HEAVY-DUTY ENGINE OIL CLASSIFICATION PANEL

OF

ASTM D02.B0.02

October 27, 2005

Southwest Research Institute – San Antonio, TX

ACTION ITEMS

1. **Publish monthly test registration report.** **ACC/RSI**
2. **Analyze FTIR Peak Height Round Robin values.** **FTIR Task Force**
3. **Analyze ISB data for 100 hour sample viscosity and calculate 2 and 3 test limits.** **Phil Scinto**
4. **Final decision on C13 parameters and finish analysis.** **Abdul Cassim and C13 SP**
5. **Issue revised ISM limits for PC-10 in time for November conference call.** **Cummins**
6. **Issue T-12 and ISB exit criteria ballots.** **Jim Mc Geehan**

MINUTES

1.0 Call to order

1.1 The Heavy Duty Engine Oil Classification Panel (HDEOCP) was called to order by Chairman Jim McGeehan at 8:30 a.m. on Thursday, October 27, 2005, in Building 209 at Southwest Research Institute.

1.2 There were 19 members present and 27 guests present. The attendance list is shown as Attachment **2.**

2.0 Agenda

2.1 The agenda is included as Attachment **1**. There were no changes to the agenda.

3.0 Minutes

3.1 The minutes from October 12, 2005 were approved with no changes.

4.0 Membership

4.1 Steve Goodier replaces Mike Lynskey for BP.

4.2 Chairman McGeehan suggests that the HDEOCP vote first at the meeting in January before the NCDT meeting. The NCDT membership does not include ACC membership. The HDEOCP must approve all tests and limits before the NCDT votes to accept the outcome of the HDEOCP vote.

4.3 The T-10 to T-9 ballot has been approved. The T-10 to T-6 vote is on the Subcommittee B ballot to be completed before the December meeting.

5.0 NCDT Report

5.1 The membership list of the NCDT was shown. See Attachment **3**. The voting rules desire a consensus result. If that is not achievable, then the membership structure comes into play. There are 3 EMA members and 3 API members.

5.2 The NCDT conducted a conference call to discuss the request to include the CAT 1P in PC-10. See Attachment **4.** There was not consensus, so the voting rules were followed and the vote was to accept the CAT 1N, 1P and C13 in the category. Concerns about the timeline were noted. This is where it became apparent that the ACC is not represented on the NCDT. There are 3 pistons deposit tests and 3 valve train wear tests in PC-10. The total number of tests for PC-10 is: 10 fired engine tests and 6 bench tests.

5.3 The NCDT timeline still shows January 2007 for first license. See Attachment **5.** A breakthrough is needed to meet the timeline. The demonstration period is over when limits are set. The HDEOCP recommends the category to the NCDT which then sends it to the API. There has been little activity of pre-registered testing. The EMA wants to monitor the amount of demonstration testing. Some test work may be going on without pre-registration. Once the tests are declared ready, then more testing may happen. The expectation was that the tests would have been declared ready. RSI does supply a monthly report of the number of registered tests. That report will be published. The demonstration period is still 4 months beginning September 23, 2005. First license is still December 27, 2006.

6.0 Matrix Status

6.1 John Zalar presented a summary of the matrix costs. See Attachment **6.** The matrix included 8 lost tests at an estimated cost of $279,000. The total cost of the PC-10 matrix is estimated to be $5,532,000. These are just the direct testing costs.

7.0 Mack T-12/T-11

7.1 Jim Rutherford presented the statisticians consensus analysis of the T-12 matrix. See Attachment **7.** There are a few tiny issues to resolve, but the analyses are complete enough to present as finished. The first step was to look for cylinder outliers and to see if there are any profiles of wear biased by cylinder location. Cylinder 1 usually has higher wear. Profiles were found for Top Ring Weight Loss (TRWL) and Cylinder Liner Wear (CLW), but not Bearing Weight Loss (BWL). All the details of the analysis are contained in the attached icons in the original PowerPoint only (available separately). The data were modeled 3 ways; all the tests in a full model (26 tests), the tests on new rings only (19 tests) and the reduced model without stand within lab as an effect (19 tests). The significant effects for oil are CLW, Oil Consumption (OC), and Delta DIR from 250 hours to 300 hours (DIR250300). There is a significant effect for lab on CLW. With transformed parameters, the Ep is calculated around the Mack Merit values proposed at the time. The lead parameters are slightly less than 1, the CLW is well over 1. TRWL is the most challenged Ep at 0.50. OC is well over 1. Targets for reference oil acceptance are still needed. Two extreme ways to decide targets are: Least Square (LS) means and arithmetic means. The Root Mean Square Error (RMSE) from the model match pretty well with the arithmetic standard deviation except for liner wear due to the lab effect. There doesn't seem to be redundant parameters, but there is not ACC consensus yet.

7.2 Greg Shank presented a T-12 update. See Attachment **8.** The T-12 Task Force met Wednesday, October 26, 2005. The task force voted that the T-12 is ready for inclusion in PC-10 and that the low SAP oil, PC-10E, be the reference oil for the T-12. There is an Operations and Hardware (O&H) level meeting scheduled for November 16, 2005 to investigate lab differences and try to tighten operations. Mack has updated the merit proposal. The weighting factors stayed the same, but the maximum, anchor points and minimum values have changed. More merit points are available for being better than the anchor and less merit points are available for being worse than the anchor. The TRWL precision is not too good, so the maximum and minimum parameters were relaxed some using 2 standard deviations. Mack Merit values using correlated BWL were also shown. These will not likely be used. The matrix results were calculated for merits using both

methods. Volvo would like to stay with lead and not use bearing weight loss. Bearing weight loss does not capture any other corrosion or source of lead. The minimum total merit value for a pass would be 1000. There is some dissatisfaction with FTIR area Method 5, so FTIR peak height value is being considered in its place. The existing round robin data will be investigated for FTIR peak height repeatability. FTIR area is off the table for the T-12, but peak height is not. Greg Shank **motioned** that these proposed merit limits be sent out for exit ballot. Bill Kleiser seconded. FTIR is not on this exit ballot, but is still being considered. If FTIR is desired, a separate exit ballot would be issued. The proposed reference oil passes 50% of the time and fails 50% of the time, so it is a borderline oil. The **motion passed** unanimously with 19 votes for, 0 against and 0 waives.

7.3 The T-11 limits and slope item on the agenda will be discussed at a later date.

8.0 Cummins ISB

8.1 Phil Scinto presented the ISB analysis. See Attachment **9.** This analysis is "mostly official", there are minor decimal differences to resolve, but the conclusions are complete. The analysis included 17 valid tests; 15 matrix tests and 2 tests on stands outside the matrix. The parameters analyzed are: Average Tappet Weight Loss (ATWL), Average Camshaft Wear (ACSW), and Average Crosshead Weight Loss (ACHWL). Outlier screening was used and there are no wear profiles in the ISB. Currently, there are soot corrections for ATWL and ACHWL. Cam shaft wear may possibly be corrected for stage B average torque. The reported torque is a snapshot of the torque during the 6 second long step of the cycle. There are no transformations needed at these wear levels. All 3 wear parameters meet the ACC precision requirements, except ATWL between stand and labs. The models have somewhat confounding parameters: stand, stage B average torque and soot. Some feel that correcting for an operational parameter (torque) is not ideal. If the stand differences are real and they can't be fixed, then more references may be necessary. The Surveillance Panel is not favoring running more references. The referencing rules for the ISB test are 12 candidate tests or 12 months for the first 2 reference periods, then 12 tests or 18 months after that. The table of Ep values shows acceptable values except the ATWL reproducibility between stand and labs. Within a stand, the repeatability is good. In most cases, the LS means and arithmetic means are close to each other. ATWL is a function of lab, stand within lab, oil, and average soot. ACSW is a function of lab, stand within lab, and oil. The stand within lab effect is eliminated if the ACSW is corrected for stage B average torque. ACHWL is a rate and report parameter and is a function of lab, oil, and average soot.

8.2 Dave Stehouwer presented the Cummins report on pass/fail limits. See Attachment **10.** PC-10E was proposed and rejected as the reference oil, because it didn't show much sensitivity. An oil that shows more sensitivity would be a better choice, but the oil has not been selected yet. Cummins is proposing a 75 mg pass limit for ATWL. For ACSW in the field, Cummins has used in internal rating method and has some Adcole cam wear results data. Using limited data from the matrix on Adcole and Mitutoyo, the service limit correlates to a 30 µm pass limit for cam wear. The labs are to send the matrix cams to Cummins for the visual rating and get all the Adcole data together so a better correlation can be developed. Since some T-11 to ISB data is coming in, but not complete yet, Cummins is proposing a placeholder viscosity limit of stay in grade at the 100 hour soot window level of 3.0% to 3.5% soot. The matrix data was not analyzed for that yet, but will need to be. Dave Stehouwer **motioned** that an exit criteria ballot be issued for the ISB test with the proposed limits. Bill Kleiser seconded. The viscosity analysis will be performed and should be complete in time for the exit criteria ballot. The ballot will include the analysis. The viscosity result should be soot adjusted back to 3.0%. The **motion passed** unanimously with 19 votes for, 0 against and 0 waives.

9.0 Caterpillar C13

9.1 Abdul Cassim presented his C13 summary. See Attachment **11.** There is no correlation between oil consumption and piston deposits. Base oil effects by parameter and technology show Group III effects. The Ep values are all greater than 0.6 with Top Land carbon (TLC) and Top Land Heavy Carbon (TLHC) greater than 1. The C13 Surveillance Panel met Tuesday, October 25, 2005. The C13 data analysis is almost complete. Further data review was requested. The Surveillance Panel agreed on 5 pass/fail parameters including oil consumption. The Surveillance Panel is waiting on CAT's choice of lower piston deposit parameter(s) instead of Unweighted Demerits (UWD). That action is to be complete by November 4, 2005. There have been reports of lower piston deposit concerns on the C13, this shows that a parameter is possible there. There is a desire to ensure that upper and lower deposits behave independently. The possible parameters are no piston, ring, or liner scuffing and no hot stuck rings. The scuffing requirement will be a non-interpretable parameter. The additional parameters are: no loss of oil consumption control, no unacceptable piston deposits in the form of excessive TLC, Top Groove Carbon (TGC) and a parameter farther down the piston such as 2nd groove deposits. The schedule is to identify the lower piston parameters by November 2, 2005 and complete outlier screening methods for an LTMS by November 5, 2005. A pass/fail limits proposal based on the new parameter and reference oil selection are still needed. The originally proposed limits need to be updated. There are stand and lab differences, but no corrections yet. Some differences have been observed in the operational data and stand set-up. Those are being resolved. The issuance of an exit criteria ballot needs to happen before the December meeting. Once the Surveillance Panel and CAT resolve the parameters and issue limits, then the HDEOCP will have a teleconference to review so that an exit criteria ballot can be issued before the December 6th meeting.

10.0 ACC Report

10.1 Joan Evans presented the ACC timing report. See Attachment **12.** Using an assumption of ten C13 stands and one month per test, 10 tests per month will be available. The ACC thinks that a best case scenario of 36 passing tests are needed if full BOI/VGRA guidelines are granted that roll over from the CAT 1R to the C13 by 01/01/2006. This would take seven to twelve months to complete. The BOI task force has investigated the use of boundaries for base oil parameters to improve the read across methods. The middle case scenario requires 73 passes if only C13 BOI guidelines are granted and would take 15 to 24 months to complete. The worst case is 223 passes without any BOI/VGRA guidelines and would take 4 to 6 years to complete. Proposed solutions will be handled through the BOI/VGRA task force. If full guidelines are granted, then December 26th is possible. This is very dependant on pass/fail limits and pass/fail rates.

11.0 Cummins ISM

11.1 The Cummins ISM exit criteria ballot returns show 9 negatives and 10 affirmatives. See Attachment **13.** Some concerns are listed. The limits are set too far from 830-2 performance. Could not find evidence of discrimination data on Top Ring Weight Loss (TRWL). Did not know there would be a performance improvement need. Since it was a designed experiment, the precision is known and the merit SYSTEM has values too close together that don't seem to be statistically based. Thought limits would be closer to 830 for backward compatibility. Test redundancy. Other limits need to be known too. Redundant wear tests. The ISB has better wear separation than the ISM. This is a step change in severity, thought that the severity would be the same. Would like to see more data on the TRWL since it has been added back. ISM was introduced as a replacement test to the M11EGR. Had it been brought in as a new test, many more tests would have been run and more data would have been available for the other parameters. New limits would fail 830-2 40% of the time, when it is supposed to be a passing oil. With the amount of variability of TRWL and Injector Adjusting Screw Weight Loss (IASWL) and the fail safe idea of sludge and Oil Filter Plugging (OFDP), then merits aren't needed. Use straight limits with tiered

limits for multiple tests instead. Proposed limits are a substantial upgrade when originally proposed as a replacement test. Supposed to be a CI-4 replacement at CI-4 limits.

11.2 The Cummins response is included as Attachment **14.** Cummins has stated that the ISM would have its own limit in PC-10. The PC-10 performance should be based on 830-2 and not on correlation with M11EGR. A 7.5 mg CHWL maximum limit will not be acceptable to Cummins. New data has expanded the 830 data set, so Cummins will look again. Backward compatibility refers to use of high sulfur fuel and its impact on wear, filter plugging and TBN retention. It does not mean the same limits. Cummins will accept staying with traditional limits and not using a merit system. Cummins will issue a revision for the November conference call. Cummins to review merit values anyway and may adjust the merit maximums based on statistics of the test so that if a result takes off it won't be a fail.

12.0 Review of all tests in PC-10

12.1 Chairman McGeehan stated that there are 10 engine tests and 6 bench tests to approve a fluid for PC-10. Charlie Passut **motioned** that the 1P be allowed as an alternative to a 1R at CH-4 limits for CI-4. Abdul Cassim seconded. The **motion carried** with 17 votes for, 0 votes against, and 2 waives.

13.0 Other Business

13.1 ILMA representative Larry Kuntschik expressed concern that the timeline is too short for the independents. If ACC is comfortable, than ILMA is comfortable. If ACC is concerned, then ILMA is concerned.

13.2 Two and three test pass limits for the ISB are needed on the exit ballot.

13.3 The EMA position is still that this must be complete with oils available by October 2006.

14.0 Next meetings

14.1 Conference call week of November 14th.

14.2 December 5th and 6th

14.3 Week of January 23rd.

15.0 The meeting was adjourned at 11:45 am.

Tentative Agenda
ASTMSECTION D.02.BO.02

HEAVY-DUTY ENGINE OIL CLASSIFICATION PANELS

Southwest Research Institute
6220 Culebra Road, San Antonio, Texas (Bld 209 Room 103)
October 27th, 2005
8:30 am-2:15 pm

Chairman/ Secretary: **Jim Mc Geehan/Jim Moritz**
Purpose: **PC-10**

Desired Outcomes: **Complete PC-10 on time**

TOPIC	PROCESS	WHO	TIME
Agenda Review	• Desired Outcomes & Agenda	Group	8:30-8:35
Minutes Approval	• October 12th , 2005	Group	8:35-8:40
Membership	• Changes: Additions • Status of API CF-4 ballot • Delivering PC-10 on time!	Jim Mc Geehan	8:40-8:45
NCDT Repor	• Cat 1N/Cat1P in PC-10 • Vote and Exit-Criteria Ballot • Time-line and first license date	Bill Runkle	8:45-9:15
Matrix Status	• Final cost of Cummins ISB; Mack T-12; Caterpillar C13 matrix. • Total number of test completed	John Zalar	9:15-9:25
Mack T-12/T-11	• Mack T-12 data analysis • Proposed Merit system • Vote and Exit-Criteria Ballot (Return date Nov. 21) • Mack T-11 limits and slope • Vote and Exit-Criteria Ballot	Greg Shank Jim Rutherford	9:25-10:15
Coffee break	•		10:15-10:30
Cummins ISB	• Data Analysis • Proposed limits • Vote and Exit-Criteria Ballot, (Return date Nov. 21) •	Dave Stehouwer Phil Scinto	10:30-11:15
Caterpillar C13	• Data Analysis • Proposed Merit system • Vote and Exit-Criteria Ballot, (Return date Nov 21)	Abdul Cassim Elisa Santos	11:15-12:15

TOPIC	PROCESS	WHO	TIME
Lunch	•		12:15-1:00
Cummins ISM	• Exit-Criteria Ballot returns • Discussion and vote	Jim McGeehan	1:00-1:45
ACC Report	• ACC's timing concerns and other issues	Lew Willians	1:45-2:00
Review of all tests in PC-10	• Engine and Bench tests.	Jim McGeehan Group	2:00-2:10
New Business	•		2:10-2:15
Next Meetings	• December 5 and 6th in Norfolk,		

HDEOCP Meeting, October 27th, 2005, San Antonio, TX

	Name	Company	Member
1	JIM MORITZ	PE	N
2	MATT URBANAK	SHELL	Y
3	JOHN ROSENBAUM	Chevron Base Oils	N
4	SCOTT DESKIN	" "	N
5	KEITH SELBY	SHELL	N
6	Frank Fernandez	Chevron Oronite	N
7	Bill Kleiser	Chevron Oronite	Y
8	CHRIS CASTANIEN	LUBRIZOL	Y
9	GREG SHANK	Volvo Power Train	Y
10	JOAN EVANS	INFINEUM	N
11	Elisa Santos	Infineum	N
12	PAT FETTERMAN	INFINEUM	Y
13	BEN WEBER	SWRI	N
14	Jim Rutherford	Chevron Oronite	N
15	Dave Smith	APT	N
16	Steve Kennedy	ExxonMobil	Y
17	MARK SARLO	SwRI	N
18	DAVID McFALL	LNG MAGAZINE	N
19	STEVE GOODIER	B.P.	N
20	MIKE LYNSKEY	BP	Y
21	JOHN ZALAR	ASTM TMC	N
22	DAVID FABER	ConocoPhillips	Y
23	Larry Kuntschik	ILMA	N
24	Phil Scinto	LZ	N
25	JON CARLSON	LZ	N

HDEOCP Meeting, October 27th, 2005, San Antonio, TX

	Name	Company	Member
26	Scott Richards	SwRI	N
27	Dan Pridemore	Afton	mailing list
28	Thomas Bünemann	Afton	N
29	Ron Bush	TEI	N
30	Scott Harold	CIBA	Y
31	Jim Glotzwiller	Infineum	N
32	Brad Carter	PerkinElmer	N
33	Roger Gault	EMA	N*
34	Ken Goshorn	Volvo Powertrain	N
35	Bengt Otterholm	Volvo Technology	N
36	Heather DeBaun	International Truck & Engine	Y
37	Abdulhamed Cassim	Caterpillar	Y
38	W.A. Runkle	Valvoline	Y
39	Joe Franklin	PerkinElmer Automotive Res.	N
40	Steven Herzog	Romax	Y
41	Bill Place	John Deere	N
42	Dave Stehouwer	Cummins	Y
43	Robert Stockwell	GM	Y
44	Charles Passut	Afton	Y
45	Cathy Devlin	Afton Chemical	N
46			
47			
48			
49			
50			

* Roger Gault voting for Mesfin Belay (DDC) by proxy

American Petroleum Institute

PC-10 New Category Development Team

October 21, 2005

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American Petroleum Institute

PC-10 New Category Development Team

October 21, 2005

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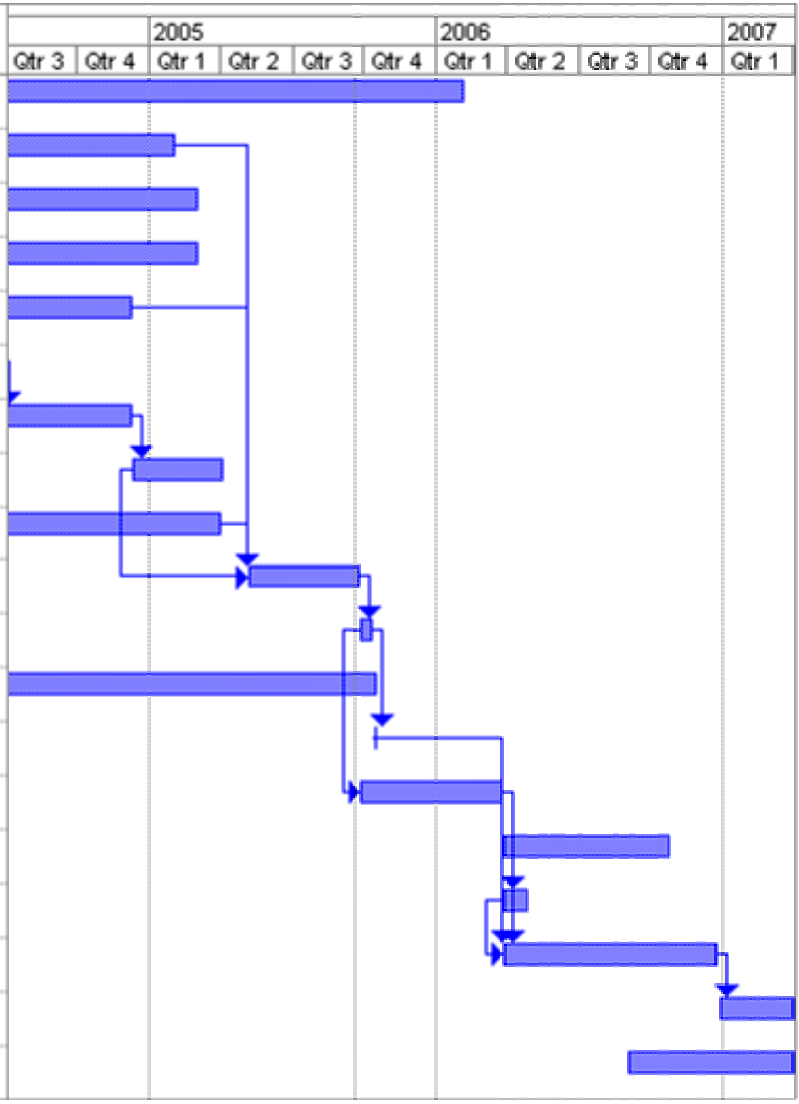
PC-10 NCDT Conference Call

October 20, 2005

EMA Request to Add Caterpillar 1P Engine Test to PC-10 Category

- Request was confirmed
- Arguments for and against were heard
- There was no consensus within NCDT
- The issue was put to a vote, according to API 1508, Appendix D guidelines
- The vote was to accept Caterpillar 1N, 1P, and C-13 tests in the caterory.
- Concerns about the effect on timeline were noted

Task Name	Start	Finish
NCDT Activity	Wed 3/26/03	Fri 2/3/06
Funding Group	Mon 2/3/03	Tue 2/1/05
New Test Development	Wed 9/25/02	Wed 3/2/05
New Test Discrimination	Fri 1/2/04	Wed 3/2/05
Matrix Design	Thu 4/1/04	Tue 12/7/04
Chemical Limits Selection	Mon 3/31/03	Tue 6/22/04
Select Matrix Oils	Wed 6/23/04	Tue 12/7/04
Matrix Oil Prep	Wed 12/8/04	Fri 4/1/05
Accept Parameters/Tests	Tue 6/22/04	Thu 3/31/05
Matrix Testing	Wed 5/4/05	Fri 9/23/05
Analyze Matrix	Mon 9/26/05	Mon 10/10/05
Select Reference Oils	Tue 6/1/04	Fri 10/14/05
HDEOCP Test Acceptance	Wed 10/12/05	Wed 10/12/05
Technology Demonstration & Limits Approval	Mon 9/26/05	Fri 3/24/06
ASTM D-2, SC-B Ballot & Approval	Mon 3/27/06	Mon 10/23/06
API Lubes Committee Final Approval	Mon 3/27/06	Wed 4/26/06
Minimum Product Qualification Interval	Mon 3/27/06	Fri 12/22/06
API Licensing	Tue 12/26/06	Mon 5/21/07
Engines in Field	Fri 9/1/06	Mon 5/21/07



PC-10 Matrix Costs

	T-12	ISB	C13	Totals
ACC/API/EMA Financed	**(8) $621,000**	**(8) $368,000**	**(14) $1,361,000**	**(30) $2,350,000**
Laboratory Financed	**(8) $643,000**	**(7) $340,000**	**(12) $1,216,000**	**(27) $2,199,000**
Lost Tests				**(8) $279,000**
Test Parts (EMA)				**$650,000**
Matrix Oils (API/ACC)				**$54,000**
Total				**$5,532,000**

J.Zalar - 10/27/05

Mack T-12
Precision Matrix Final Dataset
Consensus Analyses

Statistics Edition, Version 3
October 20, 2005

Jim Rutherford
(510) 242-3410
jaru@chevron.com

Dataset

October 14, 2005 LTMS dataset specified by the T-12 Task Force

Containing 26 tests:

- **4 Pre-matrix tests with old rings run with matrix test procedure**
- **3 Matrix tests with old rings**
- **13 Matrix tests with new rings**
- **6 Concurrent tests with new rings**

Cylinder Outliers

Using 19 tests of 26 with new rings

Profiles applied for TRWL and CLW, not for BWLU

Repeated measures analyses:


BWLU


TRWL


CLW

Profile summaries:


Profiles Summary

Calculation procedures:


TRWL&CLWos


Pbos

Modeling Summary

Compromising between all data (26 tests) with the full model (oil, lab, stand(lab), rings) and new rings data (19 tests) with rings deleted from the full model, the following transformations were used in the analyses.

		All data, Full Model		New Rings, Full Model		New Rings, Reduced Model	
Box-Cox Transformations		Significant Effects	"Outliers"	Significant Effects	"Outliers"	Significant Effects	"Outliers"
DPBFNL	natural log	Oil	55713		55713	Oil	55713
DPB2FNL	natural log		55713		55713		55713
CLW	none	Oil, Lab	55716	Oil, Lab, Marginal Stand(Lab)	56726	Oil & Lab	55937
TRWL	none	Rings					
OCFNL	natural log	Marginal Rings	55729	Oil, Marginal Lab		Oil & Lab	
Mack Merit							
BWLU	none						
IR250300	natural log		49991	Oil, Lab, Marginal Stand(Lab)		Oil & Marginal Lab	55715


BoxCox


All data, Full model


NewRingsFullModel


NewRingsReduced Model


NewRingsMeritModel

Modeling with new rings – significant effects

			Pairwise Tukey P		
Oil	**CLWos**		**820-2**	**PC10B**	**PC10E**
820-2	19.1			<.0001	0.00
PC10B	12.5		<.000		0.16
PC10E	14.6		0.00	0.16	
Oil	**lnOCFNL**	**OCFNL**	**820-2**	**PC10B**	**PC10E**
820-2	4.204	66.9		0.12	0.01
PC10B	4.124	61.8	0.12		0.55
PC10E	4.083	59.3	0.01	0.55	
Oil	**lnDIR250300**	**DIR250300**	**820-2**	**PC10B**	**PC10E**
820-2	4.673	107.0		0.04	0.03
PC10B	5.150	172.4	0.04		1.00
PC10E	5.154	173.1	0.03	1.00	

Lab	**CLWos**		**A**	**B**	**D**	**F**	**G**
A	18.6			0.69	0.00	0.84	0.01
B	17.0		0.69		0.00	1.00	0.14
D	10.6		0.00	0.00		0.01	0.10
F	17.1		0.84	1.00	0.01		0.21
G	13.8		0.01	0.14	0.10	0.21	

Precision Analyses

	All Data, Full Model		New Rings, Reduced Model			Anchor	MAD Survey Median
	S_{pp}	E_p	S_{pp}	E_p			
ln(ΔPb0-300os)*	0.293	0.77	0.288	0.78		20	4.5
ln(ΔPb250-300)*	0.382	0.75	0.363	0.79		7	2
Cylinder Liner Wear os	2.0	2.00	1.7	2.35		20	4
Top Ring Weight Loss os	20.9	0.60	24.9	0.50		50	12.5
ln(Oil Consumption)*	0.108	1.08	0.061	1.91		60	7
Mack Merit**			208	0.96			200
BWLUos***	43.7	1.76	36.4	2.12			77
ln(IR250300)	0.411		0.282				

*E_p=(LN(anchor+median/2)-LN(anchor-median/2))/ ((LN(anchor)+S_{pp}/2)-(LN(anchor)-S_{pp}/2))
**"Mad Survey Median" for Mack Merit estimated by informal survey in Mack T-12 Task Force meeting 10/11/05
*** "Mad Survey Median" for BWLUos estimated from equation relating lead and bearing weight loss applied to 4.5.

Targets?

Oil	Variable	Arithmetic Average	LSMean	Arithmetic Std Dev	Model RMSE
820-2	lnDPb0300os	2.946	2.925	0.259	0.288
PC10B		3.377	3.377	0.246	
PC10E		3.246	3.259	0.289	
820-2	lnDPb2	2.019	2.002	0.364	0.363
PC10B		2.335	2.245	0.324	
PC10E		2.268	2.251	0.448	
820-2	CLWos	18.1	19.1	3.7	1.7
PC10B		12.8	12.5	3.2	
PC10E		15.1	14.6	3.4	
820-2	TRWLos	52.4	54.6	21.4	24.9
PC10B		51.7	54.5	25.4	
PC10E		65.9	66.4	27.9	
820-2	lnOCFNL	4.216	4.204	0.090	0.061
PC10B		4.097	4.124	0.075	
PC10E		4.072	4.083	0.054	

Correlations Among Pass Criteria (original)

Here are correlations using original data.

Pearson Correlation Coefficients, N = 19
Prob > |r| under H0: Rho=0

	lnDPb0300os	lnDPb2	CLWos	TRWLos	lnOCFNL
lnDPb0300os	1.00000	0.84433	-0.33022	-0.25718	-0.29827
		<.0001	0.1674	0.2878	0.2148
lnDPb2	0.84433	1.00000	-0.00810	-0.37883	-0.28004
	<.0001		0.9738	0.1097	0.2456
CLWos	-0.33022	-0.00810	1.00000	-0.18229	0.21921
	0.1674	0.9738		0.4551	0.3672
TRWLos	-0.25718	-0.37883	-0.18229	1.00000	-0.29162
	0.2878	0.1097	0.4551		0.2257
lnOCFNL	-0.29827	-0.28004	0.21921	-0.29162	1.00000
	0.2148	0.2456	0.3672	0.2257	

Correlations Among Pass Criteria (residuals)

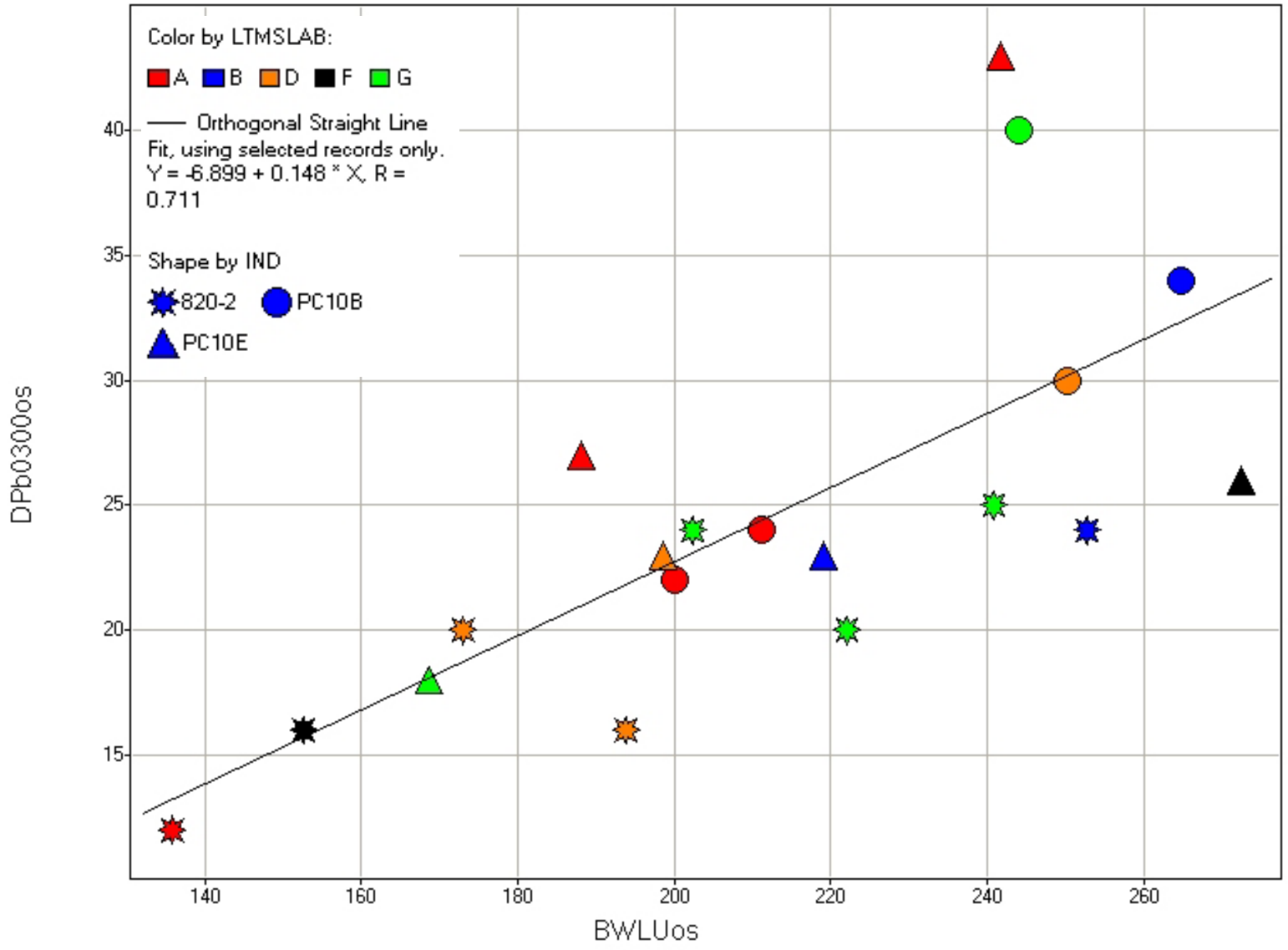
Here are correlations using residuals from final models for the new rings data.

The strong correlation between the Pb's shows both places. This says for these oils, they tell us pretty much the same thing and they usually give the same relative indication of performance.

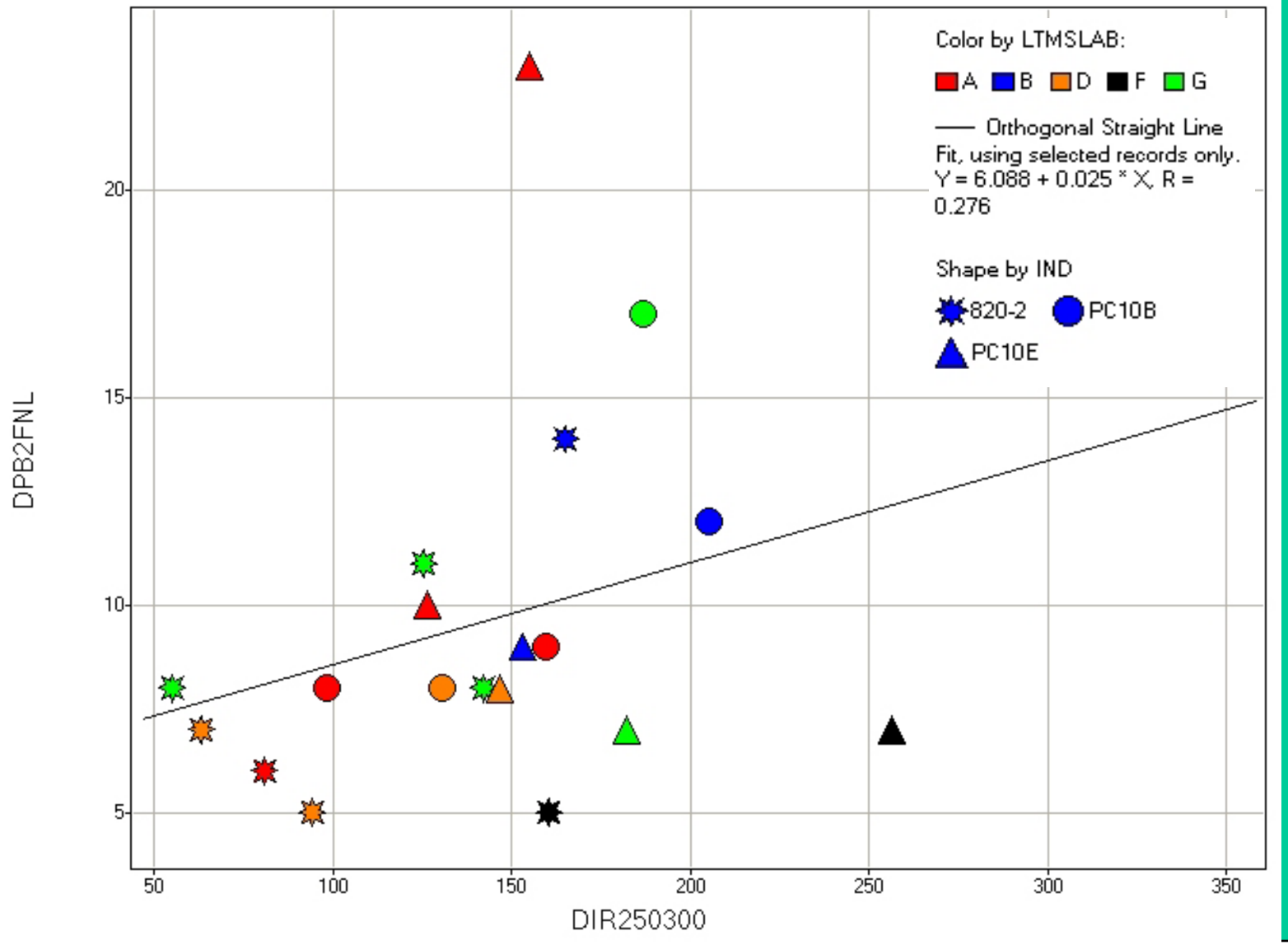
Pearson Correlation Coefficients, N = 19
Prob > |r| under H0: Rho=0

	residual_lnDPb0300os	residual_lnDPb2	residual_CLWos	residual_TRWLos	residual_lnOCFNL
residual_lnDPb0300os	1.00000	0.91423 <.0001	0.15400 0.5290	-0.32789 0.1705	0.01592 0.9484
residual_lnDPb2	0.91423 <.0001	1.00000	0.17741 0.4675	-0.31508 0.1889	0.01749 0.9433
residual_CLWos	0.15400 0.5290	0.17741 0.4675	1.00000	-0.18915 0.4380	0.13844 0.5719
residual_TRWLos	-0.32789 0.1705	-0.31508 0.1889	-0.18915 0.4380	1.00000	-0.24552 0.3110
residual_lnOCFNL	0.01592 0.9484	0.01749 0.9433	0.13844 0.5719	-0.24552 0.3110	1.00000

Lead and Bearing Weight Loss



Lead 250 to 300 and DIR 250 to 300



Mack Merit

Testkey	Oil	Lab	Delta Pb 0300	Delta PB 250300	Cylinder Liner Wear	Top Ring Weight Loss	Oil Consumption	Calculated Merit	**Final Merit**
55205	820-2	F	16	5	22	56	77	785	**Fail**
55213	820-2	G	25	11	18	30	76	959	**959**
55216	820-2	B	24	14	22	44	63	672	**672**
55217	820-2	A	12	6	22	42	64	1022	**1022**
55715	820-2	G	20	8	18	56	67	1019	**1019**
55722	820-2	D	20	7	15	45	60	1275	**1275**
55723	820-2	D	16	5	15	101	66	1022	**Fail**
56153	820-2	G	24	8	16	45	71	1084	**1084**
55712	PC10B	A	24	8	15	46	60	1194	**1194**
55728	PC10B	B	34	12	15	44	62	980	**980**
55935	PC10B	A	22	9	15	96	53	993	**Fail**
56010	PC10B	D	30	8	9	31	61	1193	**1193**
56562	PC10B	G	40	17	11	41	65	783	**Fail**
55713	PC10E	A	43	23	16	35	57	717	**Fail**
55718	PC10E	G	18	7	12	36	63	1326	**1326**
55725	PC10E	D	23	8	11	106	62	868	**Fail**
55937	PC10E	A	27	10	21	65	55	749	**749**
55940	PC10E	F	26	7	15	87	59	987	**987**
56726	PC10E	B	23	9	12	67	57	1099	**1099**

T12 Update

- **Task Force Voted the T12 Ready for Inclusion in PC 10**
- **Voted PC 10E the T12 Reference**

Mack T-12
Merit Rating

October 26, 2005

Version 3 Merit Parameters

Criterion	EOT Delta Pb	250-300 Hour Delta PB	Cylinder Liner Wear	Top Ring Weight Loss	Oil Consumption
Weight	200	200	250	200	150
Maximum	36	16	24	87	77
Anchor	20	7	20	50	60
Minimum	4	-2	16	13	43

Version 5 Merit Parameters

Criterion	EOT Delta Pb	250-300 Hour Delta PB	Cylinder Liner Wear	Top Ring Weight Loss	Oil Consumption
Weight	200	200	250	200	150
Maximum	33	13	23	100	77
Anchor	25	10	20	65	65
Minimum	10	0	12	30	45

Version 5 Merit Parameters with ABWLU Equivalents

Criterion	ABWLU	250-300 Hour Delta PB	Cylinder Liner Wear	Top Ring Weight Loss	Oil Consumption
Weight	200	200	250	200	150
Maximum	270	13	23	100	77
Anchor	216	10	20	65	65
Minimum	114	0	12	30	45

Version 3 Merit Calculations

55217	820-2	12	6	22	42	64	1022	**102**
55216	820-2	24	14	22	44	63	672	**672**
55722	820-2	20	7	15	45	60	1275	**127**
55723	820-2	16	5	12	101	66	1022	**Fai**
55205	820-2	16	5	22	56	77	785	**Fai**
55213	820-2	25	11	18	30	76	959	**959**
55715	820-2	20	8	18	56	67	1019	**101**
56153	820-2	24	8	16	45	71	1084	**108**
55712	PC10B	24	8	15	46	60	1194	**119**
55935	PC10B	22	9	15	96	53	993	**Fai**
55728	PC10B	34	12	15	44	62	980	**980**
56010	PC10B	30	8	8	31	61	1193	**119**
56562	PC10B	40	17	11	41	65	783	**Fai**
55713	PC10E	43	23	17	35	57	682	**Fai**
55937	PC10E	27	10	21	65	55	749	**749**
56726	PC10E	23	9	14	67	57	1099	**109**
55725	PC10E	23	8	11	106	62	868	**Fai**
55940	PC10E	26	7	15	87	59	987	**987**
55718	PC10E	18	7	13	36	63	1326	**132**

Version 5 Merit Calculations

55217	820-2	12	6	22	42	64	1248	124
55216	820-2	24	14	22	44	63	709	Fai
55722	820-2	20	7	15	45	60	1435	143
55723	820-2	16	5	12	101	66	1257	Fai
55205	820-2	16	5	22	56	77	952	Fai
55213	820-2	25	11	18	30	76	1069	106
55715	820-2	20	8	18	56	67	1201	120
56153	820-2	24	8	16	45	71	1206	120
55712	PC10B	24	8	15	46	60	1350	135
55935	PC10B	22	9	15	96	53	1133	113
55728	PC10B	34	12	15	44	62	937	Fai
56010	PC10B	30	8	8	31	61	1386	138
56562	PC10B	40	17	11	41	65	546	Fai
55713	PC10E	43	23	17	35	57	25	Fai
55937	PC10E	27	10	21	65	55	943	943
56726	PC10E	23	9	14	67	57	1288	128
55725	PC10E	23	8	11	106	62	1103	Fai
55940	PC10E	26	7	15	87	59	1109	110
55718	PC10E	18	7	13	36	63	1552	155

Version 5 Merit Calculations with ABWLU Equivalents

55217	820-2	136	6	22	42	64	1231	**123**
55216	820-2	253	14	22	44	63	559	**Fai**
55722	820-2	173	7	15	45	60	1452	**145**
55723	820-2	194	5	12	101	66	1175	**Fai**
55205	820-2	153	5	22	56	77	956	**Fai**
55213	820-2	241	11	18	30	76	976	**976**
55715	820-2	222	8	18	56	67	1112	**111**
56153	820-2	202	8	16	45	71	1219	**121**
55712	PC10B	211	8	15	46	60	1346	**134**
55935	PC10B	200	9	15	96	53	1124	**112**
55728	PC10B	265	12	15	44	62	981	**981**
56010	PC10B	250	8	8	31	61	1385	**138**
56562	PC10B	244	17	11	41	65	817	**Fai**
55713	PC10E	242	23	17	35	57	380	**Fai**
55937	PC10E	188	10	21	65	55	1048	**104**
56726	PC10E	219	9	14	67	57	1250	**125**
55725	PC10E	199	8	11	106	62	1111	**Fai**
55940	PC10E	272	7	15	87	59	925	**Fai**
55718	PC10E	169	7	13	36	63	1552	**155**

T12 PC10 Merit Limits

Criterion	EOT Delta Pb	250-300 Hour Delta PB	Cylinder Liner Wear	Top Ring Weight Loss	Oil Consumptio
Weight	200	200	250	200	150
Maximum	33	13	23	100	77
Anchor	25	10	20	65	65
Minimum	10	0	12	30	45

1000 Merit Min.

Considering

TIR Peak EOT 30 max
00-300 hr.Delta 10 max.

- **Move Proposed Limits to Exit Ballot**

Cummins ISB
Mostly Official
Matrix Analysis

October 26, 2005

Analysis Summary

- 17 Valid Tests Analyzed
  - 15 Matrix Tests, 2 Reference Tests
  - Tappet Wear, Camshaft Wear, Crosshead Wear
- E178 (95% CI) Used on Wear Results
  - Wear Profile Offset Not Necessary
  - All Results and Analysis Outlier Screened
- Wear Relationship with Soot Possible
  - Tappet Wear and Crosshead Wear
  - Correlations with Stand and Stage B Average Torque

Analysis Summary

- Possible Lab/Stand Effects
- No Transformations
  - Higher Wear Oils Would Likely Require
- Oil Discrimination
  - Tappet Weight Loss
  - Possible for Camshaft Wear (Model Dependent)
- All 3 Wear Parameters Meet ACC Precision
  - Note that Tappet Wear Between Stands and Labs Does Not

Concerns

- Model Dependent Conclusions
  - Some Confounding (Stand, Stage B Average Torque, and Soot)
- Correcting Camshaft Wear for Stage B Average Torque
  - Correcting Test Results for an Operational Parameter is not an Ideal Situation.
- Reference Frequency Given Engine, Stand and Lab Differences
  - Very Large Stand Effects for Tappet Wear

Precision Summary

	Repeatability s (Within Stand)	Reproducibility s (Btween Stand)	Reproducibility s (Between Lab)
Tappet Wear (mg) Soot Adj	8.1645 Ep=1.84	16.8574 Ep=0.89	16.9092 Ep=0.89
Camshaft Wear (um)	4.7021 Ep=3.19	7.1512 Ep=2.10	7.1512 Ep=2.10
XHead Wear (mg) Soot Adj	0.3817 Ep=1.96	0.3817 Ep=1.96	0.5221 Ep=1.44
Torque Adjstd Cam Wear (um)	5.0833 Ep=2.95	5.0833 Ep=2.95	6.3063 Ep=2.38

Target Summary

	Oil 830-2	PC10B	PC10E
Tappet Wear (mg) Soot Adj	LS Mean = 88.23 Mean = 85.8167 S = 16.1416	LS Mean = 93.47 Mean = 88.6833 S = 15.8176	LS Mean = 67.54 Mean = 57.86 S = 9.4796
Camshaft Wear (um)	LS Mean = 40.20 Mean =40.2667 S = 9.2058	LS Mean = 44.85 Mean = 41.9833 S = 5.6722	LS Mean = 36.86 Mean = 34.14 S = 5.0093
XHead Wear (mg) Soot Adj	LS Mean = 2.072 Mean = 2.0833 S = 0.5345	LS Mean = 2.057 Mean = 2.0667 S = 0.4367	LS Mean = 1.940 Mean = 2.0000 S = 0.4743
Torque Adjstd Cam Wear (um)	LS Mean = 40.86 Mean =40.86 S = 6.8895	LS Mean = 42.29 Mean = 42.2984 S = 4.7694	LS Mean = 33.94 Mean = 33.0695 S = 6.0193

Correlation Summary

Between Oil and Within Oil Correlations

Between Oil	OSACSW	OSATWL	OSACWL
OSACSW	1.00	0.79	0.56
OSATWL	0.79	1.00	0.54
OSACWL	0.56	0.54	1.00

Within Oil	OSACSW	OSATWL	OSACWL
OSACSW	1.00	0.54	0.33
OSATWL	0.54	1.00	0.20
OSACWL	0.33	0.20	1.00

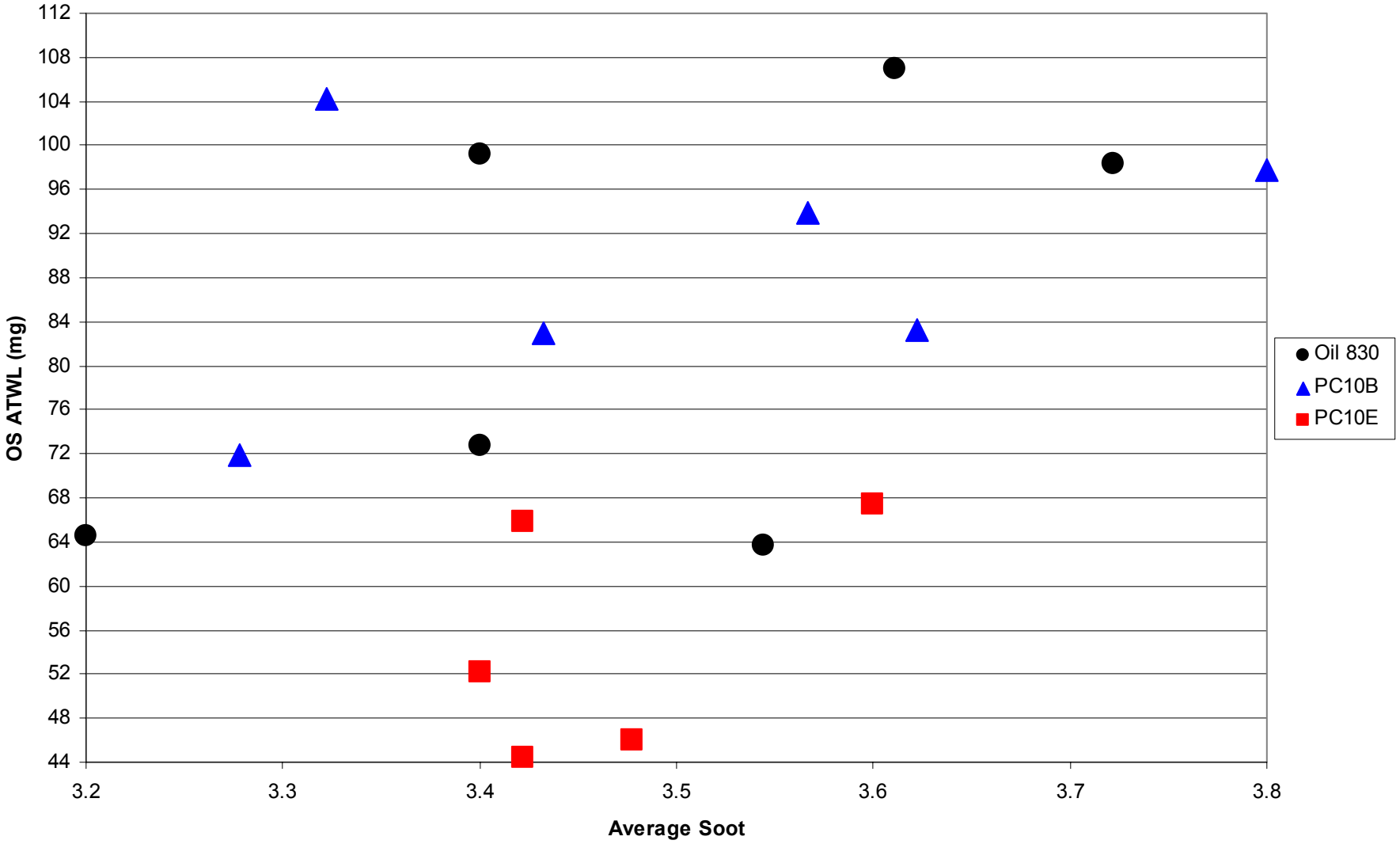
Average Tappet Weight Loss

- ATWL = f(Lab, Stand(Lab), Oil, Avg Soot)
  - Oil Discrimination (Overall p-value=0.005)
    - PC10E Lower than Other Oils
  - Lab Differences (Overall p-value=0.02)
    - Lab B Higher than Lab G
    - Stand within Lab Effects (Overall p-value=0.02)
  - Correction for Average Soot
    - Slope=76 (Correct Back to 3.50% Soot)
    - SA ATWL = ATWL – 76*(AvgSoot – 3.50)

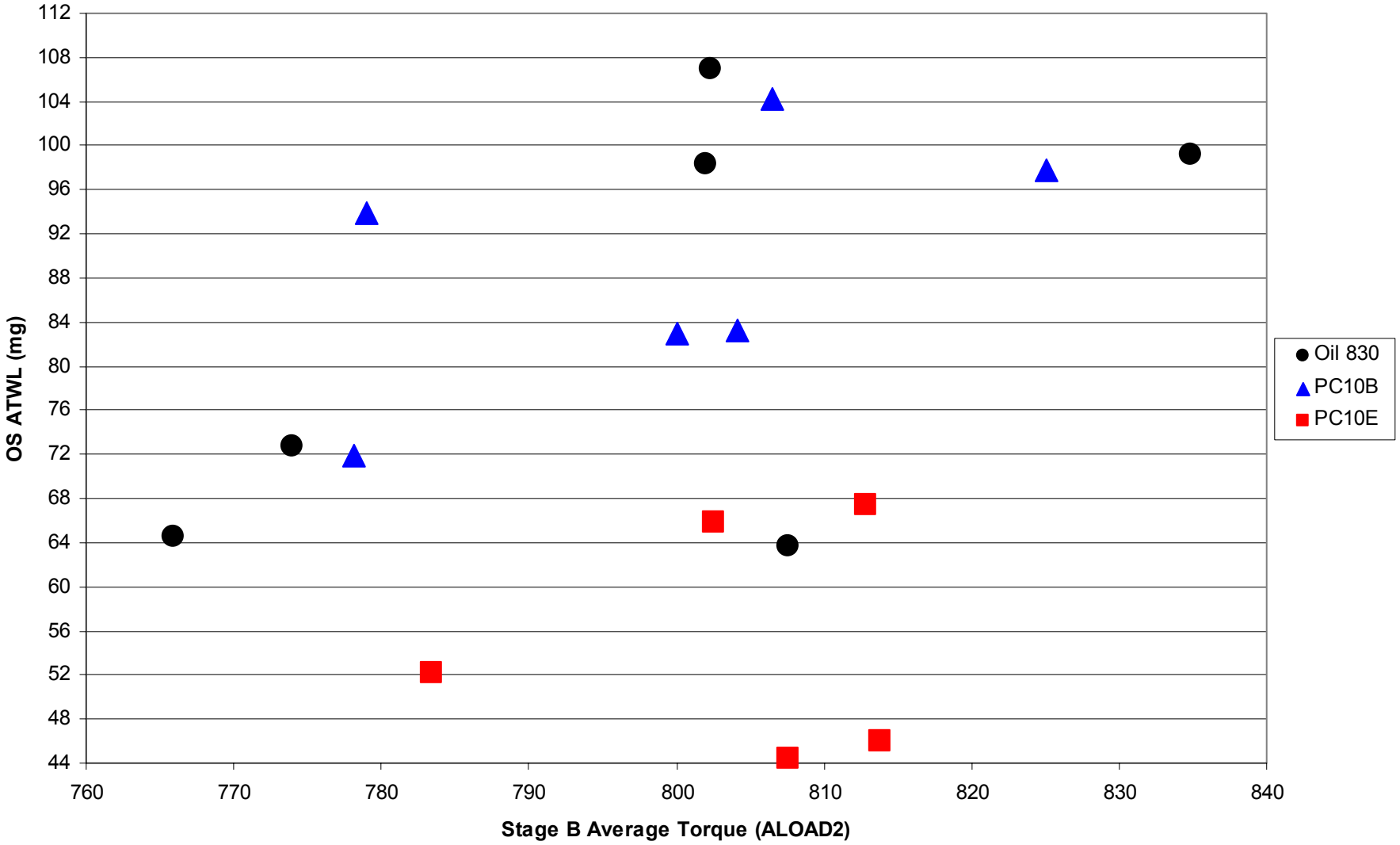
Tukey Adjusted p-Values

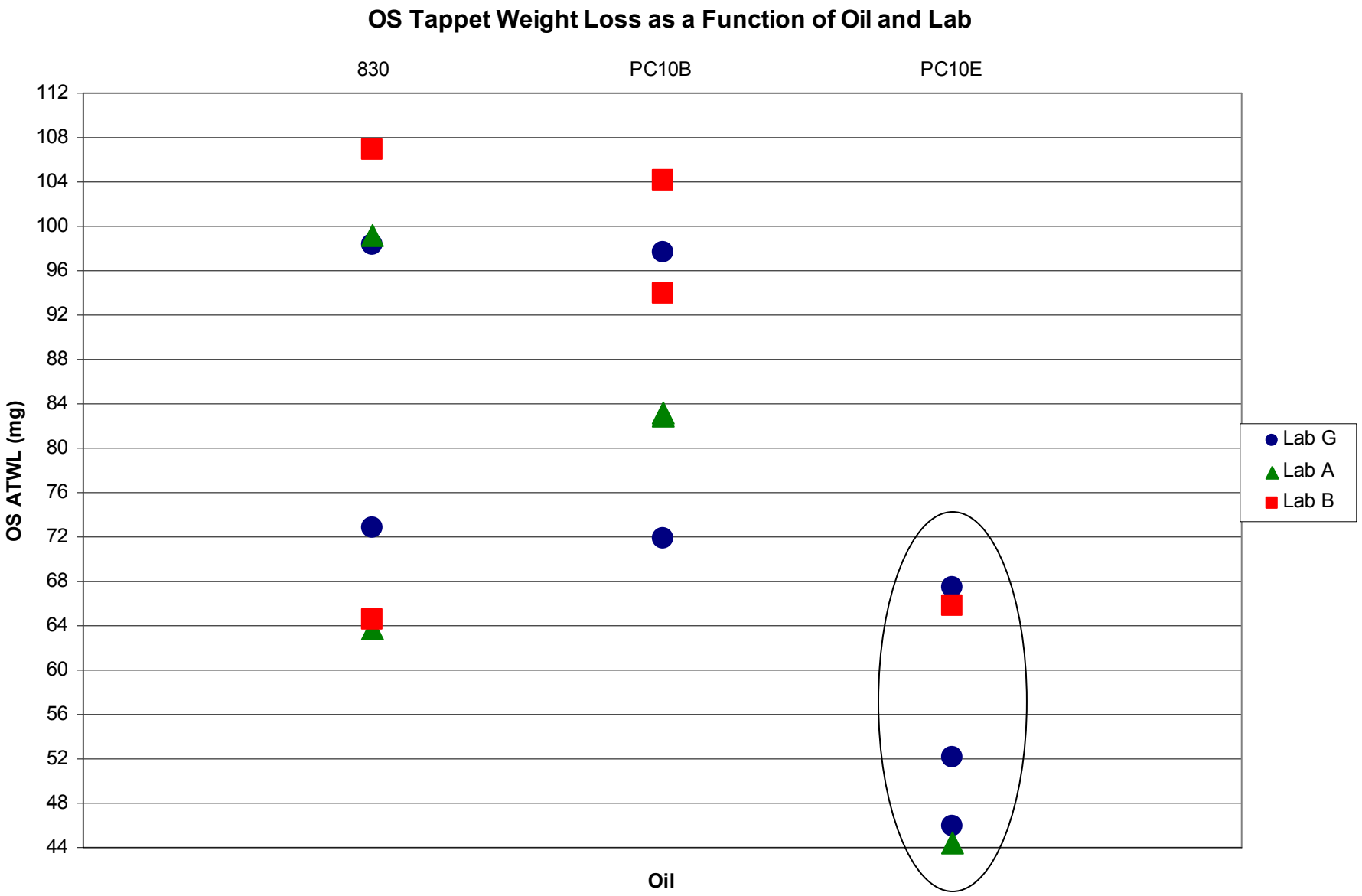
	Oil 830-2	PC10B	PC10E
Tappet Wear (mg) Soot Adj	LS Mean = 88.23 StdErr = 3.766	LS Mean = 93.47 StdErr = 3.710	LS Mean = 67.54 StdErr = 4.794
Oil 830-2		0.61	***0.01***
PC10B	0.61		***0.005***
PC10E	***0.01***	***0.005***	

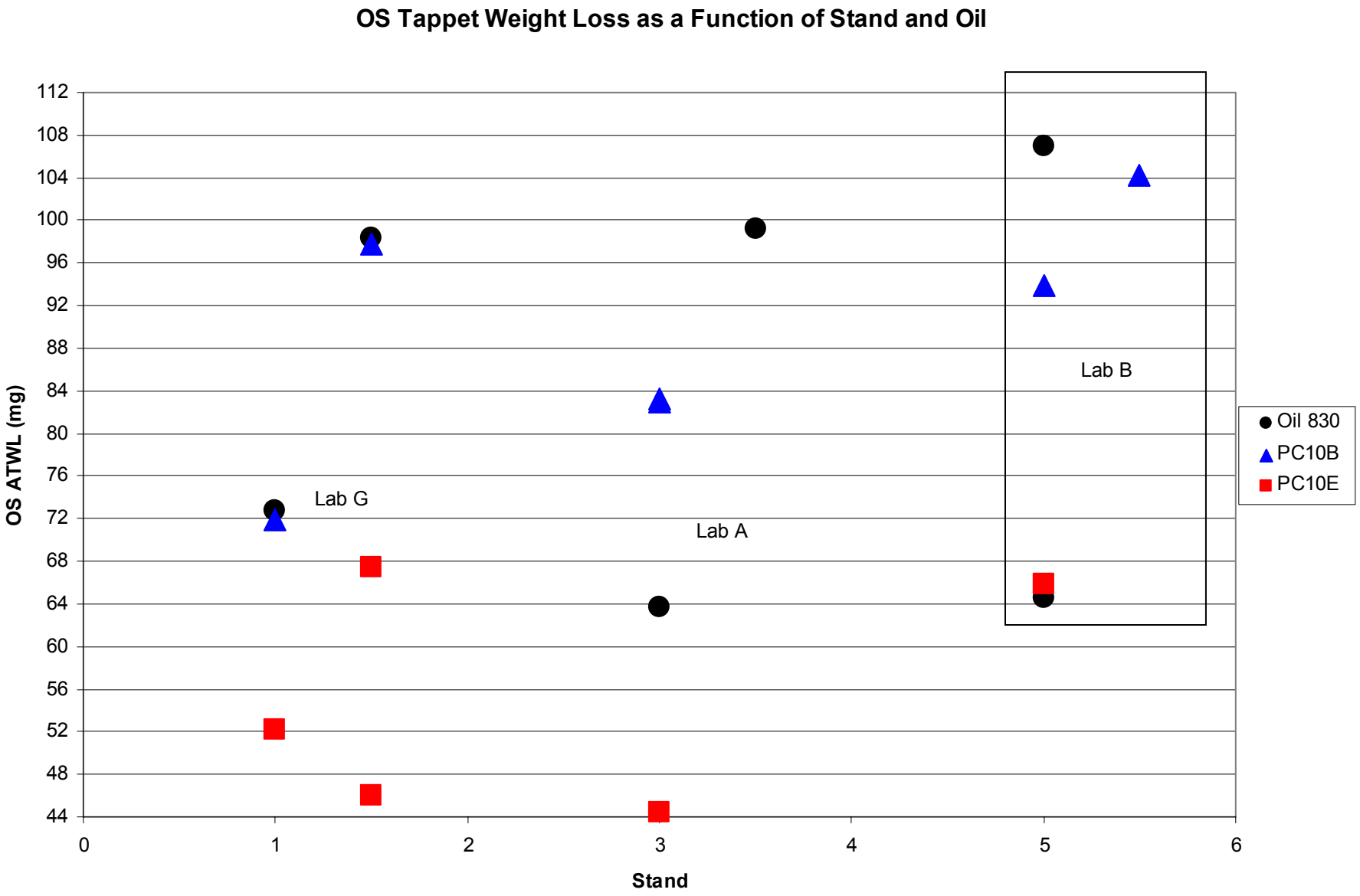
OS Tappet Weight Loss as a Function of Oil and Soot



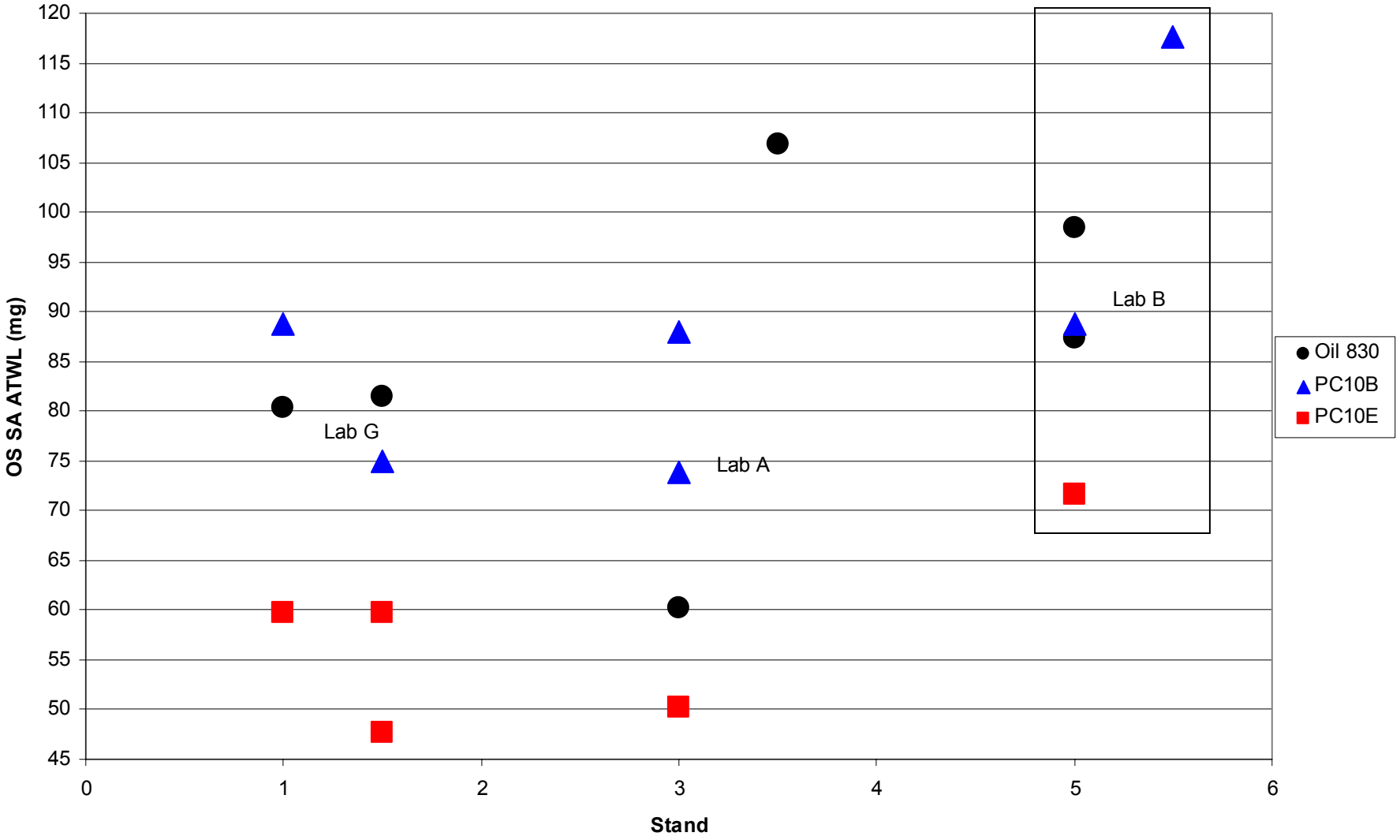
OS Tappet Weight Loss as a Function of Stage B Average Torque




OS Tappet Weight Loss as a Function of Oil and Lab
830
PC10B
PC10E
112
108
104
100
96
92
88
84
80
76
72
68
64
60
56
52
48
44
OS ATWL (mg)
Oil
Lab G
Lab A
Lab B


OS Tappet Weight Loss as a Function of Stand and Oil
OS ATWL (mg)
112
108
104
100
96
92
88
84
80
76
72
68
64
60
56
52
48
44
0
1
2
3
4
5
6
Stand
Lab G
Lab A
Lab B
Oil 830
PC10B
PC10E

OS Soot Adjusted Tappet Weight Loss as a Function of Stand and Oil

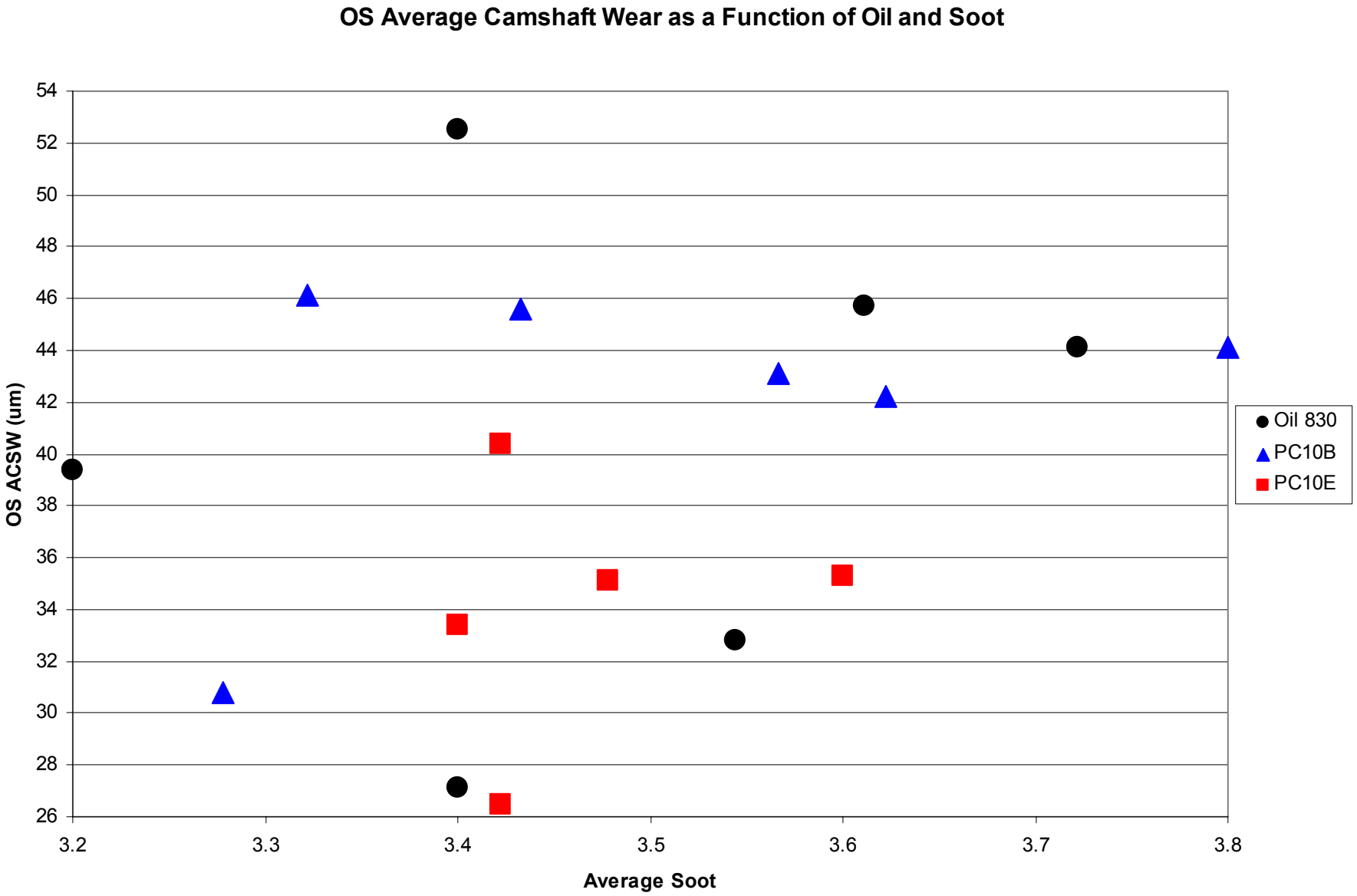


Average Camshaft Wear

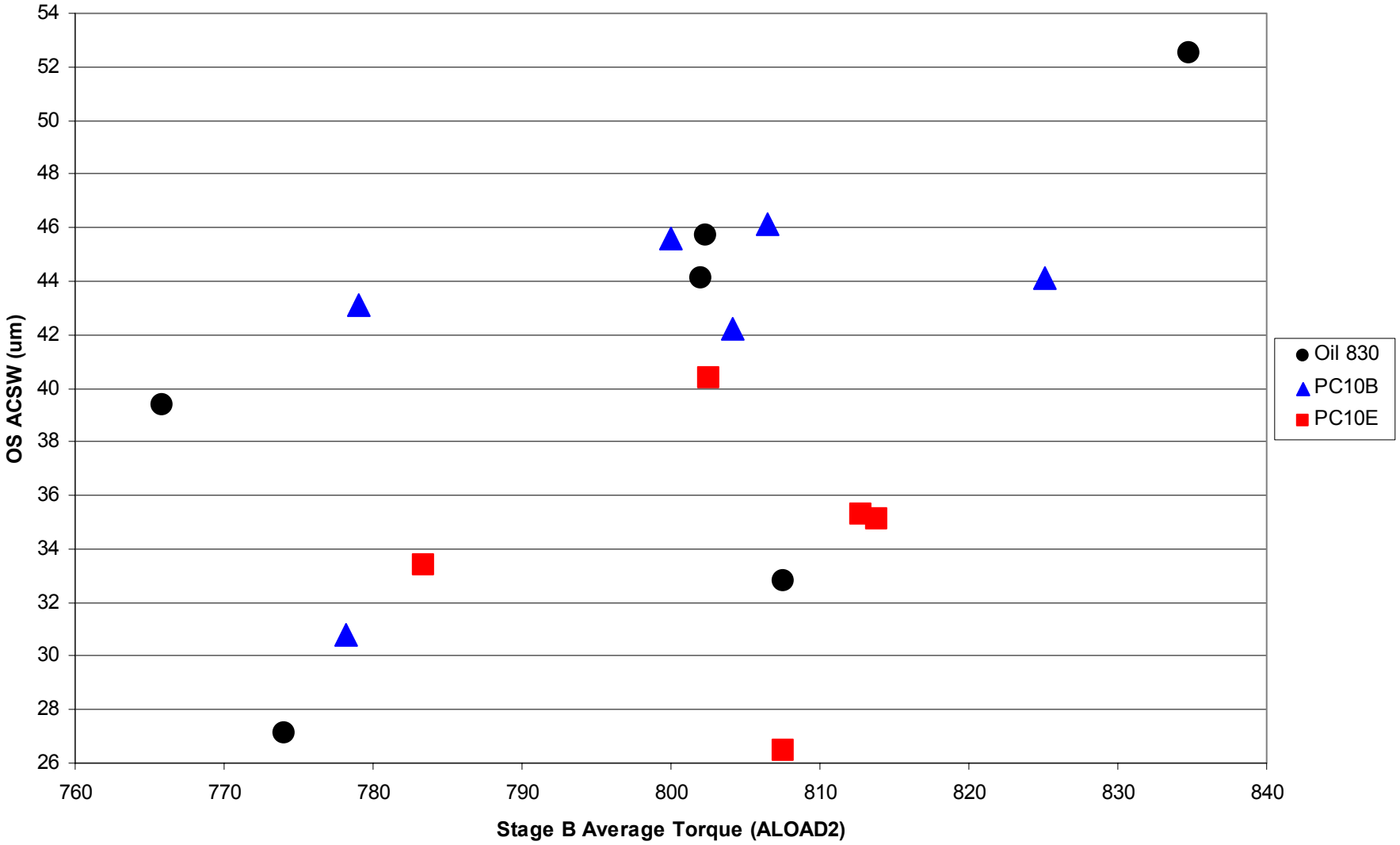
- ACSW = f(Lab, Stand(Lab), Oil)
  - Some Evidence of Oil Discrimination (p=0.08)
    - PC10B versus PC10E (p=0.07)
  - Lab Differences (Overall p-value=0.05)
    - Lab G Lower than Other Labs
    - Stand within Lab Effects (Overall p-value=0.02)
  - Other Possible Effects
    - Stage B Average Torque

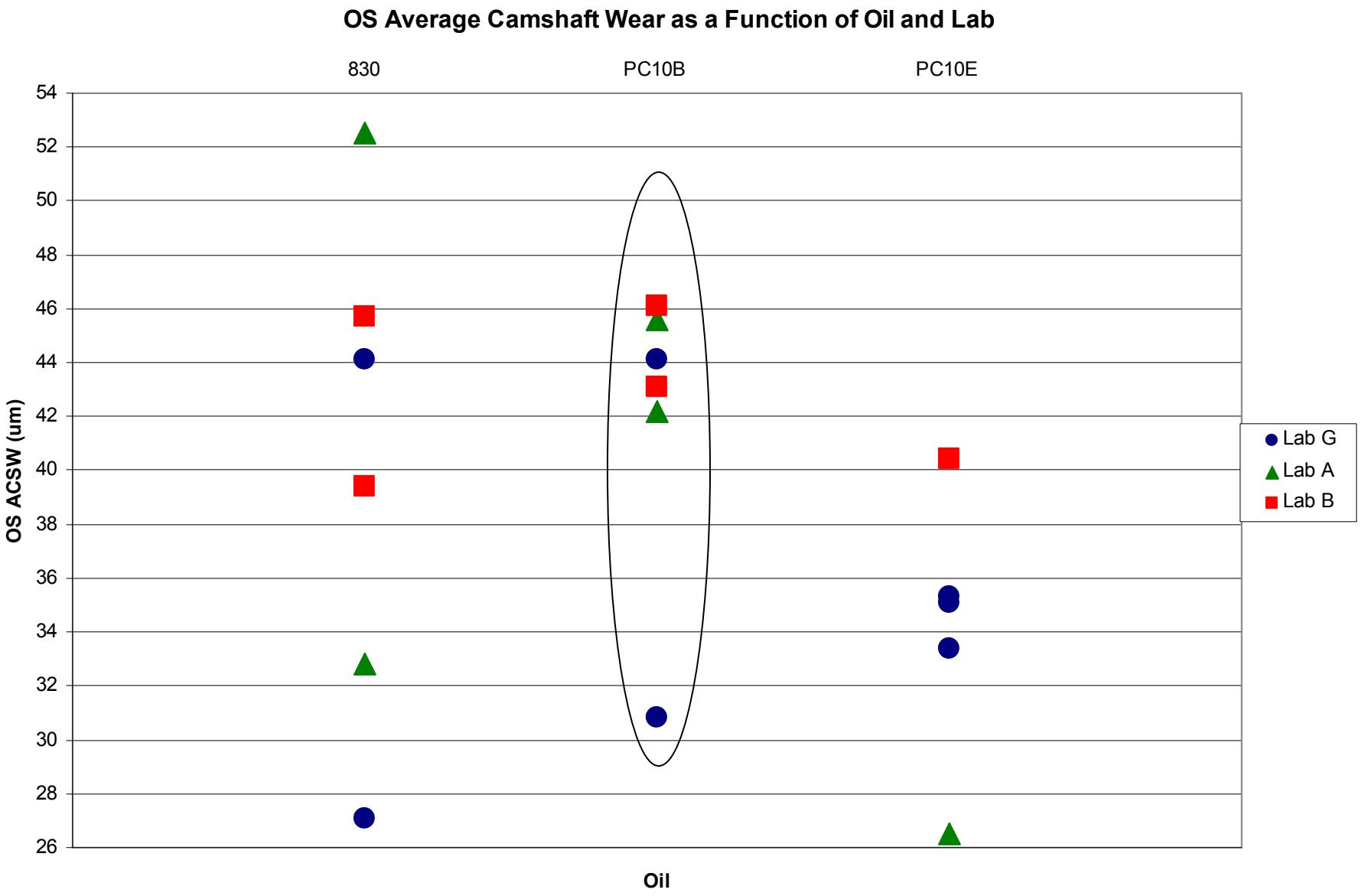
Tukey Adjusted p-Values

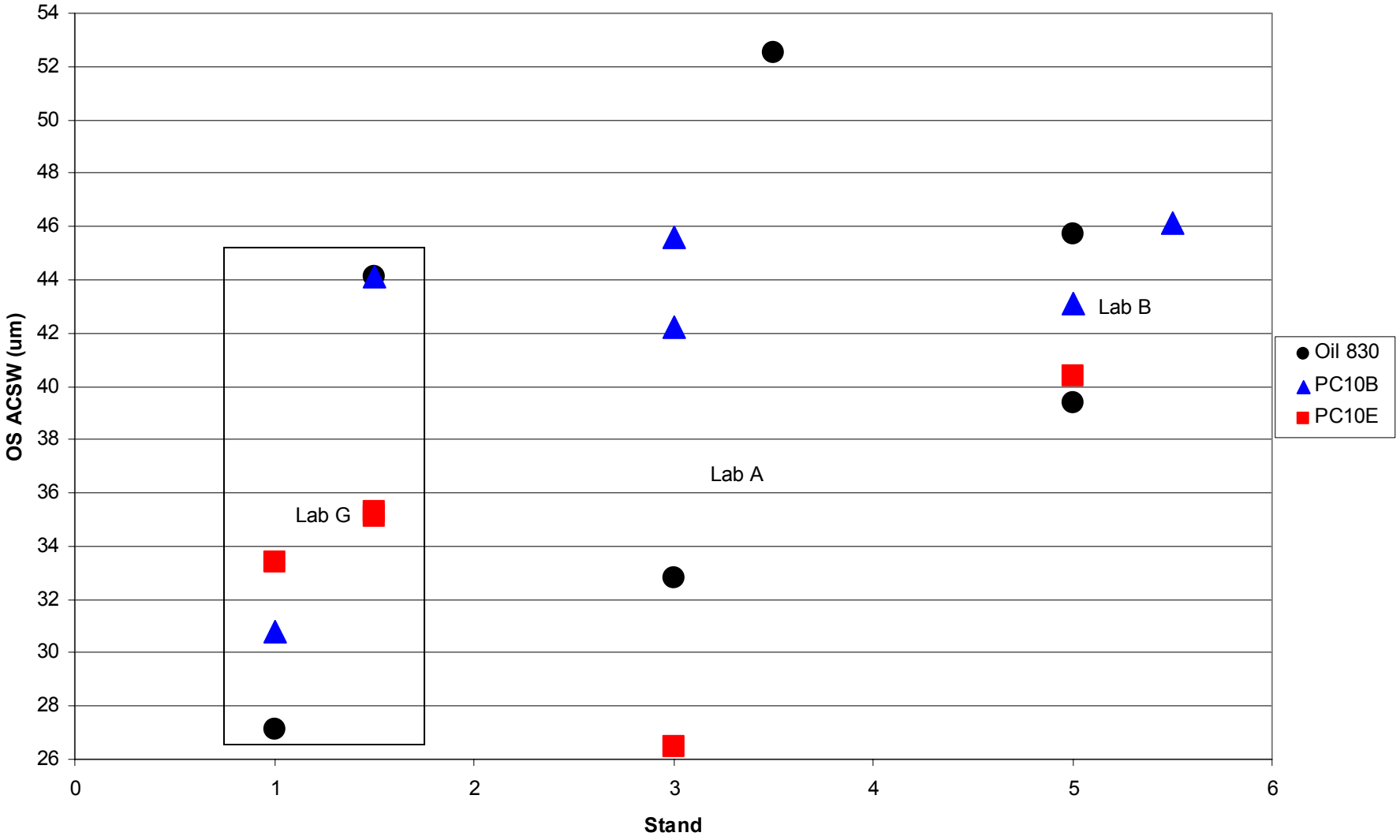
	Oil 830-2	PC10B	PC10E
Camshaft Wear (um)	LS Mean = 40.2 StdErr = 2.137	LS Mean = 44.85 StdErr = 2.137	LS Mean = 36.86 StdErr = 2.473
Oil 830-2		0.33	0.54
PC10B	0.33		***0.07***
PC10E	0.54	***0.07***	


OS Average Camshaft Wear as a Function of Oil and Soot
OS ACSW (um)
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
3.2
3.3
3.4
3.5
3.6
3.7
3.8
Average Soot
Oil 830
PC10B
PC10E

OS Average Camshaft Wear as a Function of Stage B Average Torque




OS Average Camshaft Wear as a Function of Oil and Lab
830
PC10B
PC10E
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
OS ACSW (um)
Oil
Lab G
Lab A
Lab B

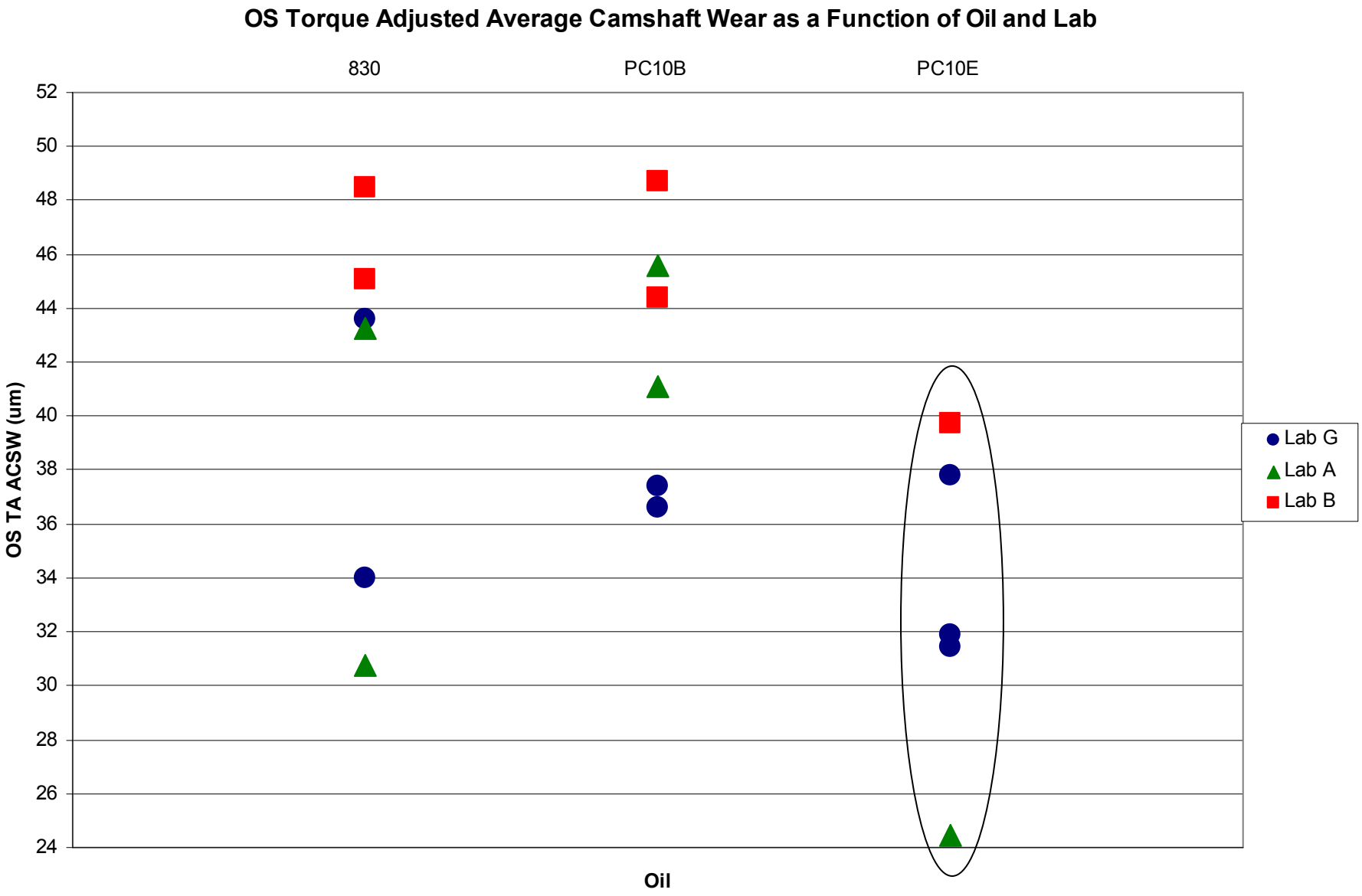

OS Average Camshaft Wear as a Function of Stand and Oil
OS ACSW (um)
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
0
1
2
3
4
5
6
Stand
Lab G
Lab A
Lab B
Oil 830
PC10B
PC10E

Average Camshaft Wear

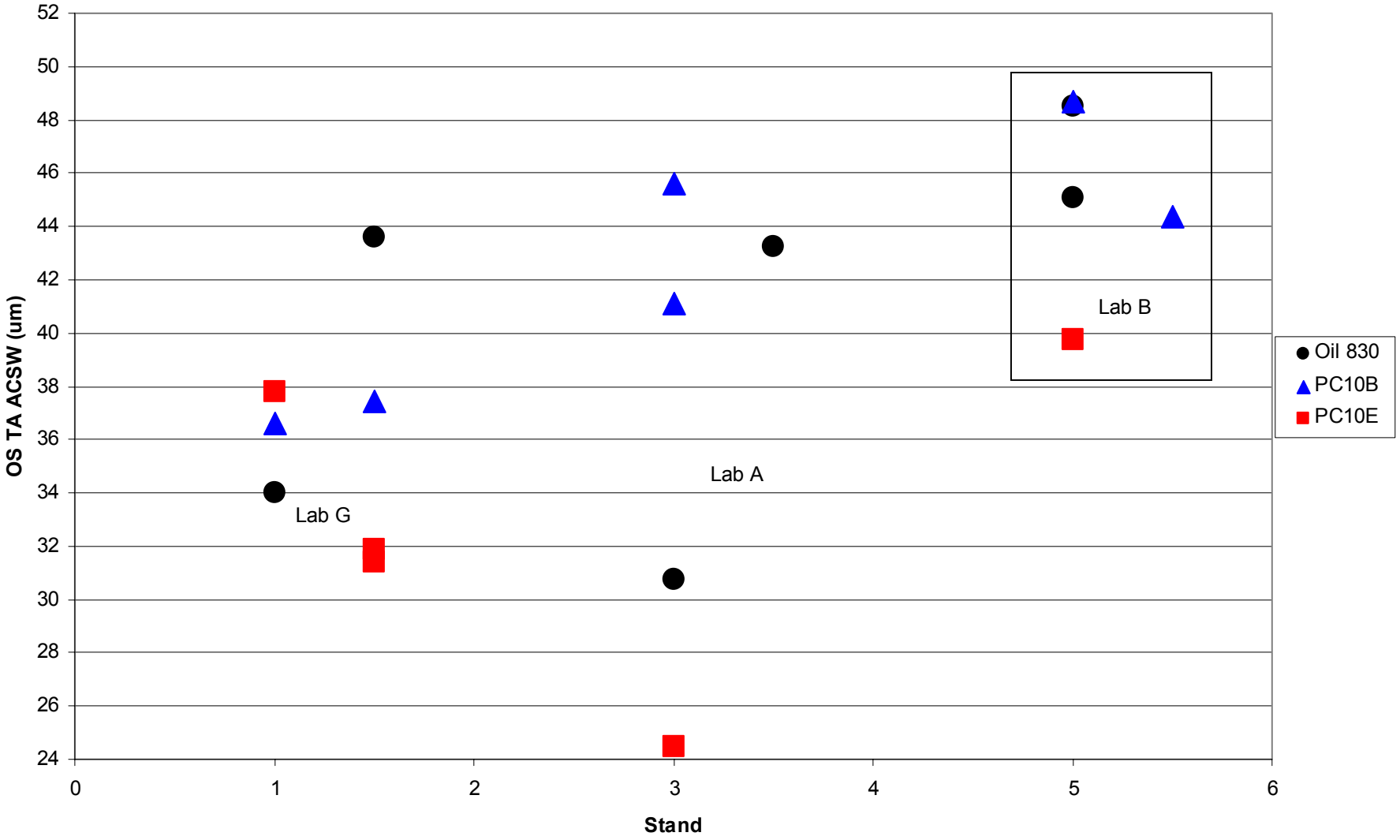
- ACSW = f(Lab, Oil, Stage B Avg Torque)
  - Some Evidence of Oil Discrimination (p=0.06)
    - PC10B versus PC10E (p=0.06)
  - Some Evidence of Lab Differences (p=0.06)
    - Lab B Higher than Other Labs
  - Torque Correction
    - Slope=0.26629 (Correct Back to 800)
    - SA ACSW = ACSW – 0.26629*(Torque – 800)

Tukey Adjusted p-Values

	Oil 830-2	PC10B	PC10E
Camshaft Wear (um)	LS Mean = 40.86 StdErr = 2.082	LS Mean = 42.29 StdErr = 2.077	LS Mean = 33.94 StdErr = 2.409
Oil 830-2		0.88	0.12
PC10B	0.88		***0.06***
PC10E	0.12	***0.06***	


OS Torque Adjusted Average Camshaft Wear as a Function of Oil and Lab
830
PC10B
PC10E
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
OS TA ACSW (um)
Oil
Lab G
Lab A
Lab B

OS Torque Adjusted Average Camshaft Wear as a Function of Stand and Oil



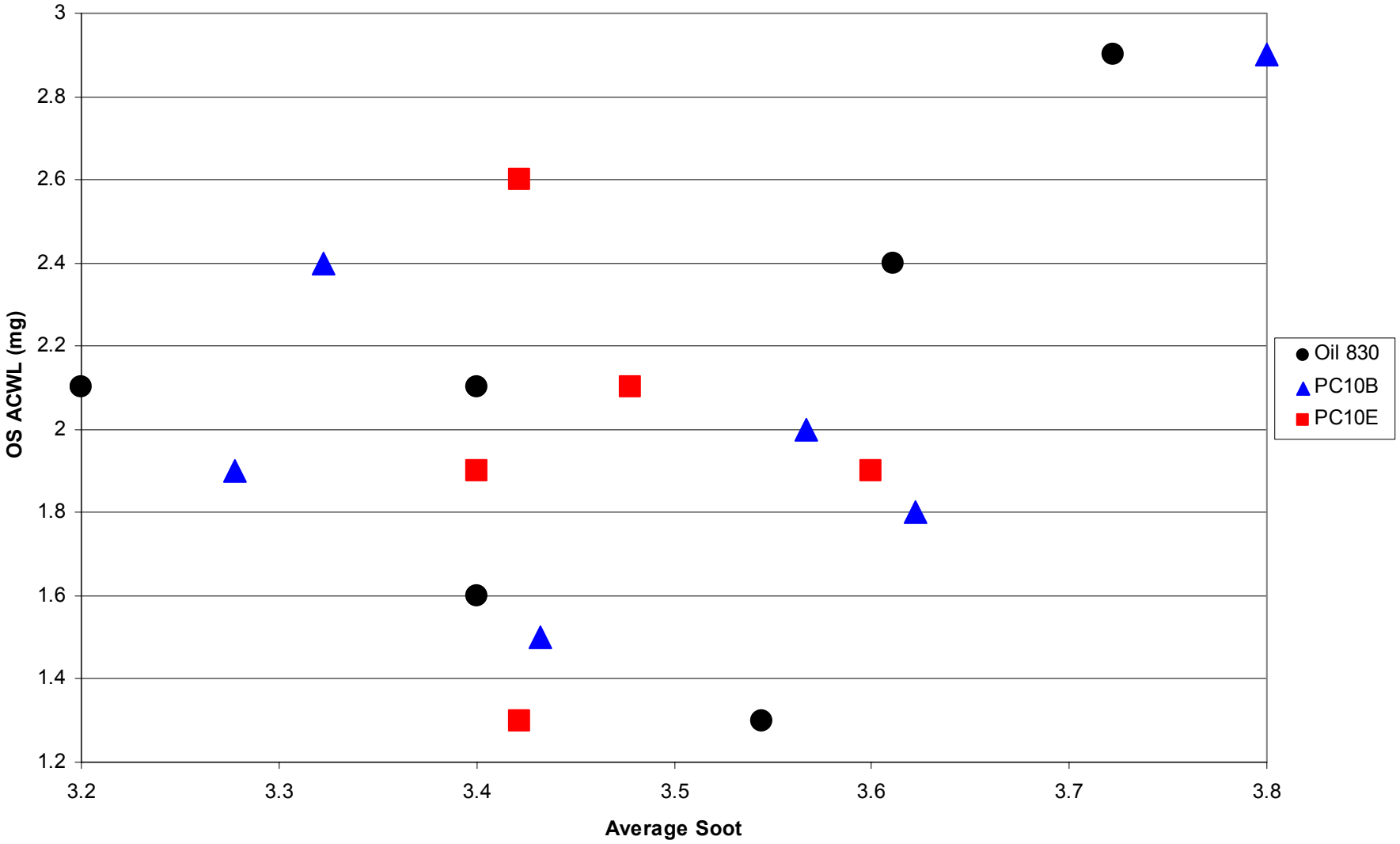
Average Crosshead Mass Loss

- ACWL = f(Lab, Oil, Avg Soot)
  - No Oil Discrimination (Overall p-value=0.85)
  - Lab Differences (Overall p-value=0.02)
    - Lab A Lower than Other Labs
    - No Stand within Lab Effects
  - Correction for Average Soot
    - Slope=1.3 (Correct Back to 3.50% Soot)
    - SA ACWL = ACWL – 1.3*(AvgSoot – 3.50)

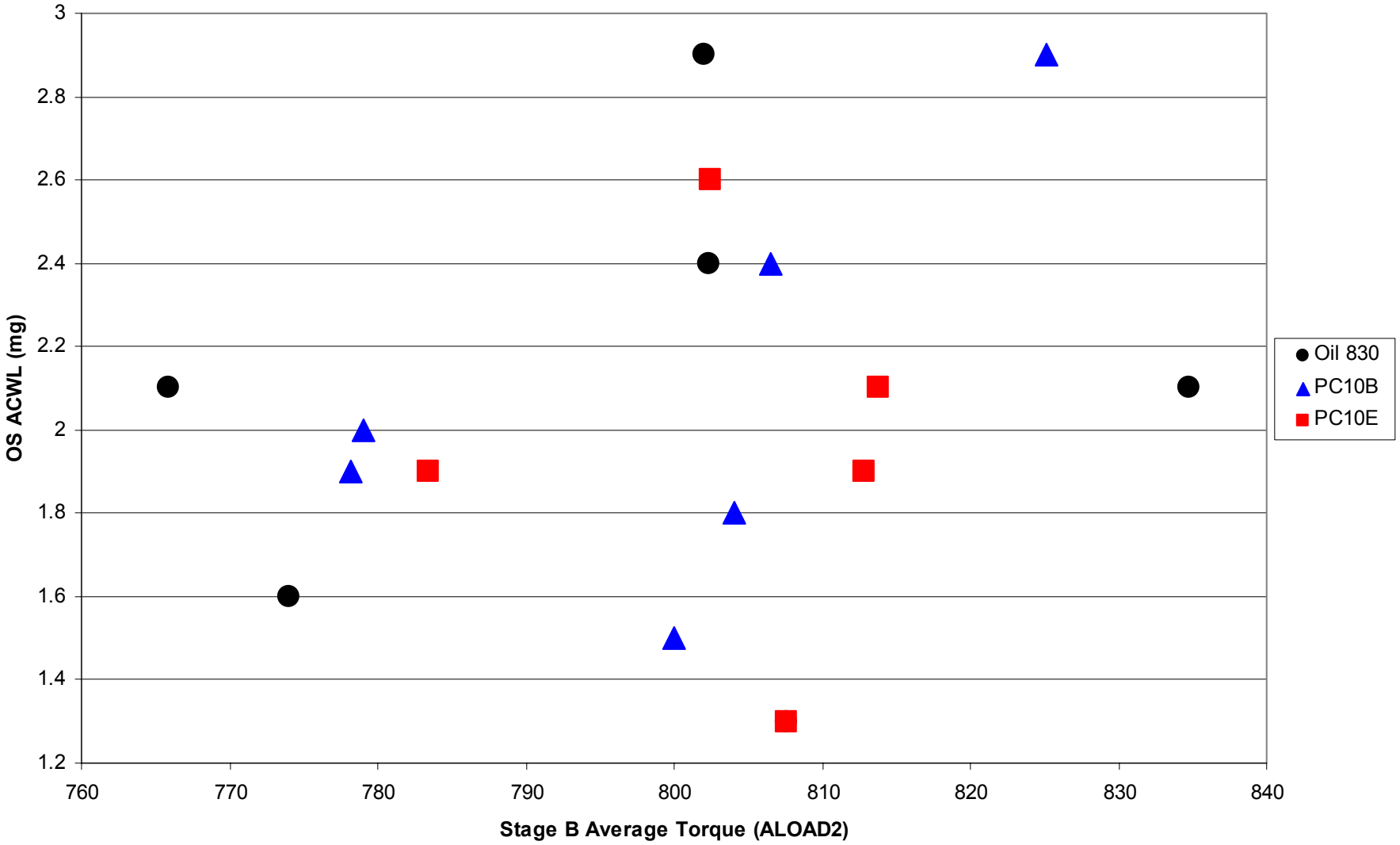
Tukey Adjusted p-Values

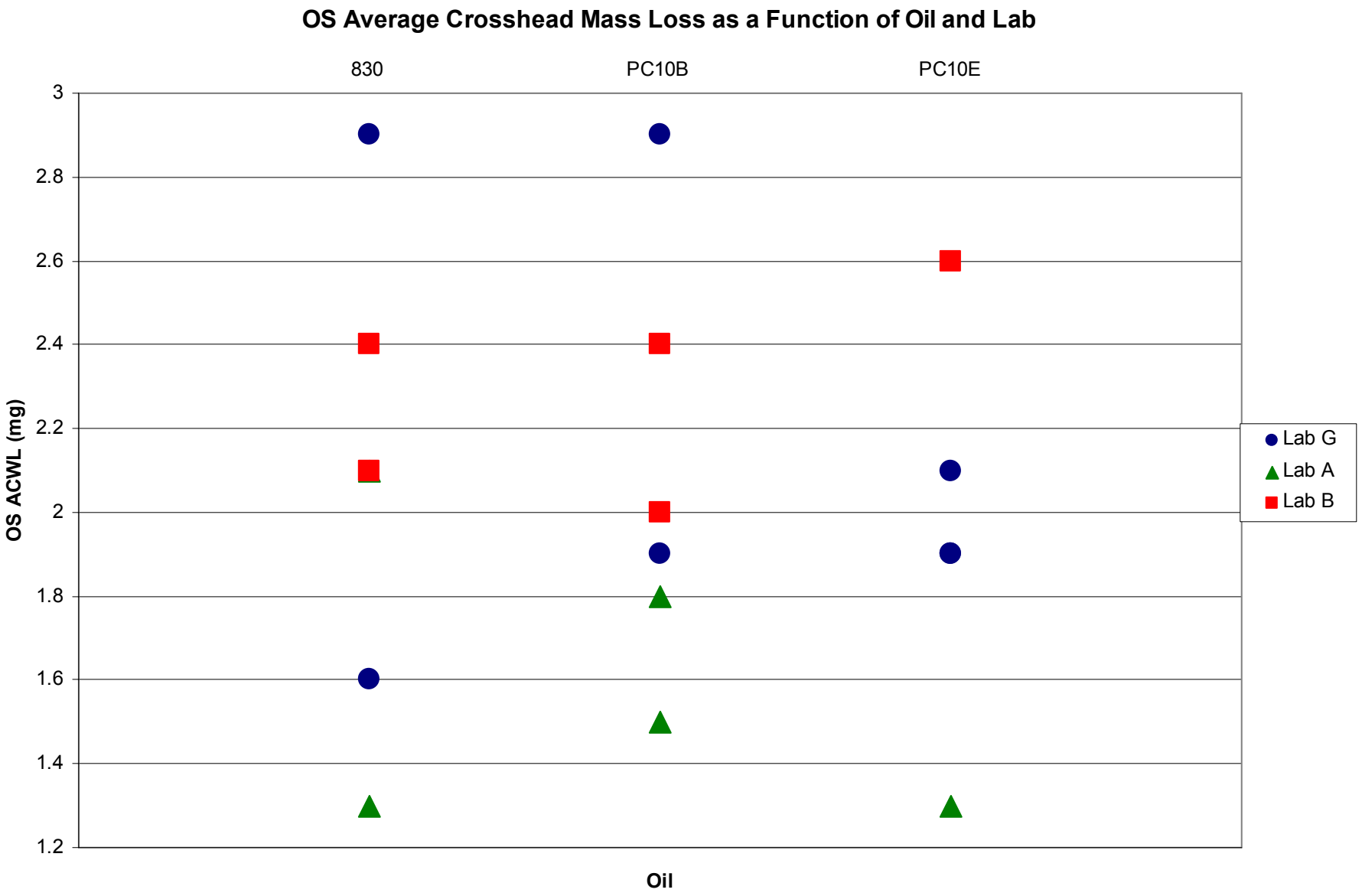
	Oil 830-2	PC10B	PC10E
XHead Wear (mg) Soot Adj	LS Mean = 2.072 StdErr = 0.1559	LS Mean = 2.057 StdErr = 0.1564	LS Mean = 1.944 StdErr = 0.1803
Oil 830-2		0.99	0.85
PC10B	0.99		0.89
PC10E	0.85	0.89	

OS Average Crosshead Mass Loss as a Function of Oil and Soot

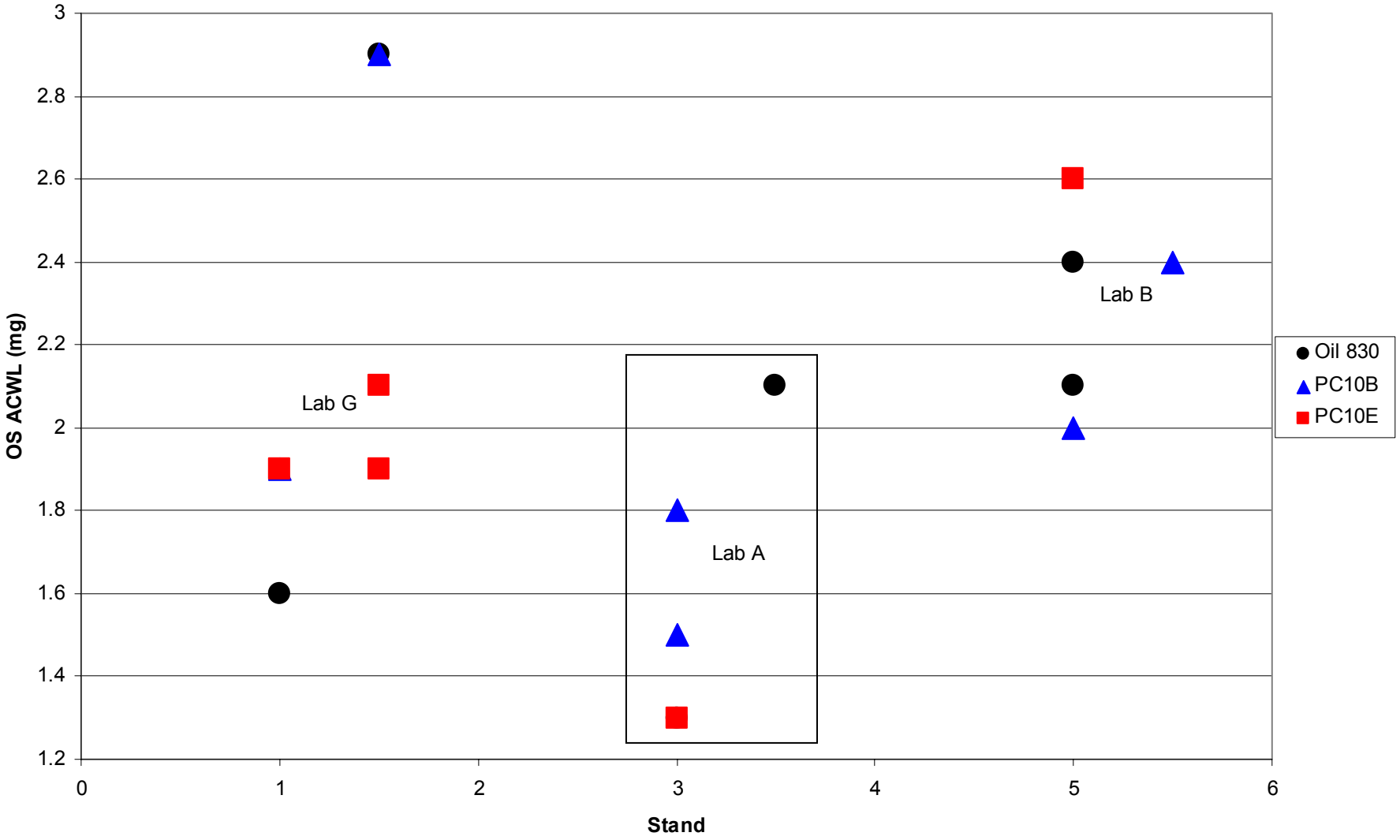


OS Average Crosshead Mass Loss as a Function of Stage B Average Torque




OS Average Crosshead Mass Loss as a Function of Oil and Lab
830
PC10B
PC10E
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
OS ACWL (mg)
Oil
Lab G
Lab A
Lab B

OS Average Crosshead Mass Loss as a Function of Stand and Oil



ISB Camshaft and Tappet Test for Lubricant Evaluation

Warren Totten

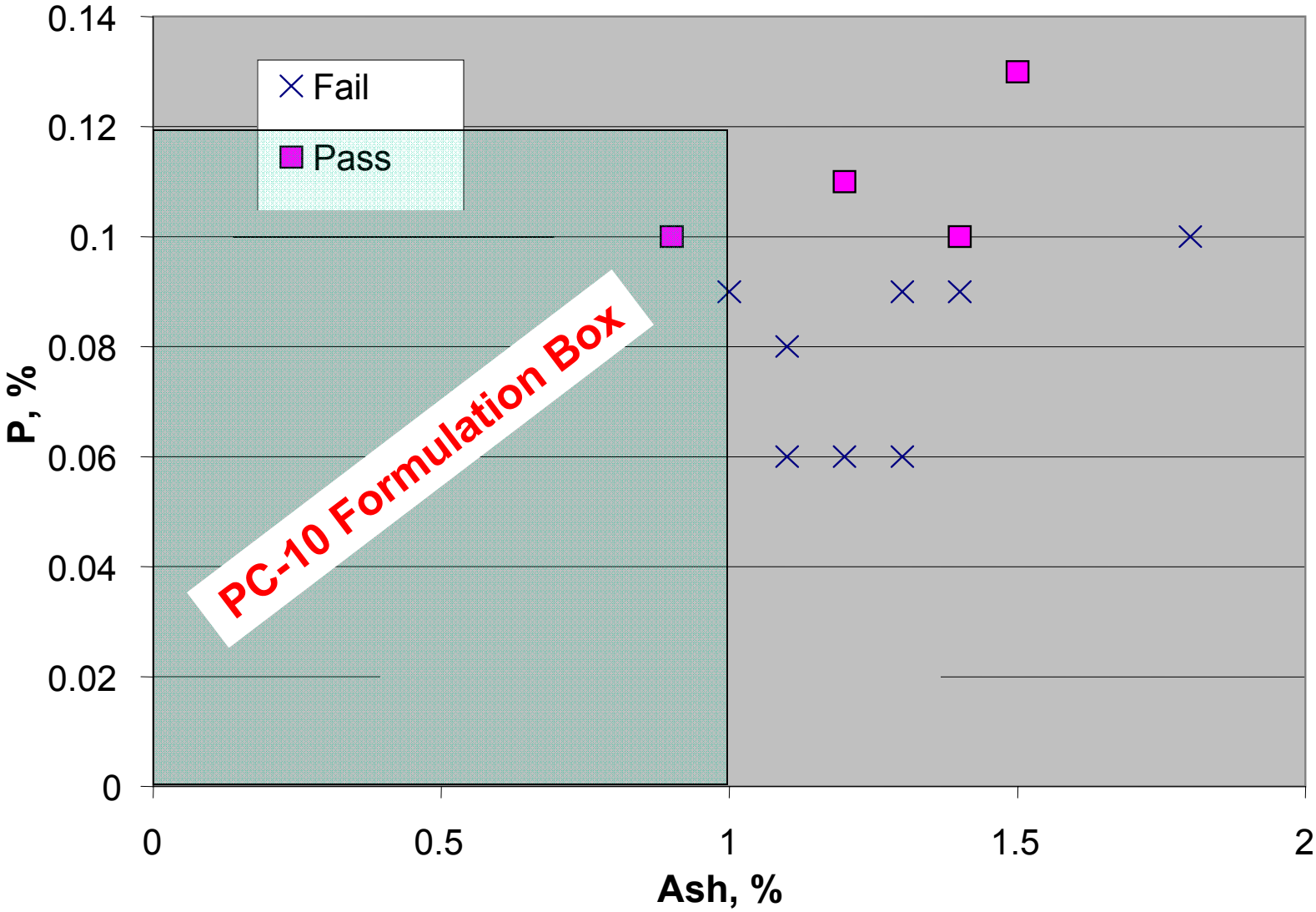
October 25, 2005

Historic Field Problem

- ISB cams have sliding contact
- Field and test cell studies showed sensitivity to lubricant phosphorous levels
- PC-10 will limit phosphorous to protect after-treatment devices.
- A sliding wear, sooted oil test was needed to protect engines in the field

Test History – B Camshaft Pitting

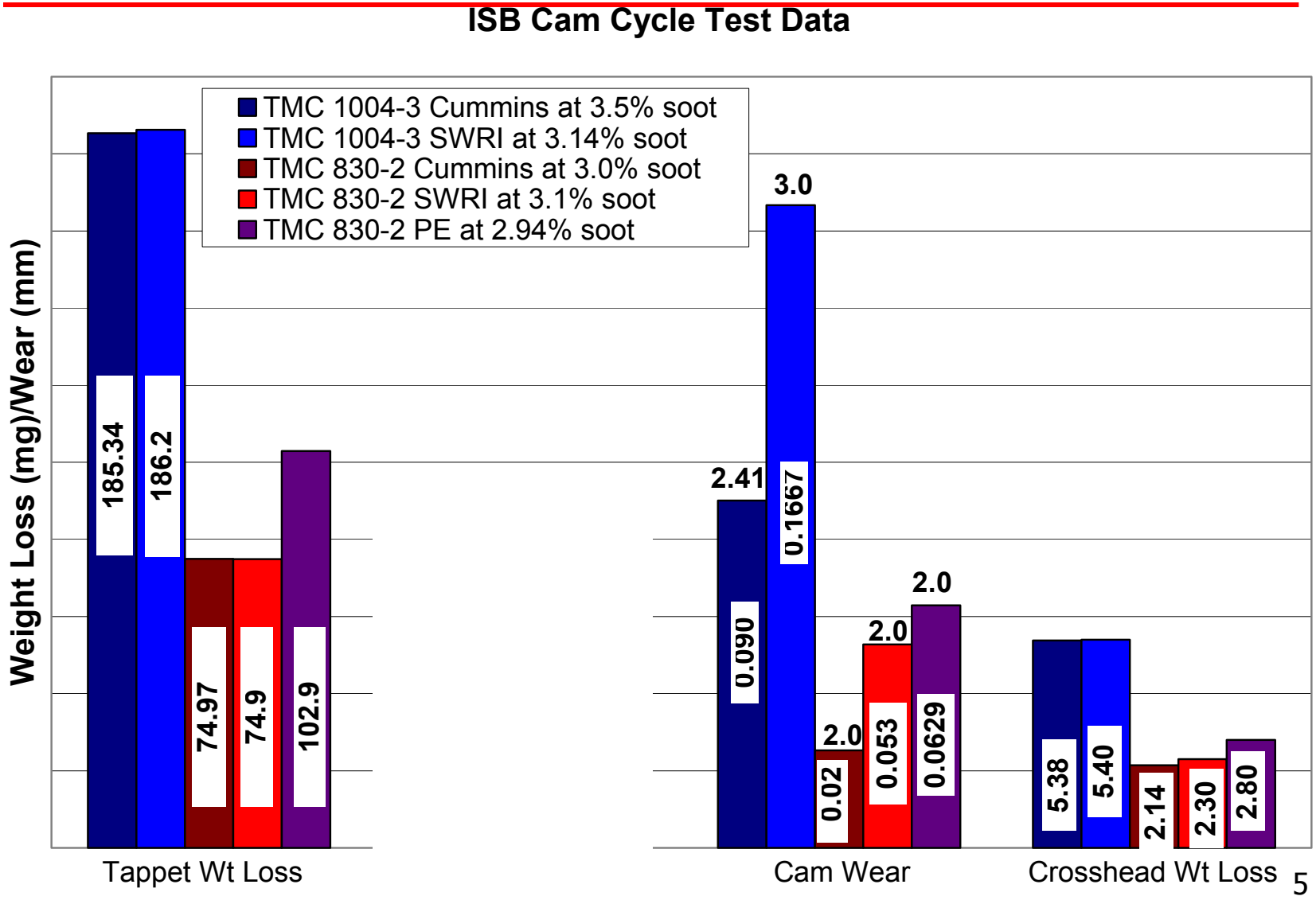
Phosphorus and Ash Effects



ISB Test Overview

- 2004 EPA Compliant engine rated at 300 HP and 600 ft-lbs lbf-ft torque
- The engine is run through a series of warm-up cycles to flush the engine oil with reference or candidate oil
- Stage I consists of a 100 hour soot generation steady-state cycle at 1600 RPM and 325 ft-lbs torque. The soot window at 100hours is 3.25 +/- 0.25% soot.
- Stage II consists of a repeating 28 second accelerated wear cycle for 250 hours. The oil pan level is verified as full by the dipstick before starting this stage.
- The wear components and other test parameters are evaluated upon successful test completion.

Discrimination Testing



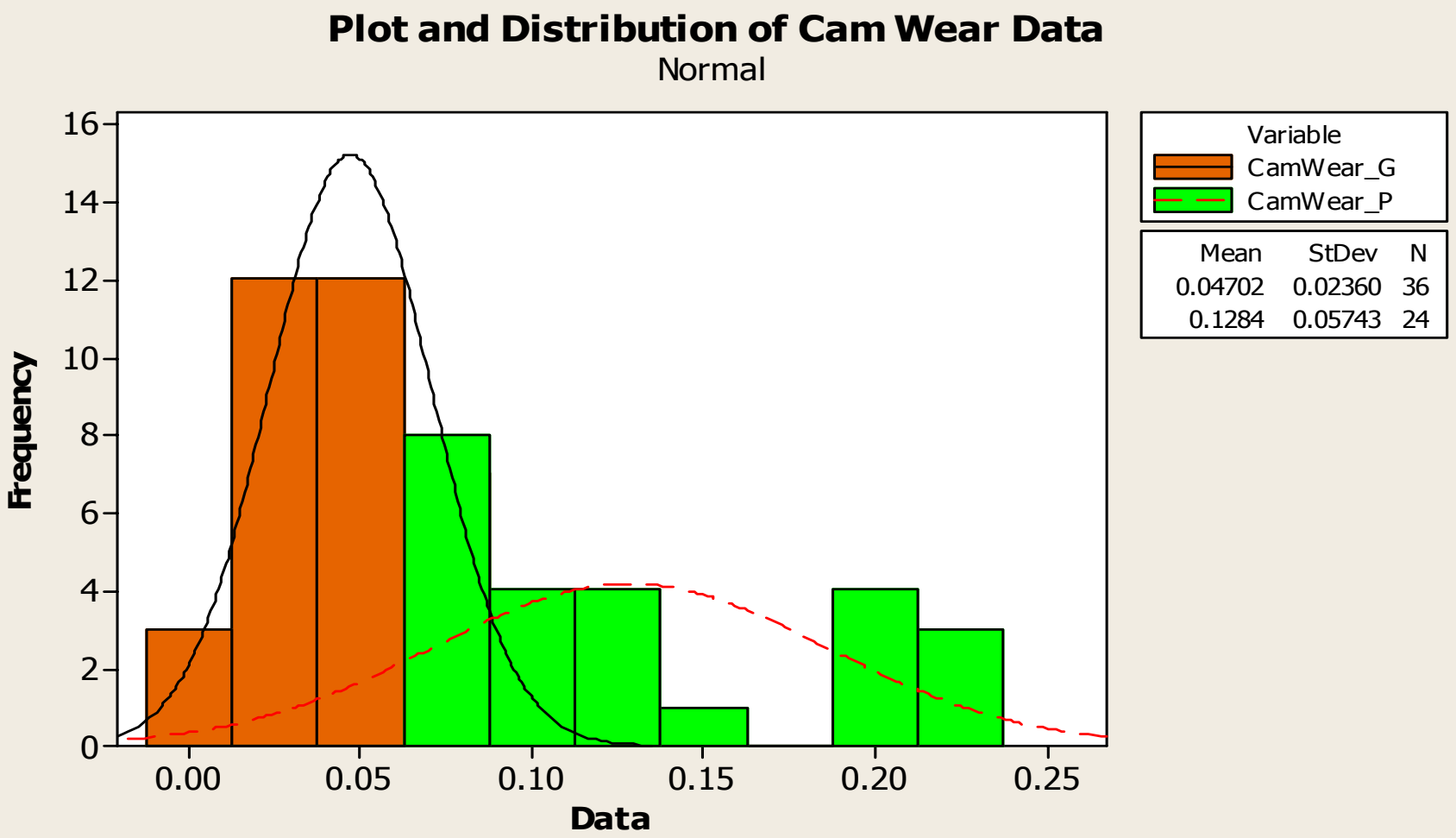
Discrimination Testing

Analysis for Wear

- Two sample t-test was used to evaluate the significance of the mean shift in the data (poor oil vs good oil)
  - There was a significant difference in the means of the data
  - The test can discriminate between oil quality on the accepted wear parameters

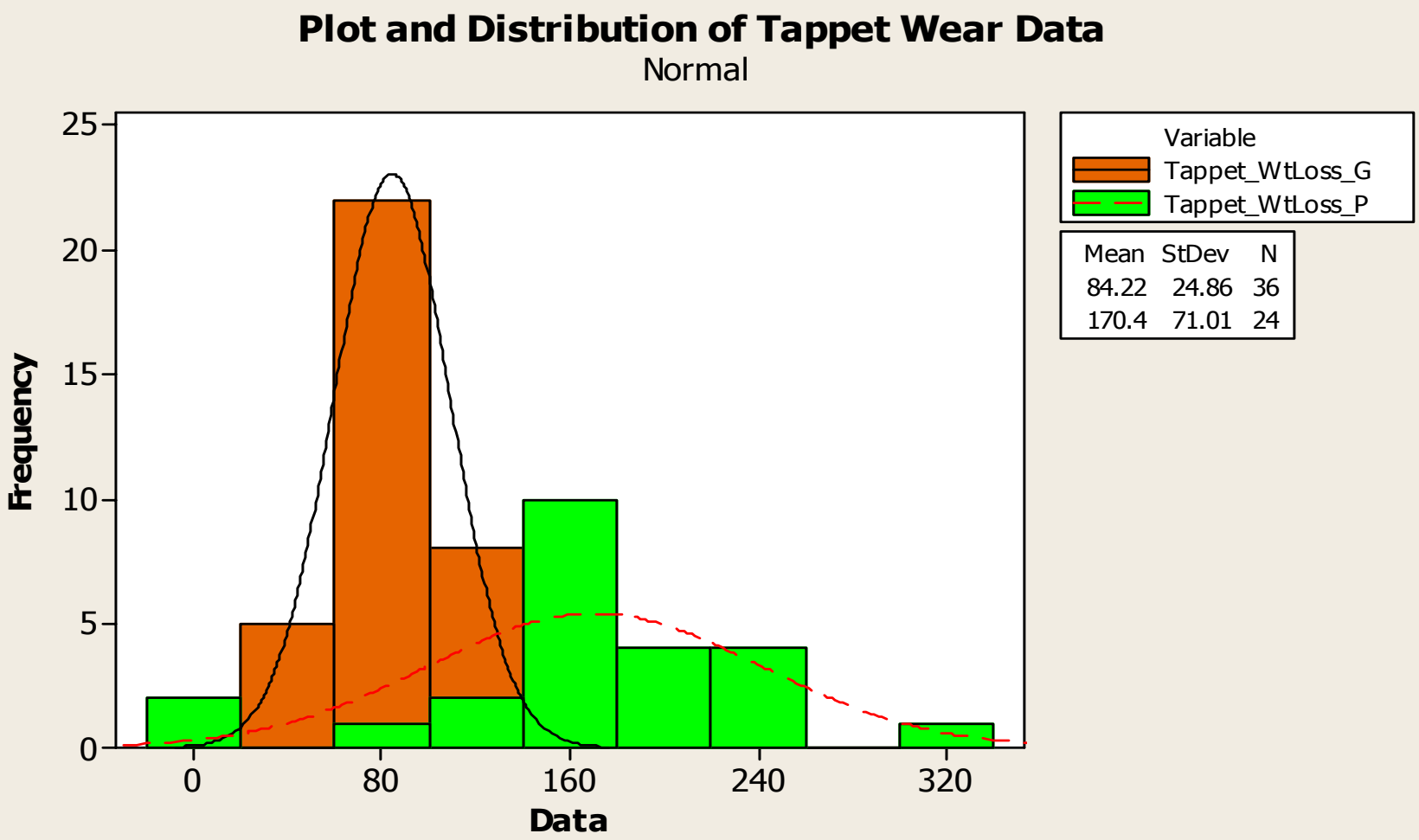
Discrimination Testing

Cam Wear Comparison



Discrimination Testing

Tappet Wear Comparison



Precision Summary
ISB Matrix Data 10/27

	Repeatability s (Within Stand)	Reproducibility s (Btween Stand)	Reproducibility s (Between Lab)
Tappet Wear (mg) Soot Adj	8.1645 Ep=1.84	16.8574 Ep=0.89	16.9092 Ep=0.89
Camshaft Wear (um)	4.7021 Ep=3.19	7.1512 Ep=2.10	7.1512 Ep=2.10
XHead Wear (mg) Soot Adj	0.3817 Ep=1.96	0.3817 Ep=1.96	0.5221 Ep=1.44
Torque Adjstd Cam Wear (um)	5.0833 Ep=2.95	5.0833 Ep=2.95	6.3063 Ep=2.38

Target Summary

ISB Matrix Data 10/27

	Oil 830-2	PC10B	PC10E
Tappet Wear (mg) Soot Adj	LS Mean = 88.23 Mean = 85.8167 S = 16.1416	LS Mean = 93.47 Mean = 88.6833 S = 15.8176	LS Mean = 67.54 Mean = 57.86 S = 9.4796
Camshaft Wear (um)	LS Mean = 40.20 Mean =40.2667 S = 9.2058	LS Mean = 44.85 Mean = 41.9833 S = 5.6722	LS Mean = 36.86 Mean = 34.14 S = 5.0093
XHead Wear (mg) Soot Adj	LS Mean = 2.072 Mean = 2.0833 S = 0.5345	LS Mean = 2.057 Mean = 2.0667 S = 0.4367	LS Mean = 1.940 Mean = 2.0000 S = 0.4743
Torque Adjstd Cam Wear (um)	LS Mean = 40.86 Mean =40.86 S = 6.8895	LS Mean = 42.29 Mean = 42.2984 S = 4.7694	LS Mean = 33.94 Mean = 33.0695 S = 6.0193

Proposed Limit

Tappet Weight Loss

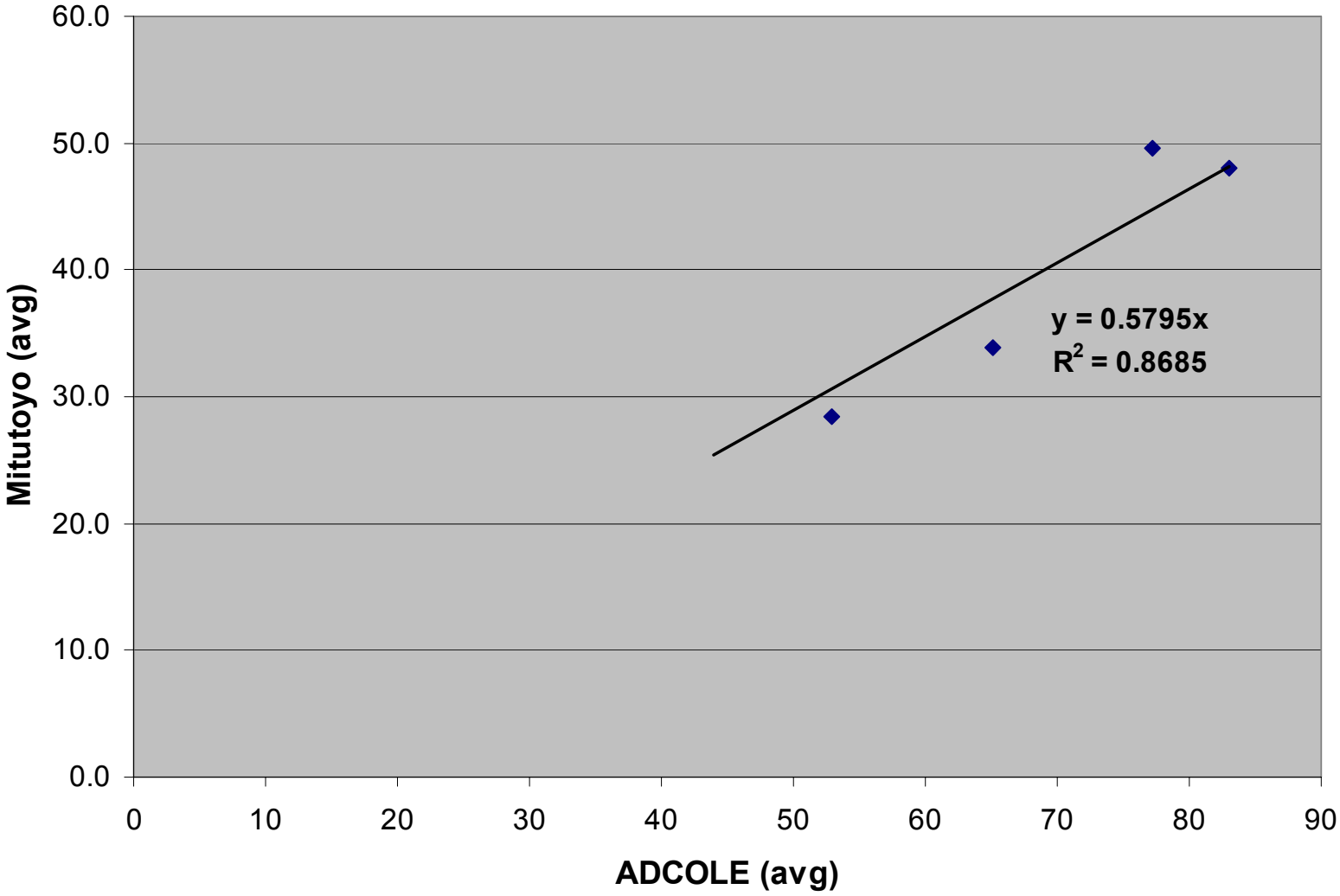
- Based upon matrix data the tappet weight loss limit is 75 mg
- 95% CI for the mean of the parameter is 65 – 86 mg

Cam Wear Issues

- Cummins uses a visual inspection scale to rate cam distress
- Cummins established a correlation between the "service rating" and the Adcole wear profile results
- Following the matrix, the Surveillance Panel adopted a Mitutoyo snap gauge measurement
- To set limits we need to relate Mitutyo to the service rating

Cam Rating Data

ADCOLE vs Mitutoyo - Average



Proposed Limit

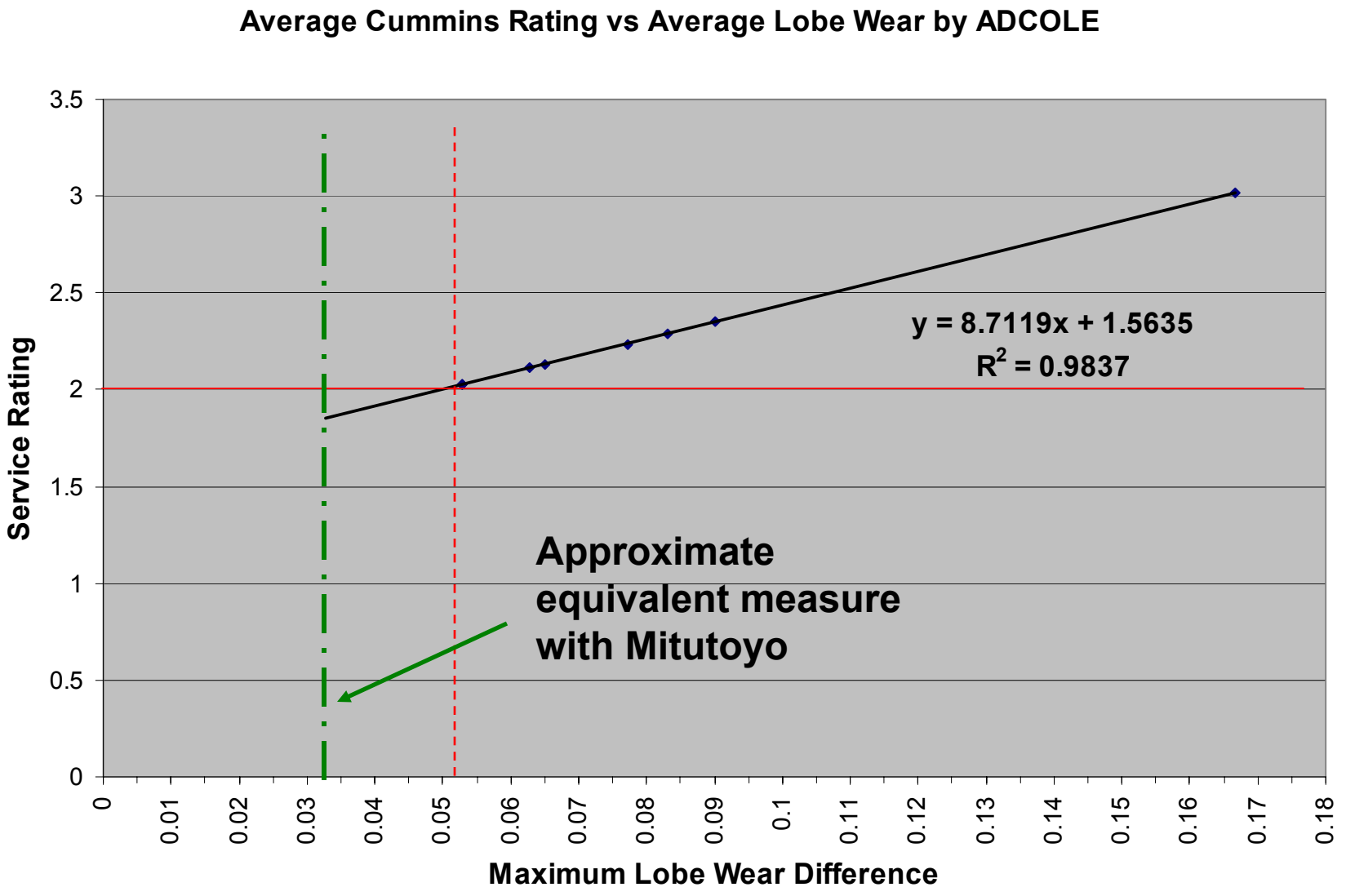
Average Cam Lobe Wear

- **Need all of the remaining ADCOLE data from the matrix to insure correlation**
- Based upon data received and the correlation the relationship between ADCOLE and Mitutoyo is:

ADCOLE = 1.725 X Mitutoyo

- Recommendation for passing cam is a rating of 2.0
- Based upon data a 2.0 correlates to a **50** µm ADCOLE rating or a **30** µm Mitutoyo
- 95% CI for the parameter is 44 – 66 ADCOLE or 25 – 38 Mitutoyo

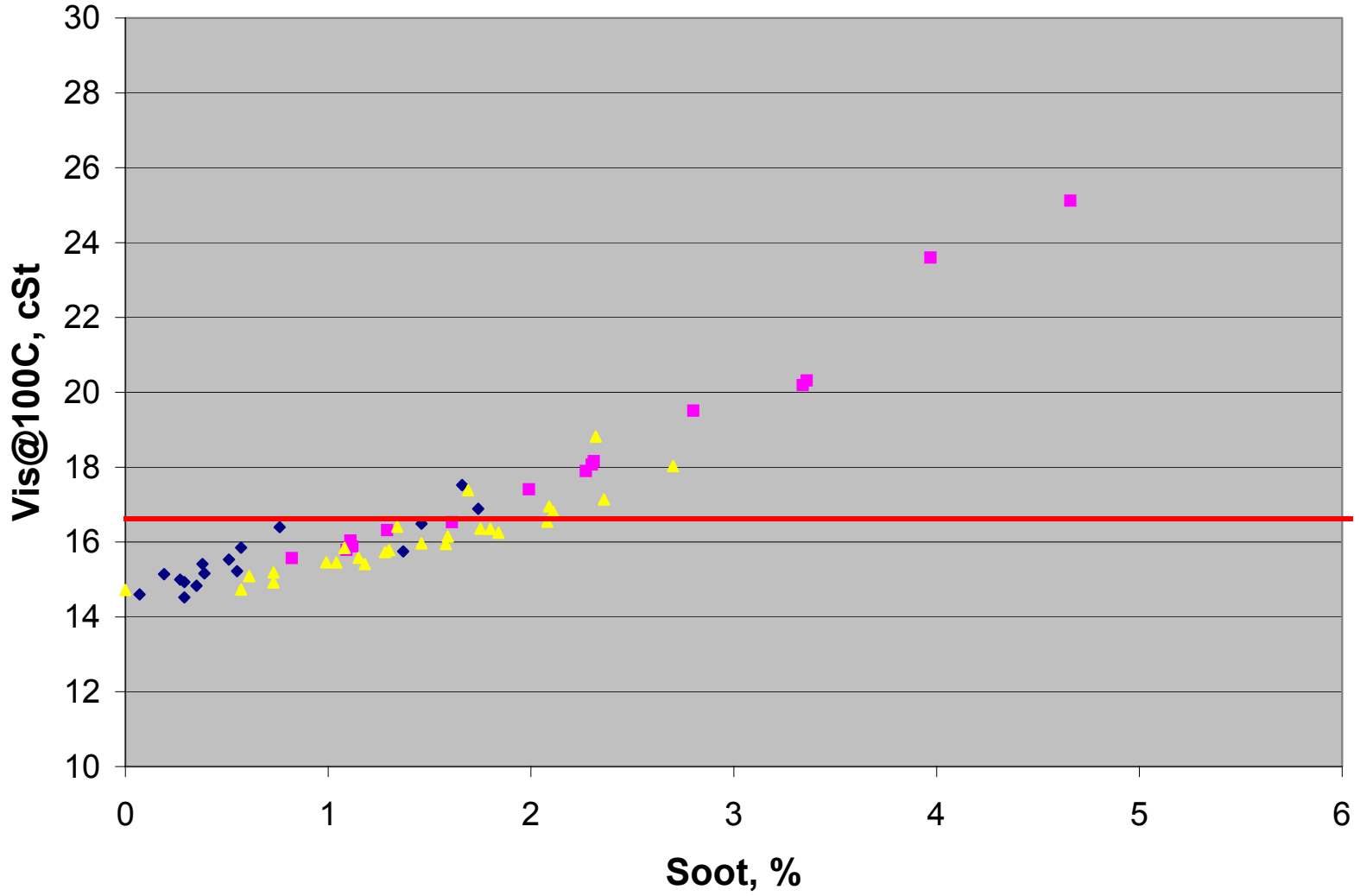
Visual Cam Rating



Cam Rating Issues

- The Surveillance Panel felt that the data correlating the Adcole and Mitutoyo to Service rating was sparse.
- All Matrix and Cams are being sent to Cummins along with Adcole data.
- They will be rated on the Service Rating scale
- The correlation between Service Rating and the wear measurement methods will be improved

ISB02 EGR, CI-4



Proposed Limit

Viscosity Increase Control

- Stay in grade requirement at the 100 hour soot window (3.25% +/- .25%)

Summary of limits

- **Tappet wear limit**
  - **Target limit 75 mg weight loss**
- **Cam wear limit**
  - **Target limit 30 µm wear by Mitutoyo snap gauge**
- **Viscosity limit**
  - **Target limit "stay in grade" at the 100 hour soot window 3.25% +/- 0.25%**

Summary of limits

- **Tappet wear limit**
  - **Target limit 75 mg weight loss**
- **Cam wear limit**
  - **Target limit 30 µm wear by Mitutoyo snap gauge**
- **Viscosity limit**
  - **Target limit "stay in grade" at the 100 hour soot window 3.25% +/- 0.25%**

- **ISB was recommended for inclusion in PC10 at recent HDEOCP meeting**
- **MOTION: Exit Ballot these limits for the ISB**

Caterpillar C13
Matrix Data Analysis

- Discussed at meeting on October 20th, 2005
- Participants: Jim Rutherford, Elisa Santos,
- Phil Scinto and John Zalar
- Participants in part: Jeff Clark and Todd Dvorak

"The industry statisticians reached consensus on analyses of the PC-10 Precision Matrices. We agreed that we have more work to do, more details to examine, more questions to address, etc. However, we don't expect the basic analyses to change substantially from what we have today and we are ready to share with the industry."

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Summary (1)

- Statistical evidence that Lab F is severe on Delta OC
- Analysis with 32 tests shows that Lab A is mild for Delta OC
- Lab B is severe for TLC and TLHC
- Additional Lab differences
  - UWD: Lab A & Lab B; Lab A & Lab G; Some indication of Lab B severity
  - TGC: Lab A & Lab G
  - TGF: Lab A & Lab F ; Lab A & Lab G




Summary (2)

- Impact of Base Oil on Delta OC seems to vary with Technology
  - Delta OC increases with Base Oil (1,2,3) for Technology B
  - And there are no significant differences among Base Oils for Technology A

- In general, Deposits for Base Oil 3 are higher compared to Base Oil 2 and Base Oil 1

- Correlation of Delta OC with Deposits is very weak: ~ 0.4 or lower, most of them not significantly different from zero

- Precision:
  - E p is greater than 1 for TLC and TLHC
  - ~ 0.85 for TGC
  - ~ 0.65 for Delta OC and TGF

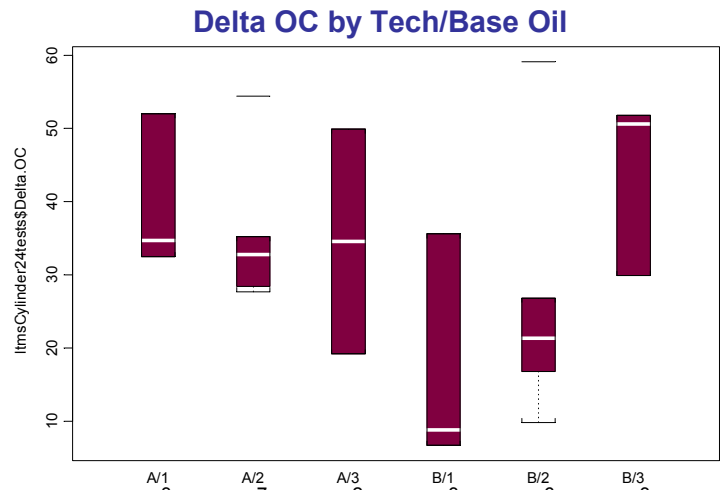


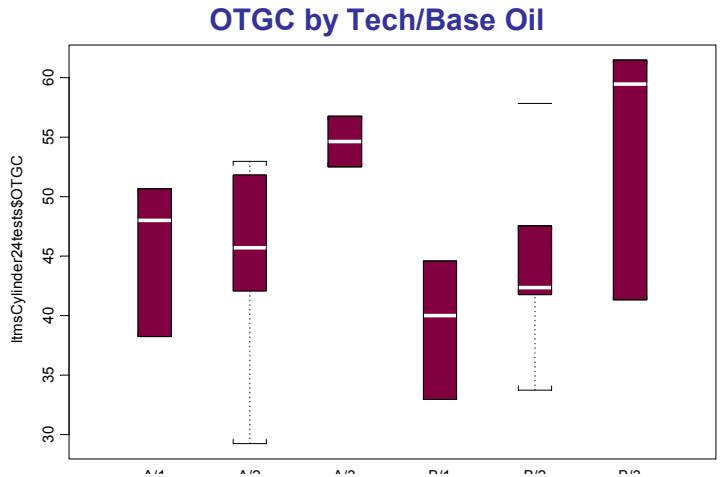

Base Oil Effect Summary from the BOI presentation (10/21/05)

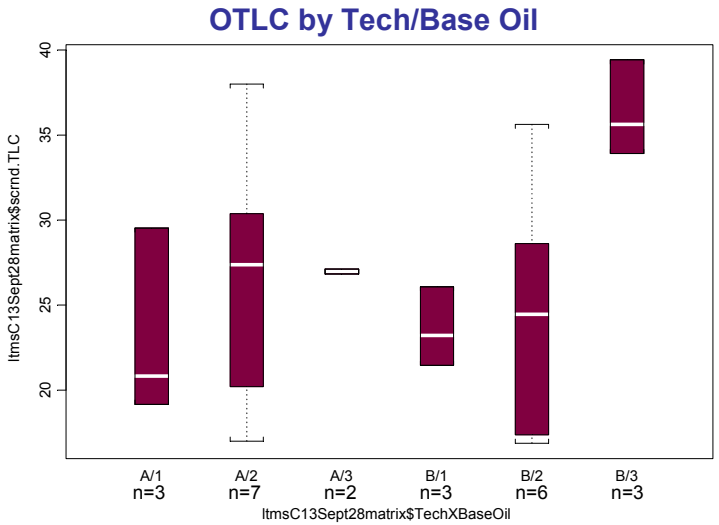
Parameter	Technology	Base Oil Effect Observed	Statistically Significant?
OC	A	Higher Sats/BOVI=Lower OC	No
OC	B	Higher Sats/BOVI=Higher OC	Group III
UWD	A & B	Group III=Higher UWD	Yes
TLC	A	Higher Sats/BOVI=Higher TLC	No
TLC	B	Group III=Higher TLC	Yes
TLHC	A	Higher Sats/BOVI=Higher TLHC	No
TLHC	B	Group III=Higher TLHC	Yes
TGF	A & B	NONE	NA
TGC	A & B	Group III=Higher TGC	No

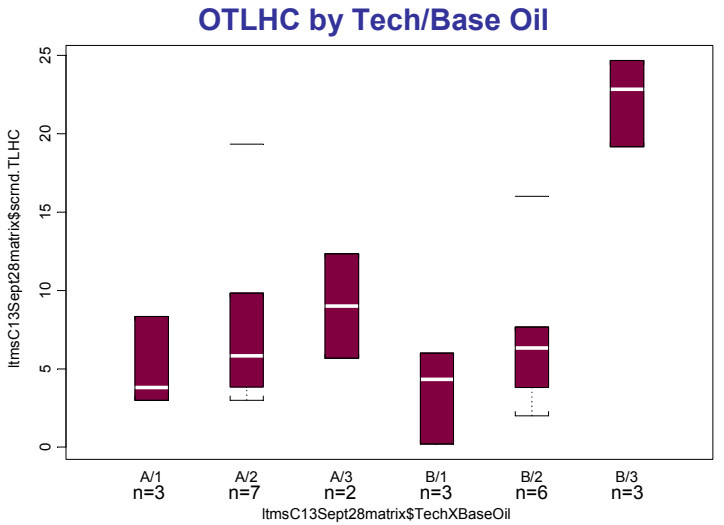



Parameter versus Tech/Base Oil Combination









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Precision

- Desirable values for E p are greater than 1
  - E p is greater than 1 for TLC and TLHC

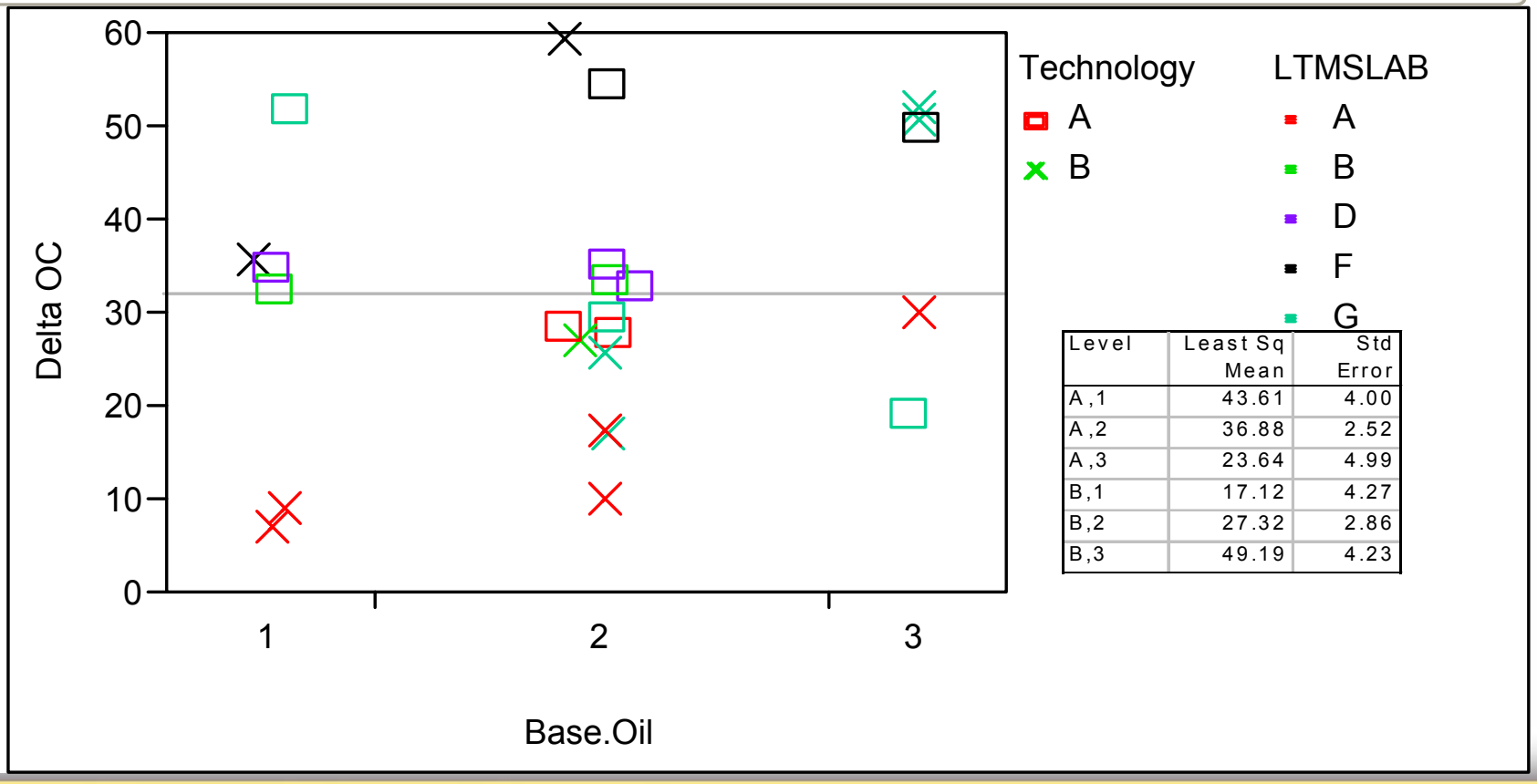
	Precision based on the model		Median of MAD survey	E p1	E p2
Parameter	24 tests	32 tests			
Delta OC	6.5	6.82	4.5	**0.6923**	**0.6598**
OUWD	8.15	8.5			
OTGC	5.85	5.74	5	**0.8547**	**0.8711**
OTGF	7.22	6.96	4.5	**0.6233**	**0.6466**
scrnd TLC	4.02	4.25	4.5	**1.1194**	**1.0588**
scrnd TLHC	3.05	3.45	4	**1.3115**	**1.1594**

MAD survey indicates the maximum acceptable difference between two test results on the same formulation




Delta OC versus Base Oil

Delta OC By Base.Oil



Level	Least Sq Mean	Std Error
A,1	43.61	4.00
A,2	36.88	2.52
A,3	23.64	4.99
B,1	17.12	4.27
B,2	27.32	2.86
B,3	49.19	4.23

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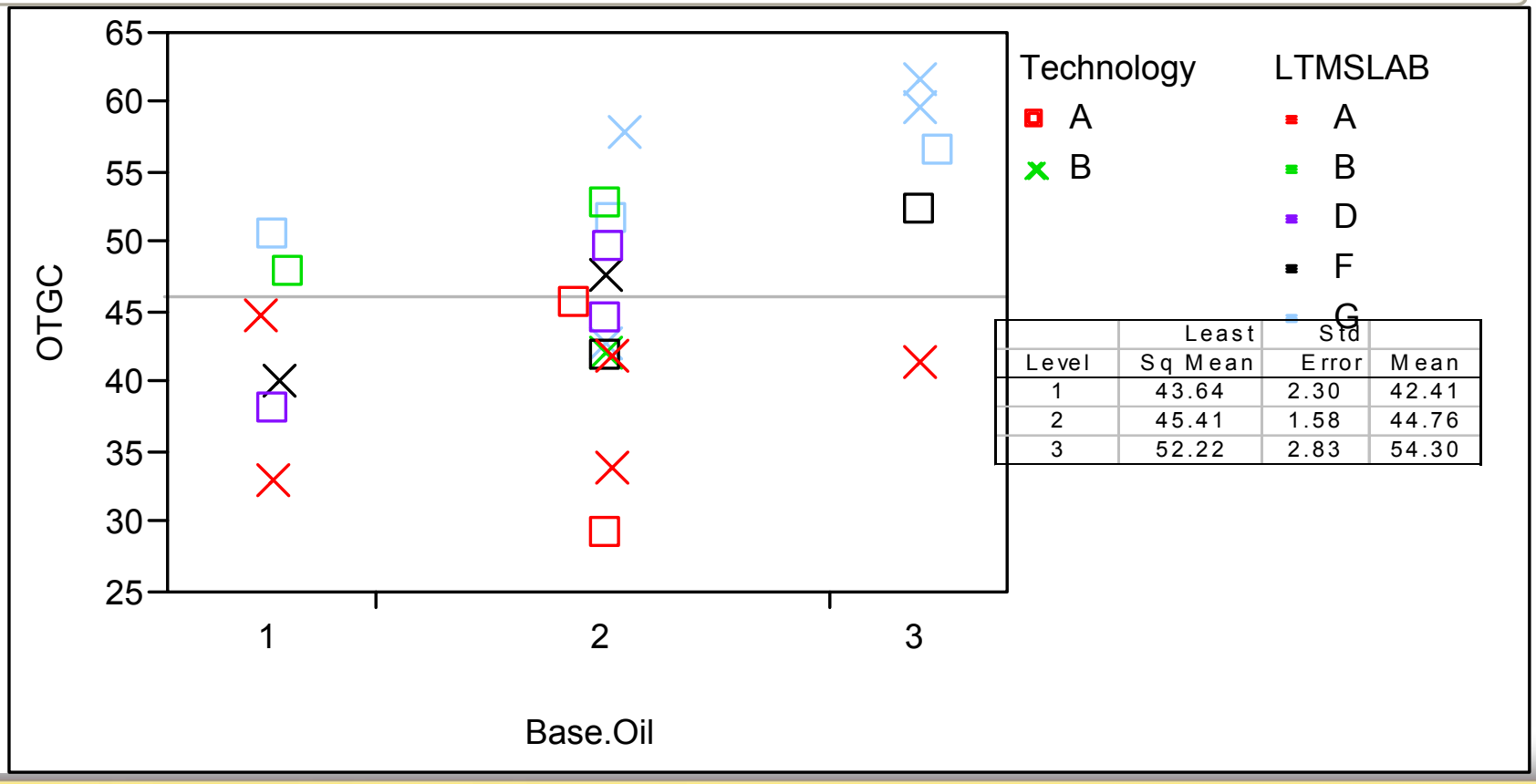
OTGC versus Base Oil

OTGC By Base.Oil



Level	Least Sq Mean	Std Error	Mean
1	43.64	2.30	42.41
2	45.41	1.58	44.76
3	52.22	2.83	54.30

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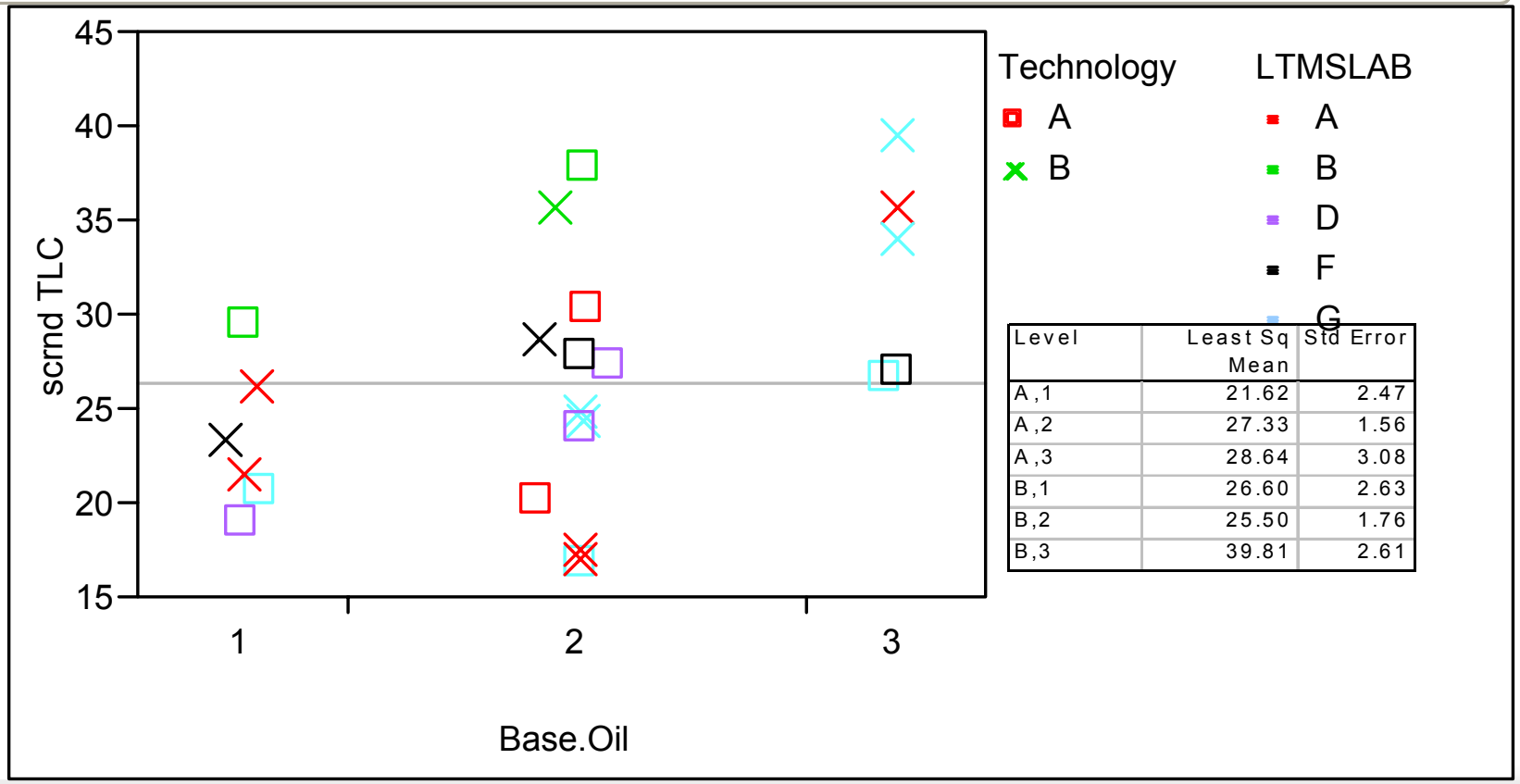
scrnd TLC versus Base Oil

scrnd TLC By Base.Oil



Level	Least Sq Mean	Std Error
A,1	21.62	2.47
A,2	27.33	1.56
A,3	28.64	3.08
B,1	26.60	2.63
B,2	25.50	1.76
B,3	39.81	2.61

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C13 SP Discussion of PC10

1. C13 data analysis almost completed by statisticians who have agreed on the main findings. Further data review was requested by SP.
2. SP agreed on five Pass/Fail parameters.
3. SP waiting on choice of lower Piston Deposit parameter(s) instead of UWD. Action to complete by end next week.
4. C13 Lab Bias Task Group was established and investigations are on-going, concentrating on Torque, Oil external (Pressure, weights and cooling) system.




C13 Pass/Fail Criteria

Caterpillar Piston Deposit Test Requirements

1. No scuffed Pistons, Rings, Liners – Non-interpretable
2. No Hot stuck Rings
3. No loss of Oil Consumption Control
4. No unacceptable Piston Deposits:
   a) TLC
   b) TGC
   c) TBD (2nd ring and groove deposits)




Identify Parameters – by Nov 2

Outlier screening methods for LTMS - Nov 5

Limits proposal with determination of :

- Means methods,
- Standard deviation based on 24 BOI tests

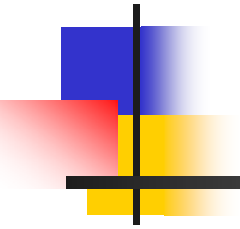
Reference Oil selection




C13 Test Limit Status

	Min	Merit Anchor	Max	Merit Weight
Oil Consumption Delta	10	25	30.6	300
TLC	20	30	35	300
TGC	30	48	51.5	250
UWD				150



ACC Position on C13 Timing

October 27, 2005

C13 Assumptions

- Ten C13 stands available in the industry
- One month per test → ten tests per month
- 30% to 50% pass rate

➔ Three to five passes per month

C13 Assumptions – Best Case

- 36 passes required if full BOI/VGRA guidelines are granted
  - All BOI/VGRA guidelines roll over from the Cat 1R to the C13 by 1/1/2006

➔ Seven to twelve months to complete

C13 Assumptions – Mid Case

- 73 passes required if only C13 BOI guidelines are granted
  - Full BOI guidelines in place by 1/1/2006
  - No VGRA guidelines are granted for the C13

➔ Fifteen to twenty-four months to complete

C13 Assumptions – Worst Case

- 223 passes required without enabling C13 guidelines
  - No BOI guidelines are granted
  - No VGRA guidelines are granted

➔ Four to six years to complete

Considerations

- Without testing relief for the C13 test:
- The October 2006 deadline requested by EMA will be missed by several years
- All oil marketers will be affected

A Proposed Solution

- Agree Caterpillar C13 BOI/VGRA guidelines through the API BOI/VGRA Task Force
  - Perhaps in conjunction with existing Caterpillar 1P BOI/VGRA guidelines
- If this is not successful, seek Caterpillar C13 testing relief through the HDEOCP

10/31/05

ASTM-HDEOCP EXIT CRITERIA BALLOT:

To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot

Company	Name	Affirmative	Negativte
Afton Chemical	Charles Passut		X
BP	Mike Lynskey		X
Caterpillar Inc	Abdul Cassim		
Chevron Oronite LLC	Wm. Kleiser		X
ChevronTexaco	Jim Mc Geehan		X
Ciba Specialty Chemicals	Scott Harold		X
ConocoPhillips	David E. Taber	X	
Cummins	Warren Totten	X	
DDC	Mesfin Belay		
Dana Corporation	Howard Robins	X	
Deere & Co	Ken Chao	X	
EMA	Roger Gault	X	
ExxonMobil	Steven Kennedy		X
GM	Robert Stockwell	X	
Infineum	Pat Fetterman		X
Int'l Truck & Engine	Heather DeBaun	X	
Lubrizol	Lewis Williams		X
Mack Division-Volvo Powertrain	Greg Shank		
PerkinElmer	Thomas M. Franklin		
RohMax USA	Steven Herzog		X
Shell	Matthew Urbanak	X	
Valvoline	Wm. Runkle Jr.	X	
Volvo Power Train	Greg Shank	X	
	Totals	10	9

EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO:
Pat Connelly via email (preferred):
patconnelly@chevrontexaco.com
or via Fax: 510-242-3758

Name: Scott Harold
Organization: Ciba Specialty Chemicals
Date: 10/25/05
Phone No.: 914 275-2711

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	☒

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

I have placed the data for the 95% confidence interval into this spreadsheet in the parameter worksheet.

ISMMeritRating1_rev 2.xls

Comments:

Need limits for other PC-10 tests to be established
Issue of redundancy still exists

EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO:
Pat Connelly via email (preferred):
patconnelly@chevrontexaco.com
or via Fax: 510-242-3758

Name: Mike Lynskey
Organization: BP
Date: 25 October 2005
Phone No.: 443 799 6977

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	☒

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

I have placed the data for the 95% confidence interval into this spreadsheet in the parameter worksheet.

ISMMeritRating1_rev 2.xls

Comments:

We understood from the PC-10 needs statement that the ISM was a replacement for the M11 test from the API CI-4 category, as can be seen from the results on 830-2 these limits appear to move the test severity significantly. We would like the test sponsor to reconsider the proposed limits or provide field data to justify the increase in severity.

As far as we are aware no discrimination data has been presented for the top ring weight loss parameter. We would like to understand what discrimination data exists prior to accepting limits.

EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO:
Pat Connelly via email (preferred):
patconnelly@chevrontexaco.com
or via Fax: 510-242-3758

Name: Jim McGeehan
Organization: Chevron
Date: October 21st 2005
Phone No.: 510-242-2268

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	X☐

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

I have placed the data for the 95% confidence interval into this spreadsheet in the parameter worksheet.

ISMMeritRating1_rev 2.xls

Comments:

This category is design to be back-ward compatible with performance equal to API CI-4 Plus oils using the reference oil 830-2. The limits propose is an up-grade beyond API CI-4 Plus. These limits should focus at the 830-2 performance and not the limits proposed. It is important in regard to category timing that these limits need to be changed to level of 830-2 level to ensure the category can be delivered on time.

EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO:
Pat Connelly via email (preferred):
patconnelly@chevrontexaco.com
or via Fax: 510-242-3758

Name: Steven Kennedy
Organization: ExxonMobil
Date: 10/24/05
Phone No.: 856-224-2432

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	☒

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

I have placed the data for the 95% confidence interval into this spreadsheet in the parameter worksheet.

Comments:

The ISM was included in the PC-10 category as a backward compatibility test. Since the limits on this ballot are far more restrictive than those already accepted as the alternate limits for API CI-4, we can not support this proposal. In particular, the fact that these limits make TMC 830 a very borderline oil is a major concern. It indicates that PC-10 would have much more severe wear requirements in a test common to both categories. We believe that the more severe limits for the ISM parameters common to CI-4 and PC-10 have not been fully justified. Also, the parameters being added need to be discussed in more detail.

EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO: Pat Connelly via email (preferred): patconnelly@chevrontexaco.com or via Fax: 510-242-3758	Name: Steven Herzog Organization: RohMax USA Date: October 24, 2005 Phone No.: 610-513-1865

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	X

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

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ISMMeritRating1_rev 2.xls

Comments:

Our understanding on the adopting of the ISM test was that it would be a replacement test for the Cummins M11 at the M11 limits. The proposed ISM limits appear to be an increase in severity versus the M11.

EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO: Pat Connelly via email (preferred): patconnelly@chevrontexaco.com or via Fax: 510-242-3758	Name: William M. Kleiser Organization: Chevron Oronite Company, LLC Date: October 24, 2005 Phone No.: 510 242 3027

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	☒

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

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ISMMeritRating1_rev 2.xls

Page 1

Comments:

Chevron Oronite feels that it is not possible to agree on PC10 tests individually. Additional testing on PC10 candidate oils is required in order to more clearly assess the relative appetites of all of the PC10 tests. Once that is complete it will be possible to evaluate the relative requirements of all tests as opposed to each individually.

In addition to the need to complete additional demonstration testing, the proposed limits are inappropriate in that they represent a significant performance upgrade versus both CI-4 and CI-4 Plus.

During all discussions regarding the conception and development of PC10, the clear intent has been a maintenance of current performance with a reduction in maximum allowable lubricant sulfated ash, sulfur, and phosphorus. All estimates of testing timelines has used performance levels equivalent to current lubricants as the target. An increase of performance will cause a lengthening of the timeline due to the impact on test pass/fail rates.

Finally, anchors and associated maximum and minimums must be based on available statistically sound data. Adjustments in ranges (i.e. maximum or minimum) which imply a test precision greater than demonstrated are not acceptable as it implies capability not demonstrated by the test method. The use less rigorous methods of evaluating data, such as engineering judgment, would be appropriate only if statistically sound data were not available. Past experience is that limits set arbitrarily beyond the capability of a test method can result in significant problems such as unexplained severity shifts.

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EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO: Pat Connelly via email (preferred): patconnelly@chevrontexaco.com or via Fax: 510-242-3758	Name: Lewis Williams Organization: Lubrizol Date: 10/24/05 Phone No.: 440-347-1111

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	X☐

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

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ISMMeritRating1_rev 2.xls

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Comments:
See attachment.

Connelly, Patricia (patconnelly)

From: Williams, Lewis [LAWM@Lubrizol.com]

Sent: Monday, October 24, 2005 12:21 PM

To: Mc Geehan, James (JIAM); Connelly, Patricia (patconnelly)

Cc: Castanien, Chris; Scinto, Phil; Shah, Mayur; Galic, Mary; Duncan, David; Baumgartner, Daryl; Matasic, James; Griggs, Michael; Domonkos, Dan; Carlson, Jon; Mackney, Derek; Wilby, Ian; Rees, Mark; Nai, Paul; Okubo, Masakatsu; Dohner, Brent; Curtis, Thomas; Carroll, Dale; Joyce, Matthew; Ribeiro, Antonio; Fisher, Alison; Marn, Don

Subject: ISM Exit Criteria Ballot

Attachments: Cummis ISM-Exit Criteria Ballot PC-10 Parameters.doc

<<Cummis ISM-Exit Criteria Ballot PC-10 Parameters.doc>>

Lubrizol votes negative on the ISM exit ballot and offers the following alternative proposals.

Proposed PC-10 Parameters

Merit System Calculations are based on the Standard Deviation of RO 830 and the application of 2.5 standard deviations from the anchor to establish the max and the min. RO 830 is a borderline passing oil.

	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	300	100	250	200	150
Maximum	7.0	125	55	122	8.7
Anchor	5.5	75	19	50	9.0
Minimum	4.0	25	7	21	9.3
Standard Deviation Used in Calculations	1.09	19	0.4245	0.3563	0.1354

1. We changed the weight on crosshead weight loss from 250 to 300 to reflect the importance and significance of this parameter in the ISM test.

2. We dropped the weight of the ASWL from 250 to 200.
3. Anchor points were set to make 830-2 a borderline passing oil.

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In general Lubrizol does not feel the ISM lends itself to using a merit system to evaluate oils. Crosshead weight loss is the true pass/fail parameters while TRWL, OFDP, ASWL and Sludge can be considered fail safe parameters. We alternatively propose conventional tiered limits based on the proposed merit system anchor point.

Tiered Limits are based upon the proposed anchors and the Standard Deviation of RO 830.

	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
1 Test Limit	5.5	75	19	50	9.0
2 Test Limit	6.0	84	23	59	8.9
3 Test Limit	6.3	88	26	64	8.9

The ISM was presented as a replacement test for the M11 EGR to assure backwards compatibility of CJ-4 oils to previous C categories. We have already agreed to ISM limits to replace the M11 EGR in previous categories. The proposed limits on the ballot are a substantial upgrade over CI-4 limits and we believe are not consistent with the intention of the ISM test development. The original goal of CJ-4 was to maintain engine durability at CI-4 PLUS levels but at reduced chemical limits to enable the use of DPFs to meet PM limits for 2007.

The limits offered in the tiered limit proposal set the pass/fail criteria such that 830-2 is borderline passing which is consistent with the objectives for the use of the ISM as a replacement test for the M11 EGR.

Lubrizol would prefer to wait until all pass/fail limits for the PC-10 category are proposed before we move forward with setting the limits on the ISM. The industry is currently in the technology demonstration period of category development where we are seeking to understand the appetites of the PC-10 category overall. Trying to set the limits on one major test before we have sufficient time to understand the performance requirements of all major tests makes setting realistic limits impossible.

Lew

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EXIT CRITERIA BALLOT

ASTM-HDEOCP	Issue Date: October 14, 2005
BALLOT FOR VOTING MEMBERS ONLY	Receipt Deadline:
Reference: Jim Mc Geehan, Chairman	October 25, 2005

RETURN BALLOT TO:	Name: Charles A. Passut
Pat Connelly via email (preferred):	Organization: Afton Chemical
patconnelly@chevrontexaco.com	Date: 10/24/05
or via Fax: 510-242-3758	Phone No.: 804-788-6372

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	X☐

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

I have placed the data for the 95% confidence interval into this spreadsheet in the parameter worksheet.

ISMMeritRating1_rev 2.xls

Page 1

Comments:

Afton Chemical votes negative on these proposed Cummins ISM PC-10 limits for the following reasons:

1) It was previously agreed not to set limits before January 23, 2006. Afton feels that as we are currently developing our PC-10 technology, setting ISM limits now is premature, since we do not yet know the proposed limits for the Cummins ISB, Mack T-12 and Caterpillar C13 tests.
2) Afton is also concerned that these proposed ISM PC-10 limits are an upgrade from those for API CI-4 Plus. We have not seen any data to justify an upgrade.

3) Afton needs more time to determine if the newly proposed weighting factors and max/min values improve or hurt the repeatability of the merit values. We would like more information on how these limits were derived and how they relate to the field. With all of the PC-10 matrix analyses currently being performed, Afton has not had adequate time to digest and understand the underlying statistics that were used to develop the limits. Afton is concerned that when using operationally valid TMC 830-2 data, it appears that the new merit maximums do not reflect the precision of the test. In particular, unless supported by a very high level of test and measurement precision, the sludge limits as defined are unacceptable. Currently, sludge ratings are reported to one decimal place. The difference between the proposed maximum and anchor values is only 0.1 units. Effectively, these two numbers are the same. They are less than one standard deviation of the reference oil (about 0.15 units) and are also less than one standard deviation of the rating workshop data. Yet one result is worth 0 merits, the other result is worth 150 merits, and nothing is available in between them.
4) Afton is concerned that TRWL is included as a pass/fail parameter, since this parameter has never been shown to discriminate in the ISM test. We presume that TRWL has been included in the proposed ISM PC-10 merit system as a fail-safe, to catch flyers, but the data suggests that these flyer results are due to operational and/or hardware problems, and are not oil related. Afton believes that it is impractical and unsupported to have TRWL as a pass/fail parameter.

Afton does, however, favor the use of a merit system for this test.

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EXIT CRITERIA BALLOT

ASTM-HDEOCP BALLOT FOR VOTING MEMBERS ONLY Reference: Jim Mc Geehan, Chairman	Issue Date: October 14, 2005 Receipt Deadline: October 25, 2005

RETURN BALLOT TO:
Pat Connelly via email (preferred):
patconnelly@chevrontexaco.com
or via Fax: 510-242-3758

Name: Pat Fetterman
Organization: Infineum
Date: 10/19/05
Phone No.: (908) 474-3099

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	☐	X☐

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

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ISMMeritRating1_rev 2.xls

Page 1

Comments:

Infineum votes negative on these limits for several reasons –

1) As we noted in our original response to including the ISM into PC-10, we are concerned that three separate tests addressing valve train wear are included in this category. We have shared data with both the Valve Train Wear Task Force and the HDEOCP showing that the ISM and ISB give the same ranking of passing and failing oils with a much better separation in the ISB than the ISM. No data has been shared with either the VTWTF or the HDEOCP to contradict these observations, and this makes one of these tests redundant. Given the better separation in

the test, Infineum believes the ISB test should be the only Cummins Valve Train Wear Test selected for PC-10.

2) The ISM was put forward by Cummins as a necessary replacement test for the M11-EGR, and as such it was accepted with very minimal testing. In fact, the only testing run under final conditions and soot loading was a mini-matrix consisting of limited tests with TMC 830-2 as the M11-EGR benchmark oil and TMC 1004 as the discriminating oil. The extent of this testing was significantly less than would be required to develop a meaningful precision statement for the ISM, but it was sufficient to show statistical separation between TMC 830-2 and TMC 1004.
   If the ISM had been presented to industry as a "new test" with significantly revised pass/fail parameters and tighter limits, it is unlikely it would have been accepted without more data to develop a precision statement.
3) The ISM was described to industry as the EMA's "backward compatibility" test to insure no loss of performance versus API CI-4. Since we have already agreed to limits which describe the CI-4 performance of oils in this test, those already agreed limits should suffice for PC-10.
4) Top Ring Weight Loss in the M11-EGR has already been agreed as redundant to Top Ring Weight Loss in the Mack T-10 based on an extensive review of candidate date showing that oils passing the parameter in the T-10 always pass the M11-EGR parameter. Since the T-12 also measures TRWL, and since the Matrix data show both PC-10 Matrix candidates out performing the T-10 reference oil, TMC 820-2, Top Ring Weight Loss in the T-12 should cover the needs of the ISM.
5) Additional ISM reference data is now available which show the above limits would fail TMC 830-2 on wear 40% of the time. TMC-830-2 average Crosshead Weight Loss averages two standard deviations below the pass/fail limit in the M11-EGR, and it has never failed the wear parameter using batch A crossheads. In addition, during the ISM development period, Cummins put forward an oil identified as ISMA which was described as "the best M11-EGR performing oil Cummins had ever seen". The above proposed limits would fail that oil 100% of the time on Injector Adjusting Screw Weight Loss. For a test described to be a "placeholder" to insure there is no loss in valve train wear protection in PC-10, this level of performance is totally unwarranted.

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ISM Exit Ballot Response

David Stehouwer

October 27, 2005

Exit Ballot

Motion	Affirmative	Negative
To accept the Cummins ISM limits for PC-10 and to move forward with an "Exit Criteria Ballot."	9	8

Proposed PC-10 Parameters

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	250	100	250	250	150
Maximum	6.0	90	20	40	8.9
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

Ballot Response

- **Cummins has stated clearly and often that ISM would have it's own limit.**
- **PC-10 performance based on 830, and not on correlation with M11 EGR**
- **ISM / M11 EGR correlation was developed across multiple oils and the pass / fail limit set as an offset from the performance 830**

Ballot Response

- New data has expanded the 830 data set.
  - Is there a severity shift?
  - Cummins needs to re-evaluate 830 limits
- "Backward Compatibility" refers to the use of high Sulfur fuel and its impact on wear, filter plugging and TBN
  - Does not mean "same limits".
- Merit System was a response to ACC desire for flexibility.
  - If it gives problems, we can consider traditional limits