IIIH Data Review Task Force Conference Call
November 30, 2015 3:30 – 5:00 Eastern

Attendees:

Chrysler: Haiying Tang, Jeff Betz
Shell: Karin Haumann,
Oronite: Jo Martinez, Robert Stockwell, Ricardo Affinito
Afton: Ed Altman, Bob Campbell
Ashland: Amol Savant
Infineum: Andy Ritchie, Gordon Farnsworth, Doyle Boese
Lubrizol: George Szappanos, Kevin OMalley
Intertek: Adison Schweitzer, Charlie Leverett
SwRI: Pat Lang, Sid Clark, Travis Kostan, Mike Lochte
TMC: Rich Grundza
OHT: Jason Bowden, Matt Bowden
IMTS: Dave Passmore
Neste Oil: Chris Castanien
Ford: Ron Romano
Toyota: Teri Kowalski, Jim Linden
GM: Bruce Matthews

Karin opened the meeting explaining the group was going to review the Toyota Proposal to Sequence IIIH Precision Matrix Data Analysis dated November 20, 2015. Karin indicated Jo Martinez would be going through the Toyota presentation; however she would be starting with the Sequence IIIH Precision Matrix IR Oxidation / Nitration Statistical Analysis from the Statistics Group dated November 18, 2015 that was emailed on 11/19/2015 to the group.

The presentations are attached in order of presentation;

Attachment #1 Sequence IIIH Precision Matrix IR Oxidation / Nitration Statistical Analysis, Statistics Group, November 18, 2015.

Attachment #2 Proposal to Sequence IIIH Precision Matrix Data Analysis, November 20, 2015, Toyota Motor Corporation.

Jo Martinez discussed the IR Analysis explaining the methods used which were Peak Height and Area Methods of looking at Oxidation and Nitration. Jo Martinez discussed the conclusions with comments on each of the Precision Matrix Oils and their comparison or Coefficient of Variation.

Questions / comments:

Ron Romano asked if he was correct in his conclusion we really don't get any advantage looking at IR Oxidation over Pvis, to which Jo Martinez answered "Yes". Ron asked if we could get a better coefficient of variance would it be better. Bob Campbell commented he thought the Transformed Data was actually a little better. Jo Martinez reviewed Slide #4 looking at LnPvis indicating the range of 438 is still a problem.

Andy Ritchie commented Infineum didn't see any benefit from looking at the Area approach over what we currently have. *The Secretary assumes he means Pvis.*

Jo Martinez next reviewed the Toyota Presentation (Attachment #2) going through each slide reading the comments, Pros, and Cons, as listed on each slide using the Smirnov-Grubbs Test to identify outlier data points.

After review of the Toyota Presentation, the group again discussed the outlier concerns with comments from; Andy Ritchie, Doyle Boese, Ron Romano, Bob Campbell, Charlie Leverett, Karin Haumann, and Jo Martinez. Some of the comments were;

Have the Statisticians looked at the Toyota Analysis and what were their comments; Jo Martinez replied they were currently reviewing the data and yes they had looked at outliers, changing their P-Value approach from 0.5 to 0.1 as a criterion.

Doyle discussed statistical interpretation used to identify outliers with follow up investigations into possible causes for the outlier which has been conducted by the group with no final conclusion as to the cause for the outlier.

Charlie Leverett asked if the outlier falls within the ASTM E-178 guidelines, which Jo Martinez indicated she had reviewed the questionable outlier under the ASTM guidelines and it fell within 0.1 significance level.

Bob Campbell commented Afton agrees they have one outlier data point at a high confidence level and they have looked extremely hard trying to understand the cause for the result. Bob Campbell indicated if the group wants to discuss how to decide upon the status of this test based on Today's discussions, that's OK. He also indicated Afton was going to re-run another 434-2 test. Bob reminded everyone that Afton's Prove-out data fell in the middle of everyone's data on 434-2 and they want to know what drove this test mild probably more than others.

Karin reviewed the question at hand, being using the data as is to set the targets / limits that determine the precision of the test, and thereby generate wider targets, or do we eliminate this test as an outlier and tighten the bands.

The group discussed whether they would ever identify the cause of the mild result and agreed this may happen again and we need to identify the cause as it is likely to happen in candidate testing. Karin agreed, commenting if the data point is used to set the limits, then there will not

be a means to single these type tests out, thereby causing labs to investigate the cause for such results.

The group then discussed results on Reference Oil 438, with Karin commenting the results for 438 were all very close through 80 hours. Karin mentioned we all realize as the oil thickens, we can have a large increase within an hour in the Sequence IIIG and she really didn't understand the concern about 438 commenting that all the oils are different chemistries and they are all going to act differently.

Ron Romano commented he felt we really need to understand what caused this result going forward as it will possibly happen in candidate testing.

Teri Kowalski mentioned her discussions with Hirano San during Toyota's review of their statistical evaluation indicating she felt it's time to possibly consider this an outlier and move on.

The group discussed additional concerns about engine build parameters, honing, cleaning, and data points that Robert Stockwell questioned about pressure data on one of the other Afton tests that cause confusion. Ed Altman and Robert discussed these data blips, with Ed suggesting there may have been a problem with the data acquisition board during that test. Ed Altman indicated the prove-out test on 434-2 run on the same stand generating 268% Pvis with nothing changed on the test stand or the engine build since that test.

Doyle Bose suggested possibly building an engine at another lab and running it at Afton.

Bob Campbell indicated he would like to see additional work on standardized honing efforts within the IIIH. The group discussed the status of the Round Robin Block and concerns that some labs have seen cylinders at the larger limit for bore size.

After continued discussion on numerous subjects focused on engine honing and potential differences between labs, Haiying Tang attempted to make a motion focused on removing the outlier data and moving forward. Teri again mentioned Hirano San's Statistical Evaluation and possibly setting up a conference call before the AOAP meeting.

The Secretary asked for a second on the motion before moving into any further discussion.

Karin Haumann seconded Haiying's motion and the group moved into discussion.

Discussion:

The group agreed to remove all data for the subject outlier test.
George Szappanos expressed concern about other labs falling into this situation and offered Lubrizol's assistance investigating the issue going so far as to offer an Lubrizol built engine to run at Afton along with whatever assistance requested to help investigate the problem.

The group agreed the industry would work together to investigate the cause of the mild results through a root Task Force made up of the test engineers to continue looking into the test results.

The group continued to discuss test variability and how the questionable outlier test might affect the limits with concerns it may wash all the precision from the LTMS.

After continued discussion, Karin decided to call the question.

Review of the Motion with participant input resulted in the following wording:

Motion: Haiying Tang / Karin Haumann
Motion to accept the Toyota Statistical Evaluation of the IIIH Matrix Data, removing test CMIR 106788 as a statistical outlier at the .1 significance level from the matrix data analysis.

Voting:

Company	Approve	Abstain	Negative
Infineum			X
Oronite	X		
Shell	X		
Chrysler	X		
Ford			X
General Motors			X
Toyota	X		
Afton		X	
Ashland	X		
Intertek		X	
Lubrizol	X		
SwRI		X	
TMC		X	
IMTS	X		
OHT		X	
Totals	7	5	3

The motion passed with 7 Approves, 5 Abstains, and 3 Negatives.

After the vote, the group discussed what needs to be done to move forward;

Ron Romano indicated he would support the motion if there was an action plan moving forward looking at other parameters to try to identify the cause for the mild results. Ed Altman agreed indicating Afton was planning to run additional testing and agreed he would work with Lubrizol to continue investigations.

Bob Campbell indicated they were going to make another run on 434-2 and Ron questioned how the statisticians would handle that data if it duplicated.

The group discussed whether data points have ever been removed from matrix testing and bill Buscher reminded everyone that the Sequence IV Panel removed two mild data points from the Sequence IV GF-3 Precision Matrix.

Bob Campbell commented he encouraged labs to run additional testing to complement Afton's re-run and after some additional discussion the group adjourned.

Adjourn: 5:12 pm Eastern

This is a compilation from notes recorded during the call, with comments from member participants during the Draft Review. Certain subjects may not necessarily be in exact order; however, they are believed to represent an accurate account of the call. If anyone feels changes or additional content may be necessary, please contact Sid Clark @ 586-873-1255 or Sidney.Clark@swri.org

Thanks, Sid

Attachment #1
11/30/2015

Sequence IIIH Precision Matrix IR Oxidation/Nitration Statistical Analysis

Statistics Group

Nov. 18, 2015

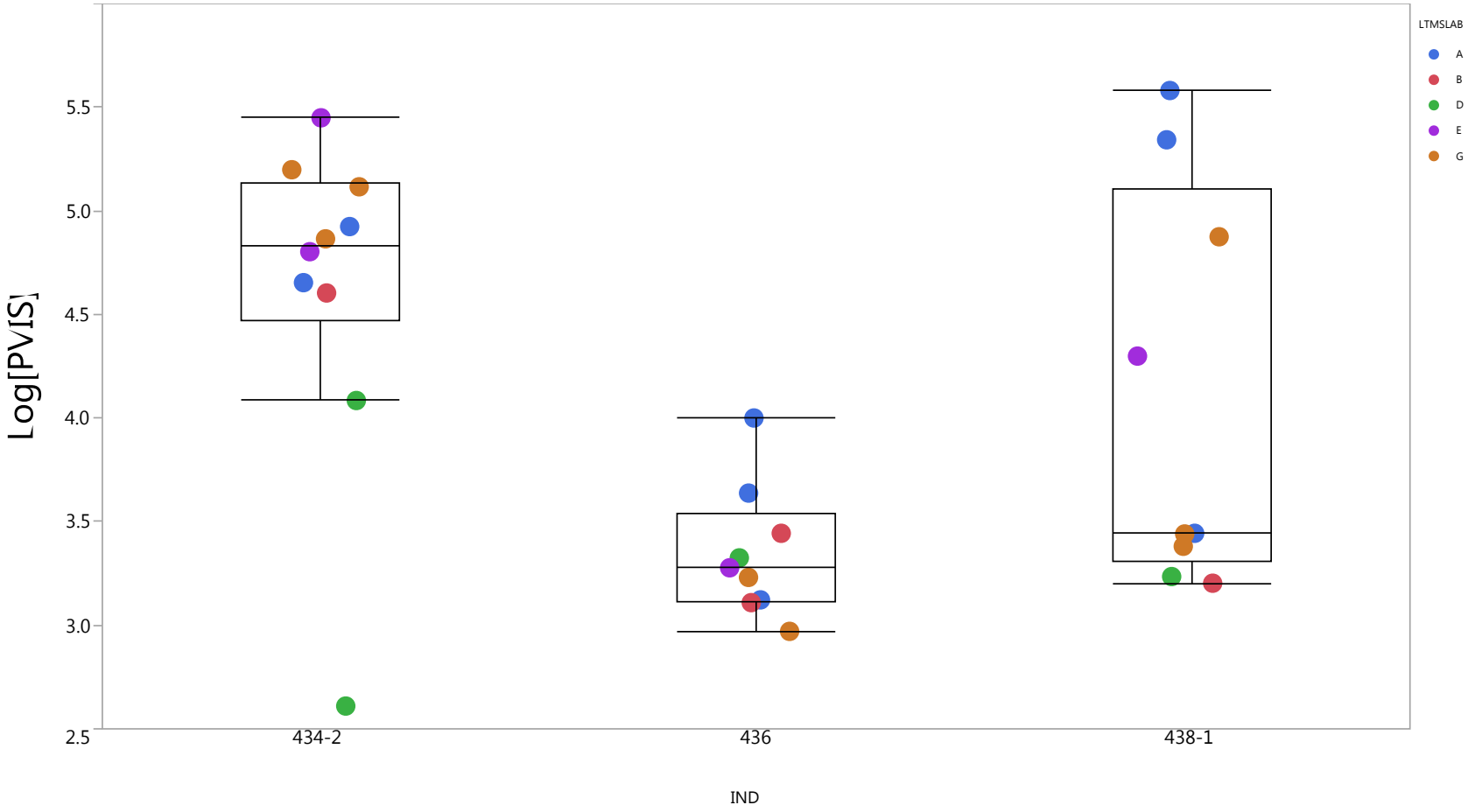
Conclusions

- IR Peak Height measurements were done by SwRI.
- If IR measurements are used, then additional work is needed to investigate measurement differences between labs.
- Coefficient of Variation of IR Area and IR Peak Height parameters are equal or worse than PVIS with the exception of Ln-transformed IRO3EOT.
- IR Oxidation Area and Peak Height parameters discriminate 434-2 vs 436 and 438-1.
  - PVIS does not discriminate between 434-2 and 438-1.
  - Range of 438-1 includes each of the other two oils for IR Oxidation parameters.
- IR Nitration Area and Peak Height parameters gave the worst Coefficient of Variation and do not discriminate between 434-2 and 436.

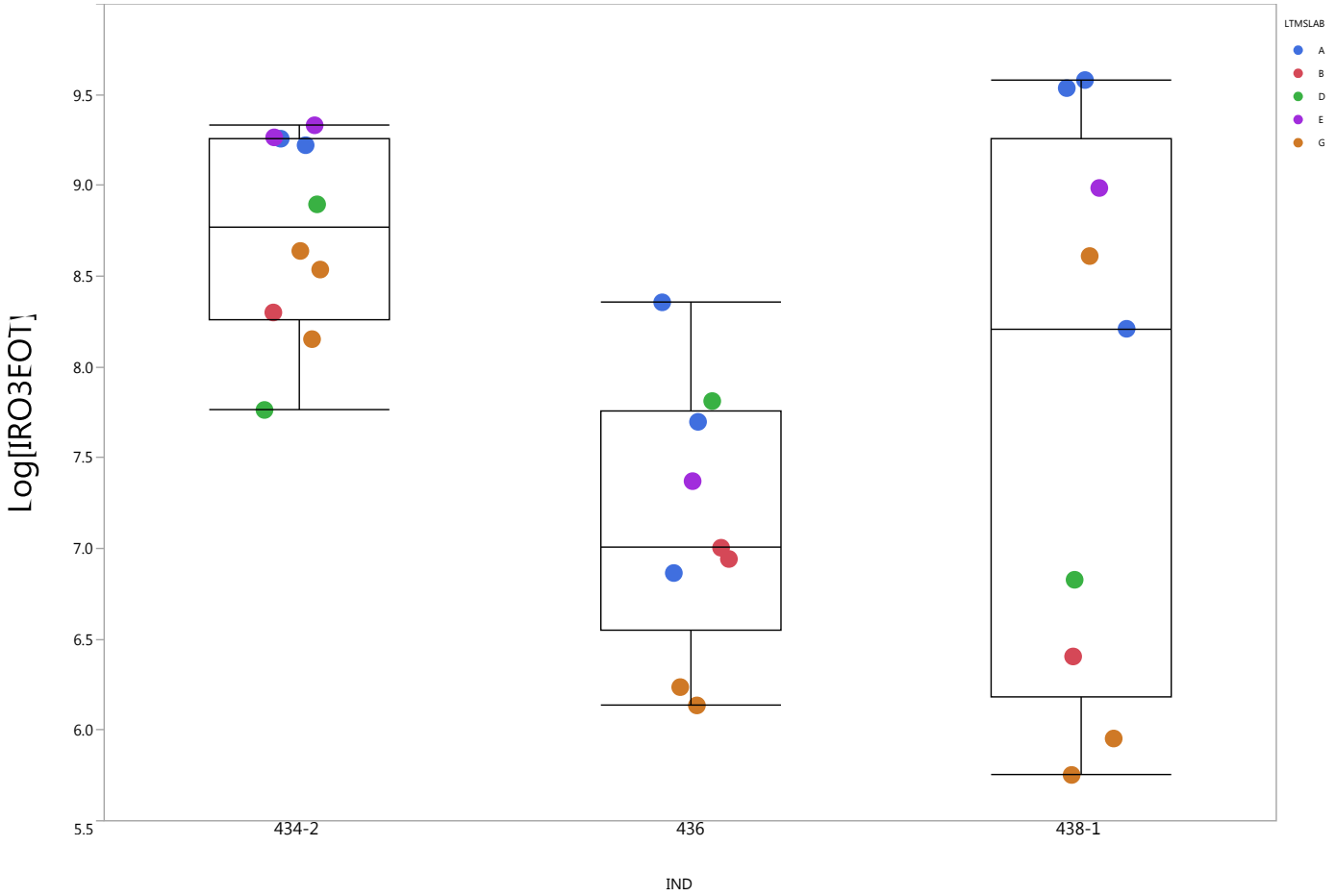
Summary

Parameter	Transformation	Summary Statistics		CV	Effects
PVIS	LnPVIS	RSquare	0.72		D < A
		RSquare Adj	0.61		A2 < A1
		Root Mean Square Error	0.5631	**0.1393**	436 < 434-2
		Mean of Response	4.0435		
		Observations (or Sum Wgts)	28		
Height	LnIRPH90	RSquare	0.73		No Lab difference
		RSquare Adj	0.62		G1 < G2
		Root Mean Square Error	0.5670	**0.1320**	436, 438-1 < 434-2
		Mean of Response	4.2947		
		Observations (or Sum Wgts)	28		
Height	SqrtIRPH90	RSquare	0.75		D < A
		RSquare Adj	0.64		A2 < A1, G1 < G2
		Root Mean Square Error	2.3746	**0.2520**	436, 438-1 < 434-2
		Mean of Response	9.4234		
		Observations (or Sum Wgts)	28		
Area	LnIRO3EOT	RSquare	0.77		B, G < A; G < E
		RSquare Adj	0.67		G1 < G2
		Root Mean Square Error	0.6844	**0.0865**	436, 438-1 < 434-2
		Mean of Response	7.9158		
		Observations (or Sum Wgts)	28		
Area	SqrtIRO3EOT	RSquare	0.79		B, D, G < A
		RSquare Adj	0.70		A2 < A1
		Root Mean Square Error	17.65444	**0.2889**	436, 438-1 < 434-2
		Mean of Response	61.11939		
		Observations (or Sum Wgts)	28		
Height	NitPH90	RSquare	0.65		No Lab difference
		RSquare Adj	0.51		No Stand(Lab) difference
		Root Mean Square Error	9.9649	**0.3535**	438-1 < 434-2
		Mean of Response	28.1890		
		Observations (or Sum Wgts)	28		
Area	IRN3EOT	RSquare	0.64		D, G < E
		RSquare Adj	0.48		No Stand(Lab) difference
		Root Mean Square Error	155.1318	**0.4070**	438-1 < 434-2
		Mean of Response	381.1429		
		Observations (or Sum Wgts)	28		

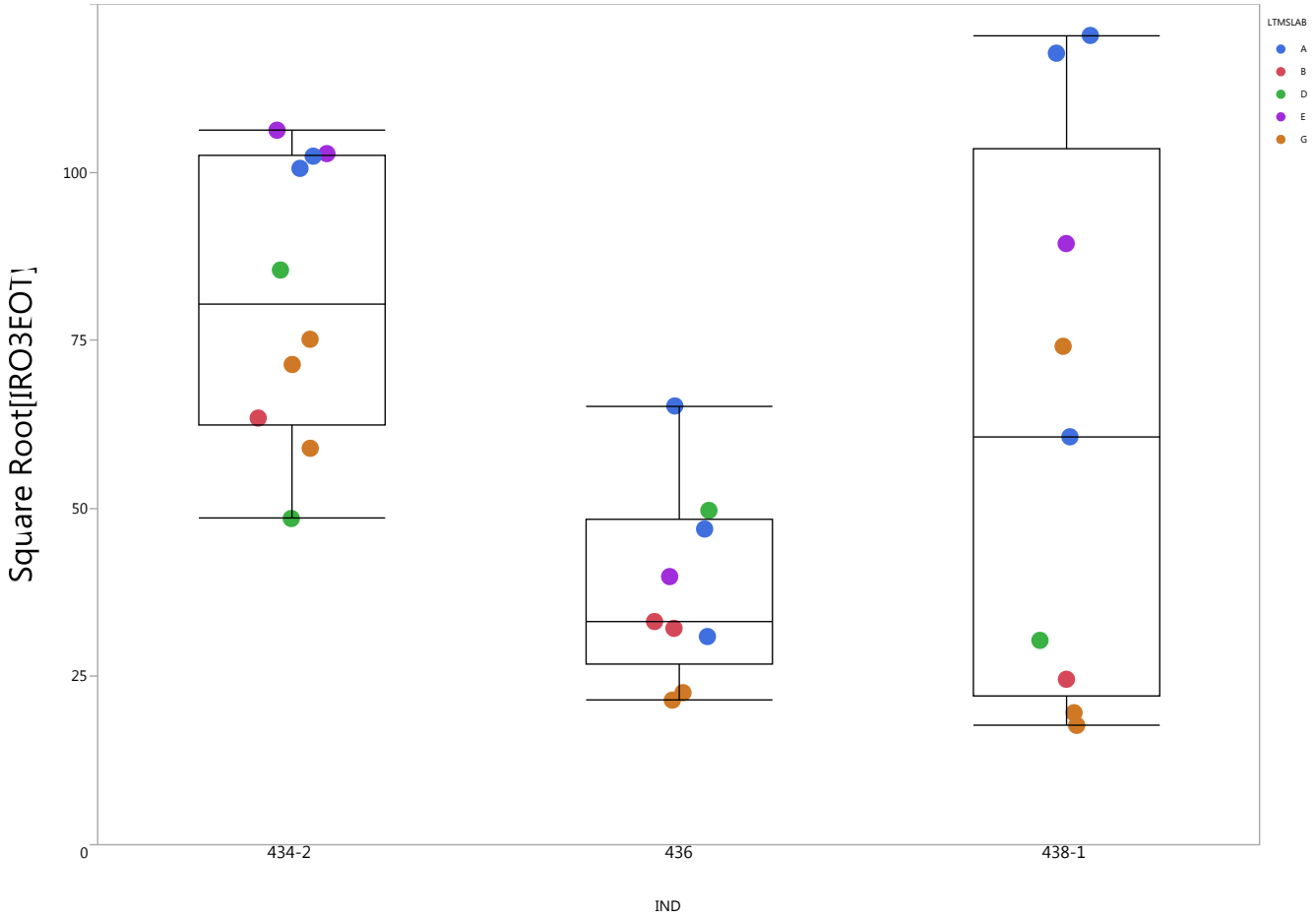
LnPVIS



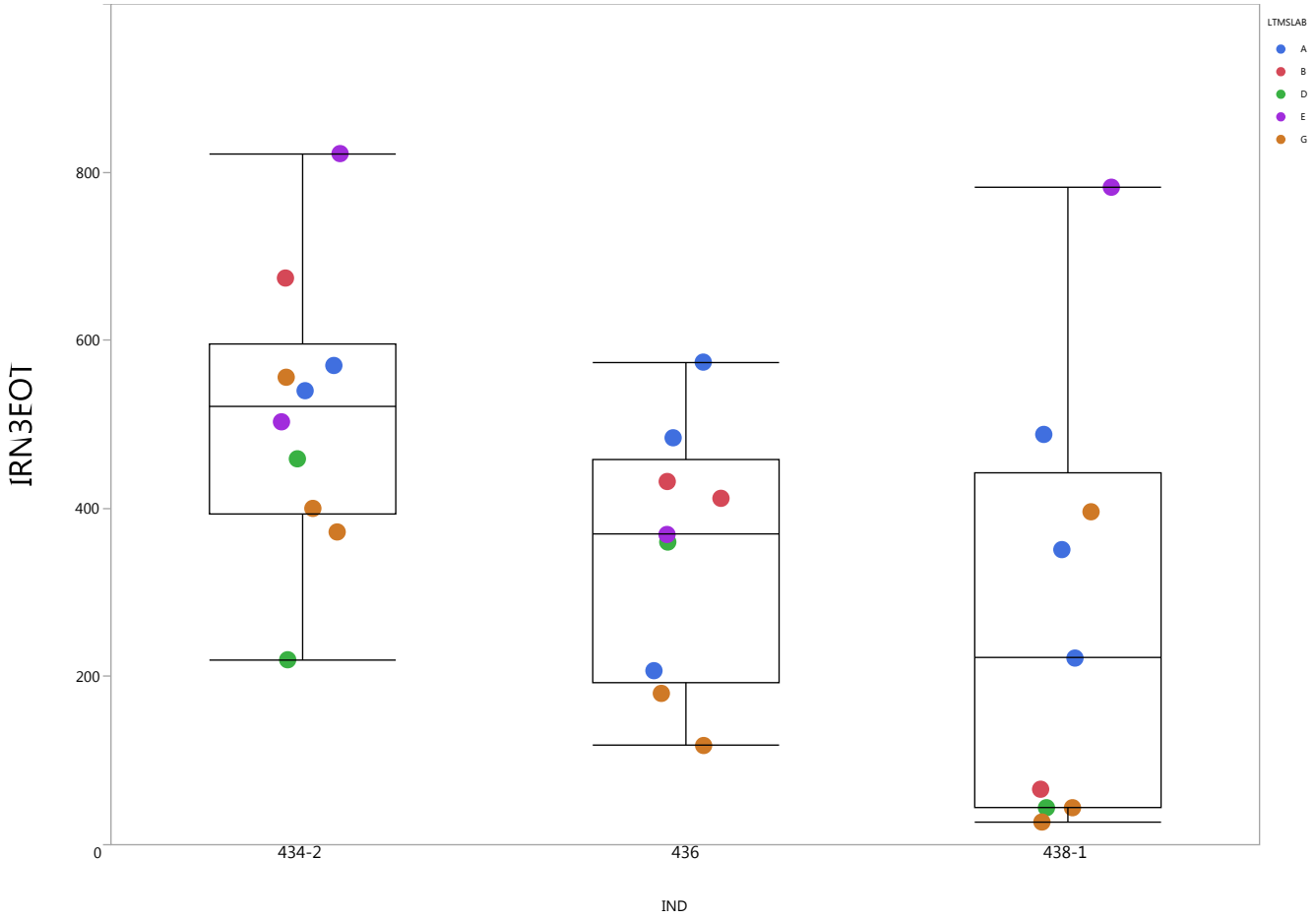
LnIRO3EOT


Log[IRO3EOT]
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
434-2
436
438-1
IND
LTMSLAB
A
B
D
E
G

SqrtIRO3EOT



IRN3EOT



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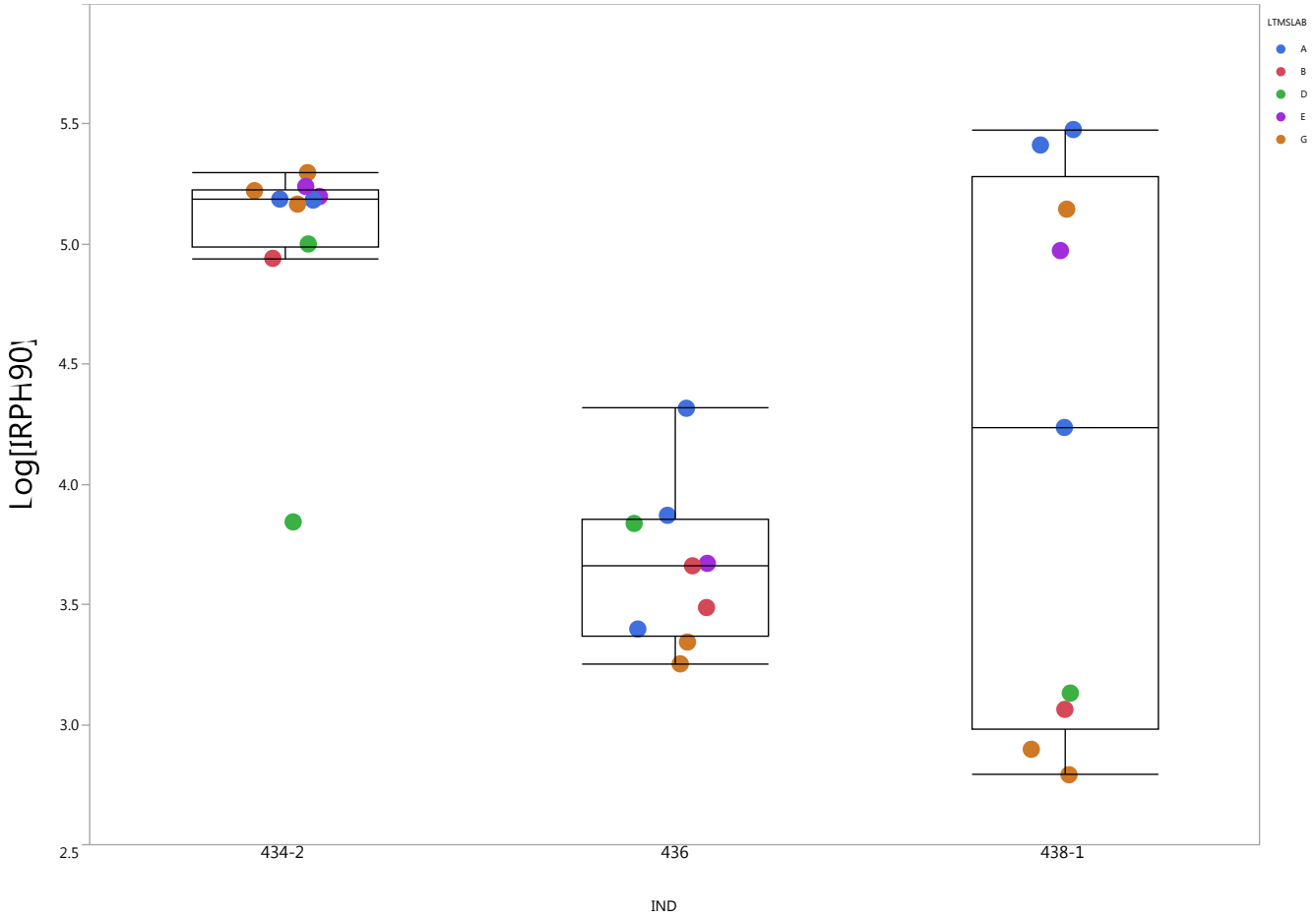
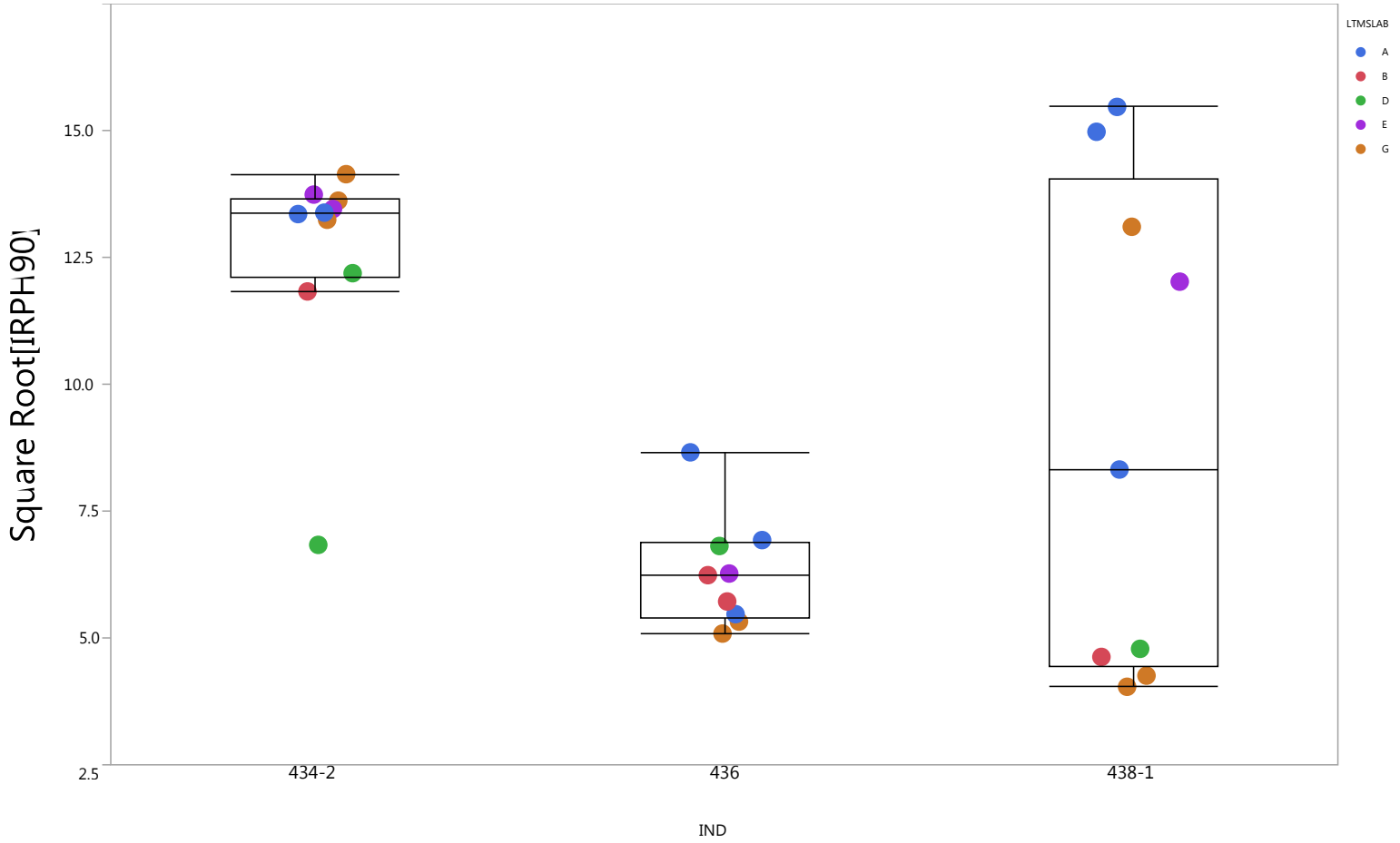
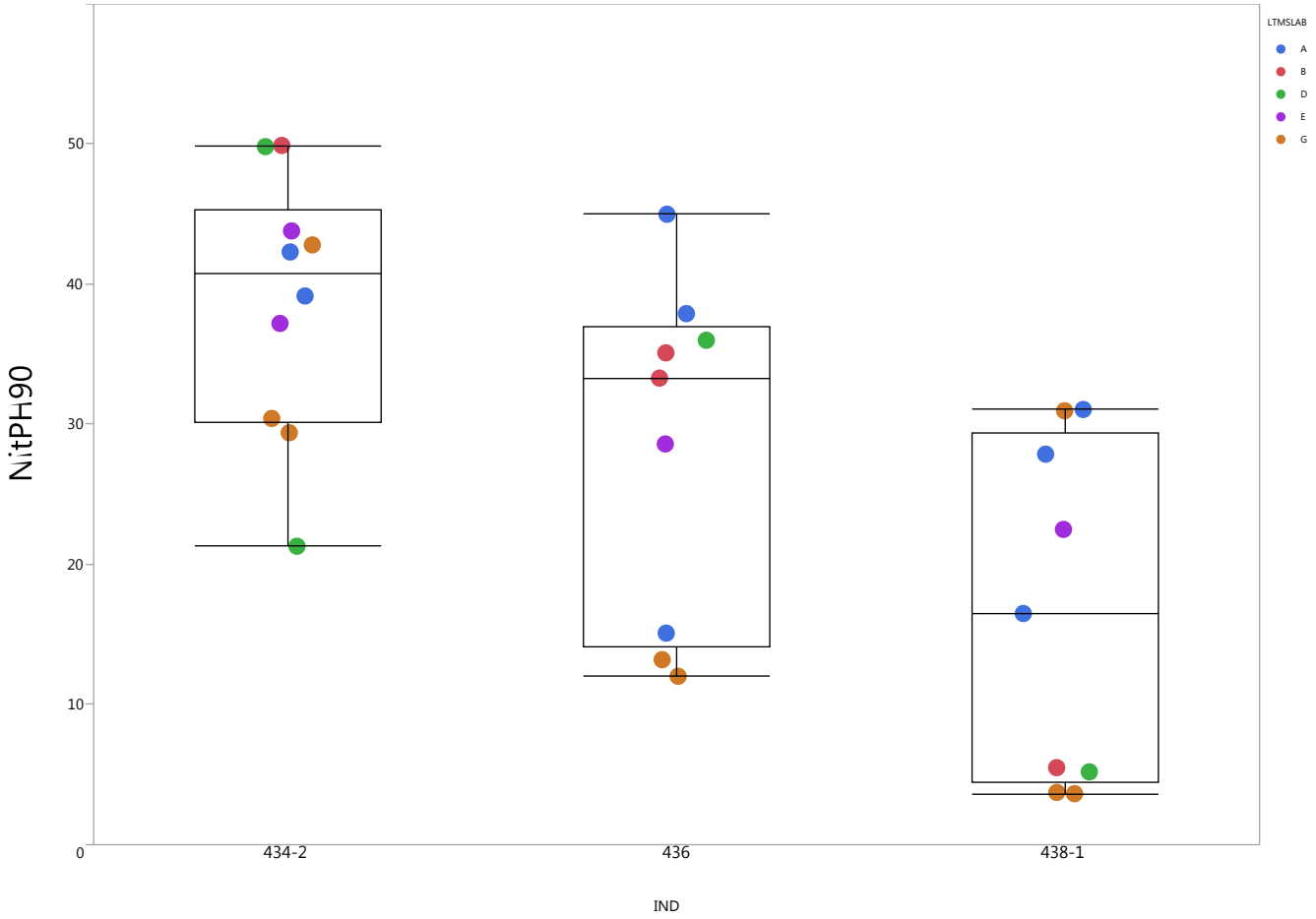


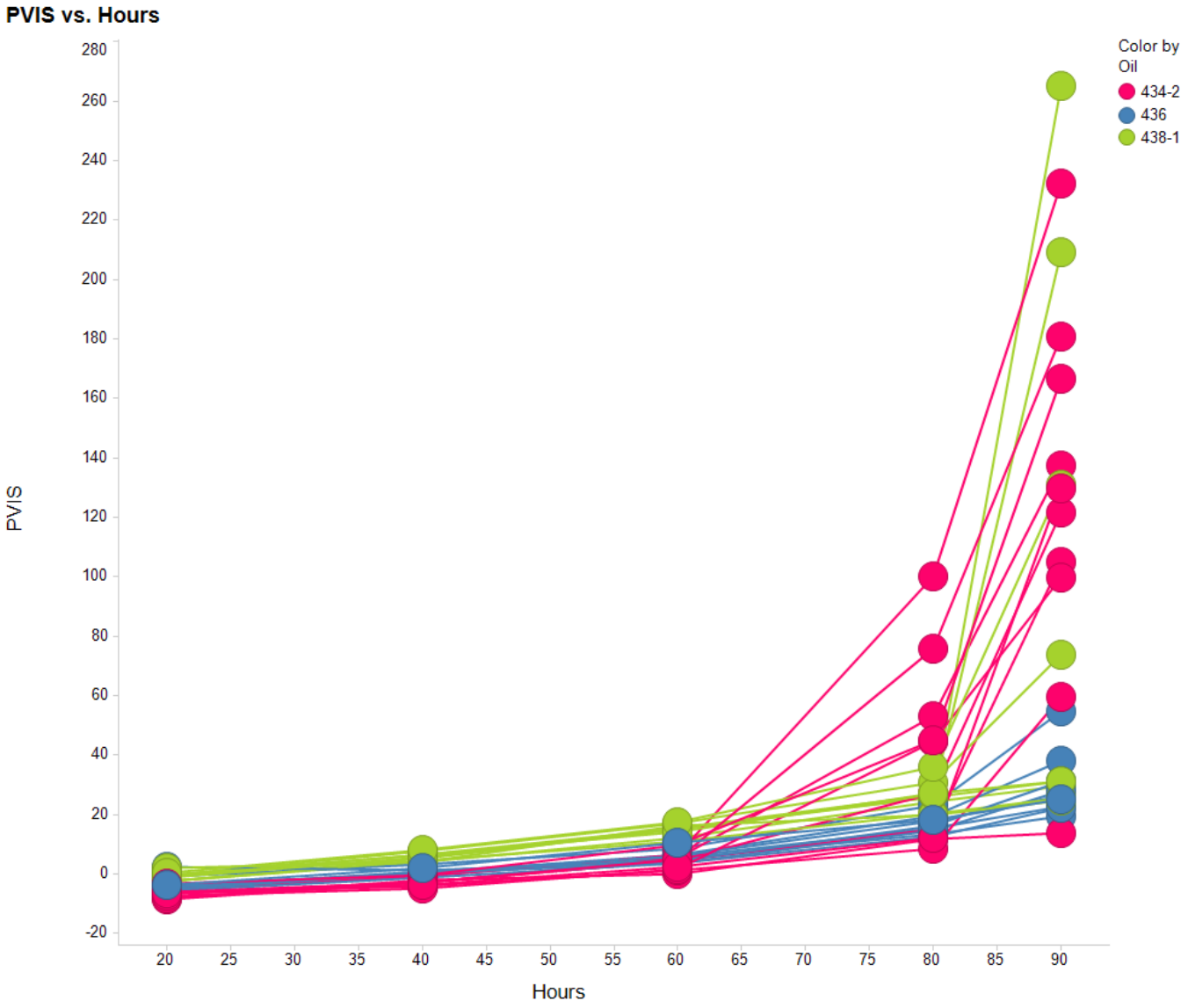
SqrtIRPH90


Square Root[IRPH90]
15.0
12.5
10.0
7.5
5.0
2.5
434-2
436
438-1
IND
LTMSLAB
A
B
D
E
G

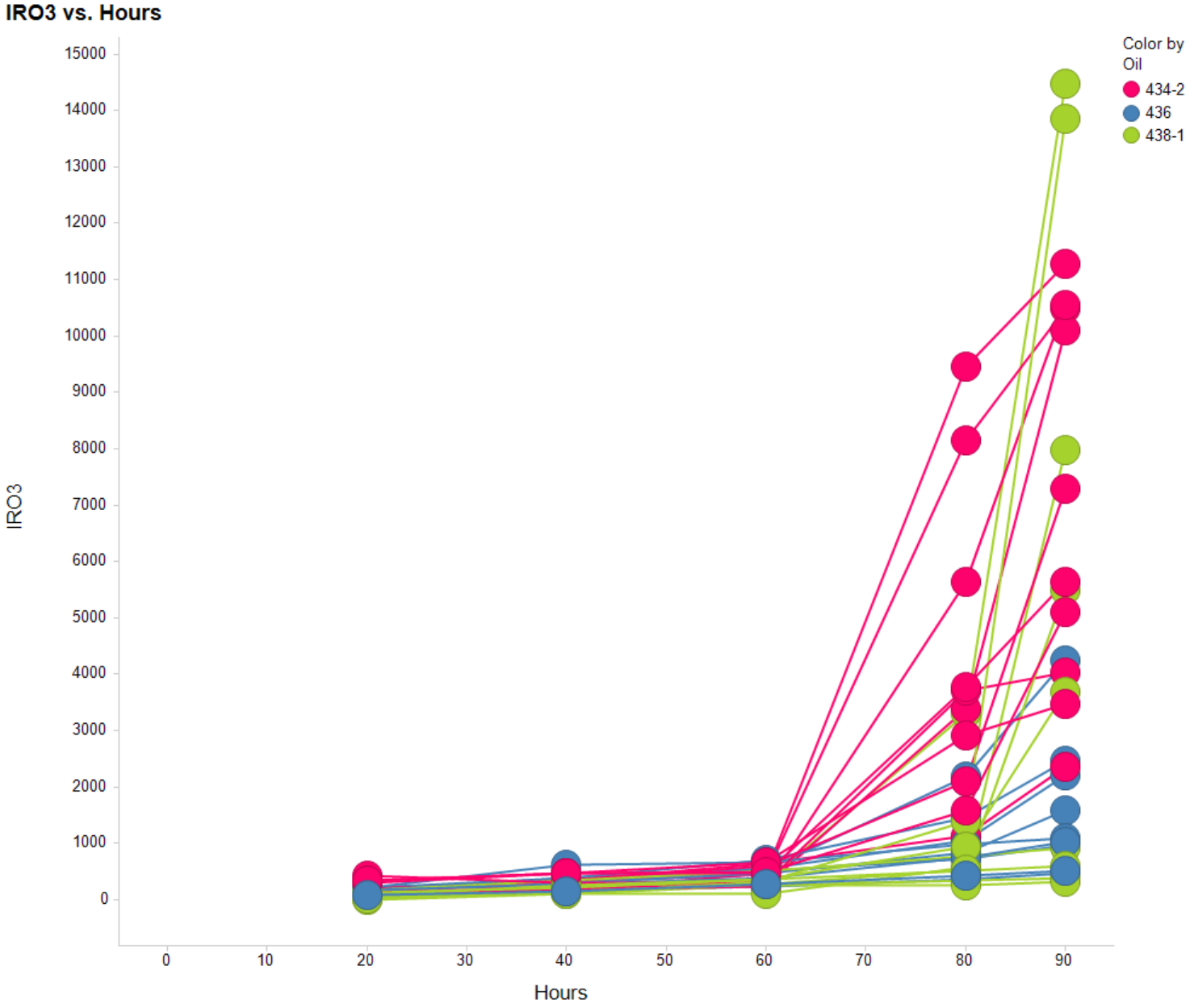
NitPH90



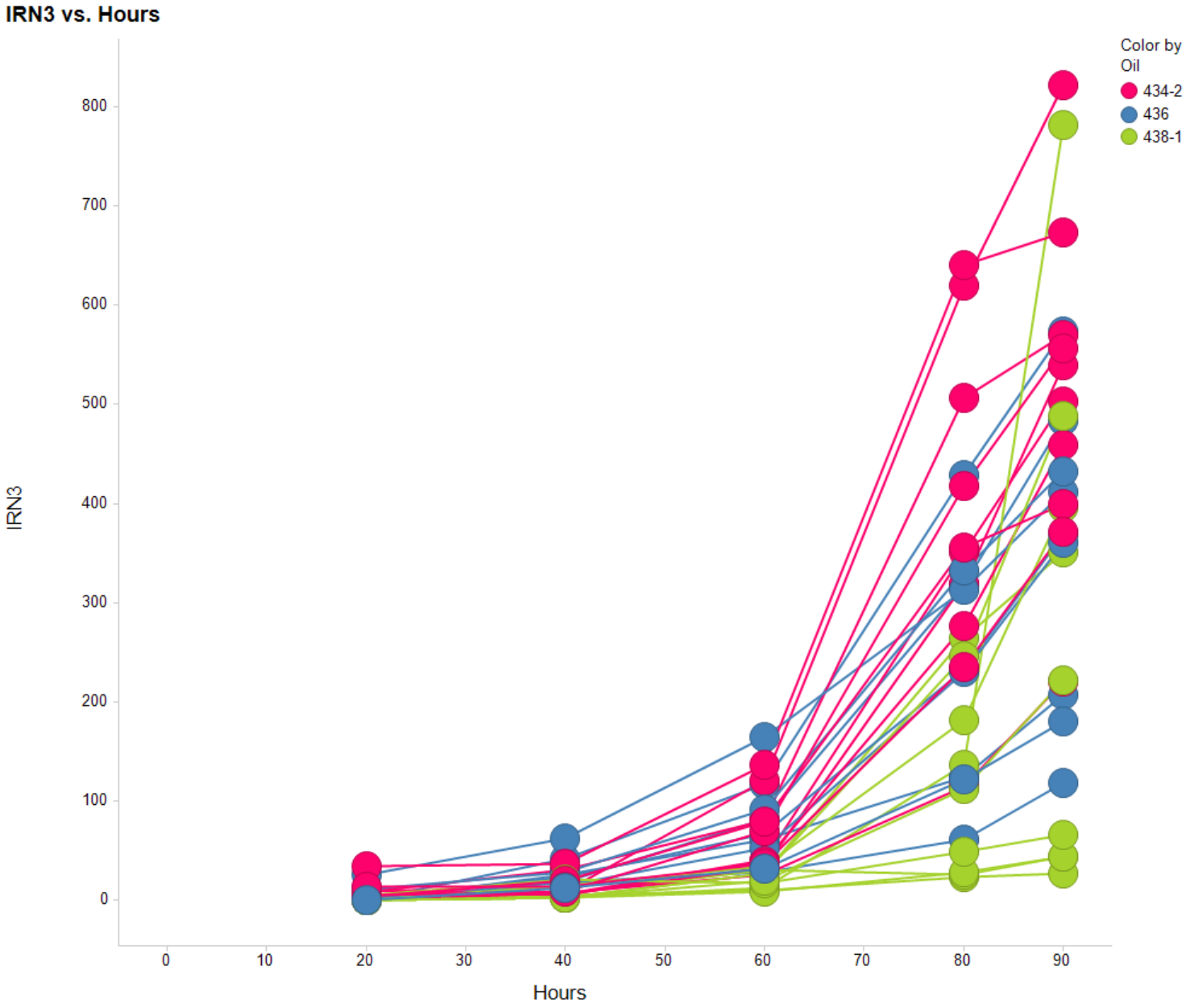
PVIS


PVIS vs. Hours
PVIS
Hours
Color by Oil
434-2
436
438-1
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90

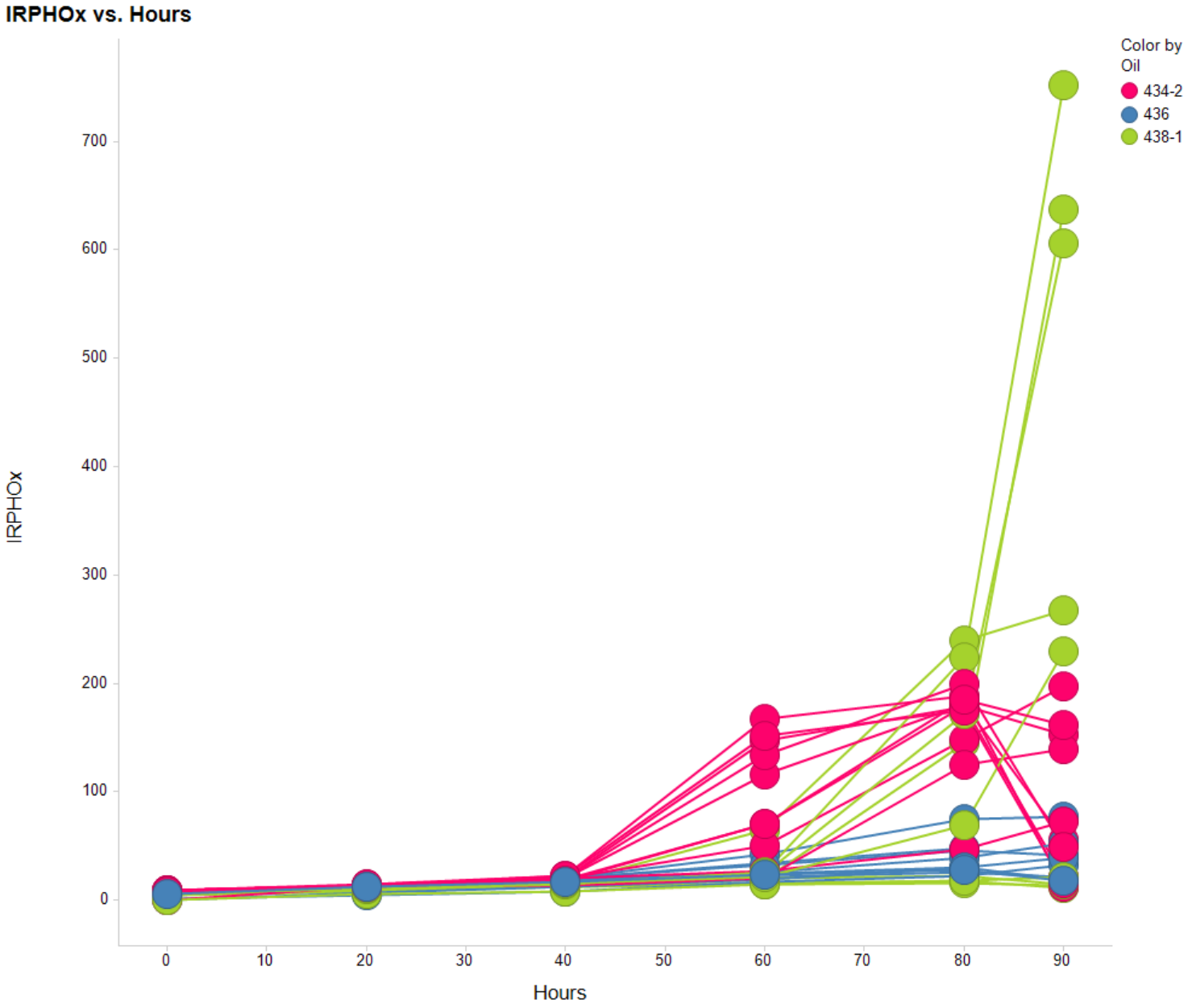
IRO3


IRO3 vs. Hours
Color by Oil
434-2
436
438-1
IRO3
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
Hours

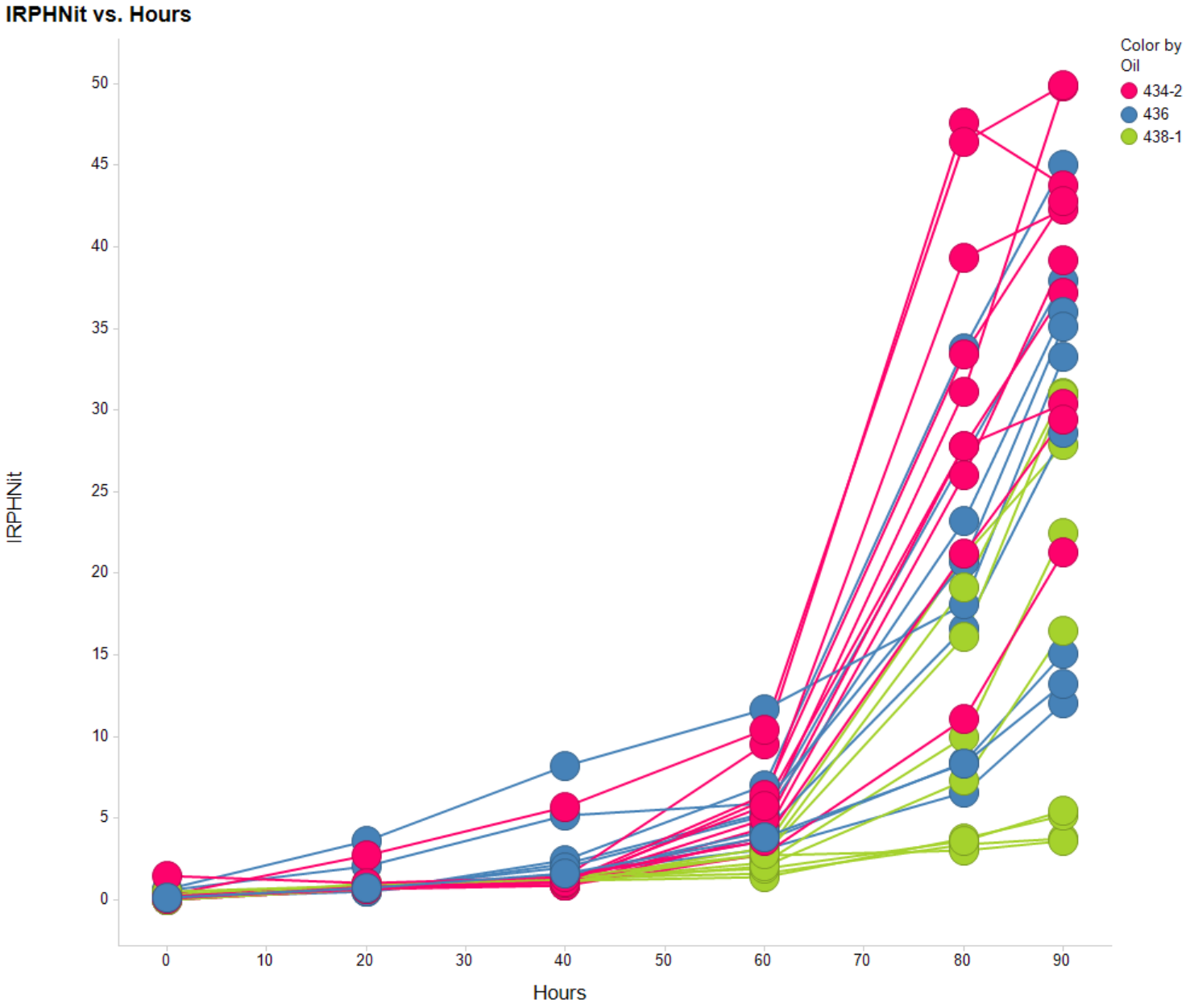
IRN3


IRN3 vs. Hours
Color by Oil
434-2
436
438-1
IRN3
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
Hours

IRPHOx


IRPHOx vs. Hours
Color by Oil
434-2
436
438-1
IRPHOx
0
100
200
300
400
500
600
700
Hours
0
10
20
30
40
50
60
70
80
90

IRPHNit


IRPHNit vs. Hours
Color by Oil
434-2
436
438-1
IRPHNit
Hours
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90

Attachment 2

TOYOTA

Proposal to Sequence IIIH Precision Matrix Data Analysis

November 25th, 2015

Toyota Motor Corporation

IIIH Precision Matrix Data

TOYOTA

Lab-Stand	Run Order	TMC REO	Test No.	PVIS	WPD	Phos Retention
G-1	1	436	106763	19.5	4.45	94.73
A-2	3	436	106775	38.0	4.62	91.51
A-2	4	436	106776	22.7	4.92	92.62
A-1	4	436	106777	54.6	4.30	92.37
E-1	2	436	106783	26.5	4.24	92.78
D-1	3	436	106786	27.8	4.72	95.30
B-1	2	436	106792	22.4	4.77	93.64
B-1	3	436	106793	31.3	4.96	98.06
G-2	1	436	111422	25.3	4.24	95.23
A-2	1	434-2	106778	137.5	3.98	78.47
A-1	3	434-2	106779	104.9	3.66	78.39
E-1	4	434-2	106780	232.4	3.40	82.09
E-1	3	434-2	106781	121.8	4.19	77.42
D-1	1	434-2	106788	13.6	4.73	79.83
D-1	2	434-2	106789A	59.4	5.60	78.85
B-1	4	434-2	106795	99.8	3.93	81.34
G-2	2	434-2	107873	166.6	4.10	79.94
G-2	3	434-2	110227	180.9	3.35	81.28
G-1	4	434-2	110228	129.6	4.28	81.22
G-1	2	438-1	106767	31.2	3.33	81.30
G-1	3	438-1	106768	29.4	3.46	80.85
A-1	1	438-1	106774	265.1	3.34	79.22
E-1	1	438-1	106785	73.6	3.97	78.07
D-1	4	438-1	106791	25.4	3.59	79.22
B-1	1	438-1	106797	24.6	3.32	76.52
A-1	2	438-1	107869	209.0	3.10	77.36
A-2	2	438-1	107870	31.3	3.42	78.49
G-2	4	438-1	107872	130.9	4.50	79.40

IIIH Data from ASTM TMC Website

Sorted by TMC REO and Test No.

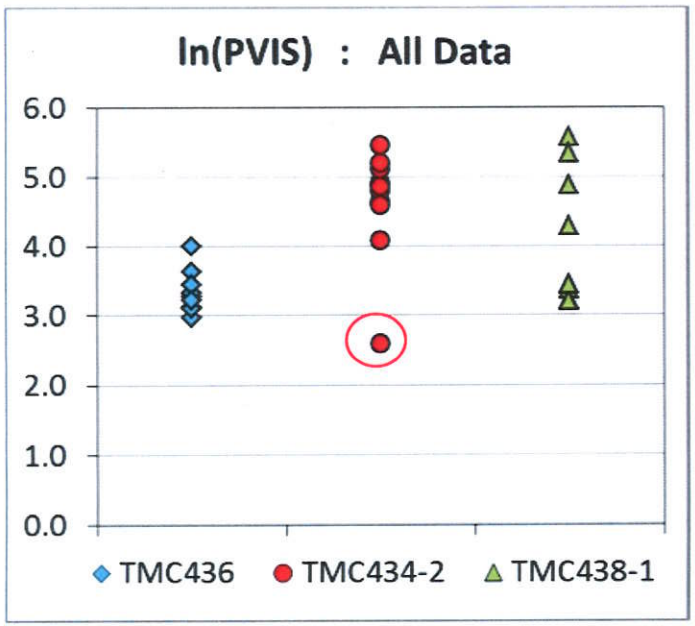
Influencing observations pointed out by Stat Group in the Seq IIIH Precision Matrix Stat Analysis Report. (Nov 9, 2015)

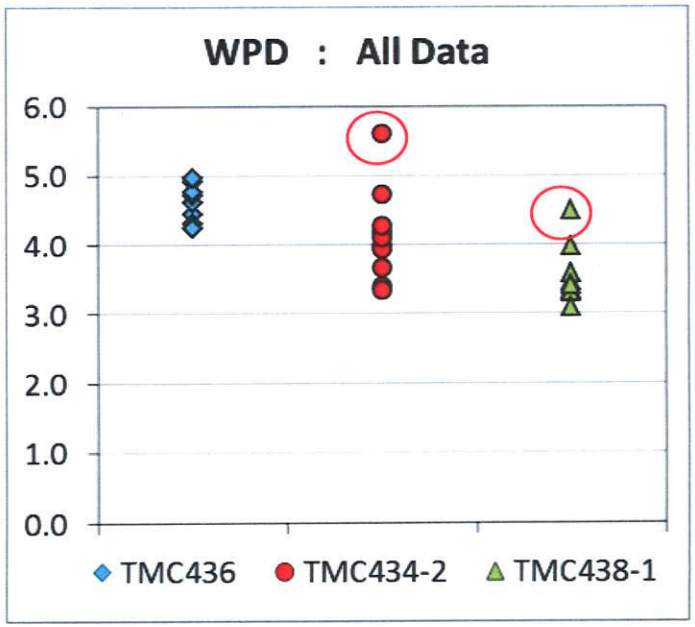
IIIH Precision Matrix Data

TOYOTA

Current Status :

- There are a few data points that influenced to decrease discriminations among reference oils.
- The IIIH SP formed TF to investigate potential problems in those test operations.
- The TF could not find clear evidence to invalidate these concerned data points.





Toyota's Thoughts

TOYOTA

- Treatment of Outliers
  - Approach 1 : Validity of Test Operations
    - Assumption : test operation variation causes the test result variation.
    - No guarantee that monitored operational parameters can capture operational variations.
    - The TF could not find operational problems to invalidate concerned data points.
  - Approach 2 : Statistical Test
    - Check if concerned data point belongs to the same population.
    - If it does not, then excludes it from calculation to set up LTMS.
    - Pros : Tighter allowance will pick up questionable reference data and invalidate its test stand.
    - Cons : Labs may face difficulty to control test stand severity, because source of variation is not yet clarified.

Approach 2

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- Outlier Test : Smirnov-Grubbs Test
  - Assuming the data population follows normal distribution, check each data point to see if it is statistically outlier.
  - Pros : Can identify outlier data point without clarifying its reason.
  - Cons : Need separate work to improve test stand that shows outlier result.

Unbiased Variance

$$u^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

Test Statistic

$$\tau_1 = \frac{x_1 - \mu}{\sigma} \qquad (\sigma = u)$$

Critical Value Calculation for Smirnov-Grubbs Test

$$\tau = \frac{(n-1)t}{\sqrt{n(n-2)+nt^2}}$$

Smirnov-Grubbs Critical Value Table

	significance level (2 tailed test)		
n	0.10	0.05	0.01
6	1.822	1.887	1.973
7	1.938	2.020	2.139
8	2.032	2.126	2.274
9	2.110	2.215	2.387
10	2.176	2.290	2.482
11	2.234	2.355	2.564
12	2.285	2.412	2.636

PVIS : TMC436

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Borderline for Outlier at 0.10 significance level, but not significant enough.

Sequence IIIH Precision Matrix Data

TMC436

Smirnov-Grubbs Critical Values

significance Level	n = 9	n = 8
0.10	2.110	2.032
0.05	2.215	2.126
0.01	2.387	2.274

Percent Viscosity Increase

					n = 9		n = 8	
Lab-Stand	Run Order	TMC REO	Test No.	PVIS	ln(PVIS)	τ	ln(PVIS)	τ
G-1	1	436	106763	19.5	2.97041	-1.1975	2.9704	-1.4041
A-2	3	436	106775	38	3.63759	0.9284	3.6376	1.7812
A-2	4	436	106776	22.7	3.12236	-0.7133	3.1224	-0.6786
A-1	4	436	106777	54.6	4.00003	**2.0832**		*3.5117*
E-1	2	436	106783	26.5	3.27714	-0.2201	3.2771	0.0604
D-1	3	436	106786	27.8	3.32504	-0.0675	3.3250	0.2890
B-1	2	436	106792	22.4	3.10906	-0.7557	3.1091	-0.7421
B-1	3	436	106793	31.3	3.44362	0.3103	3.4436	0.8552
G-2	1	436	111422	25.3	3.23080	-0.3678	3.2308	-0.1609
				Ave	3.34623		3.26450	
				VAR (Sample)	0.0984974		0.0438695	
				σ	0.313843		0.2094505	

* PVIS is transformed by natural log for normal distribution.

PVIS : TMC434-2

TOYOTA

Outlier at 0.01 significance level.

Sequence IIIH Precision Matrix Data

TMC434-2

Smirnov-Grubbs Critical Values

significance Level	n = 10	n = 9
0.10	2.176	2.110
0.05	2.290	2.215
0.01	2.482	2.387

Percent Viscosity Increase

					n = 10		n = 9	
Lab-Stand	Run Order	TMC REO	Test No.	PVIS	ln(PVIS)	τ	ln(PVIS)	τ
A-2	1	434-2	106778	137.5	4.92362	0.3661	4.9236	0.1746
A-1	3	434-2	106779	104.9	4.65301	0.0283	4.6530	-0.5118
E-1	4	434-2	106780	232.4	5.44846	1.0211	5.4485	1.5059
F-1	3	434-2	106781	121.8	4.80238	0.2148	4.8024	-0.1329
D-1	1	434-2	106788	13.6	2.61007	-2.5213		-5.6935
D-1	2	434-2	106789A	59.4	4.08429	-0.6814	4.0843	-1.9543
B-1	4	434-2	106795	99.8	4.60317	-0.0339	4.6032	-0.6382
G-2	2	434-2	107873	166.6	5.11560	0.6057	5.1156	0.6616
G-2	3	434-2	110227	180.9	5.19794	0.7084	5.1979	0.8704
G-1	4	434-2	110228	129.6	4.86445	0.2922	4.8645	0.0246
				Ave	4.63030		4.85477	
				VAR (Sample)	0.6420334		0.1554363	
				σ	0.8012698		0.3942541	

Outlier

* PVIS is transformed by natural log for normal distribution.