Unapproved Minutes of the
Sequence III Surveillance Panel
Conference Call

January 31, 2013
11:00 EST

1.0) Attendance

The attendance is shown in **Attachment 1**. The Lubrizol member has changed from Greg Seman to George Szapponos.

2.0) Approval of minutes

2.1) Minutes from November 13, 2012. - The minutes were approved without objection.

3.0) Action Item Review

3.1) 03/28/12–Continue to use RO 435 targets for RO 435-2 until next review. Grundza

Results are shown in **Attachment 2** and were reviewed by Rich Grundza of the TMC. To date 18 tests have been run. Rich noted that viscosity increase is a little more severe. Without objection, the panel decided to continue with 435 targets for 435-2. The 435-2 results will be reviewed after 30 tests.

3.2) 03/28/12-SRI to forward FTIR data on RO 434 and RO 434-1 used oil samples to Doyle Boese for statistical review. Lang/Boese

SwRI provided data and Doyle reported back on the November call; there wasn't enough data to make a conclusion. In November, labs were requested to provide more data if it was available. This item will stay on the next meeting's agenda; if no new data comes forward then at that point this issue will be dropped.

3.3) 03/28/12-TMC to review IIIG LTMS wording for potential improvements to Section 5. Grundza

Rich Grundza and Jeff Clark reviewed the wording and advised against any wording changes. It was agreed to drop this action item.

4.0) Old Business

4.1) Lab's adherence to Section 7.1.3; quarterly fuel analysis reporting. Labs

The TMC has had difficulty getting labs to comply with the quarterly reporting of fuel analyses. The Chair reminded the labs with the need to comply in a timely fashion. <**Action Item**: report quarterly fuel analysis in timely manner; **test labs**>

4.2) Drop 99 h NOx measurement in D6984, reference ASTM Rating Manual and ASTM Rating Workshop in D6984. Grundza

Rich Grundza noted the need to clean up the IIIF procedure by removing the 99 h NOx measurement and correcting several references to parts ratings and rating workshops that are outdated. He will be cleaning these via a future Information Letter. <**Action Item**: issue clean-up IL when appropriate; **Rich Grundza**>

4.3) Reference ASTM Manual 20 and ASTM Rating Workshop in D7320. Grundza

Rich Grundza noted that several references to IIIG parts ratings and workshops are outdated and noted that he will be cleaning these via a future Information Letter. <**Action Item**: issue clean-up IL when appropriate; **Rich Grundza**>

5.0) New Business

5.1) Introduction of Batch Code 11 rings into IIIF Test. BC 11 rings, size 3 are now secured from a different vendor. OH Technologies seeks direction from the SP regarding the introduction of the material. Bowden, J

Jason Bowden noted the change of vendor for all sizes of top and second rings for IIIF and IIIG (BC11 for IIIF, BC10 for IIIG). OHT is out of inventory of run 3 BC-10. Current supplies of IIIF batch code 10 rings are limited and OHT is currently out of stock for IIIF Run 3 BC10. Supplies of IIIG batch code 9 rings should last approximately 1.5 years (so we will hold off on running donated tests for the IIIG at this time). OHT is looking to the panel for guidance on introducing the new batches to the IIIF. After discussion, it was generally agreed to run a set of donated reference oil tests: each lab will donate a test, OHT will donate hardware, and TMC review fees will not be applied. Jason will craft the introduction method in greater detail and distribute for final approval. <**Action Item**: draft and circulate a method for introducing new rings; **Jason Bowden**>

5.2) Update of IIIF PVIS Severity Task Force activities and proposal. Szapponos

George Szapponos reviewed task force activities (**Attachment 3**). George noted that the task force has not identified the cause of the severity shift(s). George also addressed the Lubrizol proposal (**Attachment 4**) which uses a complex correction factor as a backup to solving the severity issue. George requested a separate teleconference and/or face-to-face meeting to

examine the proposal in greater detail. It was generally agreed to have a teleconference on the morning of Tuesday, Feb. 12. <**Action Item**: finalize teleconference details; **Dave Glaenzer**>

5.3) Update of Test Longevity Task force activiites. Altman

Due to time constraints, this item was not addressed and it will be postponed until the next meeting.

5.4) Annual calibration of Sunnen honing machine load system. Leverett

Charlie Leverett stated that Sunnen's calibration machine is currently out of service. Jerry Brys stated that Sunnen expects the machine to be back online in mid-February.

5.5) Batch Code 16 oil ring experiences. Bowden, J

Jason Bowden noted that some labs have contacted OHT regarding some oil consumption issues. OHT has had the vendor inspect Batch 15 and 16 samples and each type of inspection has concluded the parts are to print, close to mean of tolerance, and the batches are very similar to each other. The vendor's opinion is that nothing has been found that would be related to changes in oil consumption. Jason stressed that OHT will continue working with the labs on this issue.

5.6) Oil Pan Gaskets- There have been changes made to the most recent oil pan gasket and two labs have provided observations to OHT. Bowden, J

Matt and Jason Bowden updated the panel on this issue. The new pan gasket has an angle that may cause the oil pickup screen to rest on the gasket. OHT will modify the gasket to make sure that there are no clearance issues. <**Action Item**: modify oil pan gasket as noted; **OHT**>

5.7) Critical Part Modification statement. Grundza

Rich Grundza noted that both IIIF and IIIG have statements prohibiting parts modifications. Dave Glaenzer stressed the need for labs to be aware of this.

6.0) Review Scope and Objectives

6.1) All

Due to time constraints, this item was not addressed and it will be postponed until the next meeting

7.0) Next Meeting

7.1) The next meeting is tentatively scheduled for the morning of February 12, 2013. Dave Glaenzer will finalize the meeting details as noted in item 5.2, above.

8.0) Meeting Adjourned: at approximately 12:10 p.m.

ASTM Sequence III Surveillance Panel (17 Voting members) Teleconference 01/31/2013 11:00 EST date:

Name/Address	Phone/Fax/Email		Signature
Ed Altman Afton Chemical Corporation 500 Spring Street Richmond, VA 23219 USA	804-788-5279 804-788-6358 ed.altman@aftonchemical.com	Voting Member	Present ✓
Art Andrews ExxonMobil Products Research 600 Billingsport Rd. Paulsboro, NJ 08066 USA	856-224-3013 arthur.t.andrews@exxonmobil.com	Non-Voting Member	Present
Zack Bishop Test Engineering, Inc. 12718 Cimarron Path San Antonio, TX 78249-3423 USA	210-877-0223 210-690-1959 zbishop@tei-net.com	Non-Voting Member	Present
Doyle Boese Infineum 1900 E. Linden Avenue Linden, NJ 07036 USA	908-474-3176 908-474-3637 doyle.boese@infineum.com	Non-Voting Member	Present ✓
Adam Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 adbowden@ohtech.com	Non-Voting Member	Present
Jason Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 jhbowden@ohtech.com	Voting Member	Present ✓
Dwight H. Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 dhbowden@ohtech.com	Non-Voting Member	Present ✓

ASTM Sequence III Surveillance Panel (17 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Matt Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 mjbowden@ohtech.com	Non-Voting Member	Present ✓
Jerome A. Brys Lubrizol Corp. 29400 Lakeland Blvd. Wickliffe, Ohio 44092 USA	440 347-2631 jerome.brys@lubrizol.com	Non-Voting Member	Present ✓
Bill Buscher III Southwest Research Institute 6220 Culebra Road P.O. Box 28510 San Antonio, TX 78228 USA	210-522-6802 210-684-7523 william.buscher@swri.org	Non-Voting Member	Present
Bob Campbell Afton Chemical Corporation 500 Spring Street Richmond, VA 23219 USA	804-788-5340 804-788-6358 bob.campbell@aftonchemical.com	Non-Voting Member	Present
James Carter Haltermann Solutions 2296 Hulett Rd. Okemos, MI 48864 USA	517-347-3021 517-347-1024 jecarter@jhaltermann.com Cell: 517-896-0897	Voting Member	Present
Chris Castanien The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, OH 44092 USA	440-347-2973 440-944-8112 cca@lubrizol.com	Non-Voting Member	Present
Timothy L. Caudill Ashland Oil Inc. 22nd & Front Streets Ashland, KY 41101 USA	606-329-1960 x5708 606-329-2044 tlcaudill@ashland.com	Voting Member	Present
Martin Chadwick Intertek Automotive Research 5404 Bandera Road San Antonio, TX 78238 USA	210-706-1543 210-684-6074 martin.chadwick@intertek.com	Non-Voting Member	Present

ASTM Sequence III Surveillance Panel (17 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Jeff Clark Sequence III Secretary ASTM Test Monitoring Center 6555 Penn Avenue Pittsburgh, PA 15206 USA	412-365-1032 412-365-1047 jac@atc-erc.org	Non-Voting Member	Present ✓
Sid Clark Southwest Research 50481 Peggy Lane Chesterfiled, MI 48047 USA	586-873-1255 Sidney.L.Clark@sbcglobal.net	Non-Voting Member	Present ✓
Todd Dvorak Afton Chemical Corporation P.O. Box 2158 Richmond, VA 23218-2158 USA	804-788- 6367 804-788- 6388 todd.dvorak@aftonchemical.com	Non-Voting Member	Present
Frank Farber ASTM Test Monitoring Center 6555 Penn Avenue Pittsburgh, PA 15206 USA	412-365-1030 412-365-1047 fmf@astmtmc.cmu.edu	Non-Voting Member	Present
Gordon R. Farnsworth Infineum RR # 5 Box 211 Montrose, PA 18801 USA	570-934-2776 570-934-0141 gordon.farnsworth@infineum.com	Non-Voting Member	Present
Joe Franklin Intertek Automotive Research 5404 Bandera Road San Antonio, TX 78238 USA	210-523-4671 210-523-4607 joe.franklin@intertek.com	Non-Voting Member	Present
David L. Glaenzer Afton Chemical Corporation 500 Spring Street P.O. Box 2158 Richmond, VA 23218-2158 USA	804-788-5214 804-788-6358 dave.glaenzer@aftonchemical.com **Surveillance Panel Chairman**	Non-Voting Member	Present ✓

ASTM Sequence III Surveillance Panel (17 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Richard Grundza ASTM Test Monitoring Center 6555 Penn Avenue Pittsburgh, PA 15206 USA	412-365-1031 412-365-1047 reg@astmtmc.cmu.edu	Voting Member	Present ✓
Jeff Kettman GM Racing 5388 Hill 23 Drive Flint, MI 48507 USA	313-667-0493 313-319-0139 – cell jeff.kettman@gm.com	Non-Voting Member	Present ✓
Tracey King Chrysler LLC 800 Chrysler Drive CIMS 482-00-13 Auburn Hills, MI 48326-2757 USA	248-576-7500 248-576-7490 tek1@chrysler.com	Voting Member	Present
Clayton Knight Test Engineering, Inc. 12718 Cimarron Path San Antonio, TX 78249-3423 USA	210-690-1958 210-690-1959 cknight@tei-net.com	Voting Member	Present ✓
Teri Kowalski Toyota Motor North America, Inc. 1555 Woodridge Ann Arbor, MI 48105	734-995-4032 734-995-9049 teri.kowalski@tema.toyota.com	Non-Voting Member	Present
Patrick Lang Southwest Research Institute 6220 Culebra Road P.O. Box 28510 San Antonio, TX 78228 USA	210-522-2820 210-684-7523 plang@swri.edu	Voting Member	Present ✓
Charlie Leverett Intertek Automotive Research 5404 Bandera Road San Antonio, TX 78238 USA	210-647-9422 210-523-4607 charlie.leverett@intertek.com	Voting Member	Present ✓
Josephine G. Martinez Chevron Oronite Company LLC 100 Chevron Way Richmond, CA 94802 USA	510-242-5563 510-242-3173 jogm@chevrontexaco.com	Non-Voting Member	Present ✓

ASTM Sequence III Surveillance Panel (17 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Bruce Matthews GM Powertrain Mail Code 483-730-472 823 Jocyln Avenue Pontiac, MI 48340 USA	248-830-9197 248-857-4441 bruce.matthews@gm.com **Test Sponsor Representative**	Voting Member	Present ✓
Mike McMillan	mmcmillan123@comcast.net	Non-Voting Member	Present ✓
Timothy Miranda BP Castrol Lubricants USA 1500 Valley Road Wayne, NJ 07470 USA	973-305-3334 973-686-4039 Timothy.Miranda@bp.com	Voting Member	Present
Mark Mosher ExxonMobil Technology Co. Billingsport Road Paulsboro, NJ 08066 USA	856-224-2132 856-224-3628 mark.r.mosher@exxonmobil.com	Voting Member	Present ✓
Siamak Moshiri Cad Railway Industries Ltd. 155 Montreal – Toronto Highway H8S 1B4 Montreal, QC, CANADA	1-634-3131, ext. 412 smoshiri@cadrail.ca	Non-Voting Member	Present
Bob Olree GM Racing 5388 Hill 23 Drive Flint, MI 48507 USA	248-689-3078 olree@netzero.net	Non-Voting Member	Present ✓
Christian Porter Afton Chemical Corp. 500 Spring Street Richmond, VA 23219 USA	804-788-5837 804-788-6358 christian.porter@aftonchemical.com	Non-Voting Member	Present ✓
Phil Rabbat BASF Corporation 500 White Plains Road Tarrytown, NY 10591-9005 USA	914-785-2217 914-785-3681 phil.rabbat@basf.com	Non-Voting Member	Present

ASTM Sequence III Surveillance Panel (17 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Allison Rajakumar The Lubrizol Corporation Drop 152A 29400 Lakeland Blvd. Wickliffe, OH 44092 USA	440-347-4679 440-347-2014 Allison.Rajakumar@Lubrizol.com	Non-Voting Member	Present ✓
Scott Rajala Idemitsu Lubricants America Corp.	srajala@ilacorp.com	Non-Voting Member	Present
Andrew Ritchie Infineum 1900 East Linden Avenue P.O. Box 735 Linden, NJ 07036 USA	908-474-2097 908-474-3637 Andrew.Ritchie@Infineum.com	Voting Member	Present ✓
Ron Romano Ford Motor Company Diagnostic Service Center II Room 410. 1800 Fairlane Drive Allen Park, MI 48101 USA	313-845-4068 313-32-38042 rromano@ford.com	Voting Member	Present ✓
Jim Rutherford Chevron Oronite Company LLC 100 Chevron Way Richmond, CA 94802 USA	510-242-3410 510-242-3173 jaru@chevrontexaco.com	Non-Voting Member	Present ✓
Philip R. Scinto The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, OH 44092 USA	440-347-2161 440-347-9031 prs@lubrizol.com	Non-Voting Member	Present
George Szappanos replaces ~~Greg Seman~~ The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, OH 44092 USA	440-347-2153 440-347-4096 greg.seman@lubrizol.com	Voting Member	Present ✓

ASTM Sequence III Surveillance Panel (17 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Matt J. Snider GM Powertrain General Motors Corporation MC - 483-730-322 823 Joclyn Rd. Pontiac, MI 48090-9055 USA	248-672-3563 248-857-4441 mathew.j.snider@gm.com	Non-Voting Member	Present
Thomas Smith Valvoline P.O. Box 14000 Lexington, KY 40512-1400 USA	859-357-2766 859-357-7084 trsmith@ashland.com PCEOCP Chair	Voting Member	Present
Don Smolenski GM	248-255-7892 donald.j.smolenski@gm.com	Non-Voting Member	Present
Mark Sutherland Chevron Oronite Company LLC 4502 Centerview Drive Suite 210 San Antonio, TX 78228 USA	210-731-5621 210-731-5699 msut@chevrontexaco.com	Voting Member	Present
Joe Vujica The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, OH 44092 USA	440-347-2057 440-347-4096 jsvu@lubrizol.com	Non-Voting Member	Present
Ben O. Weber Southwest Research Institute 6220 Culebra Road P.O. Box 28510 San Antonio, TX 78228 USA	210-522-5911 210-684-7530 bweber@swri.edu **Sub-Committee D02.B01 Chair**	Non-Voting Member	Present
Tom Wingfield Chevron Phillips Chemical Co.	wingftm@cpchem.com	Non-Voting Member	Present

Remove

Remove

RAYMOND SMART ✓ Janet Buckingham ✓

Robert Stockwell ✓ Jessica Buchanan ✓

Scott Stopp ✓

Sequence IIIG 435-2 Results

Sequence III Surveillance Panel

January 31, 2013

Summary of Results

- 18 tests reported from six labs
- Summary in next few slides

Target Values

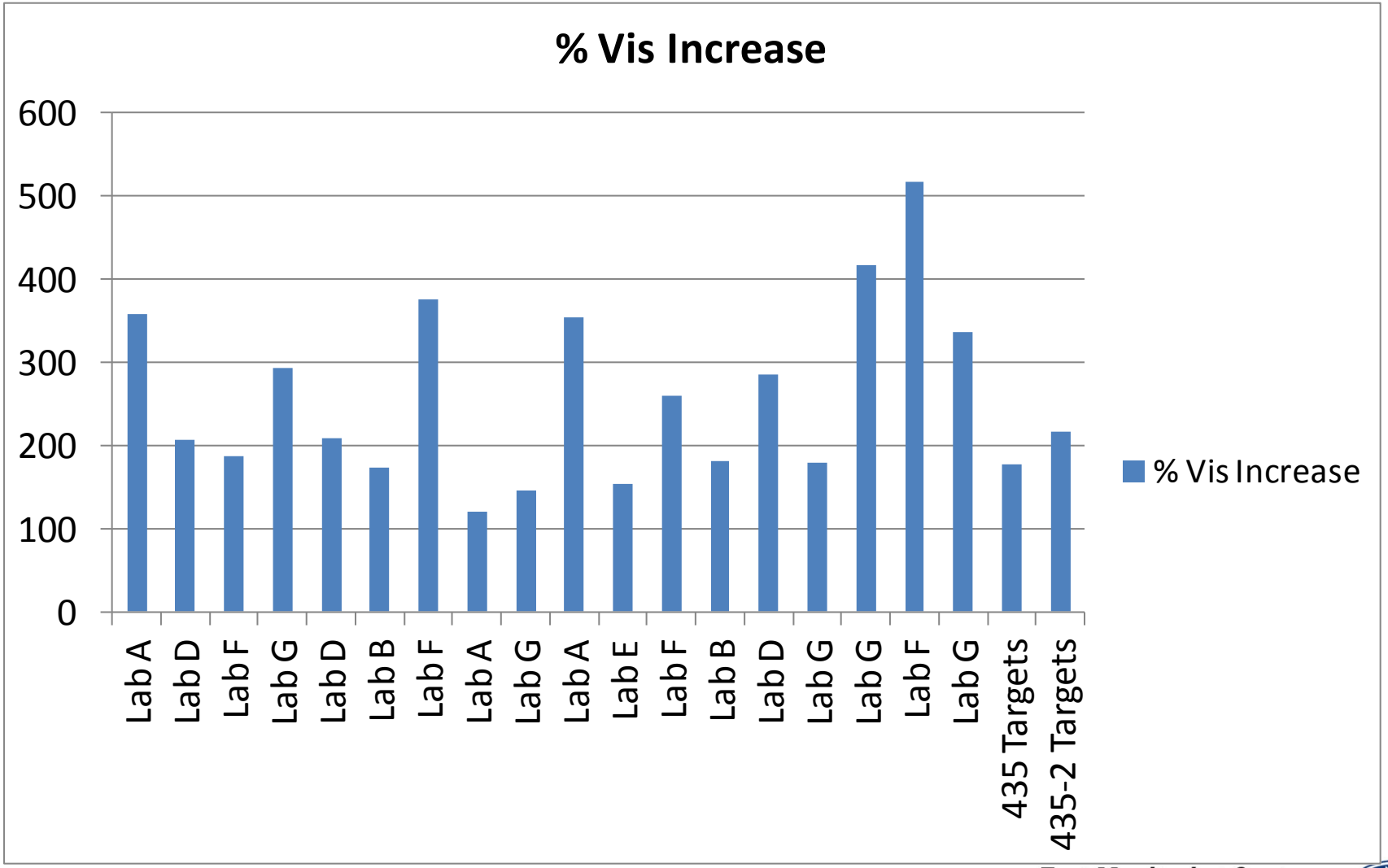
Parameter	Mean	Standard Deviation
ACLW	3.5096	0.4405
PVIS	5.3792	0.3607
WPD	3.61	0.31
PHOS	82.2	1.59

Means and standard deviations in transformed units for ACLW and PVIS

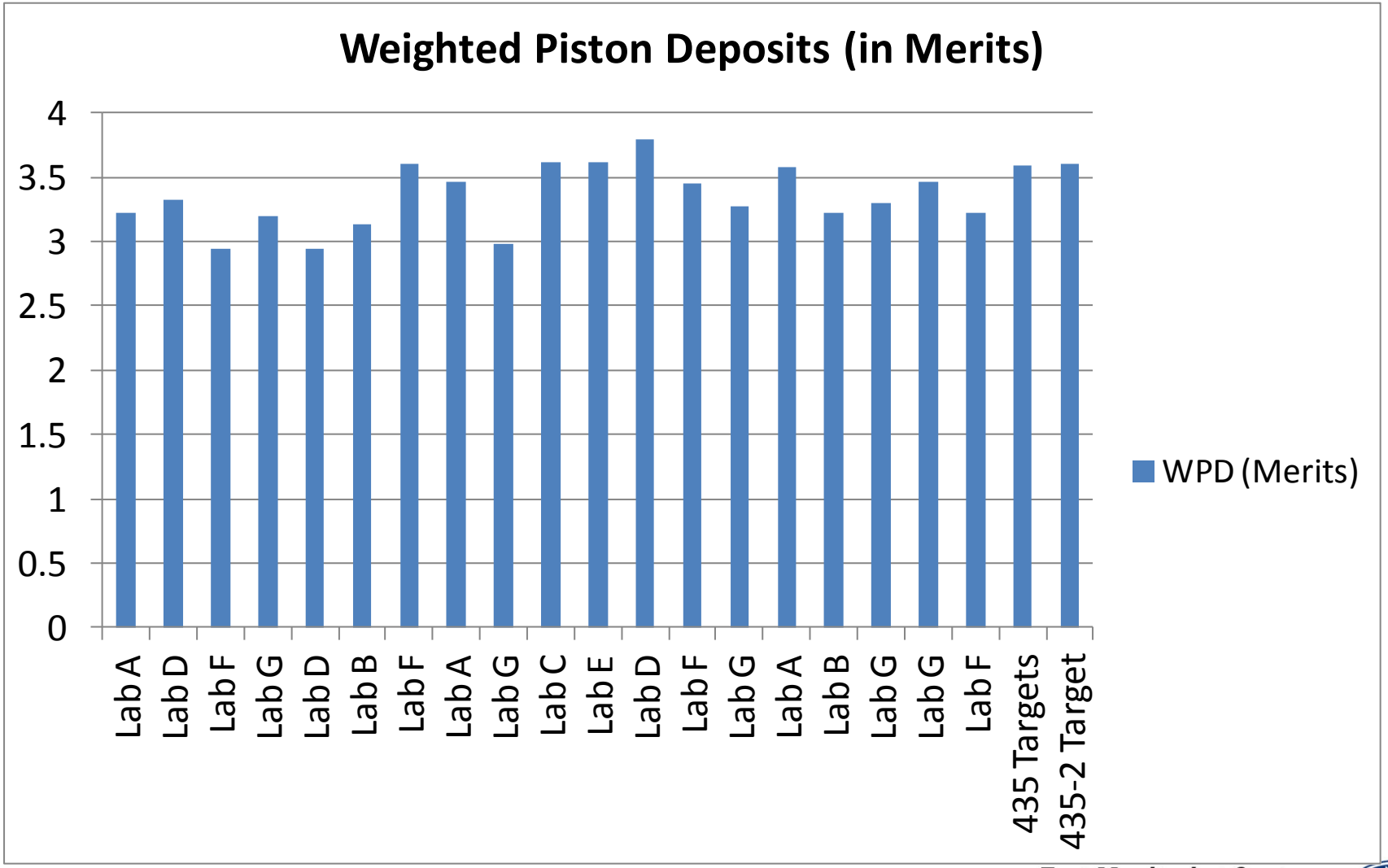
Summary of Test Results

LTMSLAB	TESTKEY	PVIS	PVISti	SA	Adjusted	ACLWti	SA	Adjusted	WPDti	SA	Adjusted
D	80559-IIIG	208.4	5.339459	0	5.339459	3.2958	0.3647	3.6605	3.33	0	3.33
A	80562-IIIG	358.4	5.88165	-0.28715	5.5945	3.5205	0.3874	3.9079	3.23	0.337	3.567
F	80561-IIIG	188.8	5.240688	0	5.240688	2.9497	0.1771	3.1268	2.94	0	2.94
G	81512-IIIG	293.7	5.682559	-0.27444	5.408121	3.1001	0.4048	3.5049	3.2	0.4164	3.6164
D	80560-IIIG	208.8	5.341377	-0.24998	5.091393	3.8754	0.1767	4.0521	2.95	0.4446	3.3946
B	80564-IIIG	173	5.153292	0	5.153292	3.6763	0.219	3.8953	3.13	0.4268	3.5568
F	82083-IIIG	376.2	5.930121	0	5.930121	3.4078	0.1908	3.5986	3.6	0.337	3.937
A	81940-IIIG	162	5.087596	-0.29715	4.790451	3.6533	0.2947	3.948	3.46	0.335	3.795
G	82617-IIIG	176.3	5.172187	-0.17878	4.993409	3.0493	0.3817	3.431	2.98	0.3734	3.3534
E	80552-IIIG	153.7	5.035003	0	5.035003	3.0865	0.1693	3.2558	3.62	0	3.62
D	80852-IIIG	286.2	5.656691	0	5.656691	2.4069	0	2.4069	3.8	0.5032	4.303
F	82084-IIIG	259.6	5.559142	-0.37931	5.179832	3.74715	0	3.74715	3.45	0	3.45
G	84613-IIIG	417.7	6.034763	-0.181521	5.853242	3.5086	0.2921	3.8007	3.27	0.4163	3.6863
A	81941-IIIG	355	5.872118	-0.378336	5.493782	2.77882	0.1993	0.297212	3.58	0.3571	3.9371
B	82079-IIIG	181.6	5.201806	0	5.201806	3.605498	0.1141	3.719598	3.22	0.4747	3.6947
G	88571-IIIG	180.3	5.194622	-0.186113	5.008509	2.5878	0.2252	2.813	3.3	0.4174	3.7174
G	90683-IIIG	337	5.82009	0	5.82009	3.70868	0.2250	3.93368	3.46	0.3406	3.80
F	87279-IIIG	561.9	6.33132	-0.344208	5.9871	3.7281	0	3.7281	3.22	0	3.22

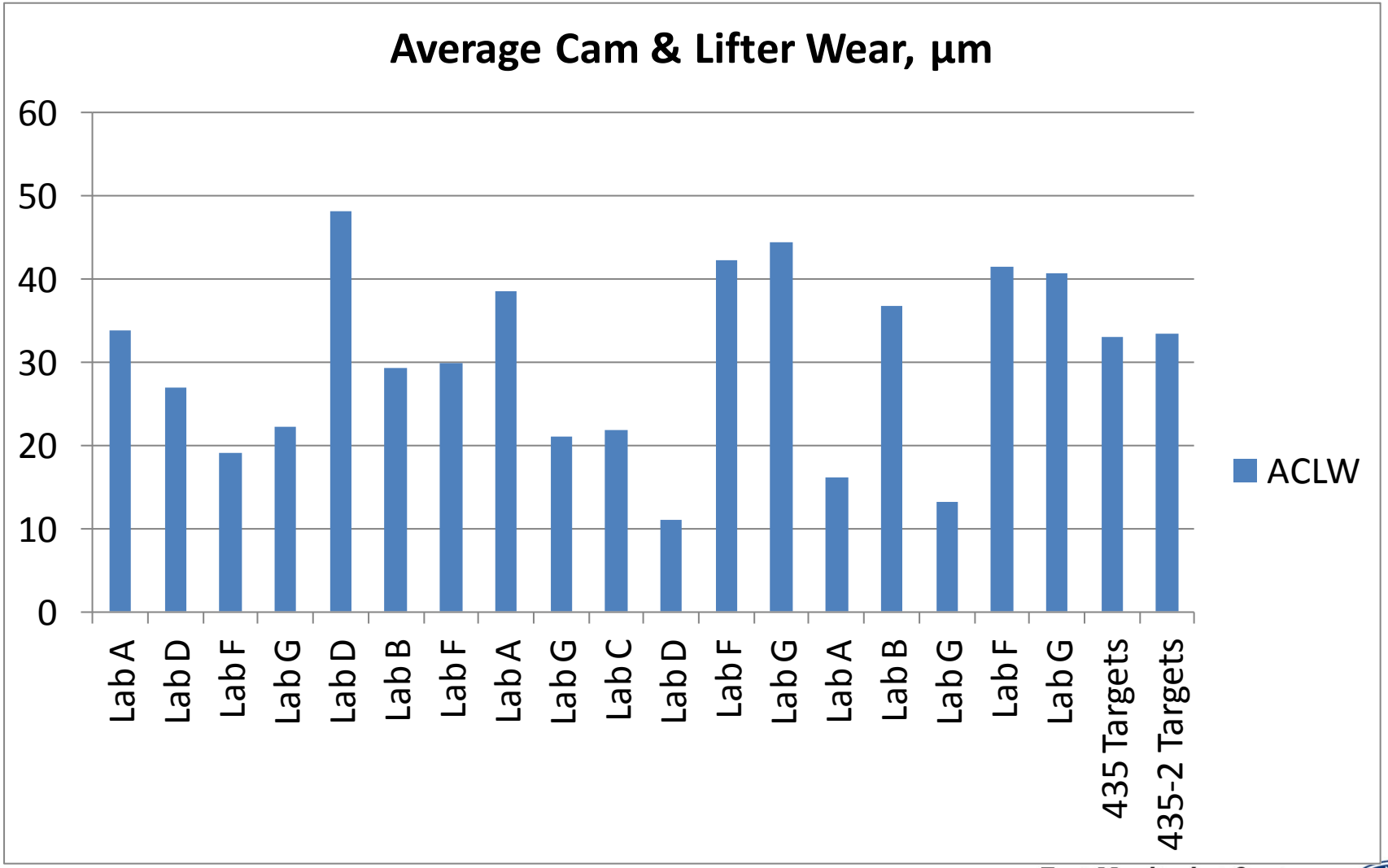
RO 435-2 Results for PVIS



RO 435-2 Results for WPD



RO 435-2 Results for ACLW



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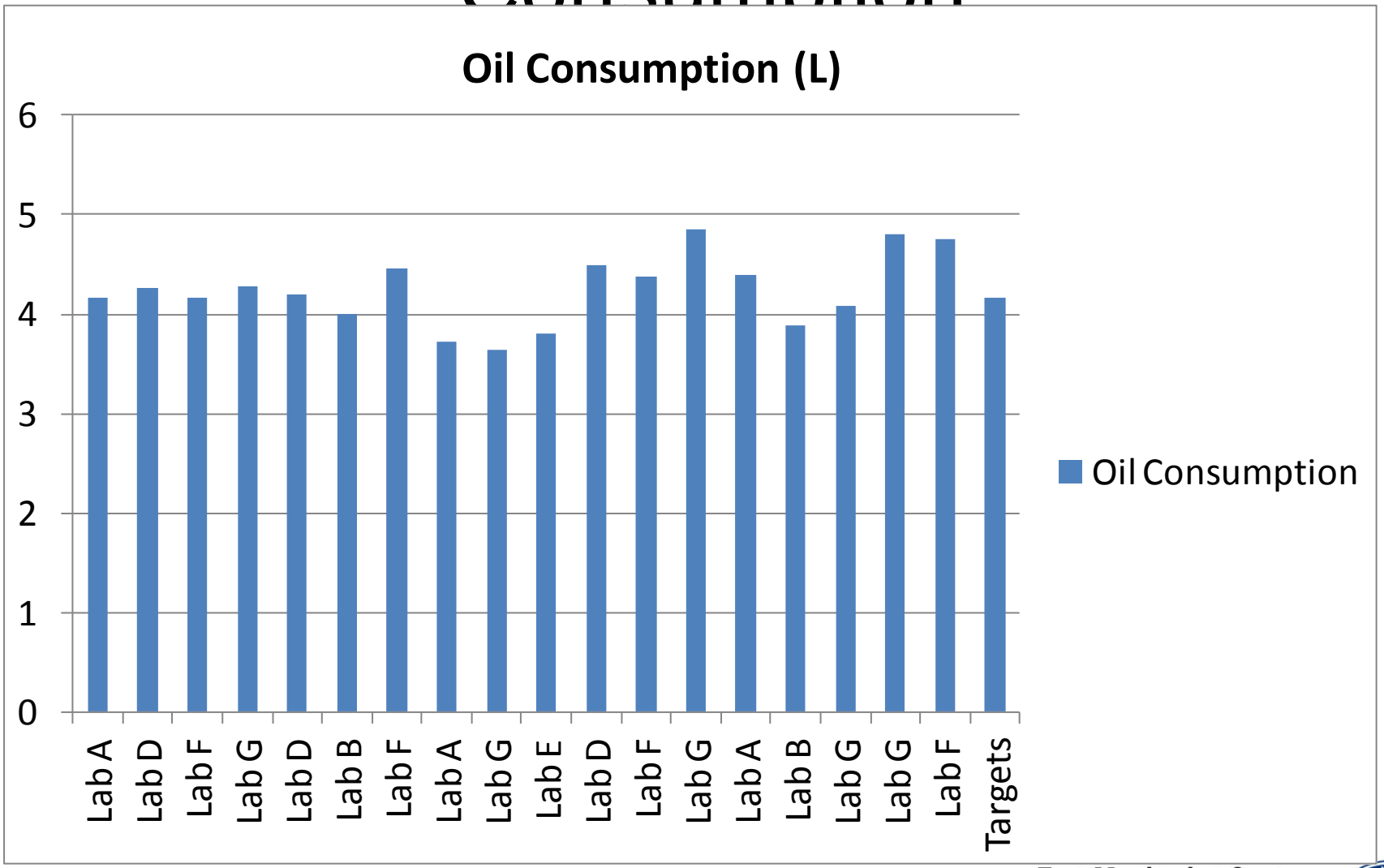
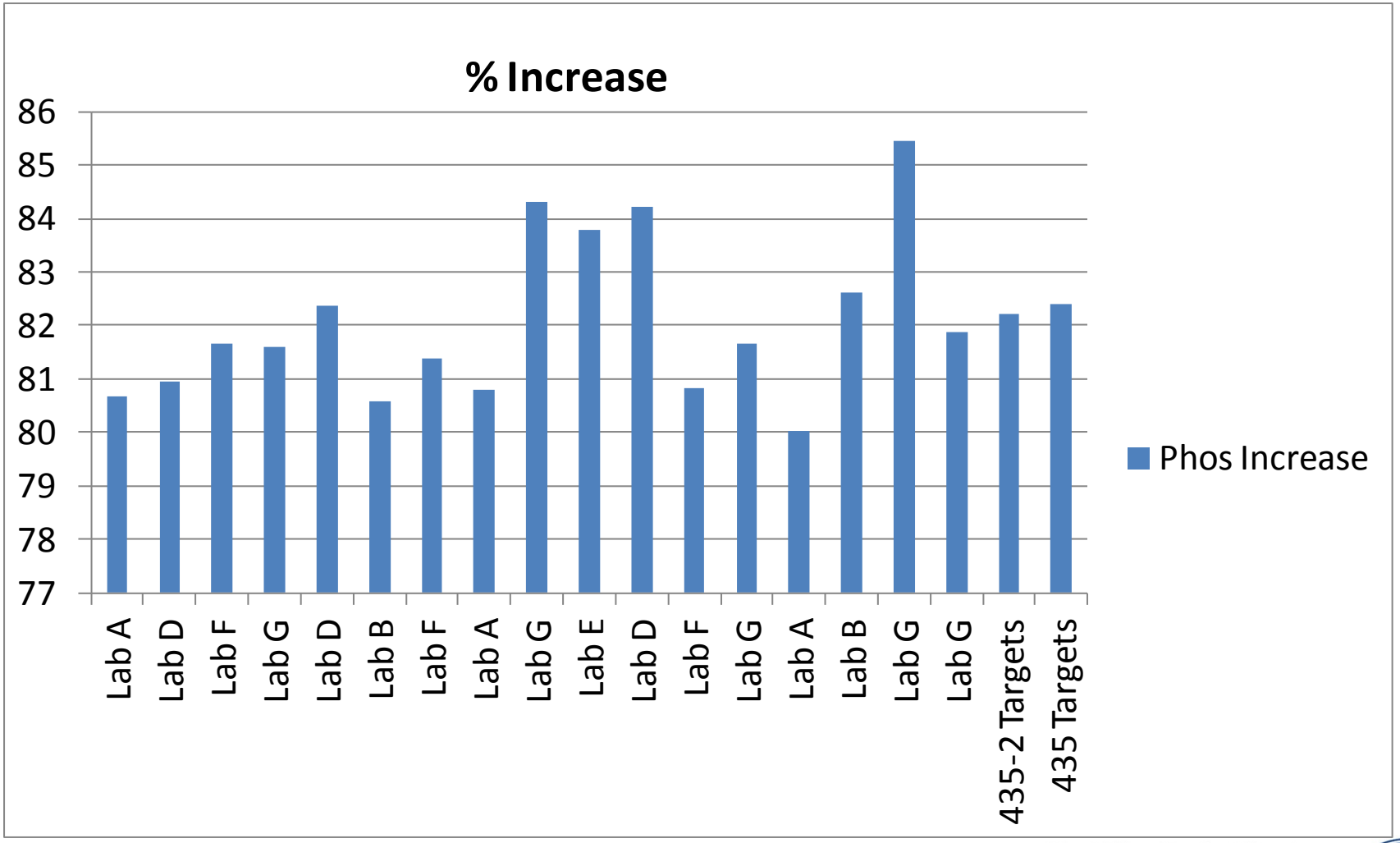
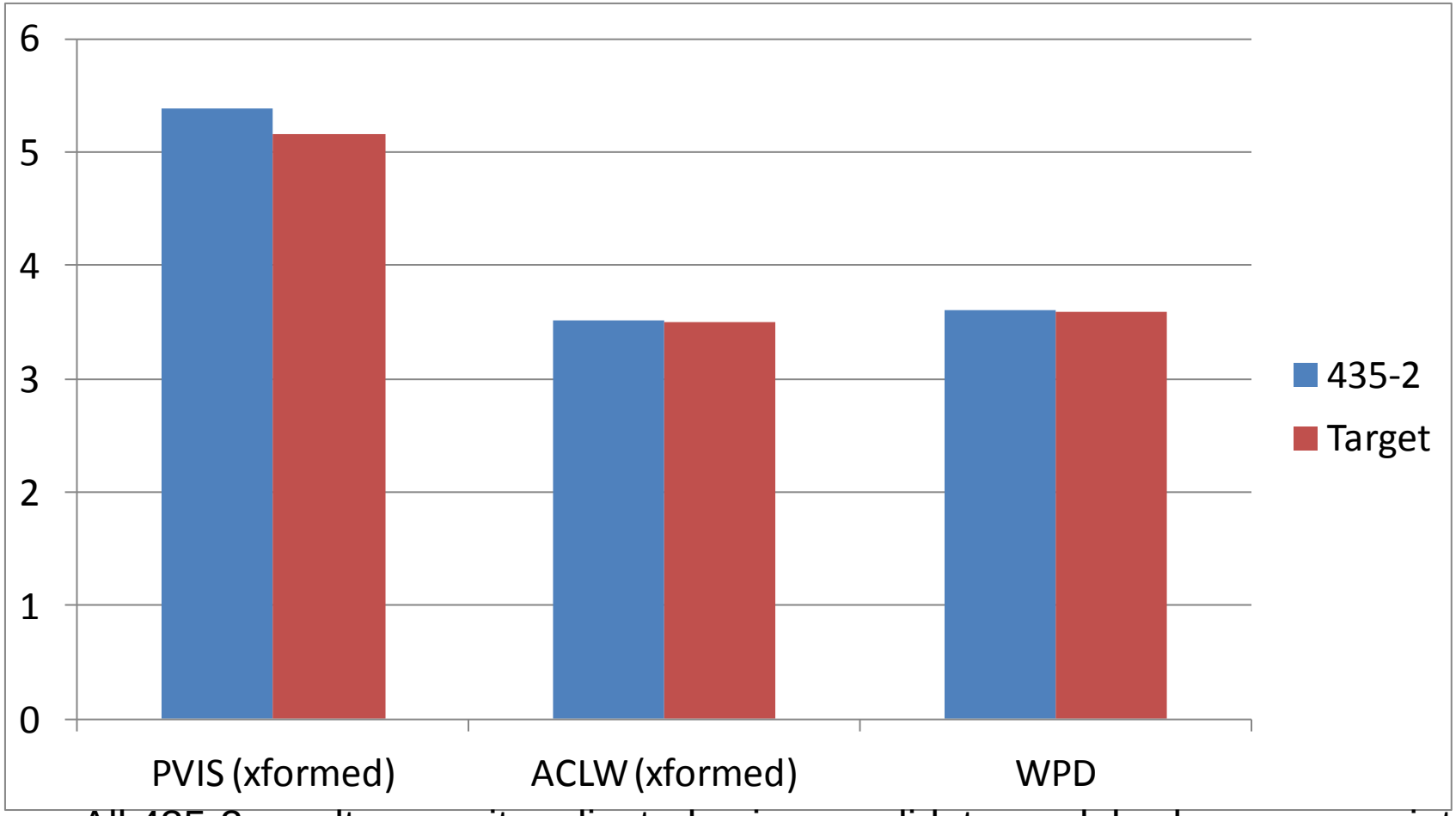
RO 435-2 Results for Oil Consumption



RO 435-2 Results for Phos Retention

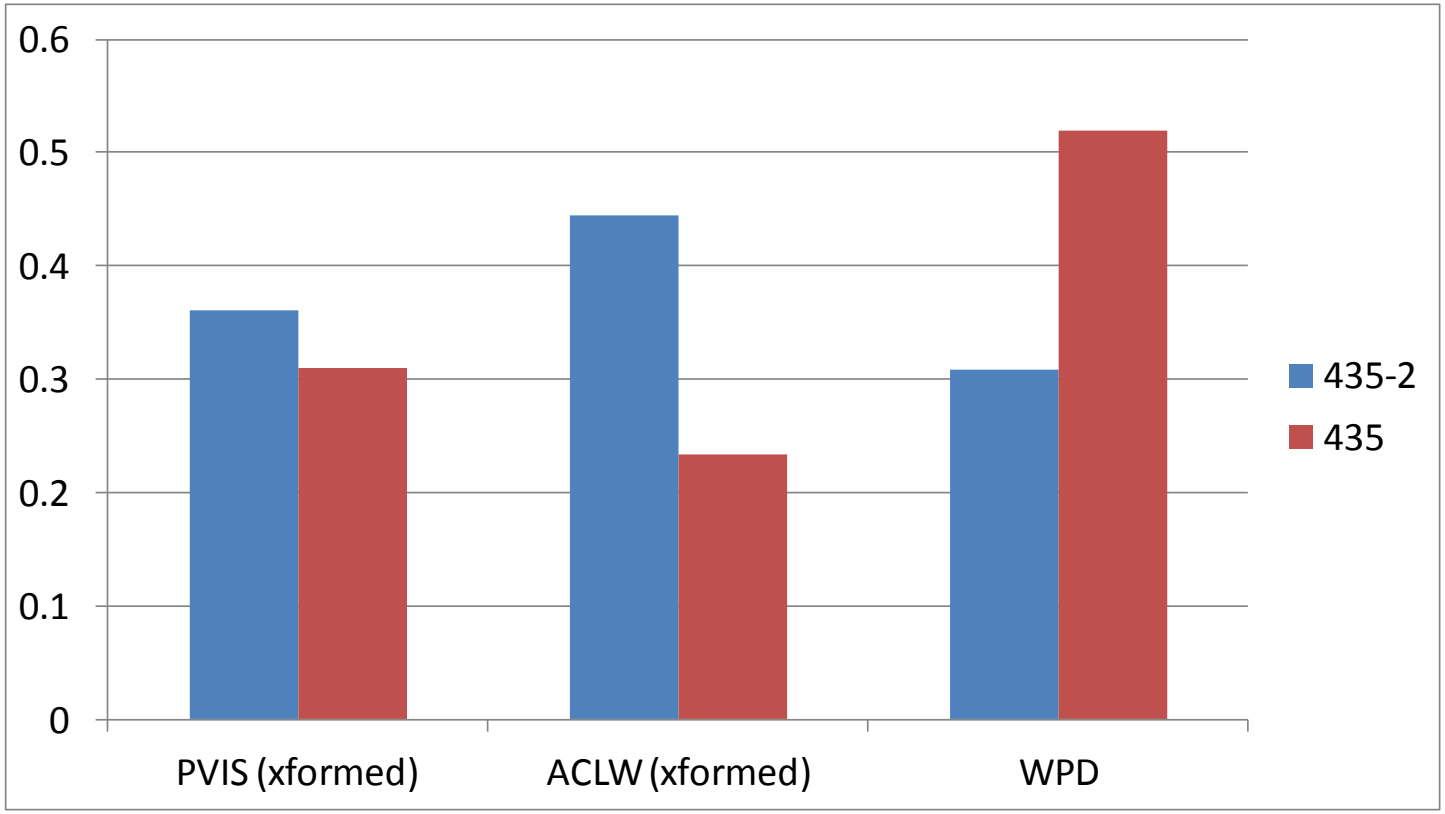


Comparison of Mean Performance of 435-2 (n= 18) with 435 targets



All 435-2 results severity adjusted using candidate model, where appropriate.

Comparison of Standard Deviations of 435-2 (n= 18) with 435 targets



All 435-2 results severity adjusted using candidate model, where appropriate.

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30-Jan-13

Subject: Sequence IIIF PVIS Task Force Proceedings

Background:

On November 13, 2012 Lubrizol presented data indicating that the Sequence IIIF test has gotten significantly more severe in PVIS than what industry reference tests reflect. The analysis showed that due to the severity shift, a "break point" was being detected in current tests that coincides with a period in which the oil's viscosity is temporarily low. If a test EOTs during this period it will artificially make the test appear mild when in fact the exact opposite is the case. This break-point was previously undetected since it would normally occur much later than 80 hours. With the current severity shift, this break-point is occurring progressively sooner.

During the SP teleconference of Nov 13, there was overall agreement that a PVIS shift has occurred and that it should be studied in more detail. A task force was formed to investigate the possible causes. Members of the task force are listed in the Appendix.

Objective:

The objective of the task force was 1) to validate the occurrence of a severity shift, and 2) to identify which aspect of the test was responsible for the PVIS shift. The areas of focus were to include: hardware, changes to test protocol, engine build, fuel, and oil.

Summary:

- A distinct PVIS severity shift was observed in 2007, and in again in 2010
- All labs are affected
- Thus far been unable to determine which test component(s) are responsible

Task Force Proceedings:

The first TF teleconference was held on 12/12/12 during which various analyses were presented:

a. Rich Grundza of the TMC presented CUSUM charts, marked with the timing of hardware changes; based on this analysis it was not evident if any particular component was responsible ("IIIF plots.pdf")
b. Rich Grundza also presented an analysis of PVIS at 60, 70, and 80 hours that corroborated Lubrizol's analysis of 11-12 ("TMC Presentation IIIF.pdf")
c. Doyle Boese of Infineum presented his analysis of the 'break-point', which also corroborated the severity shift ("IIIF Pvis 433-1 Severity Change.pptx")
d. Todd Dvorak and Ed Altman from Afton presented "Seq-IIIF-Severity-Trend-12-11-12.pptx" that showed that coincident to the PVIS shift, blowby has been increasing. He suggested that

possible factors may be ring and piston batches, however the correlation may be only to calendar date and have no relationship to the parts batches.

e. Jessica Buchanan's analysis ("PVIS severity 12-12-12 LZ.ppt") showed that an oil consumption shift may be related to an oil seal batch change, and possibly to oil filter batch. Also, a shift in APV was shown that also seems to correlate with the timing of PVIS.
f. It was anecdotally mentioned repeats of candidate oils have also shown significant shift, thus implying that the reference oil quality is not at issue. However, there was interest in looking at volatility through calcium drain analysis.
g. George Szappanos and Ed Altman discussed their analysis of oil pressure, explaining that there exists a large inconsistency in the profile of oil pressure and that it was difficult to decipher any correlation between severity and curve signature.
h. Lubrizol offered to run an investigative test to examine the impact of reducing blowby (given Dvorak's findings)

The next teleconference was January 22, 2013 to discuss Lubrizol's investigative run, the Calcium drain analysis, and next steps.

a) The "low blowby" test was reviewed ("IIIF low blowby test.pptx"), which did not improve the PVIS severity at all. The conclusion from the test was that either it was not possible to reduce blowby significantly by closing ring end-gap, or that such a small change in blowby does not impact PVIS significantly.
b) An analysis of Calcium drain oil was presented by George Szappanos of Lubrizol ("IIIF 1006 Ca.ppt"), which showed that there is a higher concentration of Ca at EOT at current versus 10 years ago. This would suggest a higher level of oil volatilization, which may be indicative of higher (local) temperatures in the engine.
c) No additional analyses or experiments were suggested.
d) Lubrizol offered that a correction factor may be a viable solution and that a proposal would be made available for review in the next week.

Appendix:

Task Force members:

Afton:	Ed Altman; Dave Glaenzer; Todd Dvorak
GM:	Angela Willis; Bruce Matthews
Lubrizol:	Jerome Brys; Buchanan, Jessica; Szappanos, George
Infineum:	Doyle Boese; Ritchie, Andrew
Intertek:	Charlie Leverett
SWRI:	Janet Buckingham; Patrick Lang; Karin Haumann
OHT:	Jason Bowden
TMC:	Richard Grundza
Ashland:	Tim Caudill

Now What?

How to Better Numerically Assess Sequence IIIF Viscosity Increase

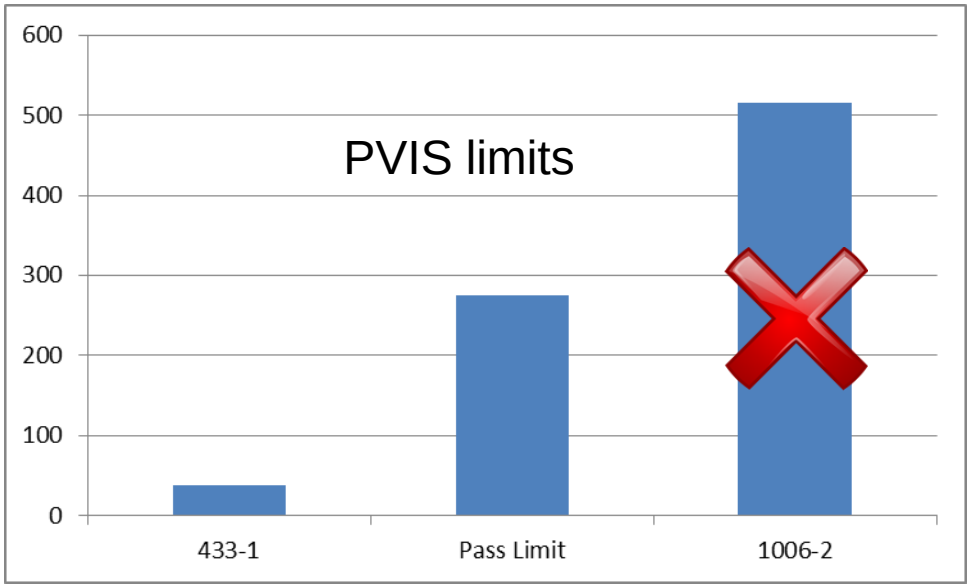
January 28, 2013

IIIF PVIS Severity - Background

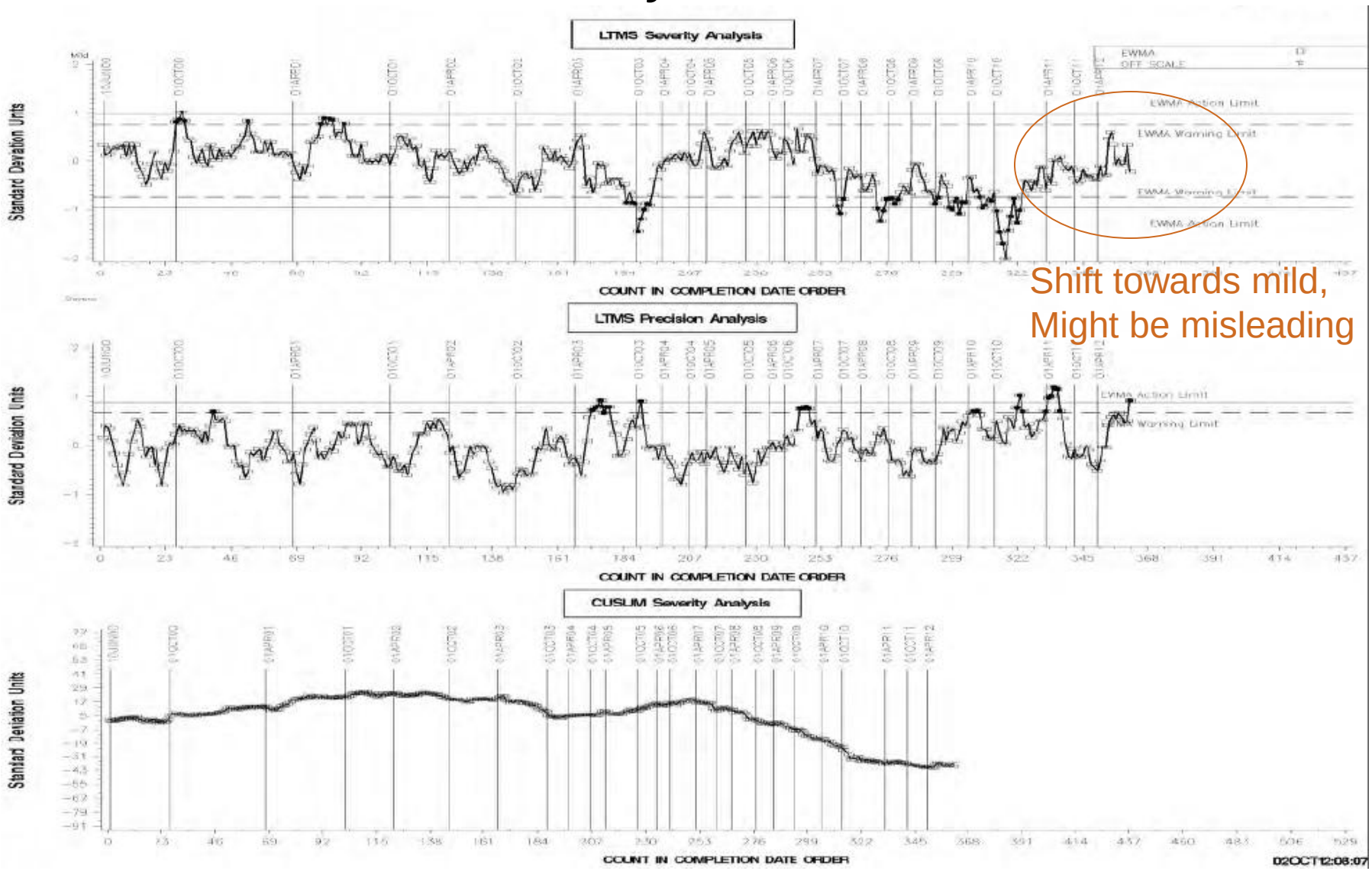
- IIIF PVIS has become more severe
- Difficult to detect the change in severity by looking at EOT PVIS due to the nature of RO 433-1
- LZ presented evidence of severity change to the Sequence III Surveillance Panel November 12, 2012
- Subsequently, IIIF PVIS Severity Task Force was created, and severity change confirmed by others in the industry

Reference oils

- IIIF 1006 reference oil dropped (PVIS target = 515%)
  - Labs could not calibrate; removed late 2010
  - 433, high reference, left as the only reference oil (PVIS target = 37%)
  - There is concern that without a severe reference oil to bracket the pass/fail limit, it's difficult to determine if the test severity has shifted.



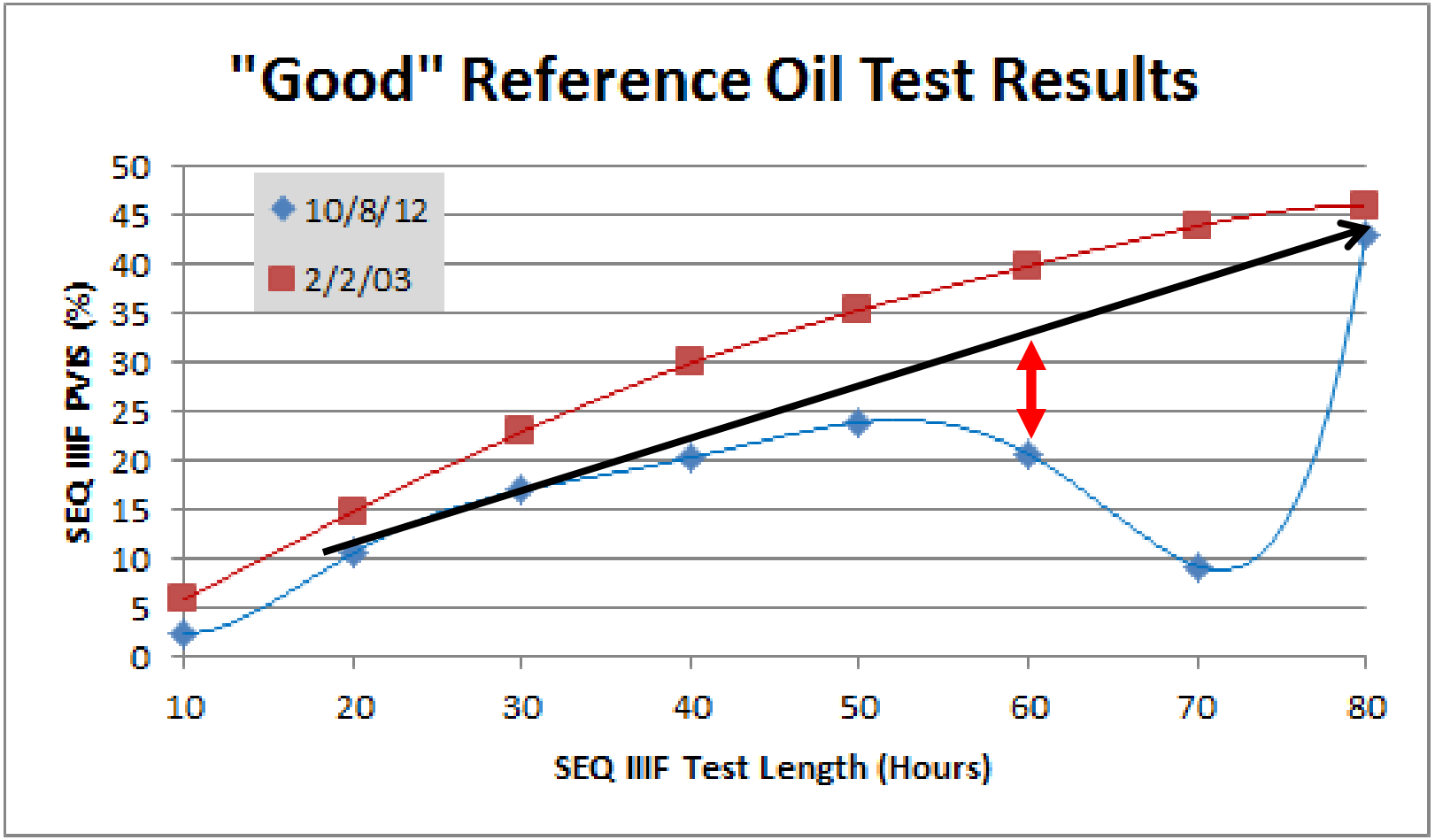
TMC Data, PVIS severity



Shift towards mild,
Might be misleading

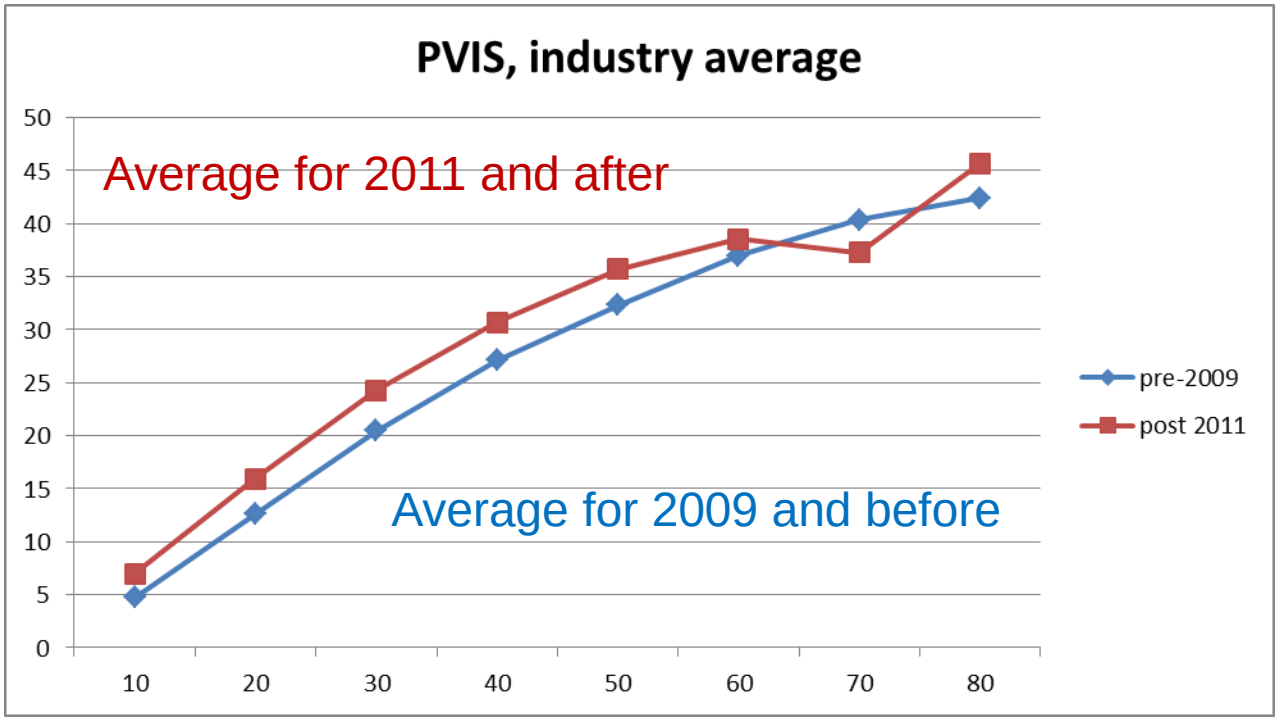
Why SEQ IIIF-HD Reference Considered “Mild”

During more severe SEQ IIIF test run, if the 60Hr data point falls inside the “Negative Viscosity Increase” during the oil breaking period, the SEQ IIIF-HD result appears to be mild when in actuality, the test is running much more severe. The “Good” reference oil generally did not “break” before 70hrs until testing after 2010.



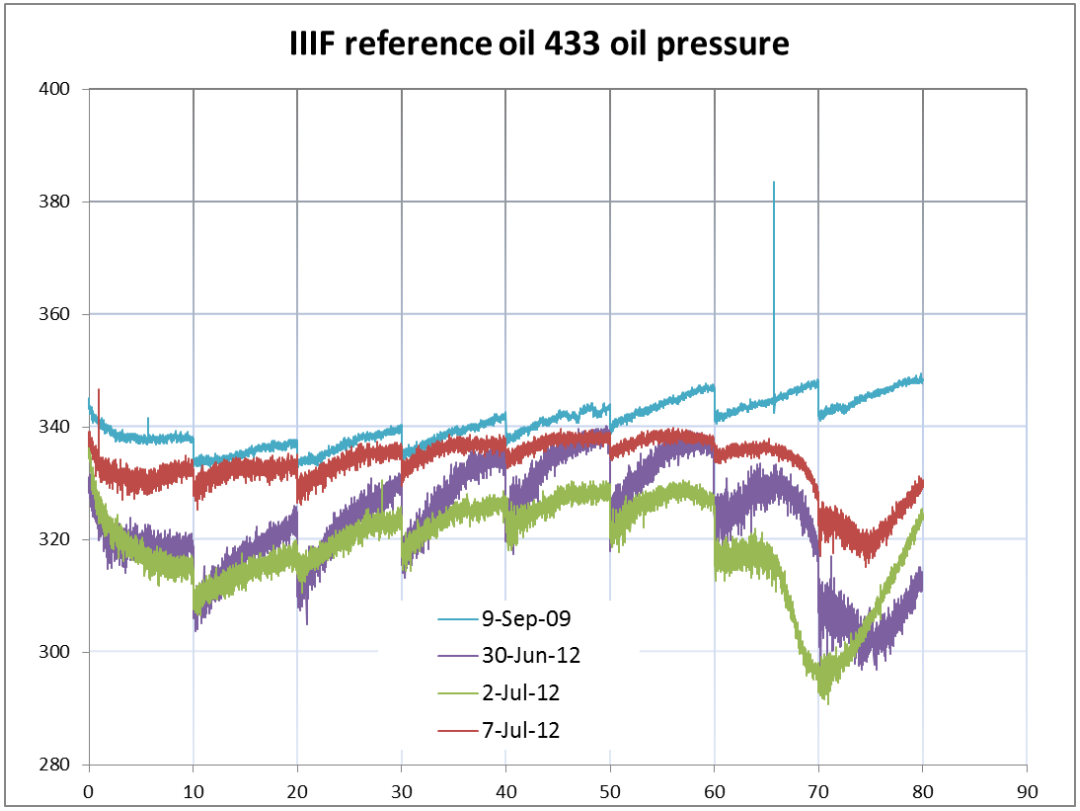
RO 433 PVIS break point, industry average

- Data analyzed before and after 2010
- Note that latest data shows a ‘break point’ at 70 hrs
- An analysis was performed to examine the PVIS delta near EOT



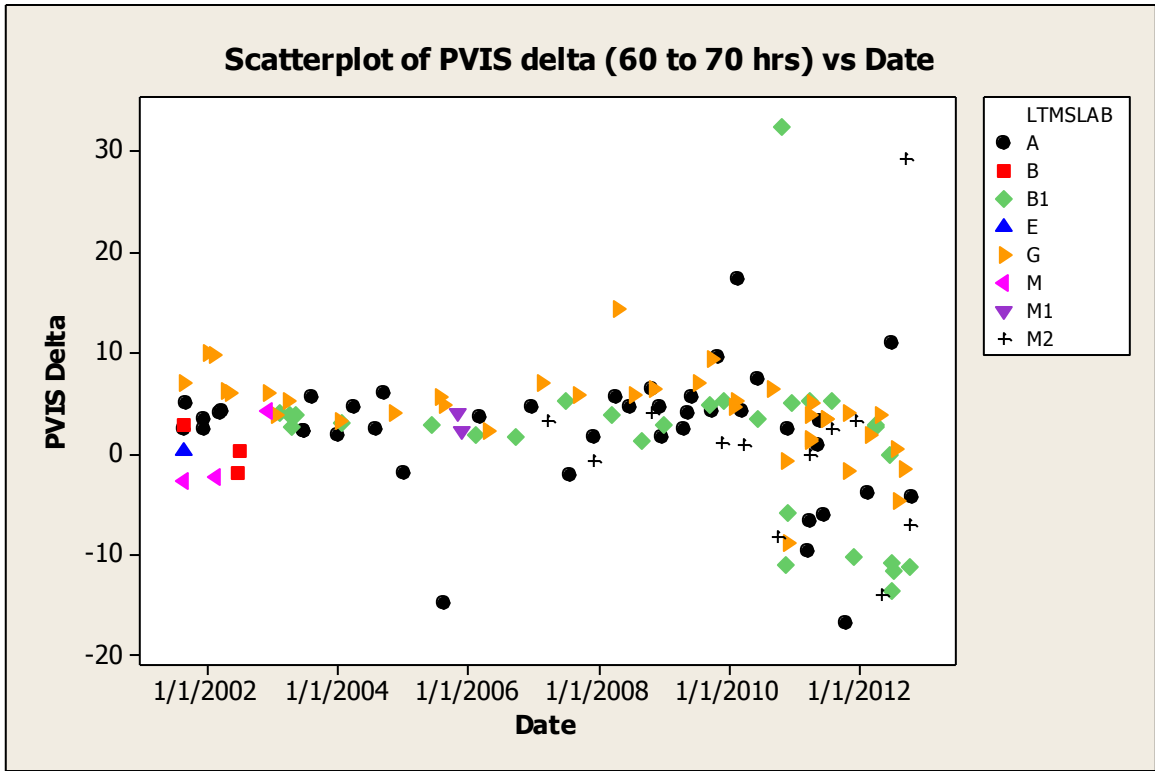
Oil pressure break point (LZ data)

- Shows break point occurring around 70-75 hrs
- Earlier tests do not show any break point



Reference Data from TMC for RO 433-1

- Starting in 2010, the change in PVIS from 60 to 70 hours shows a general decreasing trend
- This decrease in viscosity indicates the oil has lost oxidation control and has begun to 'break'

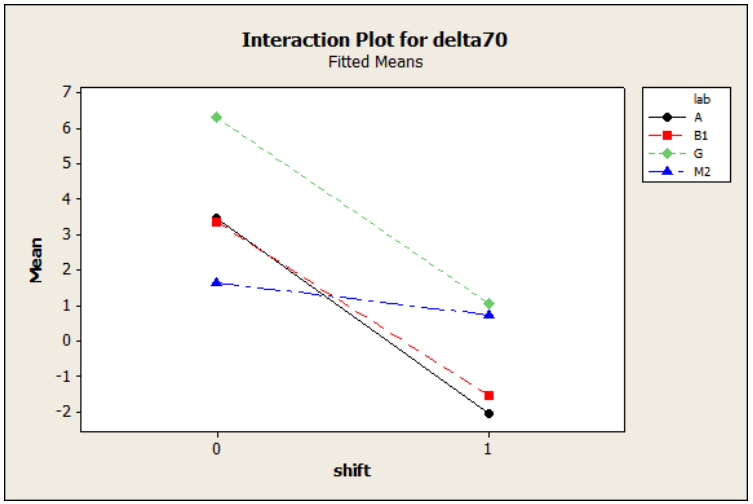


A Shift in Delta70

- A model was fit to look for evidence of a shift in severity
- The Shift was defined as 6/13/2010
- The effect of shift is significant; the interaction between lab and shift is not significant → a shift happens, and all labs experience it

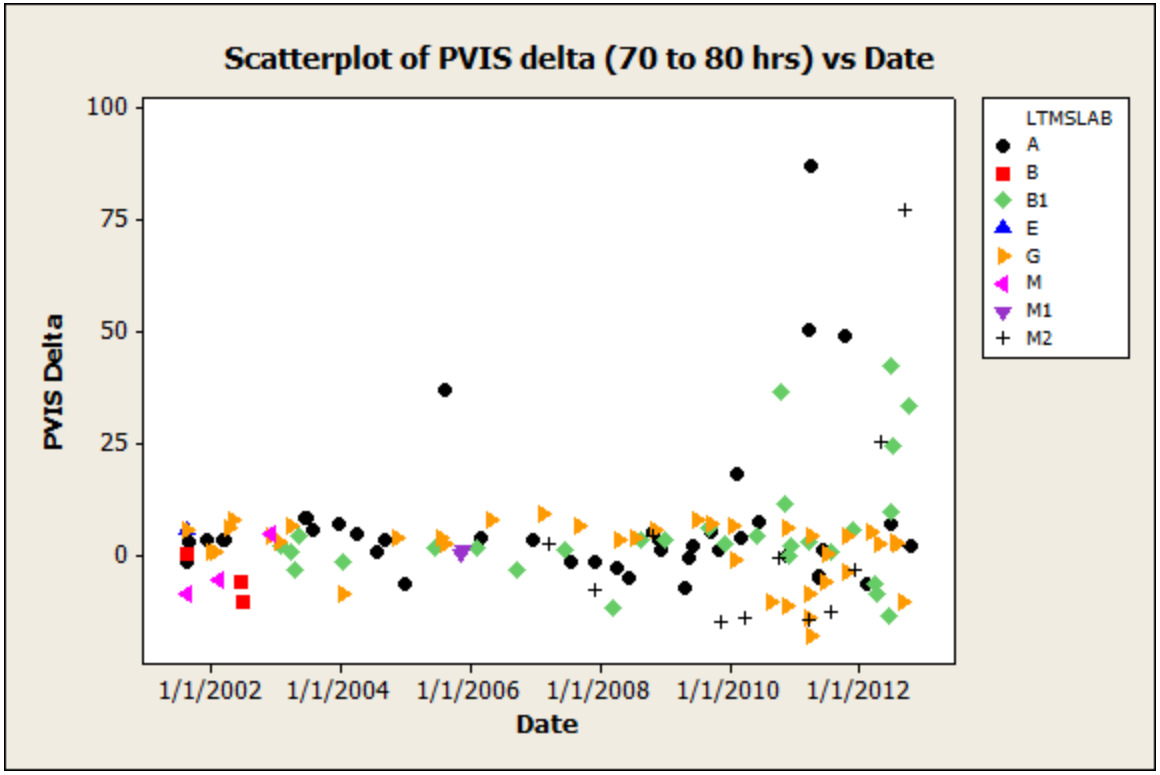
General Linear Model: delta70 versus lab, shift

```
Factor   Type   Levels  Values
lab      fixed       4  A, B1, G, M2
shift    fixed       2  0, 1

Analysis of Variance for delta70, using Adjusted SS for Tests

Source       DF   Seq SS   Adj SS  Adj MS     F      P
lab           3   192.98   198.29   66.10  1.54  0.207
shift         1   632.60   388.40  388.40  9.07  0.003
lab*shift     3    50.60    50.60   16.87  0.39  0.758
Error       113  4841.36  4841.36   42.84
Total       120  5717.53

S = 6.54552   R-Sq = 15.32%   R-Sq(adj) = 10.08%
```



Reference Data from TMC for RO 433-1

- Beginning 2010, a change is also evident in the change in PVIS from 70 to 80 hours

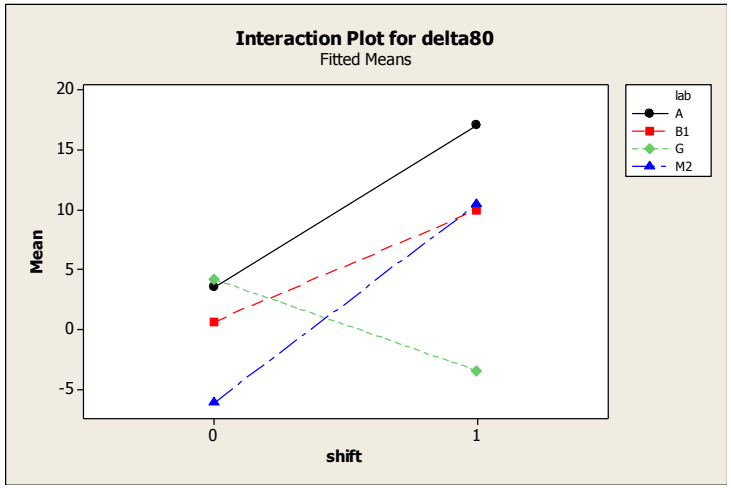


A Shift in Delta80

- A model was fit to look for evidence of a shift in severity
- The Shift was defined as 6/13/2010
- The interaction between lab and shift is significant → labs are experiencing a shift differently

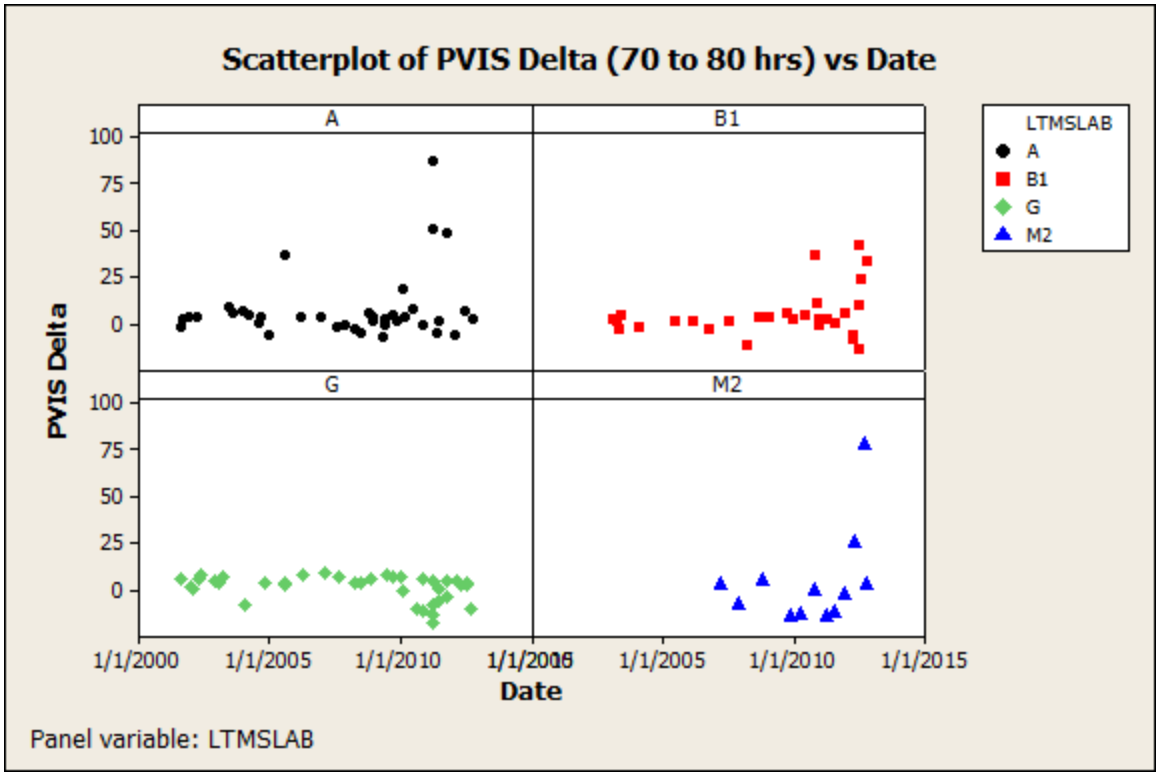
General Linear Model: delta80 versus lab, shift

```
Factor  Type   Levels  Values
lab     fixed       4  A, B1, G, M2
shift   fixed       2  0, 1

Analysis of Variance for delta80, using Adjusted SS for Tests

Source       DF   Seq SS   Adj SS  Adj MS     F      P
lab           3    775.4   1797.9   599.3  2.88  0.039
shift         1    868.1   1416.1  1416.1  6.80  0.010
lab*shift     3   2581.8   2581.8   860.6  4.13  0.008
Error       113  23539.8  23539.8   208.3
Total       120  27765.0

S = 14.4332   R-Sq = 15.22%   R-Sq(adj) = 9.97%
```



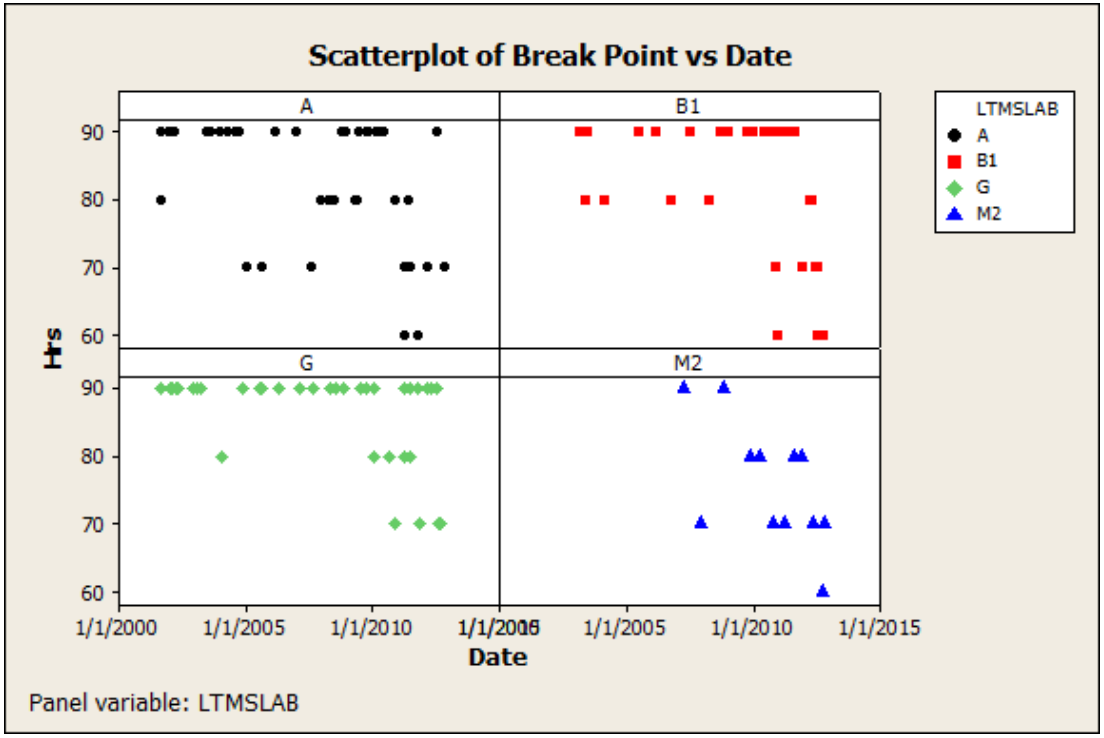
Delta80 by Lab

- Plot of Delta80 by lab, to examine interaction
- By EOT, the RO could be at three places: not yet broke, currently breaking, or already broke
- Difficult to tell using just the EOT PVIS



RO 433-1 Breaking point

- Look for the time of breaking point for RO 433-1.
- Break Point = hours when viscosity change first goes negative
  - 90 hrs means did not break before EOT
- **Conclusion: the oil is breaking sooner → the test is increasing in severity**



Executive Summary

- RO1006-2 dropped in 11/2010 because the test became too severe, but this DOES NOT magically make severity problem disappear
- Buchanan presentation shows statistical evidence that PVIS has shifted for RO433 since 06/2010 (not coincidently, about the same time RO1006-2 shifted)
- IF we cannot find an engineering solution:
  - This presentation shows how PVIS severity can be properly assessed using HOURS to 275% PVIS for the Reference Oils
  - Lubrizol proposes using HOURS in LTMS and then applying any severity adjustments based on HOURS to candidate oil PVIS

Problem

- We only have one reference oil and it is a high-performing oil
- PVIS has shifted severe even though PVIS values at 80 hours for RO433-1 are the same or even LOWER than before the shift
- Test hours are not long enough to assess the ramifications of an earlier break in the oil for RO433-1, using EOT PVIS
- Introducing new, borderline reference oils is expensive and time consuming (although this should be highly considered for the future)
  - It may not be a good idea to introduce a new reference oil when there are questions concerning the severity or precision of the test

Proposed Solution

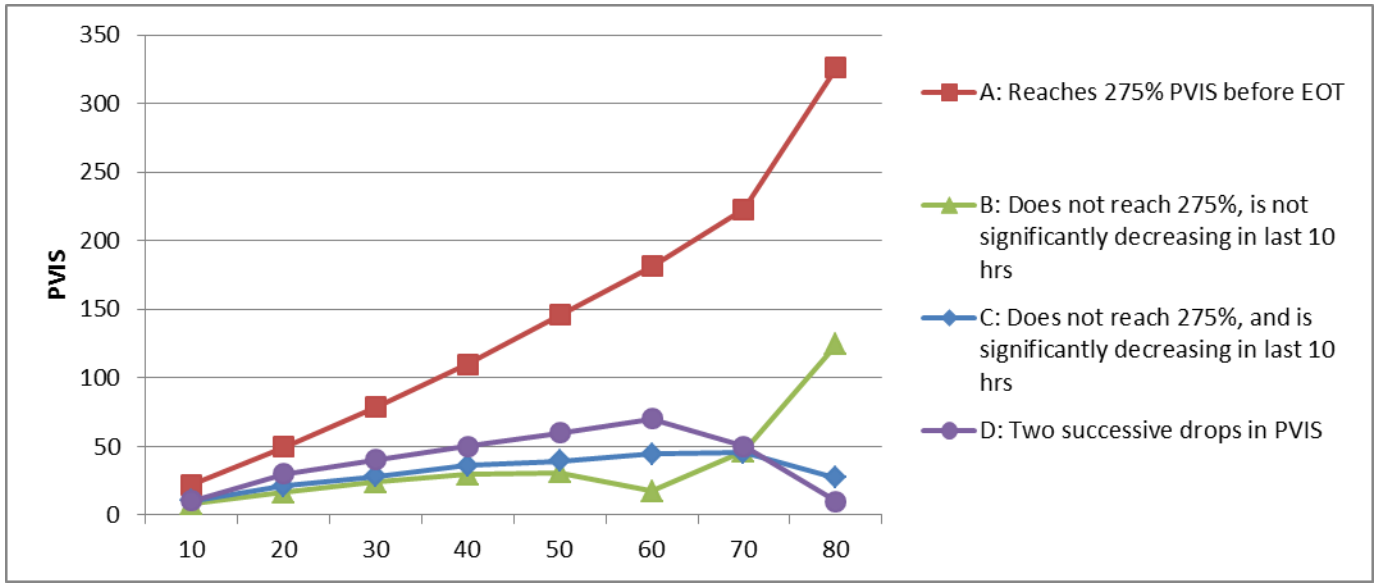
- Use HOURS to 275% Viscosity Increase for LTMS and Reference Oils ONLY
  - use HOURS to adjust where EOT PVIS is measured for candidate oils
  - We are not changing the parameter, we are just using a different transformation
  - We are not changing the pass/fail limit for candidates or how MTAC results are calculated
    - We are still using PVIS and the inverse square root transformation for MTAC

Proposed Solution

- Monitor IIIF using both RO433-1 and RO1006-2
  - Both oils demonstrate a similar severity shift when assessed using HOURS
  - Note that some data suggest that RO1006-2 may not be able to complete 80 hours in the new severity regime
- If the switch is made to HOURS for LTMS
  - Severity adjustments would change the point at which PVIS is measured for candidate oils, based on HOURS
  - No change in the pass/fail parameter for candidate oils; it remains PVIS although EOT PVIS (whether EOT is at 60 or 80 Hours) may be evaluated earlier in the test depending on test severity
  - Other test parameters continue to be measured at 80 hours

How to calculate HOURS to 275% PVIS for Reference Oils

- The Reference Oil test will fall into one of these situations:



A: Interpolate to get HOURS to 275% PVIS

B: Extrapolate HOURS to 275%, based on slope estimate

C: Extrapolate HOURS to 275%, considering the decrease in PVIS

D: Invalid Test, i.e. two successive drops in PVIS

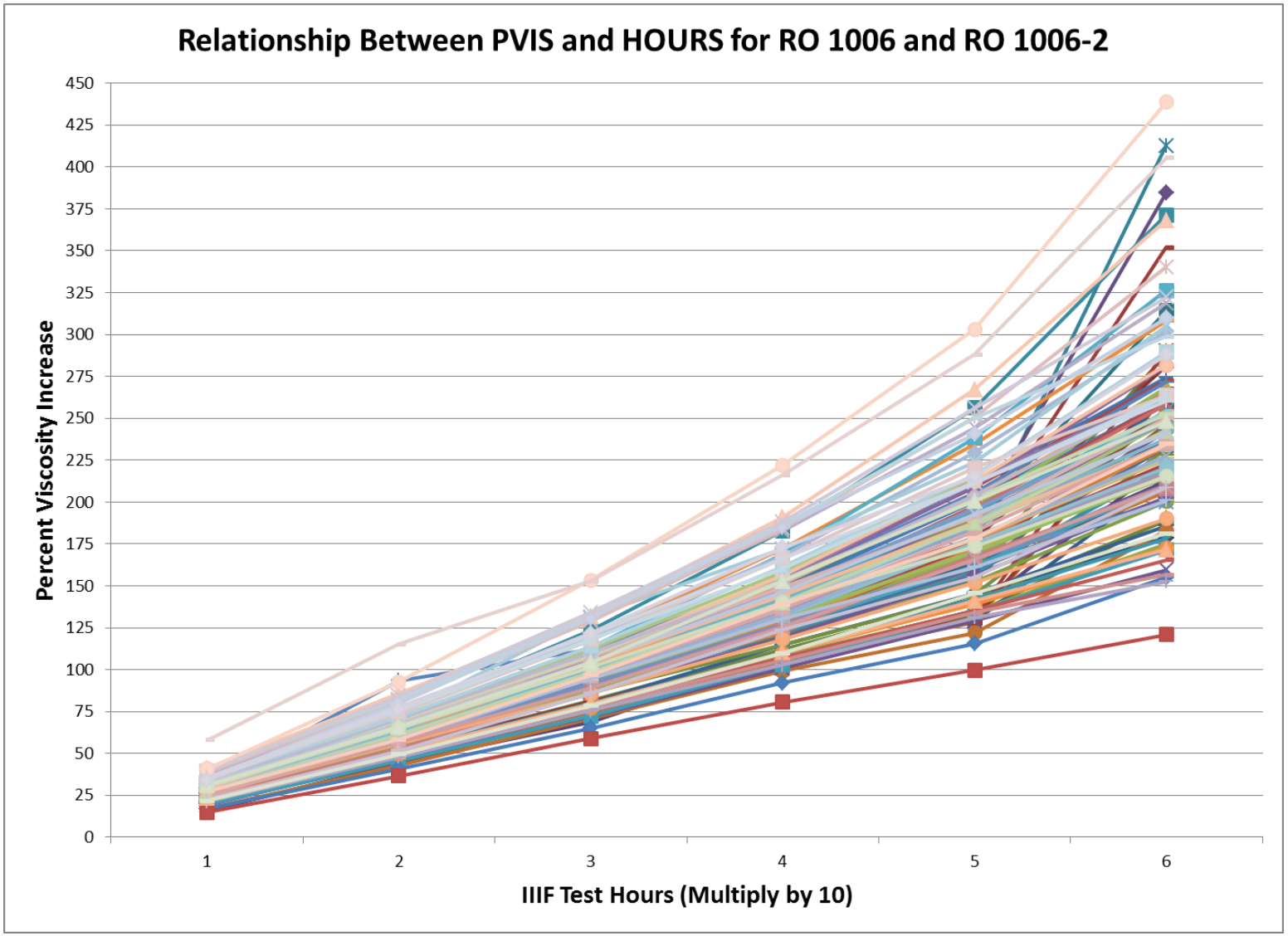
Calculating HOURS to 275% PVIS

- For Reference Oils ONLY
  - HOURS calculation is not made for candidate oils
- Case A (PVIS exceeds 275%) for a single reference test
  - Easy, just interpolate to calculate the HOURS to 275% PVIS
    - Transformation used to be determined later in presentation
- Case B (does not exceed 275%, but PVIS is not significantly decreasing) for a single reference test
  - Bit more complicated
  - Can be determined by studying the body of case A data

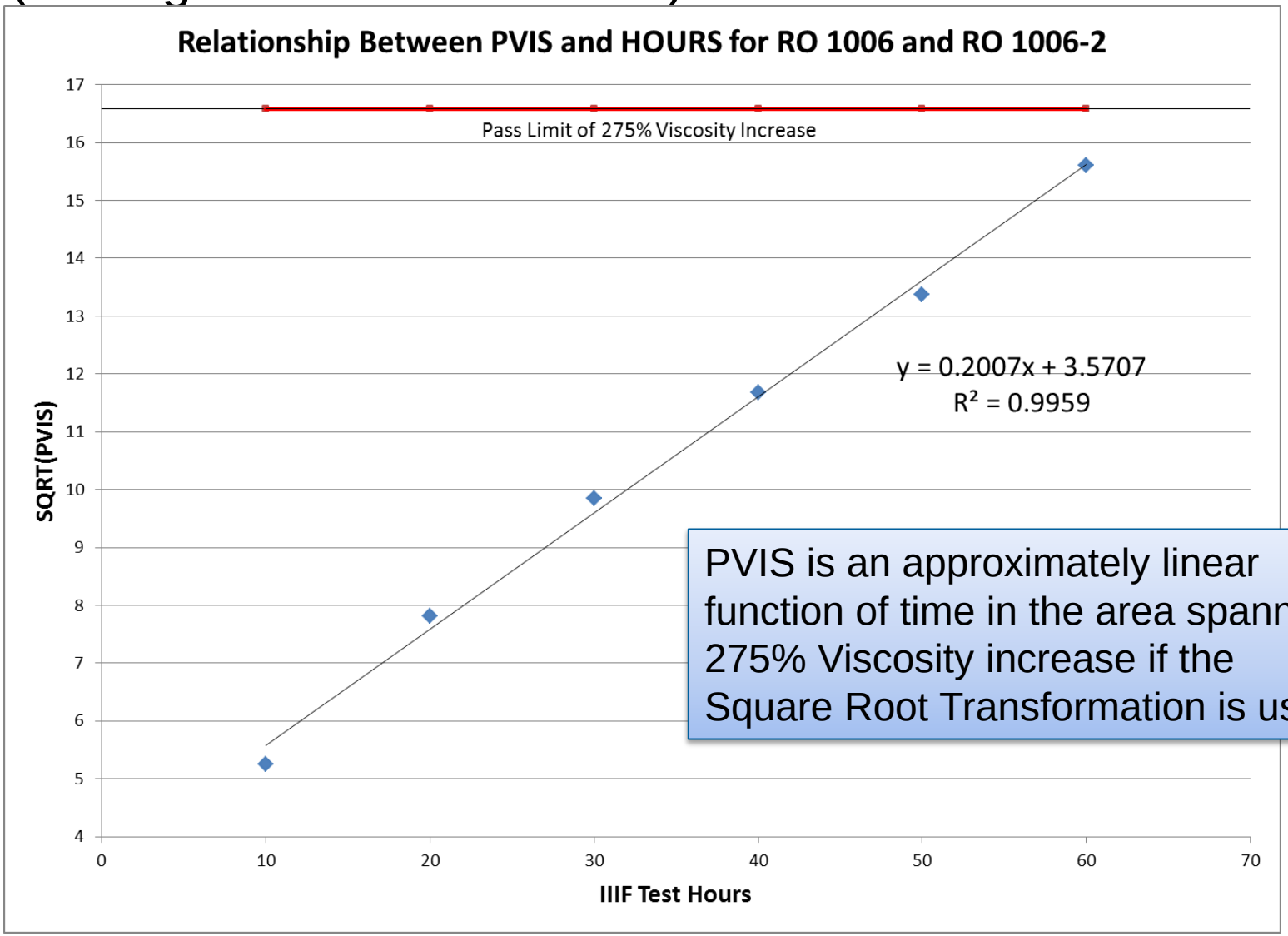
Solution: Step 1 for Case B

- Want the distribution for oils APPROACHING 275%
- Establish the distribution and nature of PVIS data at or around 275% Viscosity Increase
- RO1006 between 20 and 60 hours is best used to establish this distribution
  - Oil approaches and sometimes spans 275% Viscosity Increase during this interval and is currently our only measure of Viscosity Rate of Increase at or around 275%

Need a transformation to make linear



Square Root Transformation is much better (averaged over all RO 1006)



PVIS is an approximately linear function of time in the area spanning 275% Viscosity increase if the Square Root Transformation is used

Solution: Step 2 for Case B

- This means that for tests on oils that have reached 275% Viscosity Increase before end of test (Case A), we should use the square root transformation in interpolating HOURS
- For Case B (PVIS has not reached 275% but is not significantly decreasing)
  - Use square root transformation for linear relationship between PVIS and Test Hours at or around 275% Viscosity Increase
  - The slope in the relationship is 0.2007
- Note that this means that a slope of 0.2007 is our best guess estimate of a slope for oils that have not yet reached 275% Viscosity Increase by end of test and have not yet reached a slope of 0.2007

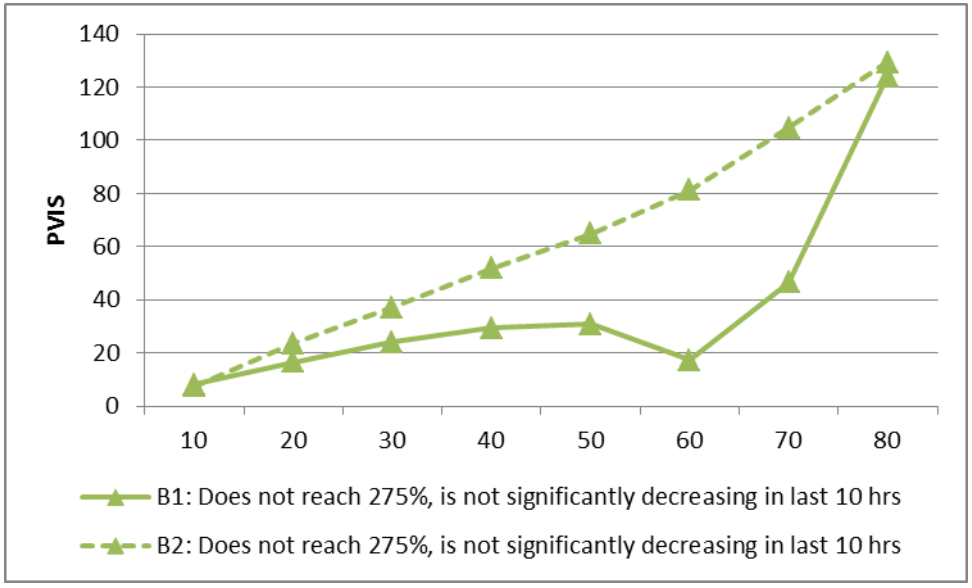
Solution: Step 3 for Case B

- Estimate the slope for tests on oils that have not reached 275%, but have a slope from 70 Hours to 80 Hours that is greater than 0.2007
- 0.2007 is our default estimate
  - We assume that all oils will increase to **at least** this slope after 80 Hours based on the RO1006 analysis
- If we have a greater slope than 0.2007 at 80 Hours, we use that slope in calculating HOURS to 275% Viscosity Increase

Solution: Case B Summary

Reference Oil does not reach 275% PVIS before EOT, and PVIS is not significantly decreasing in the last 10 hours

- Note that B1 would use the slope from 70 to 80 hours (using square root transformation), and B2 would use slope of 0.2007. This would make B1 more severe – as it should be.



Solution: Step 1 for Case C

- Estimate the slope for tests on oils that have not reached 275%, but have a ‘significant decrease’ in PVIS from 70 Hours to 80 Hours
  - This is a problem because we know that the slope will increase after the decrease in PVIS, but what will it increase to?
- Now that we are now seeing decreases in PVIS before 80 Hours, we can estimate the slope after the decrease for RO433
  - There have been 20 test results on 433 (2) and 433-1 (18) where there is a ‘significant decrease’ before 70 Hours which allows us to estimate the slope after the decrease
    - “Significant” to be defined
    - The mean slope after the decrease is 0.2301 and the median is 0.2386

Solution: Step 2 for Case C

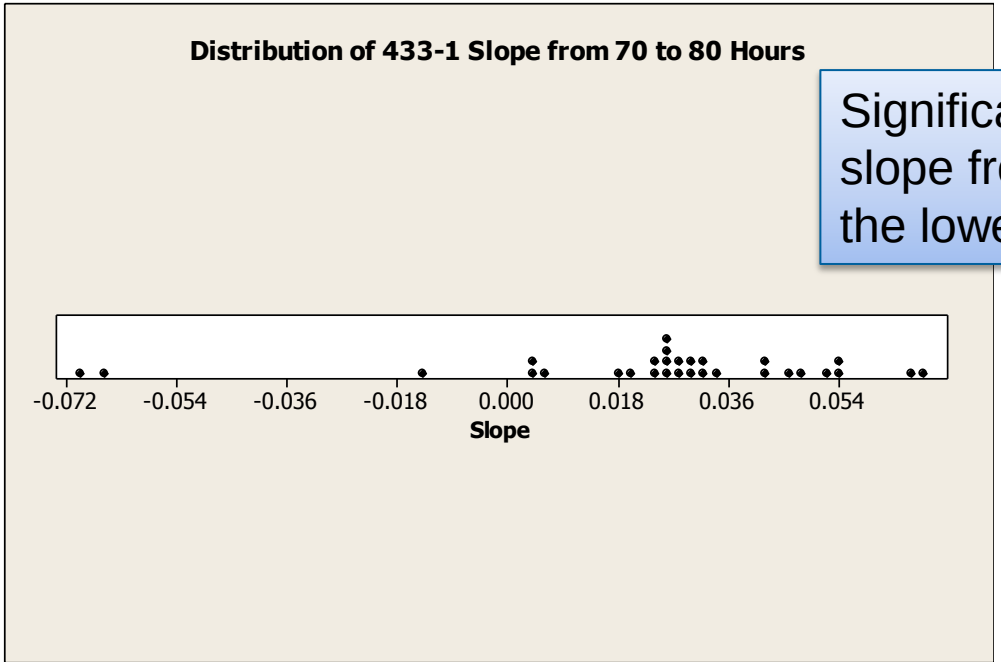
Defining ‘significant decrease’

- In dealing with decreasing oils, we have to make sure that it is a “real” decrease and not just natural variation
- Data was analyzed from before the identified date of the shift (June 2010) to estimate the average slope from 70 to 80 hours and the standard deviation of that slope
- First 30 non-outlier runs at SwRI and Intertek used
  - Enough data to assess lab effects
  - No difference between the labs
  - 8/16/2001 to 2/16/2007
  - One outlier at SwRI (8/9/2005) removed

Solution: Step 2 for Case C

Analysis of first 30 non-outlier runs at SwRI and Intertek

- Mean Slope = 0.02464
- Standard Deviation = 0.0310682
- Standard Error = 0.00567
- 95% Prediction Interval is (-0.03996, 0.08923)



Significant Decrease = when the slope from 70 to 80 hours exceeds the lower bound of the PI (-0.03996)

Solution: Case C Summary

- On any reference test, if we see a slope from 70 to 80 hours (calculated on the square root scale) of less than (-0.03996) we need to use our best estimate of the slope AFTER the oil decreases
  - We suggest using an estimate from the 20 tests on RO433 of the median slope for the after the decrease, which is 0.2386
  - This makes sense because if we use the lower slope of 0.2007 then test results from oils that decrease at 80 hours would be incorrectly less severe that test results at similar PVIS80 from oils that do not decrease

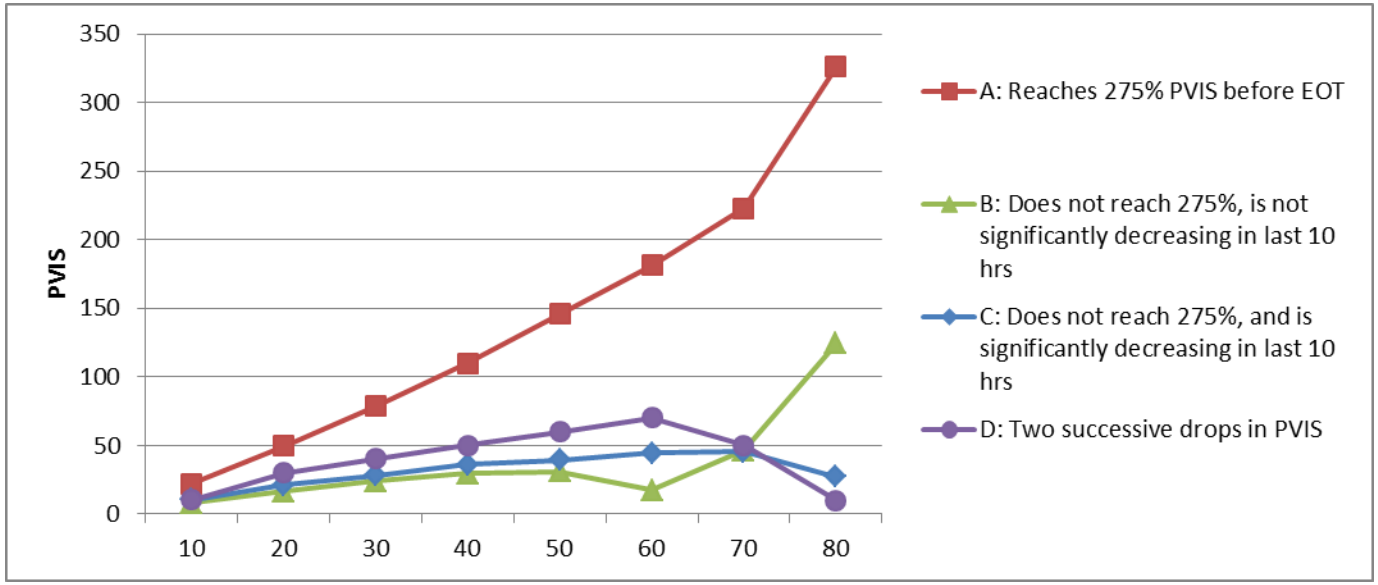
Solution: Summary of how to calculate HOURS for Reference Oils

- Oil reaches 275% Viscosity Increase before end of test
  - Interpolate HOURS on the square root scale
- Oil does not reach 275% Viscosity Increase before end of test AND is not decreasing from 70 to 80 Hours
  - Extrapolate HOURS as $\frac{\sqrt{275}-\sqrt{PVIS80}}{r}+80$ r = MAX(0.2007, Slope from 70 to 80)
- Oil does not reach 275% Viscosity Increase before end of test AND has a significant decrease from 70 to 80 Hours
  - Extrapolate HOURS as $\frac{\sqrt{275}-\sqrt{PVIS80}}{r}+80$ r = MAX(0.2007, 0.2386)
- Oil has a significant decrease from 60 to 70 hours AND from 70 to 80 hours, i.e. two successive drops in PVIS
  - Invalid test

Solution Summary

Situation A: RO reaches 275% PVIS before EOT

- Interpolate to get HOURS to 275% PVIS
  - use square root transformation

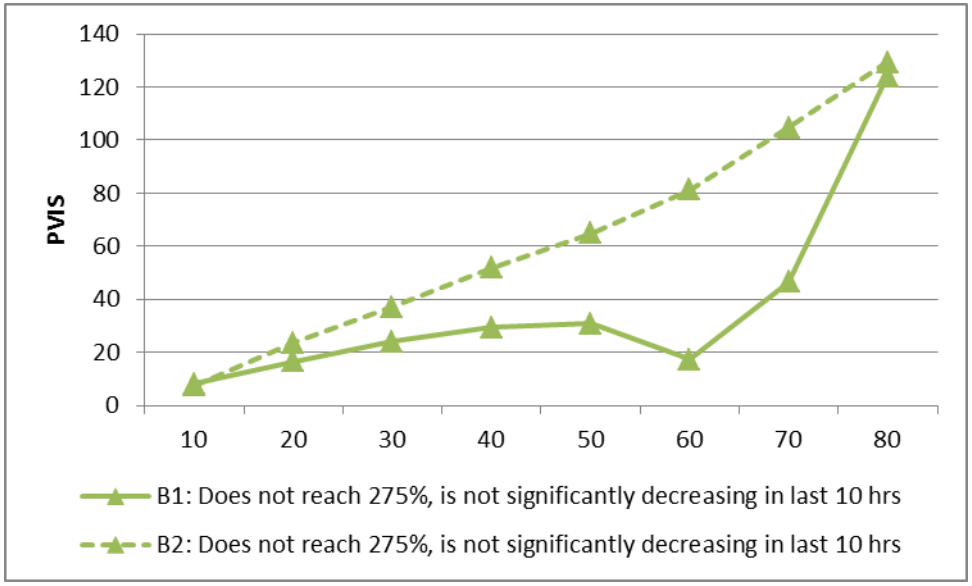


Solution Summary

Situation B: RO does not reach 275% PVIS before EOT, and is not significantly decreasing in the last 10 hours

- Extrapolate HOURS as

$$\frac{\sqrt{275}-\sqrt{PVIS80}}{r}+80$$ r = MAX(0.2007, Slope from 70 to 80)

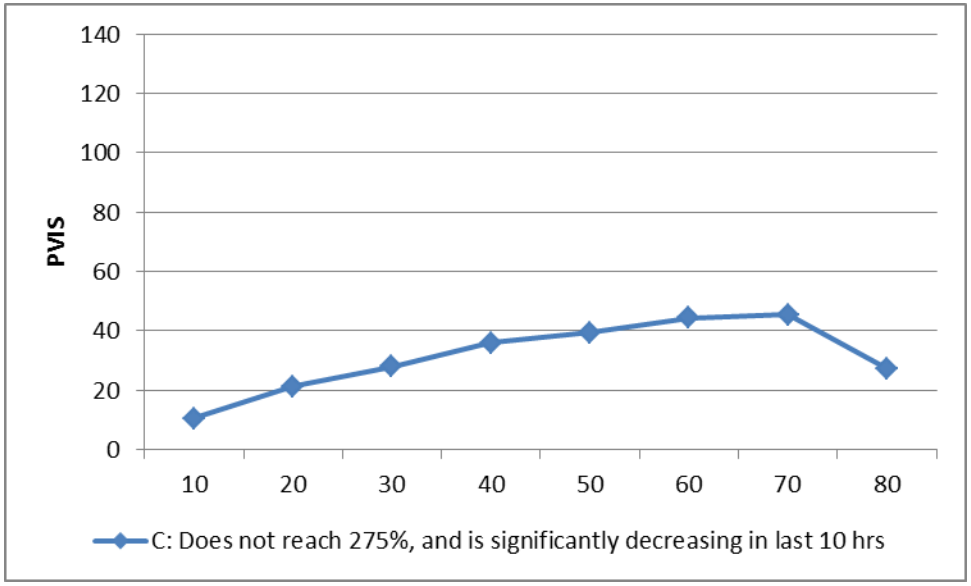


Solution Summary

Situation C: RO does not reach 275% PVIS before EOT, and PVIS is significantly decreasing in the last 10 hours

– Extrapolate HOURS as

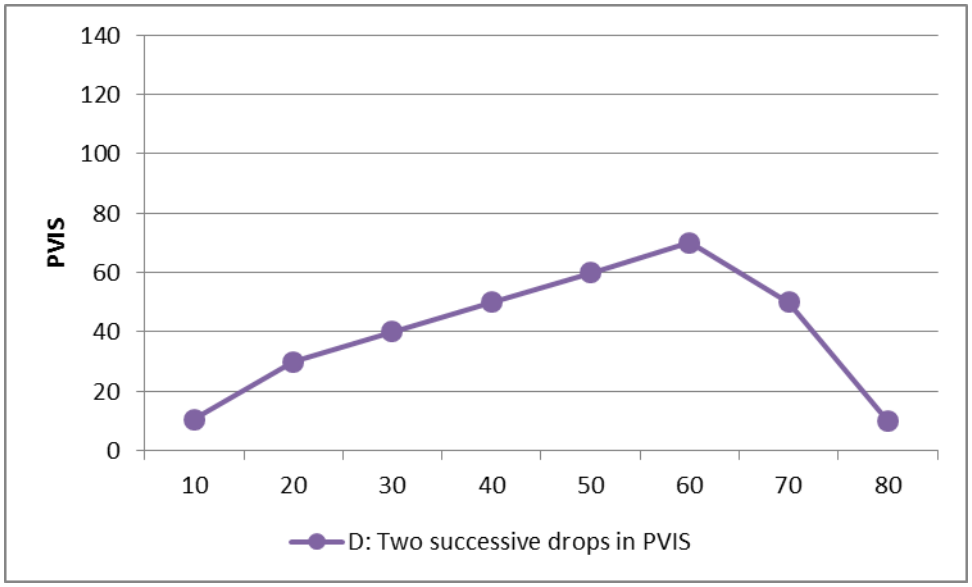
$$\frac{\sqrt{275}-\sqrt{PVIS80}}{r}+80 \quad \text{r = MAX(0.2007, 0.2386)}$$



Solution Summary

Situation D: RO has a significant decrease in PVIS from 60 to 70 hours AND from 70 to 80 hours, i.e. two successive drops in PVIS

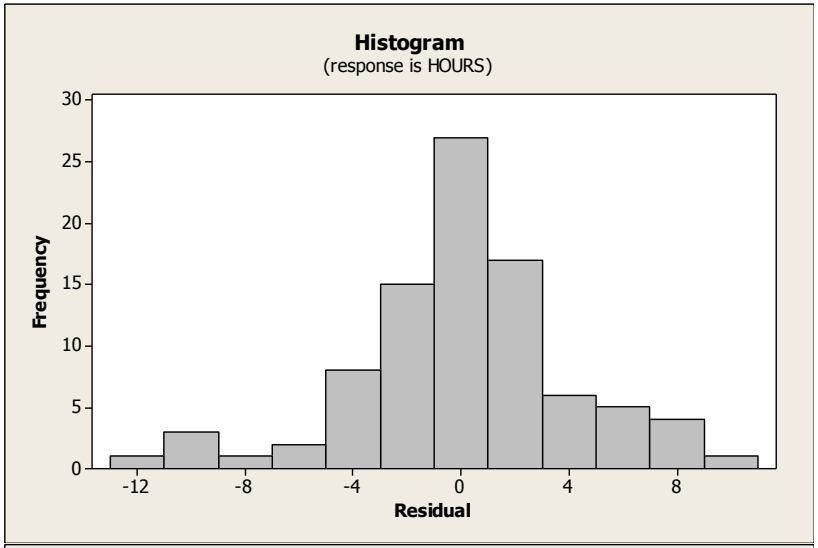
- Invalid Test
- This has not previously occurred

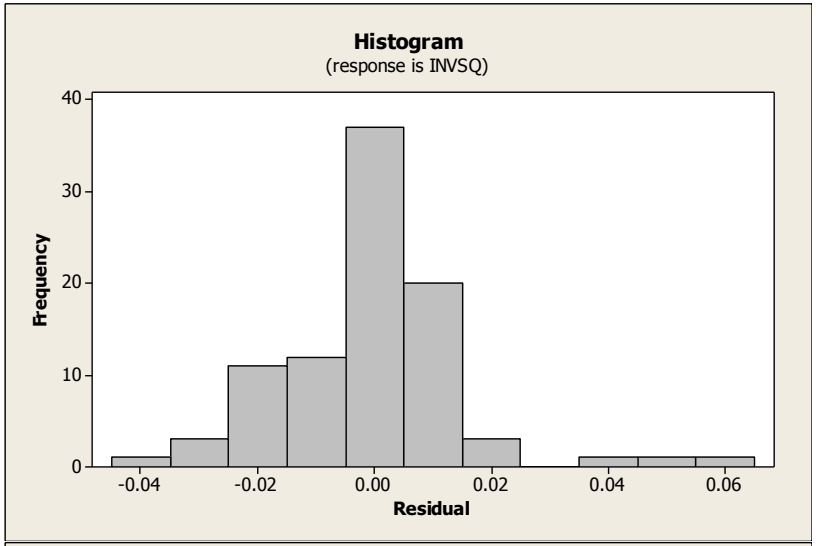


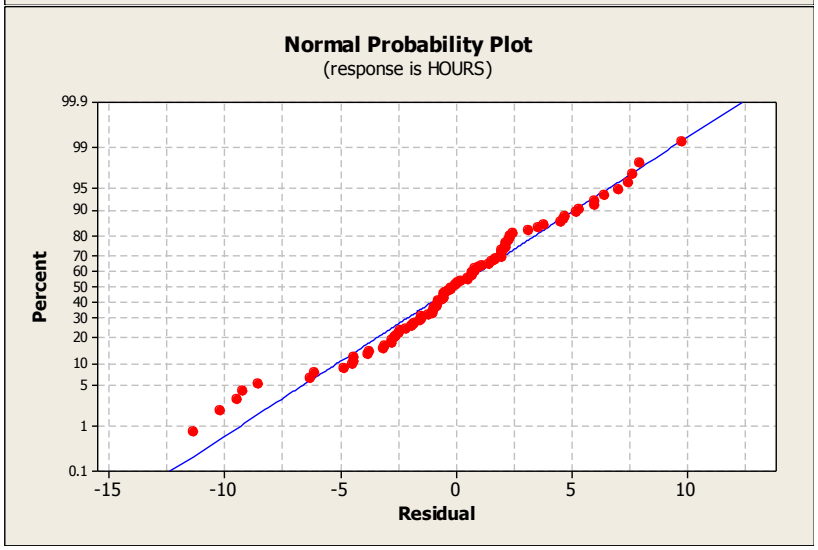
Assessment

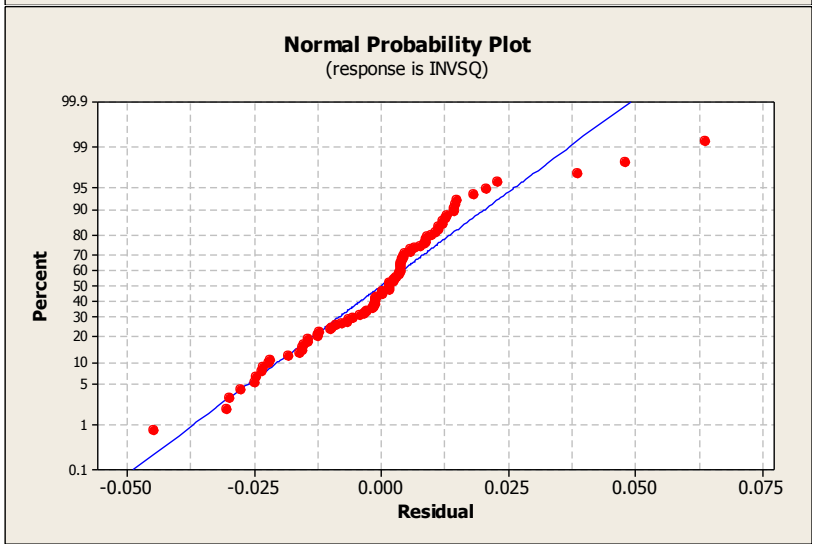
- HOURS better than 1/SQRT
  - Better residuals
    - See residual plots based on model (lab, oil) of first 30 points of 1006-2, 433-1, and 1008-1
  - More uniform variance
    - See ‘Target and Statistics’ slide
    - Note that LS Means and Standard Deviations are calculated in hours using the first 30 data points for each reference oil
  - Better discrimination among reference oils
    - F statistic for HOURS = 1818
    - F statistic for 1/SQRT = 369
  - Added bonus of ability to detect severity shifts

Assessment









Statistics and Targets

Oil	LS Mean	Within Lab Standard Deviation	Standard Deviation	Target Mean
1006-2	66.832	4.6715	5.61	66.1958
1008-1	110.524	3.54722	3.60	109.0961
433-1	131.032	3.12695	4.09	132.1539
Pooled s		3.8377	4.5152	

- Target Mean calculation
  - Plug the official LTMS reference oil PVIS target into the HOURS calculation
    - Use the target at 60 hours for 1006-2
  - Note how close the LS Means and Target Means match
    - That is really cool!!!!!!

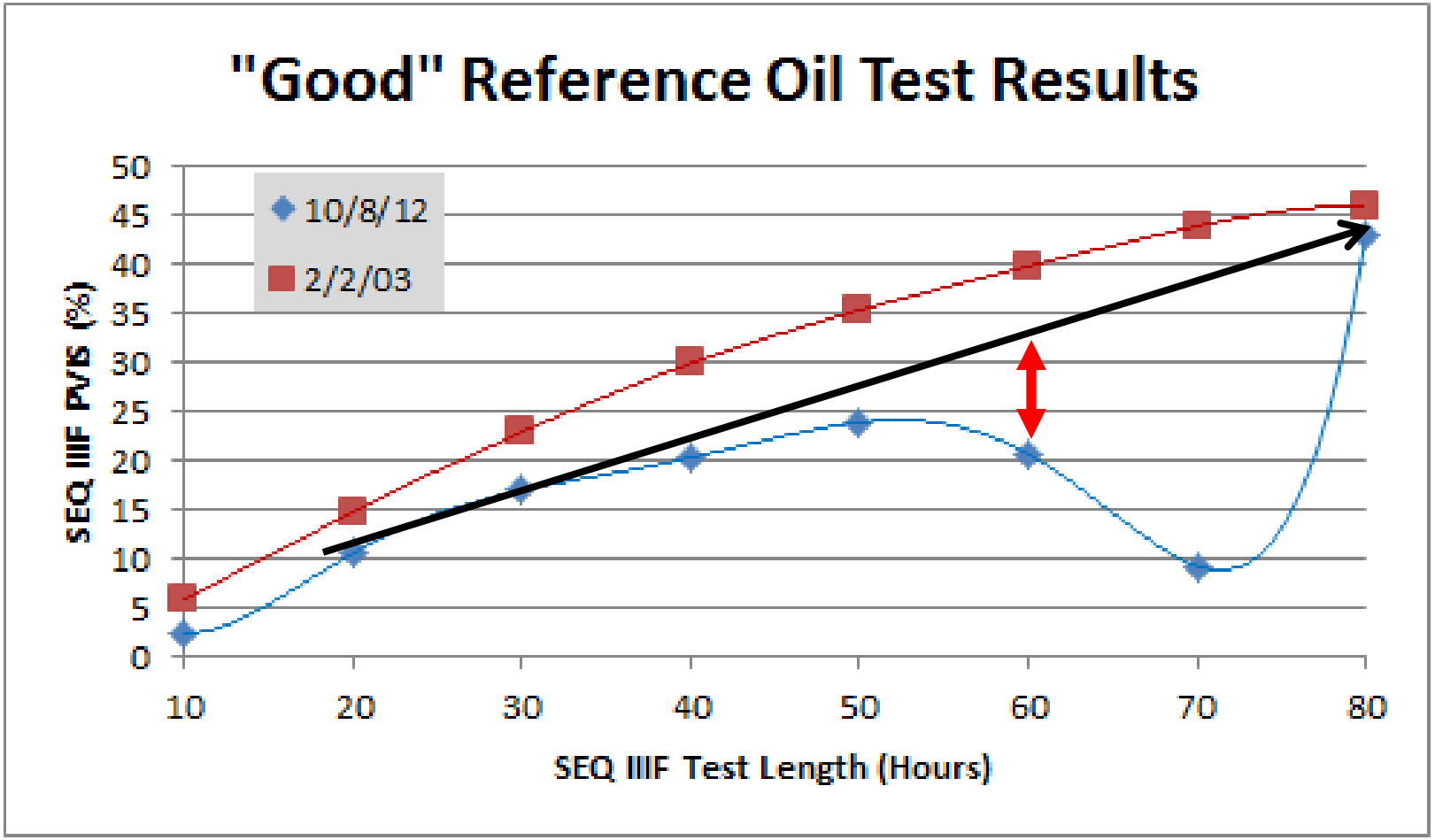
*All calculations are in hours

Reality Check

- This may be a good story, but is it reality?
- 1006-2 was dropped because it was too severe to calibrate (according to the logic)
- Life is assumed to be good because 433-1 relatively on target
- Next slide shows that we were fooling ourselves and that the fairytale is today's reality and the true picture lies in using HOURS to assess severity

Why SEQ IIIF-HD Reference Considered “Mild”

During more severe SEQ IIIF test run, if the 60Hr data point falls inside the “Negative Viscosity Increase” during the oil breaking period, the SEQ IIIF-HD result appears to be mild when in actuality, the test is running much more severe. The “Good” reference oil generally did not “break” before 70hrs until testing after 2010.



Reality Check

Oil	PVIS Yi	HOURS Yi	Target Mean
1006-2	-1.7175 (n=9)	-1.37909 (n=9)	7.7 Hours Severe
433-1	-0.20933 (n=49)	-2.42659 (n=49)	9.9 Hours Severe

- 1006-2 said we had a severity problem back in 2010
  - We dropped the oil
- Current methods DO NOT pick up on the severity for 433-1, BUT the use of HOURS does pick up on the severity issue (seen by comparing the Yi's for 433-1)
- The way we are currently monitoring Percent Viscosity Increase is insensitive to the severity change

Recent run using RO1006-2

Test Hours:	New Oil	0	10	20	30	40	50	60	70	80
Viscosity 40C, Cst	**59.0**	**56.0**	**73.5**	**92.9**	**112.3**	**134.4**	**150.8**	**225.5**	**832.0**	**8000.0**
Percent Increase			**31.2%**	**65.9%**	**100.5%**	**140.0%**	**169.3%**	**302.7%**	**1385.7%**	**#####**
Oil Consumption (ml low)		**0**	**450**	**928**	**1129**	**1295**	**1941**	**1718**	**1941**	**2174**

58.138 = Interpolated hours to 275% PVIS (using sqrt transformation)
66.2 = Target for 1006 (current PVIS target into hours)
8.1 = Difference in hours → 8.1 hours severe

- This is very close to the 7.7 hours estimate
- This confirms that the hours model fits well, even on an oil not run in a while

New Problem

- We are currently about 10 HOURS severe
  - Due to the current severity, labs will have a difficult time calibrating to the original targets
- To avoid problems with calibration, we should implement an Industry Correction Factor of 10 HOURS to both reference oil tests and candidate oil tests for PVIS
  - It is 10 HOURS based on either Yi or difference in HOURS of most recent 49 data points versus target
    - This means that 10 Hours needs to be added to reference test results monitored by HOURS
    - This means that PVIS at EOT for an 80 hour test should be measured at 70 hours for candidates and that PVIS at EOT for a 60 hour test should be measured at 50 hours for candidates

Why a Correction Factor of 10 Hours?

- We wish to do as little interpolation for the candidates as possible
- Best case: CF = 10 hours, no lab severity adjustments
  - Candidate EOT PVIS simply measured at 70 hours (or 50)
- Worst case: CF = something not 10 hours, and there are lab severity adjustments
  - Candidate EOT PVIS is interpolated
  - This isn't bad, but we would rather be in the best case

Additional Problem

- With the test being more severe, oils will encounter rapid viscosity increase before 80 Hours at an increased rate
  - This is a problem because it will mean more variability in the test

Oil	Target Standard Deviation (hours)	Standard Deviation since June 2010 (hours)
1006-1	5.61	8.54
433-1	4.09	11.94

- Unfortunately, this is NOW the test with this variability
  - It does not make sense to use the target standard deviations because they are not reality with the current state of the test
- We will need to use current standard deviations

Next Steps

- Continue to work on an Engineering solution
- In the meantime:
  - Within next 2 weeks
    - Task Force verify calculations and technical conclusions
    - Labs assess impact on their LTMS
    - Test sponsors assess impact on their candidates
  - Within 2 to 3 weeks
    - Adopt the use of HOURS for LTMS calibration and severity adjustments
    - Use an Industry Correction factor of 10 HOURS
    - Use HOURS adjustments for PVIS measurements on candidate oils
    - Use both RO 433-1 and 1006-2 to monitor the test

Next Steps Specifics

- As of 2/2013, use HOURS for IIIF LTMS, and evaluate candidate oils using HOURS adjusted PVIS
  - So, if the test is 10 HOURS severe, that would mean that EOT PVIS would be evaluated at 70 Hours and not 80 Hours, and EOT PVIS for API SH, SJ, CG-4, and CH-4 would be evaluated at 50 Hours and not 60 Hours
    - Use interpolation on the square root scale for PVIS when HOURS adjustments are not in exact 10 Hour increments
    - Implement an Industry Correction Factor of 10 HOURS for candidate oils as of 2/2013
    - Re-calculate LTMS history using HOURS and RO433 and RO1006
      - Implement an Industry Correction Factor of 10 HOURS for reference oils retroactive to June 1, 2010 for LTMS charting purposes
    - Use RO433-1 and possibly RO1006-2 to monitor the test

Reference Oil Test Targets Suggested

Oil	Target Mean (hrs)	Standard Deviation (hrs)
1006-1	66.20	8.54
433-1	132.15	11.94

- Use a pooled standard deviation of 10.3802 to calculate the HOURS adjustment for any severity adjustments to candidate oils