Special Sequence III Surveillance
Special Panel Meeting
For Review of Data and Consideration
of an "Out of Control" vote.

Teleconference

January 25, 2017 09:00 – 11:00 CST

Agenda

Concern has been voiced about the Chevron corporate WebEx disclaimer shown below in black which says that the WedEx system allows recording of the proceedings:

NOTICE TO ALL ATTENDEES REGARDING THE POTENTIAL RECORDING OF THIS CONFERENCE SESSION: CHEVRON'S WEBEX CONFERENCING SOLUTION ALLOWS MEETING HOSTS AND OTHER AUTHORIZED USERS TO RECORD CONFERENCE SESSIONS. PART OR ALL OF THIS CONFERENCE SESSION MAY BE RECORDED BY THE HOST AND/OR OTHER AUTHORIZED PERSONS, AND YOUR PARTICIPATION IN THIS CONFERENCE SHALL CONSTITUTE YOUR CONSENT TO THE RECORDING OF THIS CONFERENCE SESSION. IF YOU HAVE QUESTIONS OR CONCERNS ABOUT THE POTENTIAL RECORDING OF THIS CONFERENCE SESSION, PLEASE CONTACT THE MEETING HOST PRIOR TO JOINING THE CONFERENCE.

As the host, I have not in the past and will not in the future record any ASTM meeting and there are no "authorized persons" that may record an ASTM meeting. As a reminder to everyone the recording of ASTM meetings is prohibited.

1.0) Attendance

The attendance is shown in Attachment 1. Jorge Agudelo has replaced Sydelle Elshenawy as the BP representative.

2.0) Chairman Comments

The primary purpose of today's meeting is a continuation of an out-of-control discussion initiated during the January 11, 2017 meeting; to review the relevant presentations and formally address the Out of Control vote per the guidelines shown in Attachment 2.

3.0) Approval of minutes

3.1) Minutes from 01/18/2017 WebEx Conference

The minutes were approved without objection.

4.0) Data Review –followed by a "test out of control vote"

4.1) IAR BC3 Experiment. **Schweitzer.**

Addison Schweitzer presented IAR's experiment, Attachment 3.

4.2) SwRI BC2 BC3 blowby experiment. **Chaudhry.**

Ankit Chaudry presented SwRI's experiment, Attachment 4.

4.3) Batch 3 piston data analysis. **Martinez.**

Jo Martinez presented her analysis, Attachment 5.

4.4) Lubrizol presentation. **Szappanos.**

George Szappanos shared Lubrizol's analysis, Attachment 6.

4.4) Infineum presentation. **Ritchie.**

Andy Ritchie shared Infineum's analysis, Attachment 7.

4.5) Out-of-Control Discussion

Following the review of presentations, a long discussion ensued regarding possible paths forward. Near the conclusion of the discussion, the following motion was made:

Motion:	***The Seq. III Surveillance Panel recommend to the Passenger Car Class Panel that the IIIH test be declared out of control (Matasic, Altman).***
Tally:	8 affirmative, 6 negative, 5 abstentions
Result:	***The motion failed to carry the required 75% needed.***

Discussion resumed focusing on the future actions of the hardware task force being led by Jason Bowden. That group is expected to meet next week and will report back to the surveillance panel in the near future.

5.0) Old Business

Update on pistons and the new task force. **Bowden**

The task force is expected to meet next week.

8.0) Next Meeting

Two to three weeks depending on available information from the task force.

9.0) Meeting Adjourned

The meeting adjourned at 11:30 a.m CST.

ATTACHMENT 1

ASTM Sequence III Surveillance Panel (23 Voting members) date:

Name/Address		Phone/Fax/Email		Signature
Jorge Agudelo	Waive	jorge.agudelo@bp.com	Voting Member	Present ✓
Ed Altman	Y	ed.altman@aftonchemical.com	Voting Member	Present ✓
Jeff Betz	NV per Hais	jeff.betz@fcagroup.com	Voting Member	Present ✓
Jason Bowden	Waive	jhbowden@ohtech.com	Voting Member	Present ✓
~~Timothy L. Caudill~~		~~tlcaudill@ashland.com~~	~~Voting Member~~	~~Present~~
Richard Grundza	Y	reg@astmtmc.cmu.edu	Voting Member	Present ✓
Jeff Hsu, PE	KARIN HAUMAS N	j.hsu@shell.com	Voting Member	Present ✓ KARIN
Teri Kowalski	N	teri.kowalski@tema.toyota.com	Voting Member	Present ✓
Dan Lanctot	Waive	dlanctot@tei-net.com	Voting Member	Present ✓
Patrick Lang	Y	plang@swri.org	Voting Member	Present ✓
Dave Passmore	abstain	dpassmore@imtsind.com	Voting Member	Present ✓
Prasad Tumati	abstain	ptumati@haltermann.com	Voting Member	Present ✓
Michael Raney		michael.p.raney@gm.com	Voting Member	Present
Andrew Ritchie	Y	andrew.ritchie@infineum.com	Voting Member	Present ✓
Ron Romano	N	rromano@ford.com	Voting Member	Present ✓
Cliff Salvesen	Y	clifford.r.salvesen@exxonmobil.com	Voting Member	Present ✓
Addison Schweitzer	Y	addison.schweitzer@intertek.com	Voting Member	Present ✓
Greg Shank		greg.shank@volvo.com	Voting Member	Present
Kaustav Sinha, Ph.D.	N	LFNQ@chevron.com	Voting Member	Present ✓
~~Thomas Smith~~ Amal Sinha	Y	trsmith@ashland.com	Voting Member	Present ✓
Scott Stap		scott.stap@tgidirect.com	Voting Member	Present ✓
George Szappanos	Y	george.szappanos@lubrizol.com	Voting Member	Present ✓
Haiying Tang	N	HT146@chrysler.com	Voting Member	Present ✓

Y NV Waive

8 – 6 – 5

motion fails

meeting 2 weeks

Out of Ln Tool

1/25/17

ASTM Sequence III Surveillance Panel (23 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Ricardo Affinito	affinito@chevron.com	N-V Member	Present_____
Art Andrews	arthur.t.andrews@exxonmobil.com	N-V Member	Present_____
Robert Bacchi	robert.bacchi@basf.com	N-V Member	Present_____
Terry Bates	batesterryw@aol.com	N-V Member	Present_____
Doyle Boese	doyle.boese@infineum.com	N-V Member	Present ✓
Adam Bowden	adbowden@ohtech.com	N-V Member	Present_____
Dwight H. Bowden	dhbowden@ohtech.com	N-V Member	Present_____
Matt Bowden	mjbowden@ohtech.com	N-V Member	Present ✓
Jerome A. Brys	jerome.brys@lubrizol.com	N-V Member	Present_____
Jessica Buchanan	jessica.buchanan@lubrizol.com	N-V Member	Present_____
Bill Buscher III	william.buscher@intertek.com	N-V Member	Present ✓
Bob Campbell	bob.campbell@aftonchemical.com	N-V Member	Present_____
Jim Carter	jcarter@gageproducts.com	N-V Member	Present_____
Chris Castanien	chris.castanien@nesteoil.com	N-V Member	Present_____
Martin Chadwick	martin.chadwick@intertek.com	N-V Member	Present_____
Ankit Chaudhry	ankit.chaudhry@swri.org	N-V Member	Present ✓
Jeff Clark	jac@astmtmc.cmu.edu	N-V Member	Present ✓
Sid Clark TIM CAUDILL VALVOLINE	sidney.clark@swri.org	N-V Member	Present ✓
Tim Cushing	timothy.cushing@gm.com	N-V Member	Present_____
Phil Davies	daviesjp@bp.com	N-V Member	Present_____
Todd Dvorak	todd.dvorak@aftonchemical.com	N-V Member	Present ✓
Frank Farber	fmf@astmtmc.cmu.edu	N-V Member	Present_____
Joe Franklin	joe.franklin@intertek.com	N-V Member	Present_____
Gordon Farnsworth	gordon.farnsworth@infineum.com	N-V Member	Present ✓
David L. Glaenzer	dave.glaenzer@aftonchemical.com	N-V Member	Present_____
Rolfe Hartley	rolfehartley@gmail.com	N-V Member	Present_____
Karin E. Haumann	karin.haumann@shell.com	N-V Member	Present ✓
Martin Heimrich	martin.heimrich@swri.org	N-V Member	Present_____

ASTM Sequence III Surveillance Panel (23 Voting members) date:

Name/Address	Phone/Fax/Email		Signature
Jason Holmes	jason.holmes@basf.com	N-V Member	Present_____
Travis Kostan	travis.kostan@swri.org	N-V Member	Present ✓
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Michael Lochte	Michael.lochte@swri.org	N-V Member	Present_____
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Christian Porter	christian.porter@aftonchemical.com	N-V Member	Present_____
Phil Rabbat	phil.rabbit@basf.com	N-V Member	Present_____
Scott Rajala	srajala@ilacorp.com	N-V Member	Present_____
Jim Rutherford	jaru@chevron.com	N-V Member	Present ✓
Bob Salgueiro	bob.salgueiro@infineum.net	N-V Member	Present_____
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Amol Savant	acsavant@valvoline.com	N-V Member	Present_____
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Don Smolenski	Donald.smolenski@evonik.com	N-V Member	Present ✓
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in 3 Chris Taylor	chris.taylor@vpracingfuels.com	N-V Member	Present ✓
Ben Weber	bweber1@sat.rr.com	N-V Member	Present_____
Angela Willis	angela.p.willis@gm.com	N-V Member	Present_____

ASTM Sequence III Surveillance Panel (23 Voting members) date:

Name/Address	Phone/Fax/Email	Signature
Tom Wingfield	wingftm@cpchem.com	N-V Member Present_____
Al Lopez		✓
~~[illegible]~~		
Rich [illegible]		
Dave Glaenzer		✓
(Chem & Ind Valvoline)		
Lisa Dingwell		✓

ATTACHMENT 2

AUTHORITY TO SUSPEND INDUSTRY WIDE LABORATORY CALIBRATION STATUS WHEN A TEST IS JUDGED TO BE GIVING UNINTERPRETABLE PERFORMANCE

BACKGROUND

The Classification Panels request the authority to suspend industry wide laboratory calibration status when a test is judged to be out of control. This is needed to get immediate industry expertise solely focused on solving the test problem and prevent the continued approval of oils based on suspect data. To assure that any decision to temporarily suspend testing is justified, the following analysis process will be used and documented. This process also includes a method for determining when the test is back in control and calibrated testing can resume. This process was developed to address the concerns expressed during the earlier balloting of this subject.

FLOW PLAN

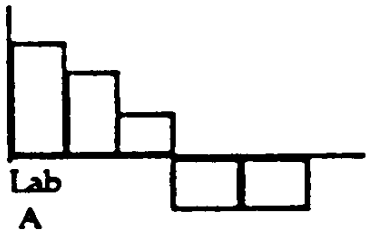
Step 1: An action alarm at the industry level must trigger on the Exponentially Weighted Moving Average (EWMA) plots, for either precision or severity, using the ASTM Reference Monitoring System.

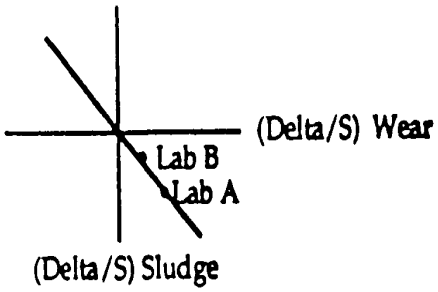
Step 2a: The test surveillance panel must consider the scope and size of the problem:

- Is the problem due to an identifiable cause?
- Is it affecting precision and/or severity?
- If the problem only affects severity, can a temporary correction be applied?
- Is the problem reference oil specific?
- Is it test lab or stand specific?
- When did the problem start?
- Are critical, non-critical, or both types of parameters involved?
- Does the problem transcend test type?
- What tools (statistical) were used to assess the problem?
- Was the problem a gradual one or an abrupt one?
- Does existing candidate oil experience support any reference oil trends?
- Has the problem been defined clearly?
- Has the available data been analyzed in a logical and methodical manner?

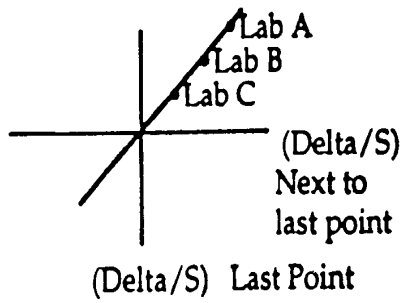
Step 2b: The following tools will be used, as a minimum, in the analysis of the problem:

DATA ANALYSIS	POTENTIAL INSIGHTS
1. All charts (lab, stand) should be made available for the Test Parameter which has gone out.	1. Time trends and changes, start of problem.
2. Mark on charts when Industry changed parts, fuel batches, etc.	2. Special Cause.
3. Plot each lab's last EWMA for the affected parameter:	3. Scope of Problem, Special Cause.
4. Provide a list of coded labs (or stands) which have had out of control signals on the Test Parameter within the last three months.	4. Scope of Problem, Special Cause.
5. Plots of known problem parameters (e.g. sludge/wear).	5. Problem discrimination.





6.	EWMA charts with $\lambda = 0.1$ (detects small shifts)	6.	Gradual vs. Step change.
7.	Youden plot of labs' last two points:	7.	Precision vs. Severity, Scope, Special cause.



8.	Dot plot of all data in last three months.	8.	Special Cause.

Step 3a: The Surveillance Panel decision to recommend to the appropriate Classification Panel that a test to be declared out of control will require a ¾ approval vote of voting members (or their alternates) present at a special Surveillance Panel meeting held to review all data developed. All negative votes must be resolved (declared non-persuasive, persuasive, or non-germane). For purposes of determining persuasiveness of a negative, a 2/3 majority vote of members present (or their alternates) will be used. The final vote plus all persuasive arguments and an action plan with timetable will be forwarded to the appropriate Classification Panel.

Step 3b: Within two weeks of such a Surveillance Panel decision, the appropriate Classification Panel will meet to determine if the test is out of control.

Step 3c: If the Classification Panel decides the test is out of control it may temporarily suspend calibrated testing. A technical memorandum will be issued immediately by the TMC (advising that calibration status for the appropriate test type cannot be technically supported in all previously calibrated laboratories effective for each stand prior to the start of the next test). This memorandum will be issued to all members of the Surveillance Panel involved, all calibrated test labs, the appropriate classification panel, and all members of Subcommittee B.

This memorandum will provide the background on the Surveillance Panel's decision, as well as a proposed action plan with timetable and milestones. A comment period will be extended for 30 days after the memorandum. Comments will go to the Subcommittee B Chairman who will determine if they are of sufficient quality to call a special session of B within 30 more days. TMC calibration status will continue to be suspended during this period unless the test has been declared back in control (see step 4a).

Step 3d: Any external communication (outside of ASTM Subcommittee B see notification list below) will be sent through the Chairman of Subcommittee B. All stake holders shown below are to be sent a letter by the Chairman of Subcommittee B notifying them of this action and stating that the performance category XX as stated in ASTM D4485 can no longer be measured until further notice. The reason that this performance can no longer be measured is that the calibration status of the uninterruptable test cannot be technically supported.

Notification List

Organization	Position
ASTM	D02.B0 Chairman
	Test Monitoring System Executive Committee Chairman
	Test Monitoring Center Director
	PCEOCP Chairman
	HDEOCP Chairman
	D02.B0.01 Chairman
	D02.B0.02 Chairman
	Membership of Effected Surveillance Panel
ACC	Product Approval Protocol Task Group Manager
	MAAG Chairman
API	EOLCS Manager
	EOLCS Chairman
Auto Alliance	
JAMA	
EMA	EMA Staff
AOAP	Chairman
DEOAP	Chairman
ACC-MA	Manager

Notification

From the TMC website (http://www.astmtmc.cmu.edu/TestStatusNotification.aspx) a notification email can be generated with the current notification member emails. The Subcommittee B chairman will need to append a letter describing the situation using the current D02 letterhead (a link is on the TMC notification page) and a notification comment to the body of the email prior to sending.

Step4d: Determination that the test is back in control will be made by the Surveillance Panel or when the industry EWMA charts for precision and severity are back within the defined control limits whichever occurs first. At that point, an information memorandum will be immediately issued by TMC to the same distribution outlined in Step 3c. Any requirements, if necessary, to resume calibrated testing will be defined in this memorandum.

ATTACHMENT 3

IIIH Batch Code 3 Piston Experiments

Addison Schweitzer

Overview

- Two experimental IIIH tests were performed on TMC RO 438-1 at IAR on BC3 Pistons to gauge impact on test severity

- IIIH 182-3-42
  - Performed on BC3 pistons with a PCV valve without a camshaft seal to allow for improved blowby condensate drain back

- IIIH 182-4-43
  - Performed on BC3 pistons with modified piston ring gaps
    - Top Ring Gap = 0.020” (IIIH Spec 0.025” ± 0.001”)
    - Second Ring Gap = 0.030” (IIIH Spec 0.035” ± 0.001”)

IIIH 182-3-42 Results (Modified PCV Valve)

Intertek
Valued Quality. Delivered.

- PVIS = 71.5% (about 0.3 standard deviations severe)
- WPD = 3.36 (about 0.7 standard deviations severe)
  - APV = 9.57
  - Hot Stuck Rings = None
- PRET = 81.13 (about 1.5 standard deviations mild)
- MRV = 24,900 cP with no YS at -30° C (about 0.33 standard deviations severe)
- **OC = 2.54 L (high oil consumption is a concern)**
  - Initial Blowby = 79.5 LPM
  - AVG Blowby = 42.9 LPM
    - Both of these blowby values are higher than historic performance on previous hardware batches.

IIIH 182-4-43 Results (Modified Ring Gaps)

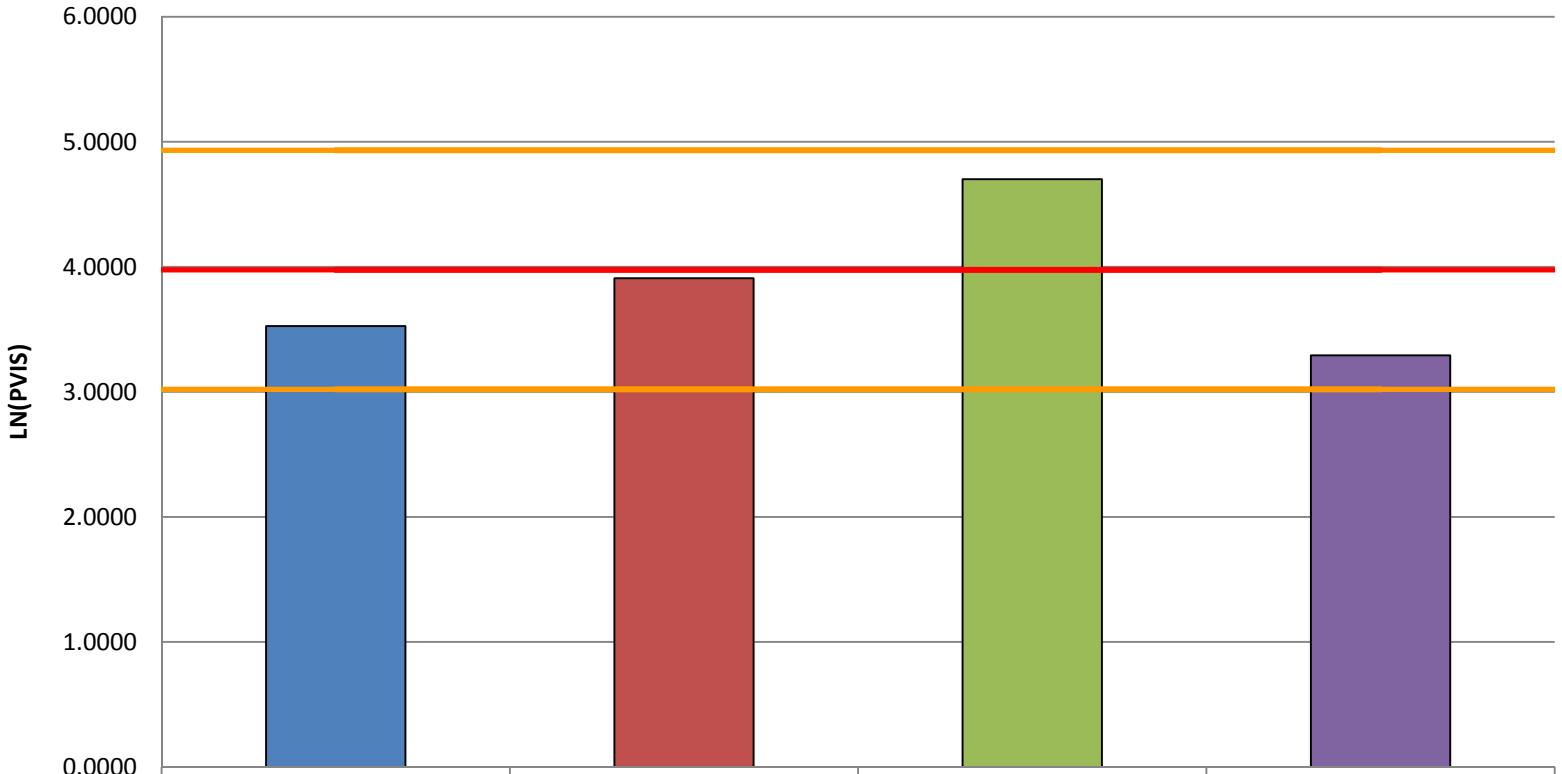
Intertek
Valued Quality. Delivered.

- PVIS = 26.9% (about 0.71 standard deviations mild)
- WPD = 3.52 (about 0.04 standard deviations severe)
  - APV = 9.73
  - Hot Stuck Rings = None
- PRET = 80.52 (about 1.04 standard deviations mild)
- MRV = 9,000 cP with no YS at -30˚ C (about 0.78 standard deviations mild)
- OC = 1.49 L
  - Initial Blowby = 56.9 LPM
  - AVG Blowby = 35.4 LPM
    - Both of these blowby values are in the range of historic performance on previous hardware batches on TMC RO 438-1

LN(PVIS)

Intertek
Valued Quality. Delivered.

IIIH Batch Code Data Comparison
LN(PVIS)

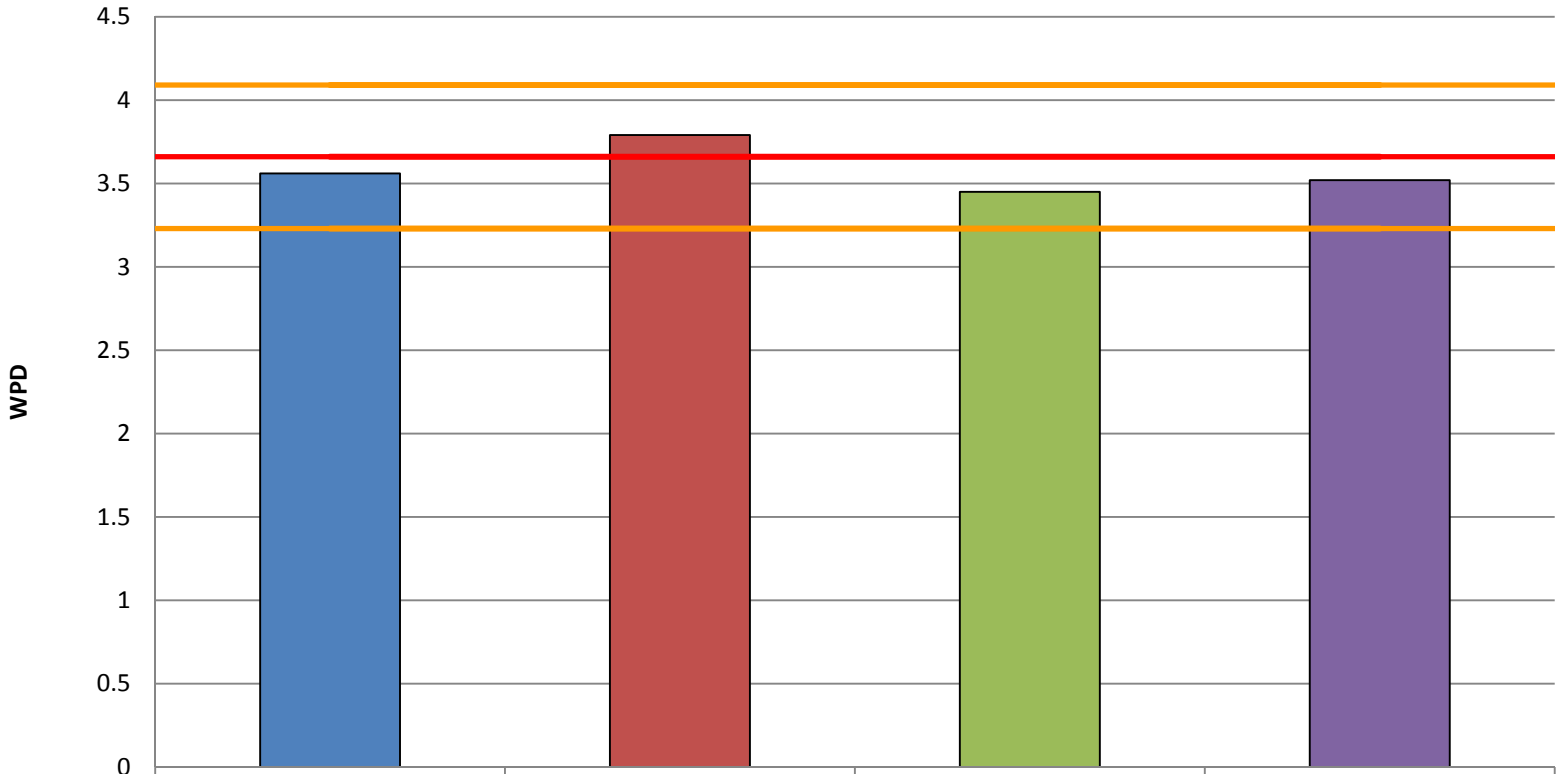


	BC1 Hardware	BC2 Hardware Avg	BC3 Hardware	Experimental Ring Gaps Hardware
LNPVIS	3.5264	3.9084	4.7014	3.2921
Target	3.9754	3.9754	3.9754	3.9754
+1s	4.9312	4.9312	4.9312	4.9312
-1s	3.0196	3.0196	3.0196	3.0196

WPD

Intertek
Valued Quality. Delivered.

IIIH Batch Code Data Comparison
WPD

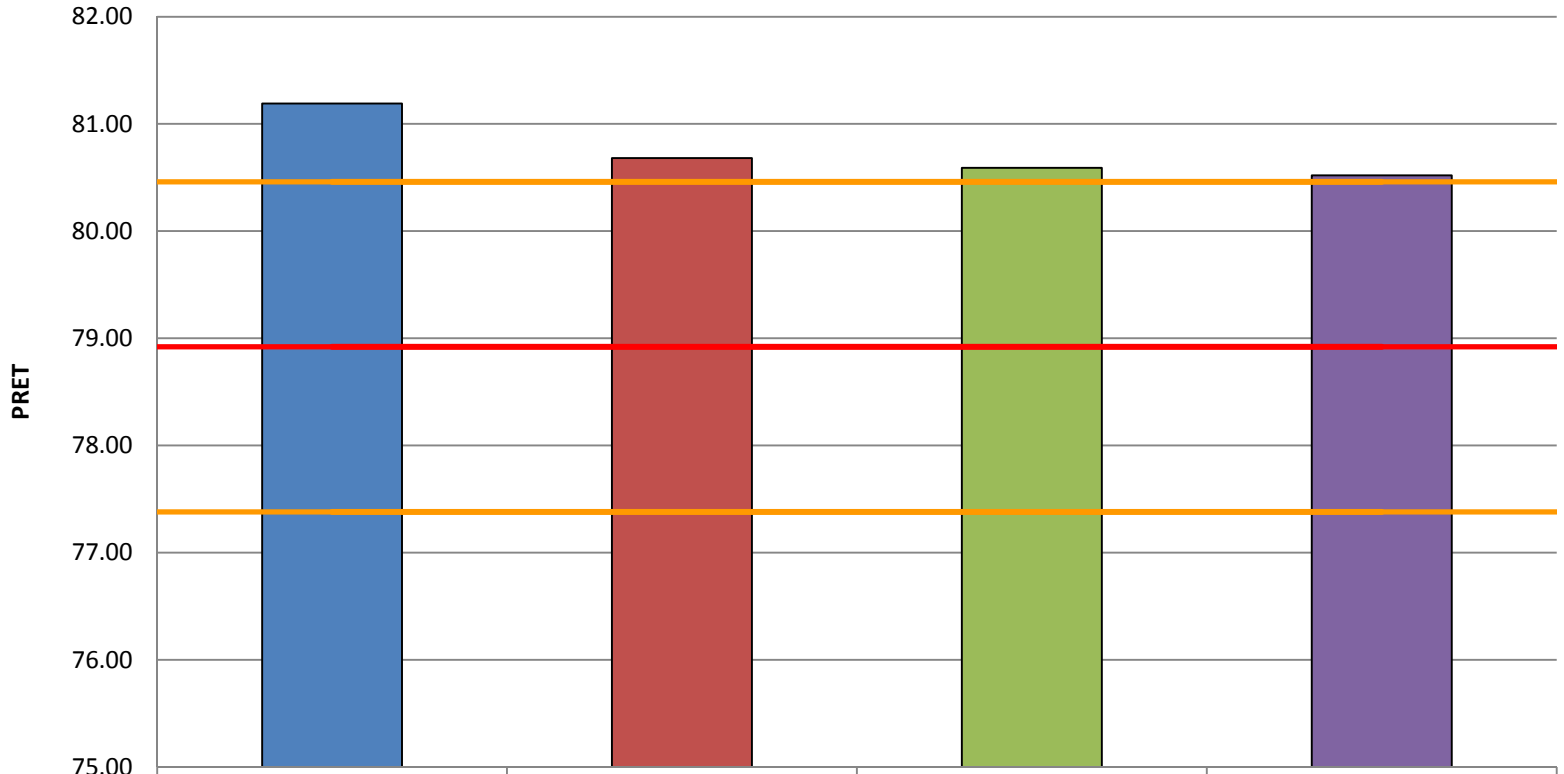


	BC1 Hardware	BC2 Hardware Avg	BC3 Hardware	Experimental Ring Gaps Hardware
WPD	3.56	3.79	3.45	3.52
Target	3.66	3.66	3.66	3.66
+1s	4.09	4.09	4.09	4.09
-1s	3.23	3.23	3.23	3.23

PRET

Intertek
Valued Quality. Delivered.

IIIH Batch Code Data Comparison
PRET

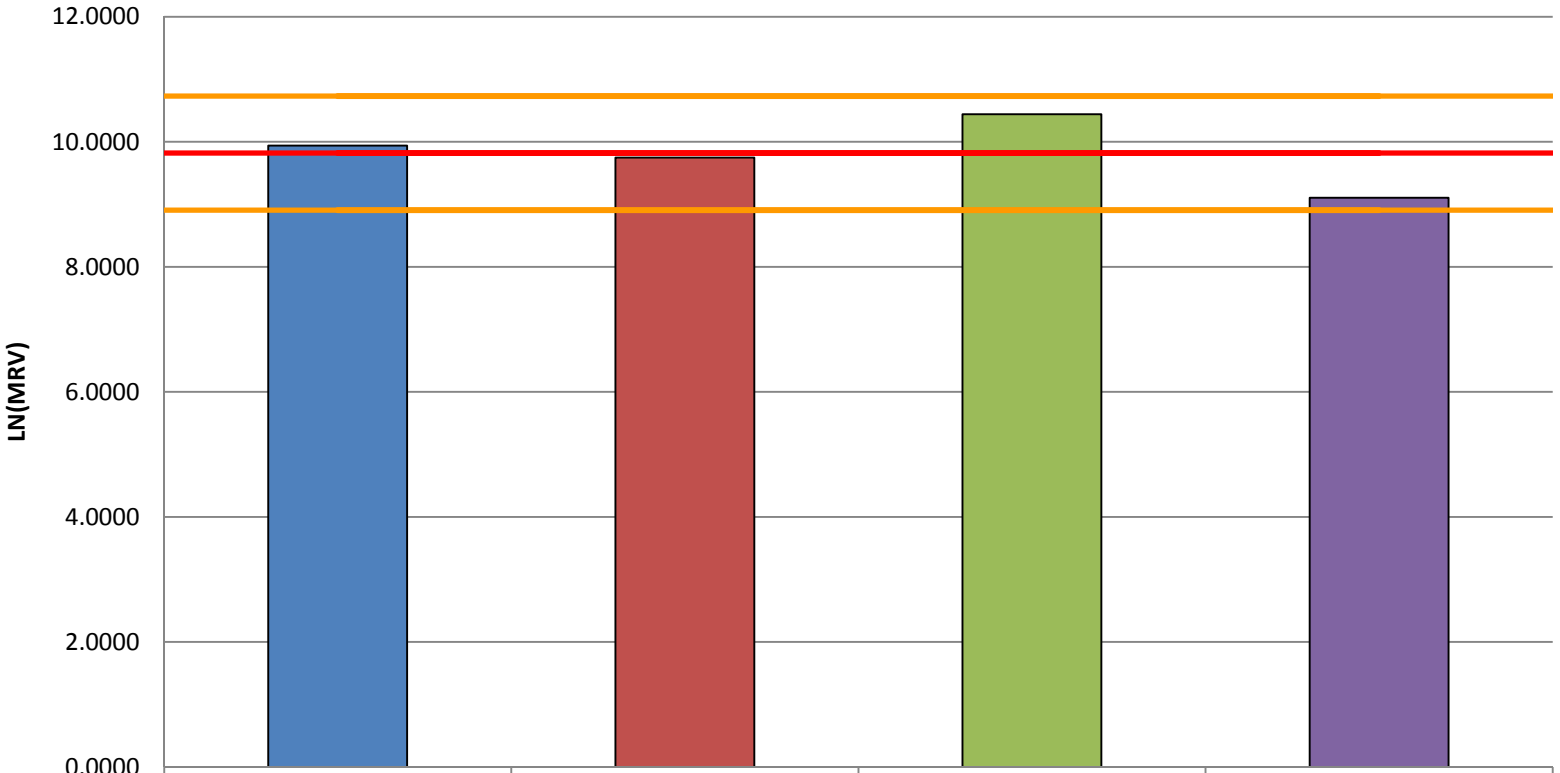


	BC1 Hardware	BC2 Hardware Avg	BC3 Hardware	Experimental Ring Gaps Hardware
PRET	81.19	80.68	80.59	80.52
Target	78.92	78.92	78.92	78.92
+1s	80.46	80.46	80.46	80.46
-1s	77.38	77.38	77.38	77.38

LN(MRV)

Intertek
Valued Quality. Delivered.

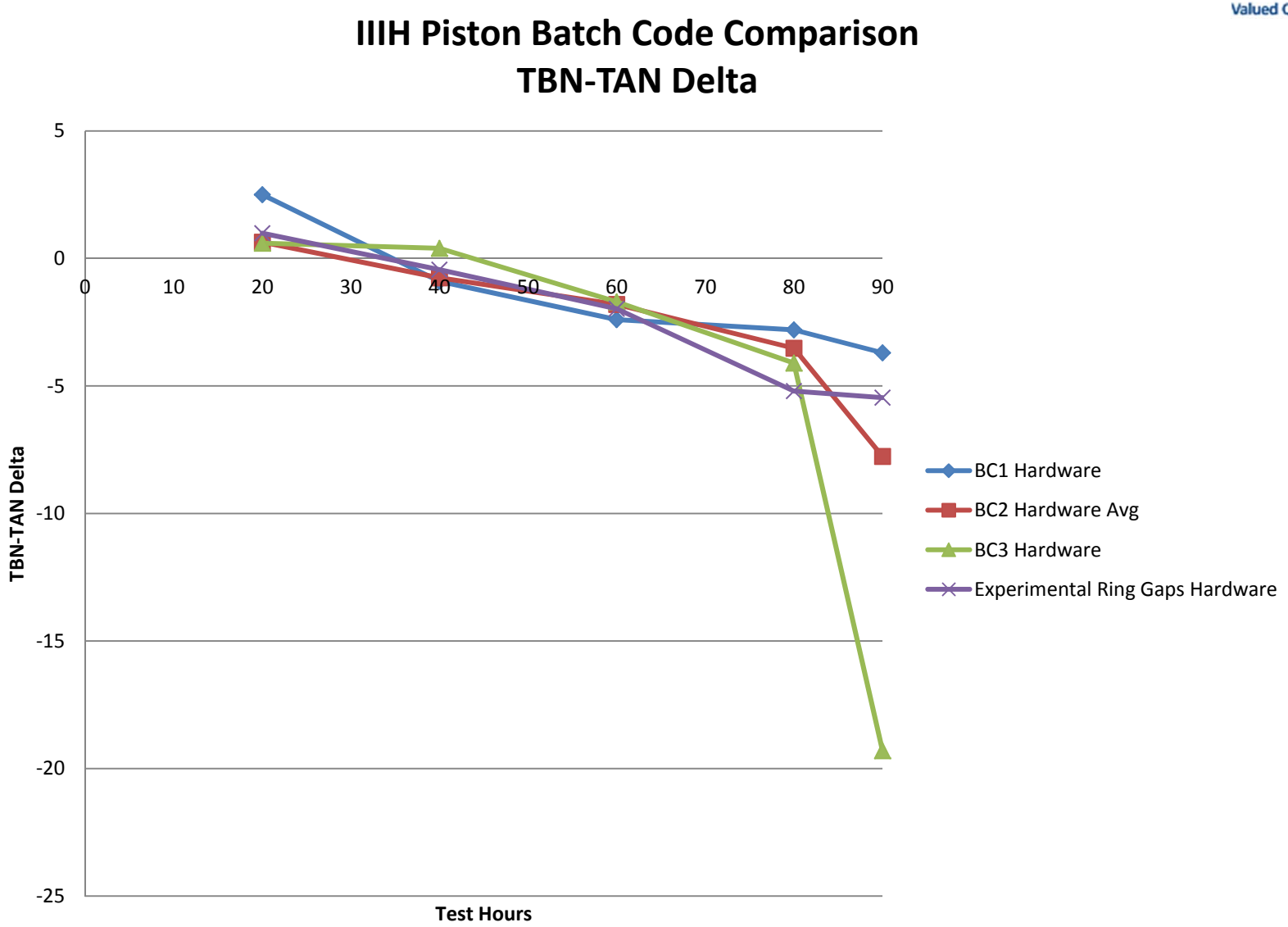
IIIH Batch Code Data Comparison
LN(MRV)



	BC1 Hardware	BC2 Hardware Avg	BC3 Hardware	Experimental Ring Gaps Hardware
LNMRV	9.9379	9.7468	10.4400	9.1050
Target	9.8189	9.8189	9.8189	9.8189
+1s	10.7321	10.7321	10.7321	10.7321
-1s	8.9057	8.9057	8.9057	8.9057

TBN-TAN Delta

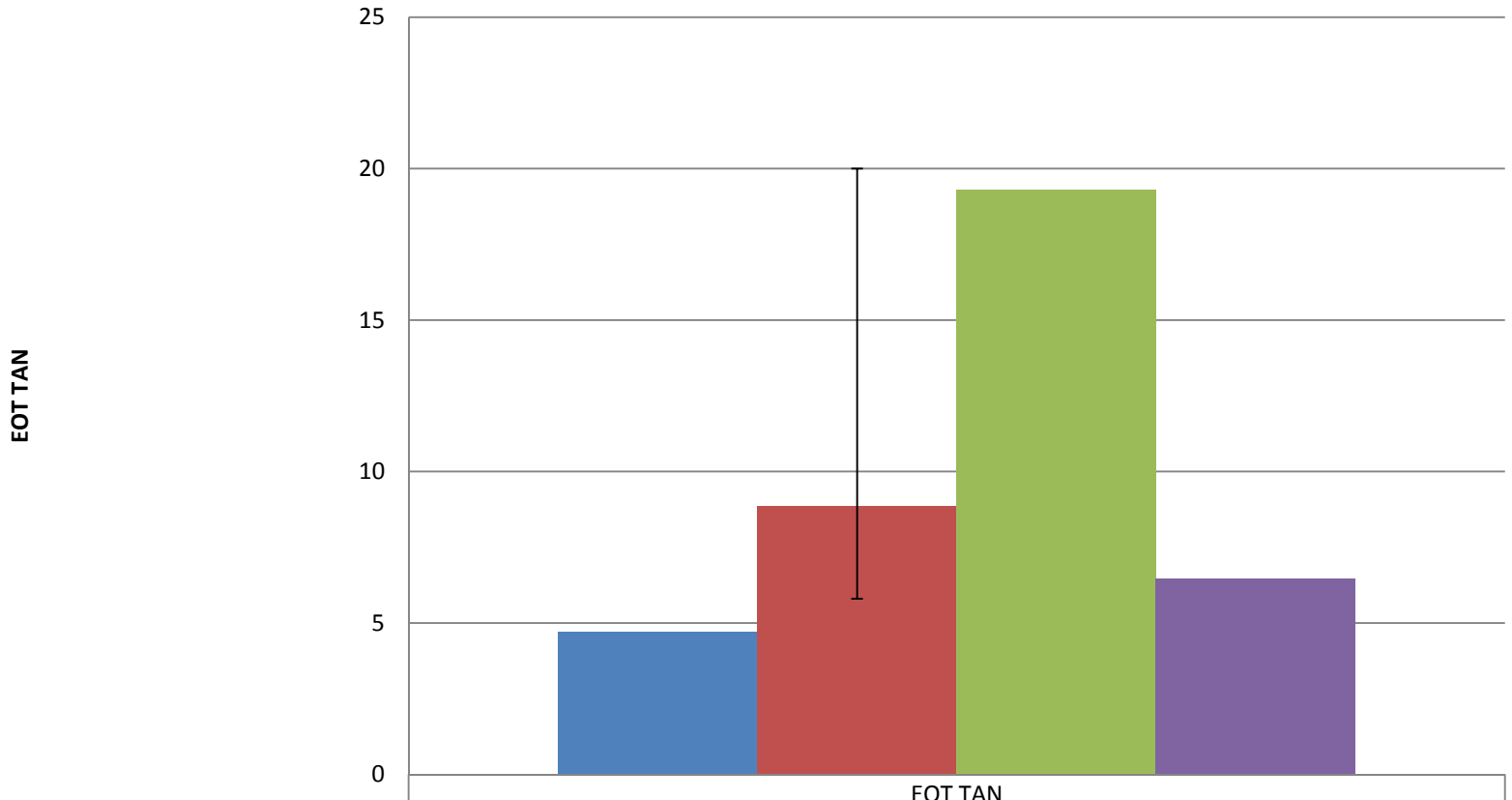
Intertek
Valued Quality. Delivered.



EOT TAN

Intertek
Valued Quality. Delivered.

IIIH Piston Batch Code Comparison
EOT TAN

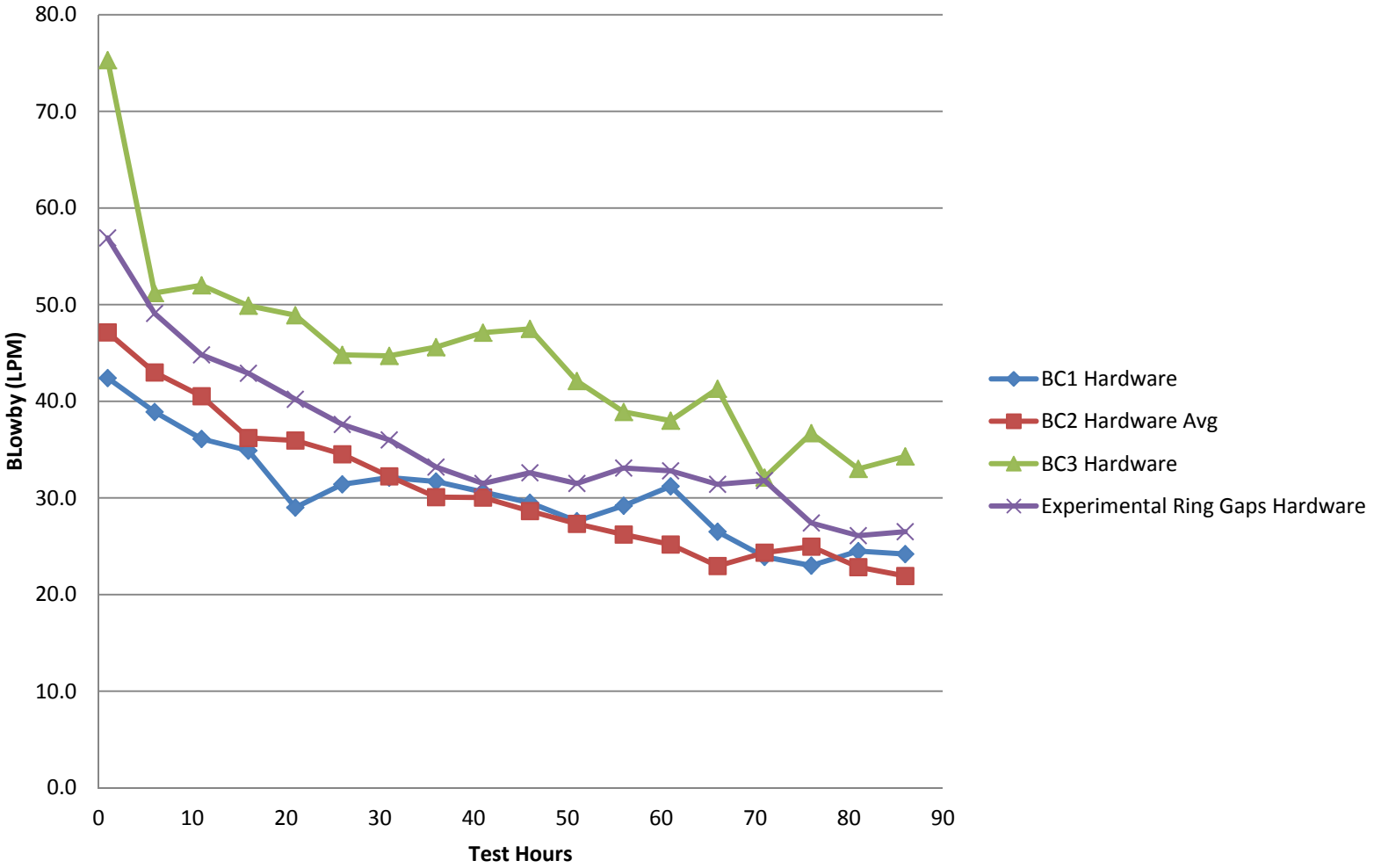


	EOT TAN
BC1 Hardware	4.7
BC2 Hardware Avg	8.88
BC3 Hardware	19.3
Experimental Ring Gaps Hardware	6.46

Blowby

Intertek
Valued Quality. Delivered.

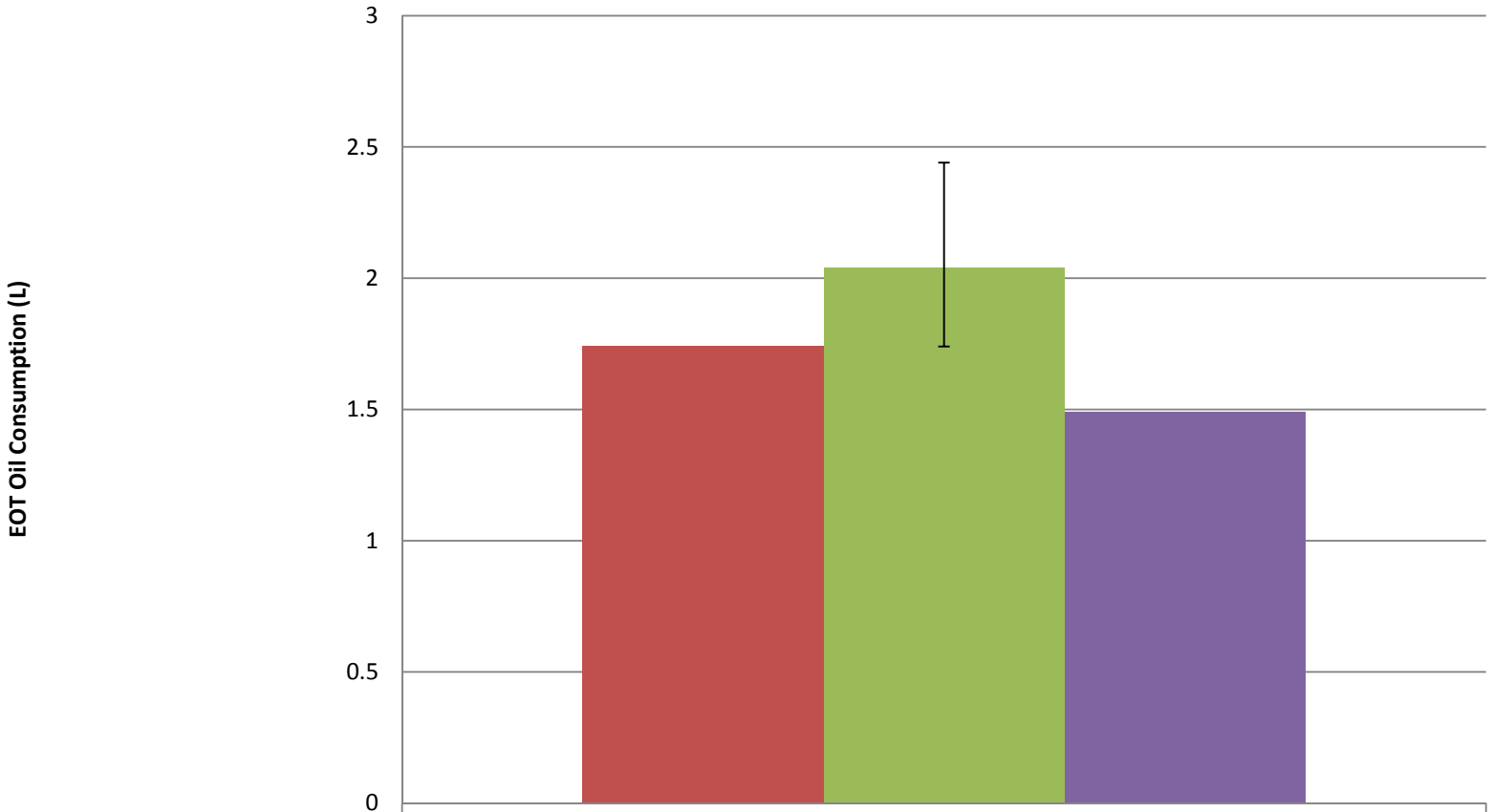
IIIH Piston Batch Code Comparison
Blowby



EOT Oil Consumption

Intertek
Valued Quality. Delivered.

IIIH Piston Batch Code Data Comparison
EOT Oil Consumption



	OILCEOT
BC2 Hardware Avg	1.74
BC3 Hardware	2.04
Experimental Ring Gaps Hardware	1.49

Recommendation

- IAR recommends to the Sequence III Surveillance Panel and Chrysler that additional testing be performed with modified IIIH piston ring gaps (Top = 0.020”, Second = 0.030”) on BC3 pistons

- Ideally the BC4 piston rings from OHT have not been cut to size and can be modified for use on BC3 pistons.

- In the event that BC4 piston rings have already been gapped by OHT, production pistons rings have been confirmed to be available as an alternate option for use on BC3 pistons after being gapped by a CPD.

ATTACHMENT 4

BC 2 / BC 3 Blow-by Comparison

SOUTHWEST RESEARCH INSTITUTE®

Ankit Chaudhry

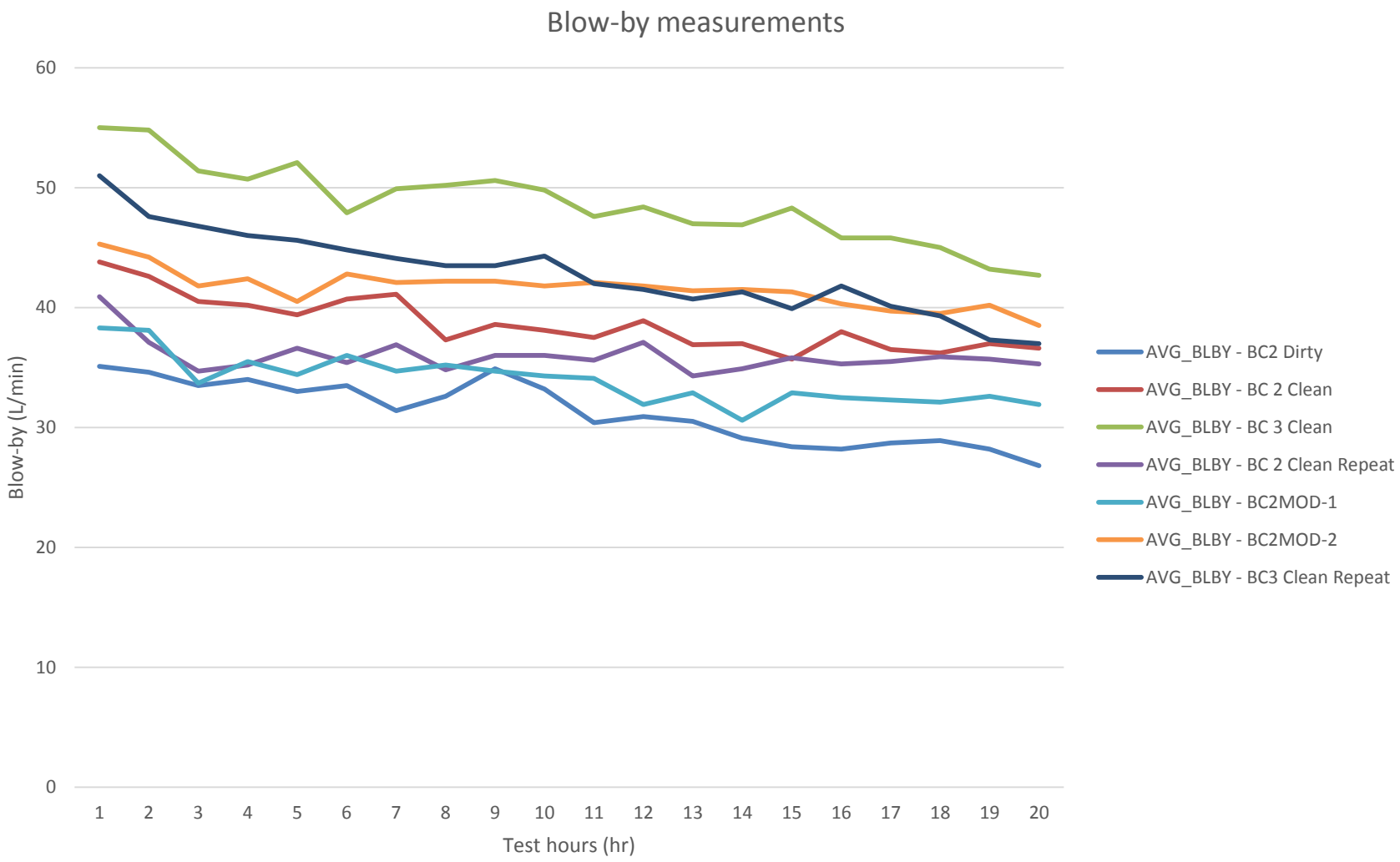
Project Engineer

January 2017

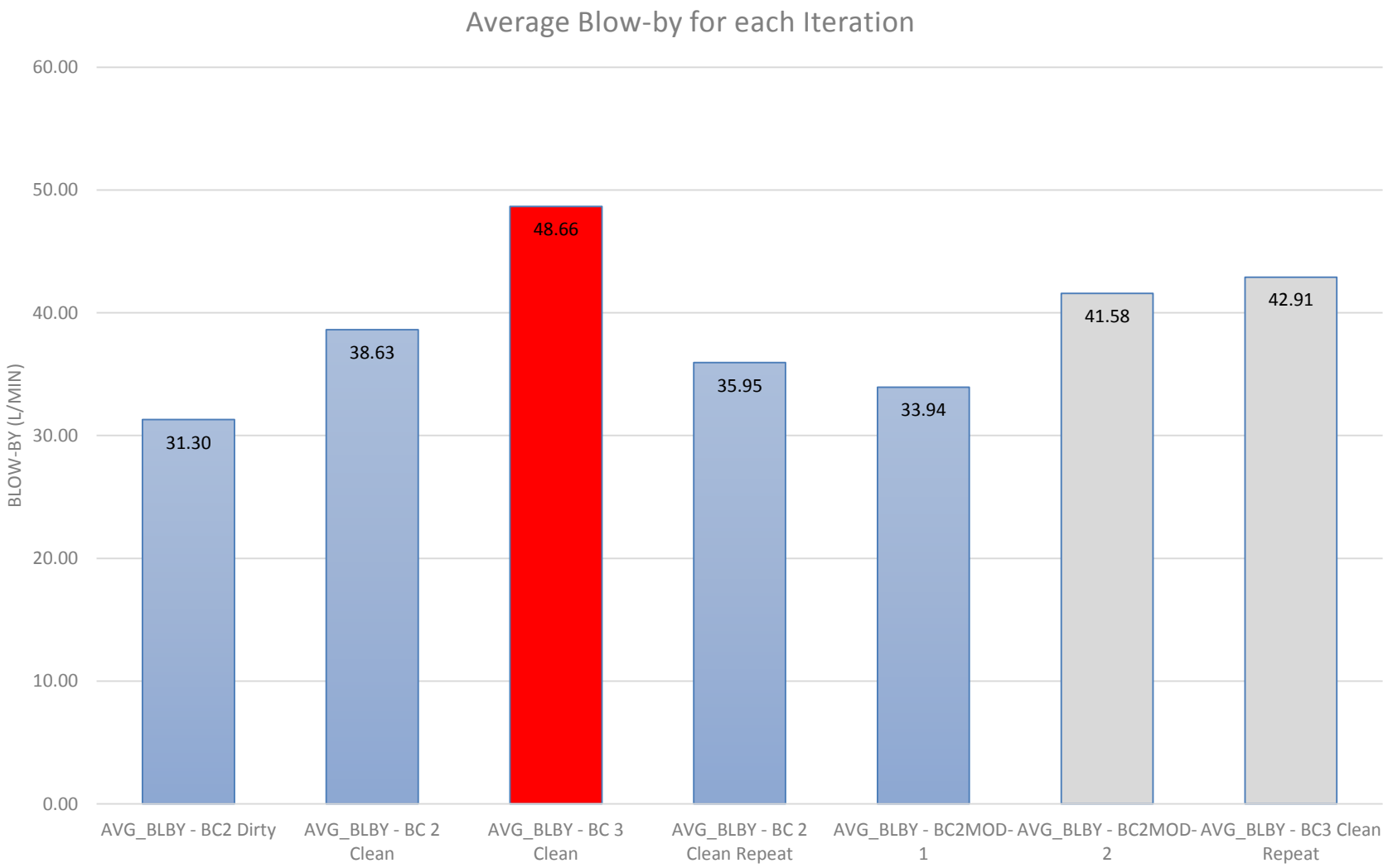
Batch Code 3 Piston repeat

- 7th Iteration
  - Slave engine was rebuild with ultrasonic cleaned batch code 3 pistons and batch code 2 rings. **These are the same pistons and rings used in iteration 3.**
    - NOTE: One of the original BC 3 piston was damaged in handling. It was replaced with another used BC3 piston. It was measured and critical dimensions were in the same range as the original pistons.
  - Goal: To determine if there is an effect of engine hours on blow-by measurements.

Blow-by Measurements (1 to 7 Iteration)



Blow-by Measurements (Avg.)



For Additional Information

Ankit Chaudhry
Research Engineer
Gasoline Lubricant Evaluations Section

Southwest Research Institute
Engine Lubricants Research Department,
Fuels and Lubricants Research Division

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ATTACHMENT 5

Sequence IIIH Batch 3 Piston Data Review

Statistics Group

Dec. 6, 2016

Statistics Group

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- Jim Rutherford, Chevron Oronite
- Jo Martinez, Chevron Oronite
- Kevin O'Malley, Lubrizol
- Martin Chadwick, Intertek
- Richard Grundza, TMC
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Conclusions

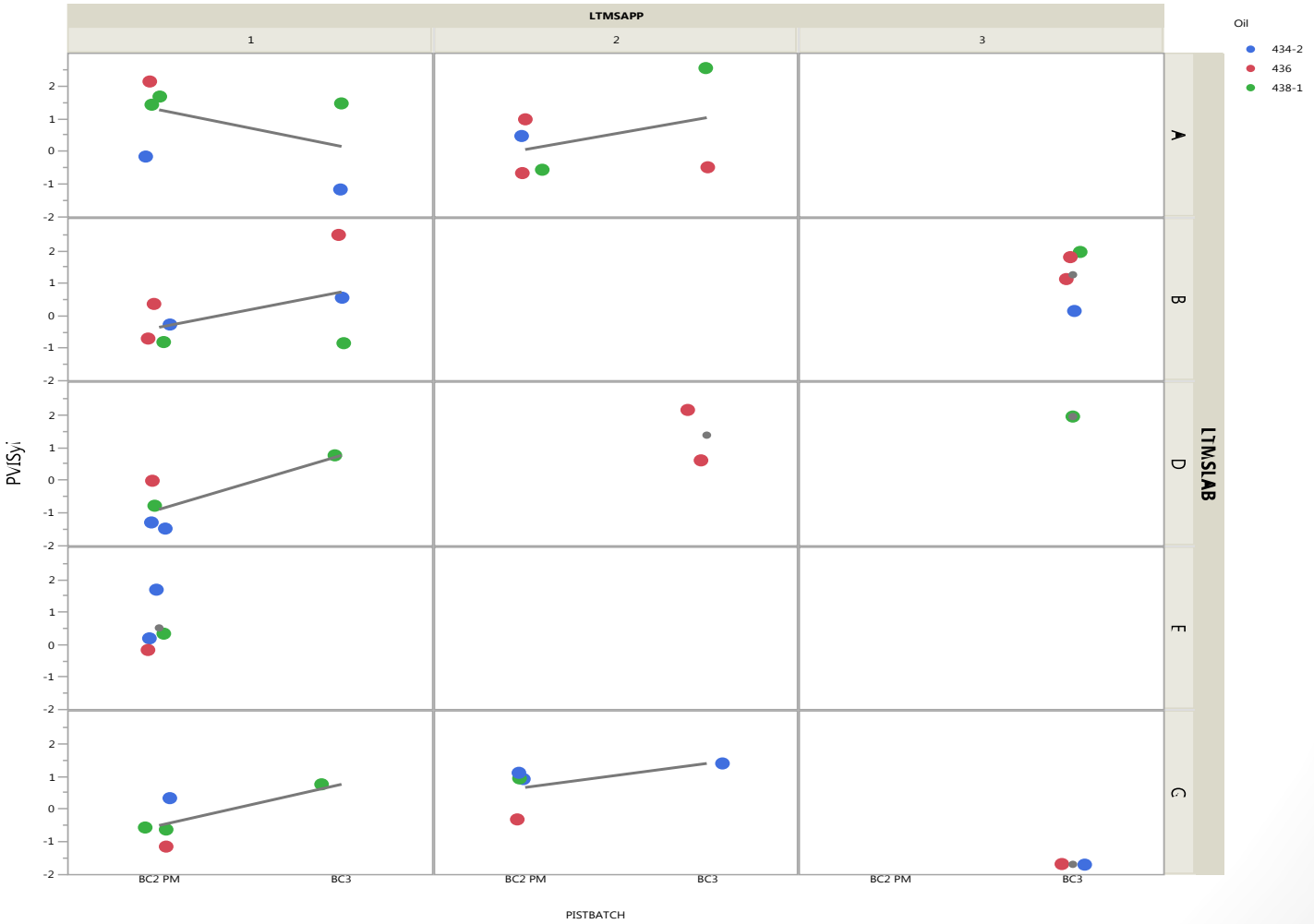
- Analyzed with BC2PM, BC2 PostPM and BC3 pistons.
- Piston Batch Severity
  - PVIS
    - BC3 is marginally severe than BC2PM, p=0.10
    - BC3, BC2PM > BC2PostPM
  - WPD
    - BC3 is not significantly different than BC2PM, p=0.15
    - BC3, BC2PM < BC2 PostPM
  - MRV
    - BC3 is not significantly different than BC2PM, p=0.14
    - BC3, BC2PM > BC2PostPM
  - Blowby1: BC3 > BC2PM, BC2PostpM
  - Blowby6: BC3 > BC2PM, BC2PostpM
  - OCEOT: BC3 > BC2PM, BC2PostpM
- Not all stands affected by Batch 3 Piston ei alarm
  - 2 out of 9 stands PVIS ei alarms most likely triggered by Batch 3
  - 1 out of 9 stands WPD ei alarm most likely triggered by Batch 3
  - 3 out of 9 stands MRV ei alarms most likely triggered by Batch 3
- Inconsistent oil response to BC3 pistons
  - Lost PVIS discrimination between 434-2 and 436 and between 434-2 and 438-1
  - Appears to have 434-2 and 438-1 PVIS ranking reversal
  - Lost MRV discrimination among the oils

IIIH Piston Data

	Piston Batch			
Oil	BC3	BC2	BC2 PM	BC2 Post-PM
434-2	5	20	10	10
436	7	14	9	5
438-1	7	16	9	7
Total	19	50	28	22

PVISyi
(Batch 3 vs Target Batch 2)

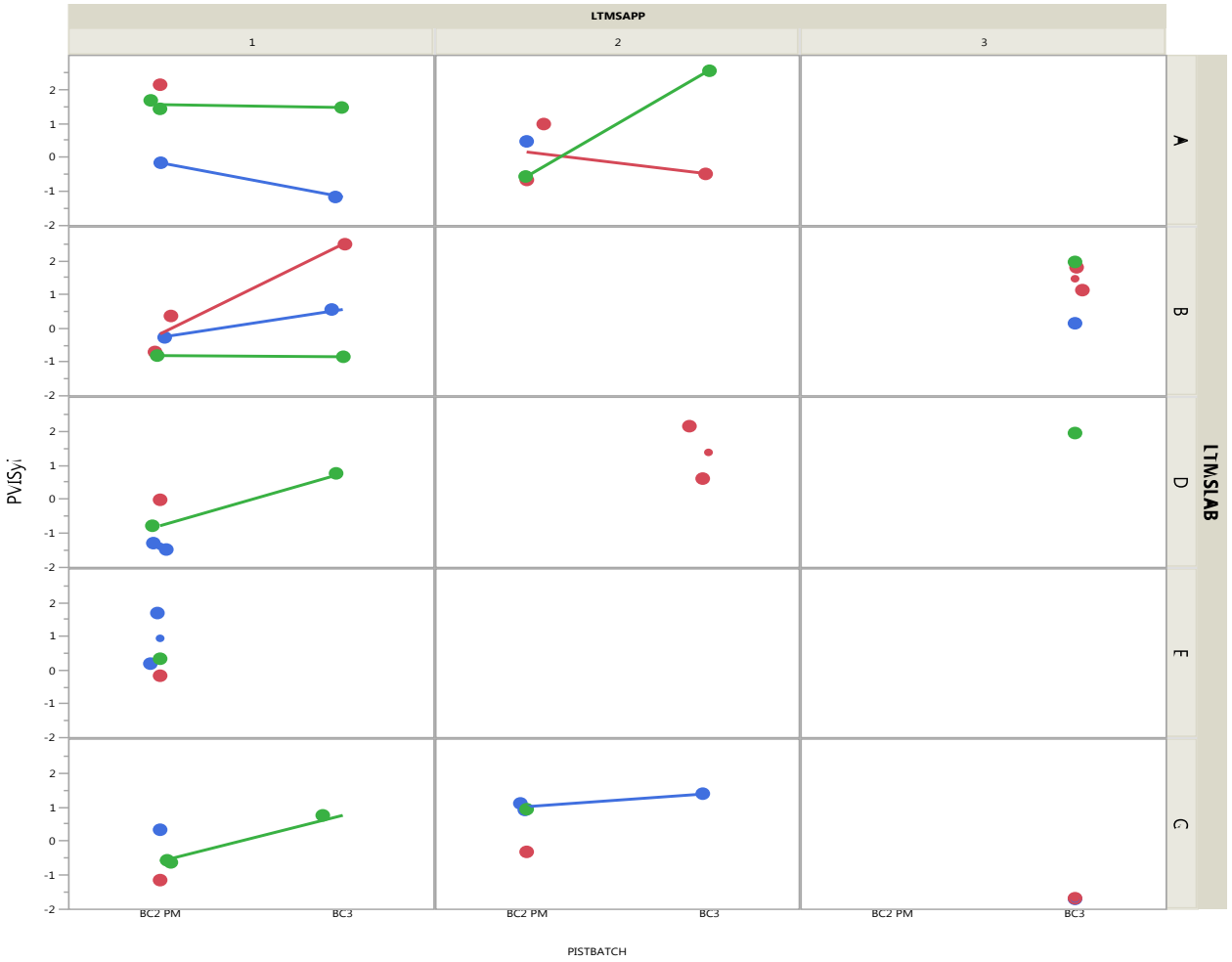
Severe



Mild

PVISyi by Oil
(Batch 3 vs Target Batch 2)

Severe

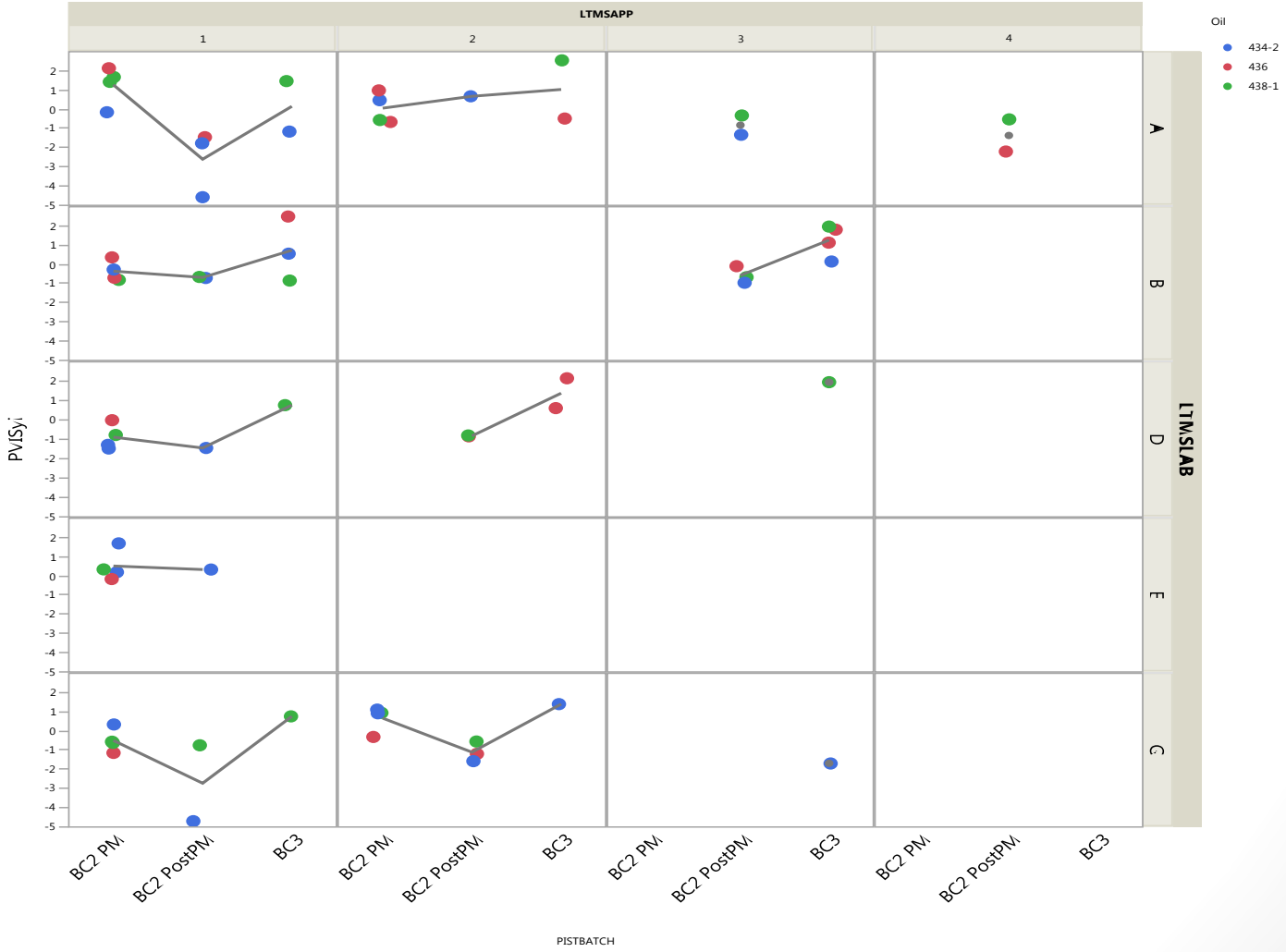


438-1 A2, D1, G2: BC2PM < BC3

Mild

PVISyi
(Batch 3 vs All Batch 2)

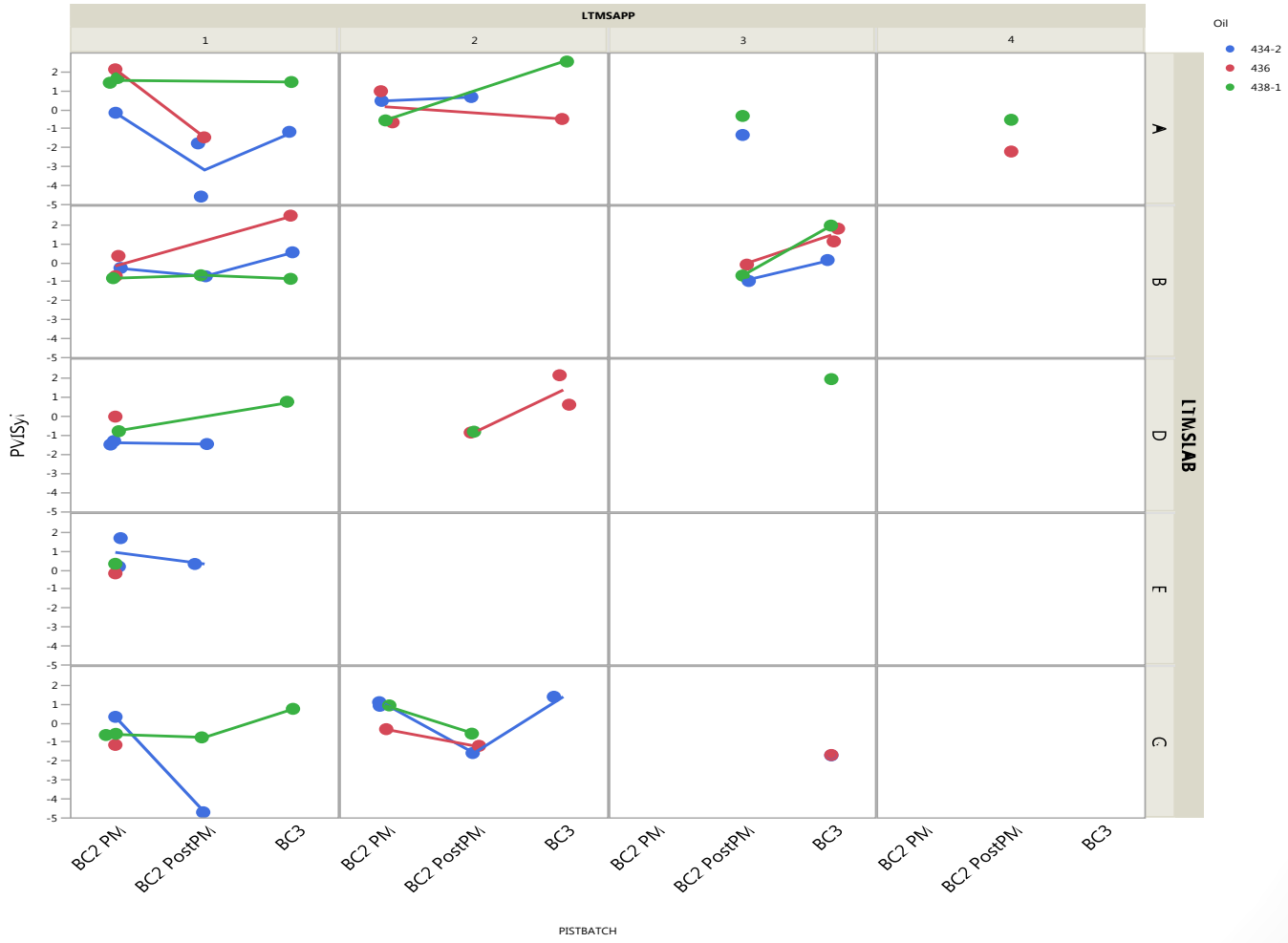
Severe



Mild

PVISyi by Oil
(Batch 3 vs All Batch 2)

Severe

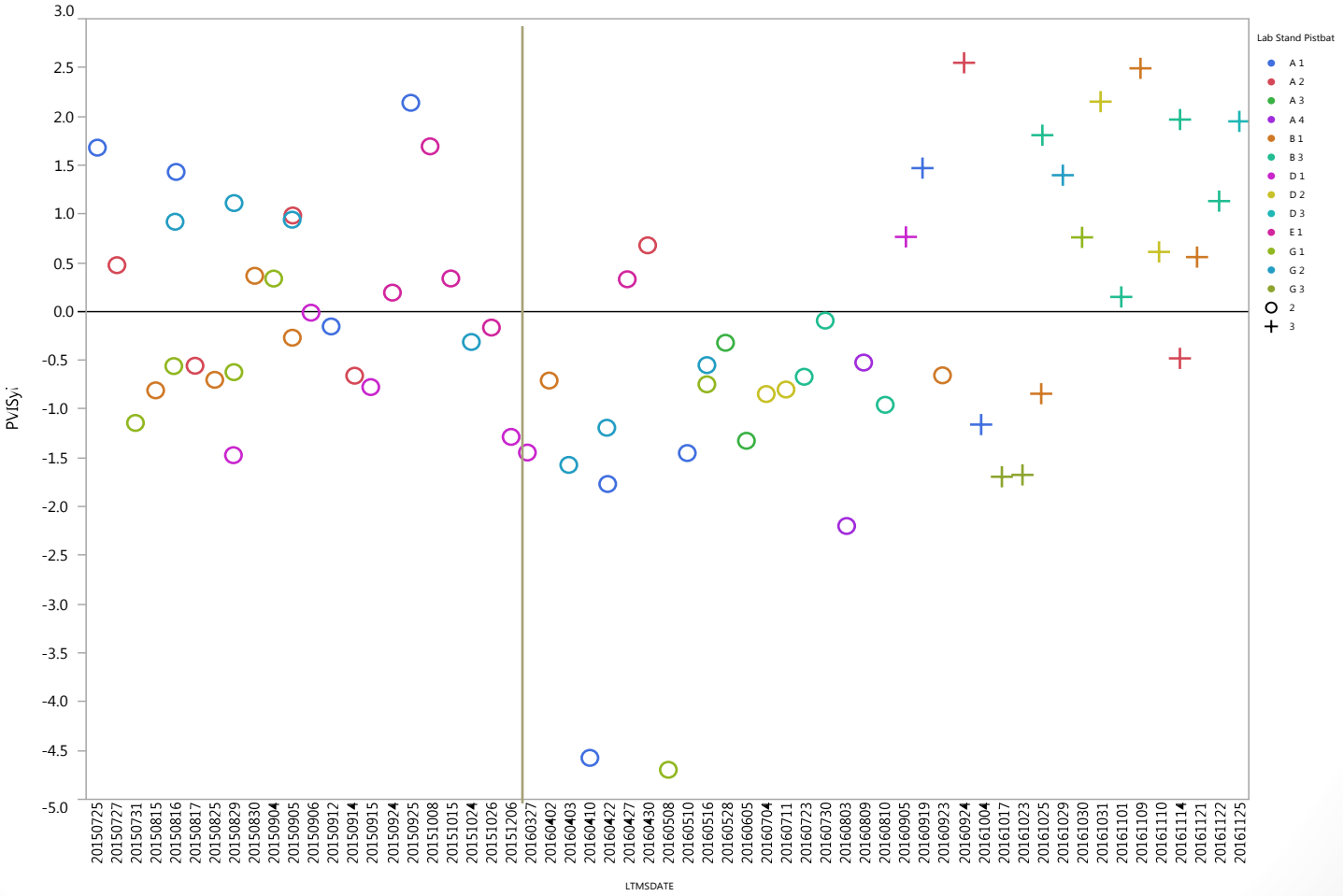


Mild

PVISyi

Severe

Target Setting

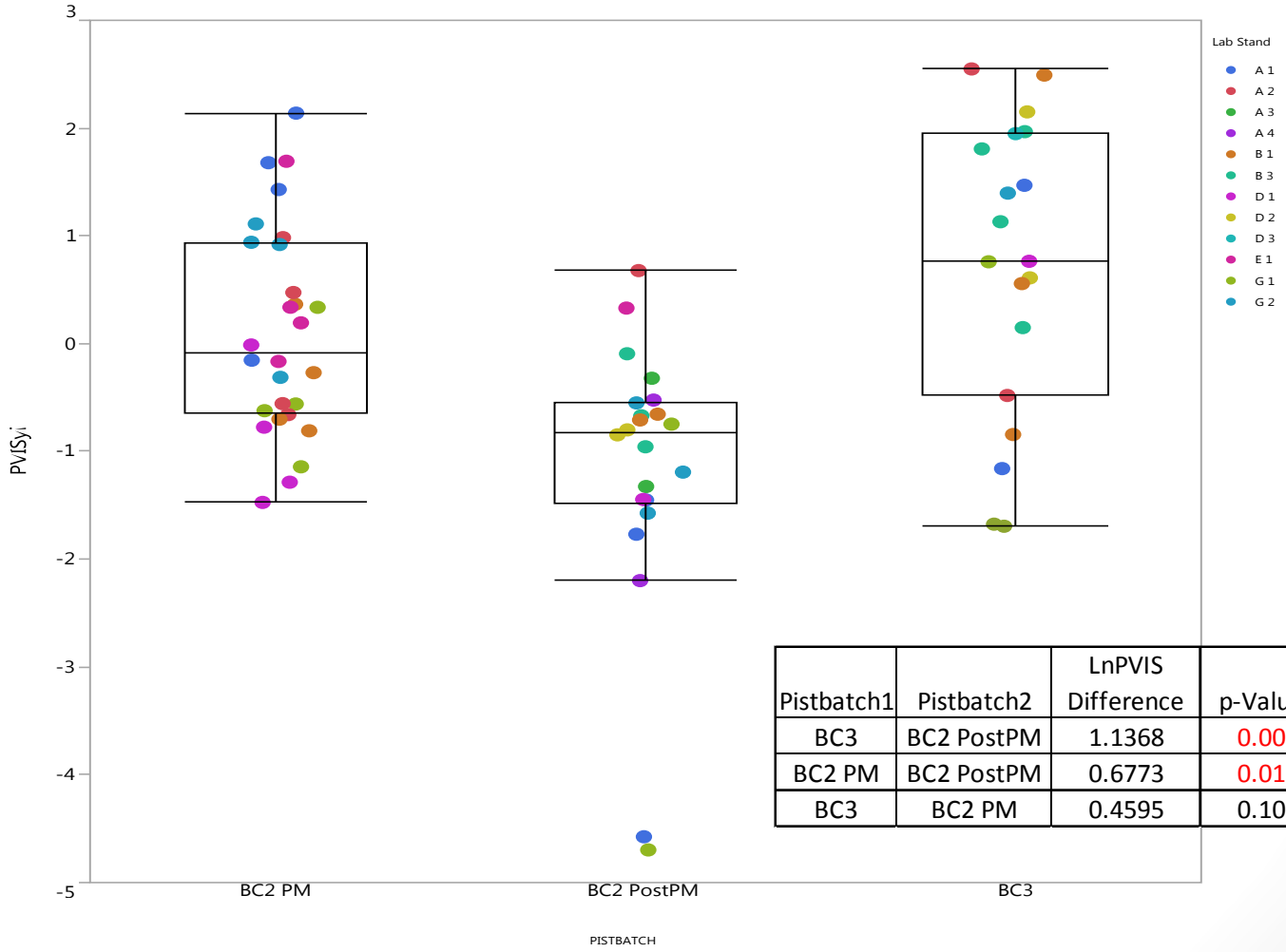


Mild

PVISyi by Piston Batch

Severe

BC3 marginally severe than BC2 PM (Target Setting)

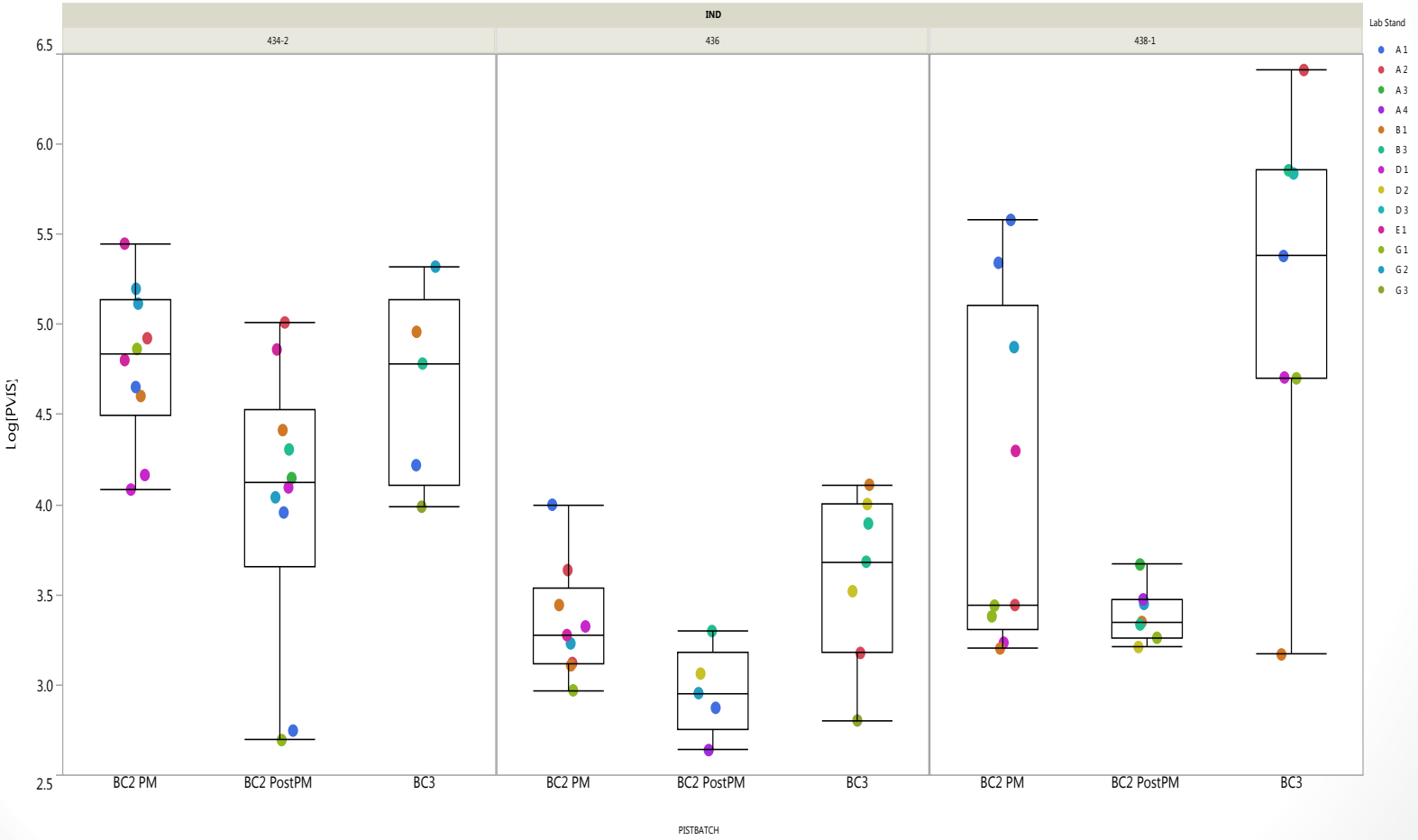


Pistbatch1	Pistbatch2	LnPVIS Difference	p-Value
BC3	BC2 PostPM	1.1368	0.00
BC2 PM	BC2 PostPM	0.6773	0.01
BC3	BC2 PM	0.4595	0.10

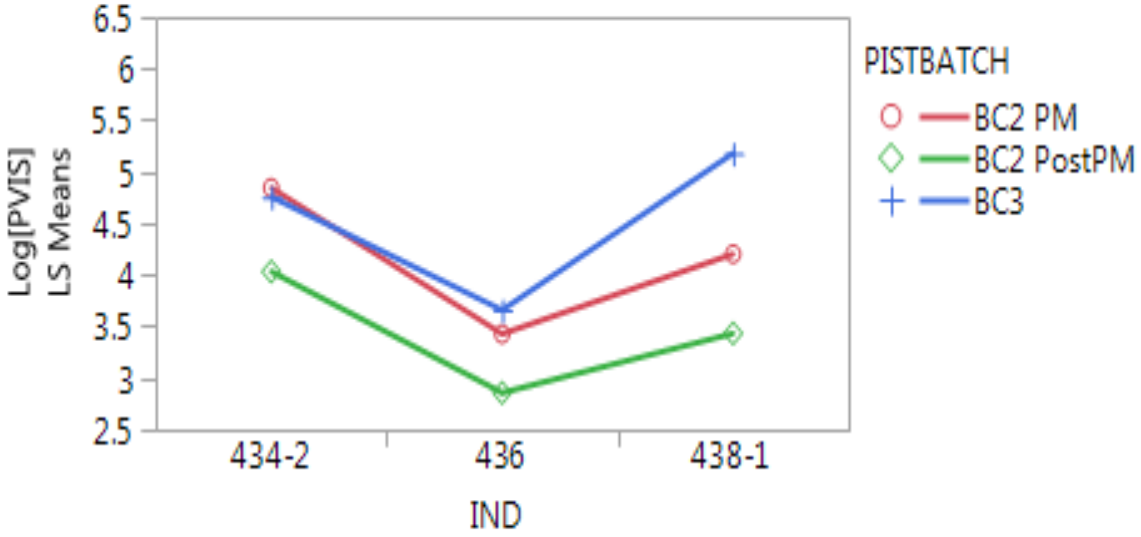
Mild

PVIS by Oil and Piston Batch

Appears to have a ranking reversal of 434-2 and 438-1 with BC3.



PVIS Oil Discrimination



Level						Least Sq Mean
BC3,438-1	A					5.1814
BC2 PM,434-2	A	B				4.8463
BC3,434-2	A	B	C			4.7601
BC2 PM,438-1	A	B	C	D		4.2047
BC2 PostPM,434-2		B	C	D	E	4.0350
BC3,436			C	D	E	3.6615
BC2 PostPM,438-1				D	E	3.4351
BC2 PM,436				D	E	3.4306
BC2 PostPM,436					E	2.8596

Levels not connected by same letter are significantly different.

BC2PM

434-2, 438-1 > 436

BC2PostPM

No discrimination

BC3

438-1 > 436

434-2

No batch differences

436

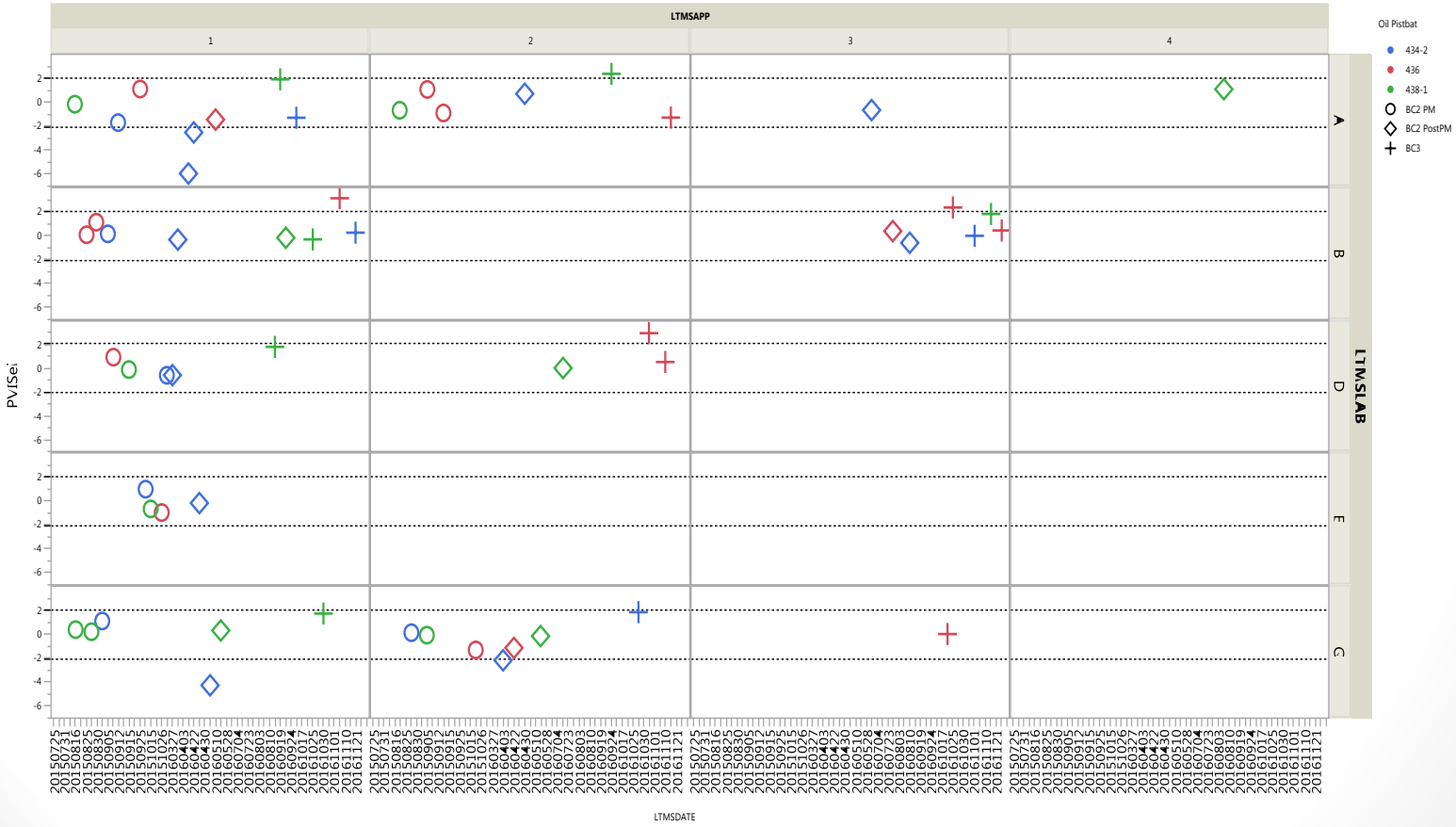
No batch differences

438-1

BC3 > BC2 PostPM

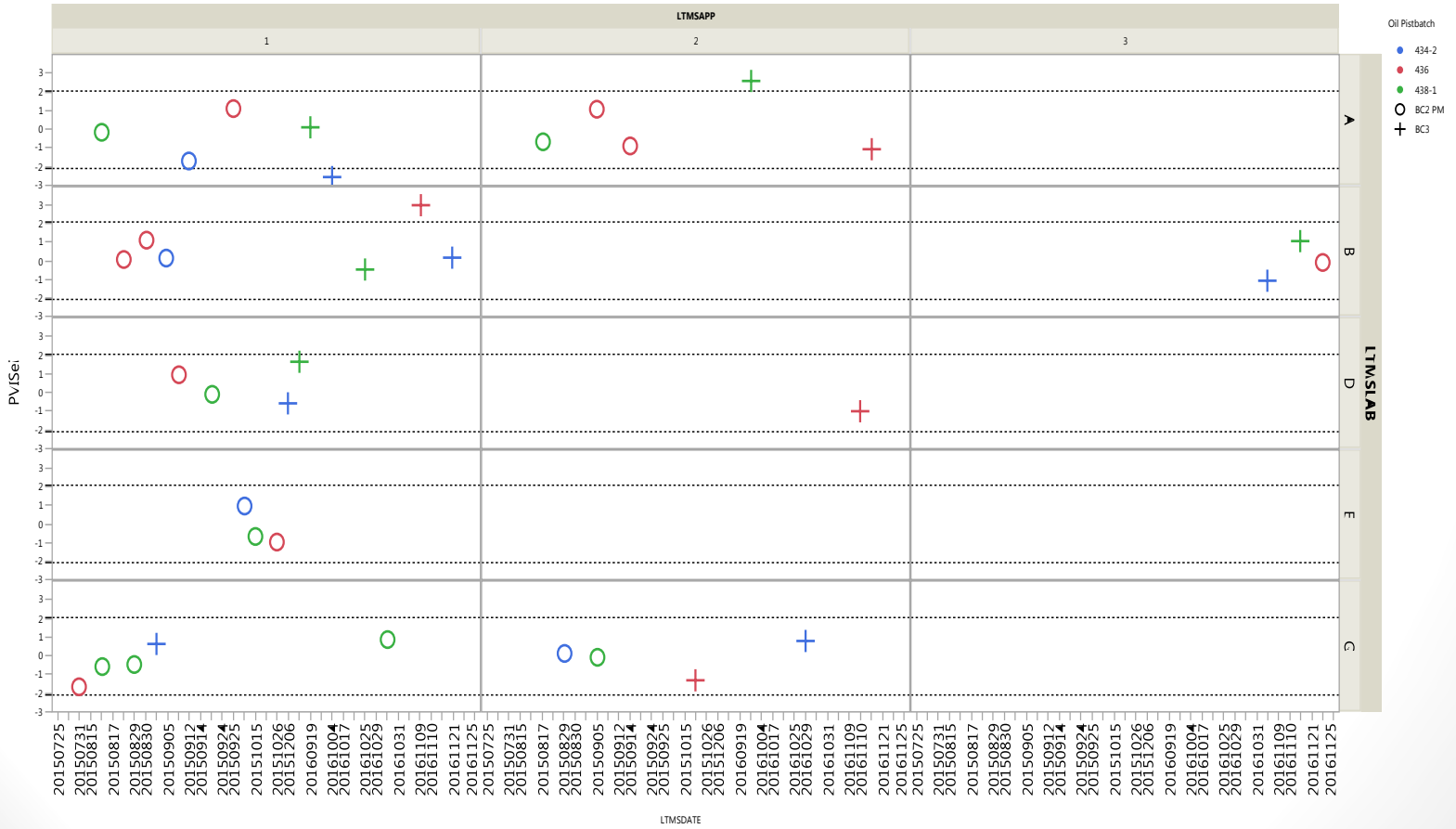
PVISei

- 7 out of 9 stands triggered ei alarm with Batch 3 Piston
- 6 out of 7 ei alarms went back to normal after 2nd test
- 1 out of 7 ei alarm triggered at 2nd run with Batch 3 Piston



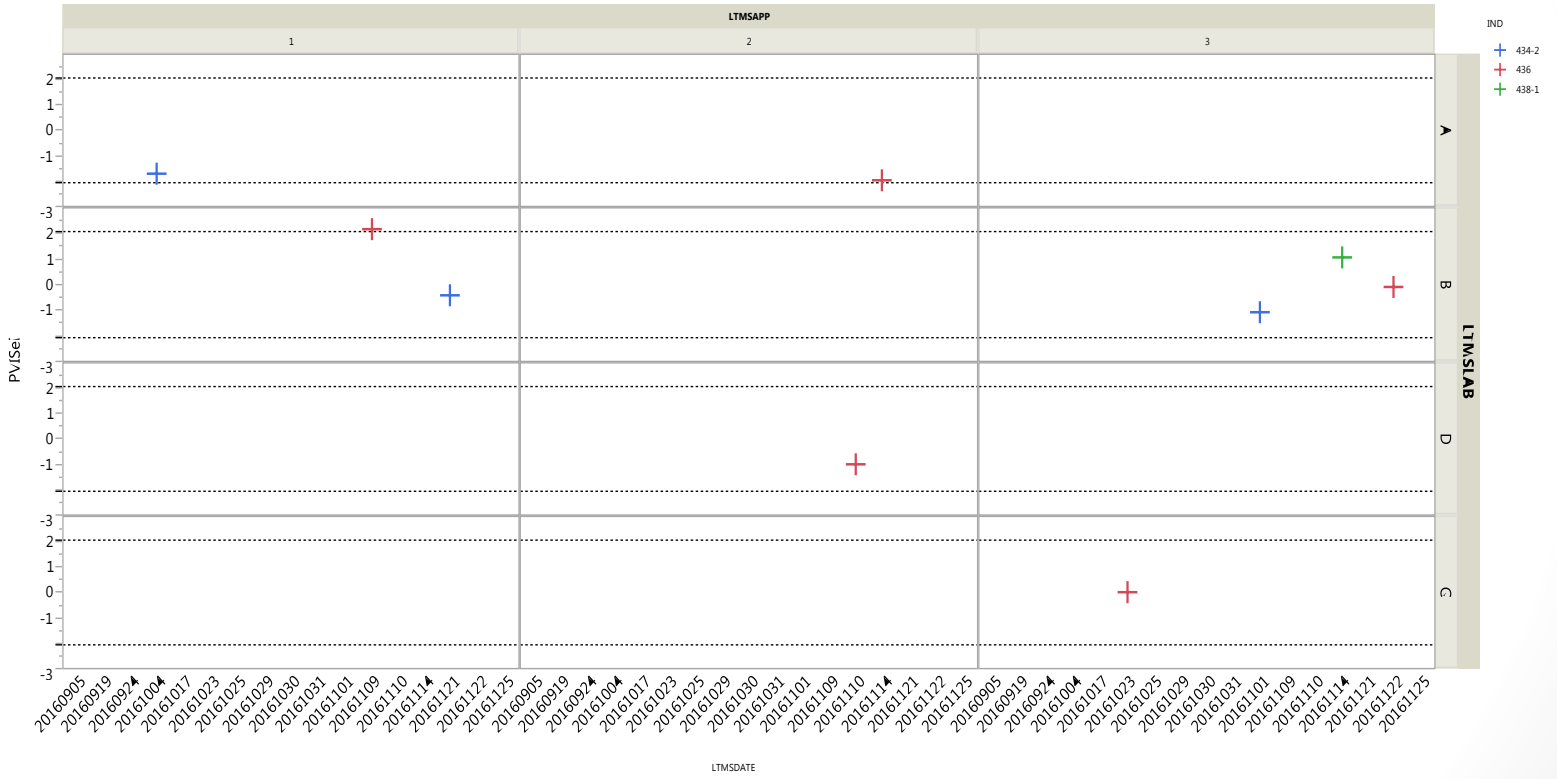
PVISei (Removing BC2 PostPM)

- 3 out of 9 stands triggered ei alarm with Batch 3 Piston
- 2 out of 3 ei alarms went back to normal after 2nd test
- 2 out of 3 ei alarm triggered at 2nd run with Batch 3 Piston



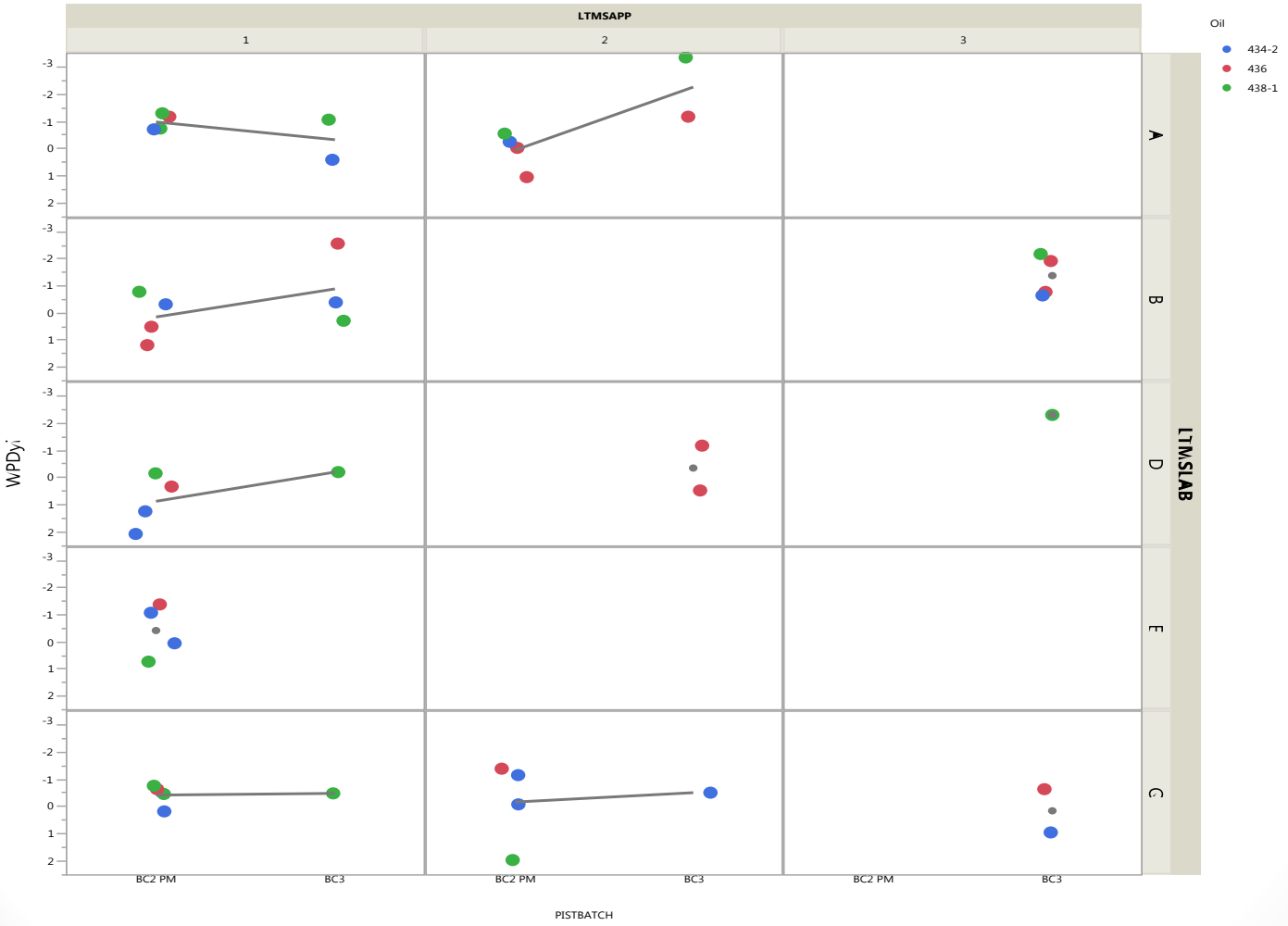
PVISei (Resetting to Batch 3)

- 2 out of 6 stands triggered ei alarm with Batch 3 Piston



WPDyi
(Batch 3 vs Target Batch 2)

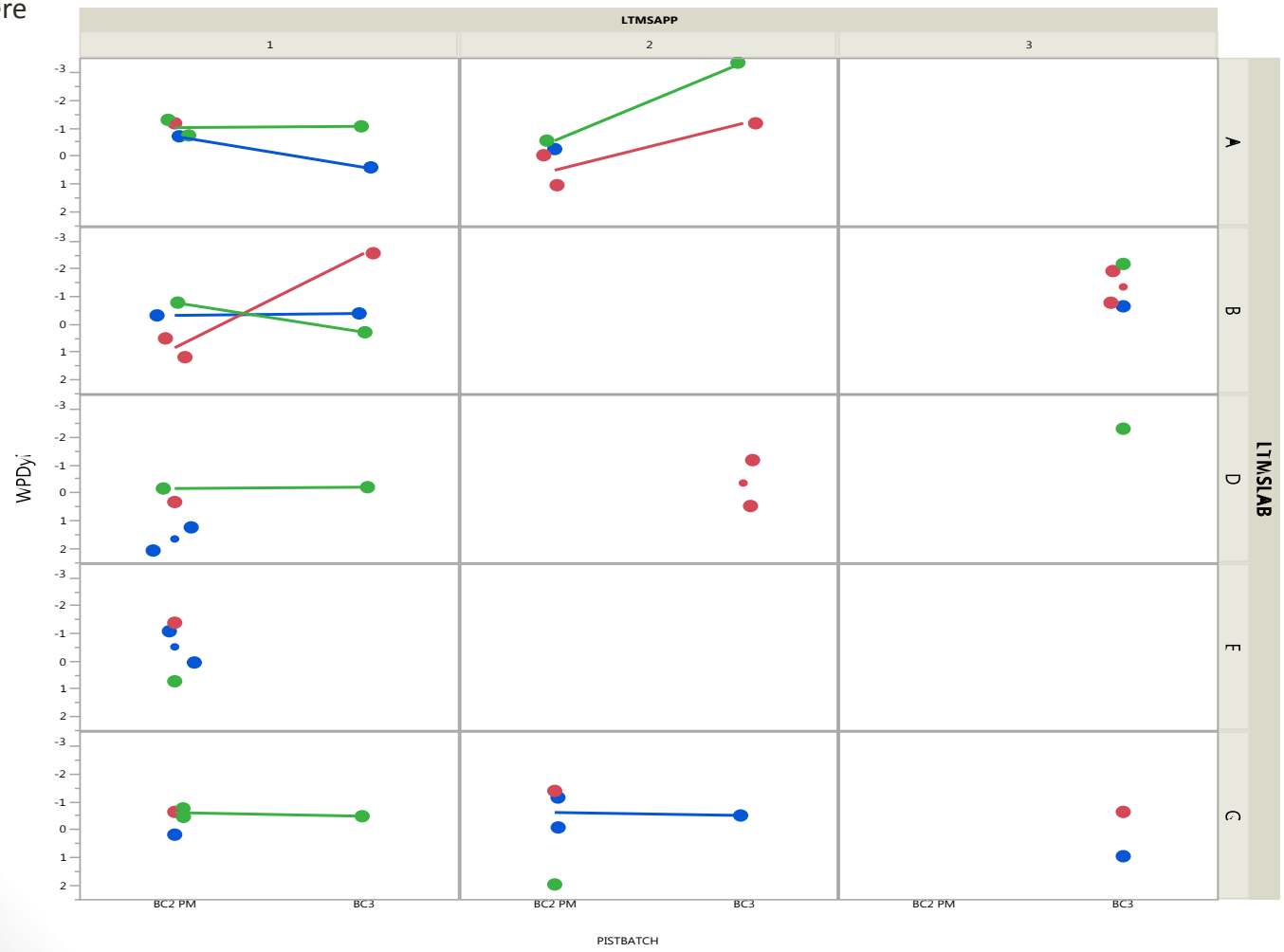
Severe



Mild

WPDyi by Oil
(Batch 3 vs Target Batch 2)

Severe

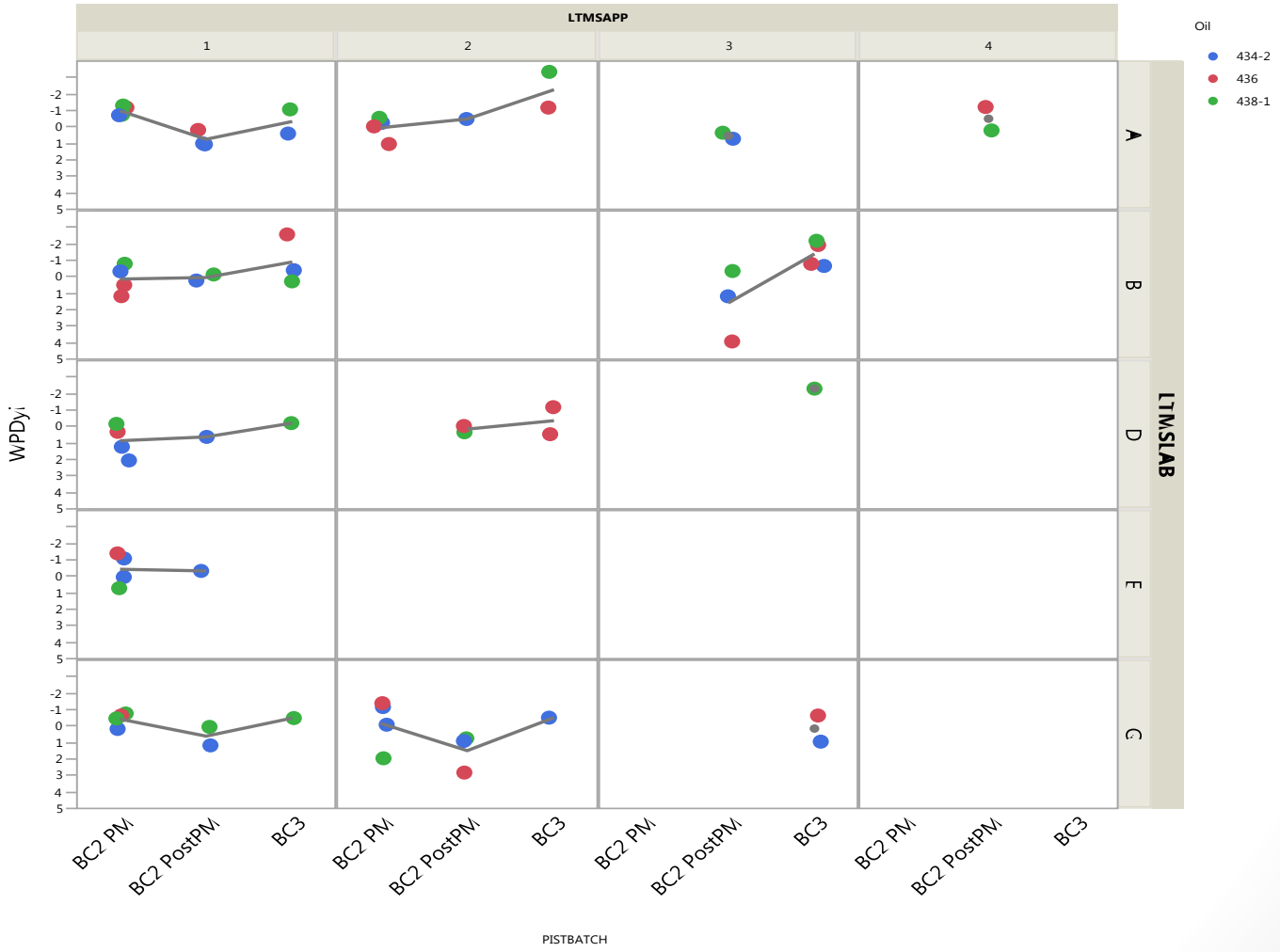


Mild

434-2 A1:
BC2PM < BC3
436 B1:
BC2PM > BC3
438-1 A2:
BC2PM > BC3

WPDyi
(Batch 3 vs All Batch 2)

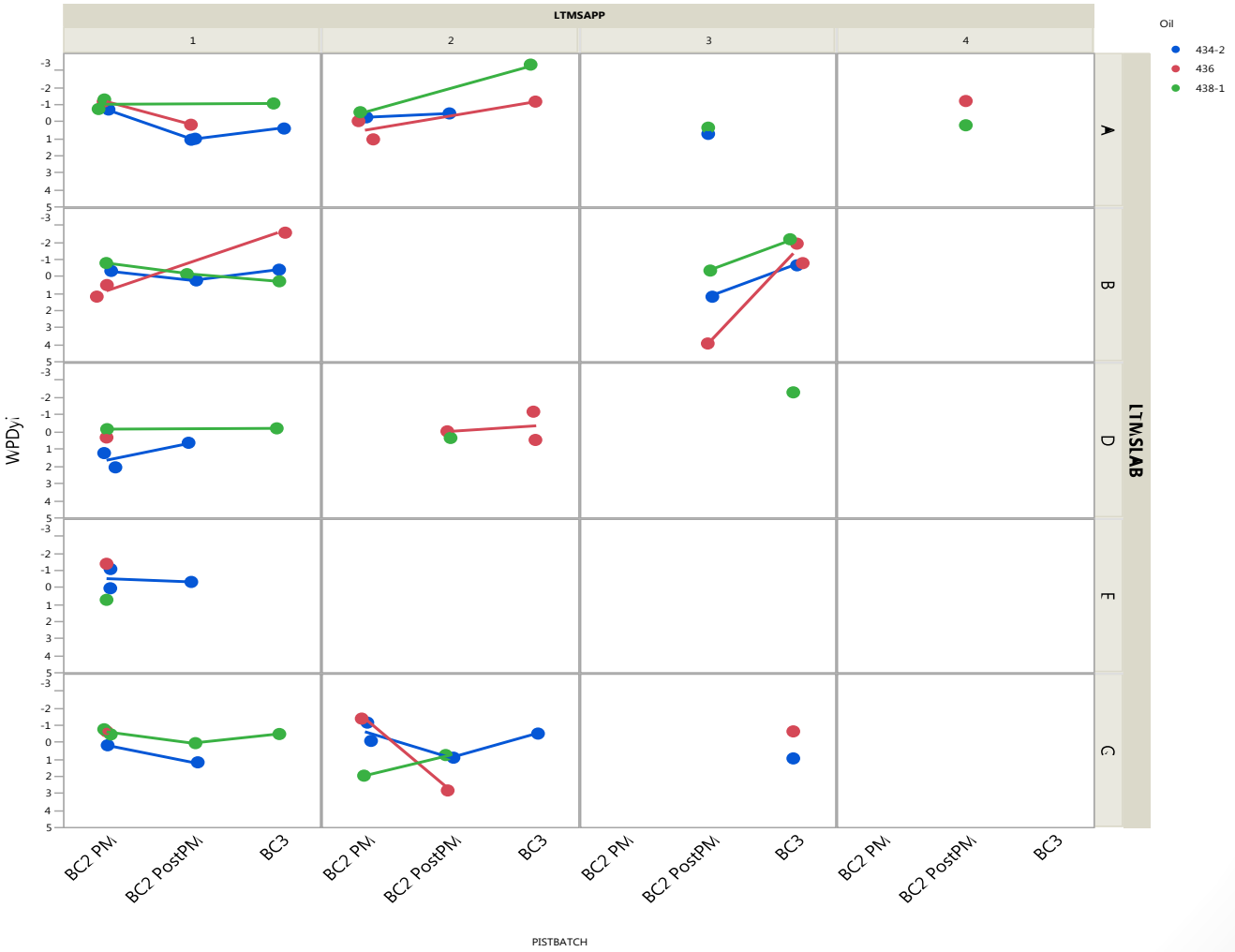
Severe



Mild

WPDyi by Oil
(Batch 3 vs All Batch 2)

Severe

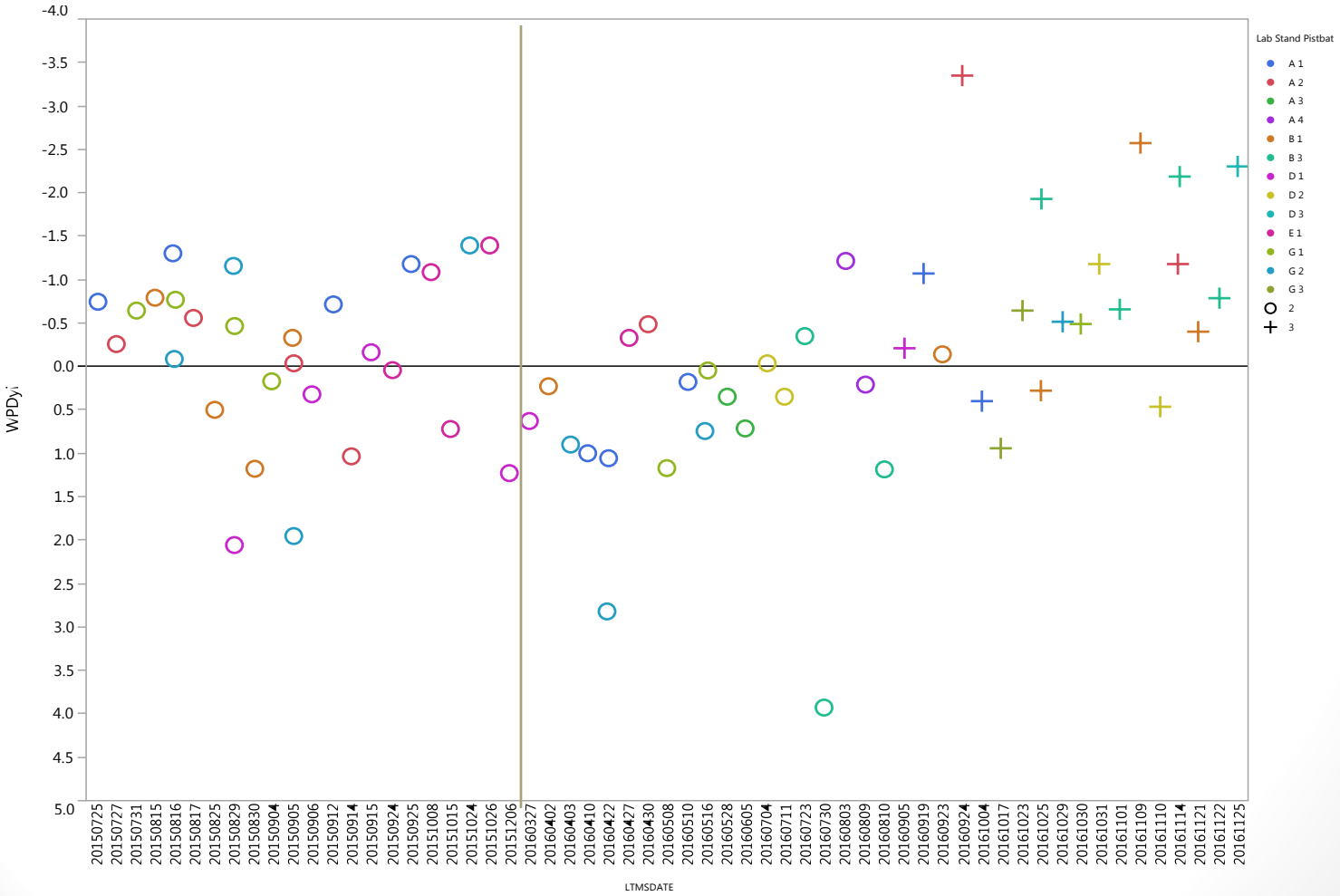


Mild

WPDyi

Severe

Target Setting

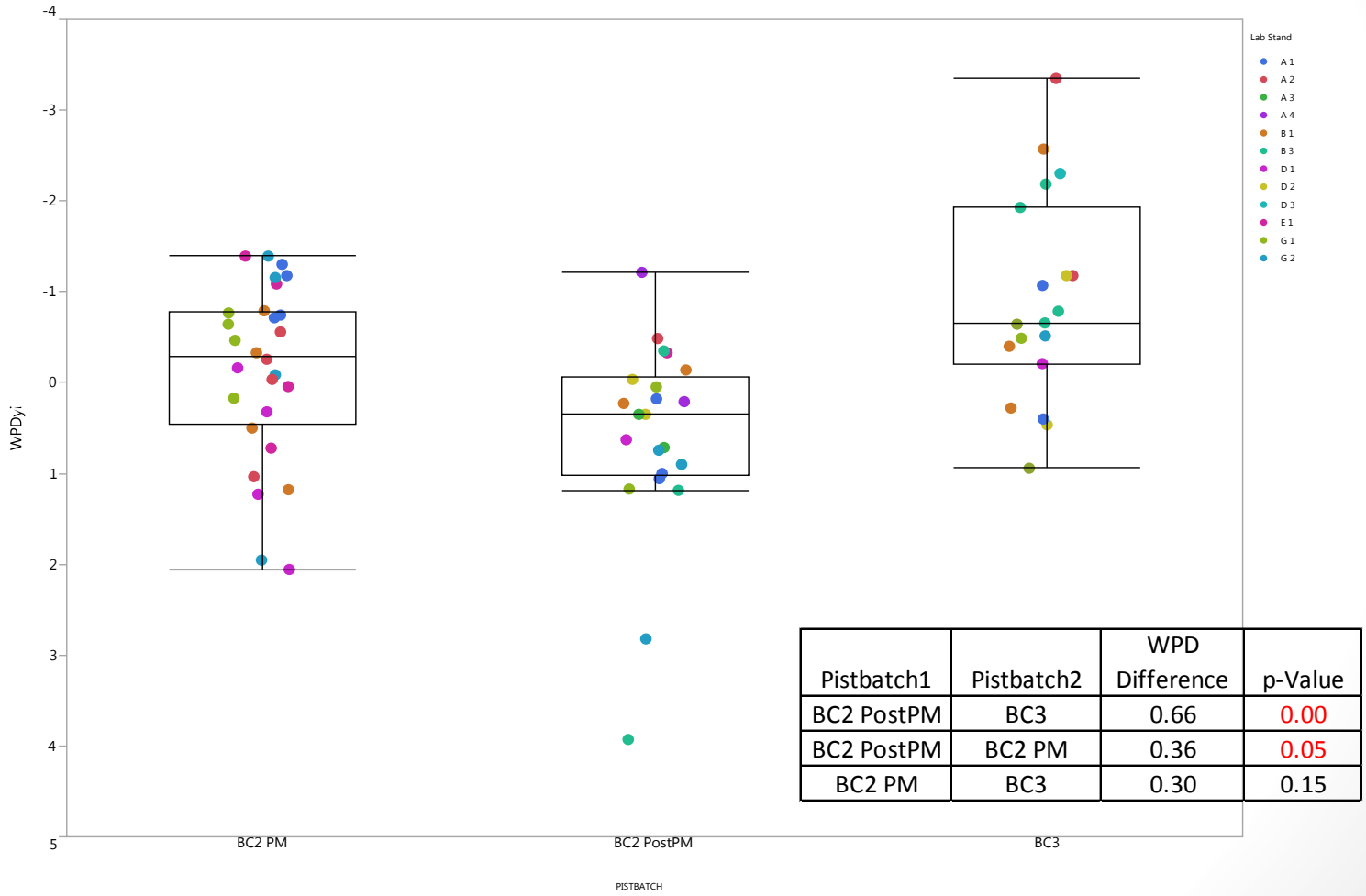


Mild

WPDyi by Piston Batch

Severe

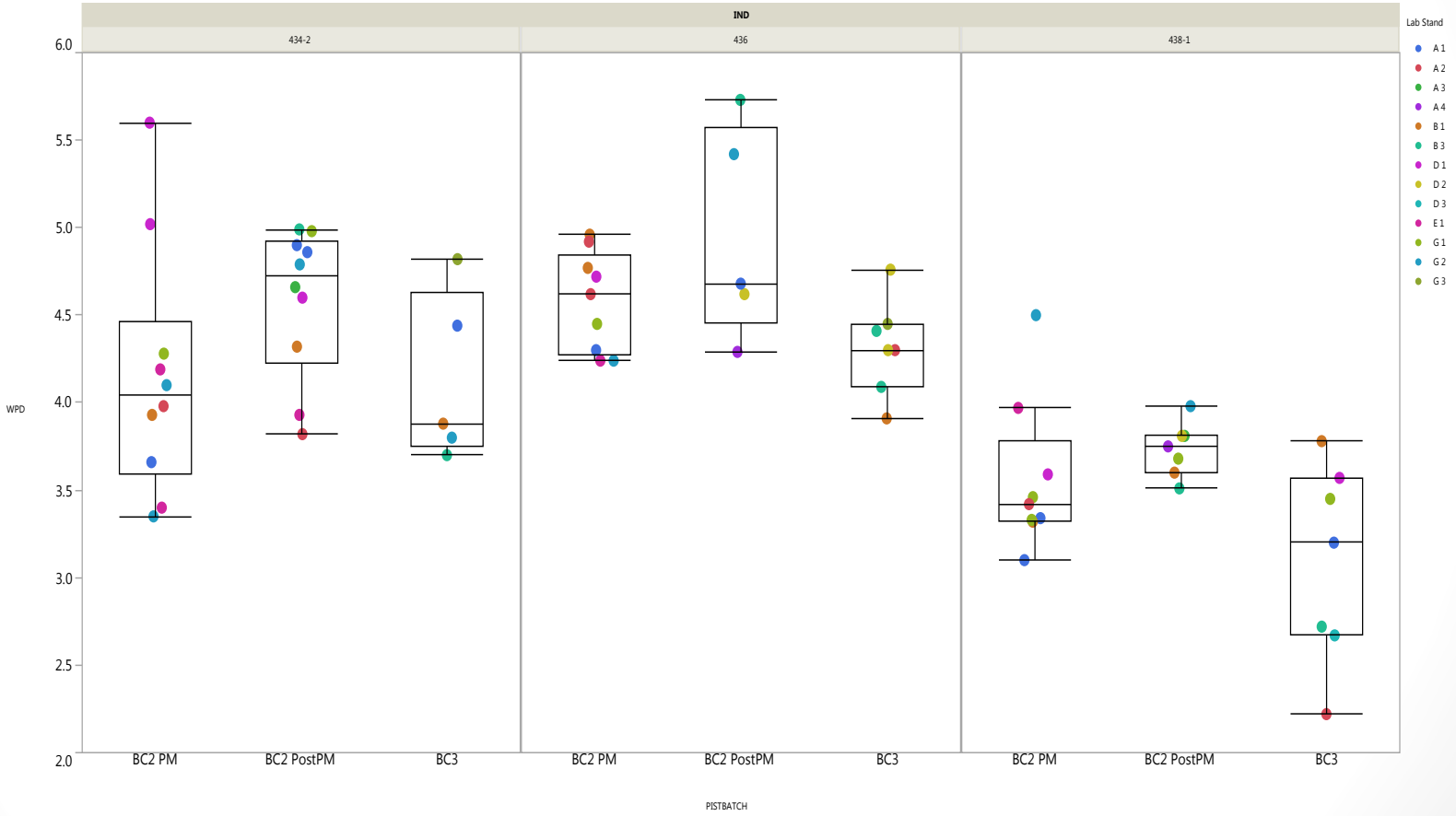
BC3 not significantly different than BC2 PM (Target Setting)



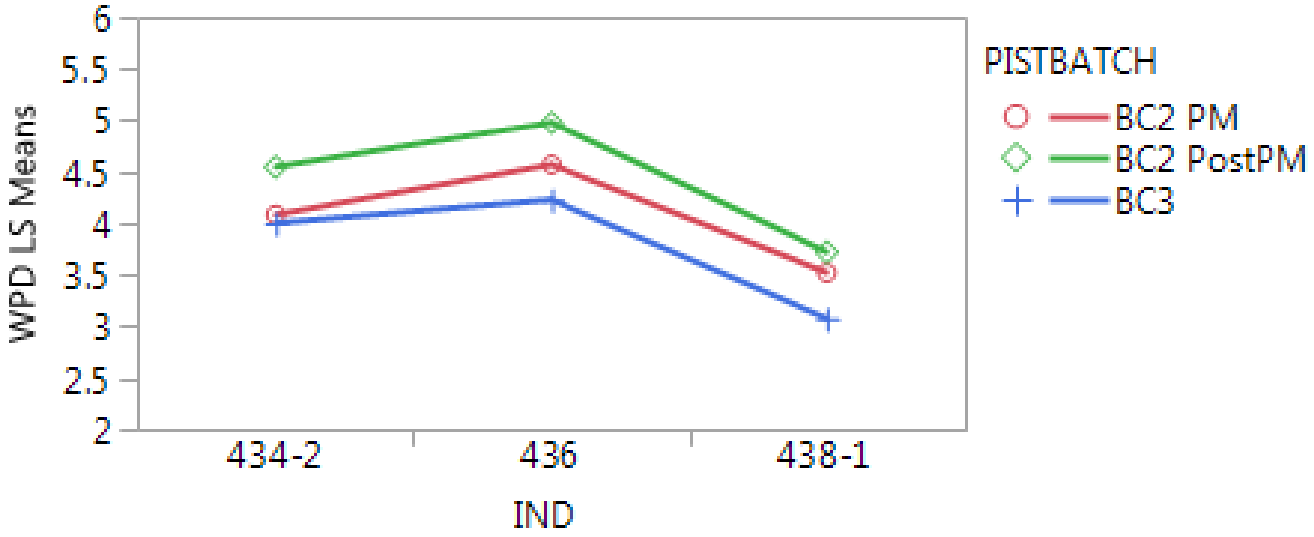
Pistbatch1	Pistbatch2	WPD Difference	p-Value
BC2 PostPM	BC3	0.66	0.00
BC2 PostPM	BC2 PM	0.36	0.05
BC2 PM	BC3	0.30	0.15

Mild

WPD by Oil and Piston Batch



WPD Oil Discrimination



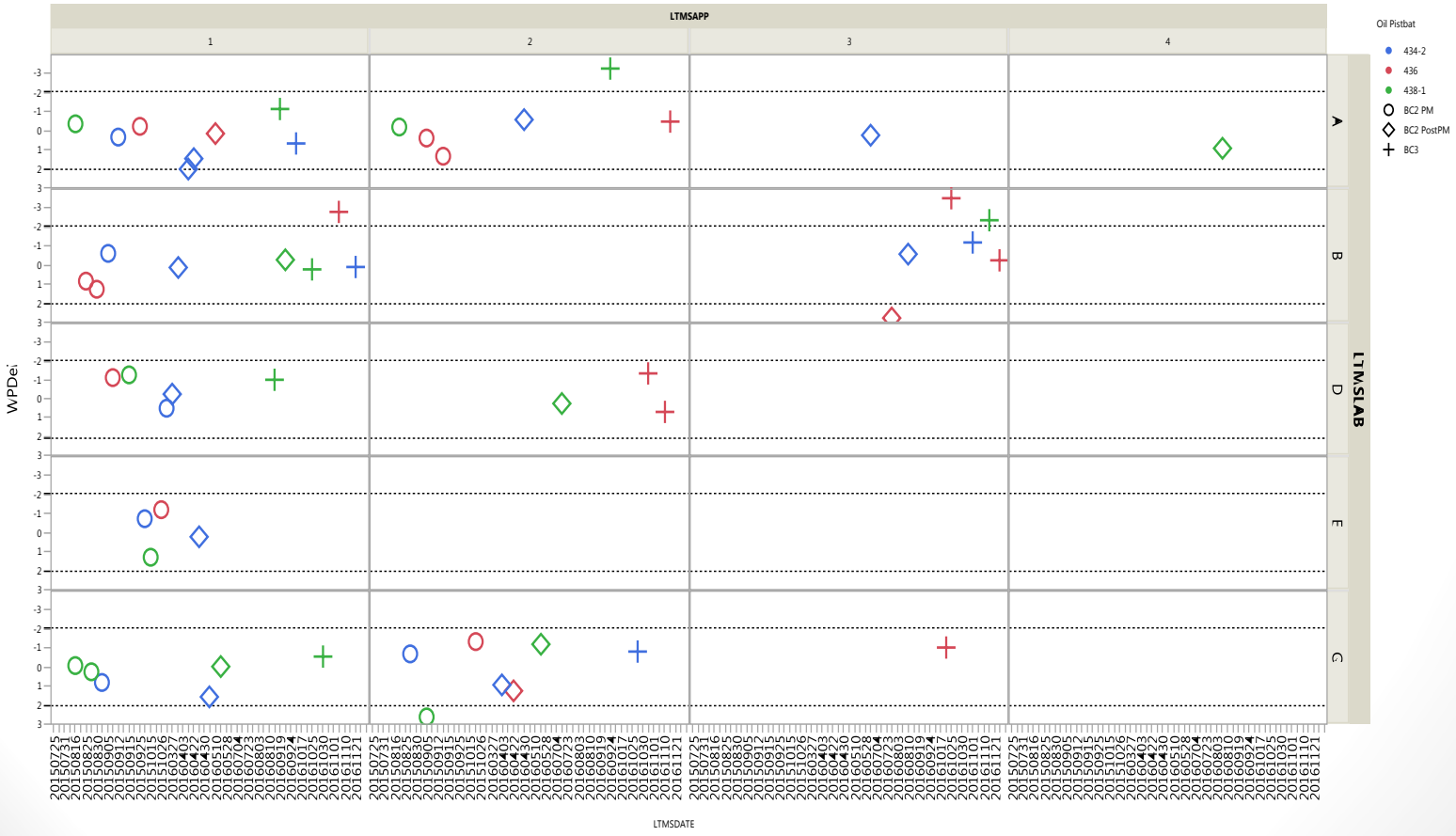
Level				Least Sq Mean
BC2 PostPM,436	A			4.98
BC2 PM,436	A			4.57
BC2 PostPM,434-2	A			4.55
BC3,436	A	B		4.23
BC2 PM,434-2	A	B		4.08
BC3,434-2	A	B	C	4.00
BC2 PostPM,438-1		B	C	3.72
BC2 PM,438-1		B	C	3.52
BC3,438-1			C	3.08

Levels not connected by same letter are significantly different.

BC2PM	434-2
438-1 < 436	No batch differences
BC2PostPM	436
438-1 < 436	No batch differences
BC3	438-1
438-1 < 436	No batch differences

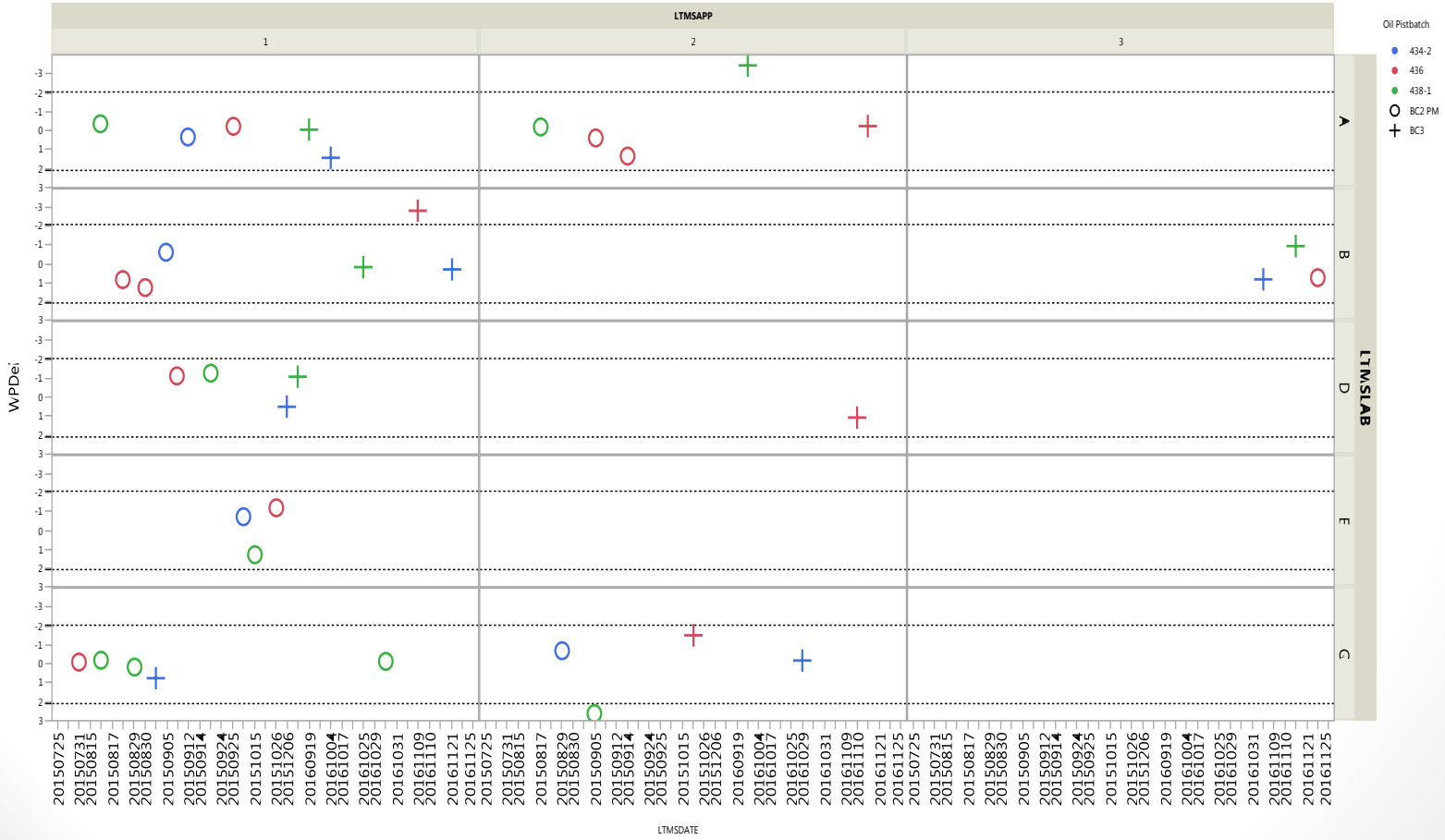
WPDei

- 4 out of 9 stands triggered ei alarm with Batch 3 Piston
- 4 out of 4 ei alarms went back to normal after 2nd test
- 1 out of 2 ei alarms triggered at 2nd run with Batch 3 Piston



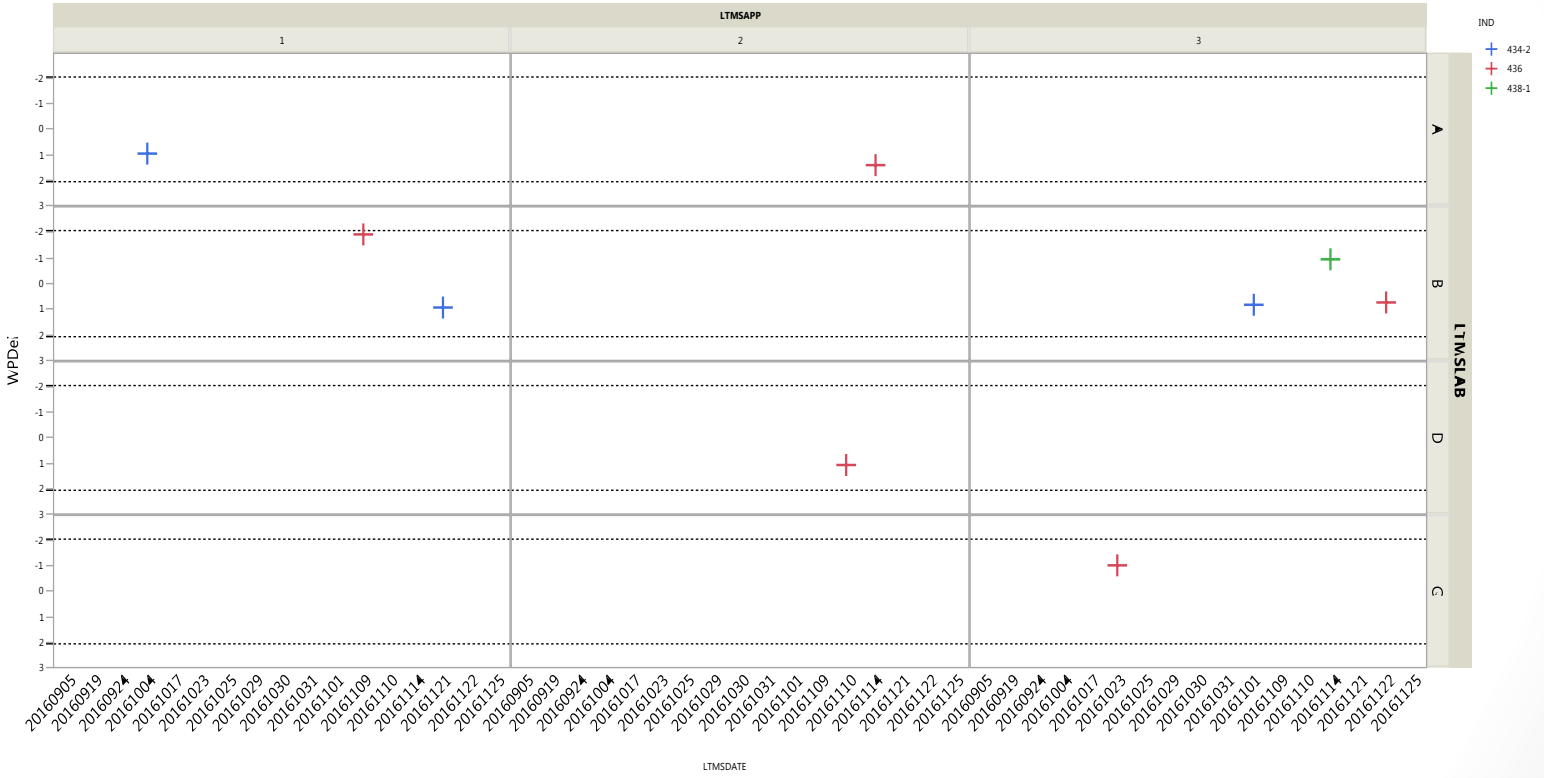
WPDei (Removing Batch 2)

- 2 out of 9 stands triggered ei alarm with Batch 3 Piston
- 2 out of 2 ei alarms went back to normal after 2nd test
- 1 out of 2 ei alarms triggered at 2nd run with Batch 3 Piston



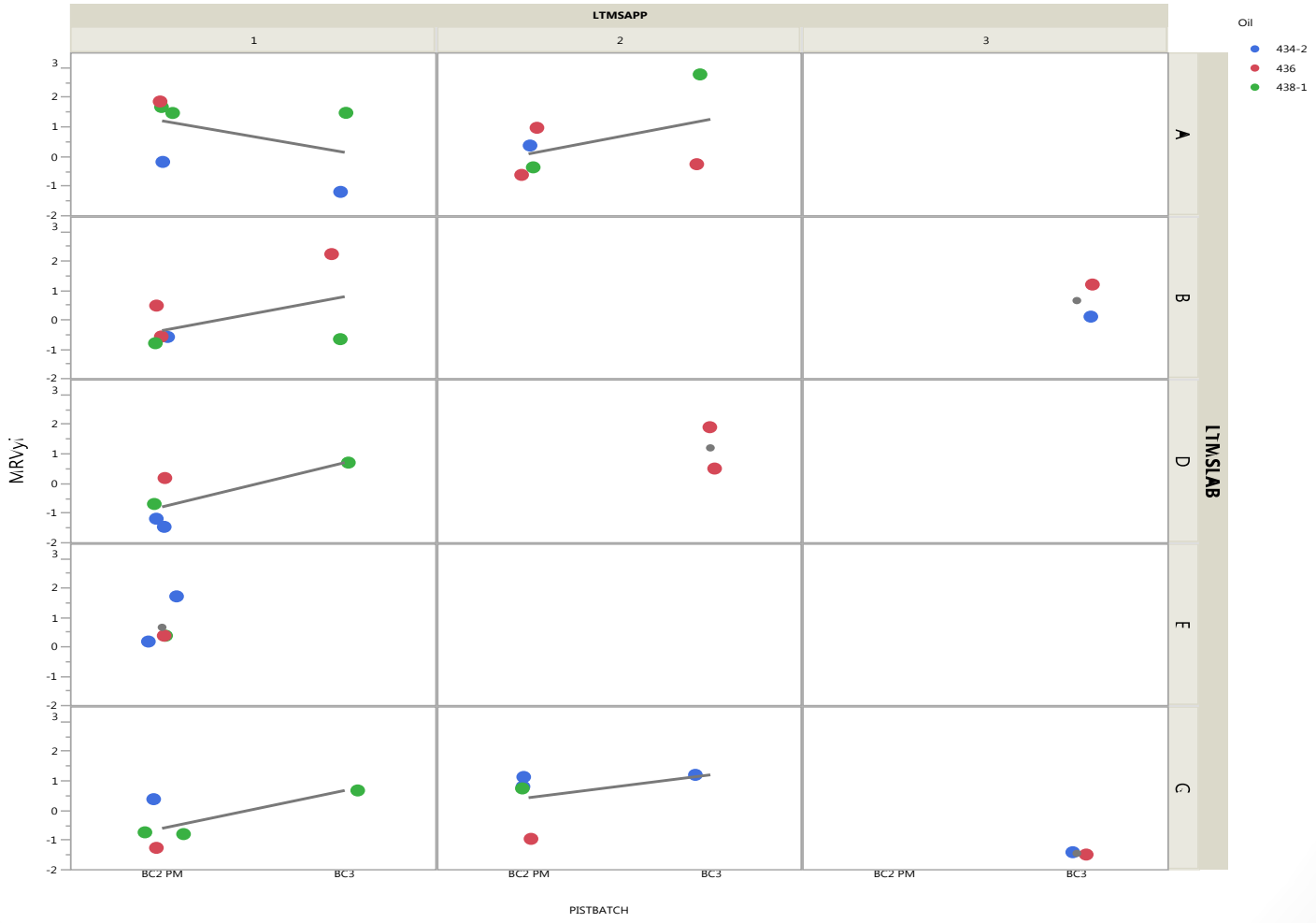
WPDei (Resetting to Batch 3)

- 1 out of 6 stands triggered ei alarm with Batch 3 Piston



MRVyi
(Batch 3 vs Target Batch 2)

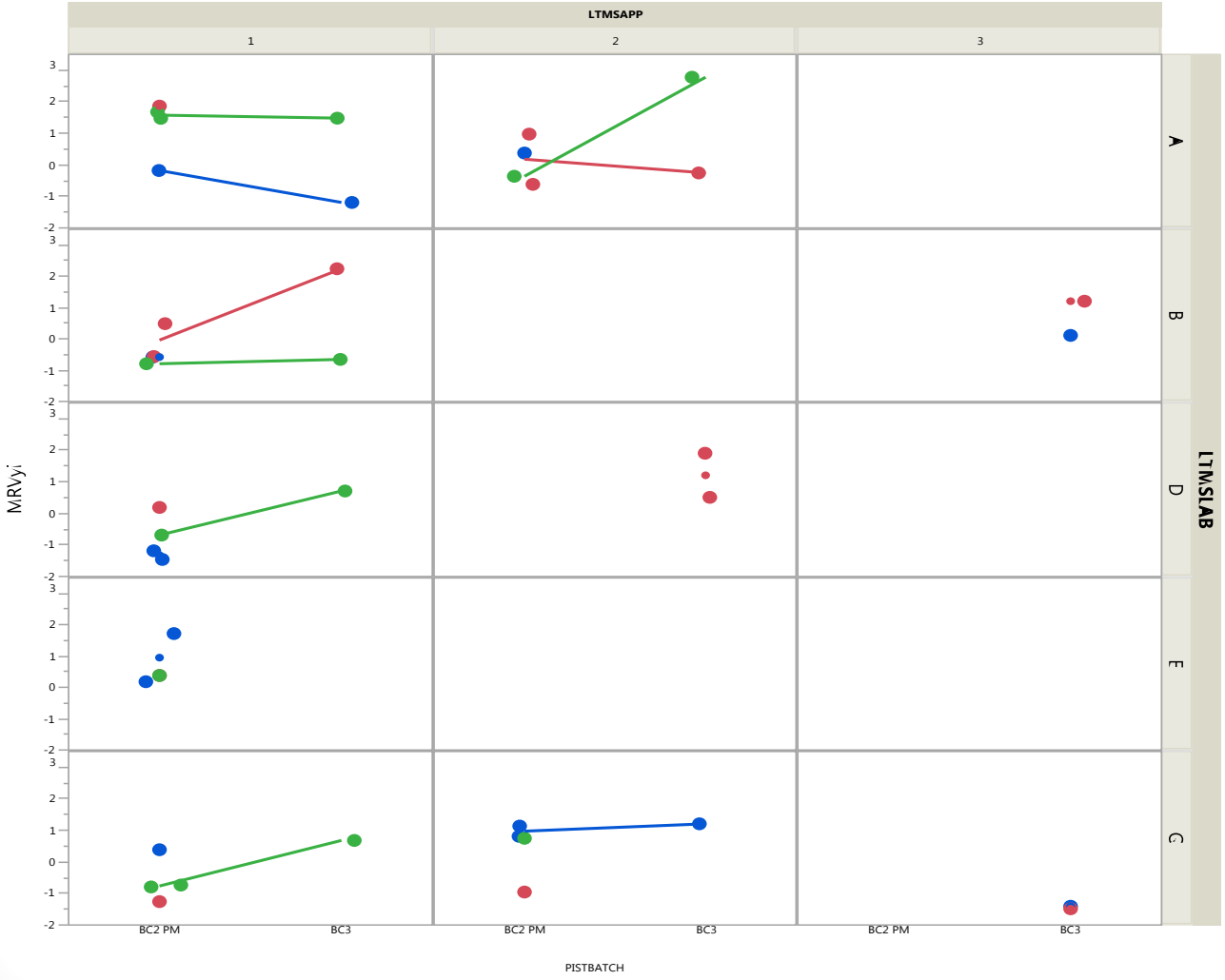
Severe



Mild

MRVyi by Oil
(Batch 3 vs Target Batch 2)

Severe

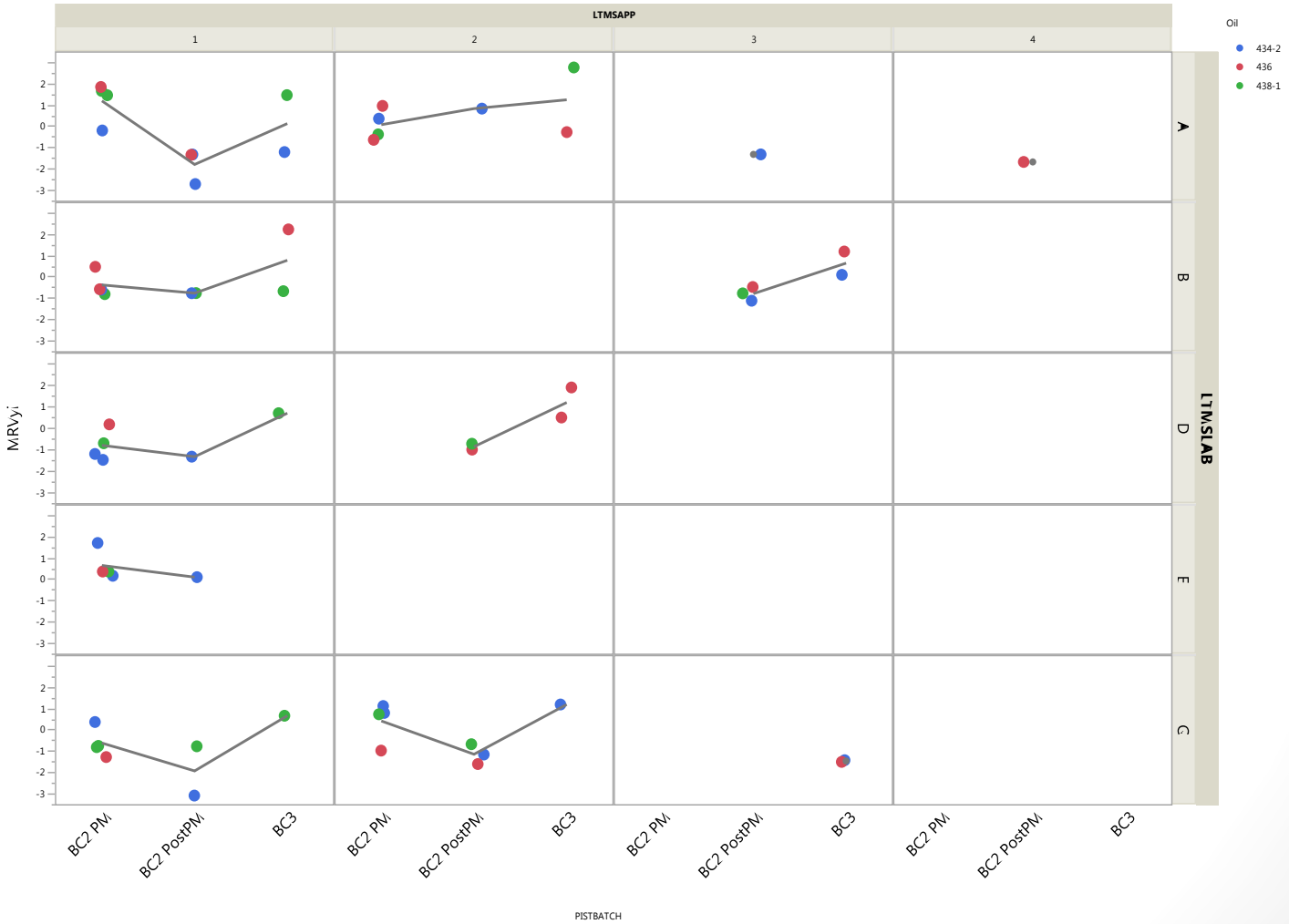


438-1 A2, D1, G2:
BC2PM < BC3

Mild

MRVyi
(Batch 3 vs All Batch 2)

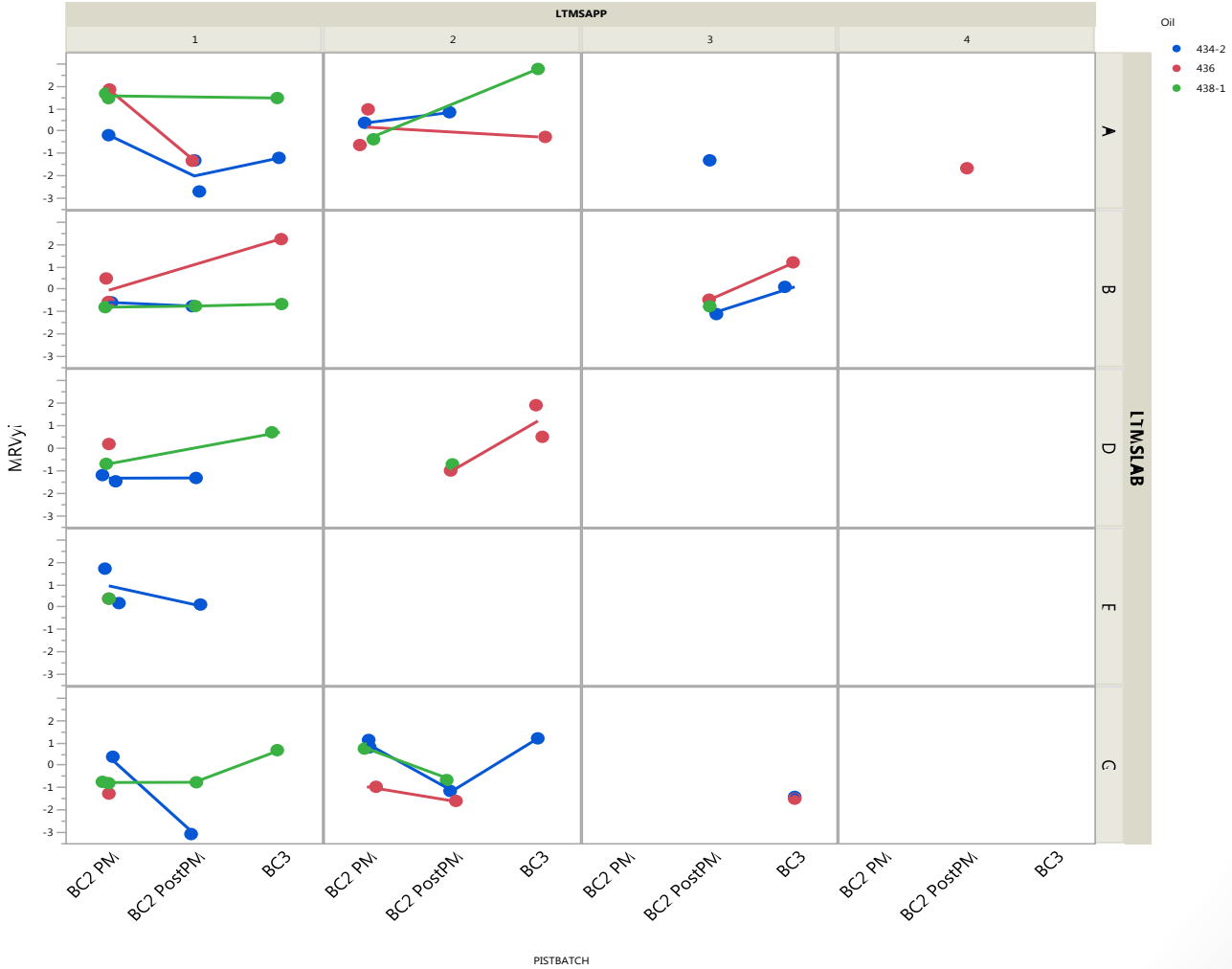
Severe



Mild

MRVyi by Oil
(Batch 3 vs All Batch 2)

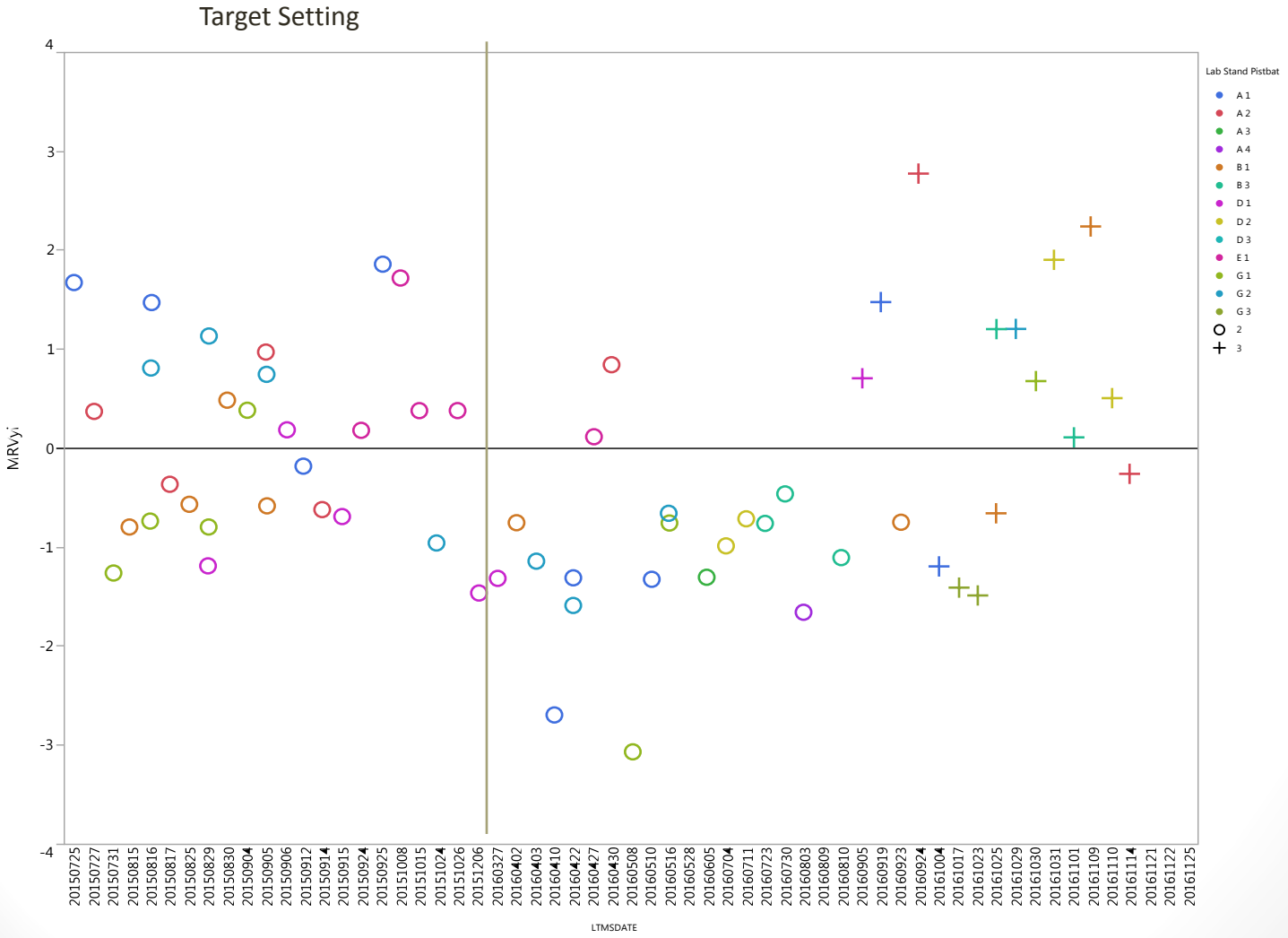
Severe



Mild

MRVyi

Severe

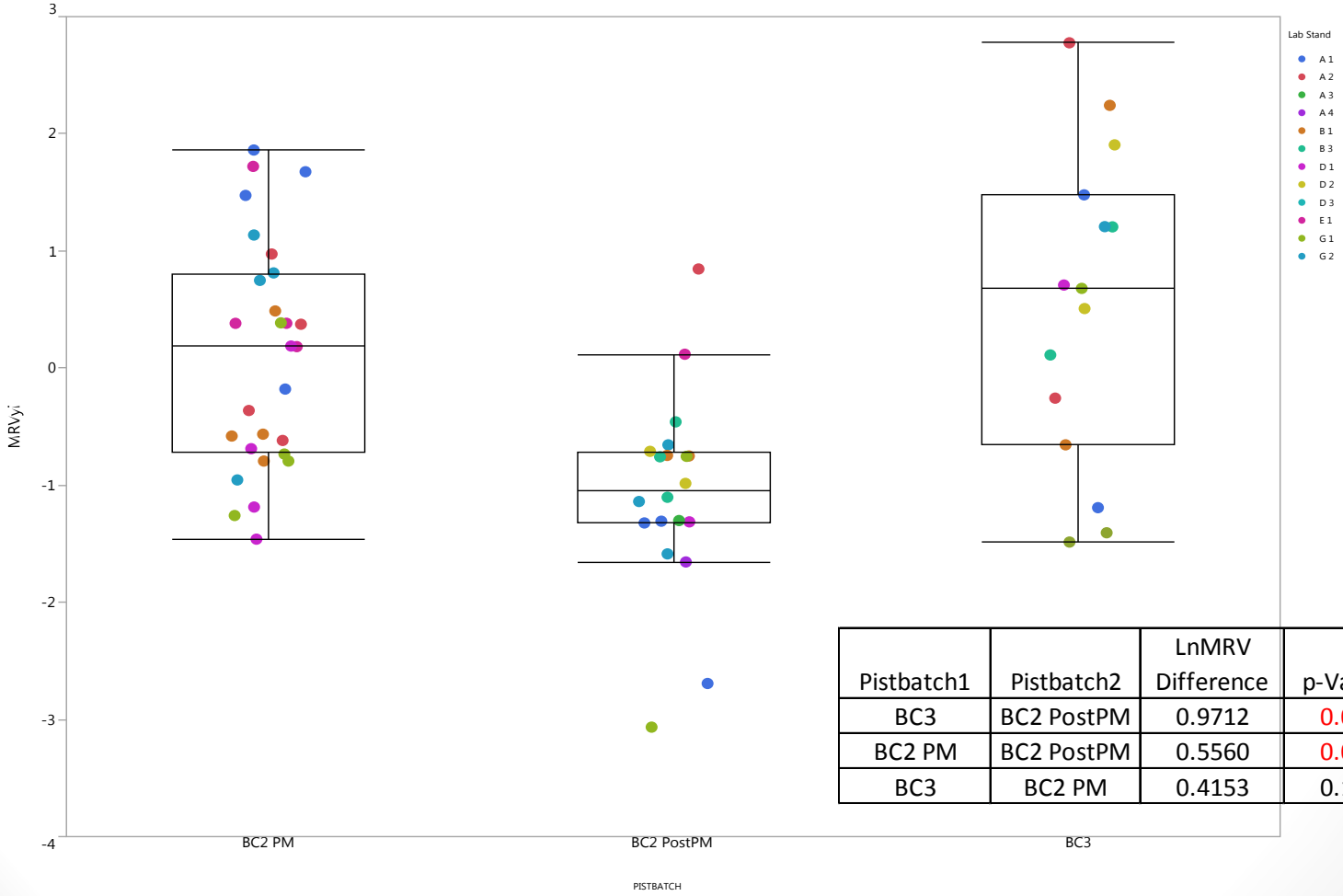


Mild

MRVyi by Piston Batch

BC3 not significantly different than BC2 PM (Target setting)

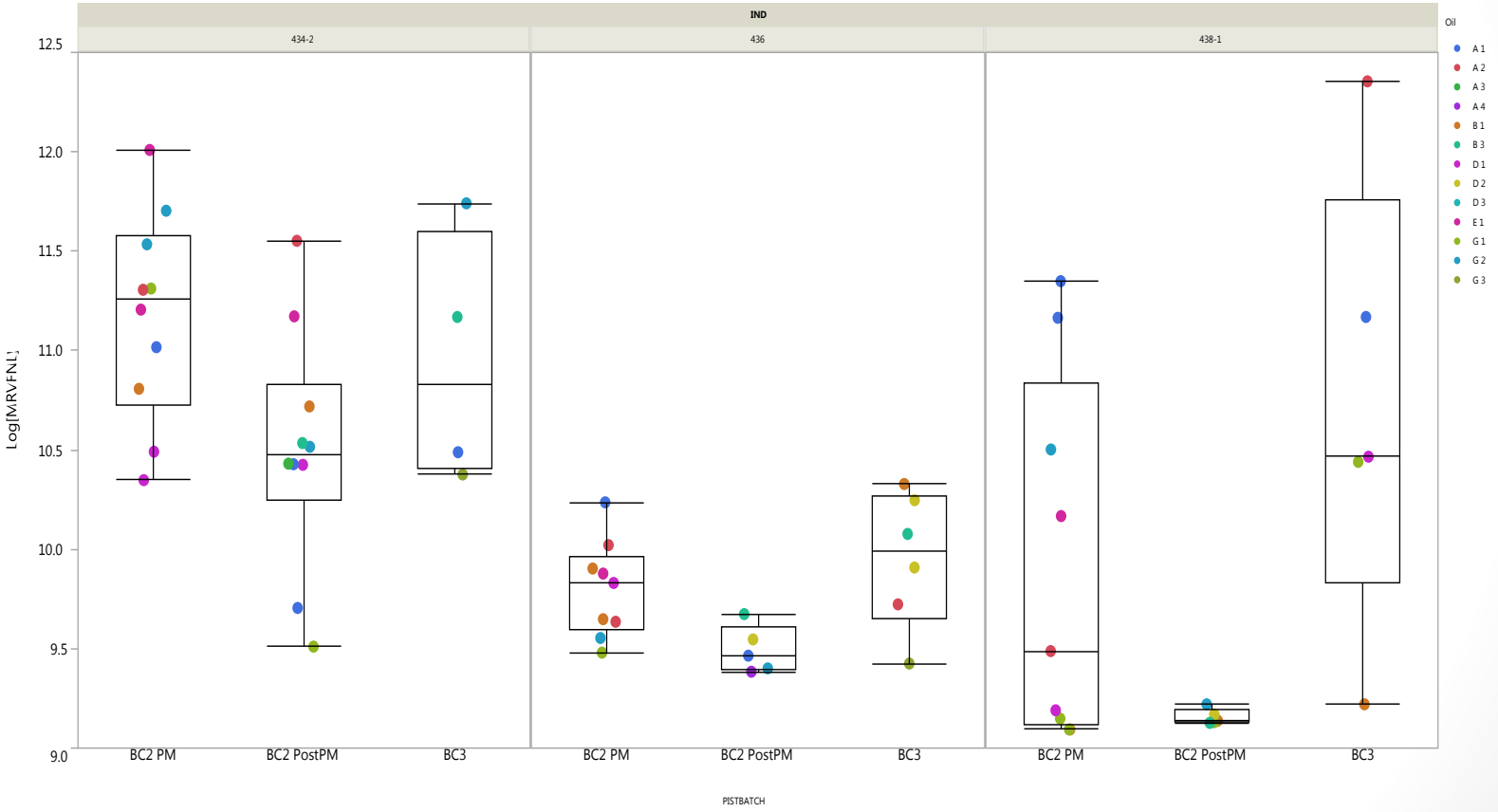
Severe



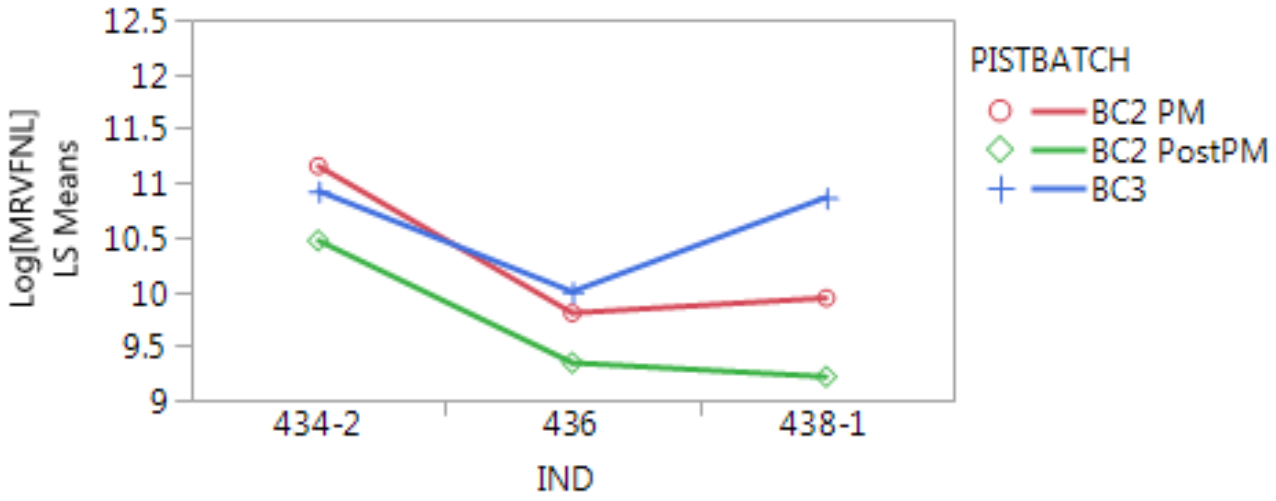
Pistbatch1	Pistbatch2	LnMRV Difference	p-Value
BC3	BC2 PostPM	0.9712	0.00
BC2 PM	BC2 PostPM	0.5560	0.02
BC3	BC2 PM	0.4153	0.14

Mild

MRV by Oil and Piston Batch



MRV Oil Discrimination



Level						Least Sq Mean
BC2 PM,434-2	A					11.1536
BC3,434-2	A	B	C			10.9255
BC3,438-1	A	B				10.8645
BC2 PostPM,434-2	A	B	C	D		10.4687
BC3,436		B	C	D	E	9.9984
BC2 PM,438-1		B	C	D	E	9.9384
BC2 PM,436			C	D	E	9.8011
BC2 PostPM,436				D	E	9.3434
BC2 PostPM,438-1					E	9.2143

Levels not connected by same letter are significantly different.

BC2PM

434-2 > 438-1, 436

BC2PostPM

434-2 > 438-1

BC3

No discrimination

434-2

No batch differences

436

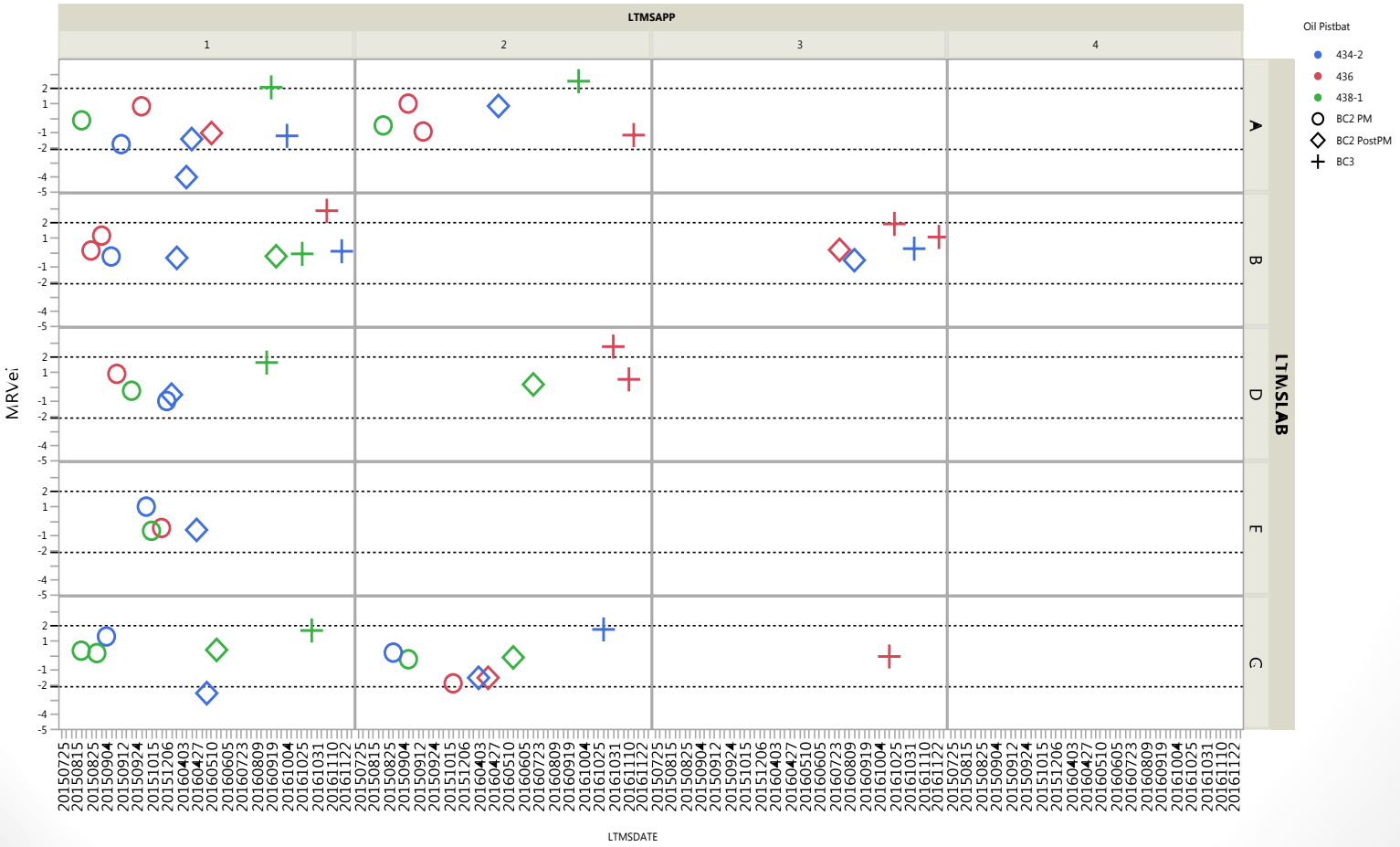
No batch differences

438-1

BC3 > BC2PostPM

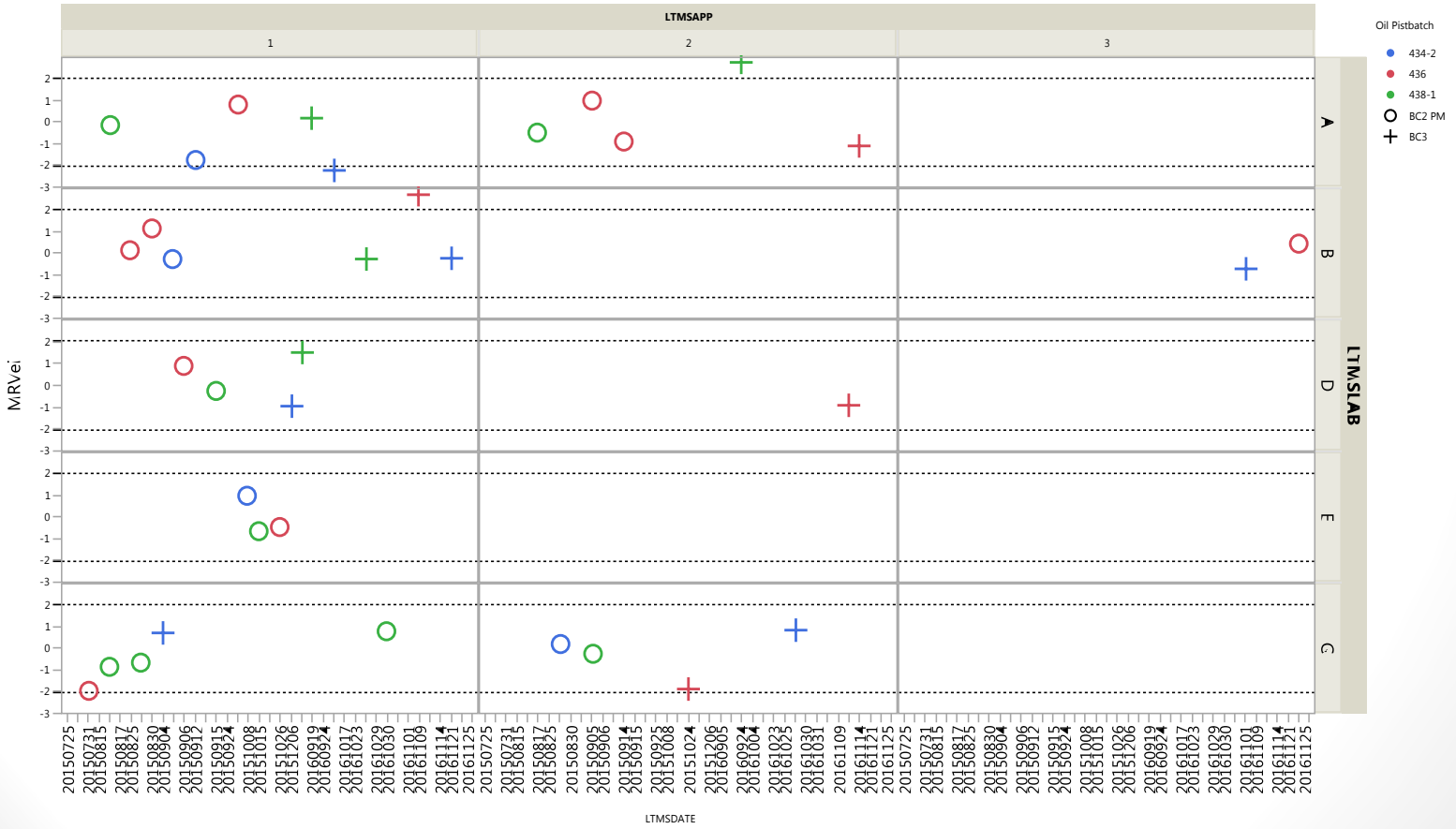
MRVei

- 6 out of 9 stands triggered ei alarm with Batch 3 Piston
- 5 out of 7 ei alarms went back to normal after 2nd test
- 1 out of 7 ei alarm triggered at 2nd run with Batch 3 Piston



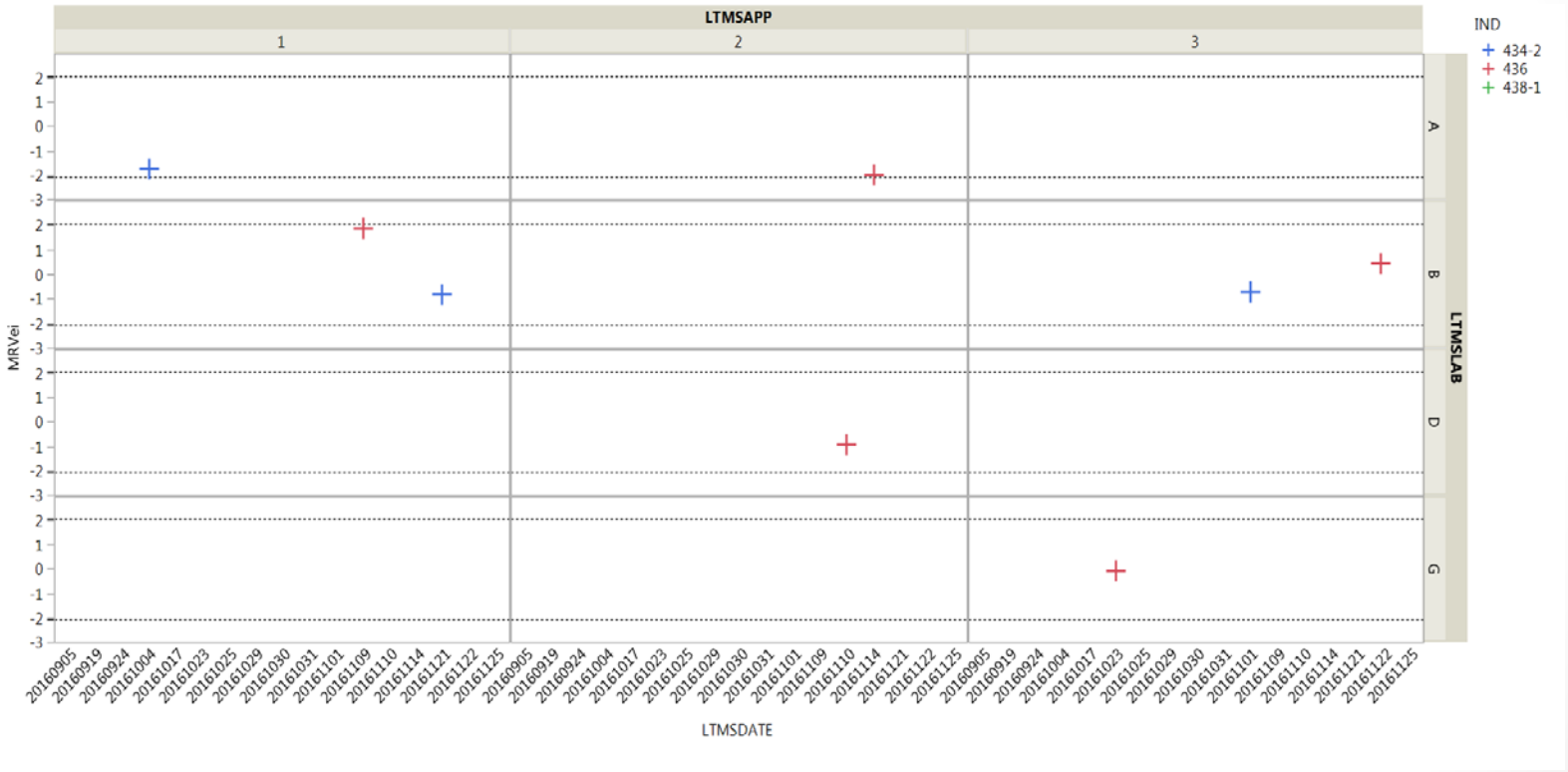
MRVei (Removing Batch 2)

- 3 out of 9 stands triggered ei alarm with Batch 3 Piston
- 2 out of 3 ei alarm triggered at 2nd run with Batch 3 Piston
- 2 out of 3 ei alarm triggered at 2nd run with Batch 3 Piston



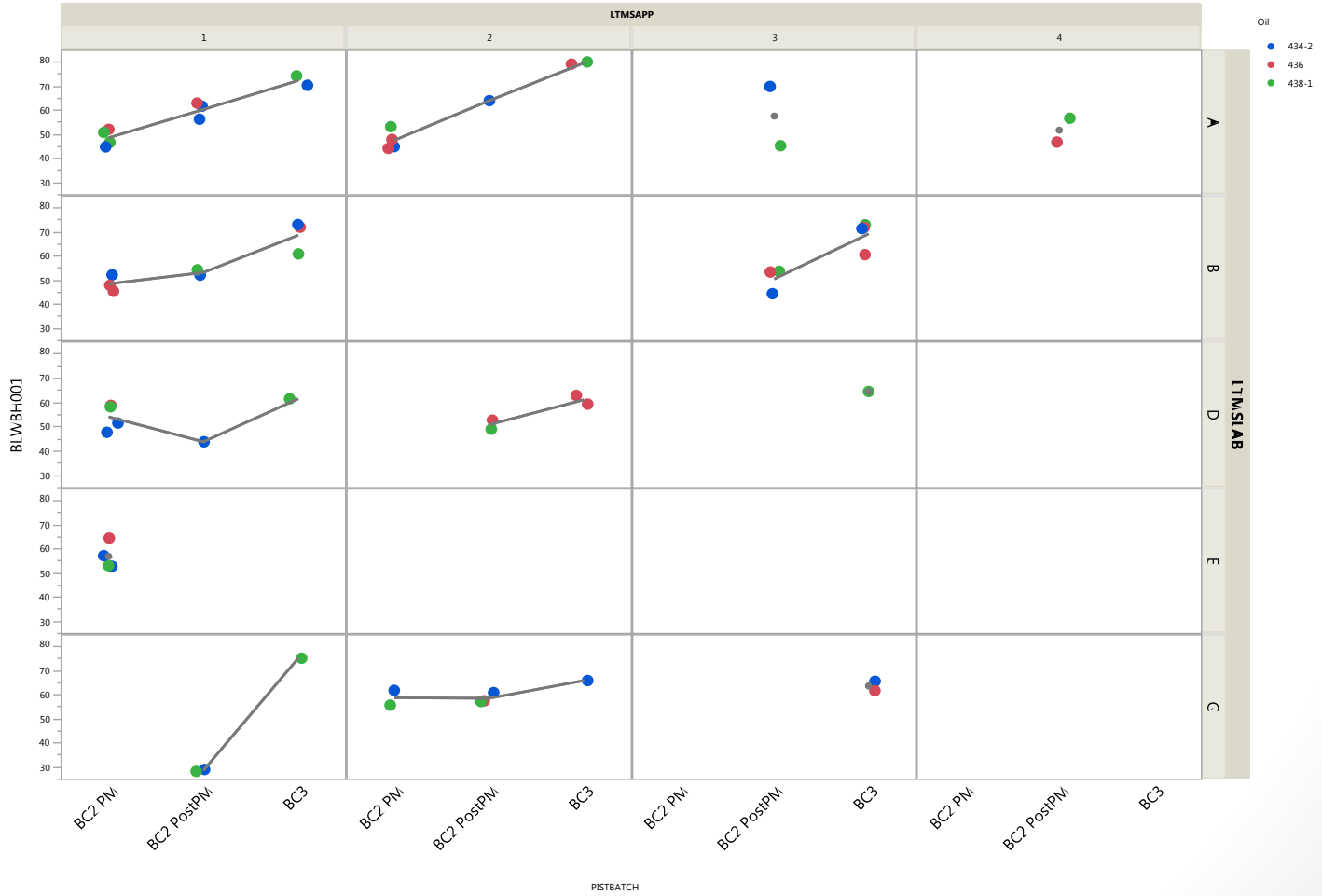
MRVei (Resetting to Batch 3)

- 3 out of 6 stands triggered ei alarm with Batch 3 Piston



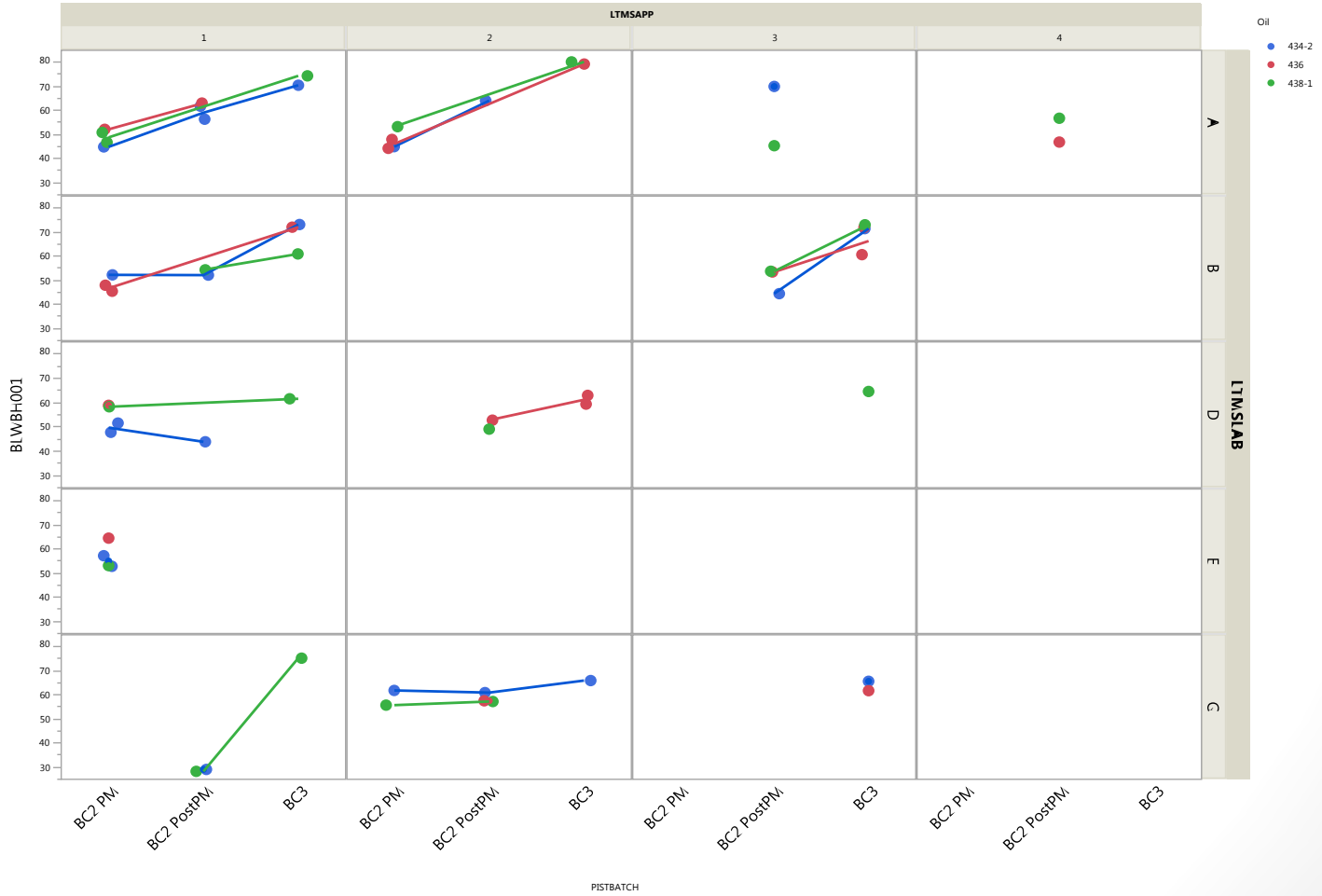
BLWBH001

- BC3 is significantly higher than BC2 PM
- Blowby correlates with WPD



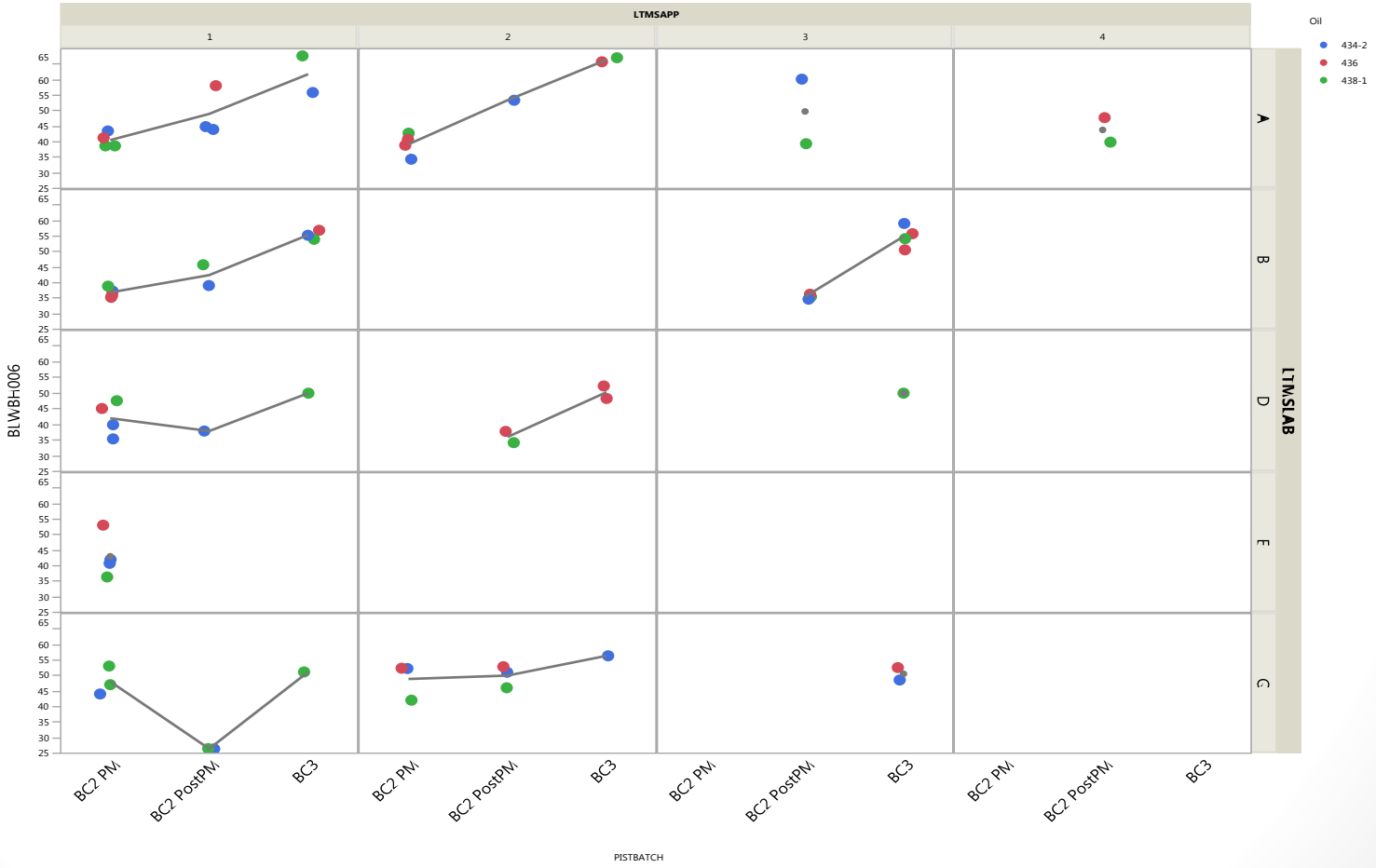
BLWBH001 by Oil

- BC3 is significantly higher than BC2 PM
- Blowby correlates with WPD



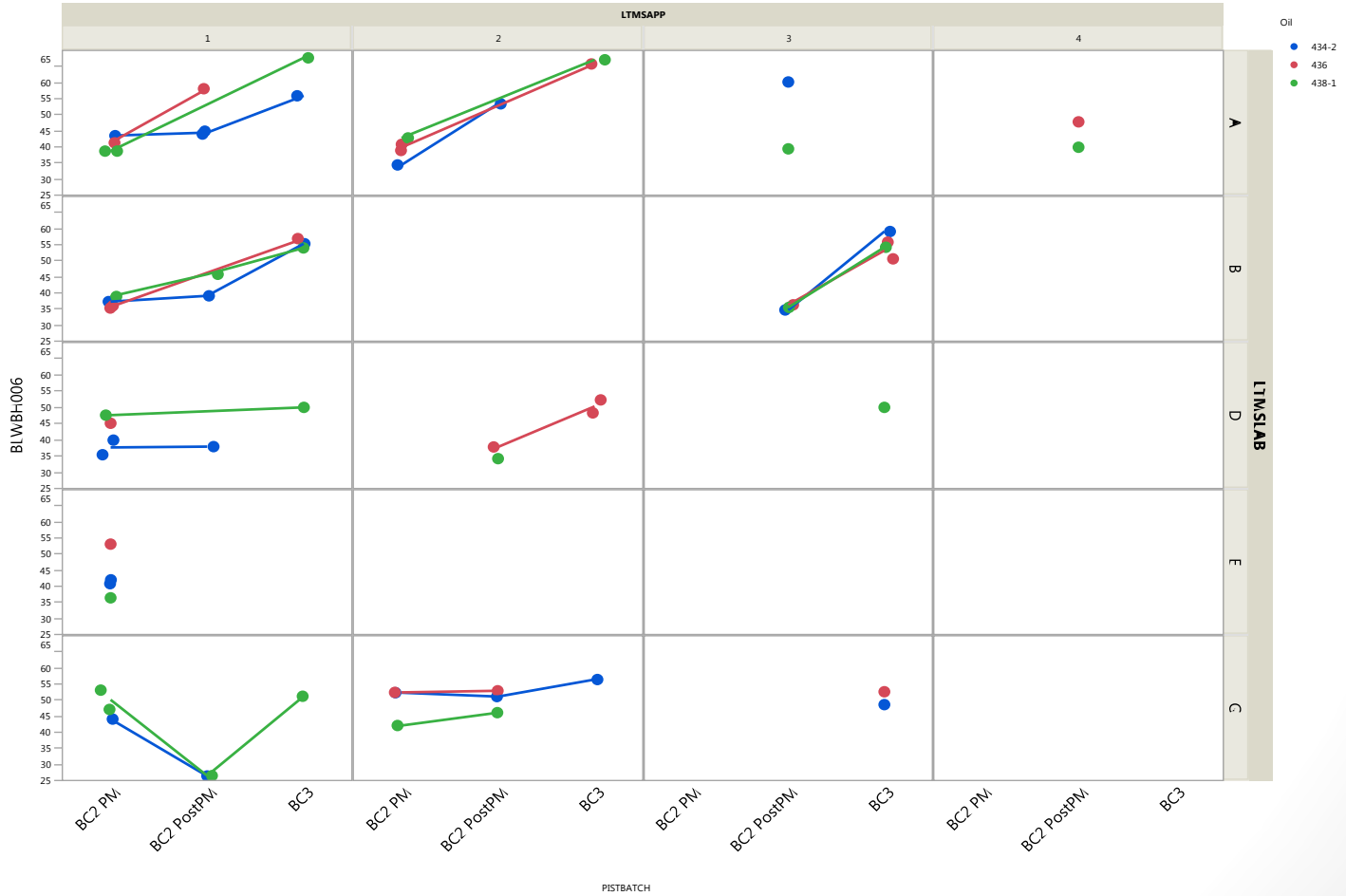
BLWBH006

- BC3 is significantly higher than BC2 PM
- Blowby significantly affects WPD



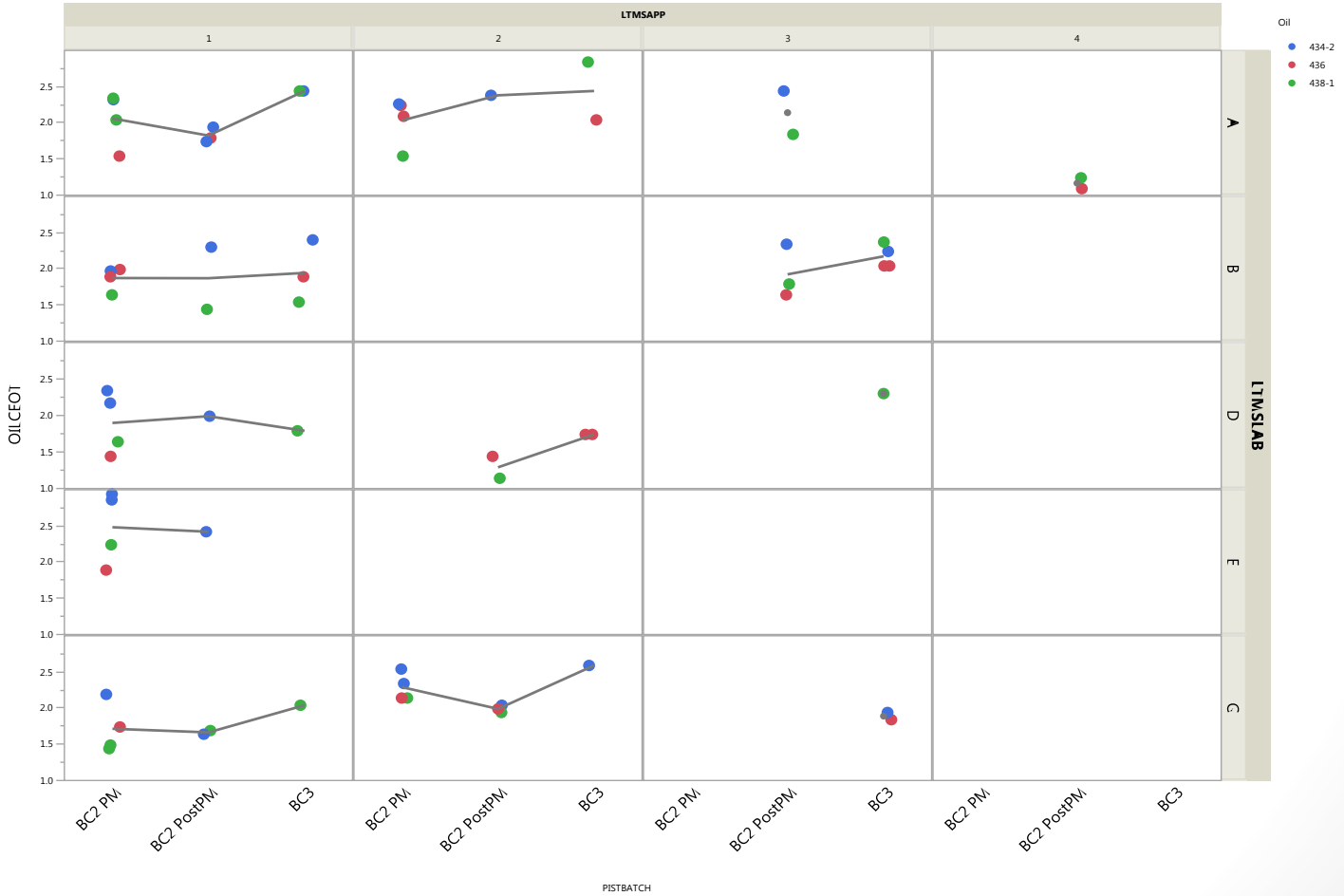
BLWBH006 by Oil

- BC3 is significantly higher than BC2 PM
- Blowby significantly affects WPD



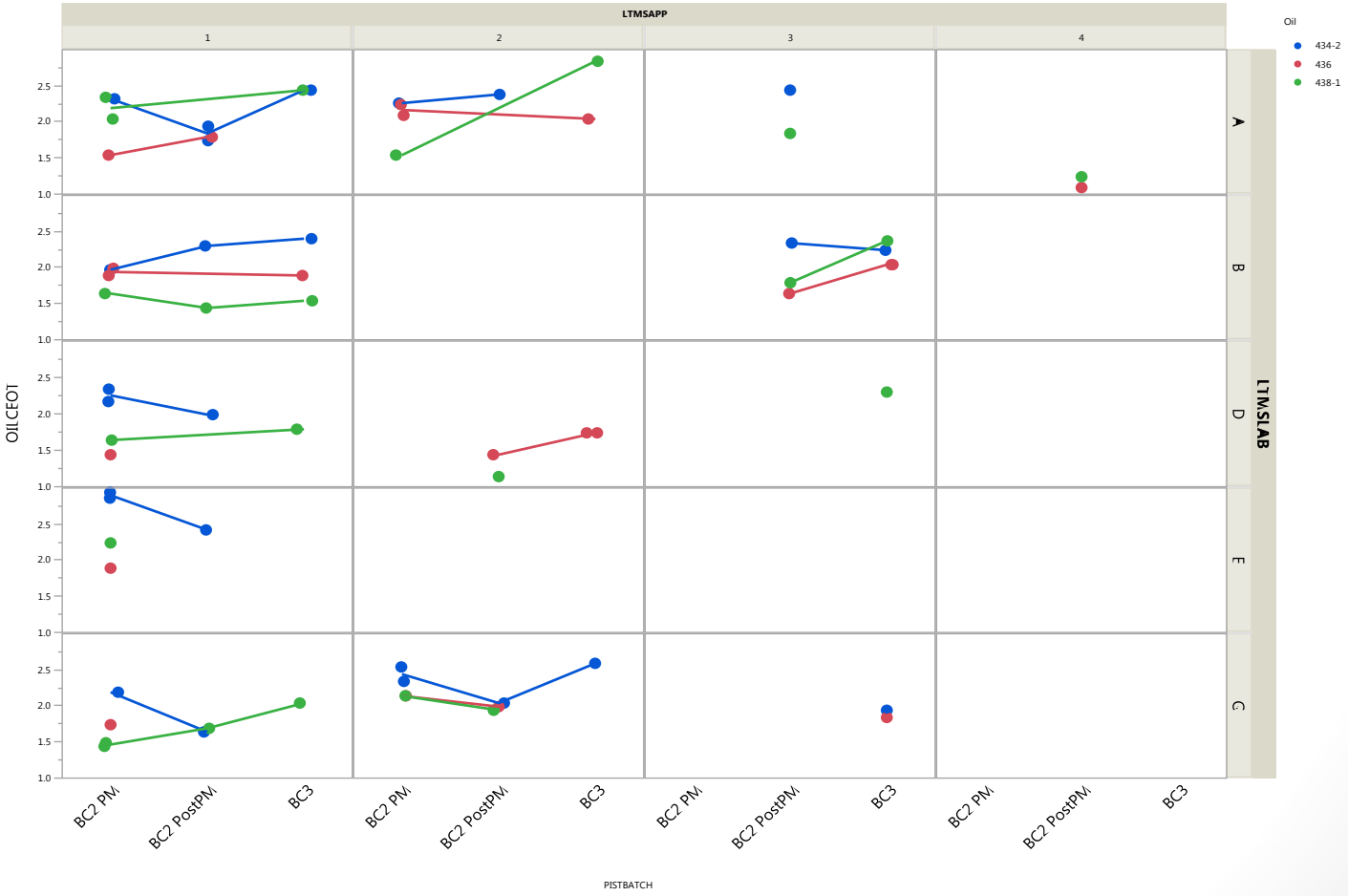
OILCEOT

- BC3 is significantly higher than BC2 PM
- OCEOT correlates with PVIS



OILCEOT by Oil

- BC3 is significantly higher than BC2 PM
- OCEOT correlates with PVIS



Option 1:
Do nothing. Current LTMS is working.

Average Yi after applying severity adjustment is worse than the average Yi of BC3

	Average Yi						Average Yi for Comparison with Severity Adjusted Yi					
All Oils	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n
	14	BC2 PM	0.0617	0.04	-0.004	14	14	BC2 PM	-0.167	0.38	-0.3434	14
	14	BC2 PostPM	-1.3792	0.64	-1.1052	14	14	BC2 PostPM	-1.396	0.26	-0.9732	14
	16	BC3	0.7316	-0.91	0.9147	12	16	BC3	1.0634	-1.09	1.454	12
	44	All	0.9575	-0.97	-0.1138	40	44	All	-0.111	-0.19	-0.0246	40
434-2	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n
	4	BC2 PM	-0.3426	0.09	-0.4588	4	4	BC2 PM	-0.2505	0.2	-0.4161	4
	9	BC2 PostPM	-1.6350	0.6	-1.1565	9	9	BC2 PostPM	-1.7738	0.56	-1.1683	9
	4	BC3	0.2360	-0.29	0.0423	3	4	BC3	0.1895	-0.31	0.2665	3
436	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n
	6	BC2 PM	0.3920	-0.3	0.3552	6	6	BC2 PM	-0.1598	0.26	-0.4134	6
	2	BC2 PostPM	-1.3214	1.5	-1.4545	2	2	BC2 PostPM	-1.2798	0.16	-1.045	2
	6	BC3	1.285	-1.21	1.4653	4	6	BC3	1.3849	-1.34	2.5364	4
438-1	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n	PVIS WPD n	Piston Batch	PVISyi	WPDyi	MRVyi	MRV n
	4	BC2 PM	-0.0295	0.51	-0.0881	4	4	BC2 PM	-0.0941	0.74	-0.1657	4
	3	BC2 PostPM	-0.6502	0.22	-0.7184	3	3	BC2 PostPM	-0.3400	-0.57	-0.3400	3
	6	BC3	1.1110	-1.17	0.9977	5	6	BC3	1.3245	-1.37	1.3004	5

Option 2:
Apply Constant ICF for BC3

- Average Yi after applying constant factor is close to Target across oils
- 434-2 after correction is farther from Target

BC3 Average Yi							BC3 After Correction				
Oil	PVIS WPD n	PVISyi	WPDyi	MRVyi	MRV n		PVIS WPD n	PVISyi	WPDyi	MRVyi	MRV n
All	19	0.7316	-0.92	0.5299	17		19	-0.0052	0.18	-0.1173	17
	ICF	**0.3395**	**-0.43**	**0.2504**							
Oil	PVIS WPD n	PVISyi	WPDyi	MRVyi	MRV n		PVIS WPD n	PVISyi	WPDyi	MRVyi	MRV n
434-2	5	-0.1500	-0.05	-0.2325	5		5	-0.9377	0.57	-0.7121	5
436	7	0.8622	-1.13	0.7404	7		7	-0.2197	0.40	-0.2930	6
438-1	7	1.2307	-1.33	0.9977	5		7	0.8755	-0.33	0.7234	5

Option 3:
Apply Fast Start (Reset LTMS to BC3)

Average Zi after applying fast start is close to average Yi of BC3

BC3 Average Yi

Oil	PVIS WPD n	PVISyi	WPDyi	MRVyi	MRV n
All	15	0.6021	-0.93	0.4581	14

BC3 Average Zi

PVIS WPD n	PVISZi	WPDZi	MRVzi	MRV n
15	0.6148	-0.98	0.5160	14

Oil	PVIS WPD n	PVISyi	WPDyi	MRVyi	MRV n
434-2	4	-0.5367	0.07	-0.5924	4
436	7	0.8622	-1.13	0.7404	7
438-1	4	1.2856	-1.58	1.1999	3

PVIS WPD n	PVISZi	WPDZi	MRVzi	MRV n
4	0.0242	-0.54	-0.0299	4
7	0.7918	-1.01	0.6752	7
4	0.8955	-1.36	0.8725	3

Note: There are only 6 stands with at least 2 BC3 runs

Concern and Recommendation

- Applying correction factors or severity adjustments cannot overcome the PVIS ranking reversal of 434-2 and 438-1.
- None of the mathematical options are recommended at this time.
- Recommend further investigation of the root cause at this time.

ATTACHMENT 6

IIIH data on Lubrizol internal reference oil

Shift between BC2 & 3 pistons

1/25/2017

Lubrizol

background

SUCCESS TOGETHER

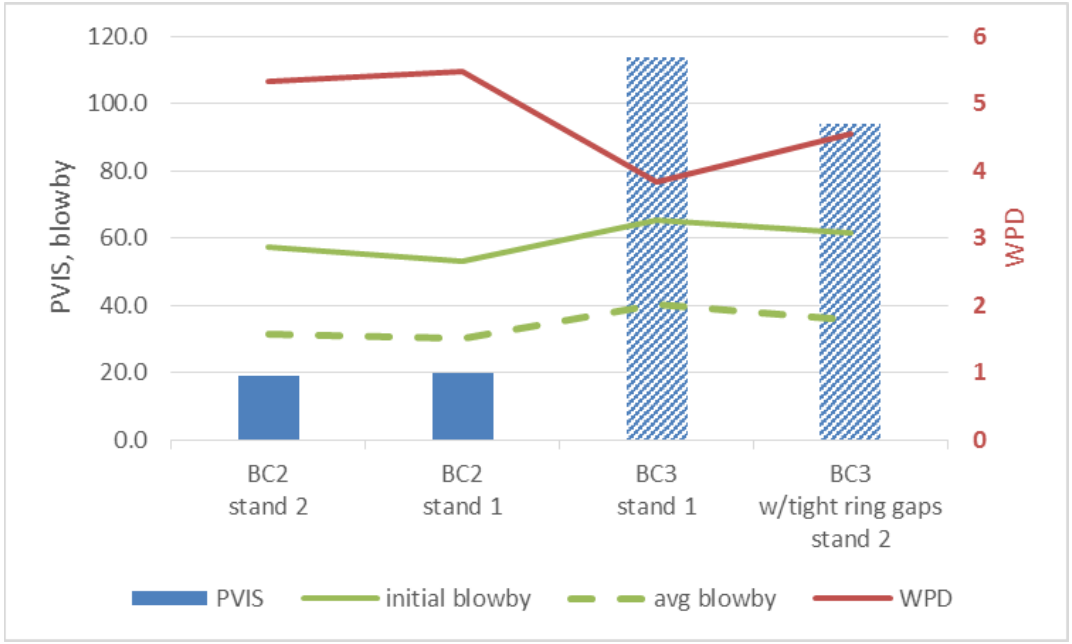
- Internal “reference” oil
- Run internally, and externally
- 10+ runs to date
- Nominal WPD of 5.0
- Nominal PVIS of 33%

Lubrizol

Severity shift between BC2 and BC3

SUCCESS TOGETHER

- Significant shift in performance
- Delta of ~90% PVIS
- Delta of ~1.5 merit in WPD
- Slight improvement when tightening ring gap (by 0.005”)



EOT	stand	PVIS	WPD	OC
7/12/16	stand 2	19	5.3	1.6
7/18/16	stand 1	20	5.5	1.6
12/18/16	stand 1	114	3.8	2.0
1/10/17	stand 2	94	4.5	1.9

* No SAs

Lubrizol

Take away messages

SUCCESS TOGETHER

- Oils respond differently to this severity change
- Higher performing oils (vs ref) may not be adequately severity adjusted

Lubrizol

IIIH DATA REVIEW WITH BC3 PISTONS

ATTACHMENT 7

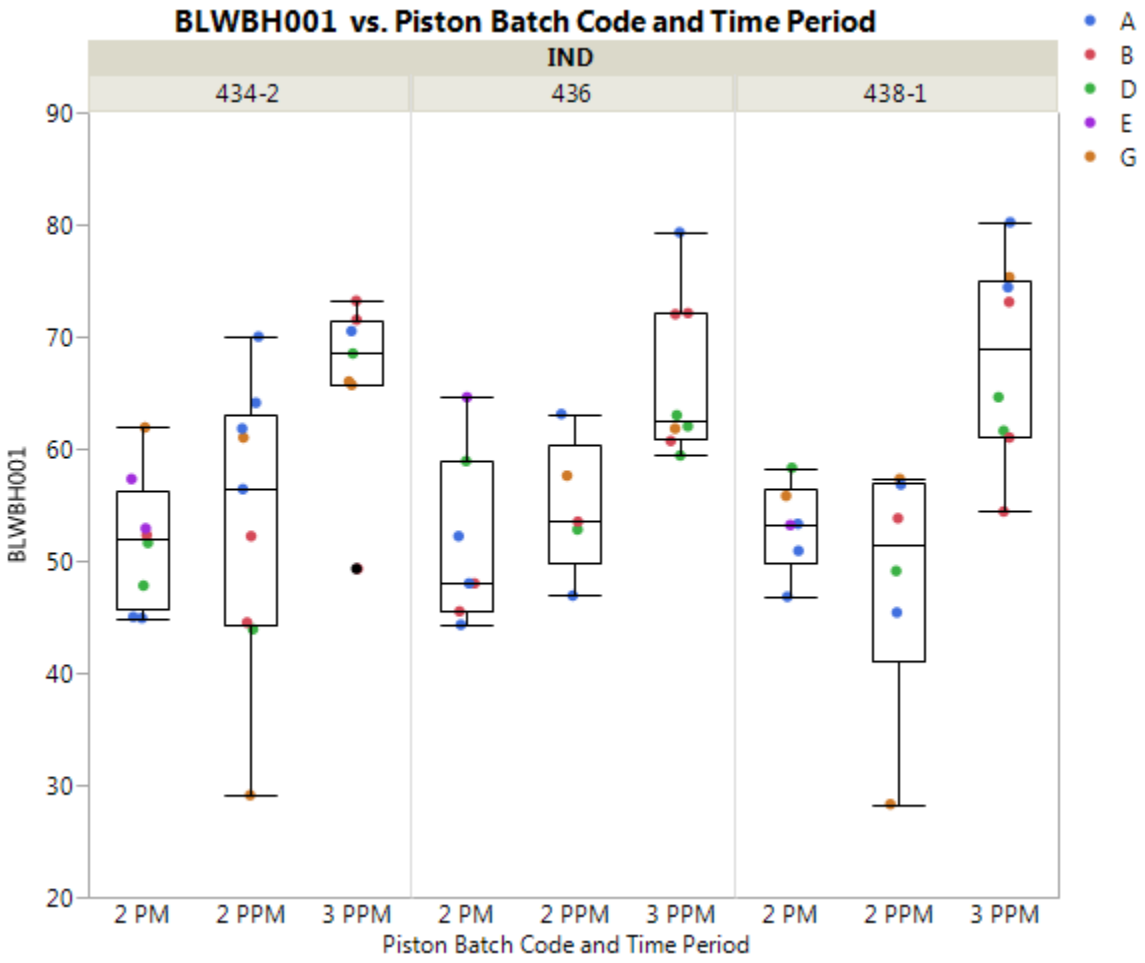
January 11th 2017

Performance you can rely on.

IIIH Reference Data with BC3 Pistons

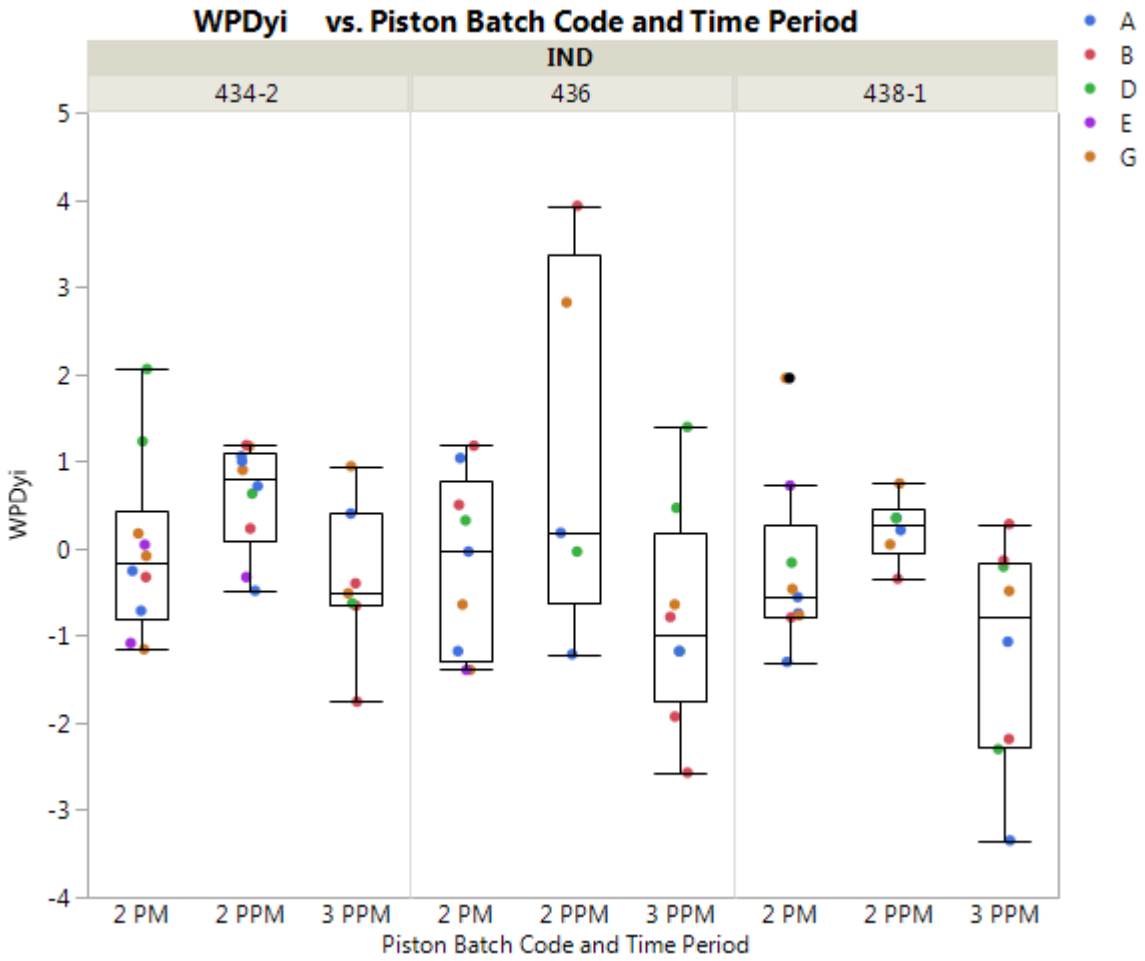
- Reference data can be divided into 3 distinct groups:
  - The PM data using Batch 2 pistons.
  - Post matrix data using Batch 2 pistons but after each of the labs made small changes to become more uniform. These changes were supposedly not to change the severity of the test but the results (WPD and PVIS) were obviously shifted mild.
  - Batch 3 pistons. This data is consistently severe of the Post Matrix data with Batch 2 and in some cases severe of the PM data and in other cases equivalent to the PM data.
    - 23 valid reference oil tests using the Batch 3 pistons were available.
- Most of the stands show a severity shift relative to the PM but others do not.
- There appears to be minimal difference between the PM Batch 2 results and the Batch 3 results for 434-2.
- The PVis ranking of RO 434-2 and 438-1 for Piston Batch 3 have reversed relative to the PM data using Batch 2.
  - The Statisticians Group does not recommend mathematical adjustments as practical adjustments will not yield the proper ranking**.**

IIIH Initial (Hour 1) Blow-by by Piston Batch Code (Includes 23 Batch Code 3 Valid Calibration Results)



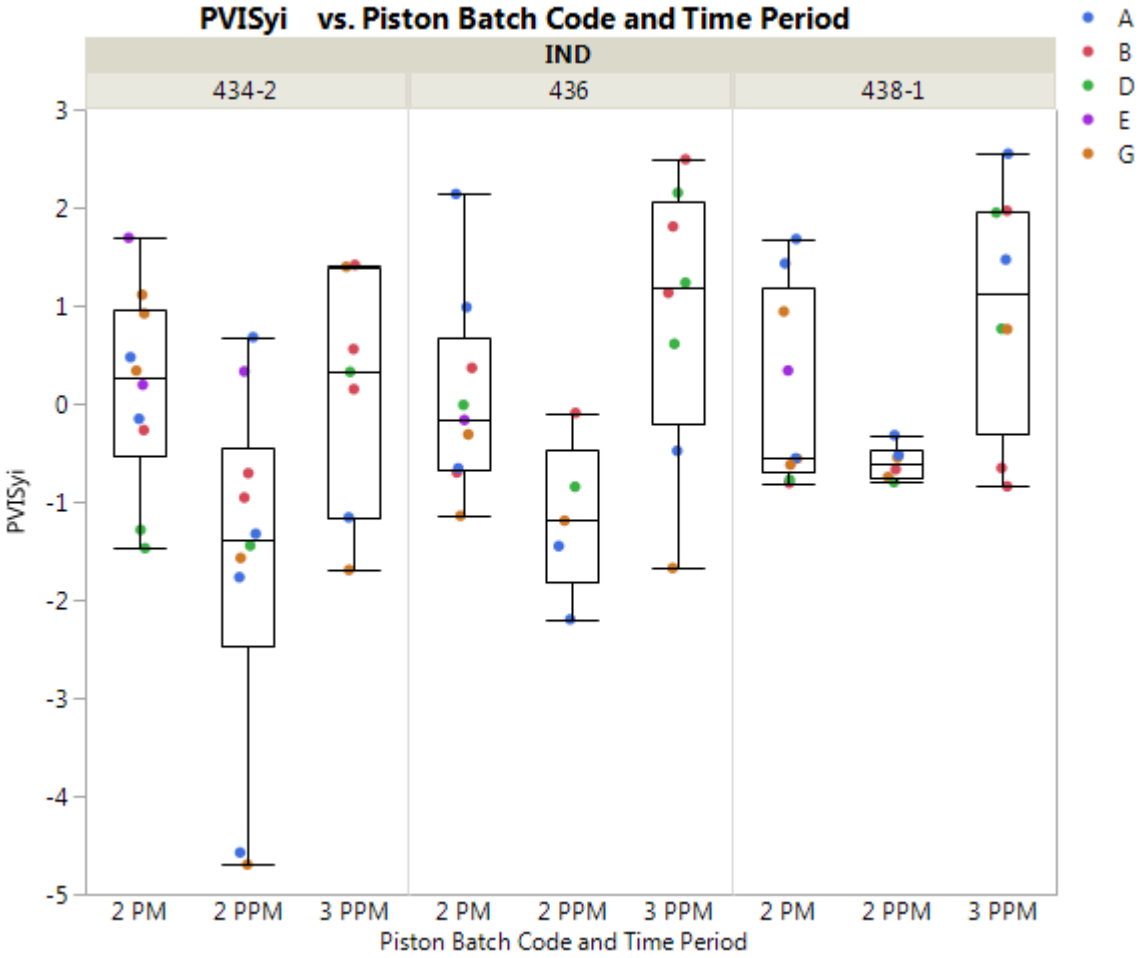
PM is Precision Matrix and PPM is Post Precision Matrix.

WPDyi (number of standard deviations from target with negative numbers being severe)



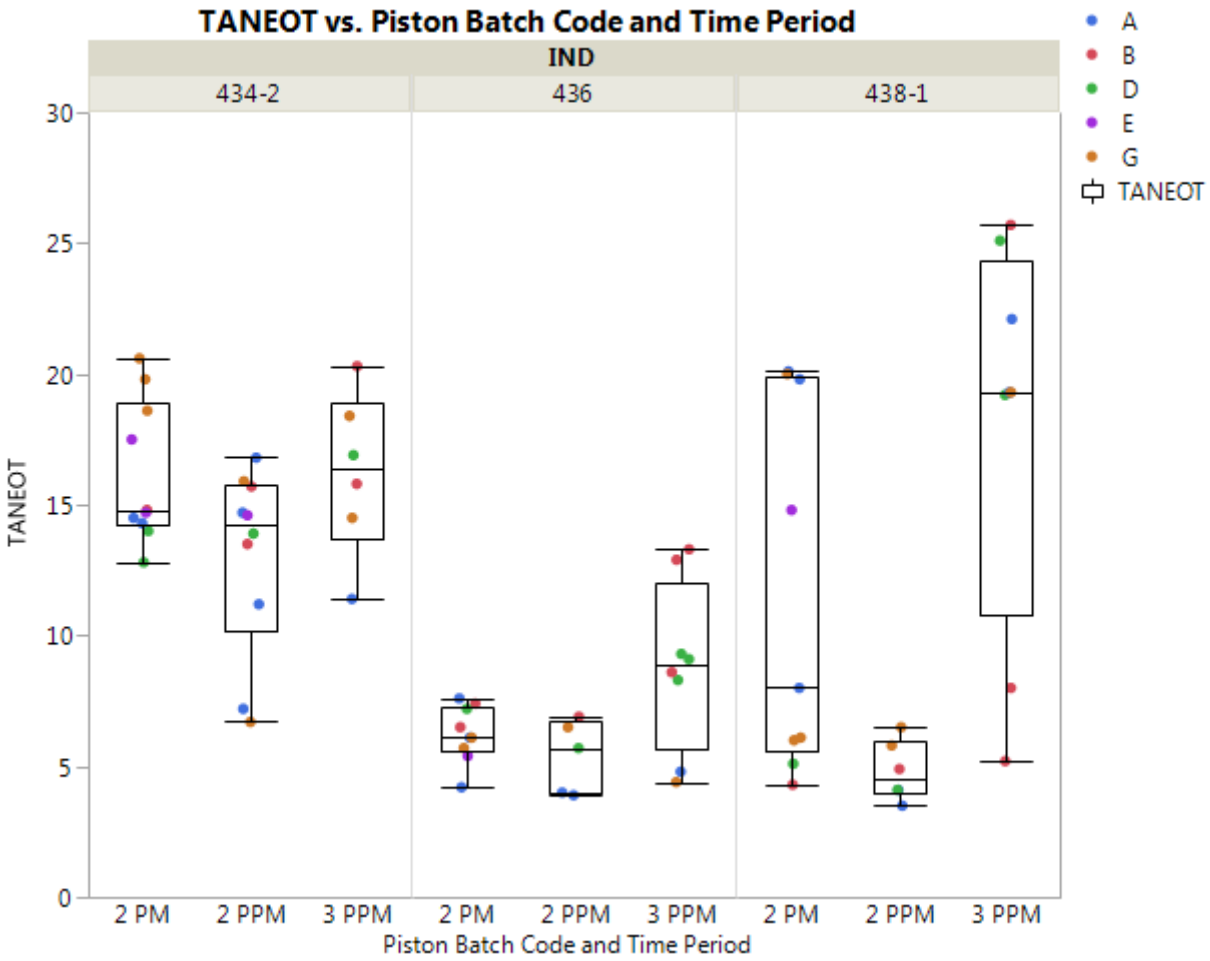
Whereas 434-2 shows little change between the PM with Piston Batch Code 2 and Batch Code 3, 436 and 438-1 have become more severe.

PVISyi (number of standard deviations from target with positive numbers being severe)



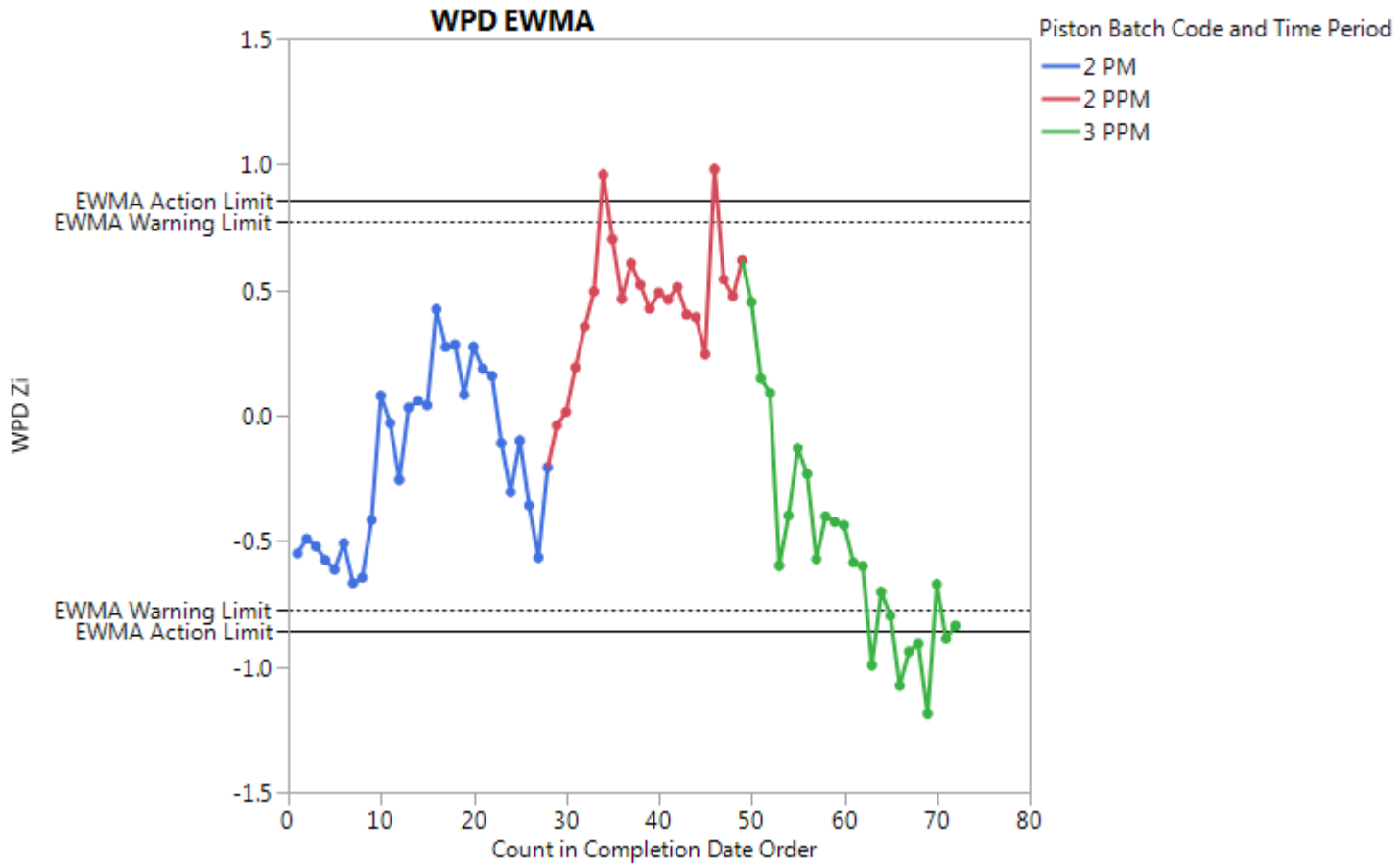
- Similar to WPD, PVISyi for Piston Batch Code 3 with 434-2 appears similar to the PM results with Batch Code 2 whereas 436 and 438-1 are more severe.

TAN EOT



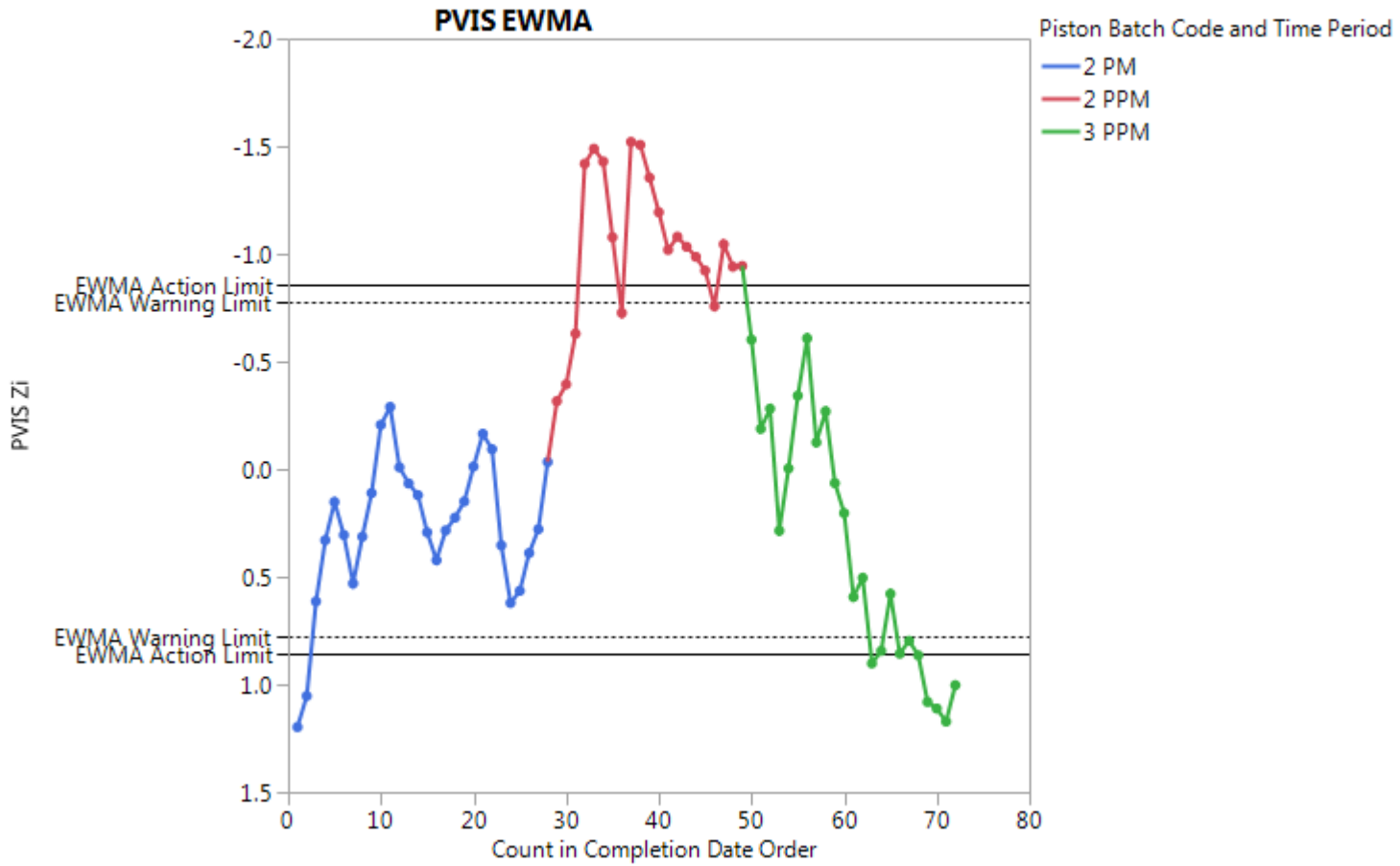
TAN EOT shows similar patterns to WPDyi and PVISyi.

WPD EWMA Chart



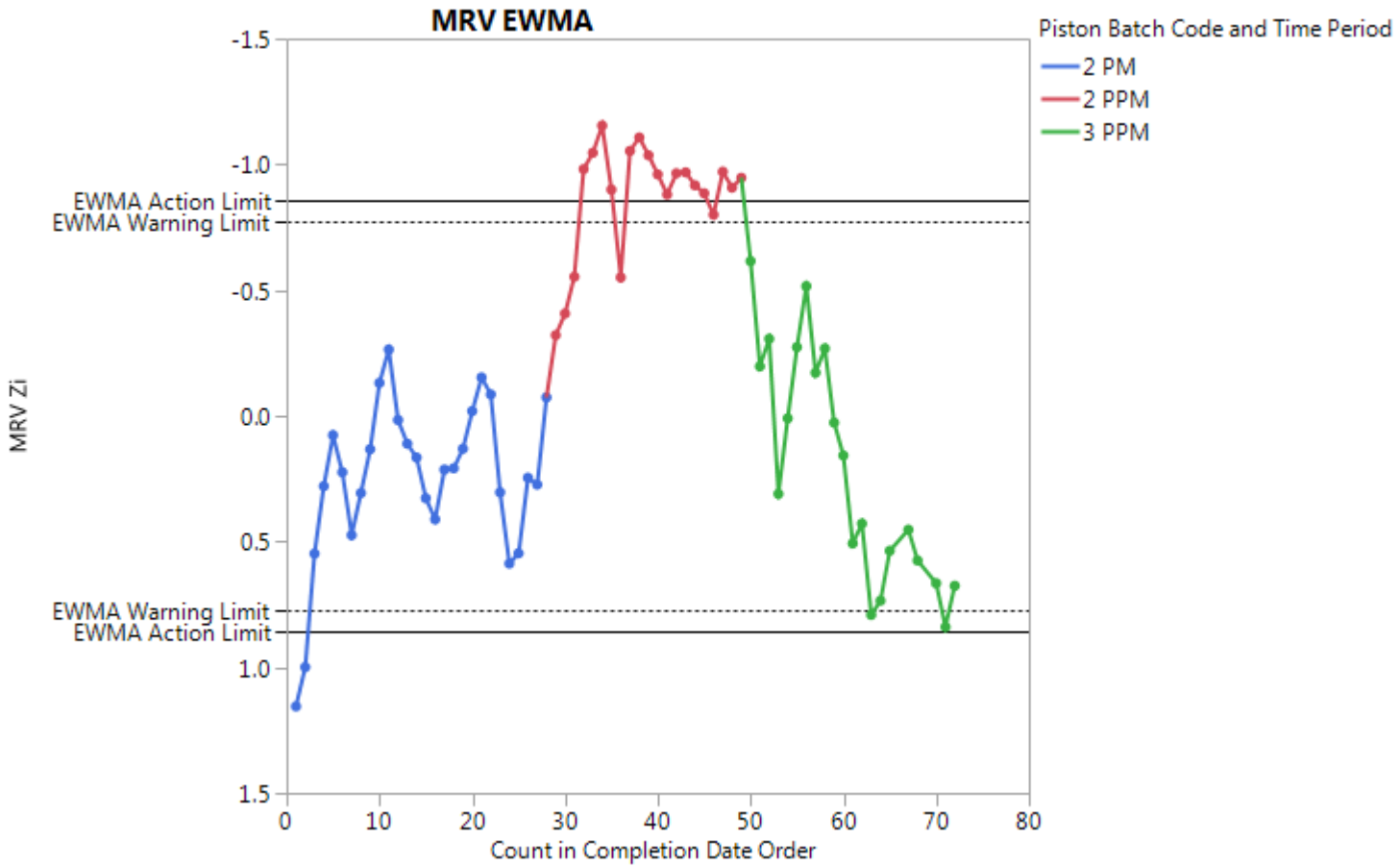
- 6 of the last 10 results have exceeded the EWMA Action Limit.

PVIS EWMA Chart



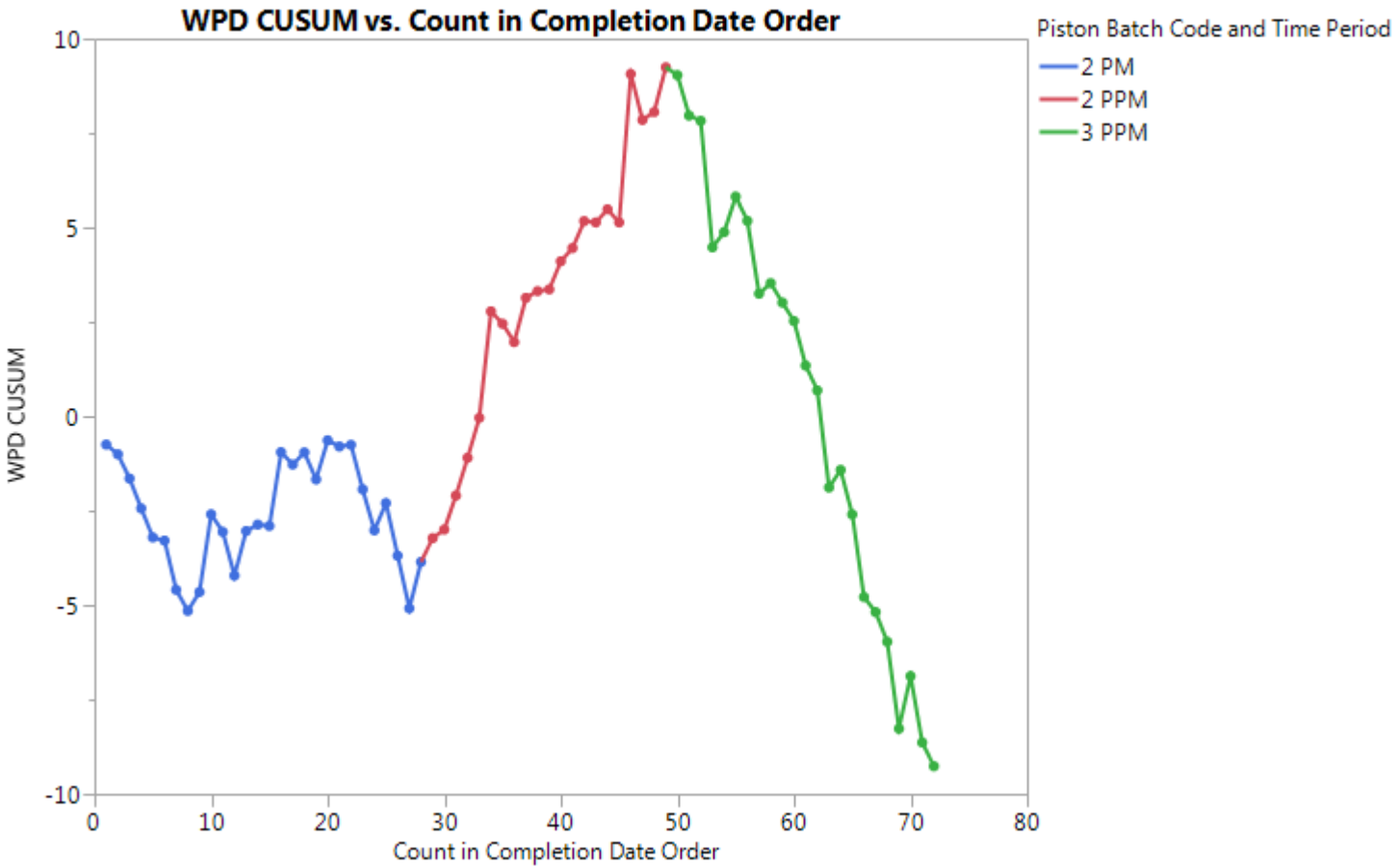
- 5 of the last 9 results have exceeded the EWMA Action Limit.

MRV EWMA Chart

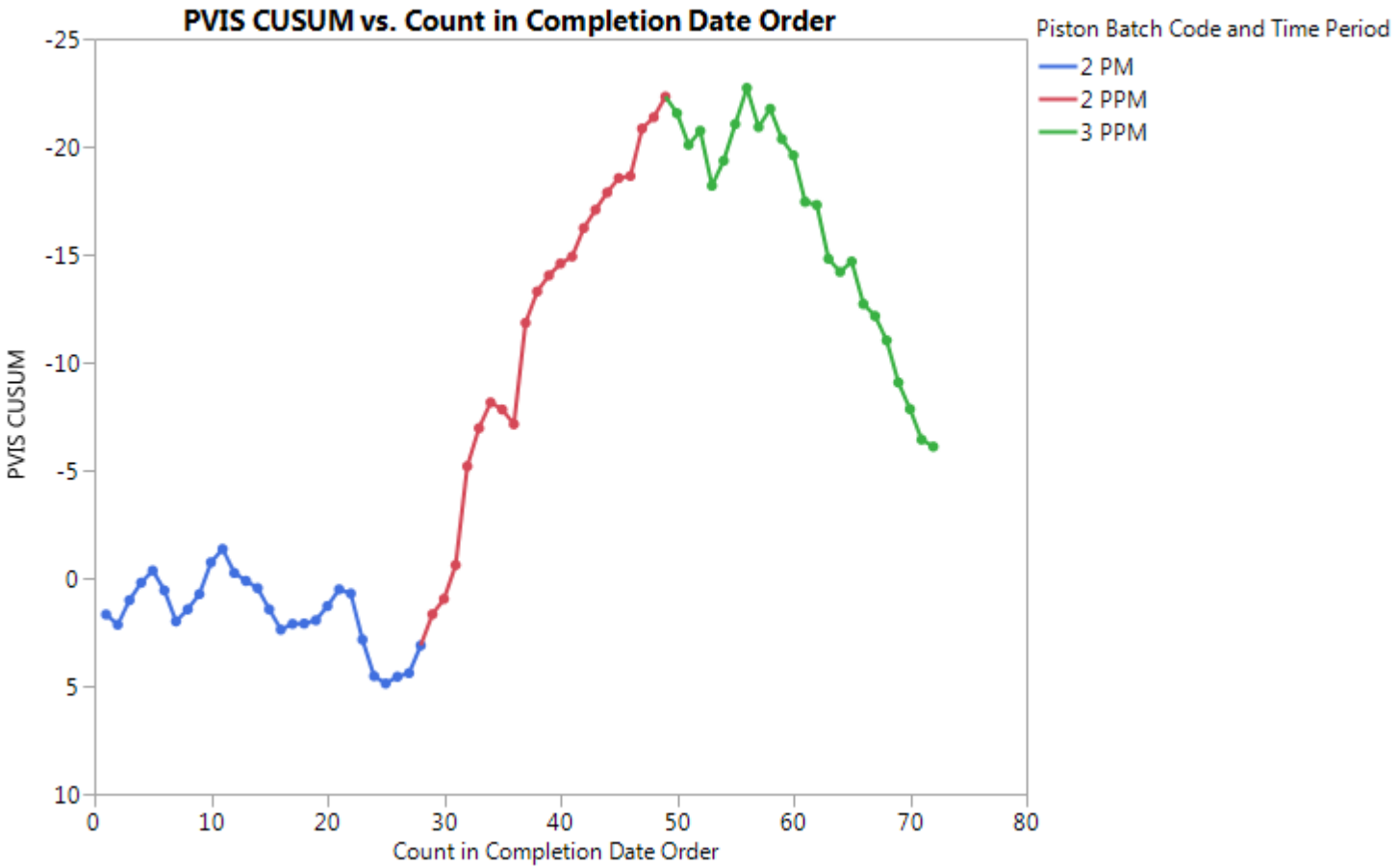


- The MRV EWMA Chart is similar to PVIS but slightly less extreme.

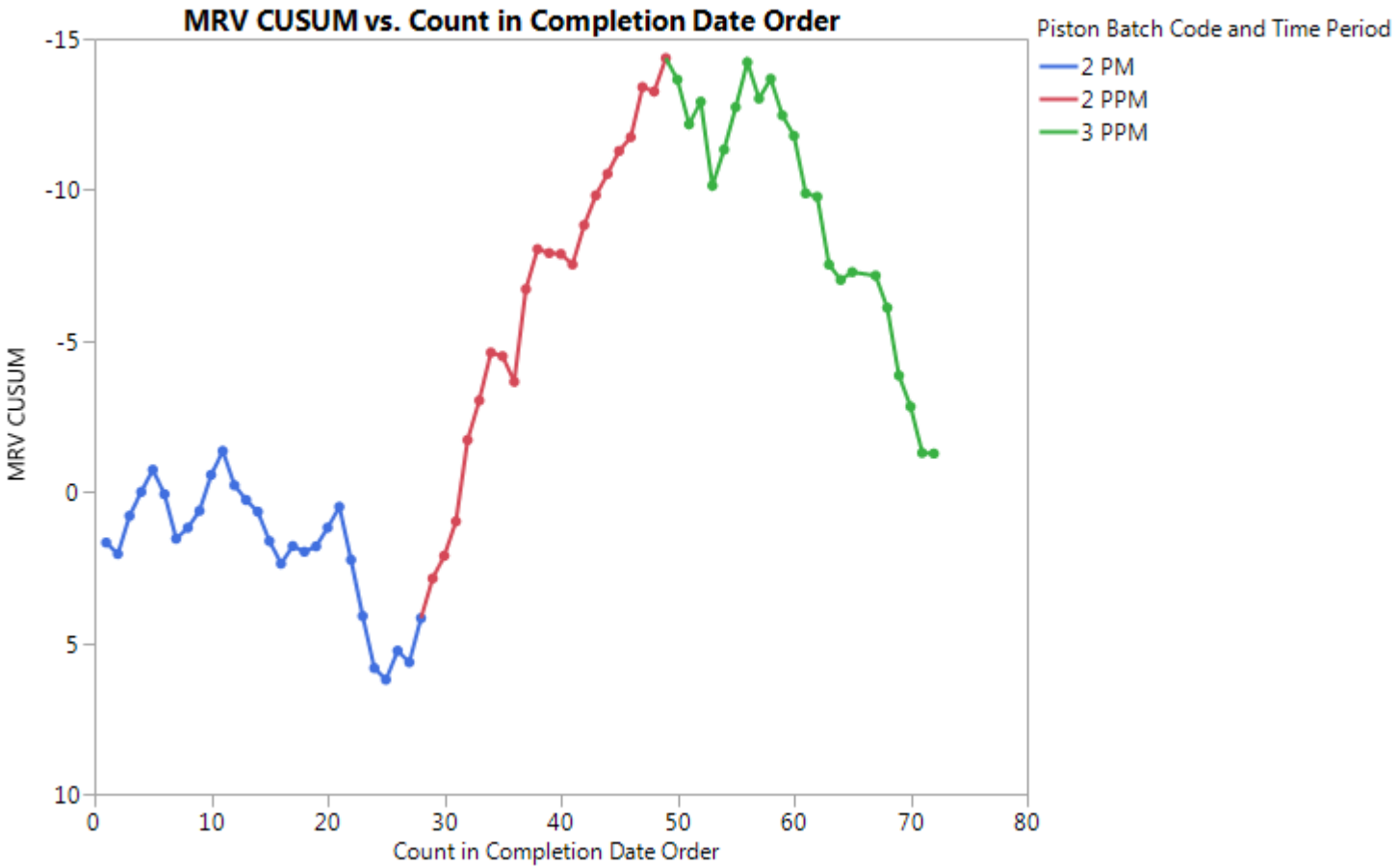
WPD CUSUM



PVIS CUSUM



MRV CUSUM



The MRV plot follows the same trend as WPD and PVIS.

Summary of observations from the IIIH LTMS control charts

1. PVIS: Tests on BC3 Pistons and Rings are trending severe and in the EWMA Action Alarm.
2. WPD: Tests on BC3 Pistons and Rings trending severe and are bouncing between the EWMA Warning and Action Alarms.
3. MRV: Tests on BC3 Pistons and Rings trending severe (approaching the EWMA Warning Alarm).
4. CUSUM plots demonstrate a distinct shift at the beginning of the Batch 2 PPM tests and then again, reversing direction, at the beginning of the Batch 3 PPM tests.

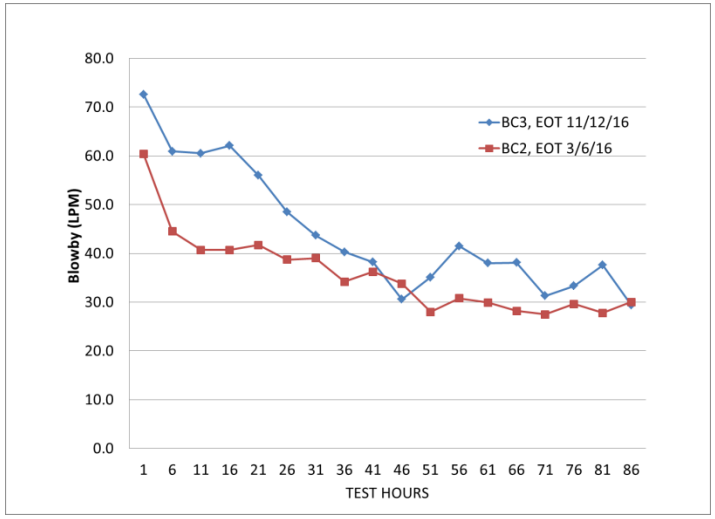
BC3 Blowby and PVIS shift is also observed with candidate oils

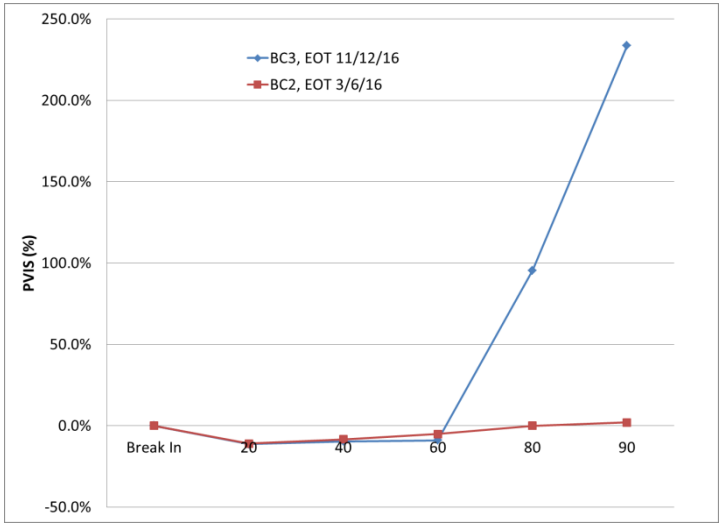
- The same batch of oil was run twice at the same lab
  - First run EOT 3/6/16, with BC2 pistons
  - Second run EOT 11/12/16, with BC3 pistons
- There was a disparity in IIIH performance between the two runs (no adjustment)

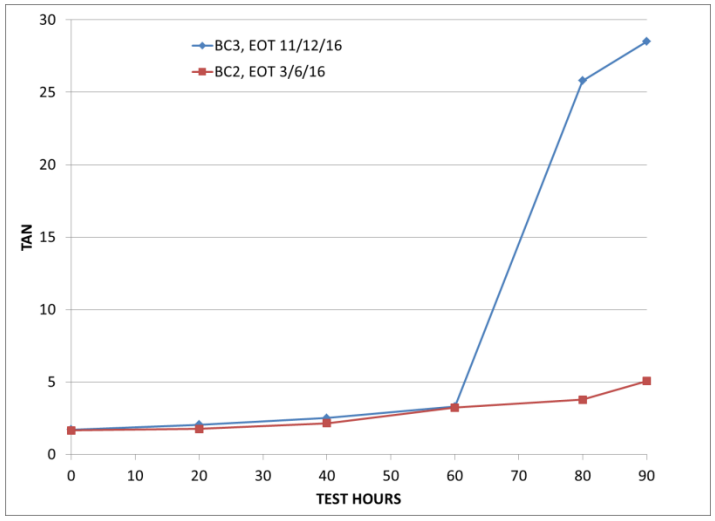
	EOT 3/6/16, BC2	EOT 11/12/16, BC3
PVIS	2.1	246
WPD	4.21	3.07

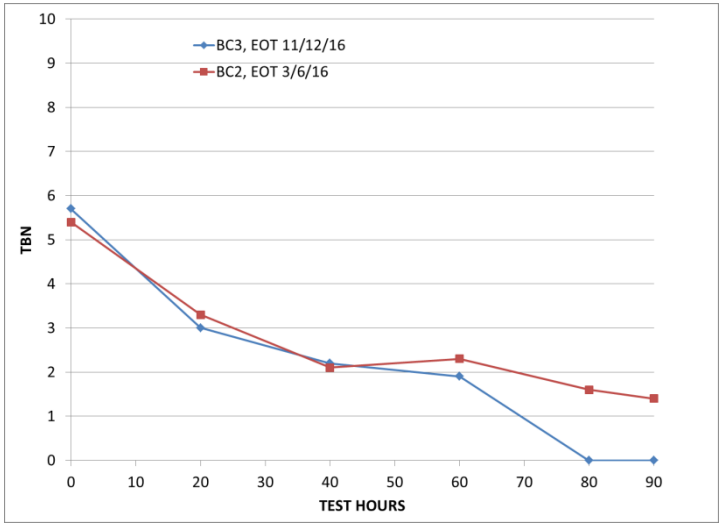
- The cumulative blow-by is ~25% higher for BC3 pistons
- With BC2 pistons, the PVIS remained low and stable throughout the test
- With BC3 pistons, a dramatic increase in PVIS appeared after 60 hours
- Both TAN and TBN are very similar between the two runs up to 60 hours
  - With BC2 pistons after 60 hours TAN gradually increases and TBN gradually decreases
  - With BC3 pistons after 60 hours TAN increases dramatically and TBN drops to zero

IIIH: Same oil, same lab, different BC batch pistons







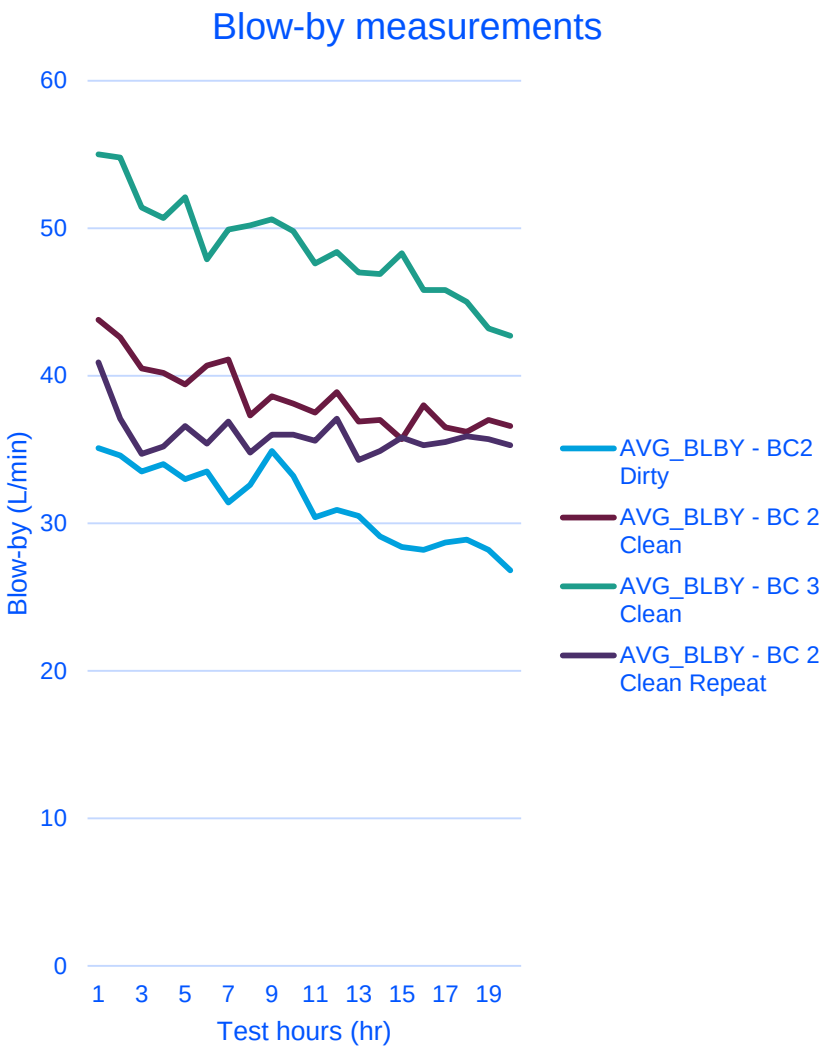


Experimental data to show BC3 Pistons are responsible for the blowby severity shift

- SwRI reported the results of their experiments at the November 15th IIIH Surveillance Panel meeting.
- Experiments were conducted with a slave IIIH engine 0-20 hour blow-by measurements with the following sequence and results:

Run Order	Description	Blow-by levels
1	BC2 Pistons Dirty	Lowest
2	BC2 Pistons Cleaned	Higher
3	BC3 pistons	Highest
4	Repeat of 2	Similar to 2)

SwRI BC2 & BC3 Piston Blow-by Comparison



- Slave engine
  - Engine had approximately 90 hours.
  - Engine was built with batch code 2 rings and pistons.
  - Aborted test at approximately 65 hours due to extended down time.
- 1st iteration
  - Slave engine ran with batch code 2 pistons and rings.
  - Goal: Establish a base line for dirty pistons and rings.
- 2nd Iteration
  - Slave engine was rebuilt with ultrasonic-cleaned batch code 2 pistons and rings.
  - Goal: To obtain data on used but cleaned batch code 2 pistons and rings
- 3rd Iteration
  - Slave engine was rebuilt with ultrasonic-cleaned batch code 3 pistons and batch code 2 rings.
  - Goal: To make sure that the pistons are the only thing that influenced the blow-by measurements.
- 4th iteration
  - Slave engine was rebuilt with ultrasonic-cleaned batch code 2 pistons and rings. **These are the same pistons and rings used in iteration 2.**
  - Goal: To get back to same blow-by values as iteration 2.

FUELS & LUBRICANTS RESEARCH
swri.org

Summary of conclusions

- **Urgent action is needed to address the current situation with BC3 pistons. Corrective action is needed to return the blowby levels and PVIS, WPD and MRV data associated with the calibration oils back to those recorded for the Precision Matrix tests.**
- **The 434 and 438 PVIS averages are reversed between the PM and subsequent BC3 datasets, making any proper mathematical adjustments impossible.**
- **The Industry LTMS control charts show EWMA action alarms for PVIS.**
  - **WPD bounces between warning and action alarms. MRV is approaching the warning alarm.**
- **The IIIH test is out of control.**
- **MOTION TO SURVEILLANCE PANEL (January 11th 2017):**
  - **The IIIH and IIIHA tests are declared out of control.**