Minutes from the July 14th Sequence III WPD Conference Call

The conference was called to order at 8:35 AM CDT

Art Andrews from ExxonMobil went through his proposal on handling the WPD shift. Some of the concerns voiced regarding this proposal were:

1) Mild labs would get a bigger boost with this correction equation
2) This correction will make the range of the data too big (potentially overcorrect)
3) TMC noted that if this correction is applied to the reference data, severe labs will still have a severity adjustment
4) This correction does not stabilize the variance in the data

Phil Scinto discussed a study that Allison Rajakumar of Lubrizol prepared which looked at 108 Sequence IIIG reference runs conducted from 2006 to the present. In summary the report concluded:

1) The standard deviation for these data is dependent on the mean which is not a good position to be in
2) The least square means for WPD does identify lab differences and on some oils and a relation to ring batch code

There were discussions on the possibility of 1/WPD as a possible correction but the group is not confident that there is a correction that will handle the problem perfectly.

One of the main concerns with a correction factor is that if the test changes again the correction may no longer fit and could potentially need to be changed.

Some feel that a change to the LTMS system might be an option; Phil Scinto mentioned that we should look at the possibility of continuous severity adjustments.

<u>Action Items for moving forward:</u>

LTMS group will discuss the IIIG WPD issue during July 16th conference call.

A statistics sub-group specific to the IIIG will be coordinated through Pat Lang to look at WPD corrections one more time.

The call was adjourned at 9:45 AM CDT

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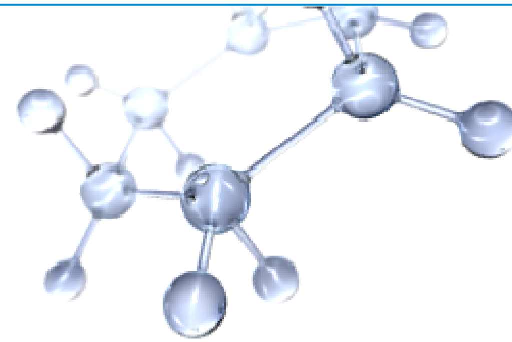

Sequence IIIG

Proposal to address WPD severity shift

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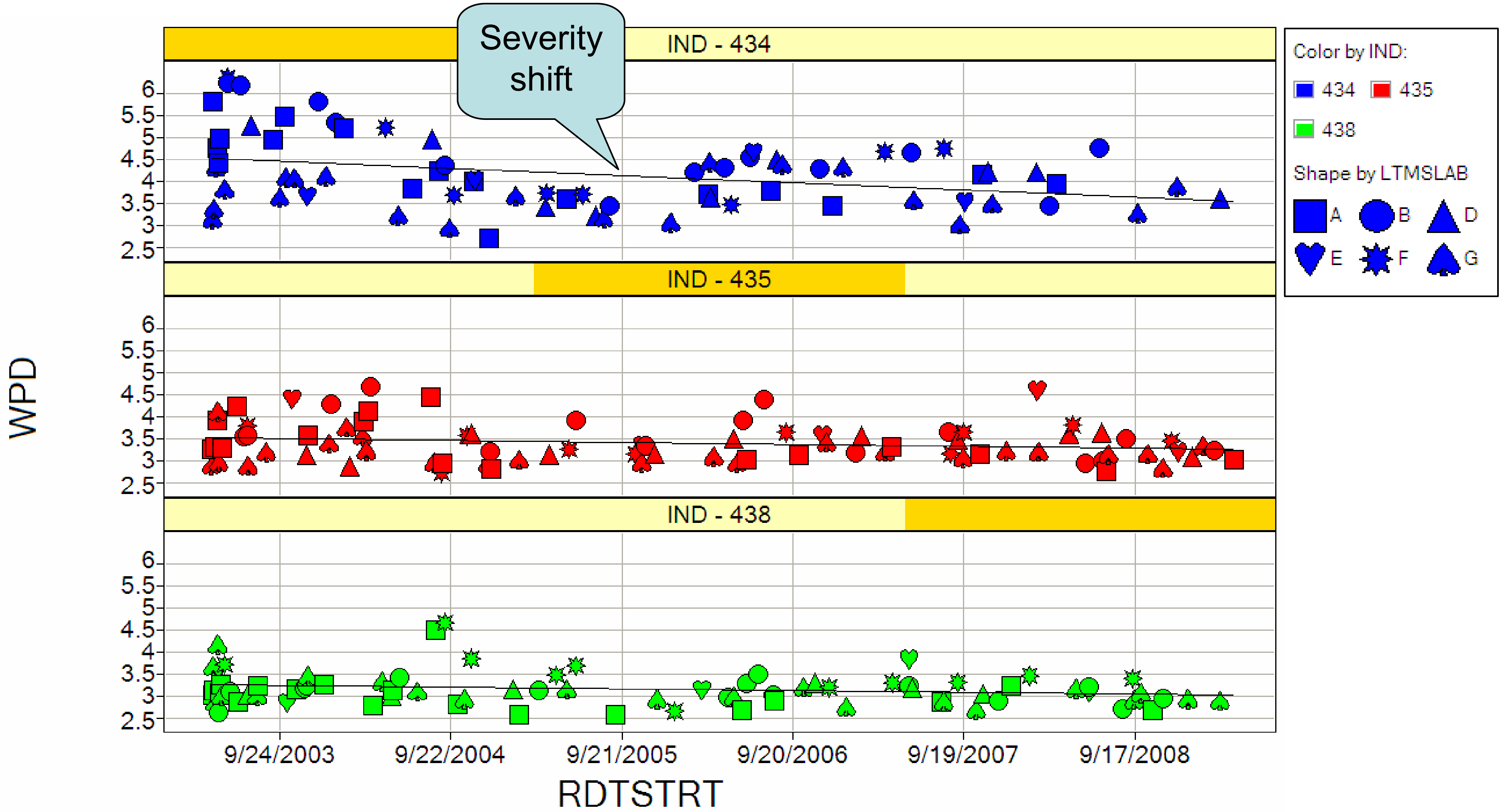
Status of Sequence IIIG WPD

- Severity shift has occurred towards more severe WPD results
- A task force has assembled to study the root cause of the severity shift, and consider actions to address
- The task force reviewed various hypotheses for severity shift's root cause
  - Root cause investigation has been ongoing effort for several years
  - No definitive conclusions are possible at this time due to test complexity
  - Some variables at play: ring batch, piston batch, fuel batch, honing
- Because root cause investigation was inconclusive, task force agrees to focus on path forward
- Another reason to focus on path forward is that test appears to have stabilized
  - Stability observed in 2006-present timeframe - possibly attribute to "Unified Engine" effort
  - Significant lab-to-lab differences (GM identifies these in the 2003-2004 timeframe in particular) have disappeared
  - Severity drift appears to have slowed or stopped
  - Reference oil WPD results remain well below their targets
- ExxonMobil proposes a path forward with this document

Historical Data



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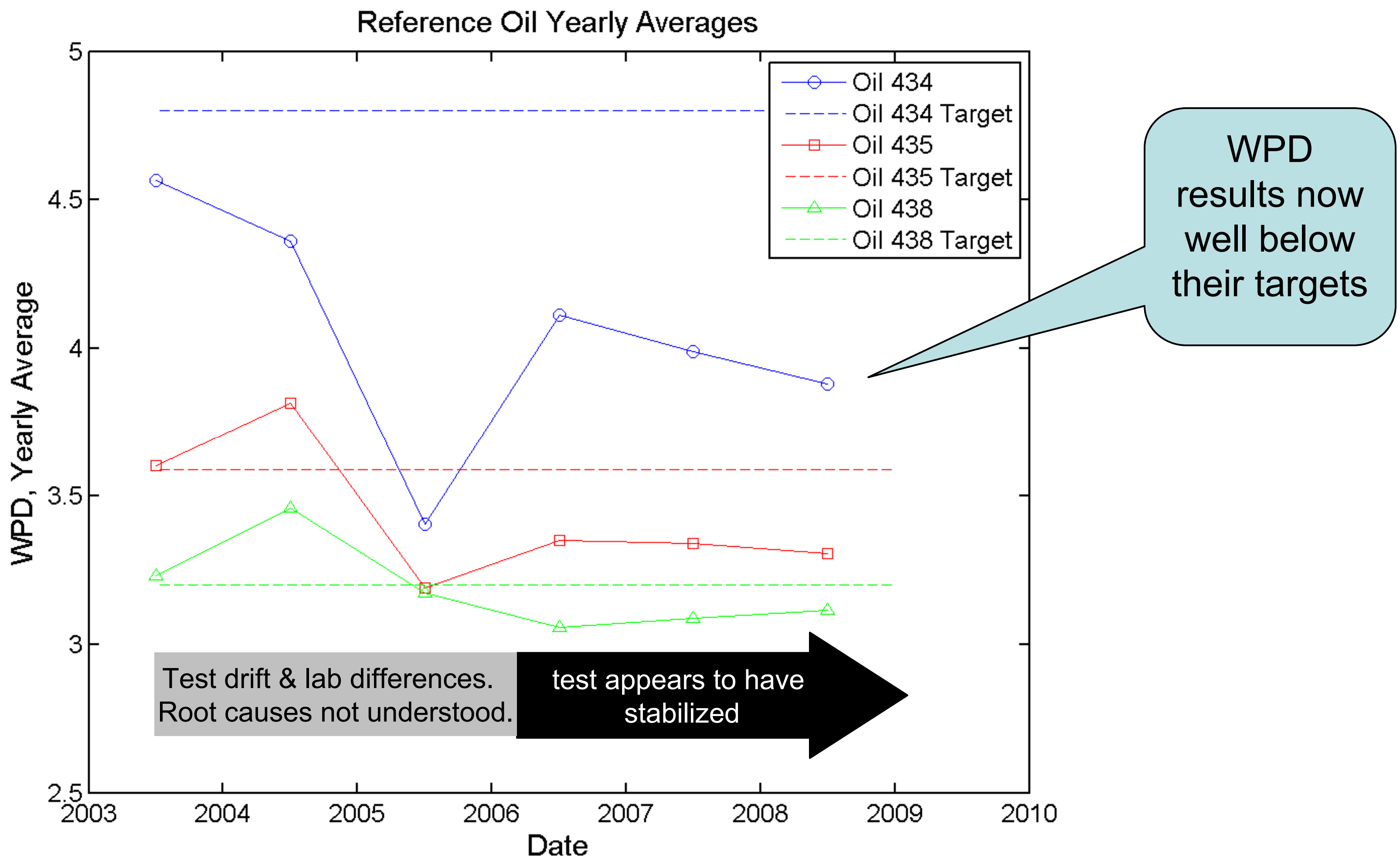
WPD Drift in Sequence IIIG



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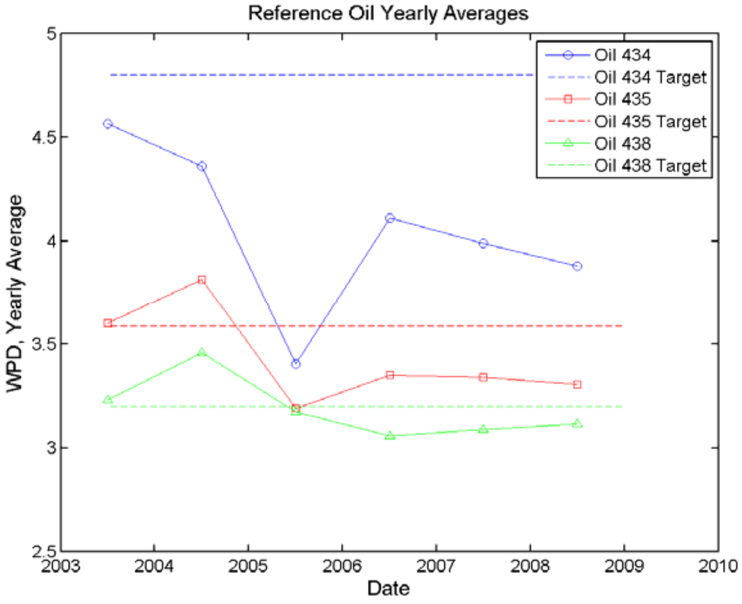
Concerns Over Severity Shift

1. **Observation**: IIIG now produces WPD results on a different scale. (scale has shifted down and/or compressed) .

   Concern: Reference oil targets, and GF-5 and other WPD limits were defined on original scale.

   Concern: Since Feb 2006, >90% of reference oil WPD results are below target – creates situation of large and persistent severity shifts.



2. **Observation**: Oil 434 has drifted the most from its target, 435 has drifted less, and 438 the least.

   Concern: An engine that receives reference oil 434 would likely trigger a greater severity adjustment. Had it received 438, severity adjustment is less likely. This creates a situation where reference oil assignments may bias test oil results.

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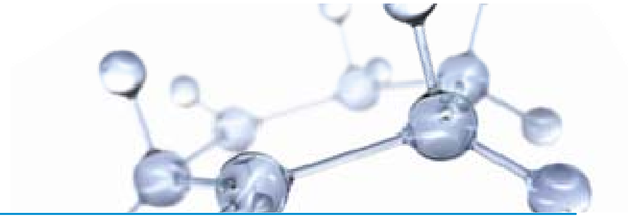
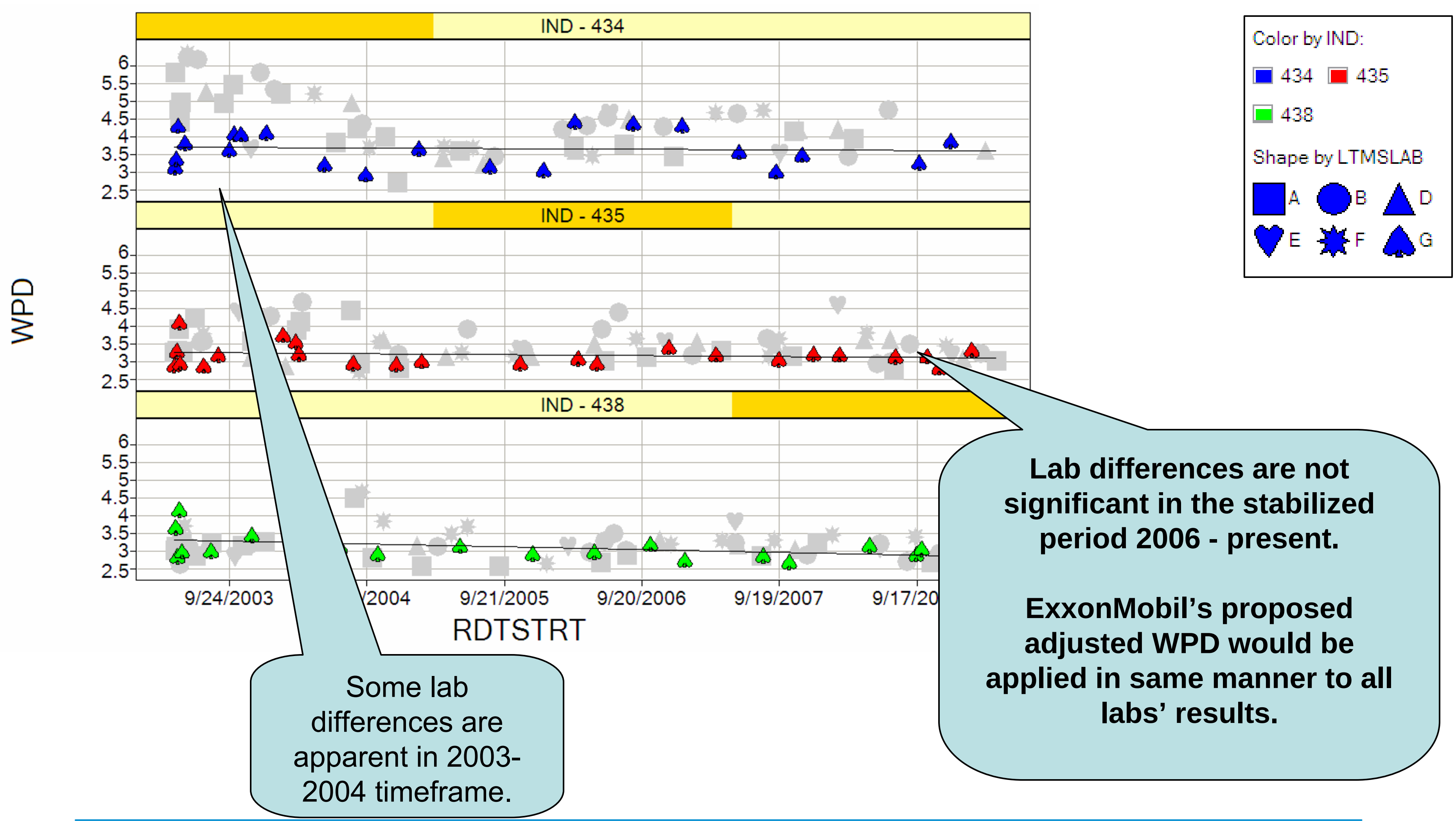
Addressing Severity Shift

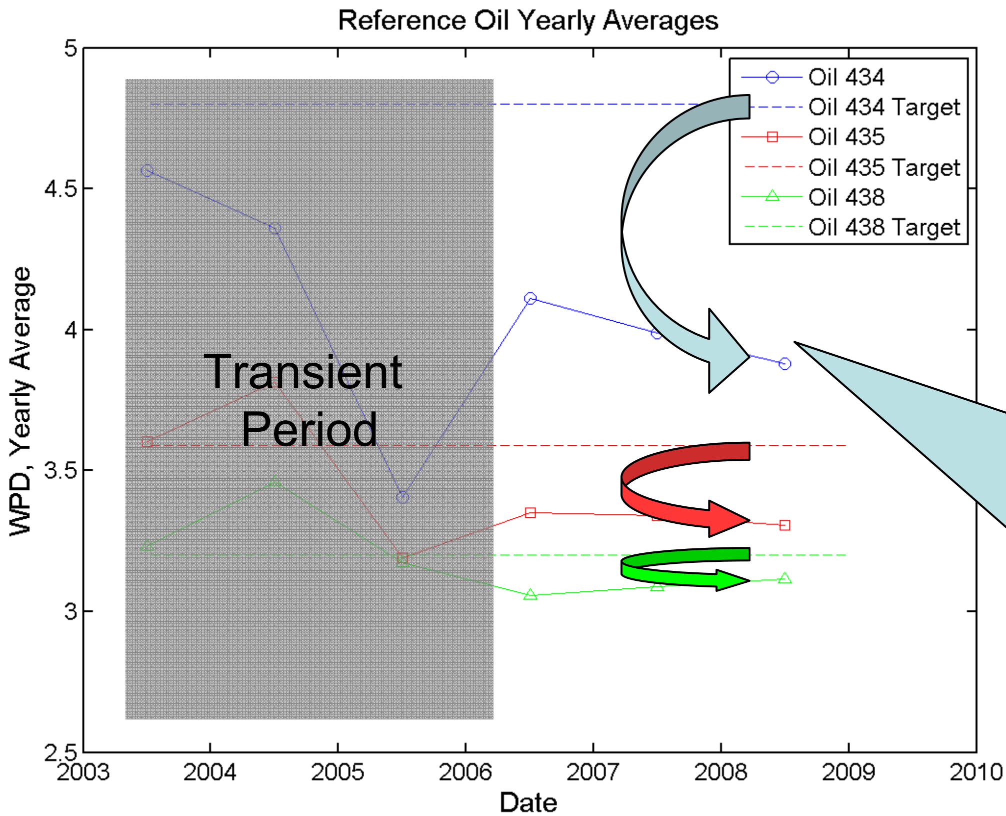


- Strategy: Identify a transformation, when applied to reference oils 434, 435, and 438, places their WPDs back on original scale
  - Simple linear adjustment based on raw WPD appears to be effective
  - Because the transformation is based on raw WPD alone, one can alternately think of it as adjustment of the WPD scale.
- We propose this adjustment be applied to reference and test oils
  - Will re-center reference oils around their limits
  - LTMS severity adjustments would be based on adjusted WPD. This allows LTMS to operate in the way it is intended, by addressing +/- deviations from targets.
  - WPD adjustment reduces the possibility of reference oil assignments biasing test oil results, because it re-centers WPD results of all three reference oils (434, 435, 438) around their targets.
- The remaining slides explain how the adjustment was determined and how it may be applied.

Historical Data: Lab Differences



Extent of Severity Shift



Oil	Target	Avg. WPD, 2/06+	Delta
434	4.80	4.03	0.77
435	3.59	3.36	0.23
438	3.20	3.10	0.10

Because the test has stabilized, the important issue going forward is the Delta between reference oil targets and their WPDs in the stabilized period.

The Delta is greater for higher WPD Oils, indicating a compression of WPD scale.

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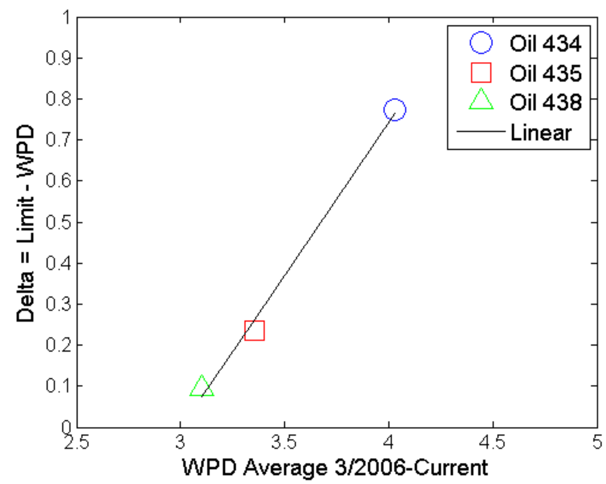
An Adjusted WPD

Oil	Target	Avg. WPD, 2/06+	Delta
434	**4.80**	**4.03**	**0.77**
435	**3.59**	**3.36**	**0.23**
438	**3.20**	**3.10**	**0.10**



- The WPD scale appears to have compressed linearly
- A simple linear re-scaling of stabilized WPD results can restore WPD values to its original scale.

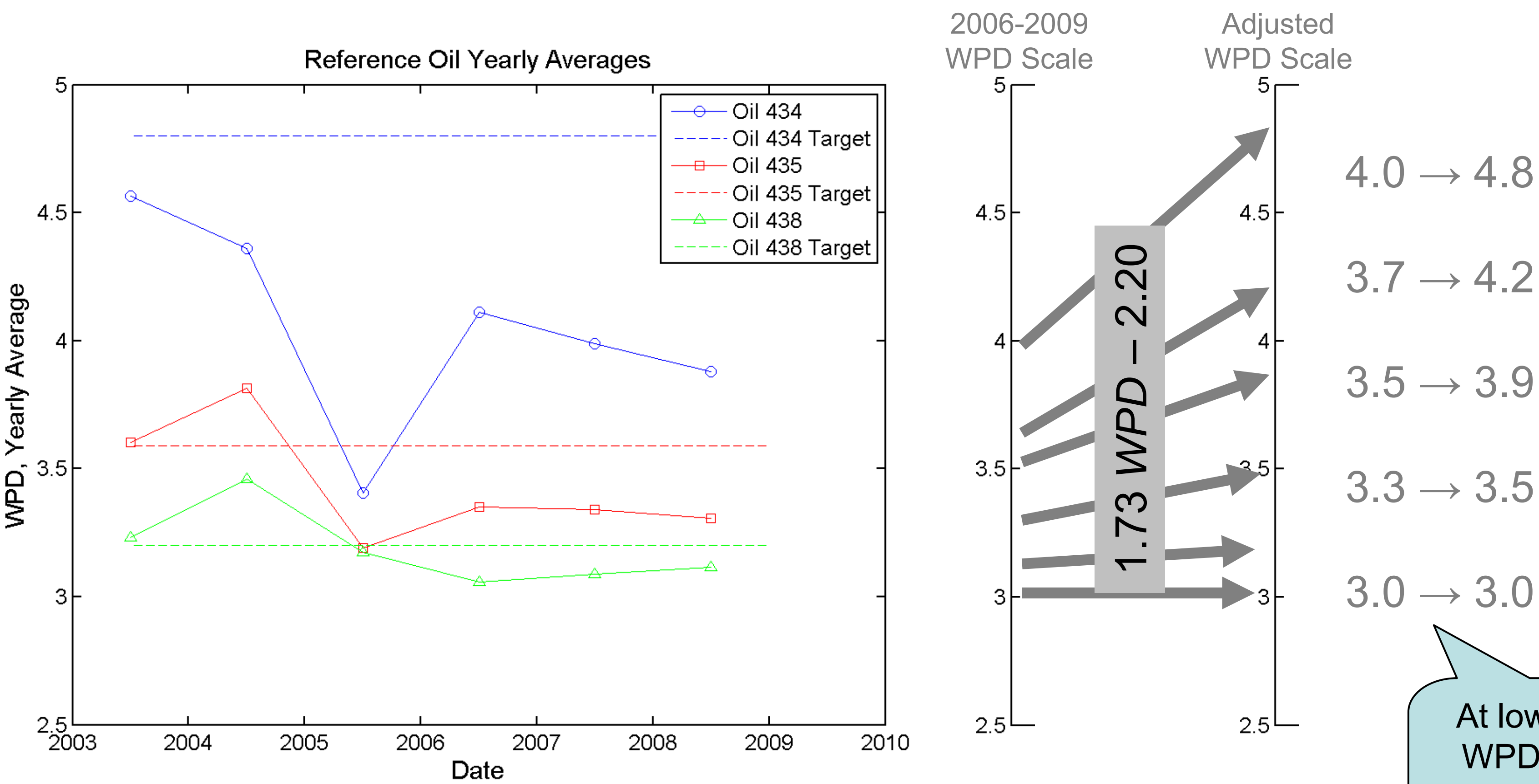
Oil	Target	Avg. WPD, 2/06+	Delta	Adjusted WPD = 1.73 WPD - 2.2
434	**4.80**	**4.03**	**0.77**	**4.77**
435	**3.59**	**3.36**	**0.23**	**3.61**
438	**3.20**	**3.10**	**0.10**	**3.16**

$$\textit{Adjusted WPD} = 1.73\ \textit{WPD} - 2.20$$

Compare this column to Targets column.

Adjustment restores WPDs to original scale.

WPD Correction as a Stretching Transformation of the WPD Scale



At low end of WPD range, adjustment is small

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Conclusions

- Sequence IIIG now appears to produce WPD results on a different scale than its initial results. This is cause for concern, because reference oil targets and GF-5 and other limits were based on the original scale. (Concern 1)

- Furthermore, high WPD reference oils have shifted the most below their targets, which creates the possibility that reference oil assignments could bias test oil results. (Concern 2)

- The test appears to have stabilized in 2006. ExxonMobil hopes to address concerns 1 and 2 by resolving the discrepancy between reference oil targets, and measured WPDs in the stabilized time period.

- By comparing the averages of stabilized WPD results to reference oil targets, the scale of WPD results appears to have compressed linearly.

Conclusions (con't)

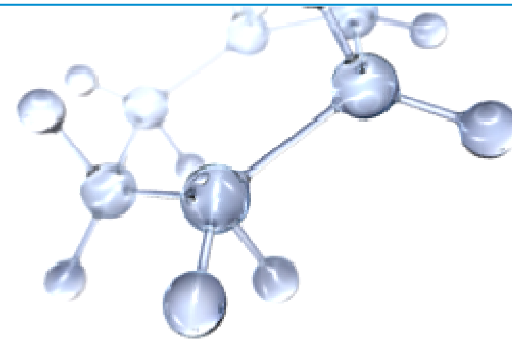
- A linear adjustment of the WPD scale effectively transforms reference oil WPD results back into the original scale. ExxonMobil proposes this re-scaling be applied to reference and test oil results. ExxonMobil proposes no changes to reference oil targets.

- The adjusted WPD centers reference oil results around their targets.
  - For this reason, LTMS variables (*Y* and *Z*) calculated with adjusted WPD reduces the possibility of reference oil assignments biasing test oil results.

- ExxonMobil sees the adjusted WPD as a straightforward solution to Sequence IIIG WPD concerns 1 and 2 (defined on previous slide).

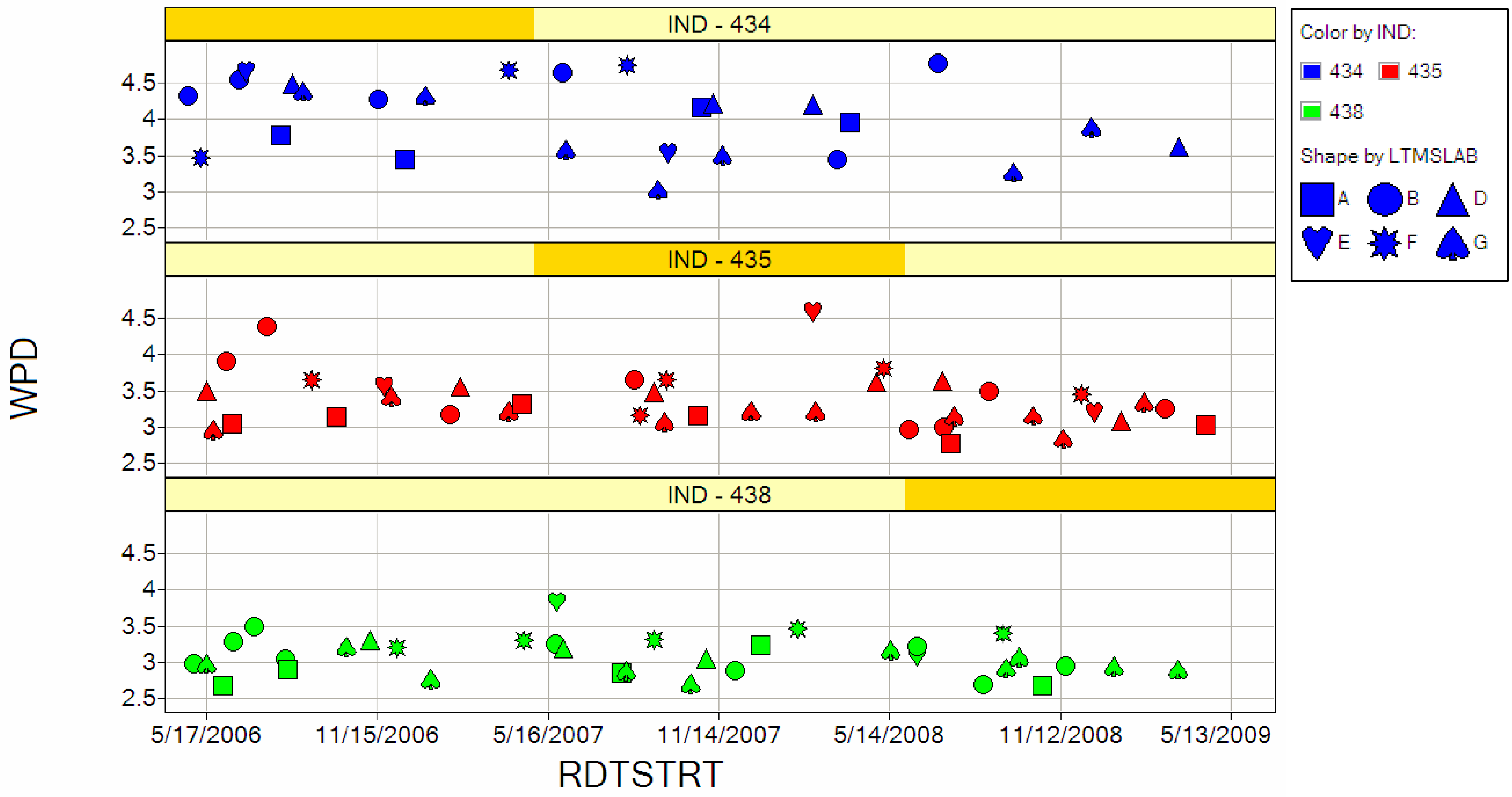
Phasing In the Adjusted WPD

- Timing for phase-in
  - Severity adjustments may be reset at this point, or recalculated based on weighted averages of past adjusted WPDs using LTMS calculations.
  - ExxonMobil welcomes suggestions about phase-in from the task force.
  - Possibly synchronize with formal introduction of new reference oil 434-1.
- Adjusted WPD may simplify Oil 434-1 introduction
  - Oil 434-1 poses a problem: define its target same as 434 target (4.8), or as mean of its WPD results (~3.9)?
  - The first choice is problematic because 434-1 target would be based on results from a different oil.
  - The second choice is problematic because with ~3.9 WPD target, 434-1 would be less likely to trigger severity adjustments than oils 435 and 438. 434-1 would give WPDs centered around its target, while 435 and 438 would continue to give WPDs consistently below their targets.
  - Adjusted WPD is a potential solution to these concerns. It transforms oil 434-1 results from 3.9 → 4.6 (similar to Oil 434 target). Allows us to define target based on 434-1 results, and reduce possibility of reference oil biasing.



Backup Slides

Test Has Stabilized ’06 – ’09



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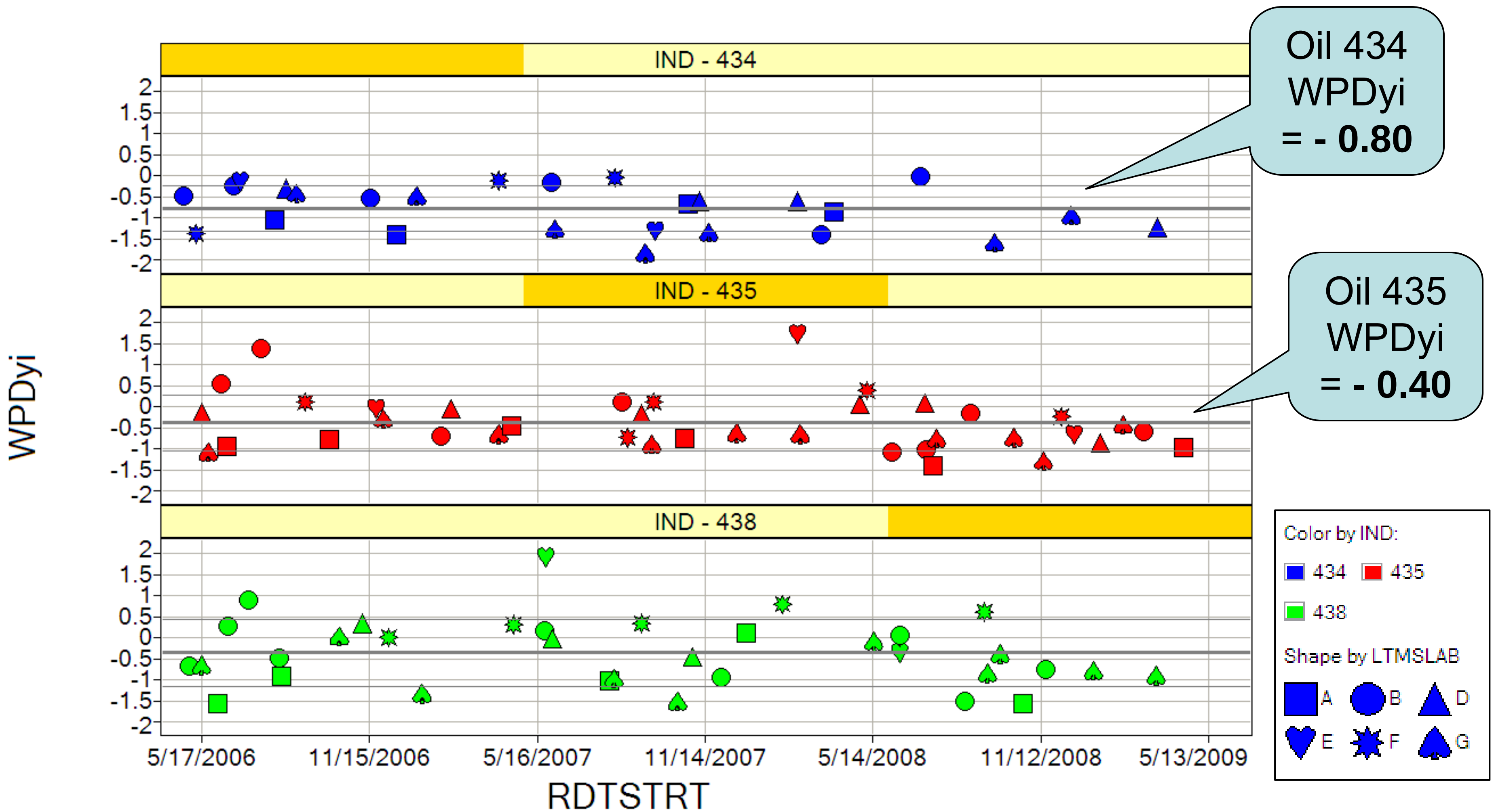
WPDyi: Oil 434 gives lower values than Oils 435 & 438

Creates concern that reference oil assignments could bias test oil results (Concern 2)



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IIIG WPD

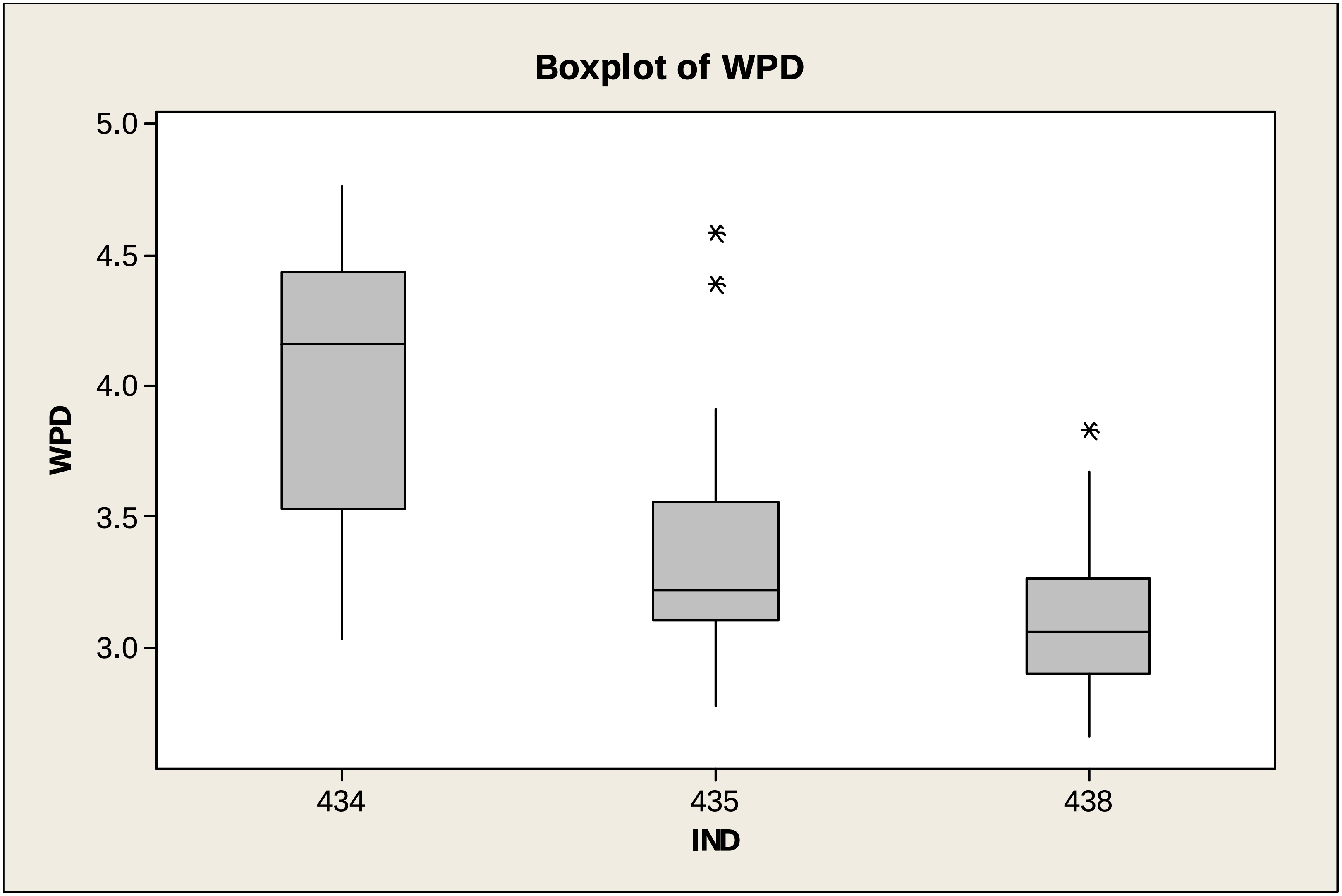
Study Using IIIG Reference Oils from 2006 to present

July 2009

Summary of Data

- 108 Runs Total
  - Oil 434 = 31
  - Oil 435 = 39
  - Oil 438 = 38
- Each oil run at the following Labs
  - A, B, D, E, F, G
- Ring Batches for each oil
  - Oil 434 = 4, 6, 7
  - Oil 435 = 6, 7
  - Oil 438 = 5, 6, 7

Boxplot of WPD by Ref Oil



ANOVA for Oil434

Dependent variable: WPD

Source	DF	Sum of Squares	Mean Square	F Value	p value
Model	7	2.5050	0.3579	1.45	0.234
Error	23	5.6774	0.2468		
Total	30	8.1823			

ANOVA for Oil434

Analysis of variance for Lab and Ring, using Adjusted SS for tests

Source	DF	Adj SS	Adj MS	F value	p value
LAB	5	1.5944	0.3189	1.29	0.302
RING	2	0.6062	0.3031	1.23	0.311

S = 0.496831

ANOVA for Oil434

Least Squares Means for WPD

Lab	Mean
A	3.536
B	4.116
D	3.832
E	3.821
F	4.026
G	3.576

Ring Batch	Mean
4	3.612
6	4.092
7	3.749

ANOVA for Oil435

Dependent variable: WPD

Source	DF	Sum of Squares	Mean Square	F Value	p value
Model	6	2.4266	0.4044	4.23	0.003
Error	32	3.0626	0.0957		
Total	38	5.4892			

ANOVA for Oil435

Analysis of variance for Lab and Ring, using Adjusted SS for tests

Source	DF	Adj SS	Adj MS	F value	p value
LAB	5	1.7297	0.3460	3.61	0.011
RING	1	0.5560	0.5560	5.81	0.022

S = 0.309365

ANOVA for Oil435

Least Squares Means for WPD

Lab	Mean
A	3.032
B	3.414
D	3.440
E	3.740
F	3.466
G	3.117

Ring Batch	Mean
6	3.498
7	3.238

ANOVA for Oil438

Dependent variable: WPD

Source	DF	Sum of Squares	Mean Square	F Value	p value
Model	7	1.1910	0.1702	3.14	0.013
Error	30	1.6256	0.0542		
Total	37	2.8166			

ANOVA for Oil438

Analysis of variance for Lab and Ring, using Adjusted SS for tests

Source	DF	Adj SS	Adj MS	F value	p value
LAB	5	1.1076	0.2215	4.09	0.006
RING	2	0.4208	0.2104	3.88	0.032

S = 0.232779

ANOVA for Oil438

Least Squares Means for WPD

Lab	Mean
A	2.708
B	2.990
D	2.974
E	3.365
F	3.145
G	2.778

Ring Batch	Mean
5	2.633
6	3.146
7	3.201

ANOVA for All Oils Combined

Dependent variable: WPD

Source	DF	Sum of Squares	Mean Square	F Value	p value
Model	10	19.7832	1.9783	16.68	0.000
Error	97	11.5064	0.1186		
Total	107	31.2896			

ANOVA for All Oils Combined

Analysis of variance for Lab and Ring, using Adjusted SS for tests

Source	DF	Adj SS	Adj MS	F value	p value
REF OIL	2	13.8088	6.9044	58.20	0.000
LAB	5	3.7411	0.7482	6.31	0.000
RING	3	1.0574	0.3508	2.96	0.036

S = 0.344417

ANOVA for All Oils Combined

Least Squares Means for WPD

Lab	Mean
A	3.019
B	3.411
D	3.340
E	3.584
F	3.469
G	3.084

Ring Batch	Mean
4	3.186
5	3.089
6	3.578
7	3.420

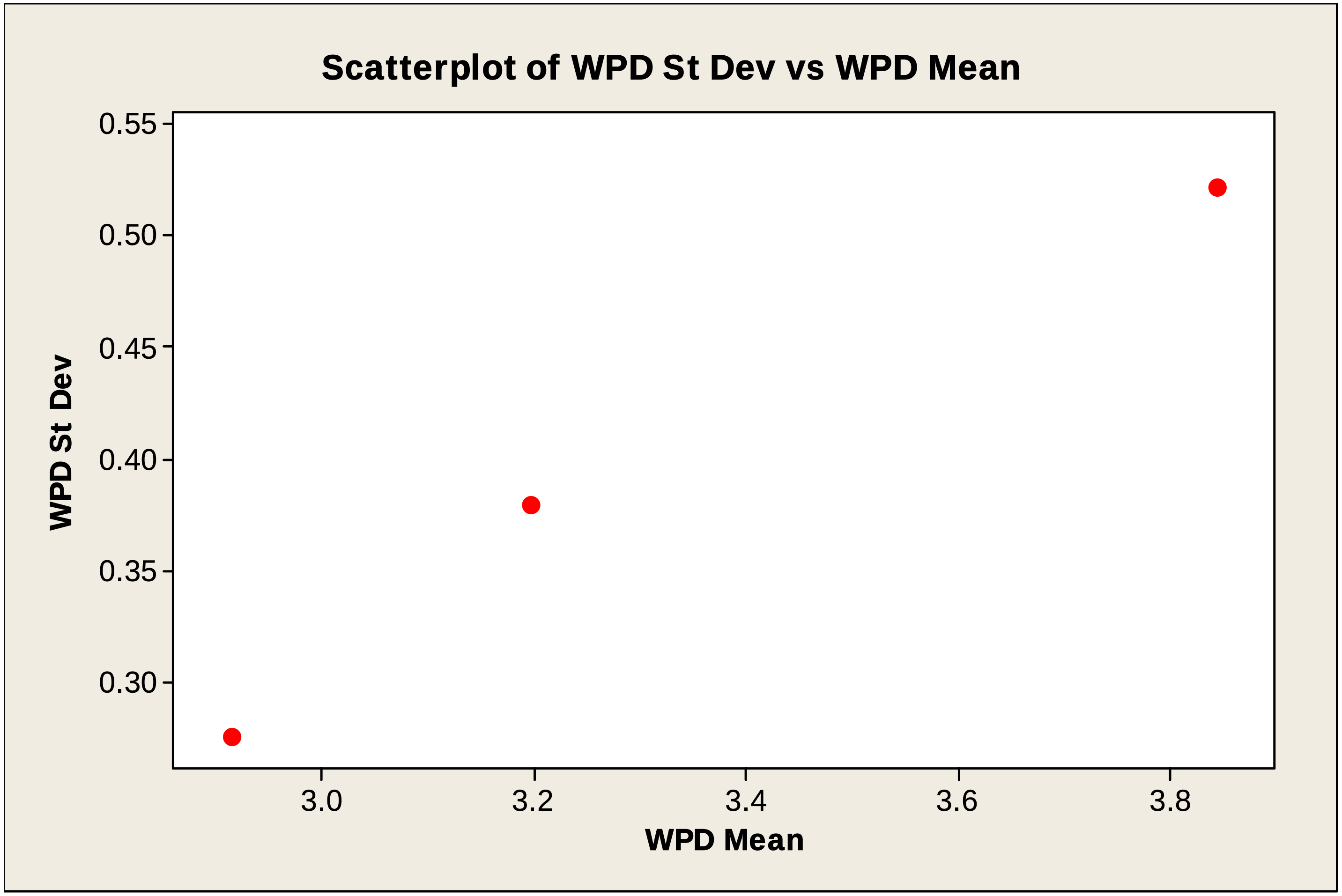
Oil	Mean
434	3.843
435	3.196
438	2.915

Table of Estimated IIIG WPD Reference Oil Statistics
Relation Between Standard Deviation and Mean

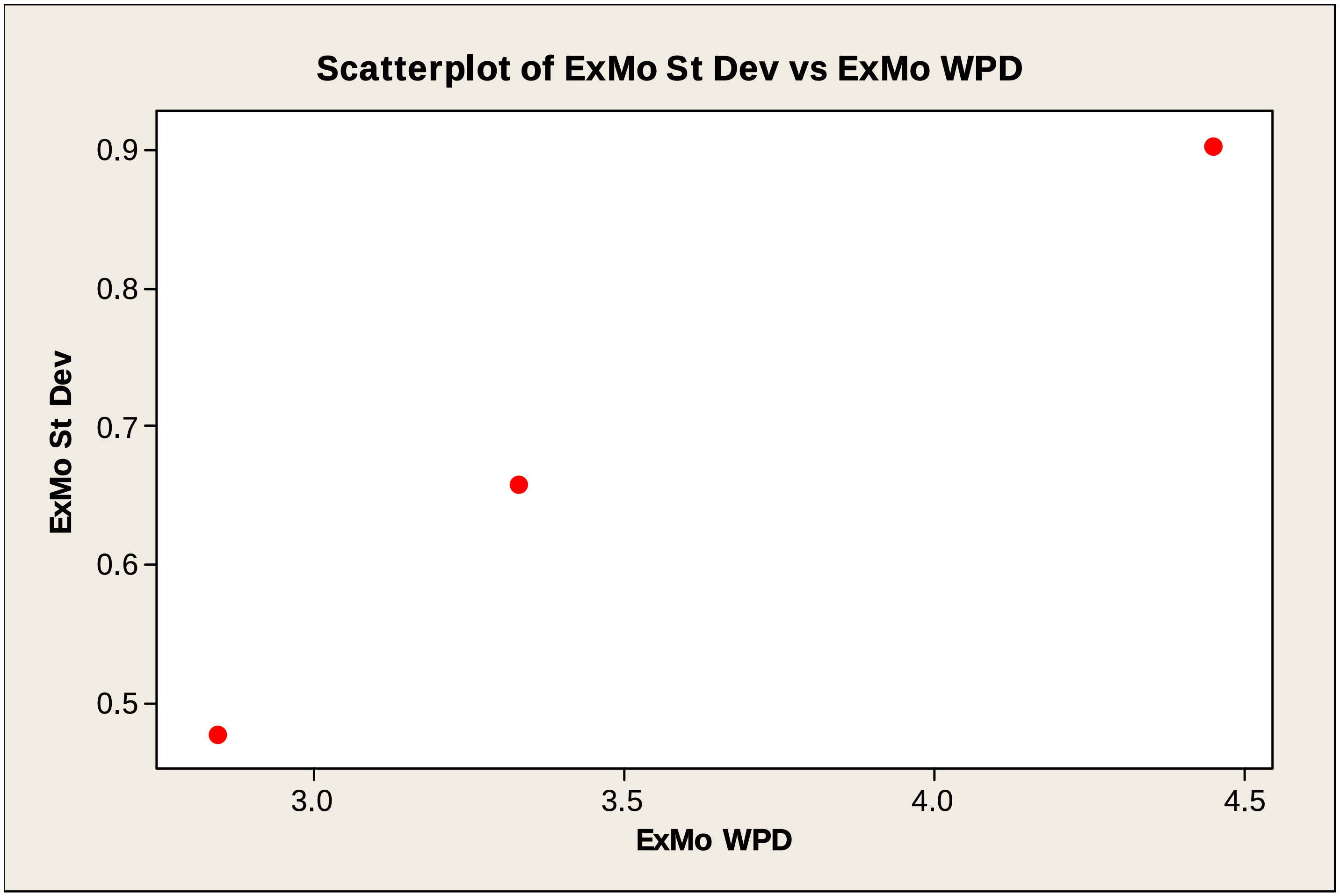
Reference Oil	Oil 434	Oil 435	Oil 438
Root MSE (Standard Deviation)	0.4968 0.8595 0.0333 0.1277	0.3094 0.5352 0.0244 0.0856	0.2328 0.4027 0.0241 0.0745
WPD Mean	3.8430 4.4483 0.2681 1.3318	3.1957 3.3285 0.3152 1.1584	2.9154 2.8436 0.3407 1.0745

Key: WPD ExMo WPD 1/WPD ln(WPD)

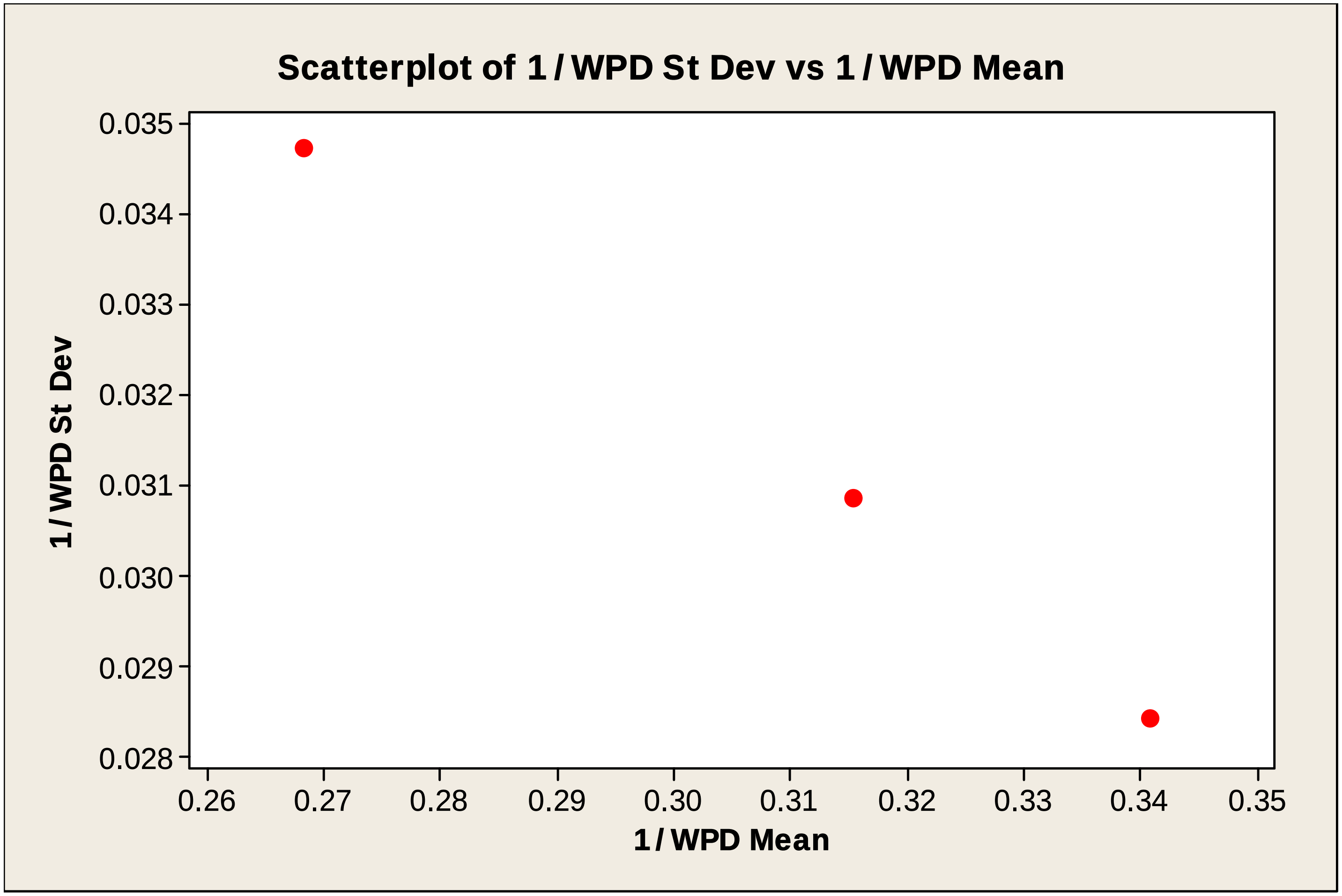
Plot: Relation Between Root MSE and WPD mean



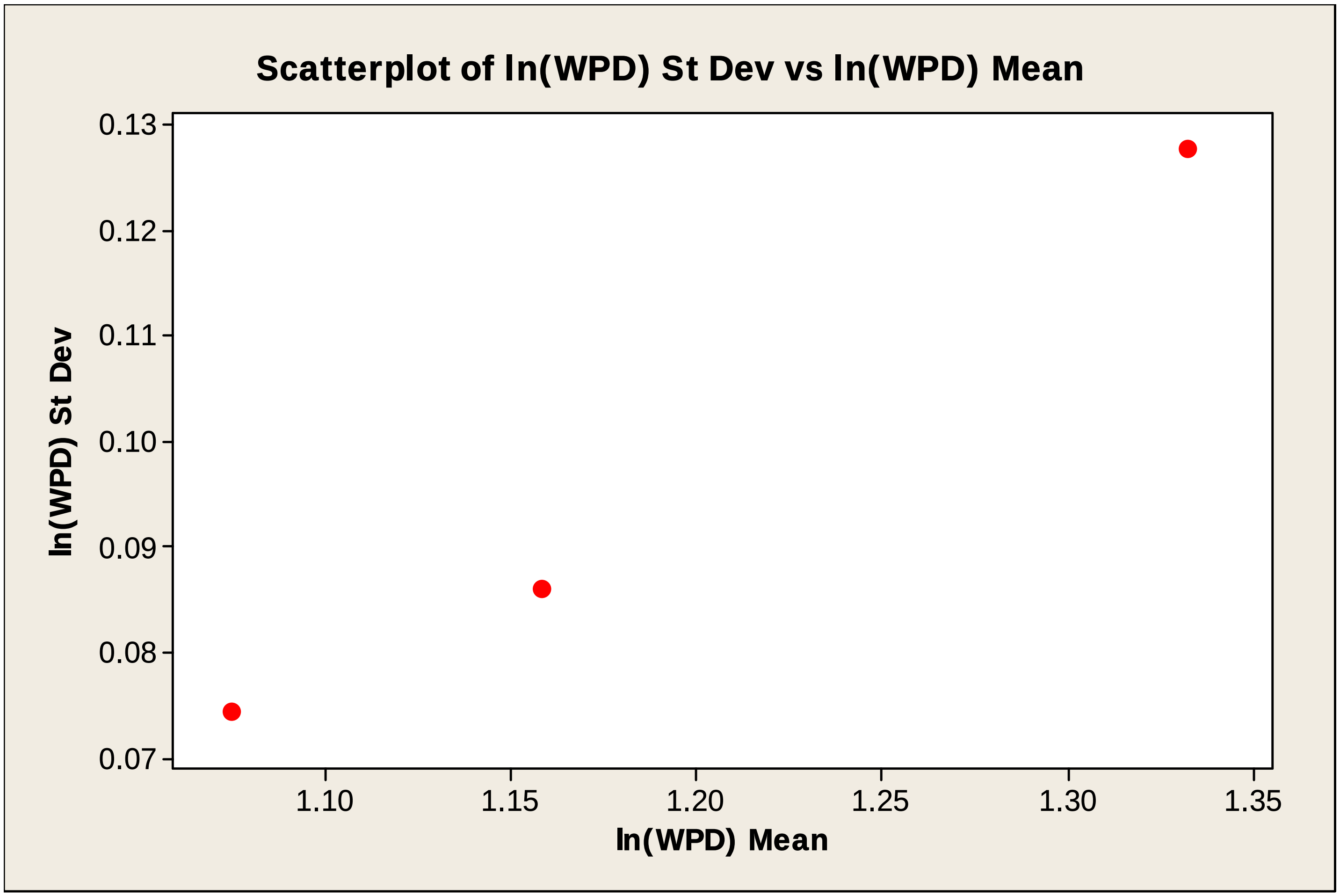
Plot: Relation Between Root MSE and ExMo WPD mean



Plot: Relation Between Root MSE and 1/WPD mean



Plot: Relation Between Root MSE and ln(WPD) mean



Conclusions

- Do not see much of an advantage in using Exxon Mobil transformation (1.73WPD – 2.2)
  - Does not stabilize variance
  - Higher variability
  - May not hold for the future and would have to come up with another transformation down the road
- In addition, the other transformations, 1/WPD and ln(WPD), do not seem to have much of an advantage over WPD in terms of stabilizing the variance
- A change in LTMS may be an option for consideration in terms of calibration costs