuals

p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.92	0.43	20.4
Oil D	0.92		0.46	14.5
Oil M	0.43	0.46		29.2

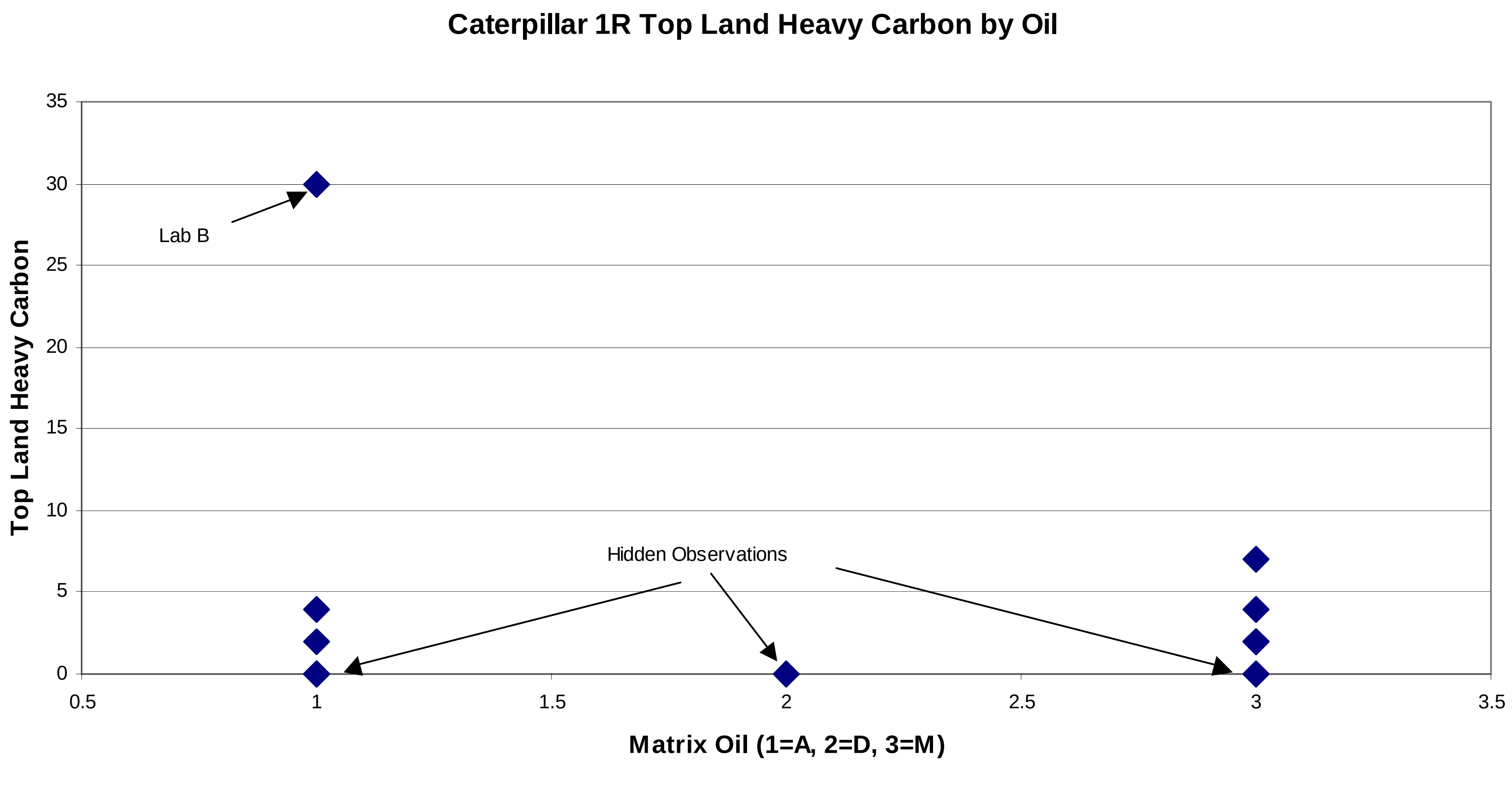

Caterpillar 1R Top Groove Fill by Oil
Top Groove Fill
Matrix Oil (1=A, 2=D, 3=M)
0
5
10
15
20
25
30
35
40
45
50
0.5
1
1.5
2
2.5
3
3.5


Top Groove Fill Least Square Means and 95% Confidence Intervals
Top Groove Fill
45
40
35
30
25
20
15
10
5
0
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

Top Land Heavy Carbon (TLHC)

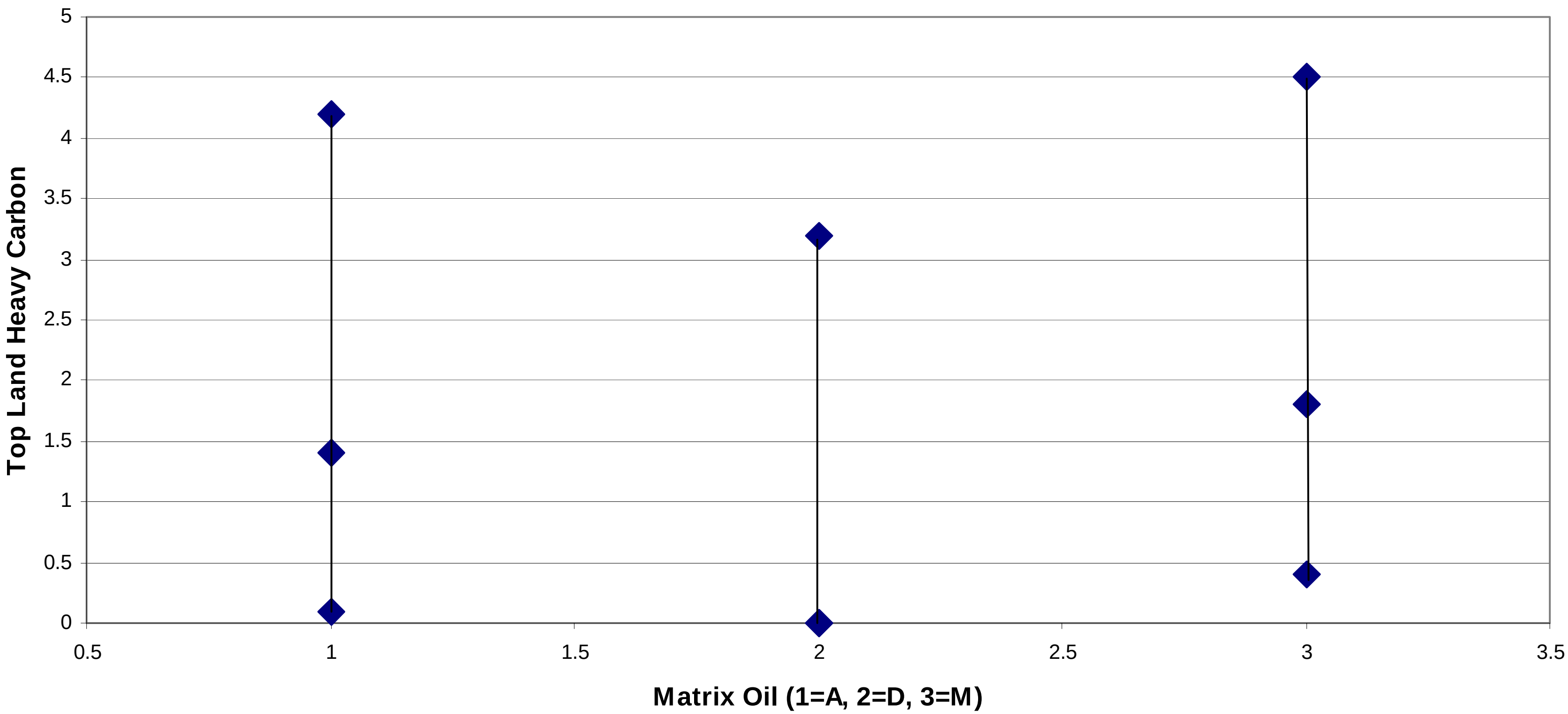
- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- LOG(TLHC+1) transformation used (historical reasons)
- No evidence of any effects
  - Root MSE = 0.95854 (15 df – Oil Model) on Log Scale
  - $R^2 = 0.11$
  - CMIR 41547 (Lab B, Oil A) had a large Studentized residual

p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.50	0.95	0.8774 (1.4)
Oil D	0.50		0.38	0 (0)
Oil M	0.95	0.38		1.02 (1.8)



Caterpillar 1R Top Land Heavy Carbon by Oil
Top Land Heavy Carbon
35
30
25
20
15
10
5
0
Lab B
Hidden Observations
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

Top Land Heavy Carbon Least Square Means and 95% Confidence Intervals



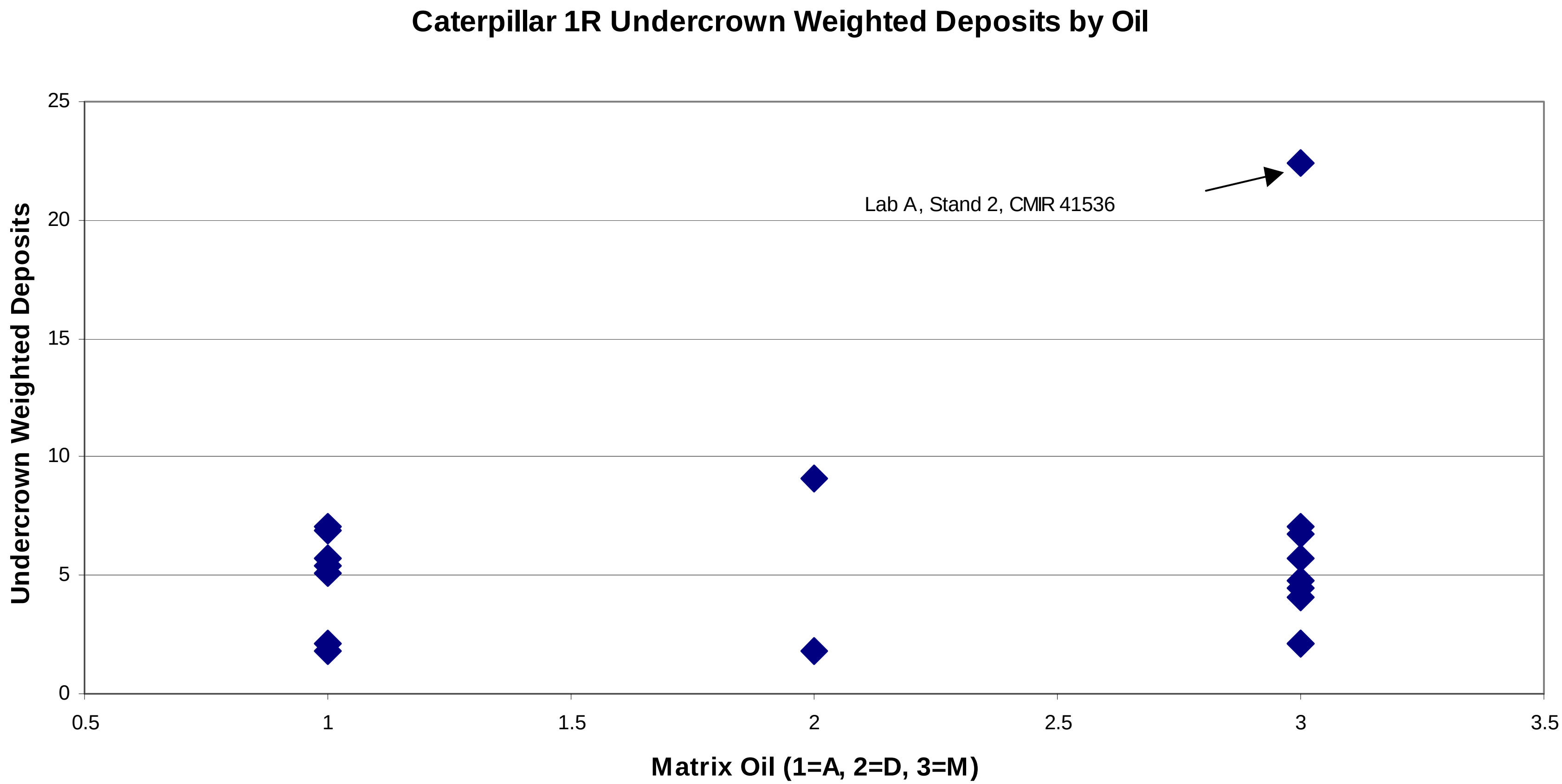
Under Crown Weighted Deposits (UCWD)

- Model factors considered include Lab (A,B,D,F,G), Stand within Lab (A1,A2,A3,G1,G2,G3) and Oil (A,D,M)
- CMIR 41536 (Oil M in A2) had a large studentized residual and may drive possible conclusions (not made here) for a transformation and lab/stand effect. The drains indicate high Copper early in the test
- Some weak evidence of a Lab effect ($0.1<p<0.2$)
  - Root MSE = 4.89 (15 df – Oil Model)
  - $R^2 = 0.03$
- This model is one possible way to analyze the data, BUT different analysis paths lead to other possible conclusions concerning lab/stand effects and transformations

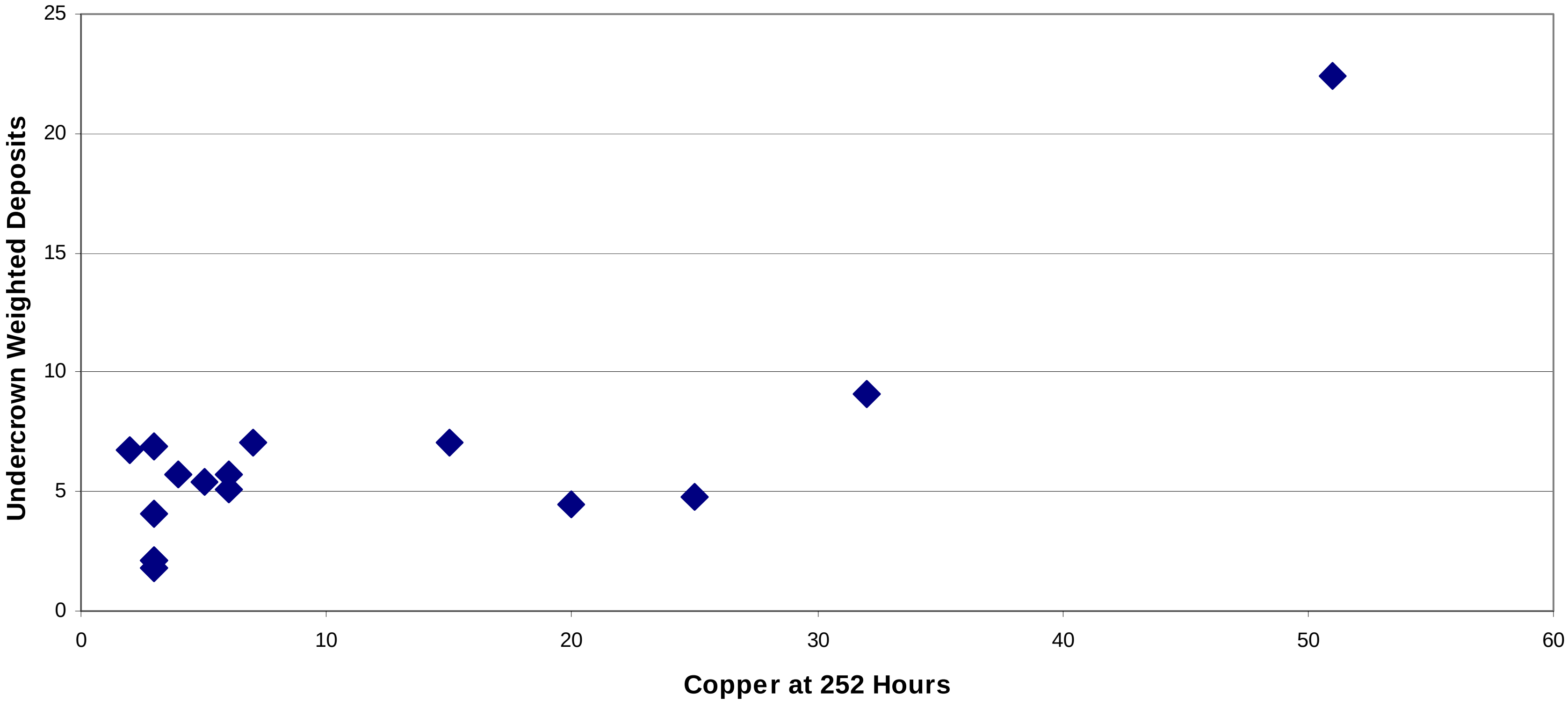
p-values in Hypothesis Test of No Difference				Least Square Mean
	Oil A	Oil D	Oil M	
Oil A		0.99	0.76	4.9
Oil D	0.99		0.95	5.5
Oil M	0.76	0.95		6.6

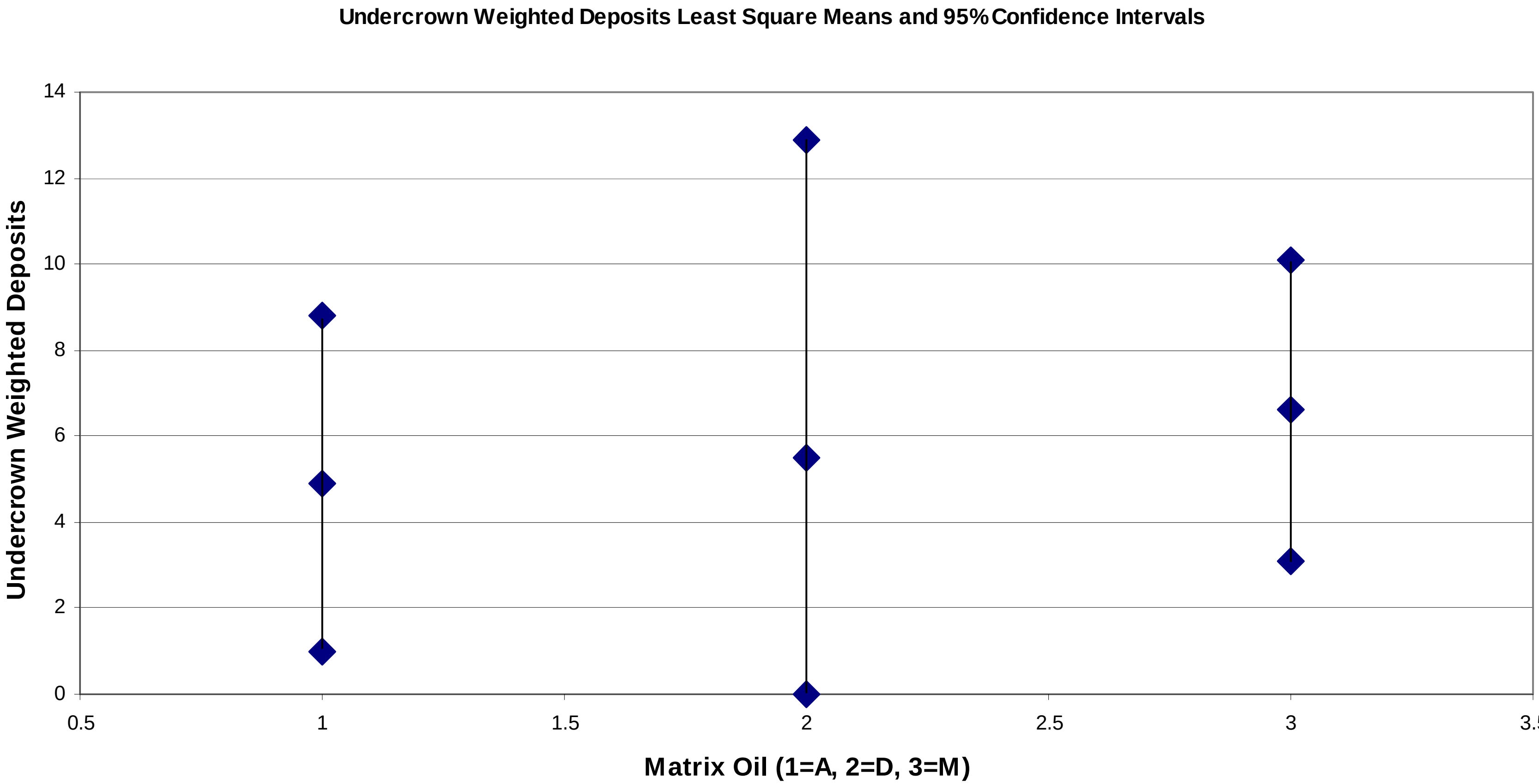
Under Crown Weighted Deposits (UCWD)

p-values in Hypothesis Test of No Difference						Least Square Mean
	Lab A	Lab B	Lab D	Lab F	Lab G	
Lab A		0.60	0.58	0.74	0.06	9.6
Lab B	0.60		1.00	1.00	0.95	4.6
Lab D	0.58	1.00		1.00	0.96	4.5
Lab F	0.74	1.00	1.00		0.87	5.5
Lab G	0.06	0.95	0.96	0.87		2.2


Caterpillar 1R Undercrown Weighted Deposits by Oil
Undercrown Weighted Deposits
0
5
10
15
20
25
Lab A, Stand 2, CMIR 41536
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

UCWD as a Function of Copper at 252 Hours




Undercrown Weighted Deposits Least Square Means and 95% Confidence Intervals
Undercrown Weighted Deposits
14
12
10
8
6
4
2
0
0.5
1
1.5
2
2.5
3
3.5
Matrix Oil (1=A, 2=D, 3=M)

Summary of 1R Least Square Oil Means and Test Standard Deviations from Best Model and Simple Oil Means

	WD		TGC		TLC	
	LS Mean	Mean	LS Mean	Mean	LS Mean	Mean
Oil A	341.2	341.2 (36.17)	34.1	34.1 (10.28)	22.8	22.8 (10.50)
Oil D	285.9	285.9 (6.51)	28.1	28.1 (3.01)	13.8	13.8 (8.84)
Oil M	333.3	333.3 (24.36)	37.9	37.9 (9.79)	21.3	21.3 (4.76)
Std Dev	29.03	NA	9.70	NA	7.84	NA

Summary of 1R Least Square Oil Means and Test Standard Deviations from Best Model and Simple Oil Means

	OC		ETOC		ALW	
	LS Mean	Mean	LS Mean	Mean	LS Mean	Mean
Oil A	8.37	8.26 (1.99)	8.15	7.89 (2.56)	0.0044	0.0044 (0.0023)
Oil D	10.31	9.90 (1.84)	11.14	10.20 (1.27)	0.0036	0.0035 (0.0021)
Oil M	9.65	9.47 (1.10)	8.86	8.44 (0.89)	0.0045	0.0040 (0.0020)
Std Dev	1.19	NA	1.35	NA	0.001064	NA

Summary of 1R Least Square Oil Means and Test Standard Deviations from Best Model and Simple Oil Means

	TGF		LN(TLHC+1)		UCWD	
	LS Mean	Mean	LS Mean	Mean	LS Mean	Mean
Oil A	20.4	20.4 (16.13)	0.8774 *1.4*	0.8774 (1.304)	4.9	4.9 (2.12)
Oil D	14.5	14.5 (9.19)	0 *0*	0 (0)	5.5	5.5 (5.16)
Oil M	29.2	29.2 (14.2)	1.020 *1.8*	1.020 (0.669)	6.6	6.6 (6.17)
Std Dev	14.75	NA	0.95854	NA	4.89	NA

Summary of 1R Lab Means

	WD	TGC	TLC	OC	ETOC	TGF	TLHC	UCWD	ALW
Lab A	322	33	17	9.4	8.8	19	1.3	10	0.003
Lab B	353	45	30	10.9	11.6	39	3.1	5	0.004
Lab D	298	28	19	10.9	10.7	15	0.7	5	0.008
Lab F	318	33	18	7.3	7.7	21	0.3	5	0.001
Lab G	317	32	20	8.7	8.1	21	0.4	2	0.006

Caterpillar 1R Matrix Data

lab	cmir	stand	oil	date	wd	tgc	tlc	oc	etoc	tgf	tlhc	alw	ucwd
A	41535	1	M	20010704	364.6	51.25	22	9.8	8.5	48	2	0.003	7.05
A	41536	2	M	20010705	350.3	30.25	16.5	7.9	6.8	25	2	0.005	22.38
A	41537	3	A	20010707	341.2	43	24.25	9.3	8.2	24	4	0.03	6.9
F	41545	1	M	20010710	356.7	46.25	26	7.9	8.5	43.4	2	0.001	5.7
G	41539	1	M	20010711	323.2	47.25	27	10.1	8.1	43	7	0.004	2.1
G	41541	3	A	20010711	310.6	24.5	15	6.6	5.5	6	0	0.006	1.8
B	41554	1	M	20010712	331.3	46	21.25	10	9.3	35	0	0.004	4.5
G	41540	2	M	20010712	356.1	29.5	22.75	10.7	9.4	16	0	0.006	4.8
A	41538	1	A	20010731	327.8	33	25.5	8	7.5	17	2	0.002	7.06
A	41760	2	D	20010801	290.5	26	7.5	11.2	11.1	8	0	0.002	9.1
A	41573	3	M	20010802	301.5	25.25	11.5	9.6	8.5	6	2	0.002	6.74
G	41542	1	A	20010803	371.6	40	16	6.8	6.4	34	0	0.006	2.1
G	41761	2	D	20010804	281.3	30.25	20	8.6	9.3	21	0	0.005	1.8
F	41546	1	A	20010804	311.7	25	13.75	5.8	5.2	4.5	0	0.002	5.7
G	41570	3	M	20010805	304.9	29.25	23.5	8.5	7.5	19	2	0.007	2.1
D	41968	1	A	20010805	317.9	23.75	21	10.3	10.2	9	0	0.008	5.4
B	41547	1	A	20010814	407.5	49.5	44.25	11	12.2	48	30	0.004	5.1
D	41543	1	M	20010902	311.2	36.5	21	10.7	9.4	27	4	.	4.06

ASTM - HDEOCP - Summary
Exit Criteria Ballot on PC-9

	Affirmative	Negative	Abstain
Cummins M11-EGR	13	6	1
Mack T-10	12	3	6
3.5 cP HT/HS	12	3	5
3.3 cP HT/HS	8	5	8
Used Oil Viscometrics	5	3	12
Cat IN	5	5	11

ASTM - HDEOCP - Summary
Exit Criteria Ballot on PC-9

<u>100% Passing Votes: 8 Tests</u>

- **Mack T-8E**
- **Elastomer**
- **Volatility**
- **Roller-Follower Wear**
- **Aeration**
- **High Temperature Corrosion**
- **Shear Stability**
- **Foam**

TMC abstain on all
Infineum abstain on volatility

ASTM - HDEOCP
Exit Criteria Ballot on PC-9

Cummins M11-EGR

Affirmative: 13	Negative: 6	Abstain: 1
Ethyl	Lubrizol	TMC
Valvoline	Imperial Oil	
Equilon	ExxonMobil	
RohMax	Infineum	
Texaco	Chevron	
Pennzoil-Quaker	Oronite	
Detroit Diesel		
John Deere		
International		
GM		
Caterpillar		
Cummins		
Mack/Volvo		

ATTACHMENT 6, 3 OF 8

ASTM - HDEOCP
Exit Criteria Ballot on PC-9

Mack T-10

Affirmative: 12	Negative: 3	Abstain: 6
Mack/Volvo	Pennzoil-Quaker	Caterpillar
Cummins	Oronite	International
GM	Infineum	John Deere
Chevron		Detroit Diesel
Texaco		TMC
ExxonMobil		Lubrizol
Imperial Oil		
RohMax		
Equilon		
Valvoline		
Ethyl		
CIBA		

ASTM - HDEOCP
Exit Criteria Ballot on PC-9

Caterpillar IN

Affirmative: 5	Negative: 5	Abstain: 11
Caterpillar	Oronite	Cummins
RohMax	Infineum	Mack/Volvo
CIBA Speciality	Chevron	Detroit Diesel
International	ExxonMobil	GM
Texaco	Imperial Oil	John Deere
		Ethyl
		Lubrizol
		Pennzoil-Quaker
		Equilon
		Valvoline
		TMC

ASTM - HDEOCP
Exit Criteria Ballot on PC-9

HT/HS "Non-Critical" Specification 3.5 cP Fresh Oil

Affirmative: 12	Negative: 3	Abstain: 5
Mack/Volvo	Pennzoil-Quaker	GM
Cummins	Infineum	TMC
Caterpillar	Equilon	Imperial Oil
International		Lubrizol
John Deere		ExxonMobil
Detroit Diesel		
Oronite		
Texaco		
Chevron		
RohMax		
Valvoline		
Ethyl		

ATTACHMENT 6, 6 OF 8

ASTM - HDEOCP

Exit Criteria Ballot on PC-9

HT/HS "Critical" Specification 3.3 cP Fresh Oil

Affirmative: 8	Negative: 5	Abstain: 8
Equilon	Ethyl	Lubrizol
RohMax	Valvoline	TMC
Imperial Oil	Infineum	Texaco
Chevron	Oronite	Detroit Diesel
ExxonMobil	Pennzoil-Quaker	John Deere
GM		International
Caterpillar		Cummins
Equilon		Mack/Volvo

ATTACHMENT 6, 7 OF 8

ASTM - HDEOCP
Exit Criteria Ballot on PC-9

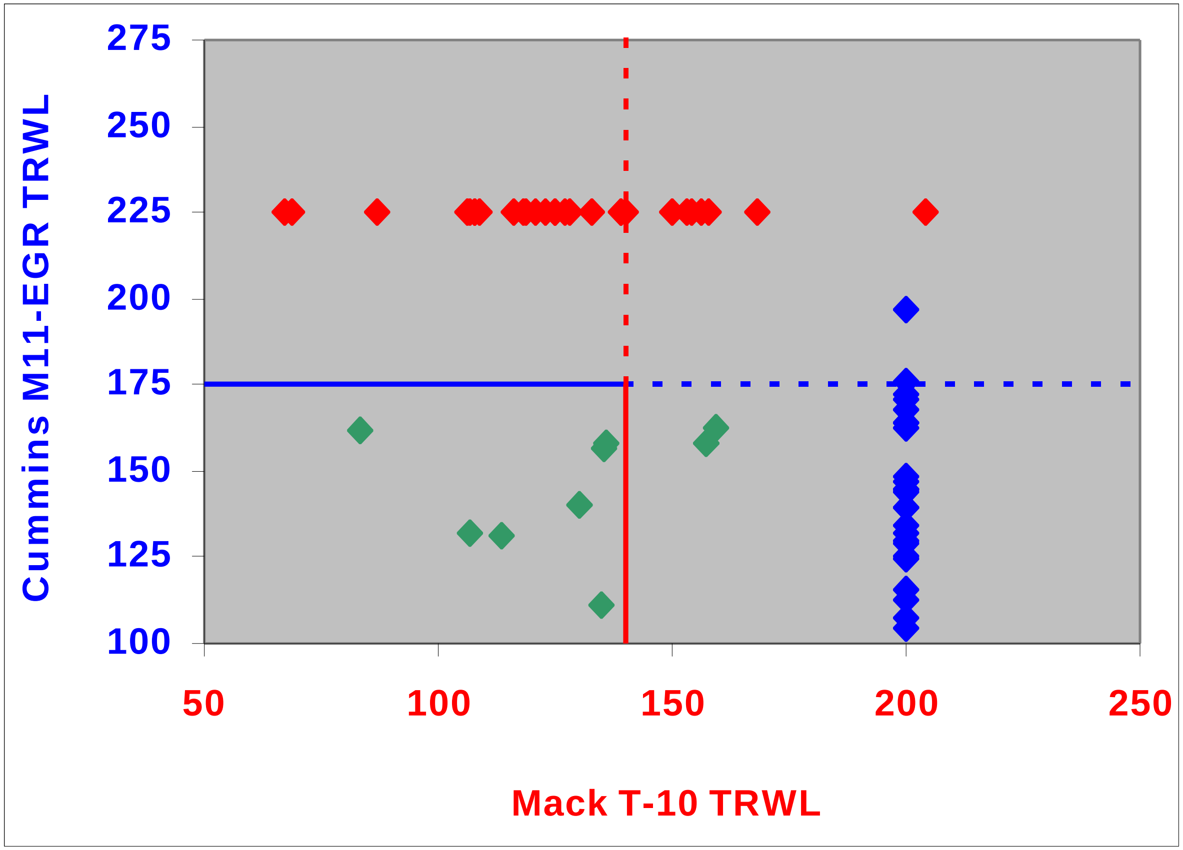
Used Oil Viscometrics

Affirmative: 5	Negative: 3	Abstain: 12
RohMax	Oronite	Ethyl
Imperial Oil	Chevron	Lybrizol
Texaco	Cummins	Valvoline
Infineum		Equilon
GM		TMC
		ExxonMobil
		Pennzoil-Quaker
		Detroit Diesel
		John Deere
		International
		Caterpillar
		Mack/Volvo

ATTACHMENT 6, 8 OF 8

ExxonMobil PC-9 Exit Ballot #2

Cummins M11-EGR:



PC-9 Matrix Data:
Least Square Means
T-10 TRWL Results
M11-EGR TRWL Results

- Cummins concerned with ring gap increase
- No significant gap increase with PC-9 matrix oils
- Mack T-10 is the primary test for TRWL
- M11-EGR TWRL limit should identify “unusual” oils
- Recommend “fail-safe” limit of 250 milligrams

ATTACHMENT 7

Cummings M11-EGR-Matrix Data
Top Ring Weight
No Significant Technology or Base Oil Effects

Oil	N	Mean	Standard Deviation	Mean Plus Two Standard Deviations	Base Stock
A	2	160.35	22.42	205.19	II (99%)
B	2	128.40	4.8	138.0	II (90%)
C	1	107.1	-	107.1	I (75%)
D	2	153.8	12.87	179.5	II (99%)
E	10	134.1	20.19	174.48	II (90%)
F	2	163.55	44.33	254.2	I (75%)
G	2	144.15	27.78	199.71	II (99%)
H	2	165.8	2.6	217.8	II (90%)
J	2	155.10	21.78	198.66	I (75%)
ALL	25	143.78	23.51	190.80	

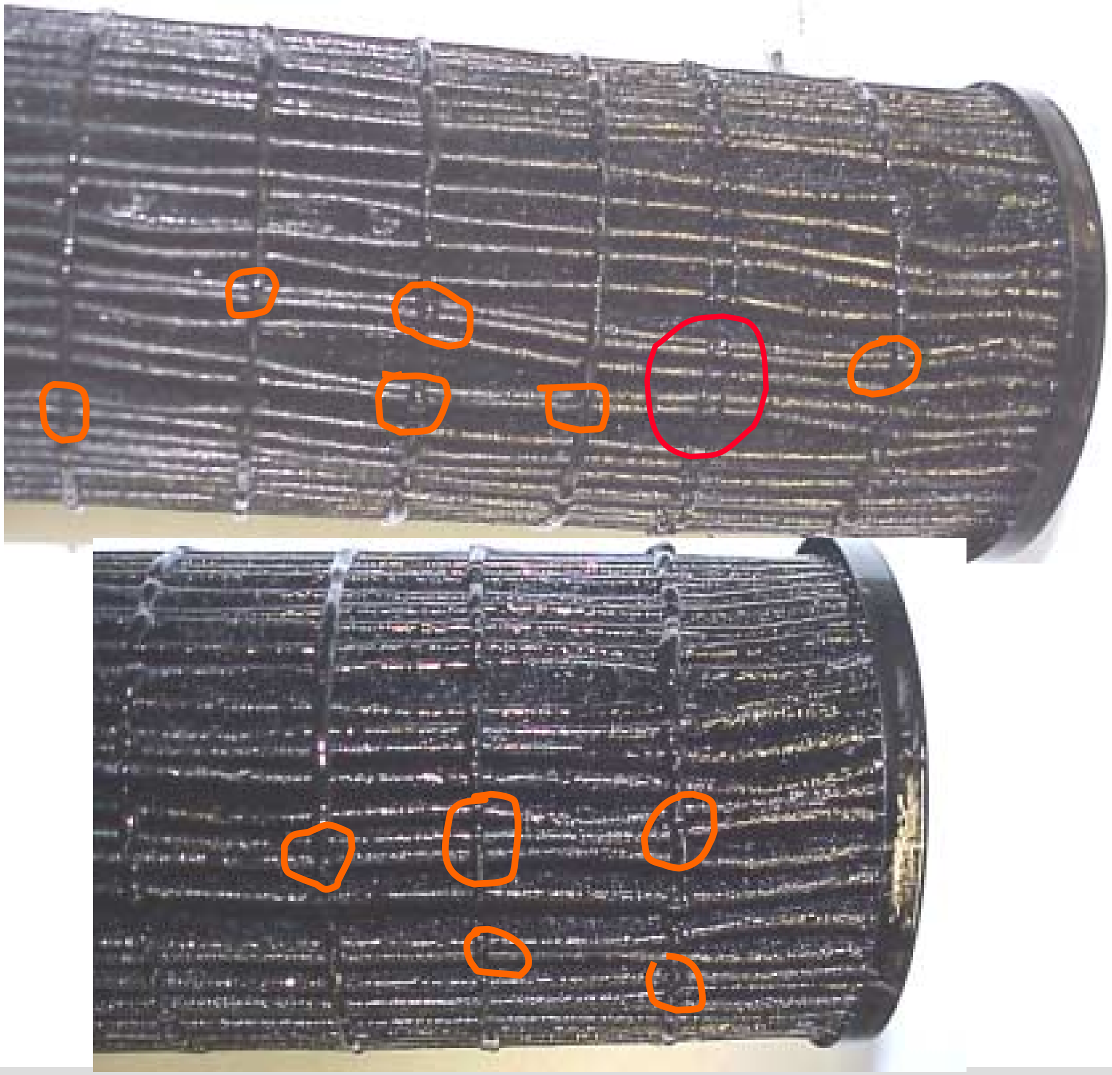
ATTACHMENT 8

Cummins M11 Filter Plugging

- **Oronite has observed variable filter performance in recent testing**
- **Filters have been examined to determine cause**
- **We observe that filters with high pressure have had the pleats glued together**

ATTACHMENT 9, 1 OF3

M11EGR Filters



ATTACHMENT 9, 2 OF3

Recommendations

- **Improve filter pleat spacing consistency**

ATTACHMENT 9, 3 OF3

M11 EGR Test

Presentation to
HDEOCP
September 26, 2001
David M Stehouwer

ATTACHMENT 10, 1 OF 7

M-11 EGR Test Status

❍ Proposed Limits

- ✓ **CWL 20 mg**
- ✓ **TWL 175 mg (no ring gap correlation)**
- ✓ **OFDP 275 kPa @ 250 hrs**
- ✓ **ASR 8.0**
- ✓ **BWL, IAS: Report Value**

David M Stehouwer, Cummins Inc.

Cummins Top Ring Weight Loss Limit - Why?

- The current proposed top ring weight loss limit for a one test pass is 175 mg for CI-4
- The limit is based upon modeling and correlation work performed on internal EGR tests and comparative liner/ring wear studies resulting in calculated acceptable engine life.
  - ✓The data analysis provides a top ring weight loss limit of 150 mg.
- Oil E is the borderline passing oil for the M11 EGR test.
- Using ASTM E-178 at 5% significance level none of the Oil E rings are excluded
  - ✓The average of this data set is 134.1 mg with a standard deviation of 20.2
  - ✓Using two standard deviations a limit of 174.5 mg is calculated.
  - ✓Based on M11 engine modeling work, Cummins requests a top ring wear limit of 175 mg.

David M Stehouwer, Cummins Inc.

Evaluation of Beaded Filters

- Concern over number and spacing of pleats
- Questionable used filters returned to FG
- Statistical sampling (36) of 550 filter batch returned to FG
- Perform flow vs. restriction
- Examine extremes for pleat count and spacing
- Perform dust capacity testing on extremes
- Refer to O&H Panel

O&M Panel Activities

- 7 runs on oil E ranged from 46 kPa to 87 kPa with a mean of 63 kPa.
- This compares to a matrix mean of 137 kPa.
- The labs will use the mean from these runs as target for oil E with the standard deviation from the matrix.
- Passing limit will remain 275 kPa.
- There will be only minimal lab severity adjustments.

Analysis of Returned Filters by Fleetguard

Oil	Filter	# Pleats	Area Cm2	Gm/100 cm2	Total Contamina Gm
E	A	61	5243	2.00	105
E	B	55	4727	1.65	80
E	MCD1 Even			1.6971	
E	MCD1 Bunched			1.3855	
E	MCD1 Average	59	5071	1.5413	78
E	MCD7 Even			0.9663	
E	MCD7 Bunched			0.8132	
E	MCD2 Average	56	4813	0.88975	43
Test	Even			4.7729	
Test	Bunched			4.4734	
Test	Average	60	5157	4.6232	238

Observations from Filter Analysis

- Pleat count is from 55 to 61 with a target of 55 min.
- Bunched pleats do remove slightly less material, but...
- Bunched pleats can remove a lot of deposit with less variation than expected
- The relationship with sludge ratings and filter deposits suggests that when an oil exceeds its capacity to hold sludge, it comes out all over the engine… filter, pan, valve covers etc.

T-10 Tiered Limits

	1 Test	2 Tests	3 Tests
Liner Wear	30	31.6	32.4
Top Ring Weight Loss	140	152.6	158.1
EOT Lead	30	35.5*	37.7*
250-300 Lead	10	12.9	14.2
Ave. Oil Consumption	60	65.2	67.5
EOT IR Oxidation (A)	750	799.2	820.9
EOT IR Oxidation (B)	600	649.2	670.9

* Calculated in transformed units (ln) and converted back to original units

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M11 EGR Tiered Limits

	1 Test	2 Tests	3 Tests
Crosshead Weight Loss	20	21.8	22.6
Top Ring Weight Loss	175	186.1	191.0
Oil Filter Delta P	275	319.0*	339.9*
Average Sludge	8.0	7.84	7.76

* Calculated in transformed units (sqrt) and converted back to original units

JLZ / 9-26-01

Discussion of
Mack T-10
Oxidation-Related Test Parameters

Presented to:

Heavy Duty Engine Oil Classification Panel

Chicago, IL

September 12, 2001

Introduction

Infineum

- ❖ **This presentation is intended to show that three of the six proposed specification parameters in the Mack T-10 test are highly correlated**

- ❖ **We are concerned that, given the high random variability of these parameters relative to their respective proposed limits, over-specification of these parameters will result in unnecessary repeat testing, even for otherwise excellent additive technologies**

- ❖ **Data is provided to show that Sequence III-F test offers a higher level of oxidation protection that the Mack T-10 IR without additional engine test burden for the additive industry**

Correlation Among Mack T-10 Test Parameters

Infineum

❖ **Following PC-9 limits have been proposed for the Mack T-10 test:**

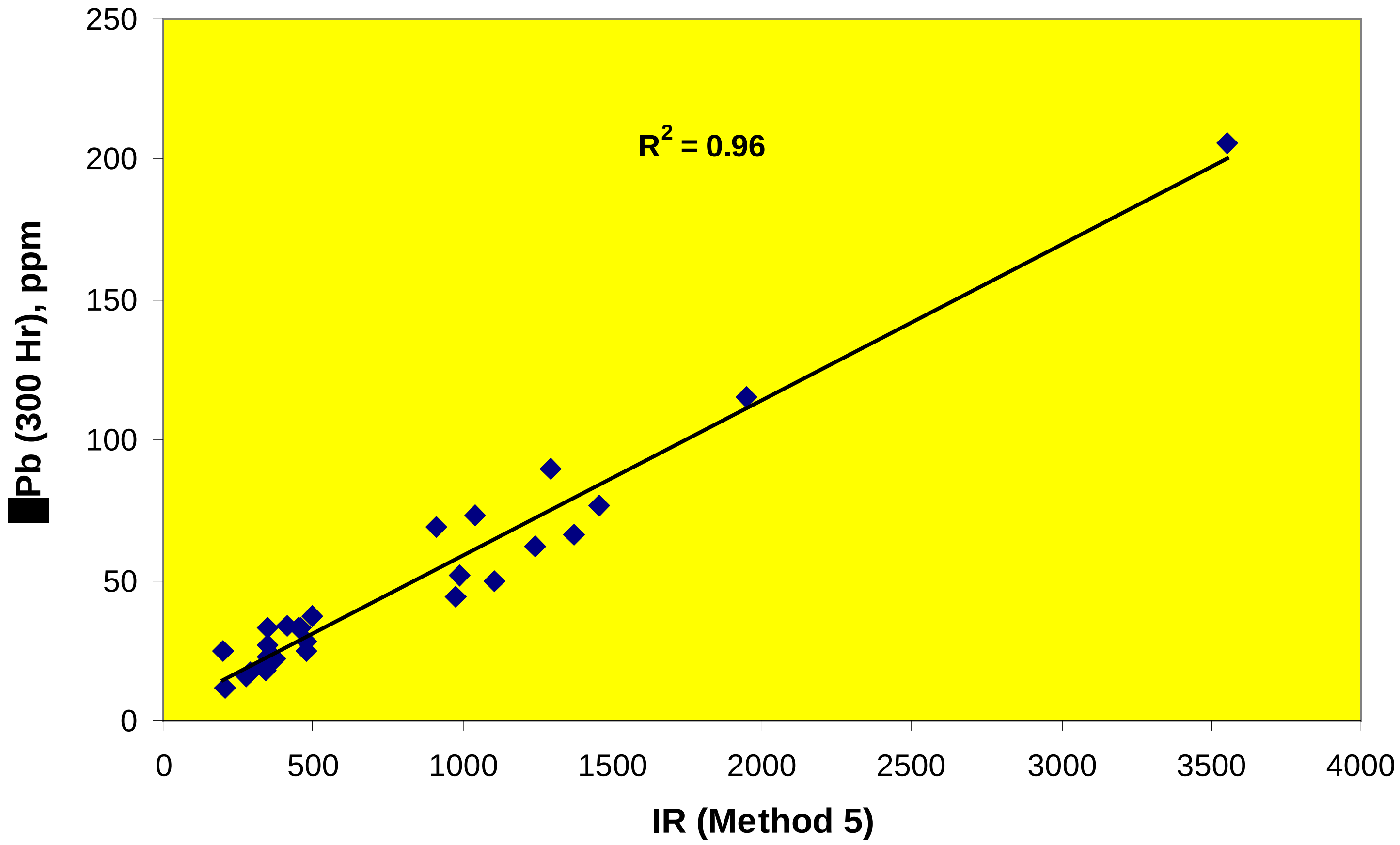
Average Cylinder Liner Wear	30 µM Max
Average Top Ring Weight Loss	140 mg Max
Delta Lead at EOT (300 Hrs)	30 ppm Max
Delta Lead between 250-300 Hrs	10 ppm Max
Oil Consumption in Phase II	60 g/hr Max
Oxidation by Integrated IR	750 Absorbance Units Max

❖ **Data on the following pages shows that three of these 6 parameters, *Delta Lead (300 Hrs), Delta Lead (250-300 Hrs) and Integrated IR,* are highly correlated with R^2 ~0.9**

ATTACHMENT 12, 3 OF 16

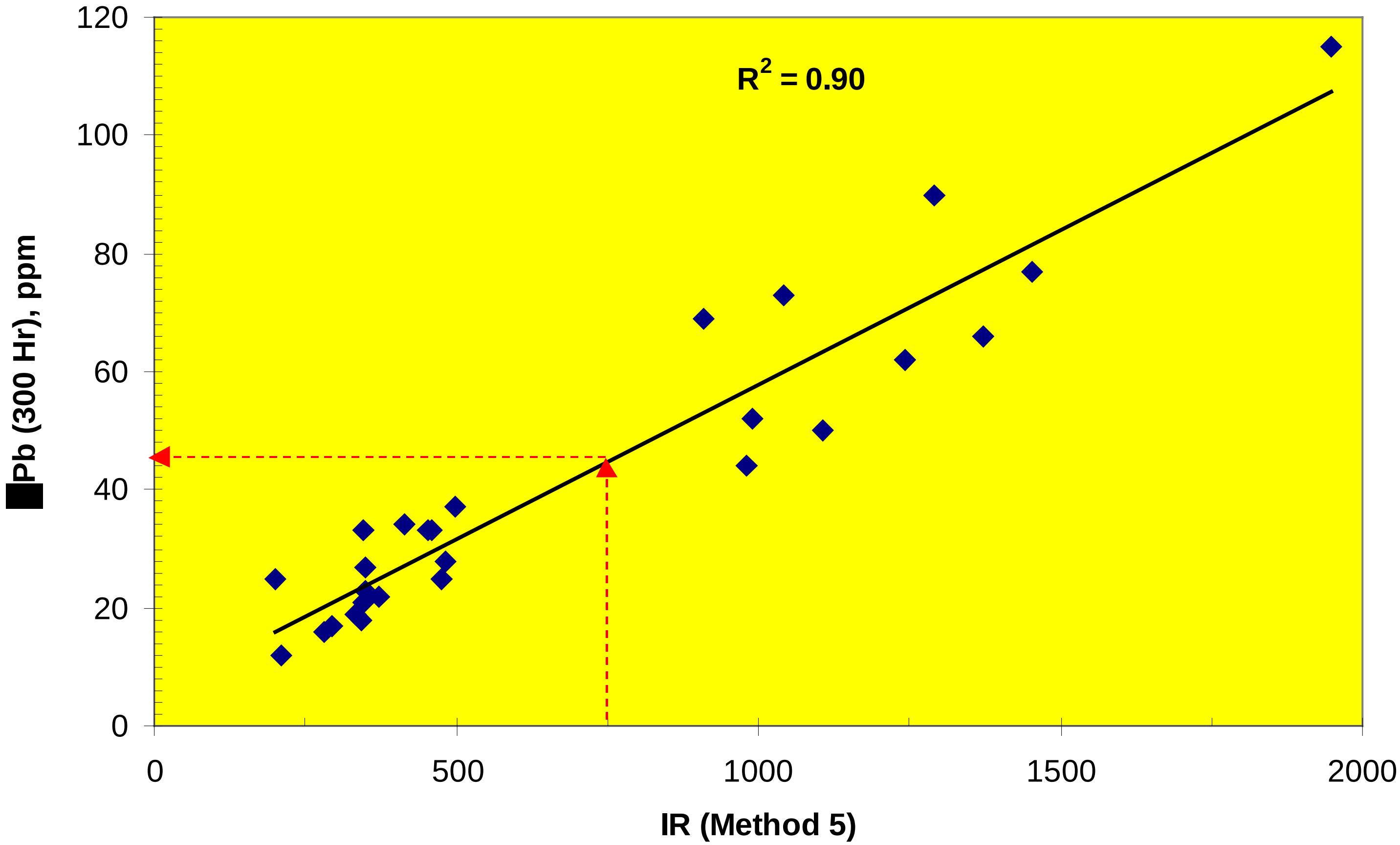
ΔPb (300 Hr) Strongly Correlates with IR

(*Matrix Data – All 28 Points*)



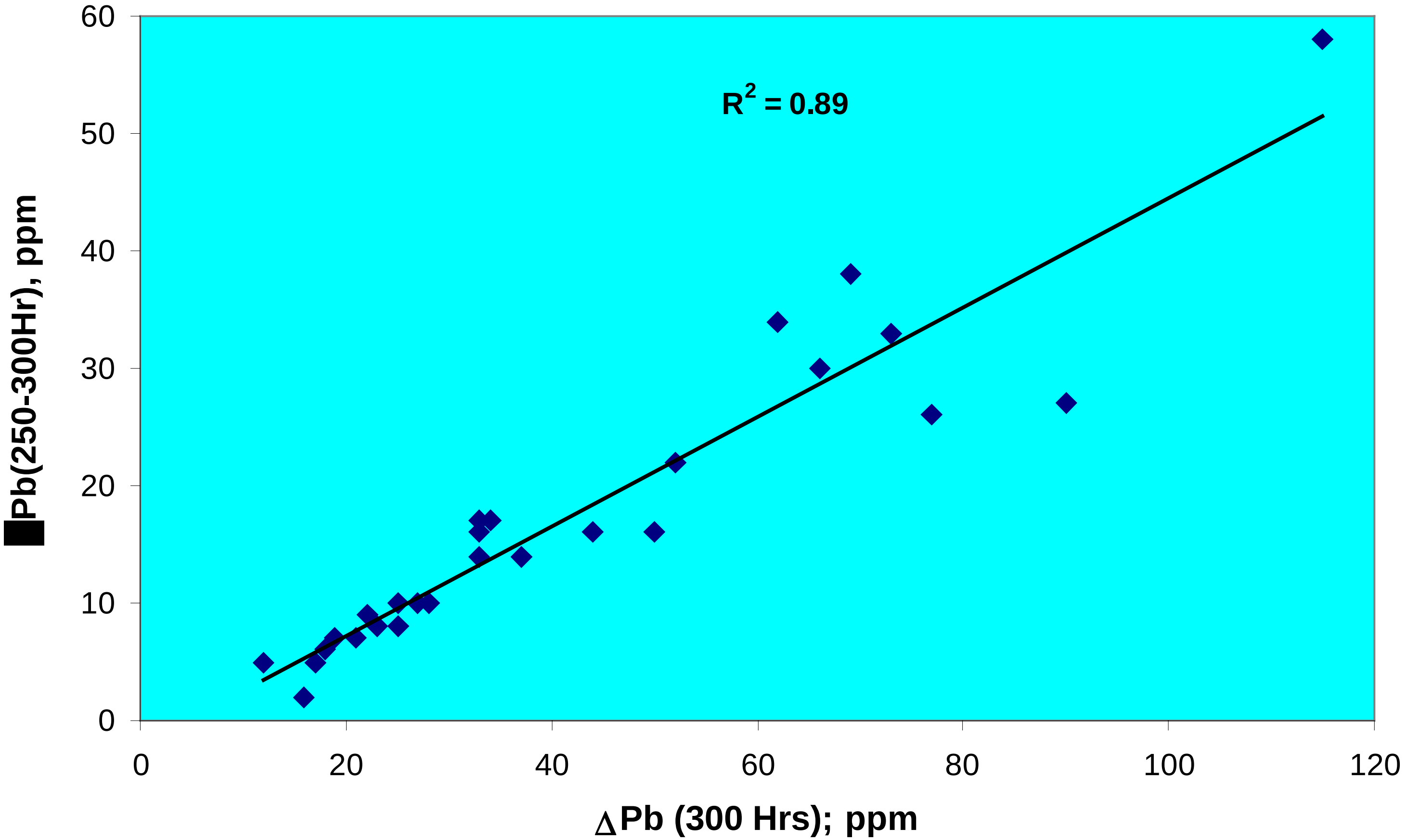
ΔPb (300 Hr) Strongly Correlates with IR

(*Matrix Data – 27 Points; One Outlier Excluded)*



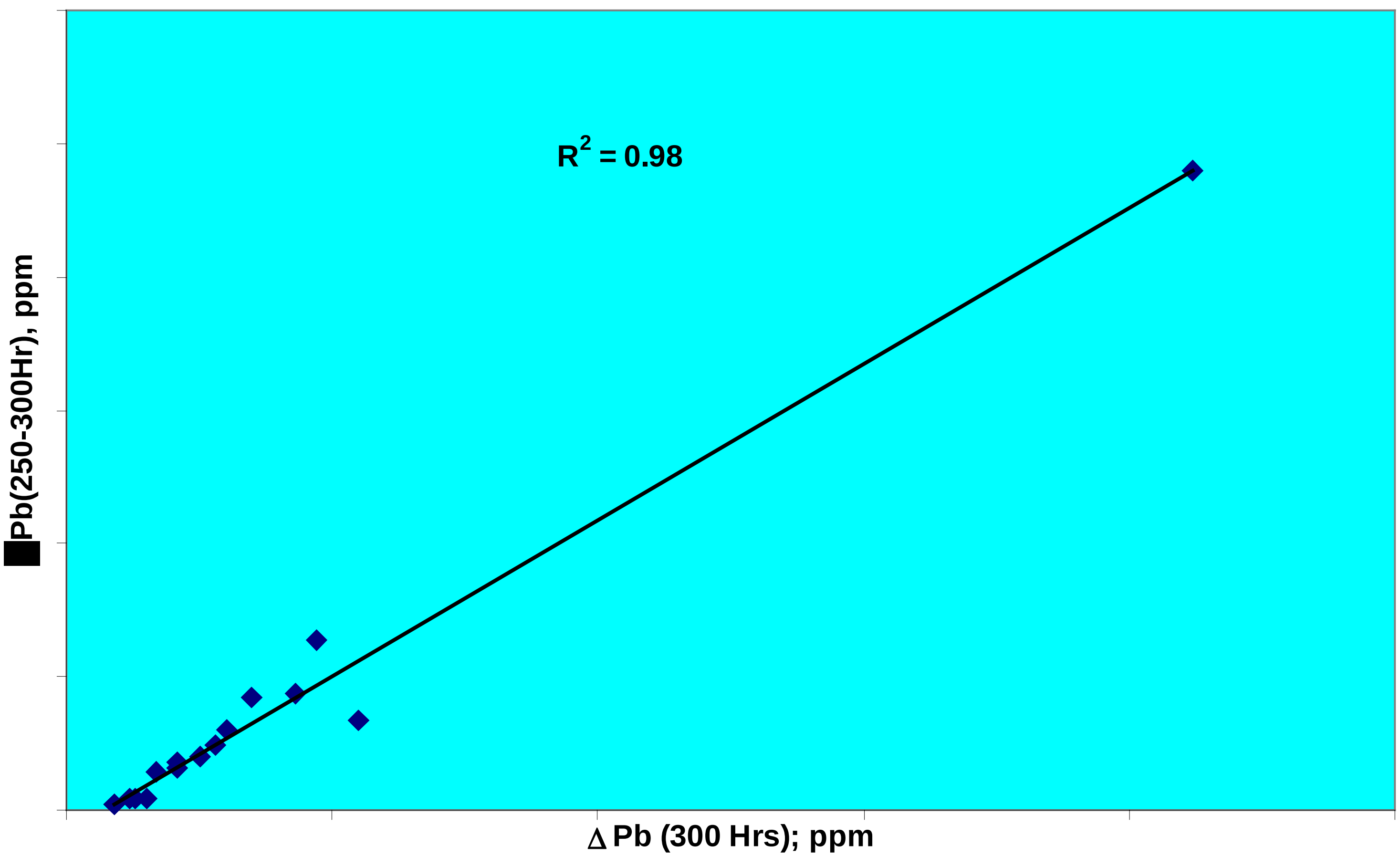
ΔPb (250-300Hr) Strongly Correlates with ΔPb (300Hr)

(*Matrix Data – 27 Points)*



Infineum PC-9 Development Data Exhibit Same Parametric Correlations as Matrix Data

Infineum



Infineum

…So what’s the problem?

Correlated test parameters exhibit high random variability

Infineum

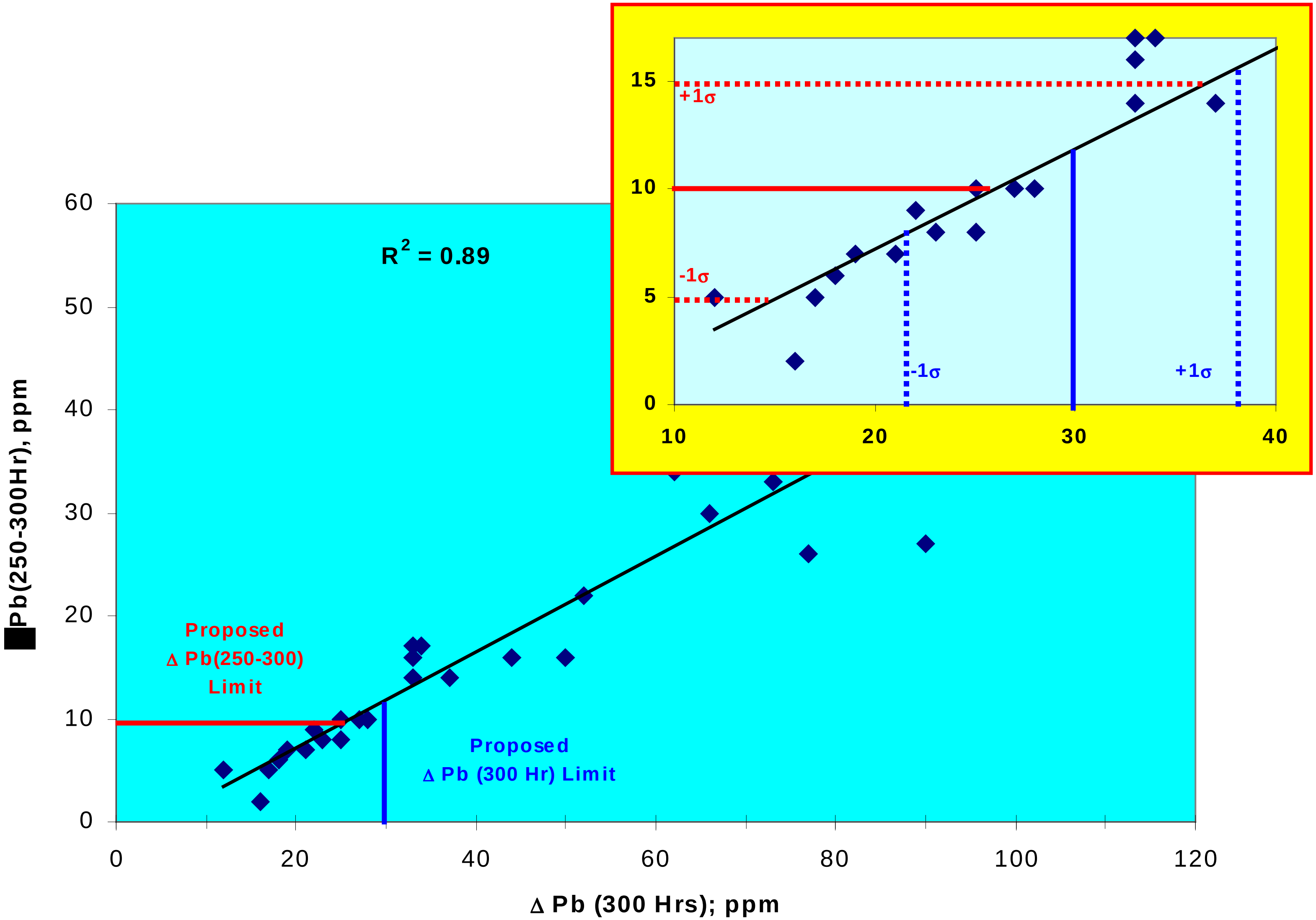
Precision Data on Featured Oil (Oil A)

CMIR	IR (Method 5)	ΔPb (300)	ΔPb (250-300)	
38809	348	23	8	
38810	334	19	7	
38811	210	12	5	
38814	452	33	16	
38942	280	16	2	
38951	497	37	14	
40230	200	25	8	
41135	482	28	10	
41410	347	33	17	
41412	1372	66	30	***Outlier?***
Mean (10 pts)	**452.2**	**29.2**	**11.7**	
StDev (10 pts)	**339.4**	**15.2**	**8.0**	
Mean (9 pts)	**350.0**	**25.1**	**9.7**	
StDev (9 pts)	**109.9**	**8.4**	**5.1**	
Proposed Test Limits	**750.0**	**30.0**	**10.0**	

For each test parameter, the random variability is quite large in relation to the proposed limit

ATTACHMENT 12, 9 OF 16

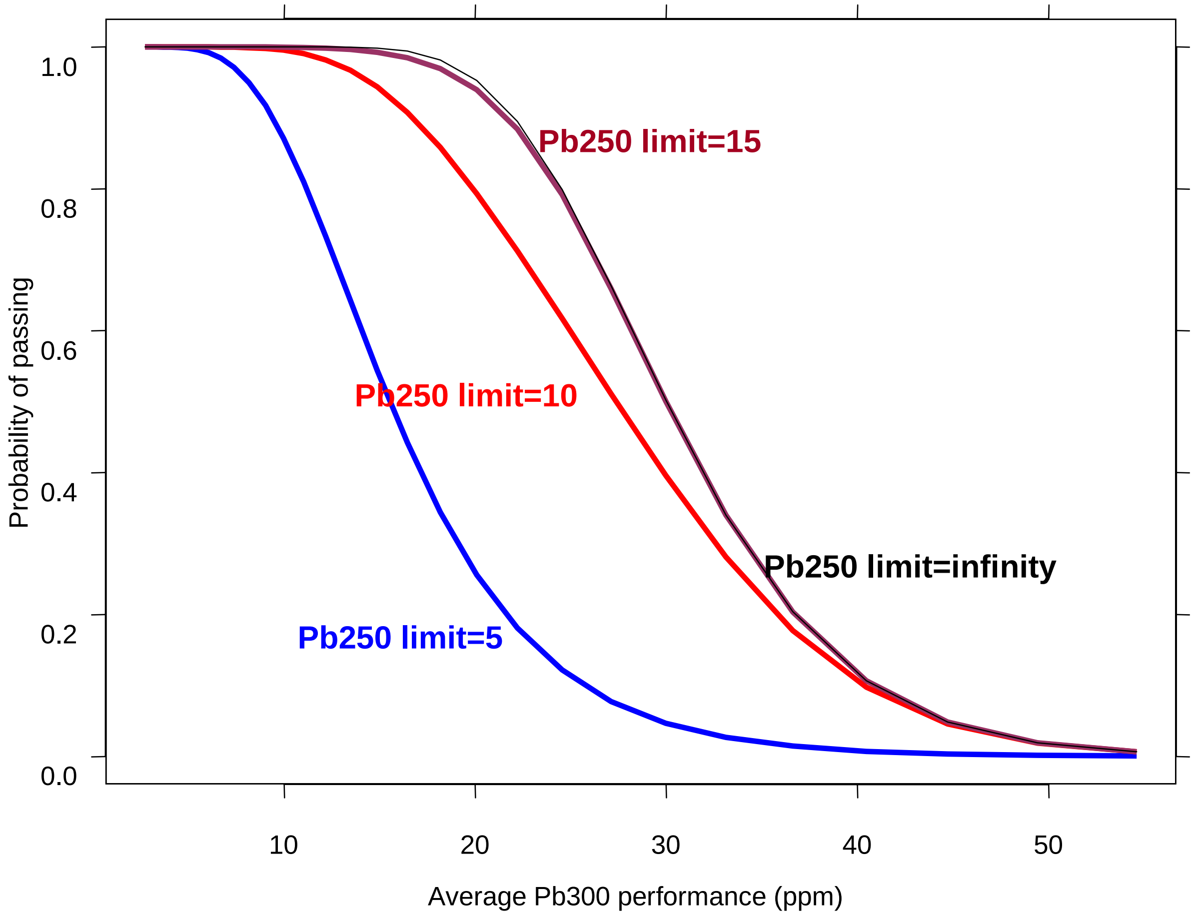
Overlapping Specifications Could Drastically Affect Pass Rate Due to Random Variations



ATTACHMENT 12, 10 OF 16

Probability of Passing is Drastically Affected by Overlapping Limits

Infineum



ATTACHMENT 12, 11 OF 16

Oxidation responses in Sequence III-F and Mack T-10 tests

Infineum

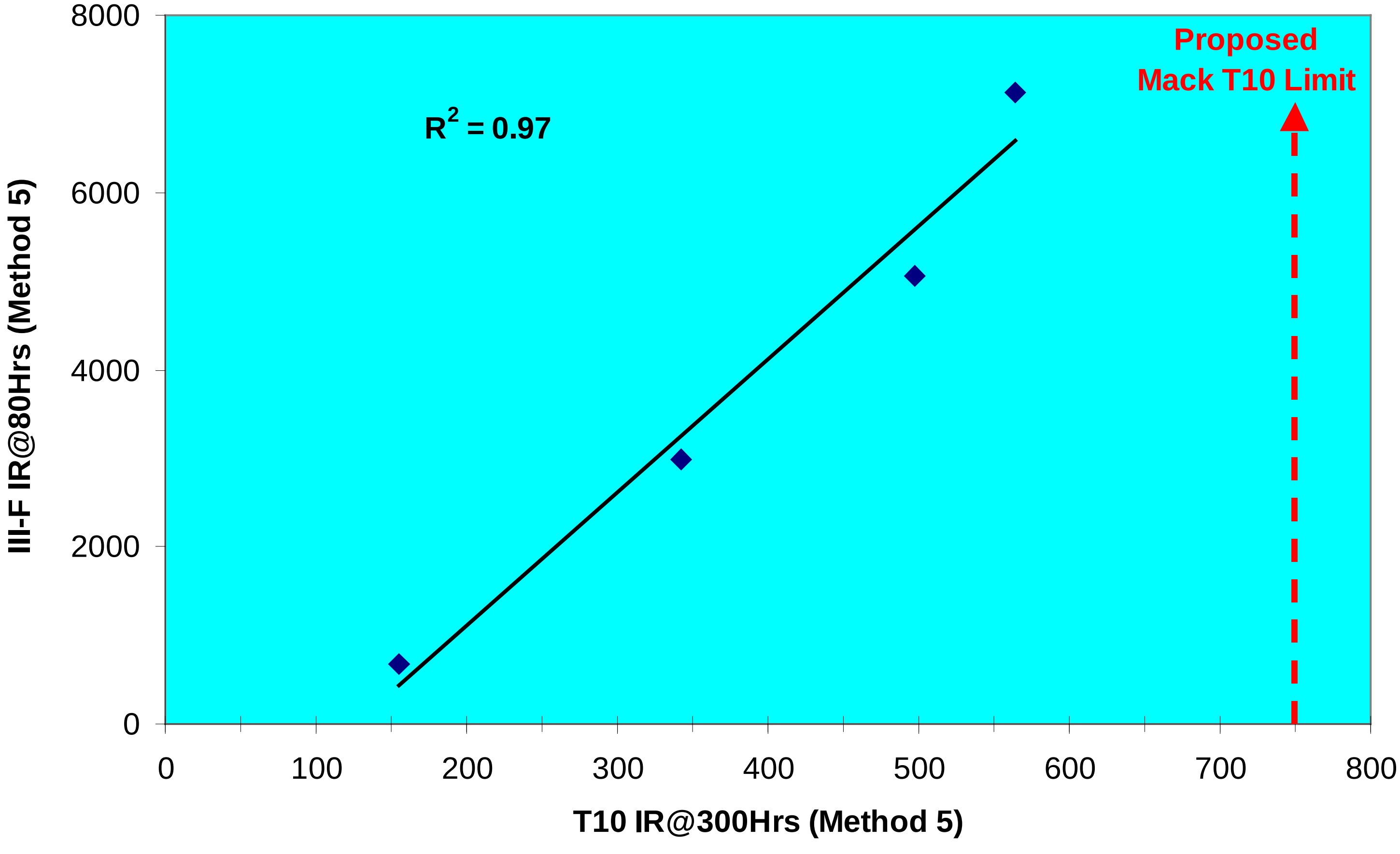
- **Infineum has found 4 oil formulations with "matched pairs" of Sequence III-F and Mack T-10 tests**
  - ie, both tests run on identical oils

- **Results from these 4 pairs clearly show that oxidation responses in the two tests are highly correlated**
  - Indeed, Sequence III-F is shown to be far more severe test of oxidation than the Mack T-10 test

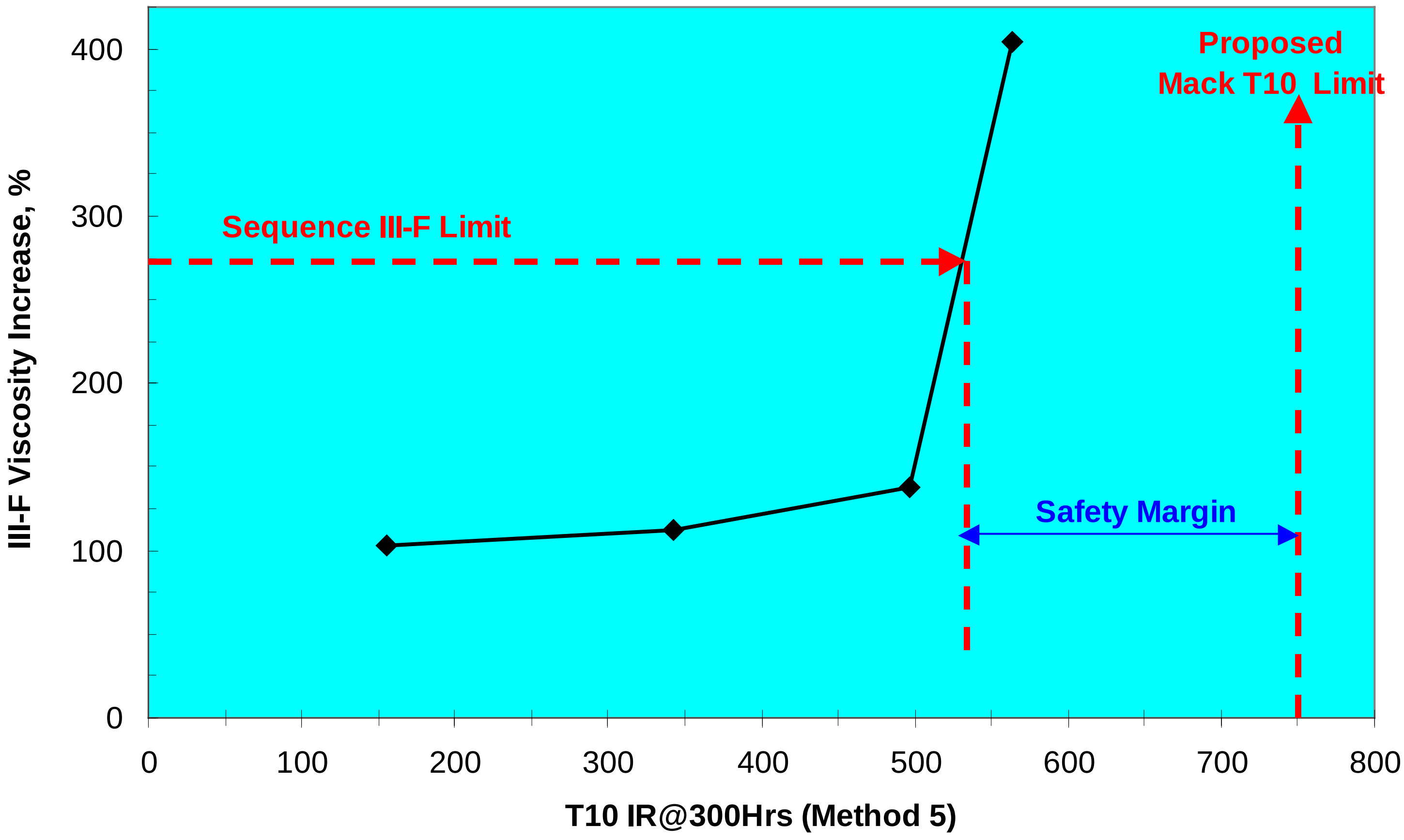
Seq.III-F IR shows Strong Correlation with Mack T-10 IR

(Infineum PC-9 Development Data)

Infineum



Sequence III-F Offers Significantly Higher Protection Against Oxidation Than Mack T-10 IR



Summary

Infineum

- **Three of the proposed spec parameters in Mack T-10 test, ΔLead(300 Hrs), ΔLead(250-300 Hrs) and IR (Method 5), are highly correlated**
  - Typical R2 ~0.9
- **Over-specification of correlated parameters can drastically reduce affect pass rate for Mack T-10 test**
  - Random variability of any of the three correlated parameters could cause a passing oil to fail
  - At $100K per test, this could result in very costly repeat testing without offering any additional hardware protection
- **Sequence III-F offers much better protection against lube oxidation than Mack T-10**

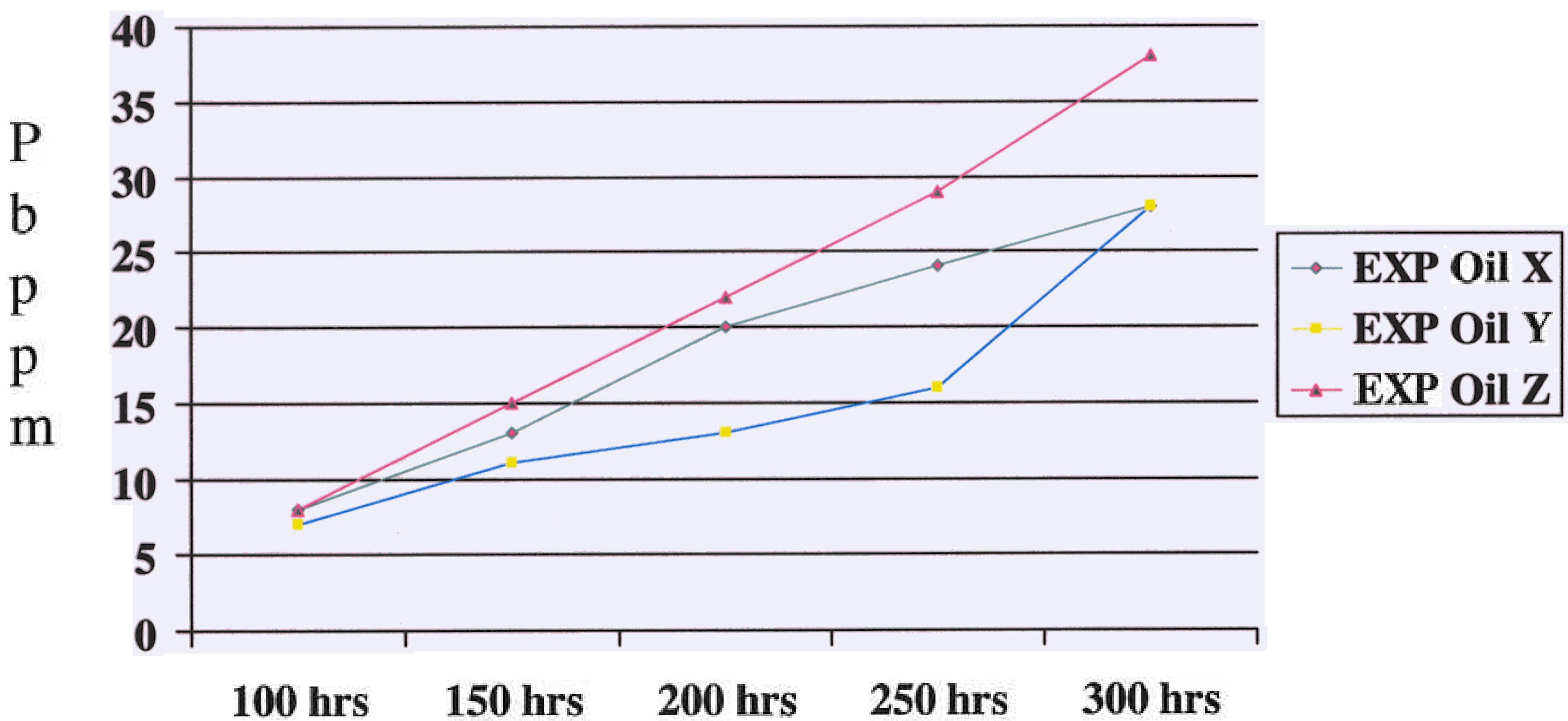
Recommendations

Infineum

- Elimintate T-10 IR and ΔLead (250-300 Hrs) paramters from PC-9 pass/fail limits for the Mack T-10 test

- Specify the Sequence III-F viscosity increase at the API SL limit as the PC-9 oxidation test
  - Sequence III-F will be run in every basestock anyway for the API SL claim
  - Sequence III-F test will ensure that antioxidant treat rate is properly matched for all basestocks

T 10 EGR Test
Lead



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Mack T10 Limits
An alternate proposal

ATTACHMENT 14, 1 OF 8

Mack T-10

- Proposed pass limits are significantly more severe than the average performance of the featured oil
- Of 27 matrix runs 5 runs would 'pass' out of 27
  - Only 2/10 runs on the 'featured' oil pass the requirements
  - 5/20 for 'PC-9' level matrix oils
- Following parameters result in the most difficulty
  - Liner wear
  - Lead increase (either EOT or last 50 hour)
- Precision of parameters results in frequent 'random' failures of a very expensive engine test

Mack T-10 Limits

- **What would be required if Oil A were to Pass 50%, 75% and 95%?**

Criterion	Mack Limit	Oil A LS Mean	75% Pass	95% Pass
Liner Wear	30	34	37	41
Top Ring Weight Loss	140	133	150	174
EOT Lead Delta	30	24	30	39
250-300 Hour Lead Delta	10	10	14	20
Average Oil Consumption	60	53	59	67
EOT IR Oxidation	750	407	530	705

- ***Is there a better alternative that insures high performance oils but reduces repeat testing due to test variability?***

ATTACHMENT 14, 3 OF 8

Mack T10 Limits
Merit System

- Utilizing statistically merit system should be considered as an alternative
  - Combined with ‘fail safe’ limits
  - Biased to the OEM desired limits
  - Accounts for test precision

- Goals for an appropriate merit based system
  - Based on test statistics
  - Clearly discriminate between PC9 and non-PC9 chemistry
  - Combine a merit rating with ‘hard’ limits which represent the point beyond which an oil is statistically beyond the desired performance envelop

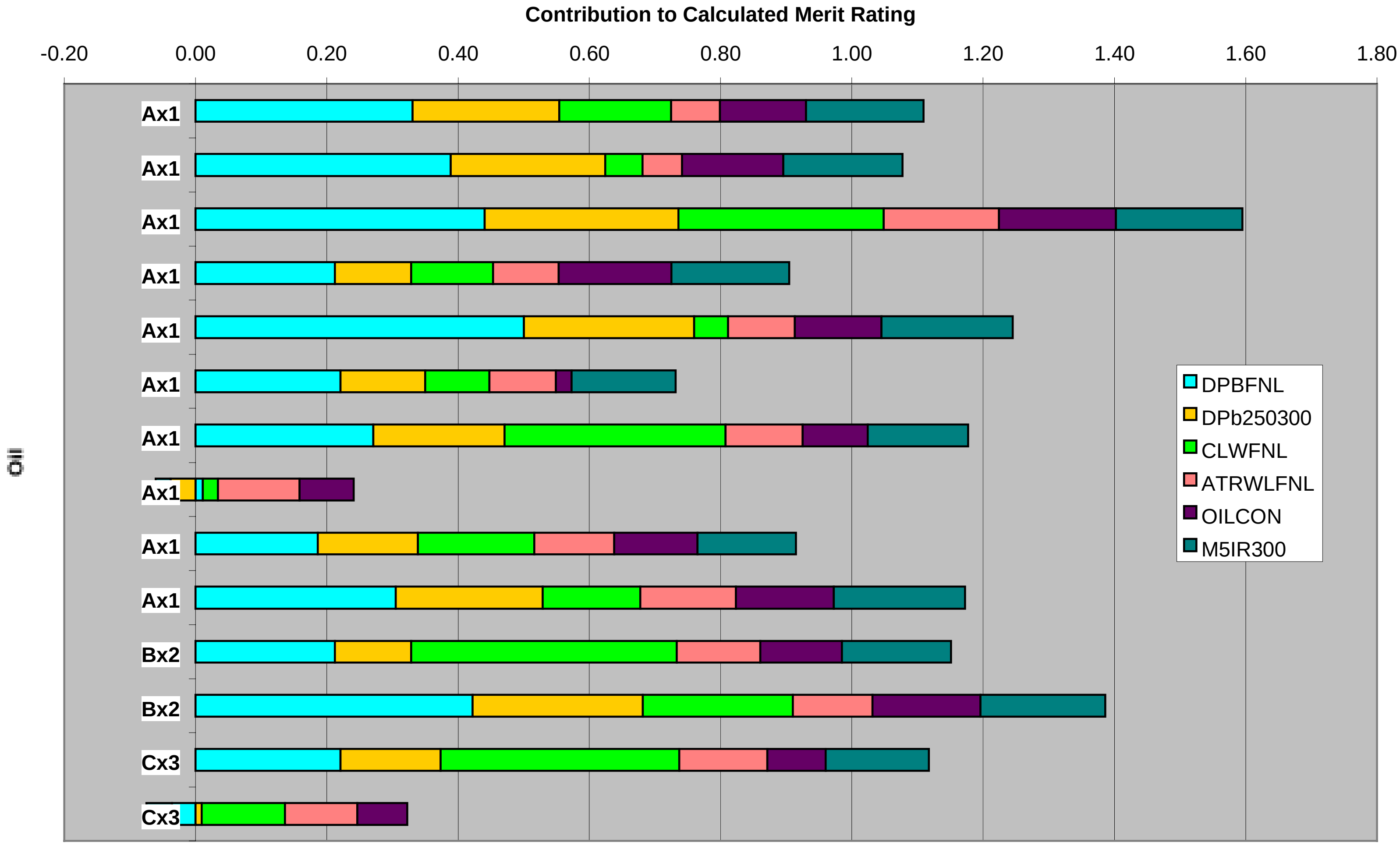
T10 Merit Proposal

- **How to interpret the following charts**
  - **Assumptions for weighting of parameters:**
    - » EOT Pb: 25%
    - » 250-300hr Pb: 20%
    - » Liner wear: 25%
    - » Ring wt. Loss, Oxidation, Oil consumption all 10%
  - **Allows ±2SD from center**
  - **Exceeding the deviation limit defines a fail**
  - **Exmple uses the Mack proposed limits as anchor point**

ATTACHMENT 14, 5 OF 8

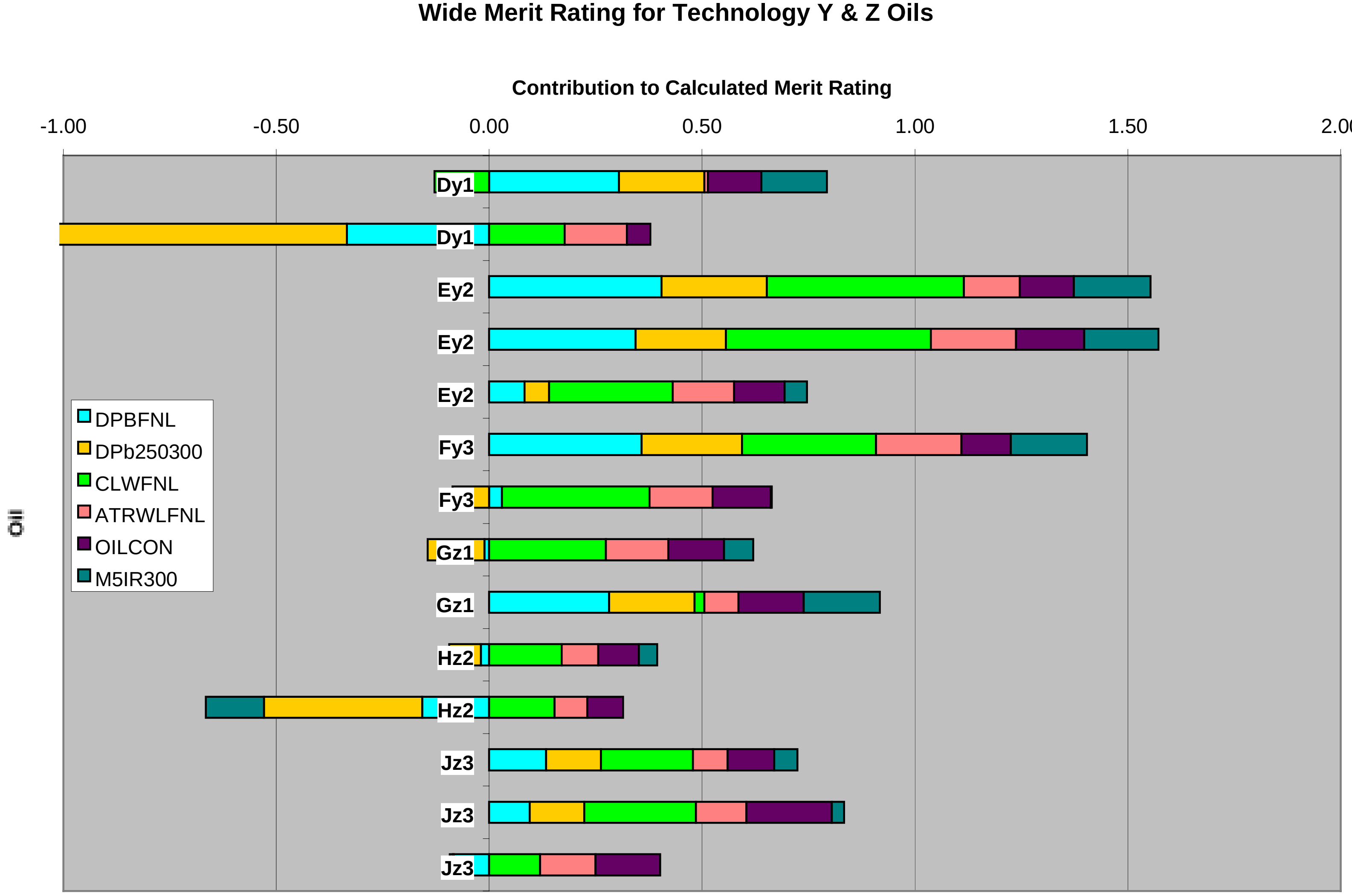
Example: Based on Mack proposed limits

Wide Merit Rating for Technology X Oils



ATTACHMENT 14, 6 OF 8

Example: Based on Mack proposed limits



ATTACHMENT 14, 7 OF 8

Merit Proposal

- **Clearly discriminates oil performance while accounting for test variability effects**
  - **Example 1:**
    - » PC9 technology combined (X and Y) ‘passes’ 70% of the time
    - » CH-4 technology ‘passes’ 28% of the time
  - **Example 2**
    - » PC9 technology combined ‘passes’ 57% of the time
    - » CH-4 technology ‘passes’ 0%
- **We believe that adoption of this system would reduce concerns about the impacts of precision of the individual parameters**

ASTM D3244 – Standard Practice for Utilization of Test Data to Determine Conformance with Specifications

Critical vs. Non-critical Specifications

JLZ / 9-26-01

ASTM D3244

- Standard practice that presents guidelines for resolving product quality disputes
- Indicates how test imprecision should be interpreted relative to specification values
- Provides a technique for comparing an assigned test value with a specification value
- Defines specifications as either “critical” or “non-critical”

Critical Specification

- A specification for which the receiver must have a high degree of assurance that the product actually meets or exceeds the quality level indicated by the specification value
- Based on the test result(s), unless the receiver can be 95% confident that the product meets or exceeds the specification, the product would be considered nonconforming and would be rejected.

Critical Specification (continued)

- Critical specifications require an assigned test value (ATV) that is “better” than the specification value (S) in order to achieve product conformance and acceptance
- “How much better?” depends on the precision (R) of the relevant test method and the number of test results (N) used to determine the ATV.

Non-critical Specification

- A specification for which the receiver only needs assurance that the product quality is not substantially poorer than is indicated by the specification value
- Based on the test result(s), unless the receiver can be 95% confident that the product fails to meet the specification, the product would be considered conforming and would be accepted.

Non-critical Specification (continued)

- Non-critical specifications allow an assigned test value (ATV) to be “worse” than the specification value (S) and still achieve product conformance and acceptance
- “How much worse?” depends on the precision (R) of the relevant test method and the number of test results (N) used to determine the ATV.

D4683 Examples

- Proposed Specification Value: 3.5cP Non-critical
- R = 0.126 (3.6% of the mean)
  - ATV based on average of two test results (different labs)
    - Acceptance Limit (AL) = 3.5 – (0.126 * 0.419) = 3.45
  - ATV based on one test result
    - Acceptance Limit (AL) = 3.5 – (0.126 * 0.593) = 3.43

D4683 Examples (continued)

- Proposed Specification Value: 3.3cP Critical
- R = 0.119 (3.6% of the mean)
  - ATV based on average of two test results (different labs)
    - Acceptance Limit (AL) = 3.3 + (0.119 * 0.419) = 3.35
  - ATV based on one test result
    - Acceptance Limit (AL) = 3.3 + (0.119 * 0.593) = 3.37

ASTM D3244 – Standard Practice for Utilization of Test Data to Determine Conformance with Specifications

Critical vs. Non-critical Specifications

JLZ / 9-26-01

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D4683 Examples (continued)

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  - ATV based on average of two test results (different labs)
    - Acceptance Limit (AL) = 3.3 + (0.119 * 0.419) = 3.35
  - ATV based on one test result
    - Acceptance Limit (AL) = 3.3 + (0.119 * 0.593) = 3.37

PC-9 SAE 10W-30 HT/HS SPECIFICATION (ASTM D 6278)

From ASTM D 3244: Utilization of Test Data to Determine Conformance with Specifications

AL = Acceptance Limit
S = Specification
R = ASTM Reproducibility of ASTM D 6278 (2.68% of mean)
N= Number of different laboratories (N=1)

AL = S + 0.255 x 1.414 x R x D

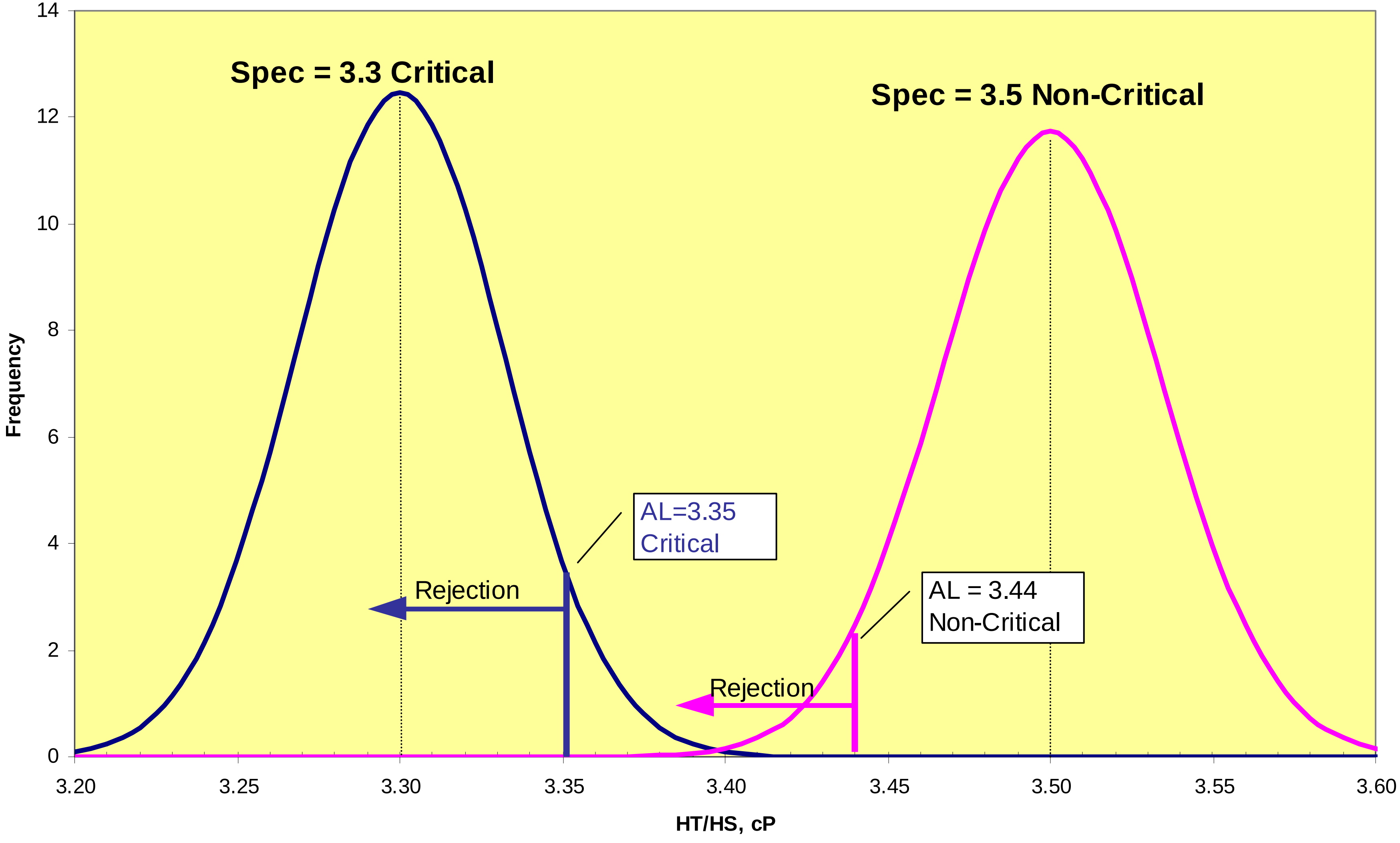
Case I: Non-Critical HT/HS Spec of 3.5 cP (Probability of Acceptance = 0.95)

AL = 3.44 (Likely blending target of 3.5 - 3.6)

Case II: Critical HT/HS Spec of 3.3 cP (Probability of Acceptance = 0.05)

AL = 3.35 (Likely blending target of 3.4 - 3.5)

Comparison of Critical and Non-Critical HT/HS SPecifications



ATTACHMENT 16, 2 OF 3

Consequences of Differing HT/HS Specifications

3.3 cP Critical HT/HS:
If the true value is equal to the specification of 3.3 cP, there is a 95% probability of rejection. If the true value is equal to the AL of 3.35 cP, then the probability of rejection is 50%. In order to decrease the probability of rejection to <50 % , the manufacturer would need to target the true value at >3.35 cP.

3.5 cP Non-Critical HT/HS:
If the true value is equal to the specification of 3.5 cP, there is a 5% probability of rejection. If the true value is equal to the AL of 3.44 cP, then the probability of rejection is 50%. In order to decrease the probability of rejection to <50 %, the manufacturer would need to target the true value at >3.44 cP.

SAE 10W-30 HTHS

ASTM HDEOCP MEETING IN

SAN ANTONIO, TX

SEPTEMBER 26, 2001

FRANK BONDAROWICZ

INTERNATIONAL TRUCK AND ENGINE CORPORATION

ATTACHMENT 17, 1 OF 3

SAE 10W-30 HTHS

- NEW ENGINES HAVE HIGHER POWER DENSITY
- 6.0L ENGINE WILL HAVE EQUAL HORSEPOWER AS CURRENT 7.3L ENGINE
- NEW ENGINES HAVE NARROWER BEARINGS AND HIGHER ENGINE SPEED
- 6.0L ENGINE WILL BE USED IN THE SAME APPLICATIONS AS THE CURRENT 7.3L PLUS NEW APPLICATIONS

SAE 10W-30 HTHS

- THE INDENDED USE OF 10W-30 OIL IS FOR LIGHT DUTY & HEAVY DUTY DIESEL ENGINES
- ACEA B2 AND HIGHER HAVE 3.5 CP HTHS
- ACEA E1 AND ABOVE HAVE 3.5 CP HTHS
- GLOBAL DHD-1 HAS 3.5 CP HTHS
- PC-9 (CI-4) WILL BE USED IN LIGHT DUTY & HEAVY DUTY DIESEL ENGINES
- THEREFORE, SAE 10W-30, PC-9 OIL NEEDS TO HAVE 3.5 HTHS

Report of T-10 MRV Study Group

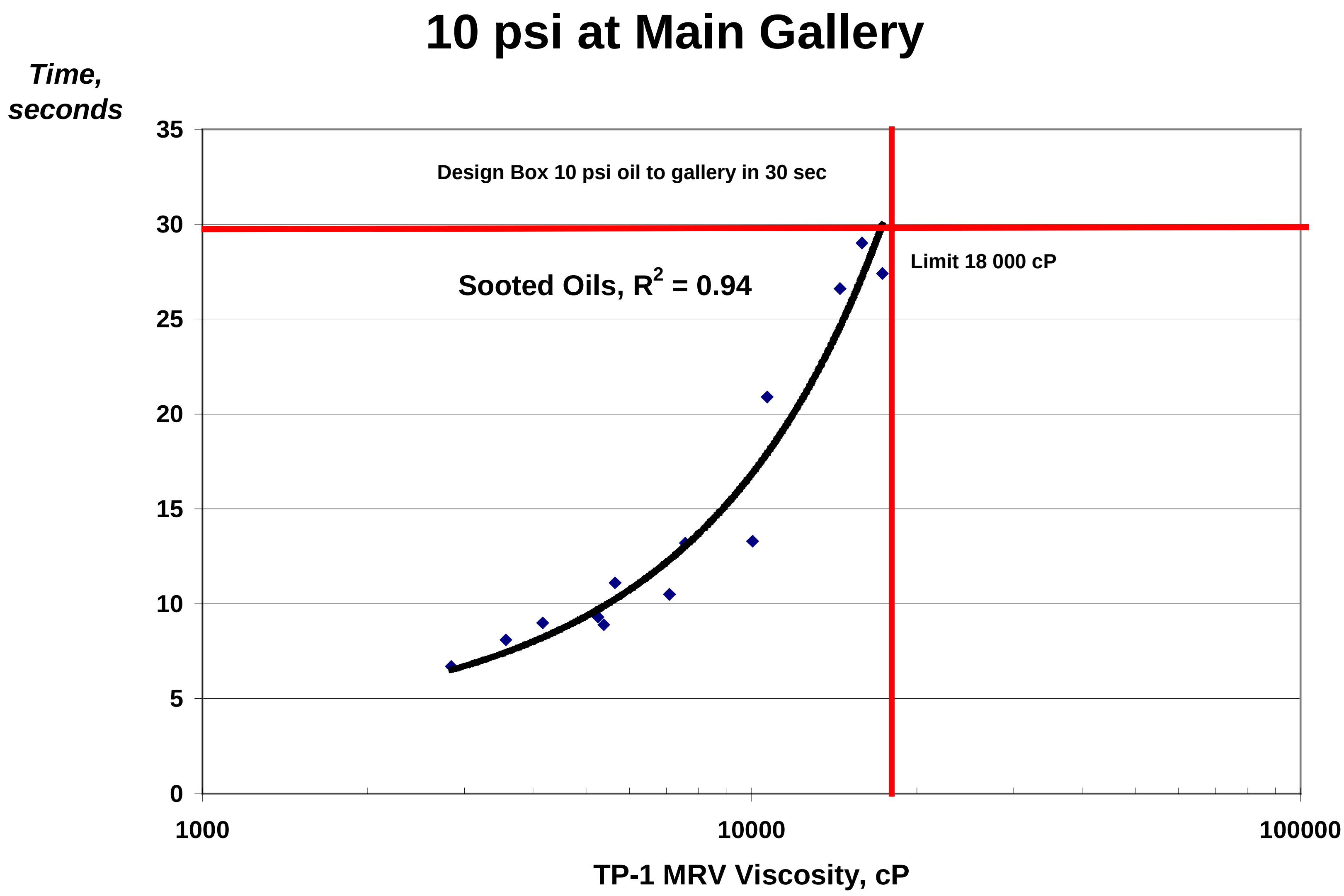
Committee Discussions

David M Stehouwer

September 12, 2001

ATTACHMENT 18, 1 OF 13

M-11 Low Temp Pumpability Experiment



M-11 Low Temp Pumpability Experiment

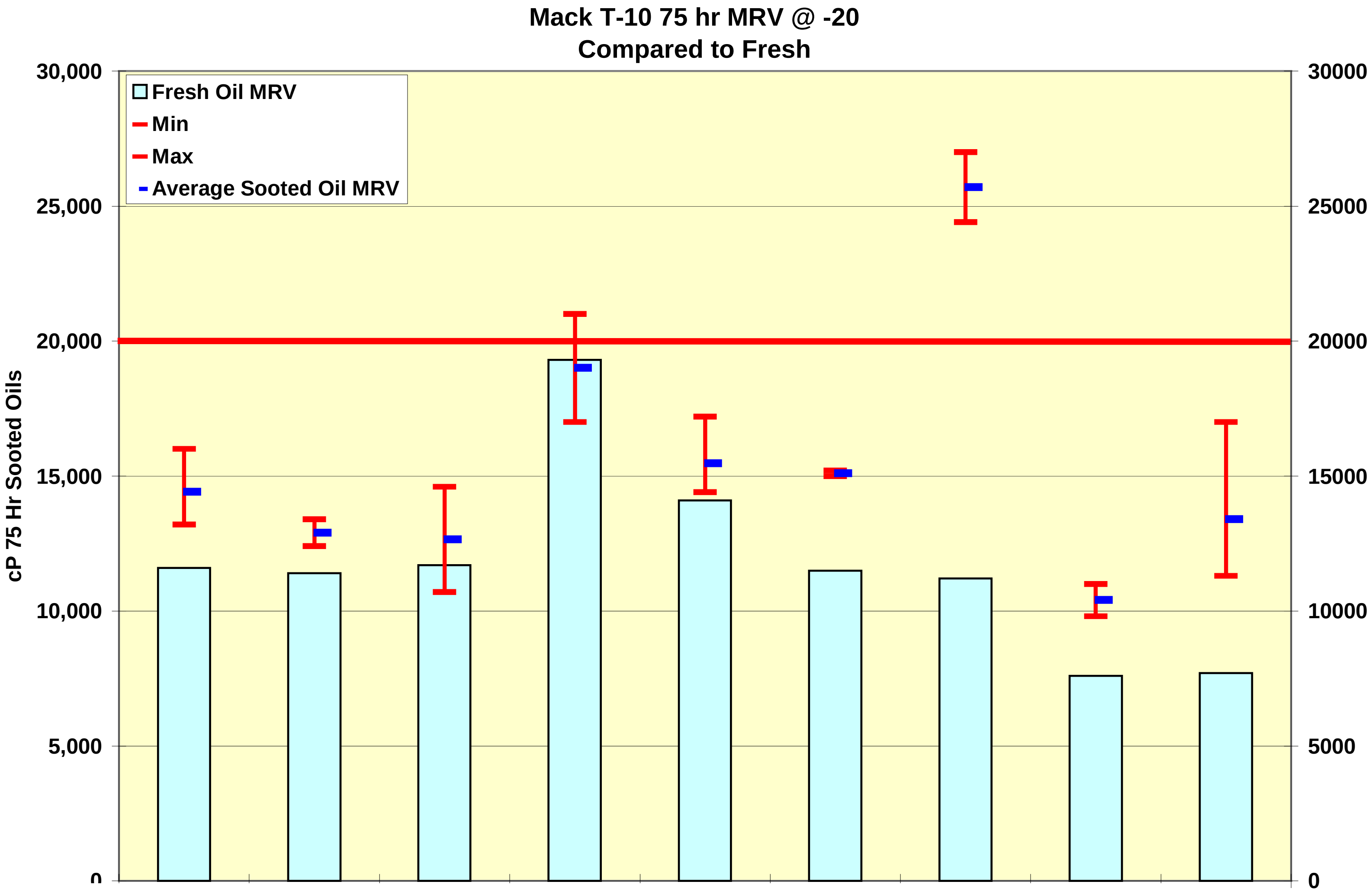
- **Starting attempts at -25C with fresh oil:**

Oil	CCS cP@ C	MRV cP -15 C	MRV cP -20 C	MRV cP -25C	Comments @ -25
10W30	7150 @ -25	2610	4450	8610	Engine Started
15W40	6800 @ -20	5590	8390	15700	Terminated Engine Noise
15W40	6350 @ -20	5330	6600	18000	Terminated Drive Shaft Broke

From M-11 Low Temp Pumpability Experiment

- Cummins design box is to have 10 PSI oil pressure to gallery in 30 sec.
- Initial data on sooted oils suggests 18 000 cP for a limit.
- Fresh oils at -25 C would not allow the engine to crank
- This suggests 20 000 cP as a critical viscosity

Sooted Oil MRV Shows Base Oil and Additive Effects



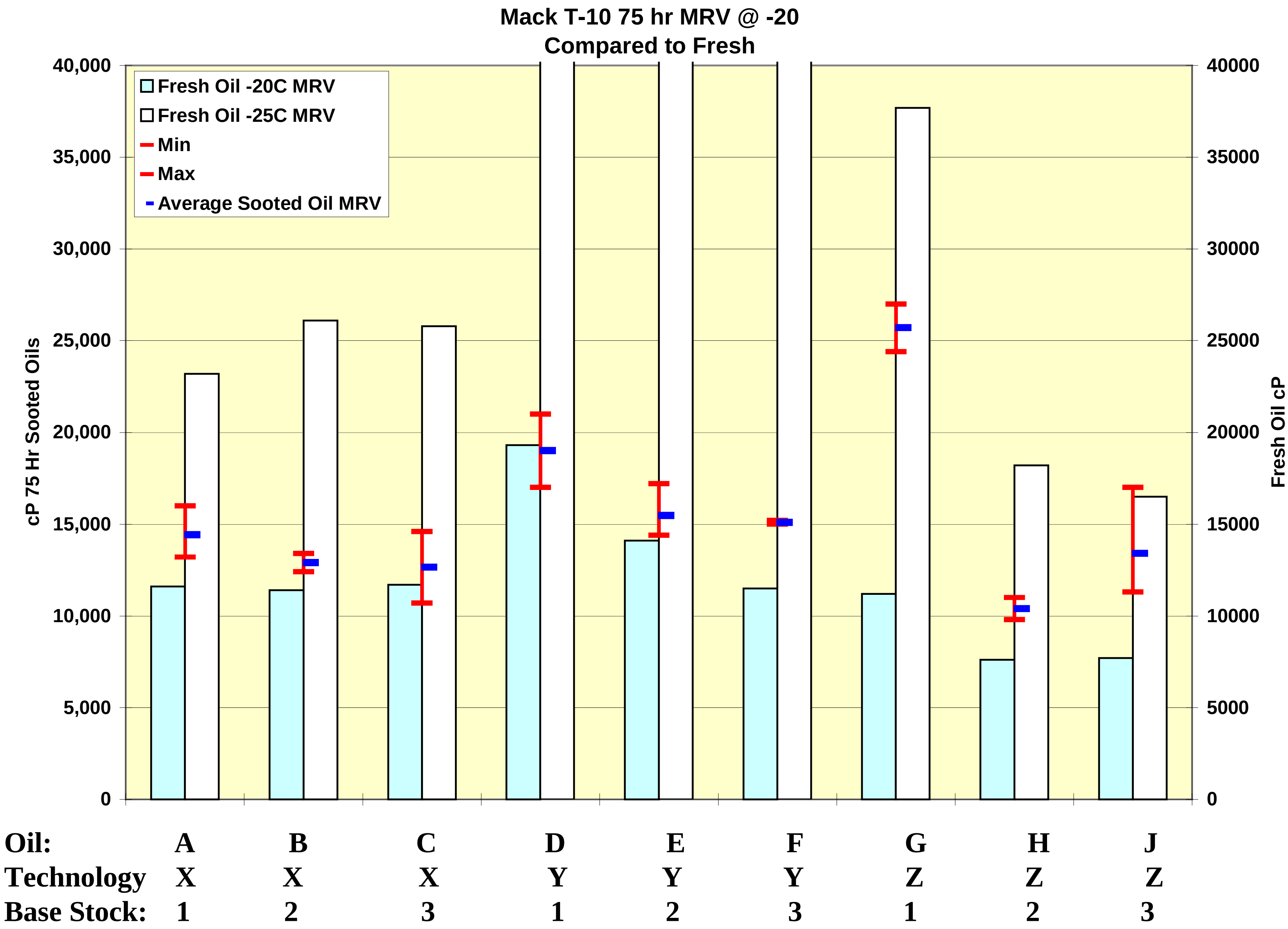
Oil:	A	B	C	D	E	F	G	H	J
Technology	X	X	X	Y	Y	Y	Z	Z	Z
Base Stock:	1	2	3	1	2	3	1	2	3

ATTACHMENT 18, 5 OF 13

Observations from Sooted Oil MRV @ -20 C

- **Oil G is bad actor**
- **Technology Z was a 10% under-treat**
- **Robust Technology will function in all basestocks**
- **Data would suggest high saturates *could* be an issue with marginal technology**
- **Oils D E F seemed close to trouble, but were formulated without flow improvers**

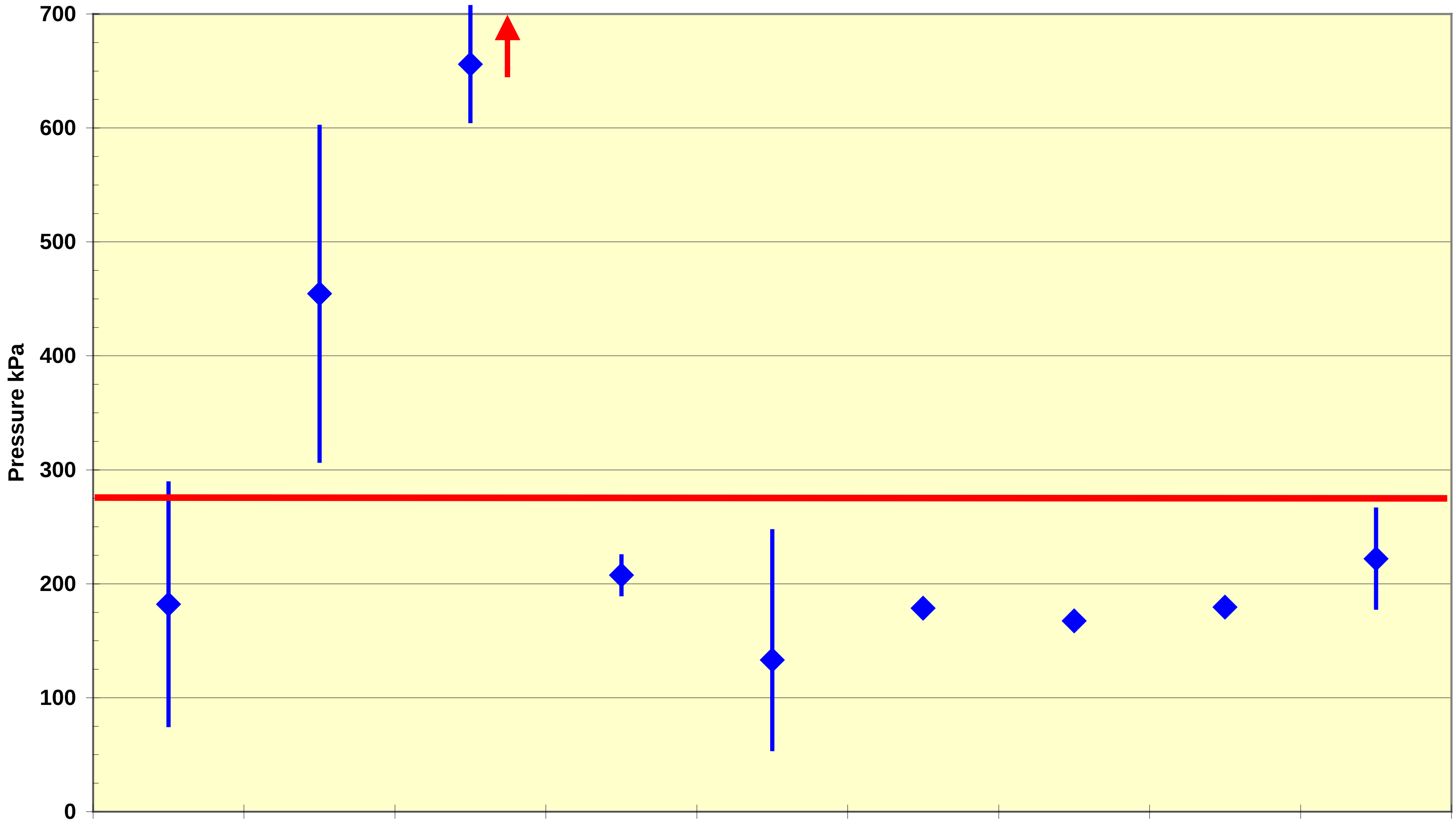
Fresh Oil and Sooted Oil MRV



Fresh and Sooted oil MRV Observations

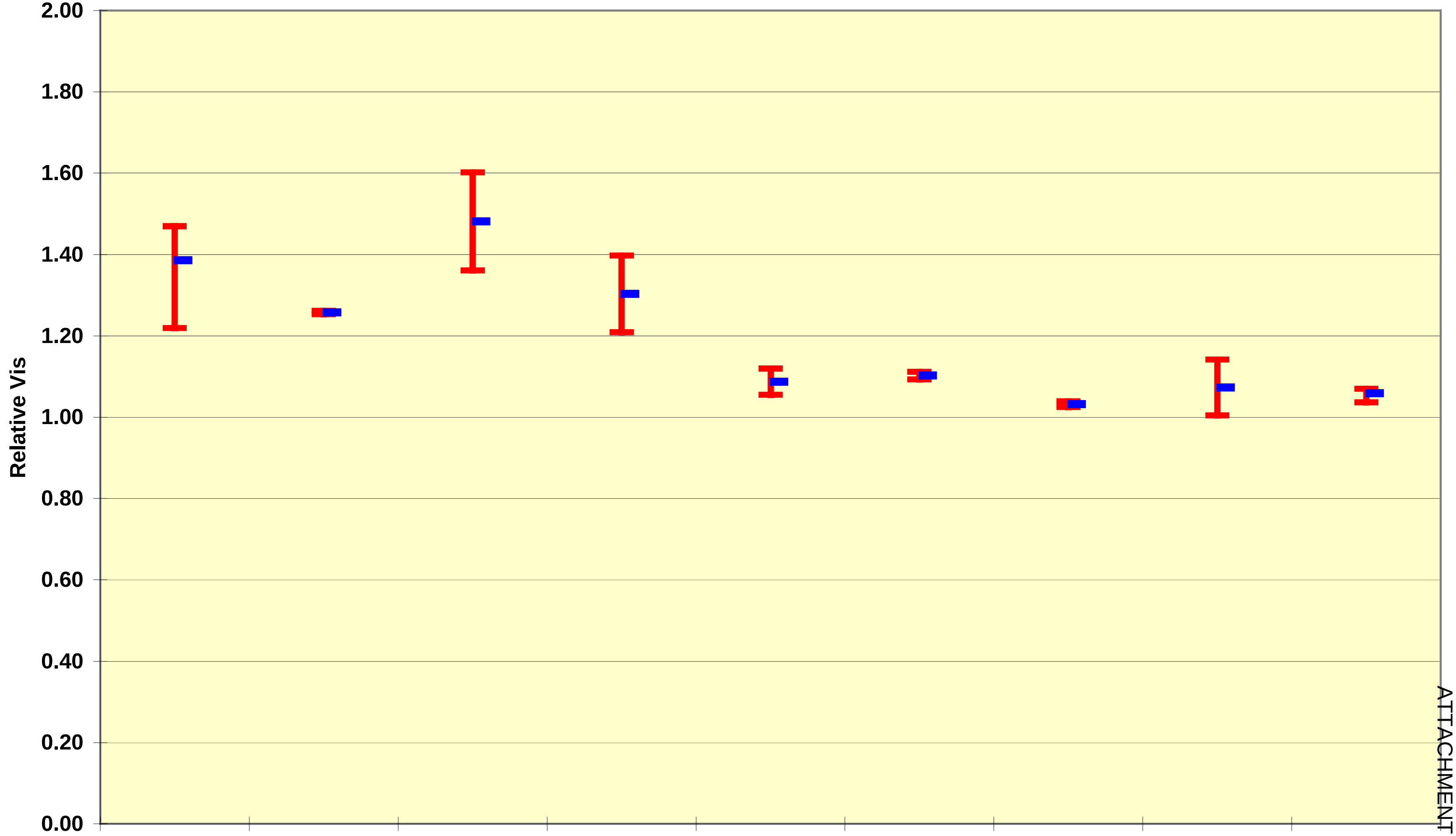
- Oils D E & F would have been caught by fresh oil MRV @ -25 C and fixed before spending $$ on a T-10
- Oil G passes the 60 000 cp @ -25 C
- If the T-10 75 hr MRV @ -20 catches an oil, a 30 000 cP MRV on fresh oil might assist as a read-across guideline.

M11 PC-9 Matrix Oil Filter Delta P @ 250 Hr.



Oil:	A	B	C	D	E	F	G	H	J
Technology	X	X	X	Y	Y	Y	Z	Z	Z
Base Stock:	1	2	3	1	2	3	1	2	3

T-10 Matrix Relative Viscosity



Oil:	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
Technology	**X**	**X**	**X**	**Y**	**Y**	**Y**	**Z**	**Z**	**Z**
Base Stock:	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**

The Case for Used Oil MRV Limit

- **Data has shown that with used oil MRV:**
  - ✓ **There is a problem with marginal technology**
  - ✓ **It effects engine operation**
  - ✓ **Basestock effect is suggested**
- **It is not picked up by fresh oil data**
- **It is not seen in M11 filter delta P data**
- **It is not seen in KV 100 on the used oil**
- **Therefore, MRV @ -20C on 75 hr used T-10 oils is needed**

75 hr Mack T-10 MRV @ -20 C:
Observations

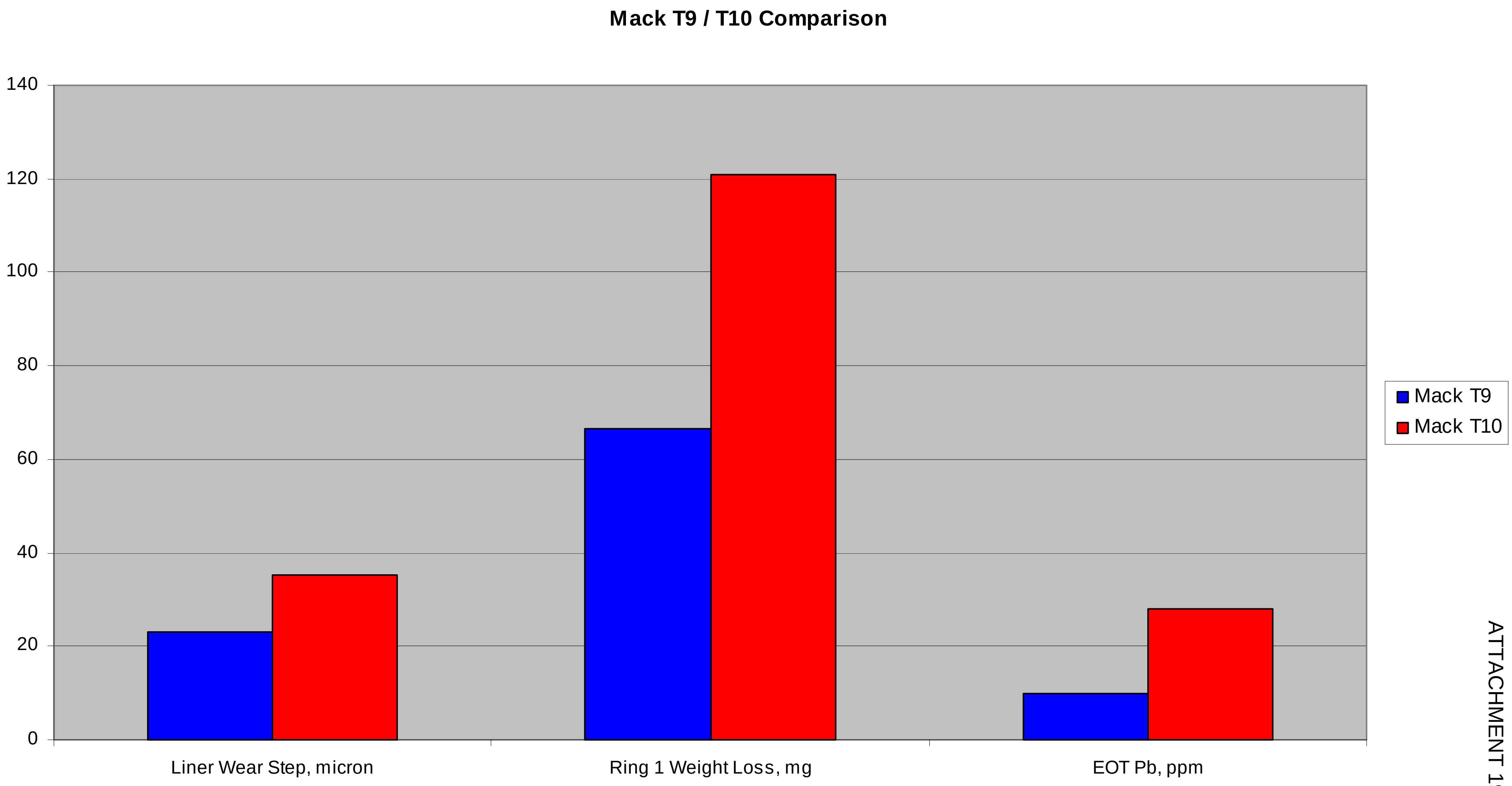
- A limit is 20 000 cP @ -20 C is supported by engine pumping data.
- Limit of 20 000 cP @ -20 C is generous
  - ✓It catches only a problem oil (assuming oil D contained low temperature flow improvers)
- Used oil MRV seems most related to robustness of DI/VM technology
- A technology matrix covering base oil types should cover this issue.
- Mack T-10 BOI guidelines Group I reads to Group I; Group II reads to Group II
- Comparing 75 hr MRV of oils G and H seems to show sensitivity to higher saturates.

Proposed T10 Used Oil MRV Limit

- Cummins proposes a limit of 20 000 cP @ -20 C on 75 hr used oil from Mack T-10
- BOI should follow Mack T-10
  - ✓Group I reads to Group I
  - ✓Group II reads to Group II
- Suggest API use a 30 000 cP @ -25 C on Fresh Oil for BOI as a safety.
  - ✓Consider alternatives

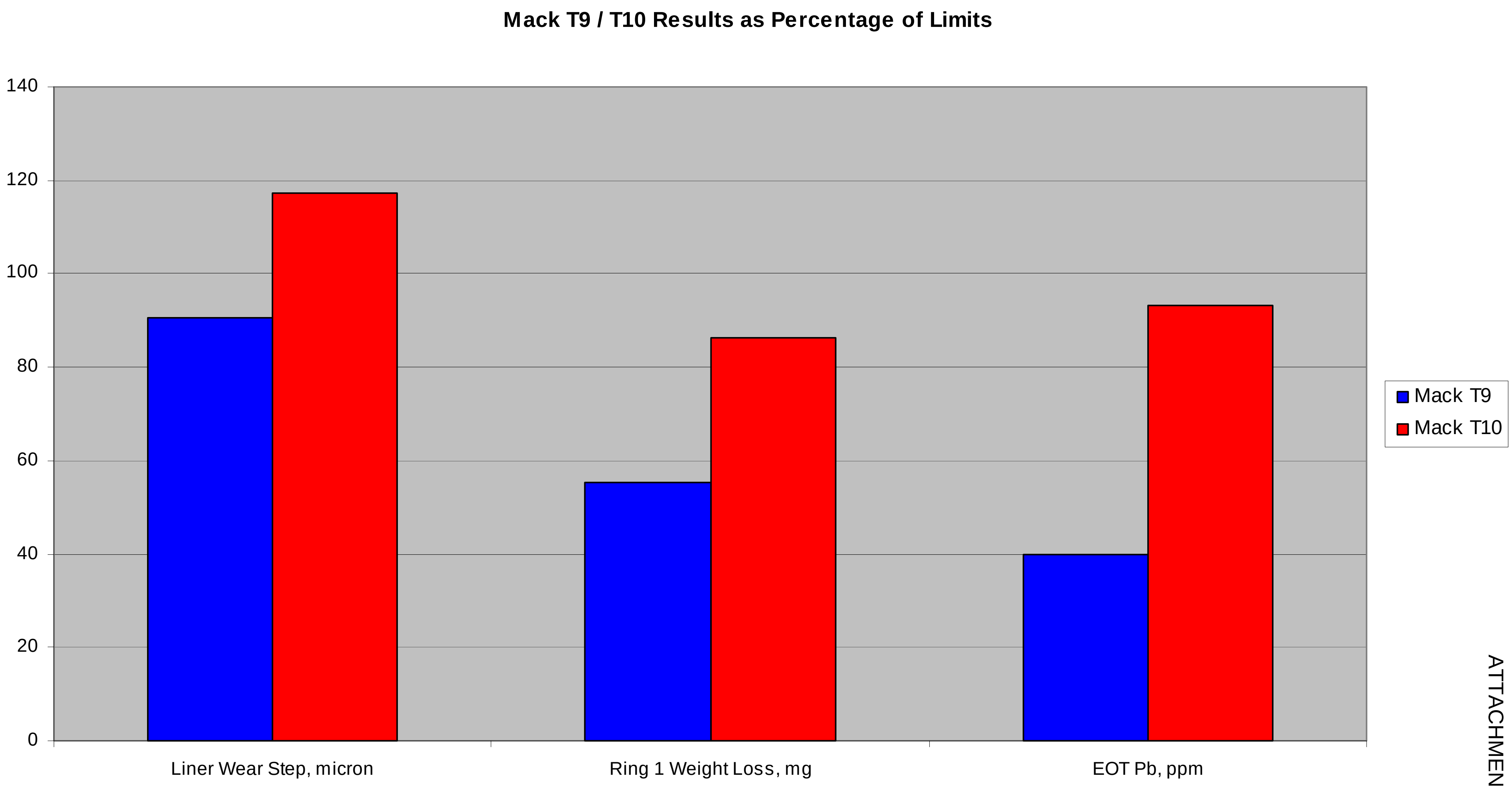
CI-4 Backward Compatibility

EGR Backward Compatibility



ATTACHMENT 19, 2 OF 6

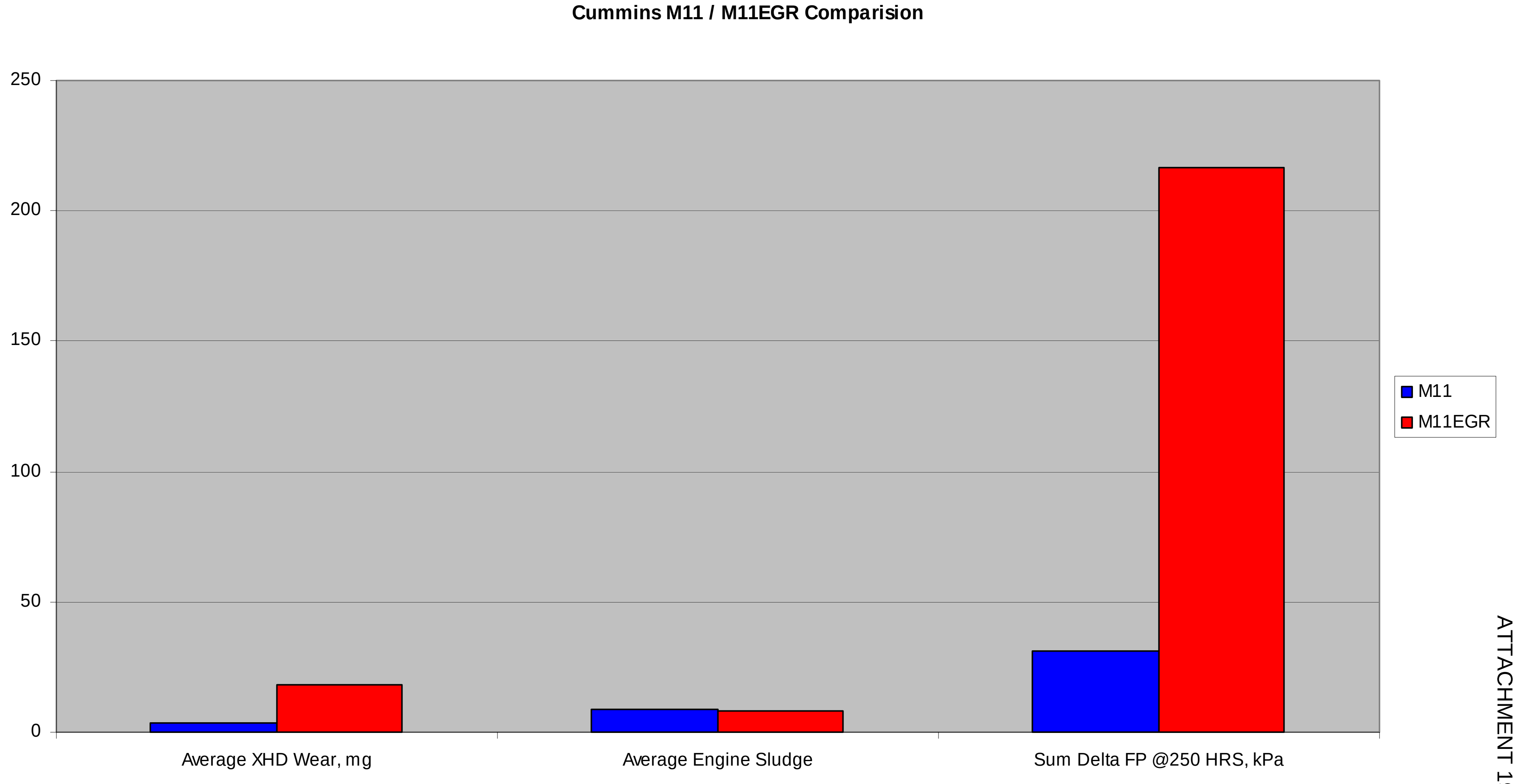
EGR Backward Compatibility



ATTACHMENT 19, 3 OF 6

LUBRIZOL

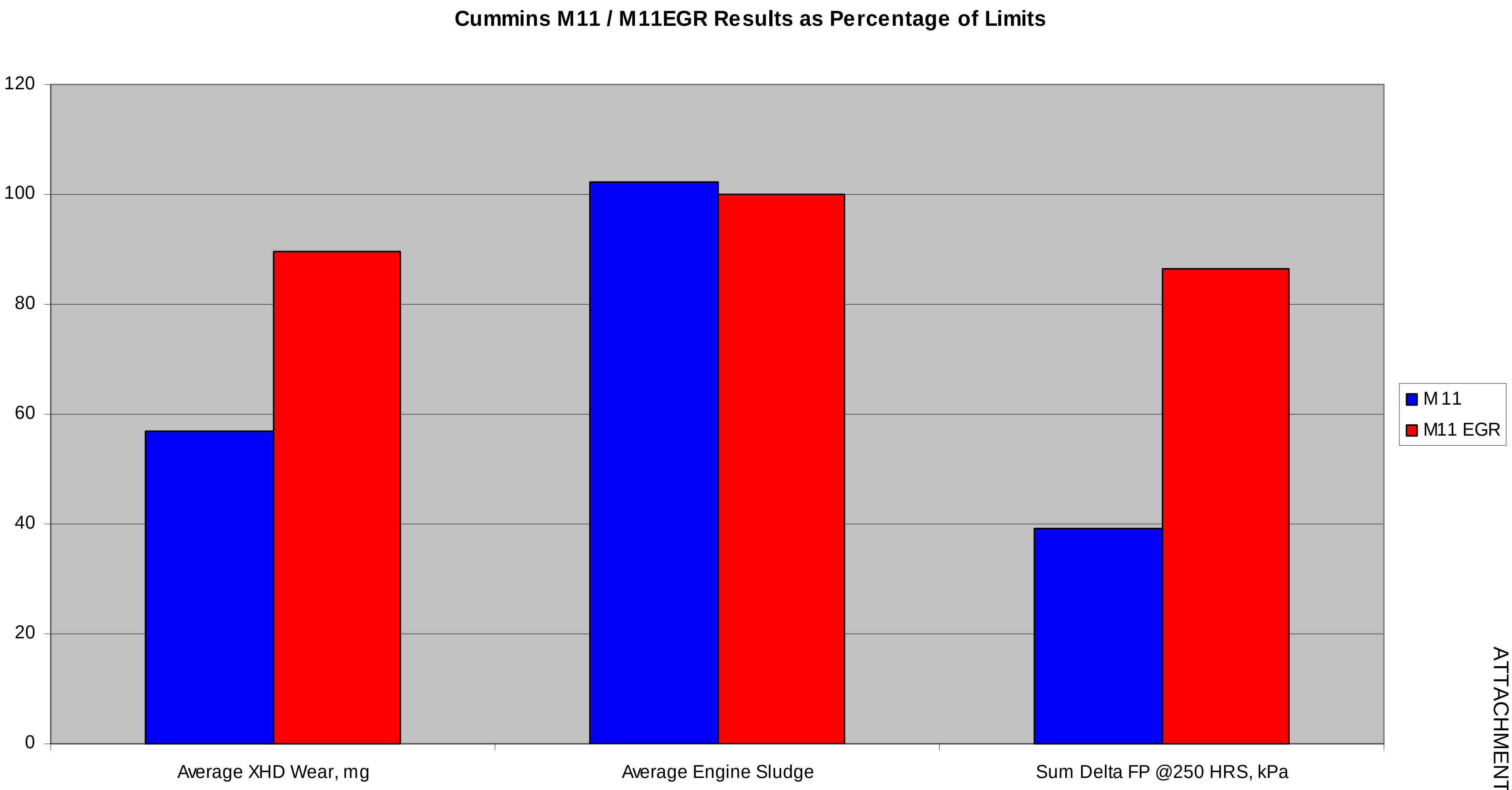
EGR Backward Compatibility



LUBRIZOL

ATTACHMENT 19, 4 OF 6

EGR Backward Compatibility



LUBRIZOL

EGR Backward Compatibility

- Performance observed in the new EGR tests is more severe than their non-EGR predecessors

- Lubrizol offers the motion that:-

  "The tests and limits as approved by ASTM B used to qualify oils for API CI-4 may be used to qualify oils for API CH-4"

LUBRIZOL

Process for Elastomer Test Severity Adjustment

- Form a Surveillance Panel Under B0.07
- Surveillance panel recommends to TMC information to be collected from Tests
  - TMC make information available to all on Website
- Surveillance panel monitors severity
  - Test sponsors can bring to panel's attention
  - Most work can be done via teleconference
  - SP can make recommendations to EMA
  - SP can make severity adjustments against fixed D4485 limits for PC-9 category

Process for Elastomer Test Severity Adjustment

- Will Call a TF/Surveillance Panel Meeting in Near Future (Sept 27 after SAE?)
  - New Chairperson to be Rebecca Grinfield of SWRI
  - If HDEOCP concurs, will implement process outlined in this presentation