HEAVY-DUTY ENGINE OIL CLASSIFICATION PANEL

OF

ASTM D02.B0.02

October 12, 2005

Chicago O'Hare Crown Plaza – Rosemont, IL

ACTION ITEMS

1. Send data and statistics for ISM Merit System to include in the ISM Exit Criteria Ballot. Cummins

2. Issue the ISM Exit Criteria Ballot. McGeehan

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 7:45 a.m. on Wednesday, October 12, 2005, in Ballroom 2 of the Chicago O'Hare Crown Plaza Hotel, Rosemont, IL.

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 (included as Attachment **1**) was modified to include time for the Valve Train Wear Task Force report and a company presentation.

3.0 Minutes

3.1 The minutes were approved as written.

4.0 Membership

4.1 There were no membership changes.

5.0 NCDT Report

5.1 The NCDT recently conducted a conference call to discuss the EMA requirements of the CAT 1N and 1P and the oxidation requirement of the PC-10 category.

5.2 The EMA met on October 11th and decided to retain the C13 and 1N tests and to add the 1P test to the PC-10 category. See Attachment **3**. The EMA would like to retain a Sequence III test in PC-10. It could be the Sequence IIIF at CI-4 limits or the Sequence IIIG at less severe limits than the current S category requirement. The EMA would still need to study data to decide the relaxed limits for the IIIG. The Sequence III was in the original request, so the decision to be made is which Sequence III test. Without the 1P in the PC-10 category, CAT will not support the 1N in later years. Another reason to include the 1P is that it runs at a higher temperature than the C13. The 1P is also for backward compatibility of legacy products. There are 1P stands available. A straw vote for inclusion of the 1P into

PC-10 yielded 11 votes to include the 1P, 4 votes not to include it and 4 waives. EMA wanted guidance on whether to use the IIIF or IIIG.

5.3 Afton showed data on the Sequence IIIG viscosity increase on PC-10 level 15W-40 fluids. See Attachment **4**. The viscosity increase correlates with NOACK volatility. A 13 on NOACK correlates with 350% viscosity increase. A Sequence IIIG with reduced limits is a real waste of money since it can't be used to qualify an oil in the S category. The EMA could support running either a Sequence IIIF or a Sequence IIIG. The IIIF is adequate for PC-10. The Sequence IIIF runs a higher oil temperature than the Mack T-12. A Sequence IIIG reads to a Sequence IIIF in the S category. Including a Sequence III in PC-10 is only for the viscosity increase requirement.

5.4 Greg Shank **motioned** that the HDEOCP accept the IIIF viscosity increase at CI-4 limits for PC-10. Dave Stehouwer seconded. The motion was amended to clarify that a passing Sequence IIIG viscosity increase of the S category of 150% suffices for a Sequence IIIF viscosity. A question about the base oil interchange of the Sequence IIIF and how it relates to the read across of the T-12 was asked. The ACC and BOI Task Force will discuss it. The **motion carried** with 18 votes for the motion, 1 vote against and zero waives. Inclusion of a Sequence III test was in the original request for PC-10, so this has been resolved.

5.5 Lew Williams **motioned** that the HDEOCP accept the Sequence IIIG at SM viscosity increase limits as the test for the oxidation requirements for PC-10. This is for viscosity increase only. Robert Stockwell seconded. This would replace the previous motion. This would raise the standard for oxidation. The **motion failed** with 8 votes for, 10 votes against, and 1 waive.

5.6 The NCDT will have a conference call to decide the request for inclusion of the 1P test.

6.0 Valve Train Wear Task Force

6.1 Infineum presented data on the various valve train wear tests. See Attachment **5**. The data includes a 10W-30 oil on the Roller Follower Wear Test and 15W-40 oils on the ISB and ISM tests. The ISB test shows the most discrimination. The ISB is the formulation defining test. If an ISB test is passed, then the RFWT and ISM should pass. Dropping the 15W-40 requirement from the RFWT doesn't help since oils will still have to pass the ISB as a 15W-40. The recommendation is to drop the RFWT and ISM tests.

6.2 The Valve Train Wear Task Force Report is included as Attachment **6**. The test sponsors do not support removal of any of the 3 valve train wear tests. Since limits are not defined yet for the ISB, the vote should be postponed until October 27th. The ISB will likely be in the category though.

6.3 Heather DeBaun **motioned** for acceptance of the report and the conclusion that the task force could not find a test to remove and for the disbanding of the task force. Warren Totten seconded. The **motion carried** with 18 votes for, 0 votes against, and 1 waive.

7.0 Matrix Status

7.1 John Zalar gave a verbal report that the matrix is complete and that the statisticians are analyzing the results. They plan a conference call the week of October 17th.

7.2 The cost estimate of the matrix at this time is $5 million, but will be refined with more accurate estimates of lost test costs.

8.0 Mack T-12/T-11

8.1 Greg Shank cautioned that the analysis of the matrix data is not complete, the statisticians have not had their conference call and more data is forthcoming.

8.2 Jim Rutherford presented the preliminary T-12 analysis. See Attachment **7**. Transformations will be needed for the 2 lead parameters, top ring weight loss and for delta IR. The first 4 tests in the matrix and the pre-matrix tests used an old ring batch. The remaining 12 matrix tests and concurrent tests used a new batch of rings. Outlier screening will be used for Bearing Weight Loss (BWL), Top Ring Weight Loss (TRWL), and Cylinder

Liner Wear (CLW). Profiles by cylinder will be used for TRWL and CLW. A first pass precision analysis shows Ep values somewhat below the ACC criterion of 1. The plan is that complete analyses will be finished by October 27th. Pass/fail limits for the T-12 test will be proposed October 27th.

8.3 Greg has received feedback on the T-11 slope proposal. Refinements are being made for a final proposal to be shown October 27th.

9.0 Cummins ISB

9.1 Warren Totten presented Phil Scinto's preliminary ISB test analysis. See Attachment **8**. There could be a soot correction for Tappet Weight Loss. The precision summary shows that all parameters have an Ep greater than 1 for repeatability and just less than 1 for reproducibility on tappet weight loss. Oil 830-2 is considered a borderline pass. The Average Cam Wear values are snap gage measurements.

9.2 A motion was made in the Cummins Surveillance Panel to move the test forward with cam wear and tappet wear as pass/fail parameters, crosshead weight loss as rate and report and remove all other parameters. See Attachment **9**. Limits will be discussed at an October 25th Surveillance Panel meeting and proposed at the October 27th HDEOCP meeting with an exit criteria ballot for the test.

9.3 Warren Totten **motioned** that the motion of the Surveillance Panel be accepted by the HDEOCP and the test carried forward. Heather DeBaun seconded. Rate and report items will be re-evaluated in the future for relevance. The **motion passed** unanimously with 19 votes for, 0 against and 0 waives.

10.0 Caterpillar C13

10.1 Elisa Santos presented a summary of her preliminary analysis to the C13 Surveillance Panel. See Attachment **10**. There appears to be an inverse relationship with base oil and technology on oil consumption. The Ep is greater than 1 for Top Land Carbon (TLC) and Top Land Heavy Carbon (TLHC), approximately 0.85 for Top Groove Carbon (TGC) and approximately 0.65 for Delta Oil Consumption (OC) and Top Groove Fill (TGF).

10.2 Steve Kennedy showed a proposed merit system for the C13 that was presented to the C13 Surveillance Panel. See Attachment **11**. This is similar to existing merit systems in use. The parameters selected so far are TLHC, Delta OC, Unweighted Deposits (UWD), and TGC. Final limits and weighting factors need to be completed following final statistical analysis and agreement by stakeholders. The Merit System should provide clear separation of Oil A and Oil D/PC-10G as failing and passing oils. Merit calculations of the matrix results were shown. Stuck rings and scuffing would stay as individual parameters outside of the merit system. Comments were made that some refinements should be made to the weighting factors and scale of values. The statisticians need to complete the analysis and the Surveillance Panel needs to spend some time on this to refine it. CAT supports a merit system.

10.3 Abdul Cassim gave a presentation of comments from the C13 Surveillance Panel. See Attachment **12**. The severe lab and the mild lab have been working together exchanging parts and thoughts. A lab bias task force has been formed and already has a list of items to investigate. The main parameters for the C13 are OC, TLHC, TGC, and UWD. Work is ongoing to improve the 1P test.

11.0 ACC and NCDT Report

11.1 Lew Williams gave a presentation on behalf of ACC. See Attachment **13**. ACC still has a 15 month best case estimate to run programs. Multiple issues could drive program timing to exceed 15 months. Setting final limits before the end of the demonstration period represents an unwarranted risk. The recommended path forward includes finalization of tests in the category, analysis of the impact of the C13 on the timeline and ways to compress the timeline, and finalize limits on January 23, 2006. Test stands are not calibrated at this time. When analysis is complete and limits are defined, an LTMS will be developed and stand calibration will be determined. Some stands may not get calibration and tests run on those stands can not be used for programs. First license then would be January 2007.

11.2 Bill Runkle showed the NCDT timeline. See Attachment **14**. Anything that changes the demonstration period or product qualification does not move up the first license date. Much discussion about how to shorten the timeline or extend the first license date ensued with no change.

12.0 Cummins ISM: PC-10

12.1 Dave Stehouwer showed an updated ISM Merit System proposal. See Attachment **15**. This is for the ISM in PC-10. Cummins is proposing a change to the weighting factors and maximum values based on field issues. Statistics were used to develop the values. The updated values appeared to raise the performance requirement of the ISM. The statistics and data will be included in the exit ballot.

12.2 Dave Stehouwer **motioned** and Robert Stockwell seconded that the updated limits shown be accepted for an exit criteria ballot to be issued as the merit system for the ISM for PC-10. The **motion carried** with 17 votes for, 1 vote against and 1 waive.

13.0 Cummins Oil Viscosity Increase

13.1 Cummins have seen some viscosity increase issues in the field. Dave Stehouwer gave a presentation showing this. See Attachment **16**. A possibility exists that a viscosity limit may be applied to the ISB test. Hopefully, the T-11 test will handle the issue. Cummins is requesting that any data on oils that have run both the T-11 test and the ISB test be shown to them.

13.2 Charlie Passut showed T-11 and ISB data. See Attachment **17**. The slope of viscosity increase vs. soot is very similar for the T-11 and the ISB.

14.0 Next meetings

14.1 The meeting in San Antonio on October 27th is planned to last most of the day.

14.2 The November 18th meeting will be dropped and there will be meetings December 5th and 6th.

15.0 The meeting was adjourned at 12:15 pm.

Final Agenda
ASTMSECTION D.02.BO.02
HEAVY-DUTY ENGINE OIL CLASSIFICATION PANELS

Crowne Plaza, Chicago O'Hare, Rosemont, IL (847-671-6350)
October 12, 2005
7:30 am-12:15 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	7:30-7:35
Minutes Approval	• September 21, 2005	Group	7:35-7:40
Membership	• Changes: Additions	Jim Mc Geehan	7:40-7:45
EMA's Requirements NCDT Report	• Cat 1N and Cat 1P • IIIF/IIIG or Mack T-12	Greg Shank Bill Runkle	7:45-8:15
Matrix Status	• Cummins ISB; Mack T-12; Caterpillar C13	John Zalar (Program Manager)	8:15-8:25
Mack T-12/T-11	• Mack T-12 analysis of all data • Mack T-11 proposal • Discussion	Greg Shank Jim Rutherford	8:25-9:15
Cummins ISB	• Analysis of all data • Discussion	Dave Stehouwer Phil Scinto	9:15-10:00
Coffee break	• Room and coffee fee		10:00-10:30
Caterpillar C13	• Analysis of all the data • Discussion	Abdul Cassim Elisa Santos	10:30-11:30
ACC and NCDT Report	• ACC's timing concerns • First license date	Lew Willians Bill Runkle	10:30-11:00
Cummins ISM: PC-10	• Merit system and proposed limits. • Discussion/ Vote/Exit-Ballot	Dave Stehouwer Group	11:00-12:00
New Business	•		12:00-12:10
Next Meetings	• October 27th SWRi, San Antonio • November 18th Chicago (7am-11am) • December 6th Norfolk, Virginia		12:10-12:15

HDEOCP Meeting, October 12th, 2005, Chicago, IL

	Name	Company	Member
1	MATT URBANAK	SHELL	Y
2	WARREN TOTTEN	CUMMINS	Y
3	JIM MORITZ	PE	N
4	Charles PASSUT	Afton	Y
5	Cathy Devlin	Afton	N
6	TOM COUSINEAU	AFTON	N
7	Todd Dvorak	Afton	N
8	Jim Rutherford	Oronite	N
9	Ken Chao	Deere & Company	Y
10	David Daber	ConocoPhillips	Y
11	JIM GUTZWILLER	INFINEUM USA LP	N
12	PAT FETTERMAN	INFINEUM	Y
13	Nancy Diggs	Infineum	N
14	Elisa Santos	Infineum	N
15	Joan Evans	Infineum	N
16	Ben Weber	SwRI	N
17	Scott Richards	SWRI	N
18	Mesfin Belay	Detroit Diesel	Y
19	BRAD CARTER	PERKINELMER	N
20	Jason Bowden	OH Technologies, Inc.	N
21	DWIGHT BOWDEN	OH TECHNOLOGIES, INC	N
22	JOHN ZALAR	ASTM TMC	N
23	JEFF CLARK	ASTM TMC	N
24	GREG SHANK	Volvo POWERTRAIN	Y
25	Chris Laroo	EPA	N

HDEOCP Meeting, October 12th, 2005, Chicago, IL

		Name	Company	Member
✓	26	Scott Zechiel	Detroit Diesel	NO
✓	27	Scott Harold	Ciba	YES
✓	28	Bill Kleiser	Chevron Oronite Co.	Yes
✓	29	Wim van Dam	Chevron Oronite	No
✓	30	Heather DeBaun	International Truck & Engine	YES
✓	31	David B Smith	APT	No
✓	32	W. A. Runkle	The Valvoline Co.	YES
✓	33	Roger Gault	EMA	No
✓	34	David Stehouwer	Cummins	No
✓	35	Steven Herzog	Rohmax	YES
✓	36	Lewis Williams	Lubrizol	Yes
✓	37	Dave Dunca[illegible]	Lubrizol	No
✓	38	Chris Castanien	Lubrizol	No
✓	39	AbdulHamid Cassim	CAT	Yes
✓	40	Dan Pridemore	Afton	No
✓	41	Mike Lynskey	BP	Yes
✓	42	[illegible]	TEI	No
✓	43	Ken Goshorn	Volvo Powertrain	No
✓	44	Robert Stockwell	GM PT	YES
✓	45	Steven Kennedy	ExxonMobil	Yes
✓	46	[illegible]	Chevron	Yes
	47			
	48			
	49			
	50			

mailing 115[illegible]

EMA Request for PC-10

- Retain CAT C13 Test in Category
- Retain CAT 1N Test in Category
- Add CAT 1P Test to category

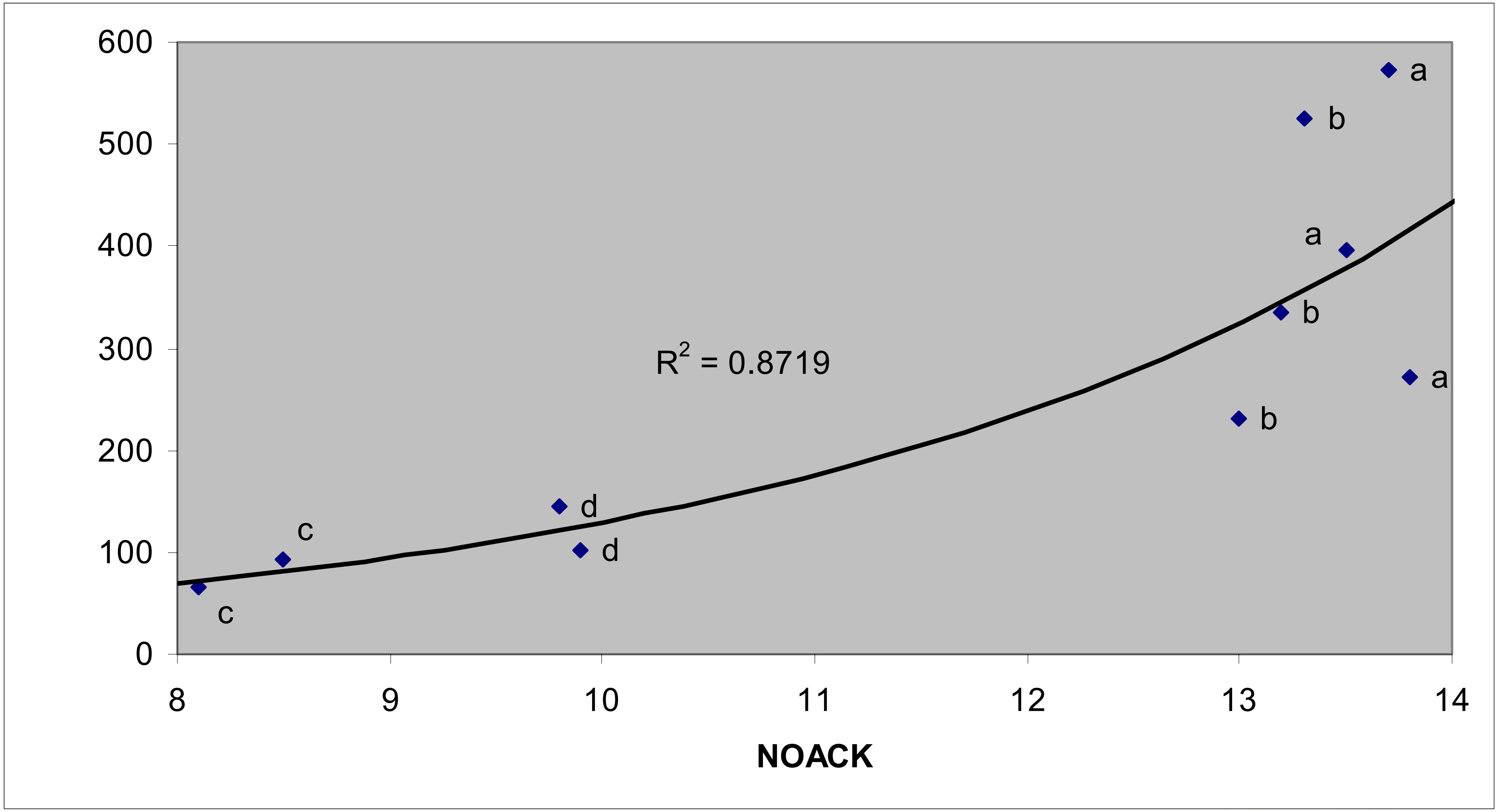
EMA Request for PC-10

- Retain Sequence III Test
- IIIF or IIIG Test
- IIIF at CI4 Limits or IIIG @

Less Severe Limits the S Category

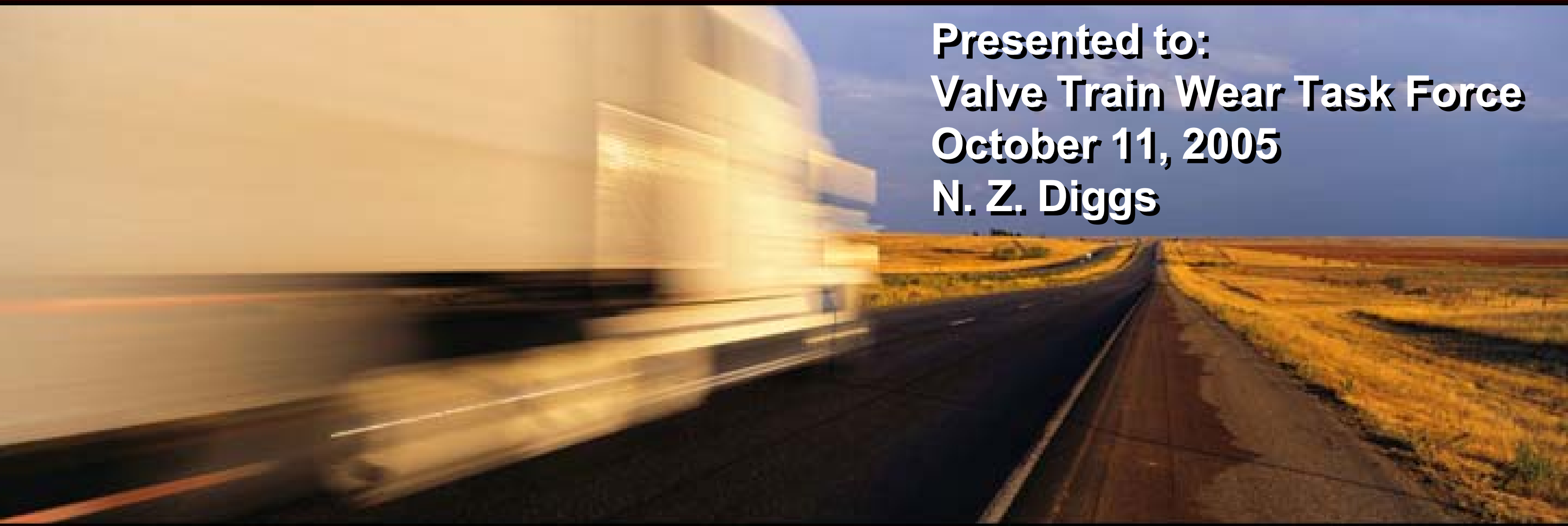
A Passion for Solutions™

Sequence IIIG % Viscosity Increase for Representative PC-10 15W-40 Fluids



Afton CHEMICAL

Infineum Technology: Miles Ahead



Presented to:
Valve Train Wear Task Force
October 11, 2005
N. Z. Diggs

Infineum

PC 10

RFWT Performance

- Infineum test database:

Grade	Pass Rate	Oils Tested
10W-30	**92%**	25
10W-40	**100%**	2
15W-40	**100%**	13

- 10W-30's are slightly harder to pass than 15W-40's
- Most programs test in 10W-30 first in order to get VGRA coverage to 15W-40
- Industry does not gain anything by dropping requirement for 15W-40 RFWT.

Valve Train Wear Test Comparison

- Comparison of similar oils in different valve train wear tests:

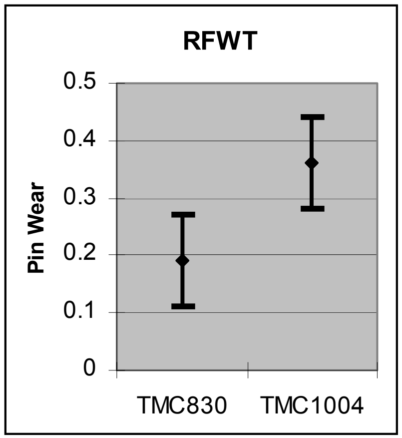
Oil Description	Oil A-1 Gp I 0.12% P	Oil A-2 Gp II 0.12% P	Oil B Gp I 0.12% P	Oil C Gp I 0.12% P	TMC830 Avg	TMC1004 Avg
Performance Level Grade	PC-10 15W-40	PC-10 15W-40	PC-10 15W-40	**CI-4 10W-30**	CI-4 15W-40	CG-4 15W-40
M11EGR Crosshead Wear	--	--	--	16.8	13.8 (3.1)	--
ISM Crosshead Wear	7.0	--	6.1	--	5.3 (1.4)	7.9 (1.2)
ISB Tappet Wear	134*	56	135	--	84 (18)	193 (9)
ISB Crosshead Wear	2.9	2.0	2.0	--	1.9 (0.8)	5.6 (2.3)
RFWT pin wear	--	0.22	--	0.28	0.19 (1 test)	0.36 (0.08)

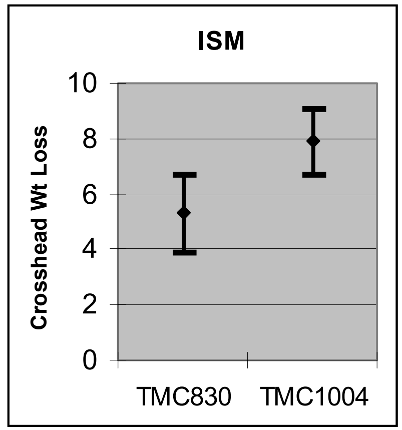
*134 was on early ISB procedure.

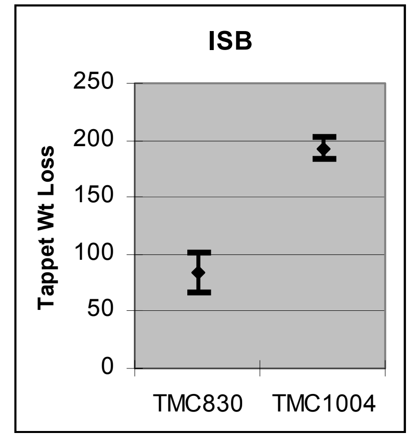
Standard deviation in parentheses.

Valve Train Wear Test Comparison

- Comparison of reference oils in different valve train wear tests: (graphical comparison)







- The ISB test shows much more discrimination than the ISM or the RFWT.
- A CG-4 oil like TMC1004 is may occasionally pass the ISM and the RFWT.
- An oil formulated to pass the ISB provides the most wear protection.

Recommendations

- Dropping the RFWT requirement for 15W-40 oils:
  - No reduction in antiwear protection because oils will have to pass the Cummins ISB.
  - However, industry gains little by dropping this requirement because 10W-30 reads to 15W-40 now
- Dropping RFWT altogether:
  - No reduction in antiwear protection because oils will have to pass the Cummins ISB
- Cummins ISM vs ISB:
  - The ISB shows better discrimination than the ISM.
  - In our experience, an oil formulated to pass the ISB (e.g. TMC830) will easily pass the Cummins ISM.
  - No reduction in antiwear protection.
- **Keeping the RFWT and the ISM in the PC-10 category adds redundant tests and drives unnecessary test costs.**

- Task Force met 10-10-05
- Reviewed tests' appetites, data
- Test sponsors do not support the removal of any of the three valve train wear tests
- Request the HDEOCP disband the Valve Train Wear Task Force

Chevron ORONITE

Mack T-12
Precision Matrix Preliminary Analyses

Presented to T-12 Task Force
October 11, 2005

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TEAM ORONITE
EMPOWERED TO EXCEL.

Transformations

Using all data (26 tests) with the full model (oil, lab, stand(lab), rings), we get

Box-Cox Transformations

DPBFNL	natural log
DPB2FNL	natural log
CLW	none
TRWL	natural log
OCFNL	none
BWLU	none
IR250300	1/sqrt

The natural log transformations were used in these analyses.

Outlier Screening

TMC dataset has some outlier screened, some not.

Within Test Cylinder Profiles Tests for Significnace

	Cylinder	x Oil	x Stand	x Lab	x Rings
BWLU					significant
InTRWL	significant			significant	
CLW	significant		significant	marginal	

For InTRWL and CLW, there is evidence of a profile. However, the interaction with lab says the profiles aren't the same for all labs.

For these analyses, outlier adjustments without profiles were used.

If labs F & D are removed for InTRWL and labs B, F & D are removed for CLW, the cylinder x lab interaction becomes insignificant but the cylinder effect remains significant. However, for CLW, the cylinder x stand interaction is still marginally significant

MatrixAnalCylinders7.sfs

All data

1. First pass model all data 26 tests:

   Result = f(oil, stand(lab), lab, rings)

   Results: lnPbFNL, lnDPb2FNL, CLWoa, lnTRWLoa, OCFNL, BWLUoa, IR250300

2. First pass model "outliers"

   - lnDPB2FNL 55713 matrix PC10E lab A
   - CLWoa 55716 matrix old rings PC10B lab G
   - OCFNL 55729 matrix old rings PC10E lab B
   - IR250500 49991 prematrix old rings 820-2 lab D

3. First pass model significant effects

   Rings: OCFNL, lnTRWLoa

   Oil & Lab: CLWoa

All tests with new rings

1. New rings model 16 tests:

   Result = f(oil, stand(lab), lab)

   Results: InPbFNL, InDPb2FNL, CLWoa, InTRWLoa, OCFNL, BWLUoa, IR250300
2. First pass model "outliers"
   - InPbFNL 55713 PC10E lab A
   - InDPB2FNL 55713 PC10E lab A
   - BWLUoa 55713 PC10E lab A
   - IR250300 56726 PC10E lab B
3. First pass model significant effects

   Oil & Lab: CLWoa

   Oil: IR250300

   Marginally significant:

   Oil: OCFNL

   Lab: IR250300

Matrix only

1. Matrix only model all data 16 tests:

   Result = f(oil, lab, rings)

   Results: InPbFNL, InDPb2FNL, CLWoa, InTRWLoa, OCFNL, BWLUoa, IR250300
2. Matrix only model “outliers”
   - InPbFNL 55713 PC10E lab A
   - InDPB2FNL 55713 matrix PC10E lab A
   - CLWoa 55716 matrix old rings PC10B lab G
   - OCFNL 55729 matrix old rings PC10E lab B
   - BWLUoa 55713 matrix PC10E lab A
3. Matrix only model significant effects

   Oil & Lab: CLWoa

   Marginally significant:

   Rings: InTRWLoa, OCFNL,

   Oil & Lab: IR250300

MatrixOnly.htm

MatrixOnlyResids.sfs

Precision Analyses

	First Pass Analysis		New Rings Only		Matrix Only			Anchor	MAD Survey Median
	S_{pp}	E_p	S_{pp}	E_p	S_{pp}	E_p			
In(ΔPb0-300)*	0.373	0.61	0.352	0.64	0.329	0.69		20	4.5
In(ΔPb250-300)*	0.400	0.72	0.464	0.62	0.424	0.68		7	2
Cylinder Liner Wear oa	2.8	1.43	1.5	2.67	2.1	1.90		20	4
In(Top Ring Weight Loss oa)*	0.324	0.78	0.386	0.65	0.377	0.67		50	12.5
Oil Consumption	6.5	1.08	3.3	2.12	7.1	0.99		60	7
BWLUoa	40.6		37.2		35.3				
IR250300	68		25		32				

$$^*E_p=(LN(anchor+median/2)-LN(anchor-median/2))/ ((LN(anchor)+S_{pp}/2)-(LN(anchor)-S_{pp}/2))$$

Cummins ISB
Preliminary-Unofficial
Matrix Analysis

October 10, 2005

Analysis Summary

- 18 Valid Tests Analyzed
  - 15 Matrix Tests, 3 Reference Tests
  - Tappet Wear, Camshaft Wear, Crosshead Wear, Valve Adjusting Screw 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 Stand Effects that are Model Dependent
- Transformations
  - Valve Adjusting Screw
  - Higher Wear Oils Would Likely Require for Other Parameters
- Possible Lab Differences that are Model Dependent
- Oil Discrimination
  - Tappet Weight Loss
  - Ppossible for Camshaft Wear (Model Dependent)
- All 4 Wear Parameters Meet ACC Precision
  - Note that Tappet Wear Between Stands and Labs Does Not
- There is Some Redundancy Among Parameters

Concerns

- Discrimination Never Established for:
  - Valve Adjusting Screw
- Model Dependent Conclusions
  - Some Confounding (Stand, StgB Torque and Soot)
- Reference Frequency Given Engine, Stand and Lab Differences
  - Very Large Stand Effects for Tappet Wear
- Valve Adjusting Screw Outliers
  - ***7 of 18 Tests Affected by Outlier Criteria***

Precision Summary

	Repeatability s (Within Stand)	Reproducibility s (Btween Stand)	Reproducibility s (Between Lab)
Tappet Wear (mg) Soot Adj	7.7091 Ep=1.95	16.8994 Ep=0.89	17.3196 Ep=0.87
Camshaft Wear (mg)	4.5111 Ep=3.33	7.1589 Ep=2.10	7.1589 Ep=2.10
XHead Wear (mg) Soot Adj	0.3655 Ep=2.05	0.3655 Ep=2.05	0.5138 Ep=1.46
LN Valve Adj Screw (mg)	0.4540 0.7690 (at mean) Ep=1.95	0.4540 0.7690 (at mean) Ep=1.95	0.5194 0.8821 (at mean) Ep=1.70

Target Summary

	Oil 830-2	PC10B	PC10E
Tappet Wear (mg) Soot Adj	LS Mean = 87.86 Mean = 84.3667 S = 16.1065	LS Mean = 93.11 Mean = 91.1429 S = 17.6173	LS Mean = 67.13 Mean = 56.38 S = 9.4848
Camshaft Wear (mg)	LS Mean = 40.45 Mean =40.2667 S = 9.2058	LS Mean = 45.10 Mean = 43.00 S = 5.835	LS Mean = 37.11 Mean = 34.14 S = 5.0093
XHead Wear (mg) Soot Adj	LS Mean = 2.068 Mean = 2.0667 S = 0.5279	LS Mean = 2.05 Mean = 2.1143 S = 0.4180	LS Mean = 1.940 Mean = 1.980 S = 0.4868
LN Valve Adj Screw (mg)	LSM = 0.4343 (1.54) M = 0.4343 (1.54) S = 0.0.3438	LSM = 0.5053 (1.66) M = 0.5531 (1.74) S = 0.6289	LSM = 0.6157 (1.85) M = 0.5282 (1.70) S = 0.4690

Correlation Summary

Between Oil and Within Oil Correlations. While No Correlations Exceed 0.85, There is Some Redundancy Among the Parameters. 95% of the Variability In the 4 Parameters Can be Captured in 3 Principal Components.

Between Oil	OSACSW	OSATWL	OSACWL	LNOSVASL
OSACSW	1.00	0.81	0.57	0.22
OSATWL	0.81	1.00	0.55	0.27
OSACWL	0.57	0.55	1.00	0.27
LNOSVASL	0.22	0.27	0.27	1.00

Within Oil	OSACSW	OSATWL	OSACWL	OSVASL
OSACSW	1.00	0.60	0.55	-0.33
OSATWL	0.60	1.00	0.44	0.24
OSACWL	0.55	0.44	1.00	-0.01
OSVASL	-0.33	0.24	-0.01	1.00

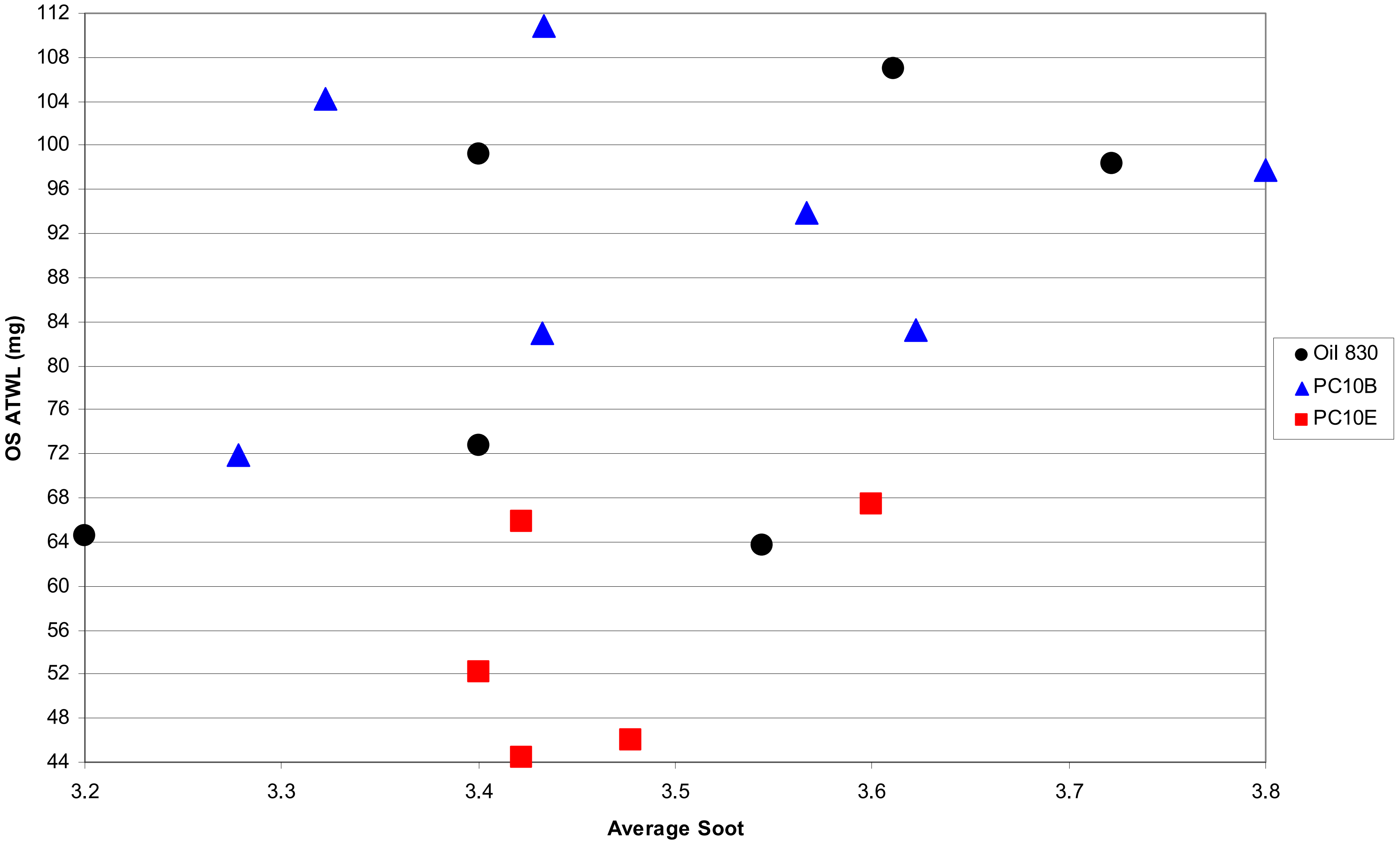
Average Tappet Weight Loss

- ATWL = f(Lab, Stand(Lab), Oil, Avg Soot)
  - Oil Discrimination (Overall p-value=0.002)
    - PC10E Lower than Other Oils
  - Lab Differences (Overall p-value=0.006)
    - Lab B Higher than Lab G
    - Stand within Lab Effects (Overall p-value=0.007)
  - Correction for Average Soot
    - Slope=75.11 (Correct Back to 3.481% Soot)

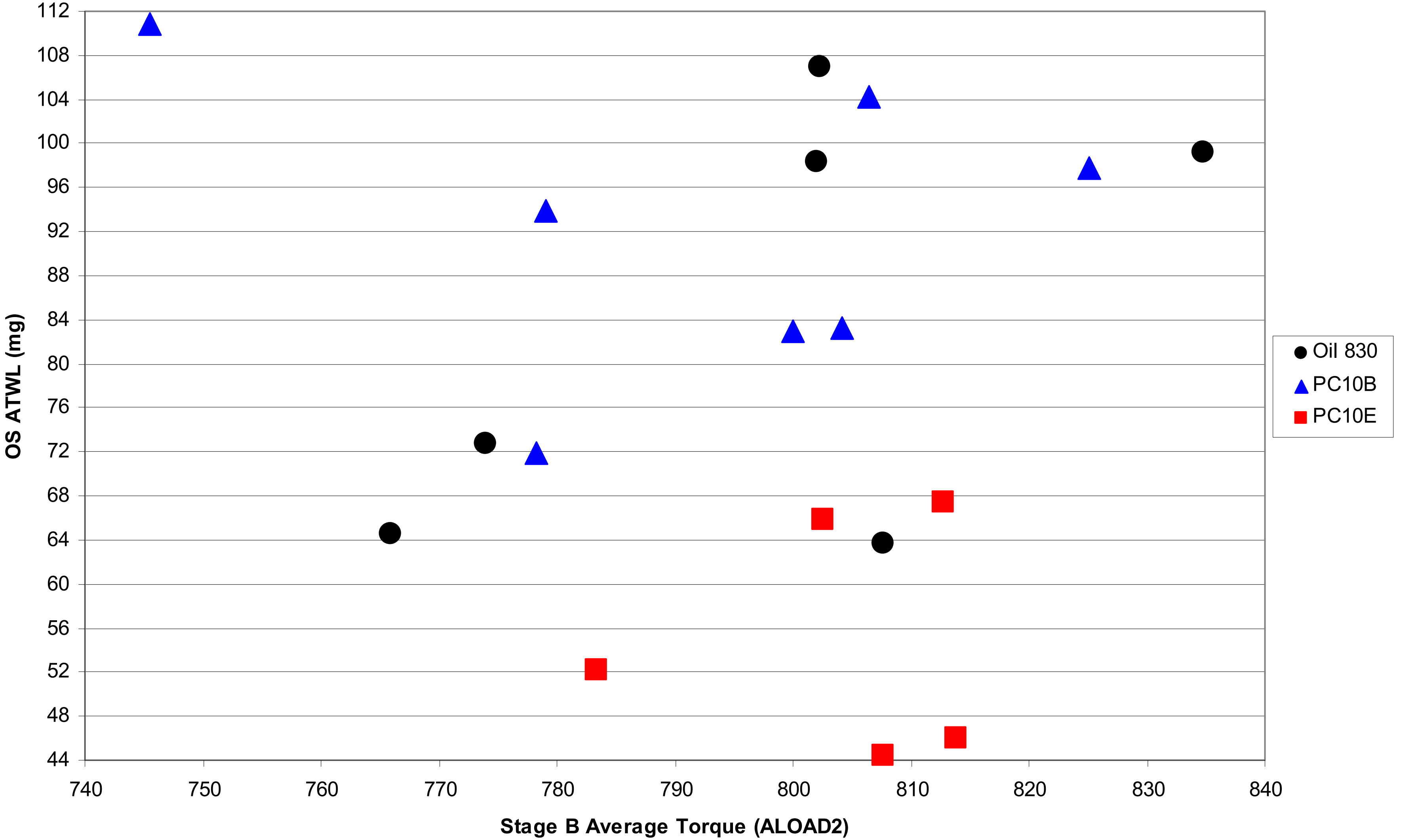
Tukey Adjusted p-Values

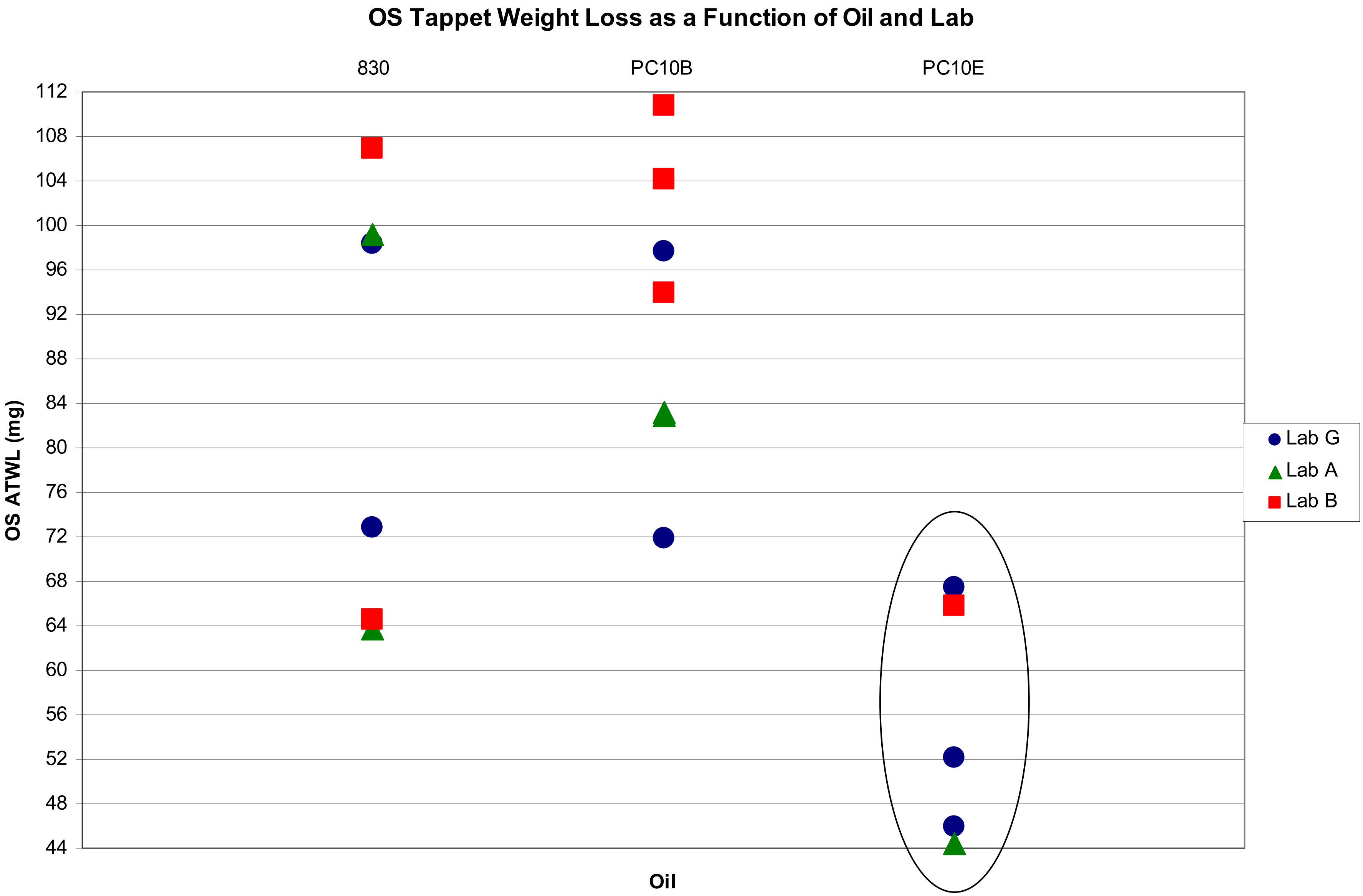
	Oil 830-2	PC10B	PC10E
Tappet Wear (mg) Soot Adj	LS Mean = 87.86 StdErr = 3.405	LS Mean = 93.11 StdErr = 3.393	LS Mean = 67.13 StdErr = 4.324
Oil 830-2		0.57	***0.01***
PC10B	0.57		***0.025***
PC10E	***0.01***	***0.025***	

OS Tappet Weight Loss as a Function of Oil and Soot

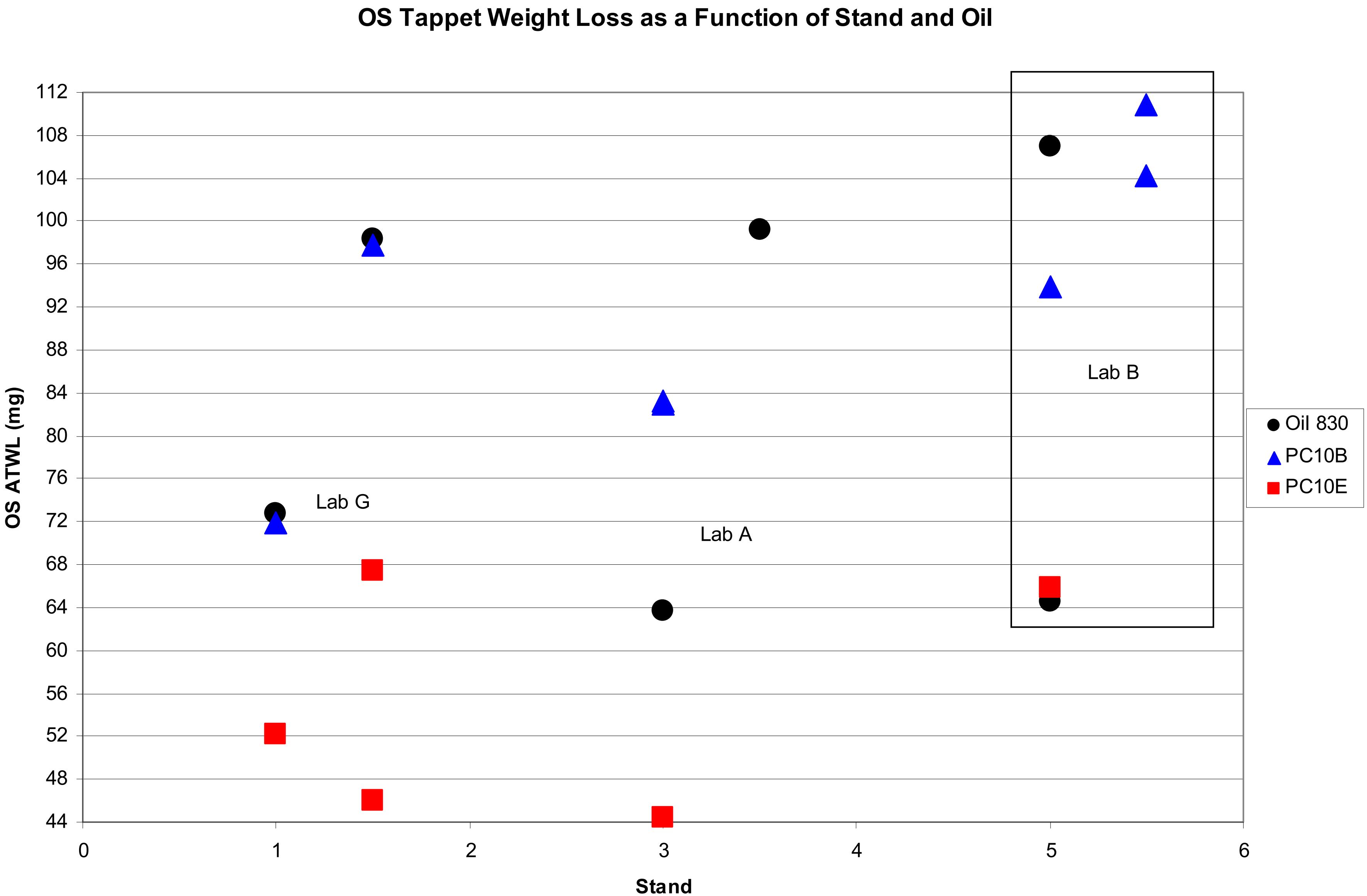


OS Tappet Weight Loss as a Function of Stage B Average Torque





Unofficial ISB Matrix Analysis

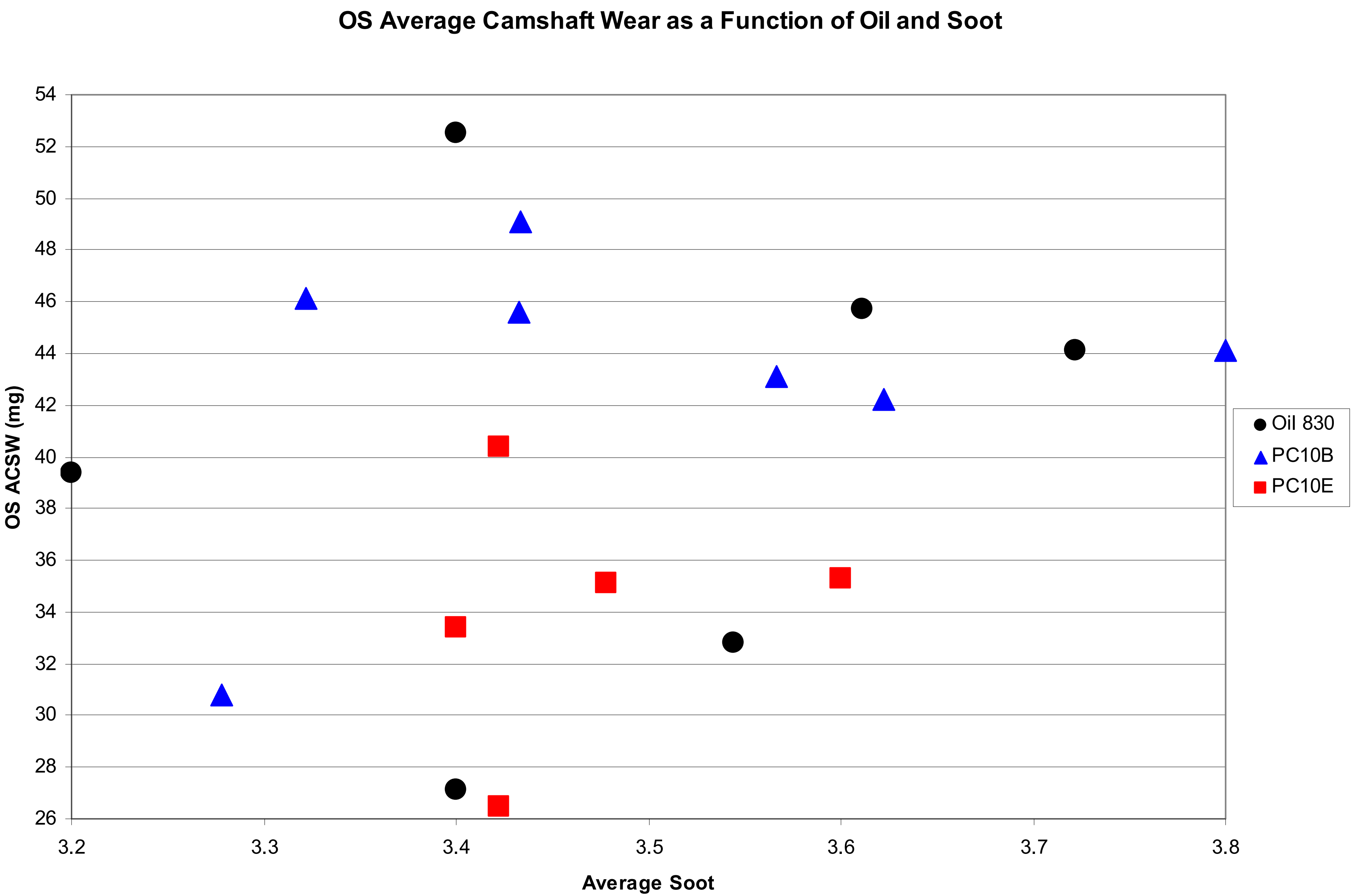

OS Tappet Weight Loss as a Function of Stand and Oil
OS ATWL (mg)
112
108
104
100
96
92
88
84
80
76
72
68
64
60
56
52
48
44
0
1
2
3
4
5
6
Stand
Lab G
Lab A
Lab B
Oil 830
PC10B
PC10E

Average Camshaft Wear

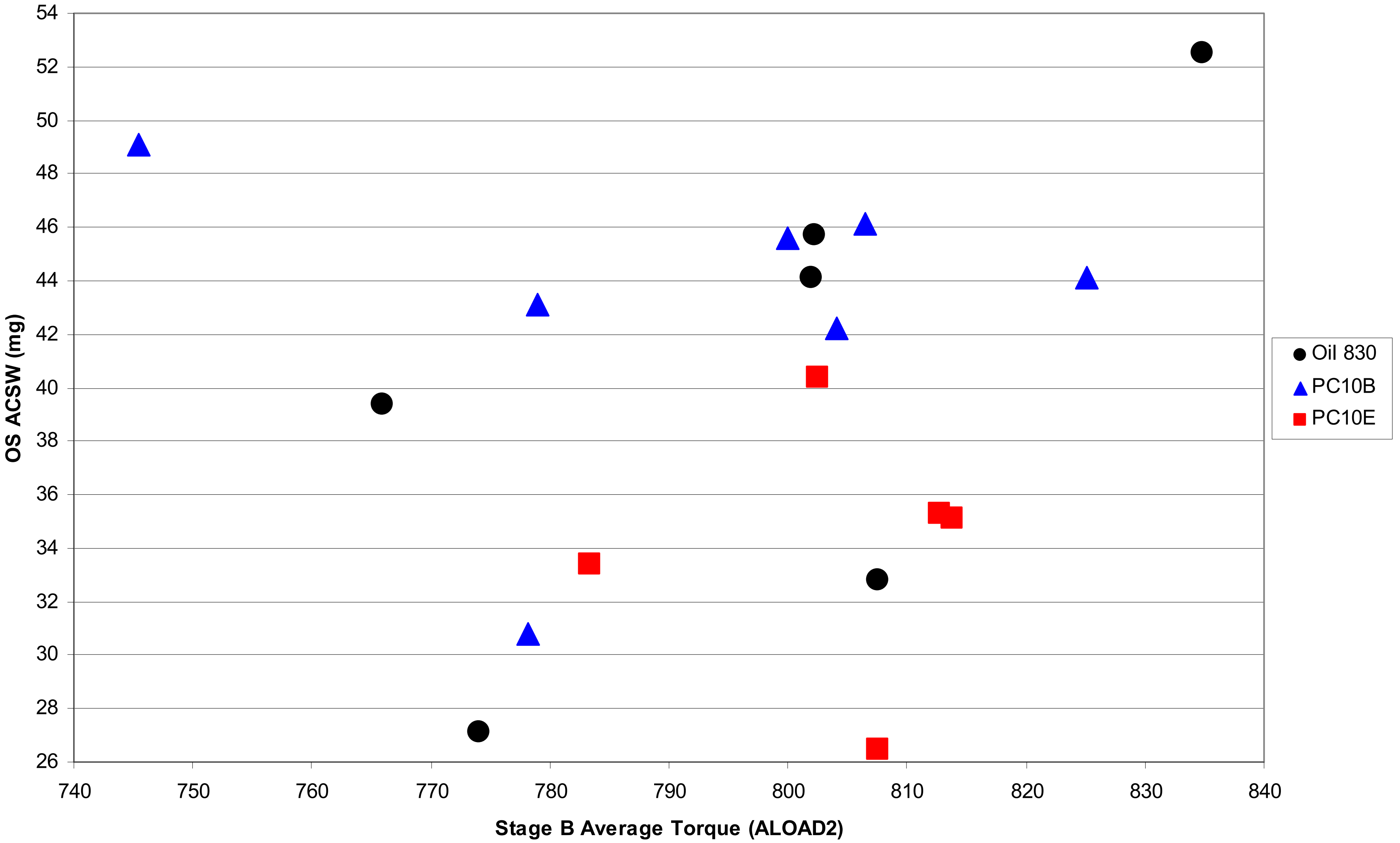
- ACSW = f(Lab, Stand(Lab), Oil)
  - Some Evidence of Oil Discrimination ($p=0.06$)
    - PC10B versus PC10E ($p=0.05$)
  - Lab Differences (Overall p-value=0.03)
    - Lab G Lower than Other Labs
    - Stand within Lab Effects (Overall p-value=0.01)
  - Other Possible Effects
    - Soot
    - Stage B Average Torque

Tukey Adjusted p-Values

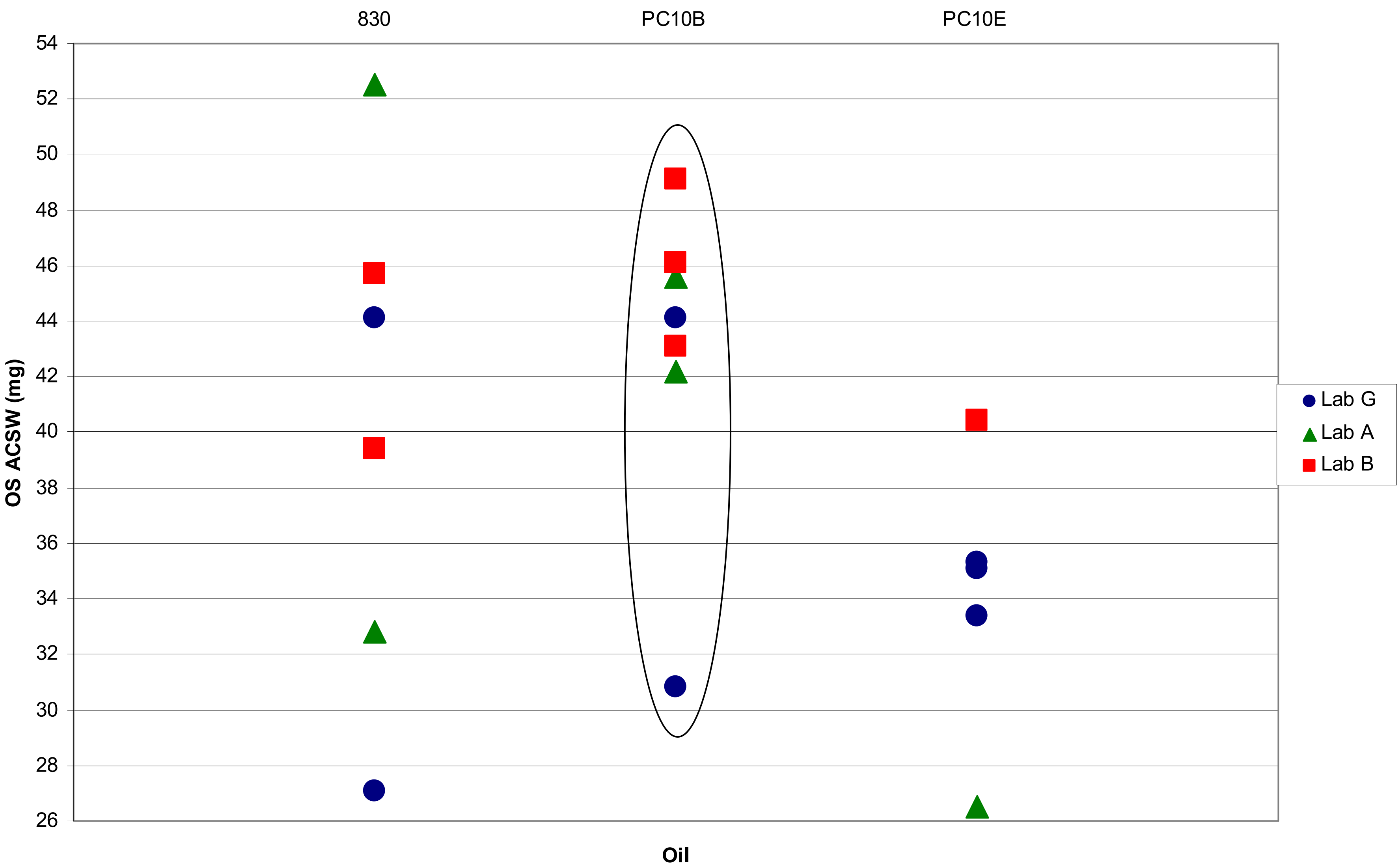
	Oil 830-2	PC10B	PC10E
Camshaft Wear (mg)	LS Mean = 40.45 StdErr = 1.980	LS Mean = 45.10 StdErr = 1.980	LS Mean = 37.11 StdErr = 2.312
Oil 830-2		0.29	0.51
PC10B	0.29		***0.05***
PC10E	0.51	***0.05***	


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

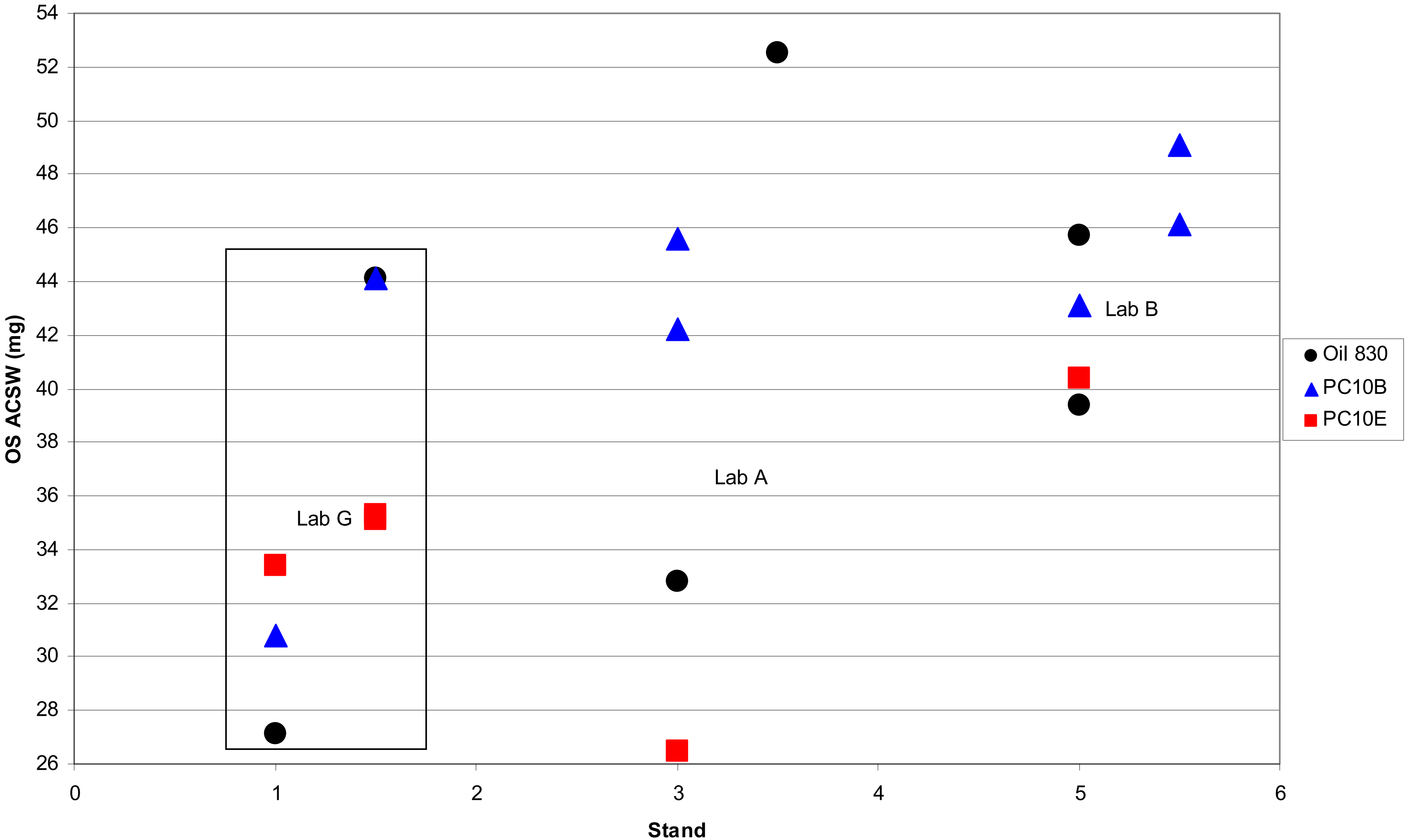
OS Average Camshaft Wear as a Function of Stage B Average Torque



OS Average Camshaft Wear as a Function of Oil and Lab



OS Average Camshaft Wear as a Function of Stand and Oil

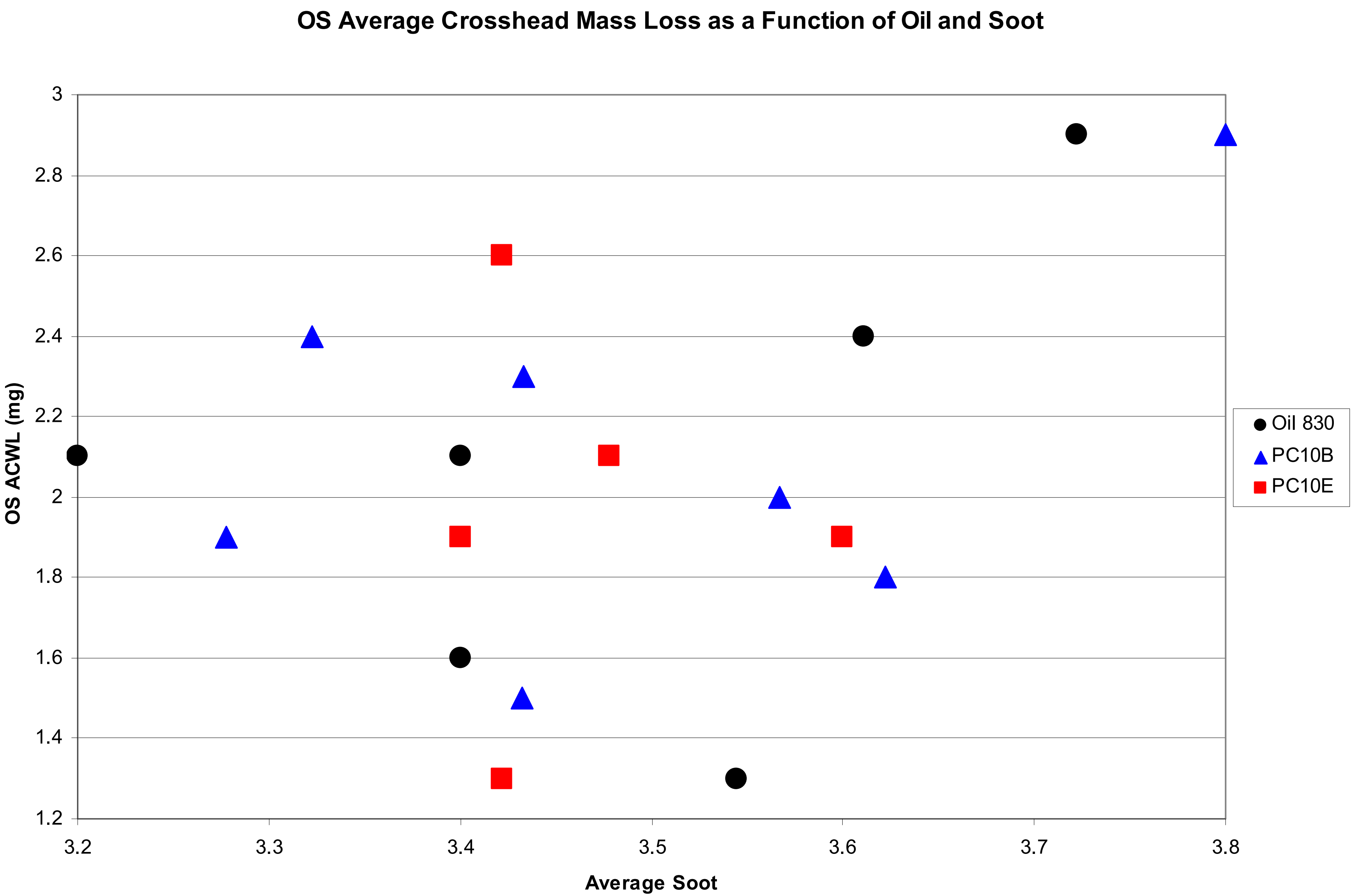


Average Crosshead Mass Loss

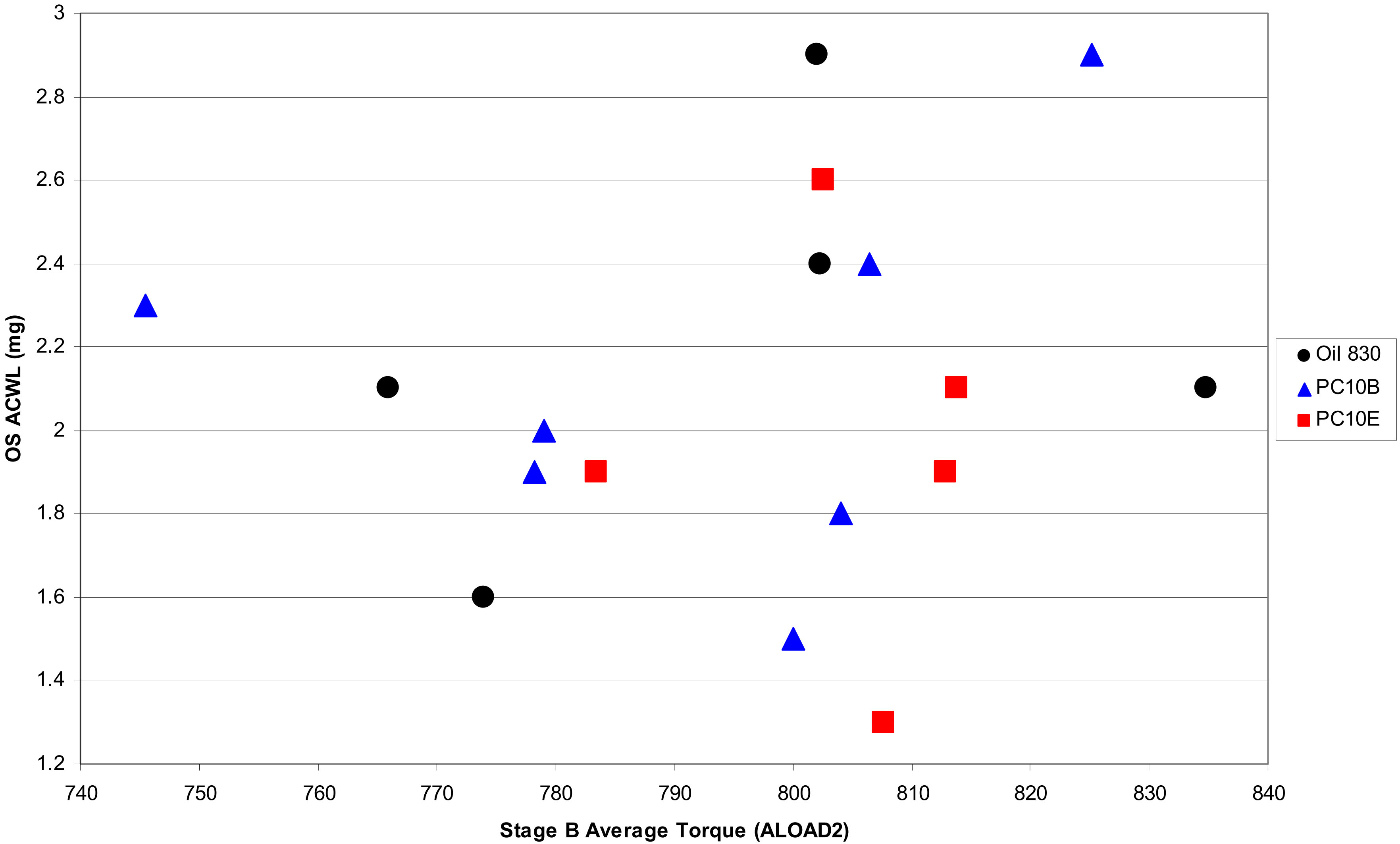
- ACWL = f(Lab, Oil, Avg Soot)
  - No Oil Discrimination (Overall p-value=0.84)
  - Lab Differences (Overall p-value=0.01)
    - Lab A Lower than Other Labs
    - No Stand within Lab Effects
  - Correction for Average Soot
    - Slope=1.31 (Correct Back to 3.481% Soot)

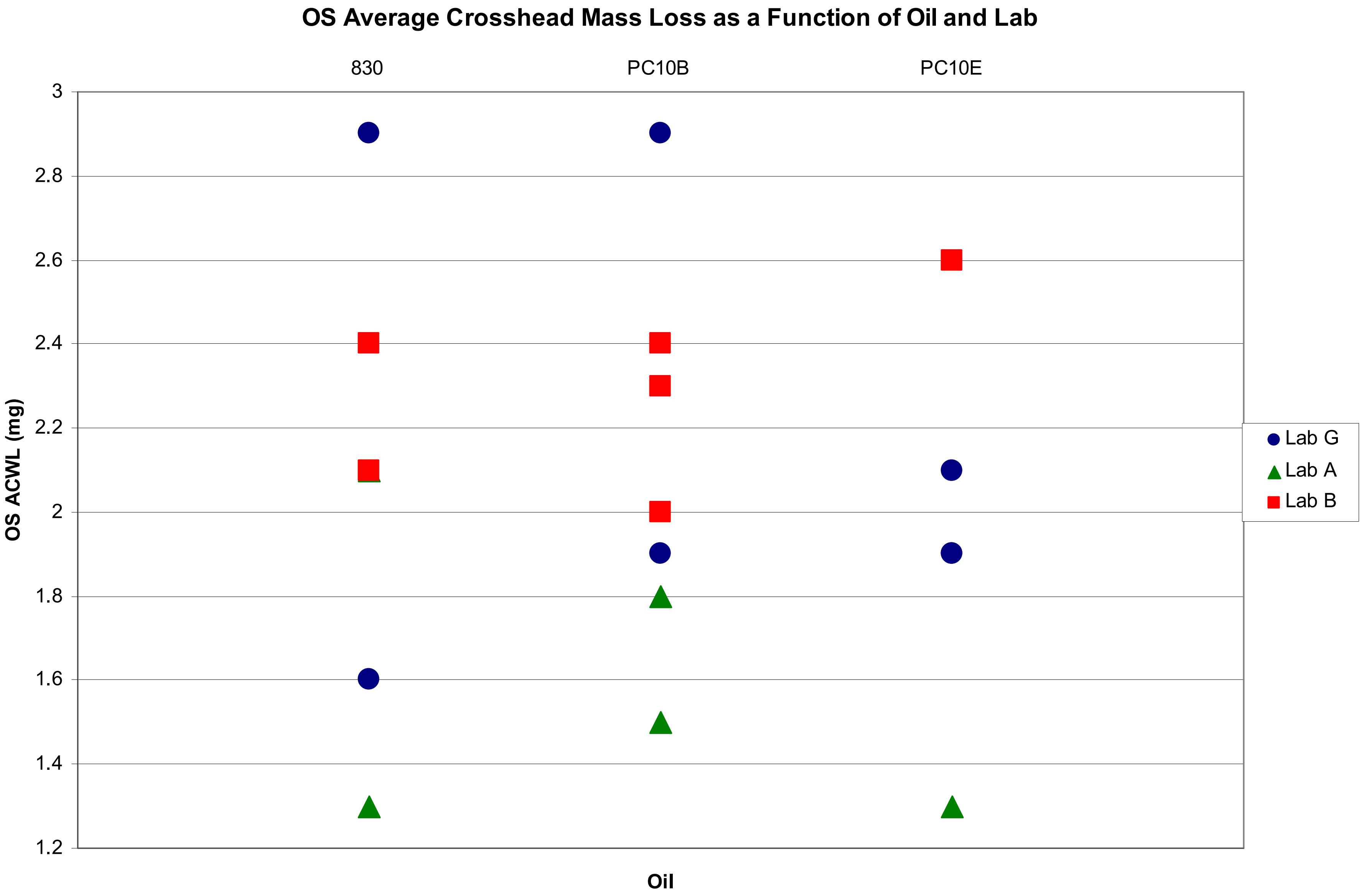
Tukey Adjusted p-Values

	Oil 830-2	PC10B	PC10E
XHead Wear (mg) Soot Adj	LS Mean = 2.068 StdErr = 0.1492	LS Mean = 2.050 StdErr = 0.1399	LS Mean = 1.940 StdErr = 0.1723
Oil 830-2		0.99	0.84
PC10B	0.99		0.88
PC10E	0.84	0.88	


OS Average Crosshead Mass Loss as a Function of Oil and Soot
OS ACWL (mg)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
3.2
3.3
3.4
3.5
3.6
3.7
3.8
Average Soot
Oil 830
PC10B
PC10E

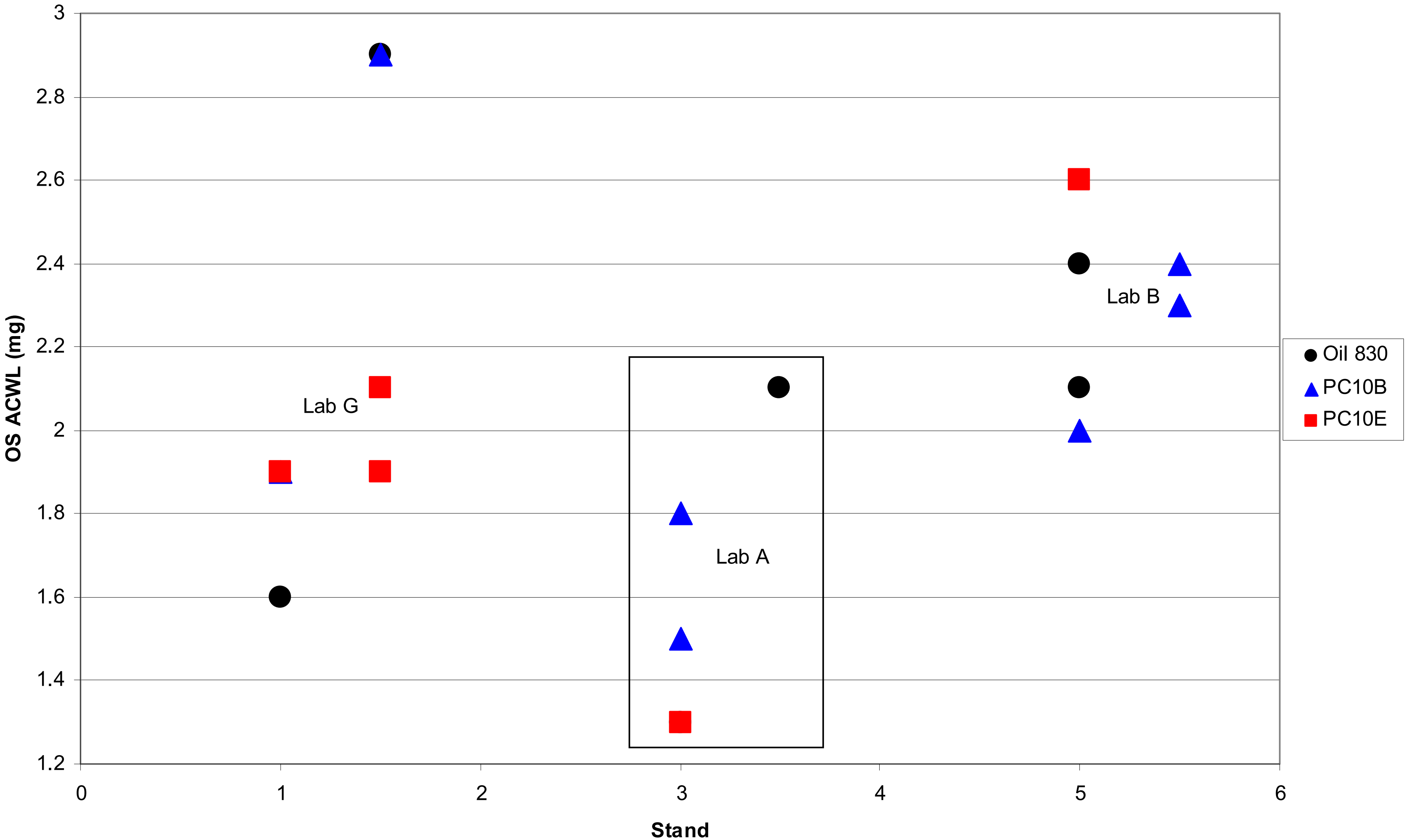
OS Average Crosshead Mass Loss as a Function of Stage B Average Torque





Unofficial ISB Matrix Analysis

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



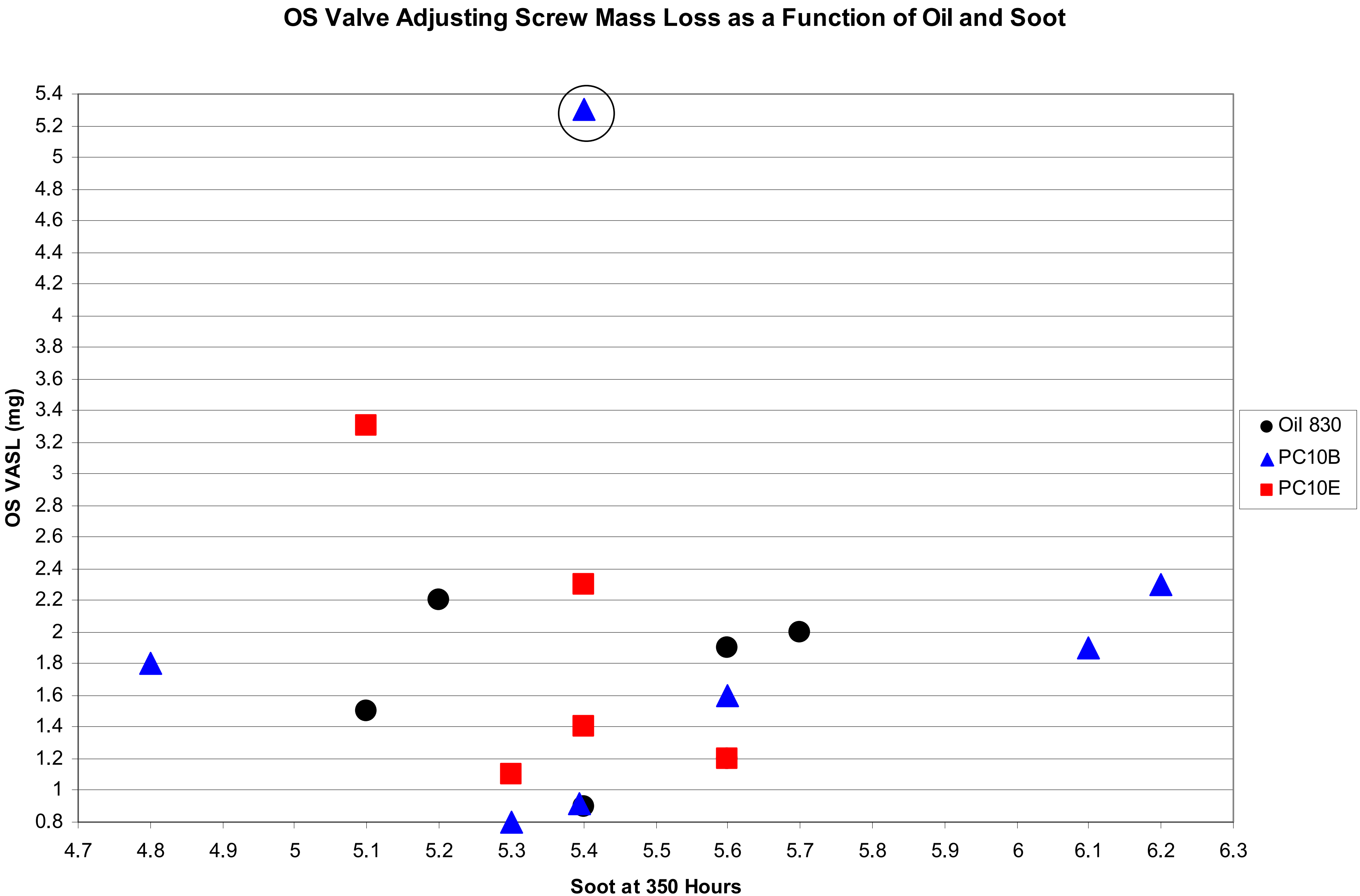
Unofficial ISB Matrix Analysis

Valve Adjusting Screw Mass Loss

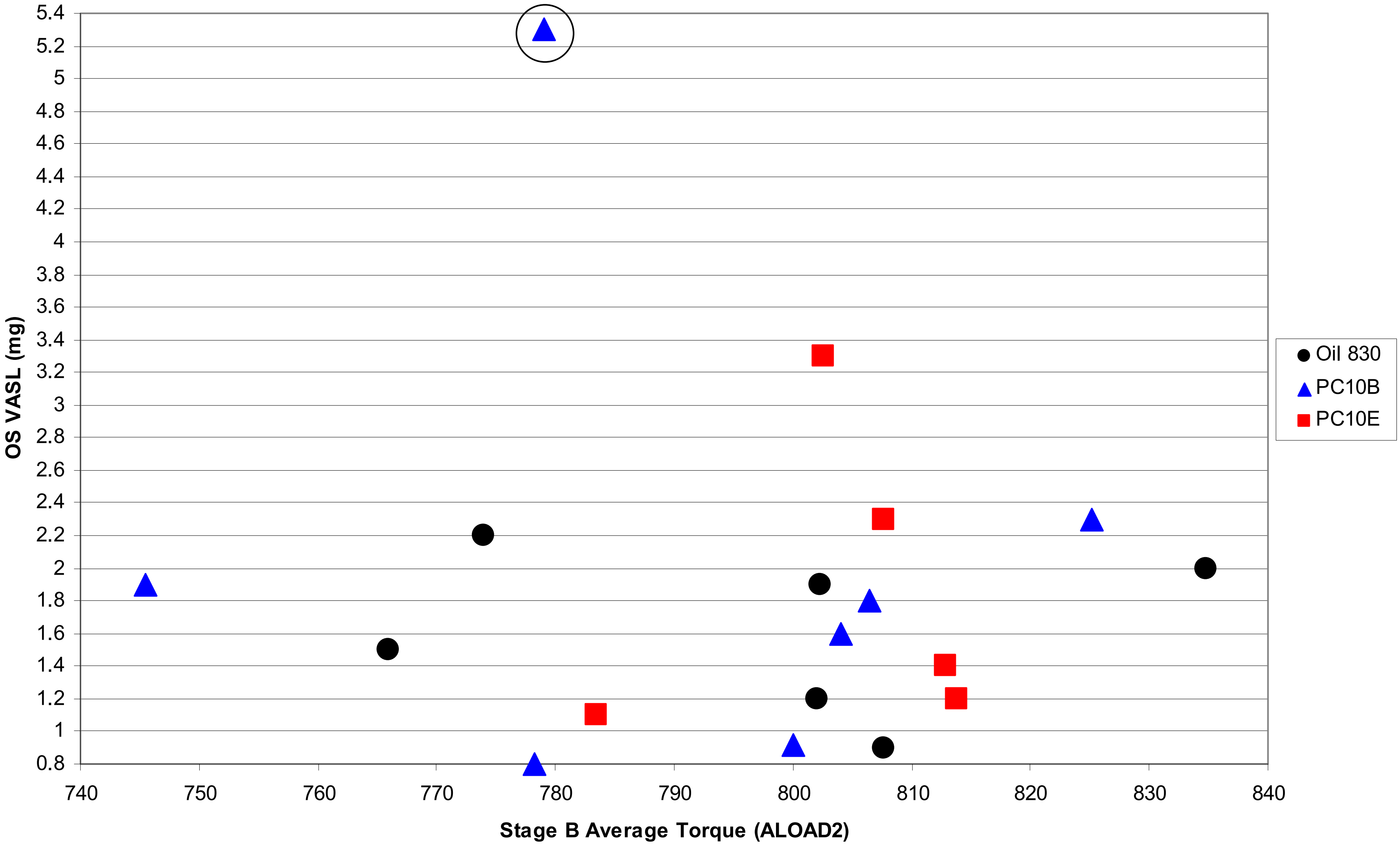
- LN(VASL) = f(Lab, Oil)
  - No Oil Discrimination (Overall p-value=0.82)
  - Some Evidence of Lab Differences (p=0.10)
    - Lab B May be Higher than Other Labs
  - Use of Natural Log Transformation
    - Borderline Need if Remove Outlier
  - One Very Unusual Observation
    - Potential Outlier: PC10B in Lab B (VASL=5.3)
    - Standardized Residual>2.5 if Untransformed

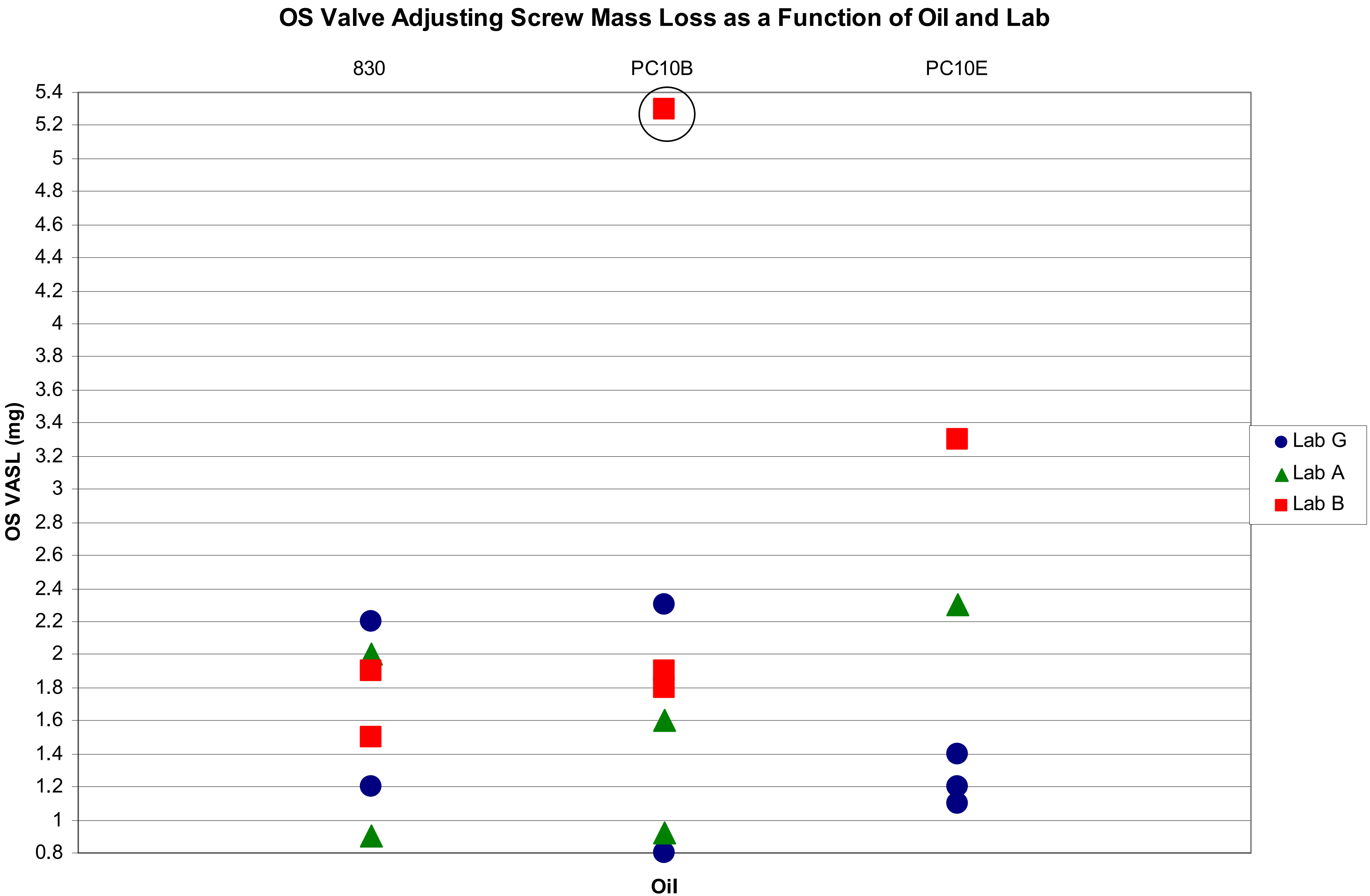
Tukey Adjusted p-Values

	Oil 830-2	PC10B	PC10E
Valve Adjusting Screw (mg)	LS Mean = 0.4343 StdErr = 0.1854	LS Mean = 0.5053 StdErr = 0.1730	LS Mean = 0.6157 StdErr = 0.2120
Oil 830-2		0.96	0.80
PC10B	0.96		0.92
PC10E	0.80	0.92	

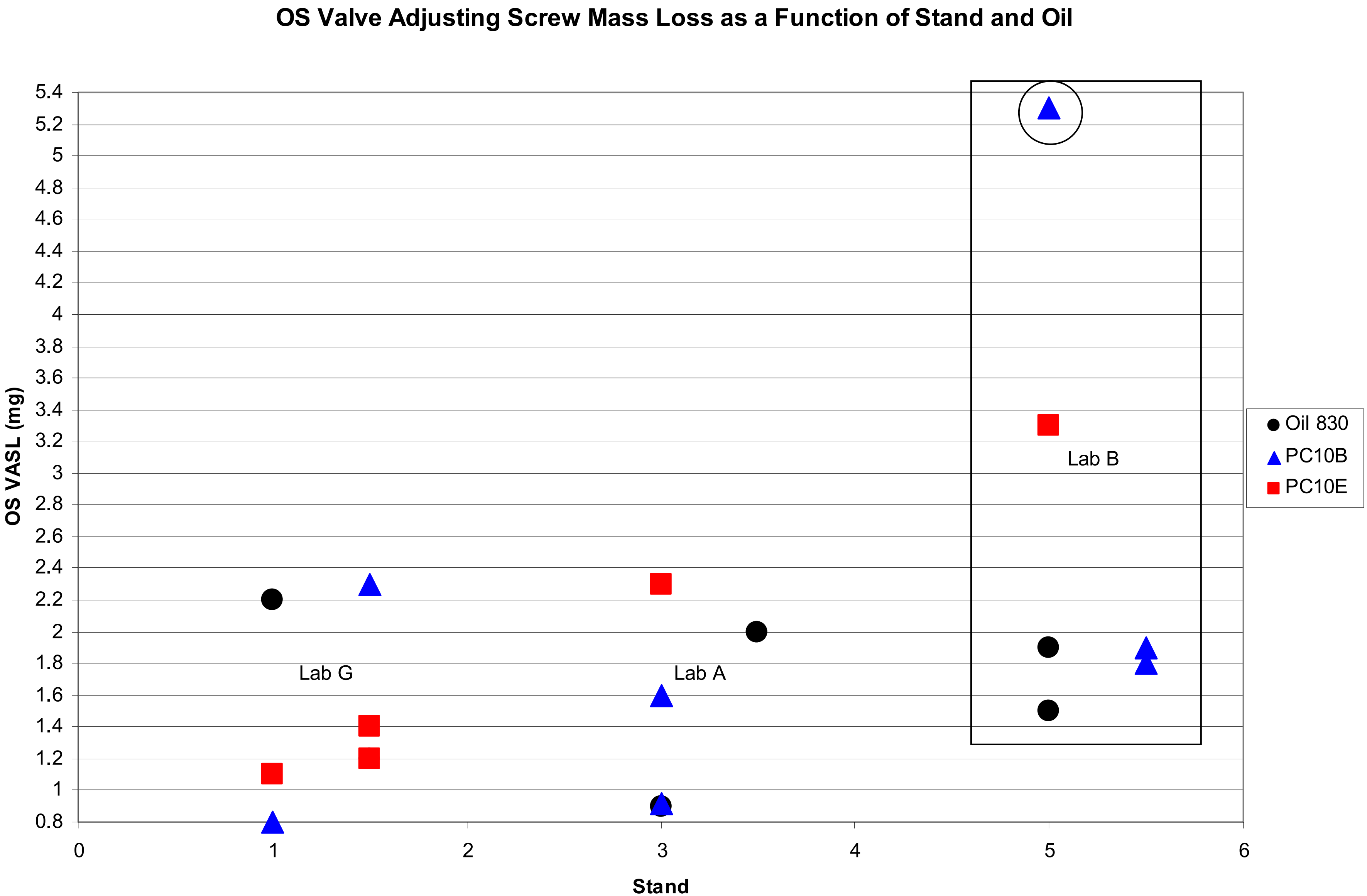

OS Valve Adjusting Screw Mass Loss as a Function of Oil and Soot
OS VASL (mg)
Soot at 350 Hours
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
4.7
4.8
4.9
5
5.1
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
6
6.1
6.2
6.3
Oil 830
PC10B
PC10E

OS Valve Adjusting Screw Mass Loss as a Function of Stage B Average Torque





Unofficial ISB Matrix Analysis


OS Valve Adjusting Screw Mass Loss as a Function of Stand and Oil
OS VASL (mg)
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0
1
2
3
4
5
6
Stand
Lab G
Lab A
Lab B
Oil 830
PC10B
PC10E

Cummins Surveillance Panel on the ISB

MOTION – “To move the test forward with cam wear and tappet wear as pass/fail parameters, crosshead weight loss as rate and report and remove all other parameters”

– Reference oil TBD
– Limits to be discussed at Oct 25 SP meeting
– O & H meeting required for discussion of possible soot correction, reference targets and operational validity criteria

Preliminary C13 matrix analysis

Elisa Santos

October 7th, 2005

Draft 4

Outline

Summary (1)

- Statistical evidence that Lab F is severe on Delta OC and OC % Inc.
- 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 B; Some indication of Lab B severity
  - TGC: Lab A & Lab G
  - TGF: Lab A & Lab F ; Lab A & Lab G

Impact of Base Oil on Delta OC

- It is observed that Delta OC increases when moving from Base Oil 1 to Base Oil 2 to Base Oil 3 for Technology B.
  - There is statistical evidence that Delta OC for Base Oil 3 is larger than the other Base Oils.
- It is observed that Delta OC decreases when moving from Base Oil 1 to Base Oil 2 to Base Oil 3 for Technology A.
  - Note, however, that there is not enough statistical evidence to conclude that the Base Oils are Different.

Summary (2)

- 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: ~ 0.36 or lower, most of them not significantly different from zero

Summary (3)

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

Data Source

- TMC file with 32 tests; 26 valid matrix tests; 5 valid mini matrix tests; 1 extra test
  - 24 PC10 oils + 2 Oil A + 3 Oil D + 3 PG10 G
  - Test 55017 was eliminated from the analysis because was operationally invalid.
  - Test 55739 was aborted.

LAB	# of tests
A	7
B	3
D	3
F	4
G	7

	# of tests		
Technology	Base Oil 1	Base Oil 2	Base Oil 3
A	3	7	2
B	3	6	3

→ 24 tests for PC10 oils

Modeling

- 24 PC10 Oils:
  - The model used for the analysis includes Lab, Stand(Lab), Technology Type and Basel Oil Type
- PC10 Oils + mini matrix + PC10G:
  - The model used for the analysis includes Lab, Stand(Lab) and Oil Type
- Transformations were used when deemed necessary to satisfy the assumptions of the model and to allow for performing valid tests of hypothesis.
- The tests are corrected for multiple comparisons
  - With respect to the plots with confidence intervals: if the confidence intervals overlap then there are no significant differences between Labs (or Oils).
- Precision is the residual standard error of the final model for each parameter. The estimates are given in their original scale.

Oil Consumption

Delta OC

OC % INC

Delta OC: 24 tests

- Lab differences
  - – Statistical evidence that Lab F is severe
- No differences between Stands inside Labs
- 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 decreases with Basel Oil (1,2,3) for Technology A
- Final Model: Lab, Technology, Base Oil and interaction of Technology & Base Oil

Impact of Base Oil on Delta OC

- It is observed that Delta OC increases when moving from Base Oil 1 to Base Oil 2 to Base Oil 3 for Technology B.
  - There is statistical evidence that Delta OC for Base Oil 3 is larger than the other Base Oils.
- It is observed that Delta OC decreases when moving from Base Oil 1 to Base Oil 2 to Base Oil 3 for Technology A.
  - Note, however, that there is not enough statistical evidence to conclude that the Base Oils are Different.
  - For instance, the difference between A1 and A3 is ~20, standard error is 6.6, 95% conf interval for the difference is A1 - A3 is [-1.68; 41.61]. For the difference to be statistically significant this interval must not include zero.

DRAFT C13 MERIT SYSTEM

Presented to C13 SP
Steve Jetter
Oct. 10, 2005
Chicago

Why use Merit Based System for C13?

- **Similar to other tests that currently use or intend to use a merit based system**
  - Test has multiple pass/fail requirements
  - Test is timely and costly to run
- **Merit based system provides opportunity to capture precision of test in limits for a single test run**
  - Allows overall strong performing oil to pass, even if one pass/fail parameter is above traditional 1-test limit
  - Does not allow an oil with a single parameter outside precision of test to pass even if other areas are very strong due to the CAP limits
  - Should decrease the overall number of C13 tests needed to qualify oils as it will eliminate some failing results that would be caused by a single parameter
- **Proposed system is based on T10 system from a calculation perspective and is designed to have a pass/fail limit at 1000 merits**

What parameters to include?

- **Parameters in DRAFT were chosen based on the following criteria (using Elisa's 9/16/05 analysis)**
  - Oil Consumption and Deposit Parameters that showed the most discrimination between oils and deposit parameters that showed "good" correlation with OC
    - **TLHC, Delta OC, UWD (discrimination)**
    - **TGC (correlation with OC)**
  - Ring Sticking and Piston/Liner Scuffing not deemed as good parameters due to on/off nature
    - **Propose these to be separate pass/fail requirements**
  - Parameters selected by this process are consistent with what Caterpillar has indicated they desire from the test

How to set limits and weightings?

- **Final limits and weightings need to be completed following final statistical analysis and agreement by stakeholders**
- **DRAFT limits determined by following criteria**
  - Merit System should provide clear separation of Oil A and Oil D/PC-10G as Failing and Passing oils
  - Anchor Limits: Set at levels proposed by Caterpillar which separate above pass/fail oils
  - Cap Limits: Set at level that 3-test limits would be using 9/16/05 estimates of test precision on the parameters
  - Max Merit Limits: Set at level consistent with best performance observed in the Matrix data for the parameter
- **DRAFT weightings set to emphasis the parameters that showed the most discrimination and have been most critical to Caterpillar during the test development**

Proposed Merit System

Parameter	Anchor	Cap	Max Merit	Weight
Delta OC	25	30.6	10	300
TLHC	11.5	13.2	3	300
TGC	48	51.5	30	250
UWD	130	135.3	95	150

- **Example Calculations**

	Delta OC	TLHC	TGC	UWD	Merits	Assessment
Oil @ Anchors	25	11.5	48	130	1000	Pass
Average Oil D	17.3	6.0	44.4	118.2	1448	Pass
Average Oil PC-10G	15.0	10.3	35.8	111.4	1490	Pass
Average Oil A	30.8	19.0	54.9	143.2	-1500	Fail
Exceeding Anchor	29	6	35	125	1182	Pass
Exceeding Cap	31	6	35	125	1075	Fail

Mini-Matrix/Matrix Data Merits

TESTKEY	54824	54825	55017	54827	54828	54826	55736	55741	55740
LTMSLAB	A	G	H	G	F	G	A	D	B
IND	OILA	OILA	OILA	OILD	OILD	OILD	PC10G	PC10G	PC10G
Delta OC	28.4	26.6	37.3	13.3	20.2	18.5	8.3	20.6	16.0
ATGC	51.8	54.5	58.4	44.2	41.4	47.7	33.5	35.0	39.0
ATLHC	18.0	12.0	27.0	6.0	4.0	8.0	11.0	10.0	10.0
AUWD	139.4	129.4	160.7	116.9	111.6	126.2	110.0	105.5	118.8
Single Paramerter Pass/Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass
4 Parameter System									
Oil Consumption Delta, g/hr	118	214	-359	534	396	430	600	388	480
Top Land Heavy Carbon	-847	212	-2435	494	565	424	318	353	353
Top Groove Carbon	-21	-217	-494	303	341	254	451	431	375
Total Unweighted Demerits	-117	153	-719	206	229	166	236	255	198
Total Merits	**-867**	**361**	**-4008**	**1538**	**1531**	**1274**	**1604**	**1427**	**1406**
Pass / Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass
Outcome of Test?	Same	Same	Same	Same	Same	Same	Same	Same	Same

Mini-Matrix/Matrix Data Merits (Con't)

TESTKEY	56269	56384	56386	56381	56389
LTMSLAB	G	B	D	G	F
IND	PC10A	PC10A	PC10A	PC10C	PC10C
Delta OC	52.0	32.5	34.7	19.2	49.9
ATGC	51.3	48.0	38.3	61.3	52.5
ATLHC	5.0	8.0	3.0	12.0	6.0
AUWD	117.2	131.1	105.6	136.4	129.9
Single Paramerter Pass/Fail	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**
4 Parameter System					
Oil Consumption Delta, g/hr	-1146	-102	-220	416	-1034
Top Land Heavy Carbon	529	424	600	212	494
Top Groove Carbon	12	250	385	-699	-71
Total Unweighted Demerits	205	118	255	-30	150
Total Merits	**-400**	**690**	**1020**	**-101**	**-461**
Pass / Fail	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**
Outcome of Test?	Same	Same	Same	Same	Same

Mini-Matrix/Matrix Data Merits (Con't)

TESTKEY	55737	55738	56273	56388	56733	56385	56387
LTMSLAB	A	G	D	F	A	B	D
IND	PC10B	PC10B	PC10B	PC10B	PC10B	PC10B	PC10B
Delta OC	27.7	29.5	32.8	54.4	28.4	33.4	35.2
ATGC	29.3	51.8	44.7	42.1	45.7	53.0	45.9
ATLHC	10.0	3.0	10.0	6.0	8.0	19.0	5.0
AUWD	103.9	117.9	120.5	115.0	114.1	143.3	116.2
Single Paramerter Pass/Fail	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**
4 Parameter System							
Oil Consumption Delta, g/hr	155	59	-118	-1275	118	-150	-246
Top Land Heavy Carbon	353	600	353	494	424	-1024	529
Top Groove Carbon	500	-24	296	332	282	-104	279
Total Unweighted Demerits	262	202	191	215	218	-225	209
Total Merits	**1270**	**837**	**721**	**-234**	**1041**	**-1503**	**771**
Pass / Fail	**Pass**	**Fail**	**Fail**	**Fail**	**Pass**	**Fail**	**Fail**
Outcome of Test?	Different	Same	Same	Same	Different	Same	Same

Mini-Matrix/Matrix Data Merits (Con't)

TESTKEY	56274	56378	56379	56268	56270	56383
LTMSLAB	F	A	A	A	G	G
IND	PC10D	PC10D	PC10D	PC10F	PC10F	PC10F
Delta OC	35.6	8.8	6.7	29.9	50.6	51.8
ATGC	40.0	33.0	44.6	41.3	59.5	61.5
ATLHC	2.0	4.0	6.0	23.0	19.0	24.0
AUWD	119.0	104.7	114.4	124.0	146.4	144.8
Single Paramerter Pass/Fail	Fail	Pass	Pass	Fail	Fail	Fail
4 Parameter System						
Oil Consumption Delta, g/hr	-268	600	600	38	-1071	-1136
Top Land Heavy Carbon	600	565	494	-1729	-1024	-1906
Top Groove Carbon	361	459	298	343	-569	-711
Total Unweighted Demerits	197	259	217	176	-314	-270
Total Merits	**890**	**1882**	**1609**	**-1173**	**-2977**	**-4023**
Pass / Fail	Fail	Pass	Pass	Fail	Fail	Fail
Outcome of Test?	Same	Same	Same	Same	Same	Same

Mini-Matrix/Matrix Data Merits (Con't)

TESTKEY	55742	56126	56272	56267	56382	56380
LTMSLAB	F	G	B	A	G	A
IND	PC10E	PC10E	PC10E	PC10E	PC10E	PC10E
Delta OC	59.1	16.8	26.8	9.8	25.4	17.3
ATGC	47.5	42.8	42.0	33.8	57.8	41.8
ATLHC	7.0	7.0	16.0	6.0	6.0	2.0
AUWD	120.6	109.8	124.4	97.5	138.6	104.0
Single Paramerter Pass/Fail	**Fail**	**Pass**	**Fail**	**Pass**	**Fail**	**Pass**
4 Parameter System						
Oil Consumption Delta, g/hr	-1527	464	204	600	279	454
Top Land Heavy Carbon	459	459	-494	494	494	600
Top Groove Carbon	256	323	334	448	-452	337
Total Unweighted Demerits	190	237	174	289	-94	261
Total Merits	**-621**	**1482**	**217**	**1831**	**227**	**1652**
Pass / Fail	**Fail**	**Pass**	**Fail**	**Pass**	**Fail**	**Pass**
Outcome of Test?	Same	Same	Same	Same	Same	Same

C13 SP Discussion of PC10

SP agreed C13 data analysis needs to be completed by statisticians who will meet next week. Data will be presented to SP after review.

C13 Lab Bias Task Group was established and investigations are on-going.




CONFIDENTIAL

Oct 12, 2005

C13 SP Discussion of PC10

Task Group action items identified and to be reviewed on Fri 14 teleconf:

1. Differences in oil consumption severity
   1. Investigating oil pan, external weigh system
   2. Fresh Oil Additions every 50 hours
2. Oil Gallery Pressure
3. Torque levels
4. Swapped ECM between labs (not ECM related)
5. Throttle control wiring
6. Labs will install equipment to measure exhaust CO2 levels for AFR differences
7. Tighten operational control limits




CATERPILLAR®

Caterpillar C13 Test Matrix Update

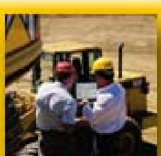
1. All tests completed
2. Preliminary analysis indicates Lab and BOI issues
3. Surveillance Panel made recommendations to reduce differences between labs, sub-group setup to do this.
4. Main Parameters OC, TLHC, TGC, UWD
5. High correlation between TLHC – TLC, TGF - TGC
6. Merit system proposed based.




C13 Test Status

Caterpillar Piston Deposit Test Requirements

1. No scuffed Pistons, Rings, Liners
2. No stuck Rings
3. No loss of Oil Consumption Control
4. No unacceptable Piston Deposits




CATERPILLAR®

C13 Test Limit Status

	1P Limit	Single Parameter limit	Merit Anchor
Oil Consumption Delta	14.6	25	30.6
TLHC (TLC)	12.0 (40)	11.5 (48)	13.2
TGC	36	48	51.5
Unweighted Demerits	118	128	135.3




ACC Position on PC-10

October 12, 2005

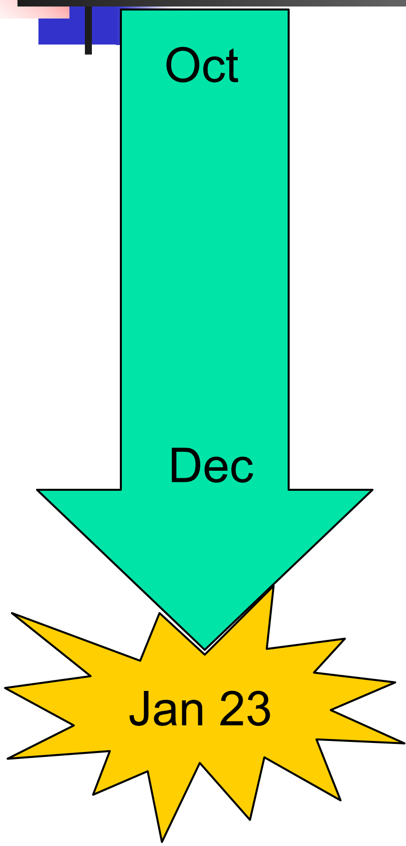
PC10 Timeline Issues

- ACC 15-month estimate to run programs is a best case optimistic estimate
- Multiple issues could drive program timing to dramatically exceed 15 months
  - C13 base oil interchange
  - C13 pass/fail rate, number of parameters, etc.
  - Addition of new tests such as the 1P

PC10 Timeline Issues

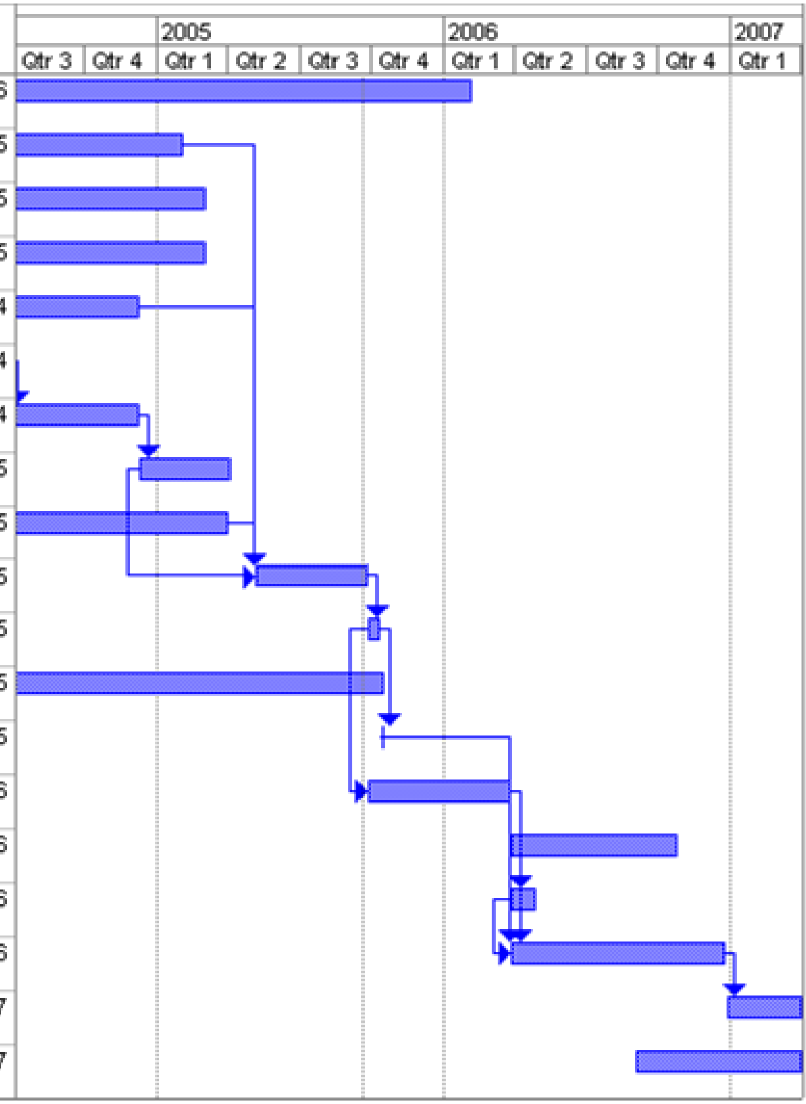
- Industry has already agreed to a 4-month technology demonstration period,
  - This is reduced from 6 months, but does not reduce the 15-month total time for PC-10 reformulation
  - Allows product developers to understand PC10 test appetites and identify potential conflicts among tests
  - Required in order to make informed limit-setting decisions
  - Further reduction in this period may result in decisions being made on incomplete or erroneous data.
- ACC member companies feel that setting final limits prior to completion of the demonstration period represents an unwarranted risk.

Recommended Path Forward



- Analyze matrix data and ballot acceptance of ISB, T12, and C13. Finalize tests to define category
- ACC analysis of impact of C13 scenarios on timeline
- Analyze C13 BOI data and review with API BOI/VGRA TF
  - Impact on timeline is a key factor for category success
- Discuss tentative test limits and options to allow compression of timeline by alternate ways of evaluating deposits and oil consumption BOI
- ACC companies complete technology demonstration and identify areas of concern regarding potential limits
- Finalize limits

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



Proposed Cummins ISM Merit Rating System

presented to

Cummins Surveillance Panel

And

HDEOCP

Merit Rating System Terms

- Anchor – if an oil averaged exactly at the anchor for each criterion, it would be a borderline oil
- Maximum – limit of acceptable performance for an individual criterion
- Minimum – best possible performance for an individual criterion, or better number gives no better performance
- Weight -- relative contribution of individual criterion to total merit

Proposed Merit Rating System

- A result at or below the anchors for all five criteria would pass the test.

- If any of the five criteria results is above the maximum, the test fails.

- If results are below the maximums for all five criteria but one or more results is above the anchors, a mathematical system determines whether marginal numbers above the anchors are compensated by better than anchor results on other criteria.

Straw Man Parameters from June 2005

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
Weight	225	150	250	225	150
Maximum	6.5	90	25	45	8.6
Anchor	5.0	65	12	30	9.0
Minimum	3.5	40	5	15	9.5

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

Comparison of 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

Criterion	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge
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Maximum	6.5	90	25	45	8.6
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Minimum	3.5	40	5	15	9.5

Reasons for Changes

- Weightings more accurately reflect Cummins concerns.
  - Crossheads and Adjusting Screws are far more important than Top Ring Wt Loss
  - Tighter "Max" on Adj. Screw eliminated a field problem oil.
  - Keep TRWL with low weighting instead of making it "rate and report".
- More robust filters give lower OFDP
  - Tighter "Max" is in line with results to date

Multiple Test Acceptance Procedure

- Multiple test evaluation would consist of averaging the five individual criteria across multiple tests. The Cummins ISM Merit Rating System would be applied to the averages for the criteria.

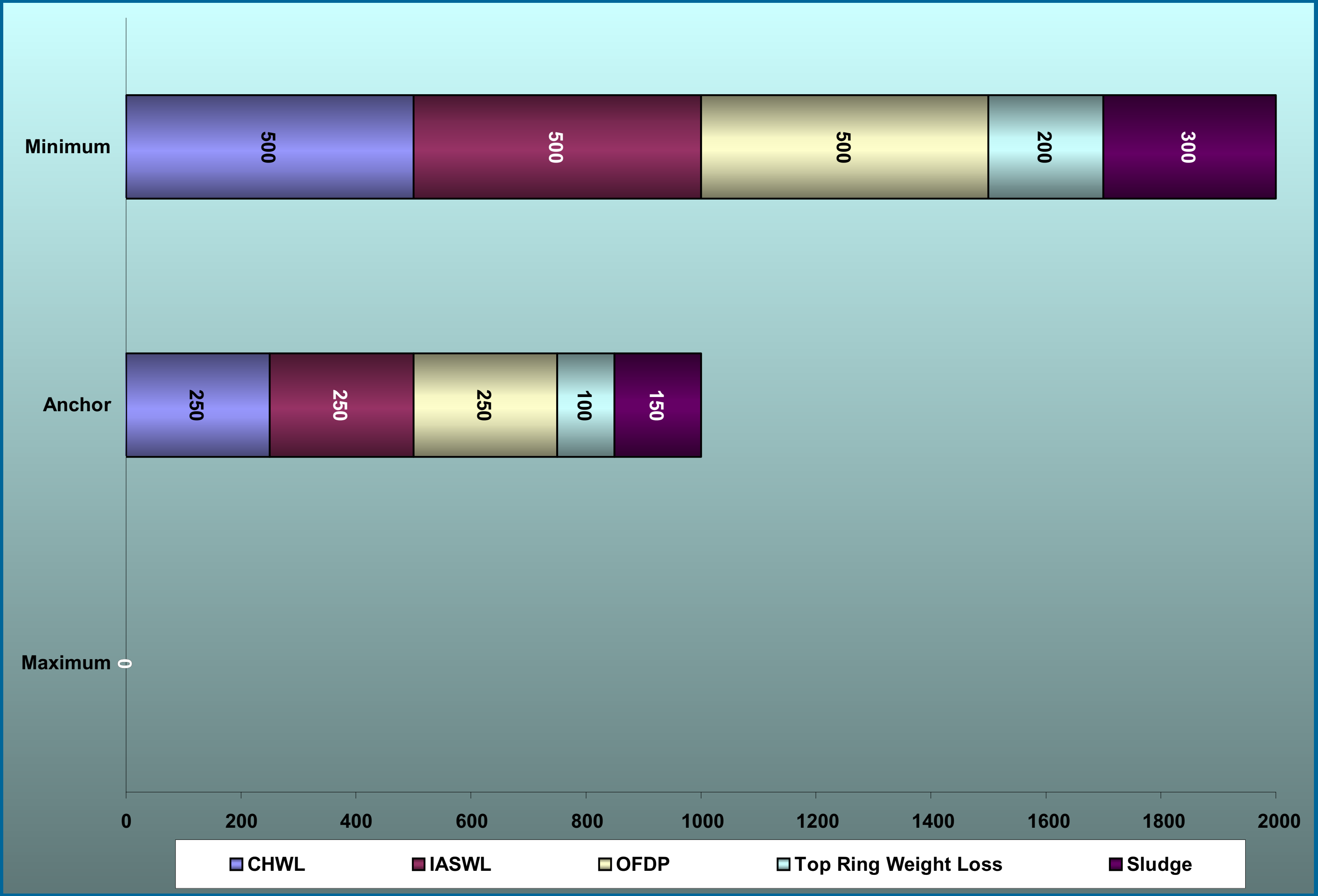
Examples Using Hypothetical Test Results

	Crosshead Weight Loss	Top Ring Weight Loss	Oil Filter Delta P	Adjusting Screw Weight Loss	Sludge	Calculated Merit	**Final Merit**
On the border	5.0	65	12	30	9.0	1000	**1000**
Borderline Failures	**6.1**	65	12	30	9.0	725	**Fail**
	5.0	**91**	12	30	9.0	896	**Fail**
	5.0	65	**21**	30	9.0	719	**Fail**
	5.0	65	12	**41**	9.0	725	**Fail**
	5.0	65	12	30	**8.8**	700	**Fail**
One parameter can make up for another	**6.0**	65	**5**	30	9.0	1000	**1000**
	5.0	**70**	**10**	30	9.0	1051	**1051**
	5.0	65	**15**	**20**	9.0	1073	**1073**
	5.0	65	12	**30**	**9.5**	1150	**1150**
	4.0	65	12	30	**8.9**	1017	**1017**
Beyond Limit Failure	**6.6**	40	5	15	9.5	1350	**Fail**
	3.5	**91**	5	15	9.5	1796	**Fail**
	3.5	40	**21**	15	9.5	1469	**Fail**
	3.5	40	5	**41**	9.5	1475	**Fail**
	3.5	40	5	15	**8.8**	1550	**Fail**

Values for Matrix Oil Tests

Reference Tests								
28402	1004-3	8.3	61	35	139	9.0	-3268	**Fail**
30048	1004-3	7.4	72	238	155	9.0	-9809	**Fail**
35313	1004-3	9.4	62	24	138	9.0	-3147	**Fail**
43672	1004-3	7.8	64	110	59	8.9	-3621	**Fail**
50254	1004-3	8.0	53	126	191	9.1	-7251	**Fail**
51225	1004-3	8.5	46	75	44	7.9	-3763	**Fail**
47644	830-2	5.7	57	9	20	9.2	1179	**1179**
50224	830-2	4.6	44	10	38	9.0	1022	**1022**
51799	830-2	4.4	56	12	34	9.1	1077	**1077**
52996	830-2	2.4	68	7	24	9.0	1511	**1511**
52997	830-2	**7.0**	34	11	25	9.1	748	**Fail**
54195	830-2	4.7	40	13	27	9.1	1192	**1192**
54204	830-2	4.9	78	**27**	41	8.8	-95	**Fail**
50769	ISMA	5.9	76	10	**137**	**8.6**	-2456	**Fail**
51224	ISMA	5.9	44	3	**43**	9.1	832	**Fail**

Potential Criteria Contributions



Benefits of Merit System

- More cost effective testing
- Consistent with reducing the time between ASTM acceptance and first date of API licensing
- Allows test developer to weight individual criteria
- Adds incentive for improved performance
- Flexibility in setting up system
- Easier to gain consensus on limits

Oil Viscosity Increase
A Request for Industry Data

David Stehouwer

October 2005

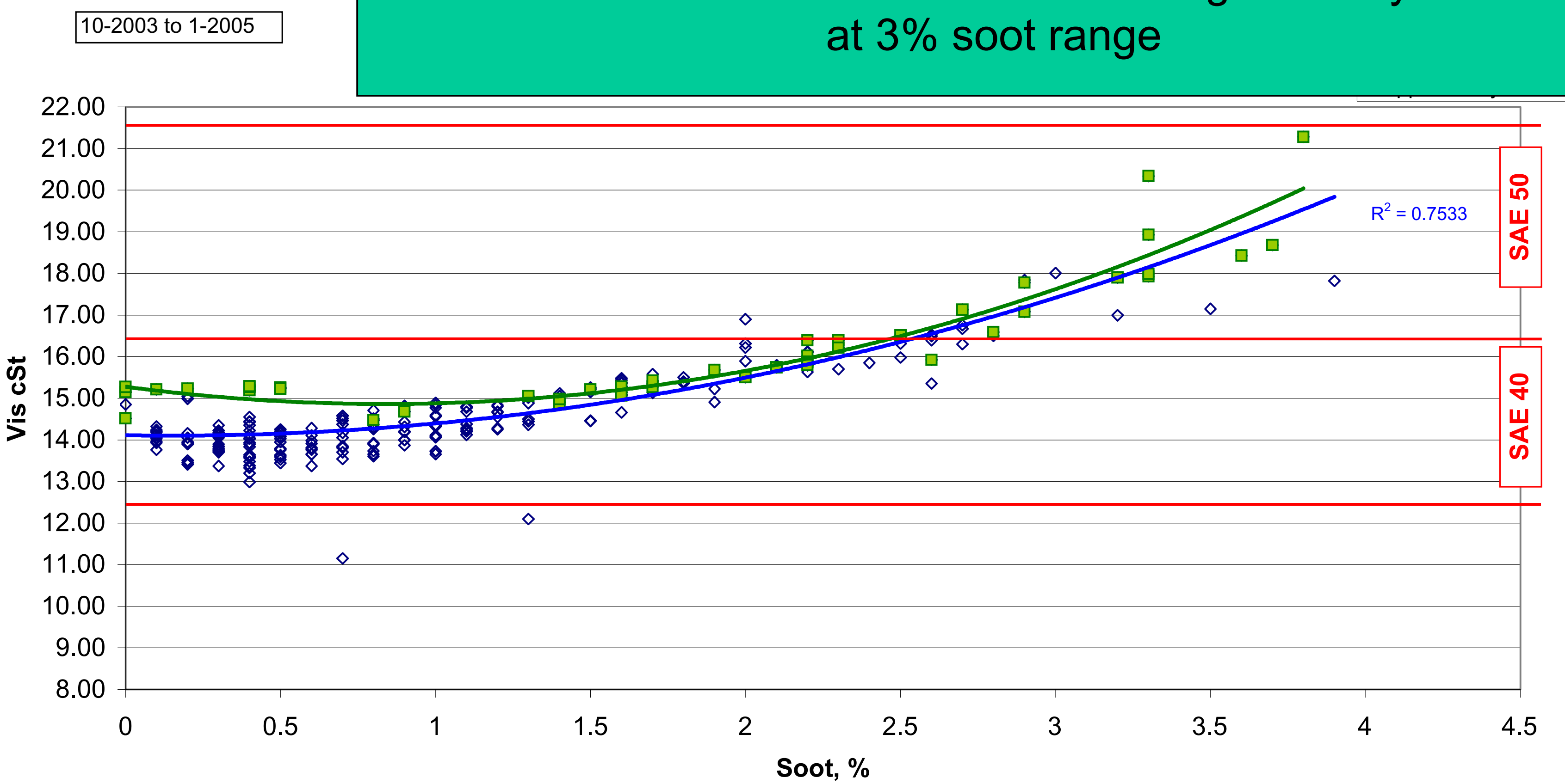
Cummins

Field Complaints of Soot / Viscosity Increase

- Many Engines
- Many Oils
- Possible Viscosity Limits for ISB Test in PC 10
  - ✓ Maybe the T11 will satisfy this need
- SEND DATA
  - ✓ Please

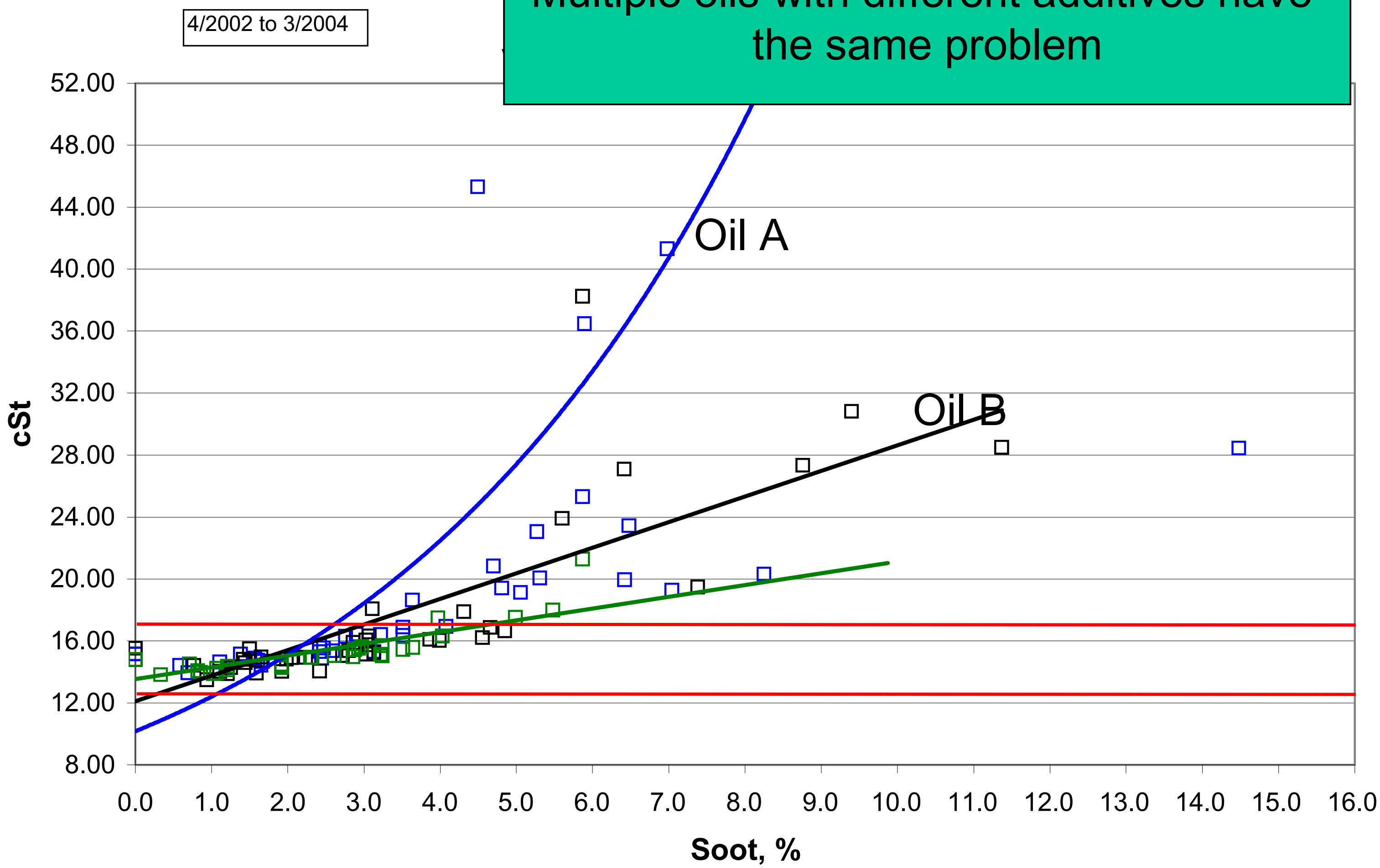
ISX EGR, Oil A (additive A), Fleet B

Commercial CI-4 oils show exceeding viscosity limit at 3% soot range



ISM EGR, Oil A and B, Fleet C

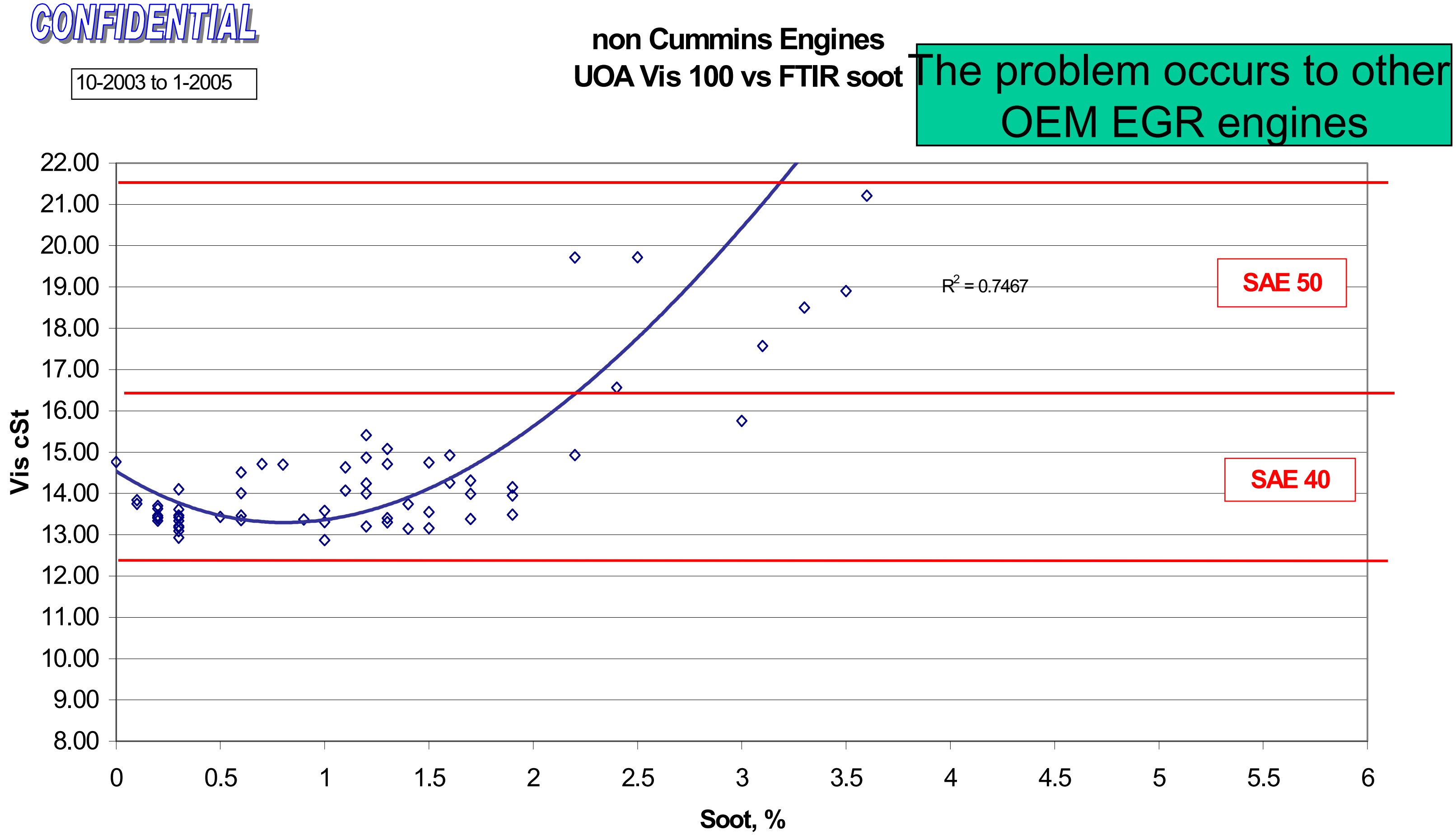
Multiple oils with different additives have the same problem



Non-Cummins EGR Engines, Oil A

CONFIDENTIAL

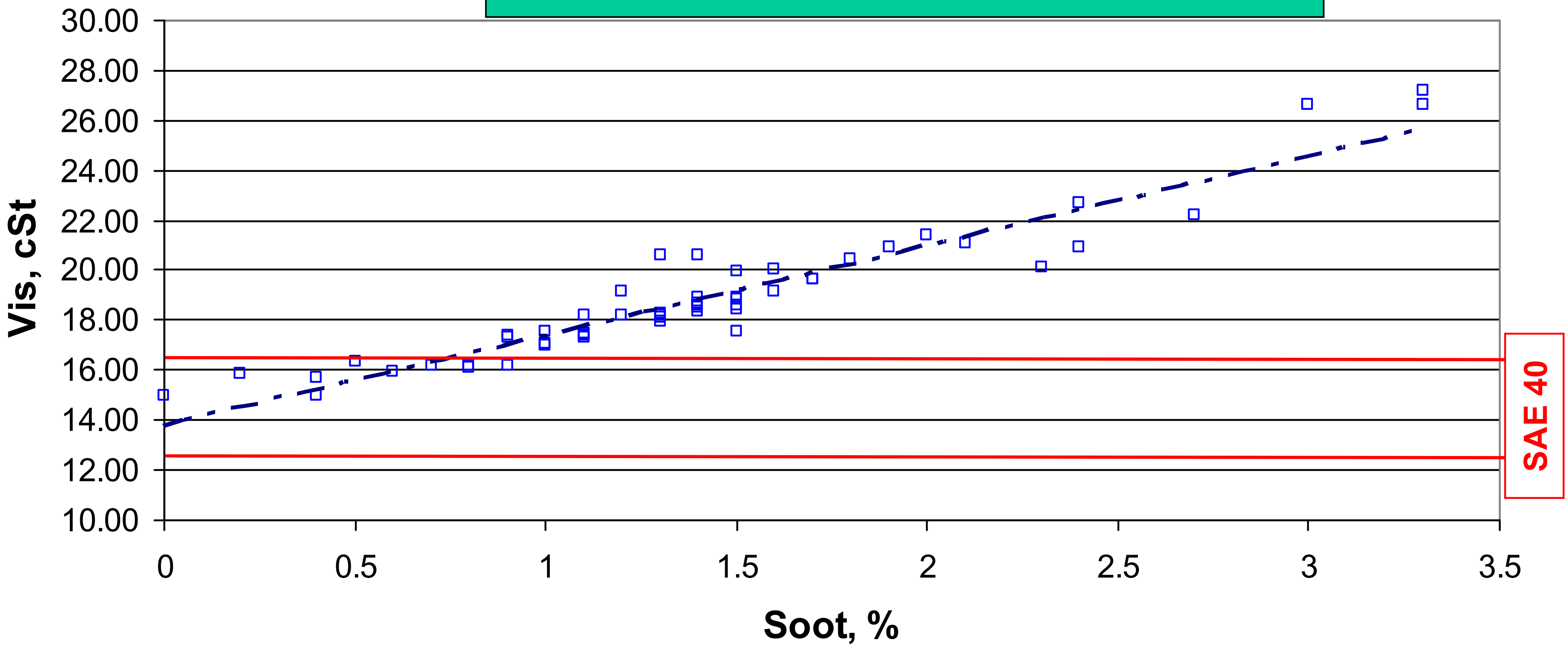
10-2003 to 1-2005



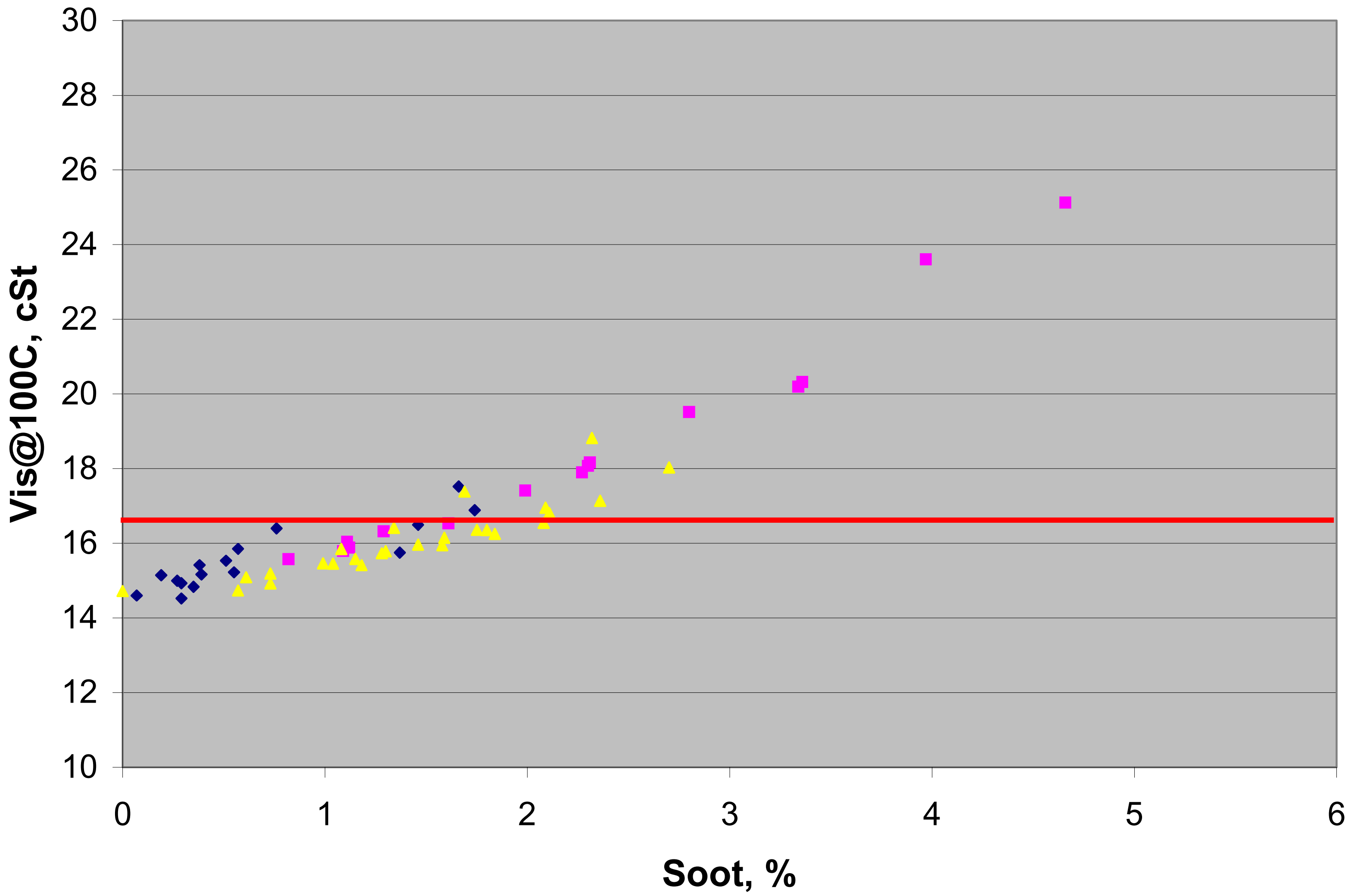
ISB non-EGR, Oil A (additive A), fleet A

10-2003 to 1-2005

The problem occurs to non-EGR MR engines

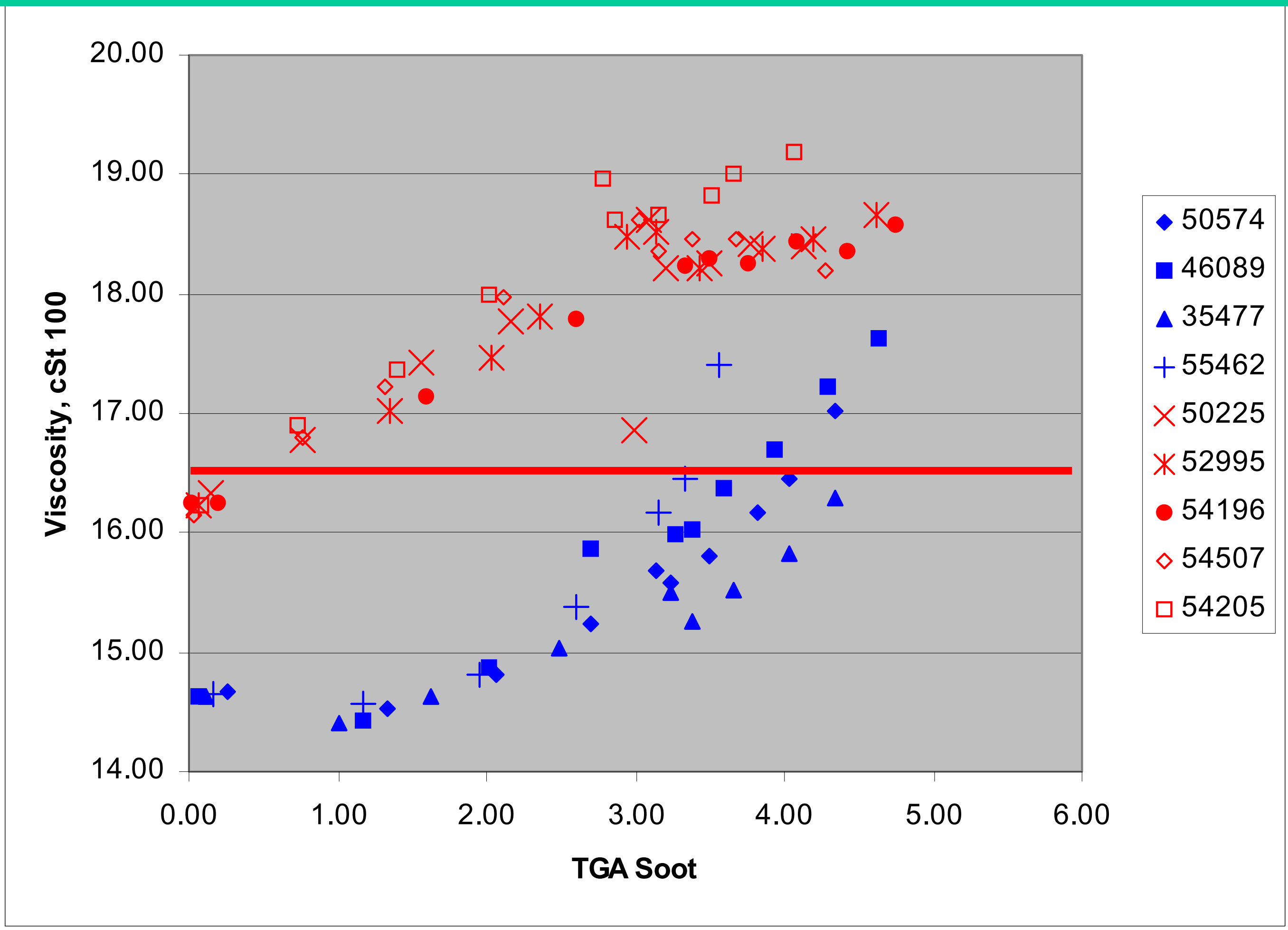


ISB02 EGR, CI-4



ISB Cam Cycle Test
830 (CI-4) vs. 1004 (CG-4)

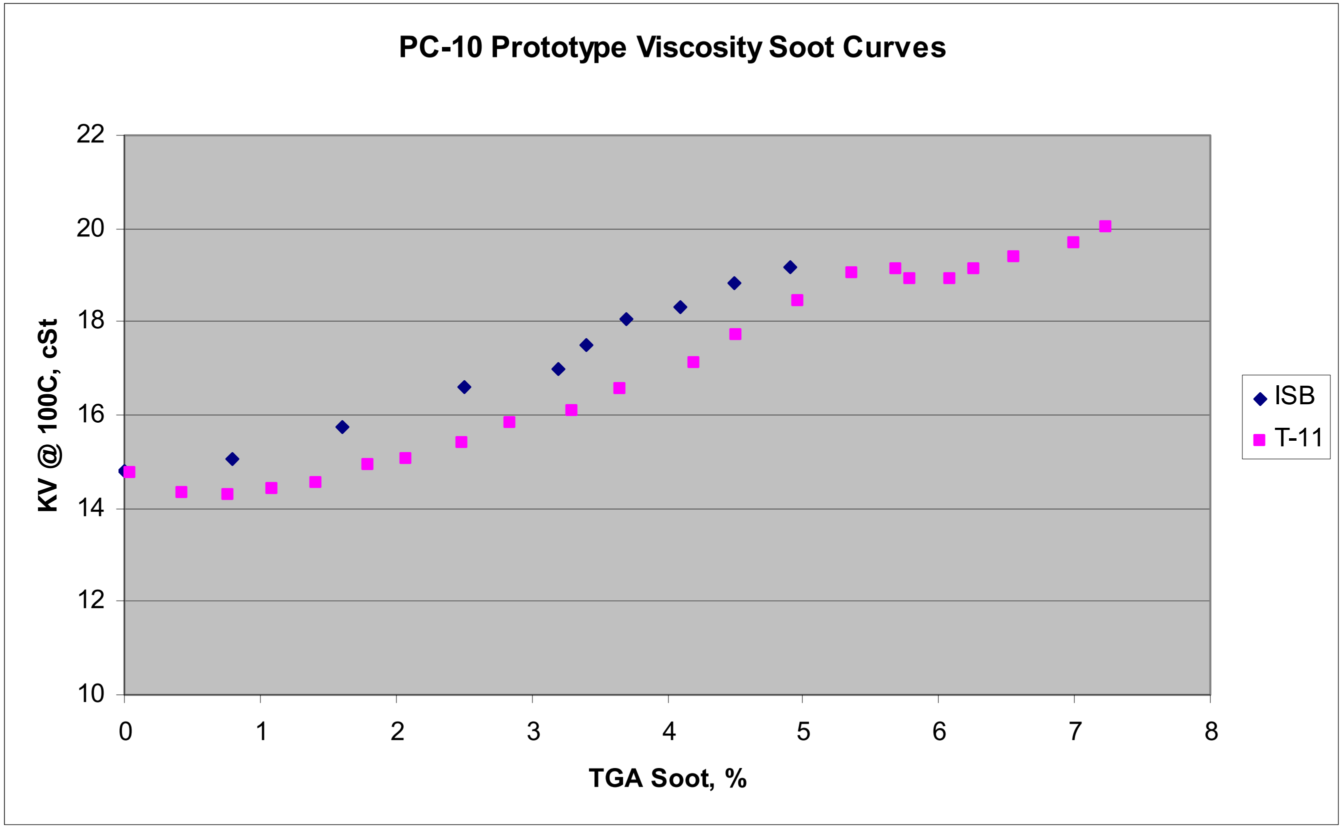
Put a viscosity control limit in ISB cam cycle test since MR vis increases more than HD



Send Data

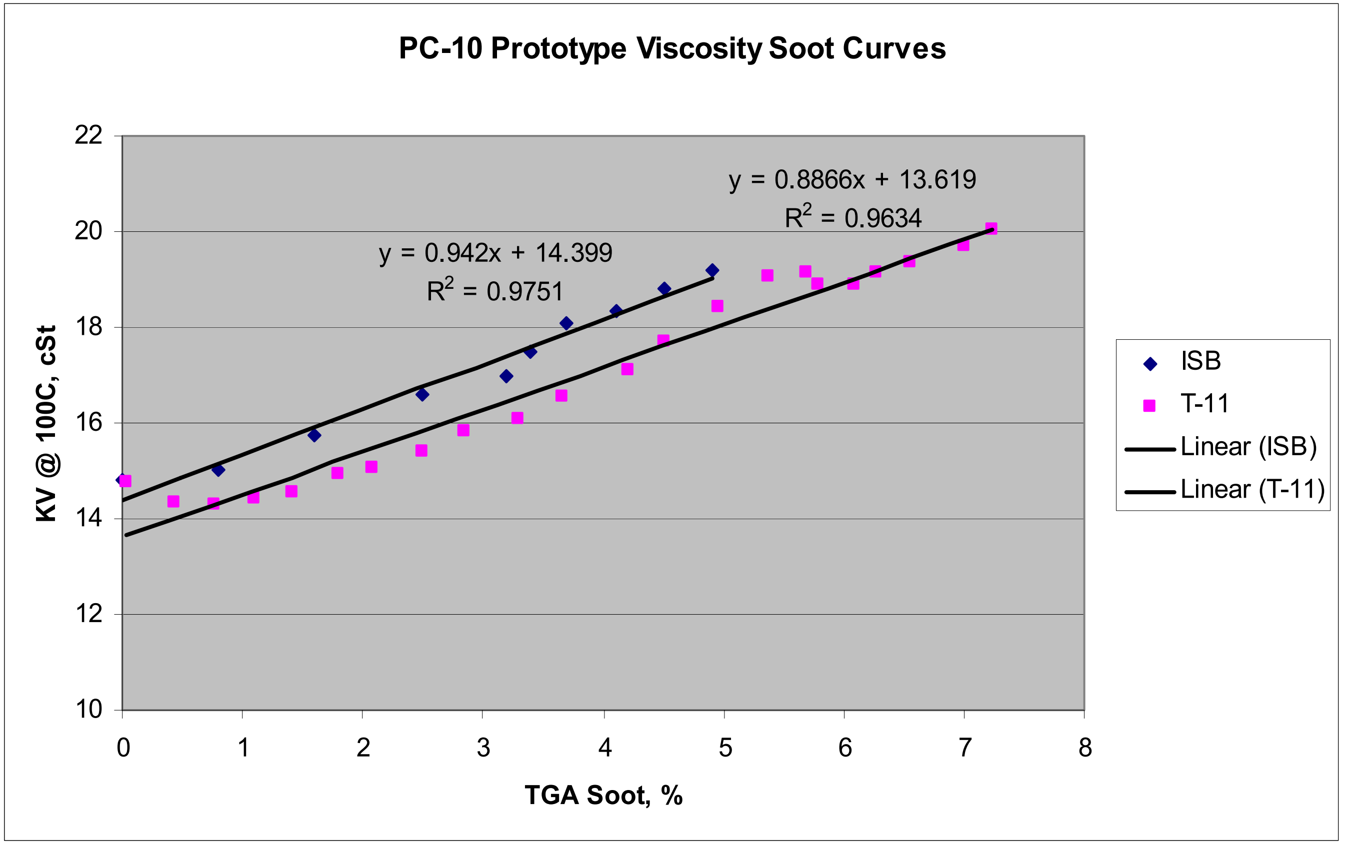
- **Possible Viscosity Limits for ISB Test in PC 10**
  - ✓ **Maybe the T11 could satisfy this need**
  - ✓ **Currently, T11 considers viscosity @ 6% and above**
  - ✓ **Soot viscosity curve tends to "break" for failing oils**
  - ✓ **ISB "poor" oils show steady increase**
- **Need data showing viscosity vs soot for oils in both ISB and T11**
- **SEND DATA**
  - ✓ **Please**

ISB vs. T-11 Viscosity Soot Curve



Afton Chemical

ISB vs. T-11 Viscosity Soot Curve



A linear trend line was used to approximate the viscosity-soot curve slope above. Linear calculation of the slope between 1 and 5 % soot found:

- ISB Slope = 1.039 cSt / % Soot
- T-11 Slope = 1.036 cSt / % Soot