Sequence III Surveillance Panel Meeting

Teams
Thursday August 24, 2023 1:00 – 2:30 CDT

Agenda

1.0) Attendance

2.0) Chairman Comments

None

3.0) Approval of minutes

3.1) Minutes from 5/3/2023 Meeting
Approved

4.0) IIIH Action Items

4.1) IIIH Hardware Update – Bowden
1-year of BC 5 pistons in stock
2.5-years of batch 8 rings
Batch 6 pistons are in stock. The SP will determine the implementation strategy closer to required first use.

4.2) Fuel Update - Haltermann
No report

4.3) Statistics Review – Kostan
Some parameters have been off target for a while – discussion about appropriate actions
T. Kostan led this portion of the meeting, see the included stats group presentation for details. During the next meeting there will be motions to update the 438-2 WPD targets and now that more data is available to adjust the reference oil standard deviations. This will remove the reference oil impact on the severity adjustments.

The likely target date for implementing these changes will be September 8, 2023. Since the panel will have had two weeks to think through the implications of these changes before the meeting when this will be voted on, that time will be considered the 2-week waiting period. There is a small test bias from not resetting the 438-2 WPD targets. There was some discussion to back calculate the targets for three calibration periods – think through how far back this should go for the discussion at the next meeting.

4.4) Update about rebuilding engines –
Meeting ended on topic 4.3 when we ran out of time.

4.5) Other Topics

5.0) Old Business

5.1) TBD

6.0) New Business

6.1) TBD

7.0) Review / Update Scope and Objectives

8.0) Next Meeting

Thursday September 7 at 1pm CDT

9.0) Meeting Adjourned

ASTM Sequence III Surveillance Panel (19 Voting members) date: 8/24/2023

Signature: RJ Stockwell

Present	Name/Address		Phone/Fax/Email		
	Jorge Agudelo		jorge.agudelo@bp.com	Voting Member	Present ____
✓	Adrian Alfonso	MARTIN L	adrian.alfonso@intertek.com	Voting Member	Present ____
✓	Jason Bowden		jhbowden@ohtech.com	Voting Member	Present ____
	Michael Deegan		mdeegan@ford.com	Voting Member	Present ____
✓	Richard Grundza		reg@astmtmc.org	Voting Member	Present ____
	William Hairston		whhairston@jhaltermann.com	Voting Member	Present ____
✓	Jeff Hsu, PE		j.hsu@shell.com	Voting Member	Present ____
	Teri Kowalski		teri.kowalski@toyota.com	Voting Member	Present ____
✓	Dan Lanctot		dlanctot@tei-net.com	Voting Member	Present ____
✓	Patrick Lang		plang@swri.org	Voting Member	Present ____
✓	Ben Maddock		Ben.Maddock@AftonChemical.com	Voting Member	Present ____
✓	Dave Passmore	SID CLARK	dpassmore@imtsind.com	Voting Member	Present ____
✓	Michael Raney	TIM CUSHING	michael.p.raney@gm.com	Voting Member	Present ____
	Andrew Ritchie	TODD	andrew.ritchie@infineum.com	Voting Member	Present ____
✓	Amol Sawant		acsawant@valvolineglobal.com	Voting Member	Present ____
✓	Michael A Scudiero		michael.a.scudiero@exxonmobil.com	Voting Member	Present ____
✓	Robert Stockwell		robert.stockwell@chevron.com	Voting Member	Present ____
✓	George Szappanos		george.szappanos@lubrizol.com	Voting Member	Present ____
✓	Haiying Tang		haiying.tang@stellantis.com	Voting Member	Present ____

NO VOTES WERE TAKEN

Effective Sept 9 apply after Sept 9

... slide 59 changes

Name/Address	Phone/Fax/Email	Signature:	
✓ Ricardo Affinito	affinito@chevron.com	N-V Member	Present_____
Laura Birnbaumer	labi@chevron.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_____
Bill Buscher III	william.buscher@intertek.com	N-V Member	Present_____
✓ Bob Campbell	bob.campbell@aftonchemical.com	N-V Member	Present_____
Domingo Carreon	domingo.carreon@intertek.com	N-V Member	Present_____
Jim Carter	jcarter@gageproducts.com	N-V Member	Present_____
Timothy L. Caudill	tlcaudill@ashland.com	N-V Member	Present_____
✓ Martin Chadwick	martin.chadwick@intertek.com	N-V Member	Present_____
Jeff Clark	jac@astmtmc.org	N-V Member	Present_____
✓ Sid Clark	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@Infineum.com	N-V Member	Present_____
Joe Franklin	joe.franklin@intertek.com	N-V Member	Present_____
✓ Izabela Gabrel	IGabrel@h-c-s-group.com	N-V Member	Present_____
✓ Travis Kostan	travis.kostan@swri.org	N-V Member	Present_____
Walter Lerche	walt.lerche@gm.com	N-V Member	Present_____
Charlie Leverett	charlie.leverett@yahoo.com	N-V Member	Present_____
Michael Lochte	Michael.lochte@swri.org	N-V Member	Present_____
✓ Jo Martinez	JoMartinez@chevron.com	N-V Member	Present_____
Murdock, William A.	william.murdock@swri.org	N-V Member	Present_____
Mark Overaker	mhoveraker@jhaltermann.com	N-V Member	Present_____
Scott Rajala	srajala.1460@idemitsu.com	N-V Member	Present_____

ASTM Sequence III Surveillance Panel (19 Voting members) date:

Name/Address	Phone/Fax/Email	Signature:	
✓ Andrew Rohlfing	Andrew.Rohlfing@AftonChemical.com	N-V Member	Present_____
Cliff Salvesen	clifford.r.salvesen@exxonmobil.com	N-V Member	Present_____
Elisa Santos	elisa.santos@infineum.com	N-V Member	Present_____
Hirano Satoshi	satoshi_hirano_aa@mail.toyota.co.jp	N-V Member	Present_____
Philip R. Scinto	prs@lubrizol.com	N-V Member	Present_____
✓ Amanda Stone	Amanda.Stone@newmarket.com	N-V Member	Present_____
Chris Taylor	pslservicesinc@gmail.com	N-V Member	Present_____
Jonathan VanScoyoc	VANSCJ@cpchem.com	N-V Member	Present_____
Angela Willis	angela.willis@willisadvancedconsulting.com	N-V Member	Present_____
Dean Wingert	dwingert@ford.com	N-V Member	Present_____
Justin Wolfe	Justin.Wolfe@lubrizol.com	N-V Member	Present_____
Yue Zhang	Yue.Zhang@Lubrizol.com	N-V Member	Present_____

Other Attendees:

✓ MIKE SCUDIERO

IIIH Severity Review

STATS GROUP

JULY 2023

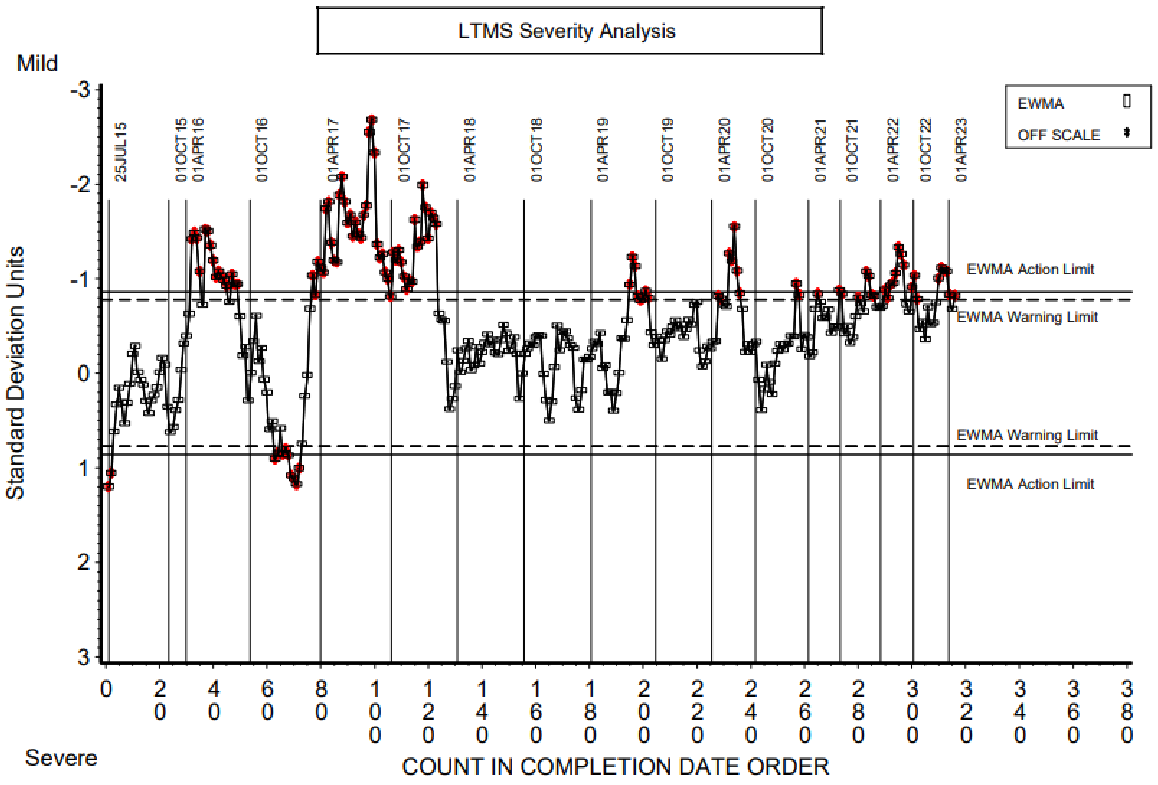
Stats Group

- Amanda Stone, Afton
- Ricardo Affinito, Chevron Oronite
- Jo Martinez, Chevron Oronite
- Todd Dvorak, Infineum
- Martin Chadwick, Intertek
- Phil Scinto, Lubrizol
- Seth Demel, Shell
- Travis Kostan, SwRI
- Richard Grundza, TMC

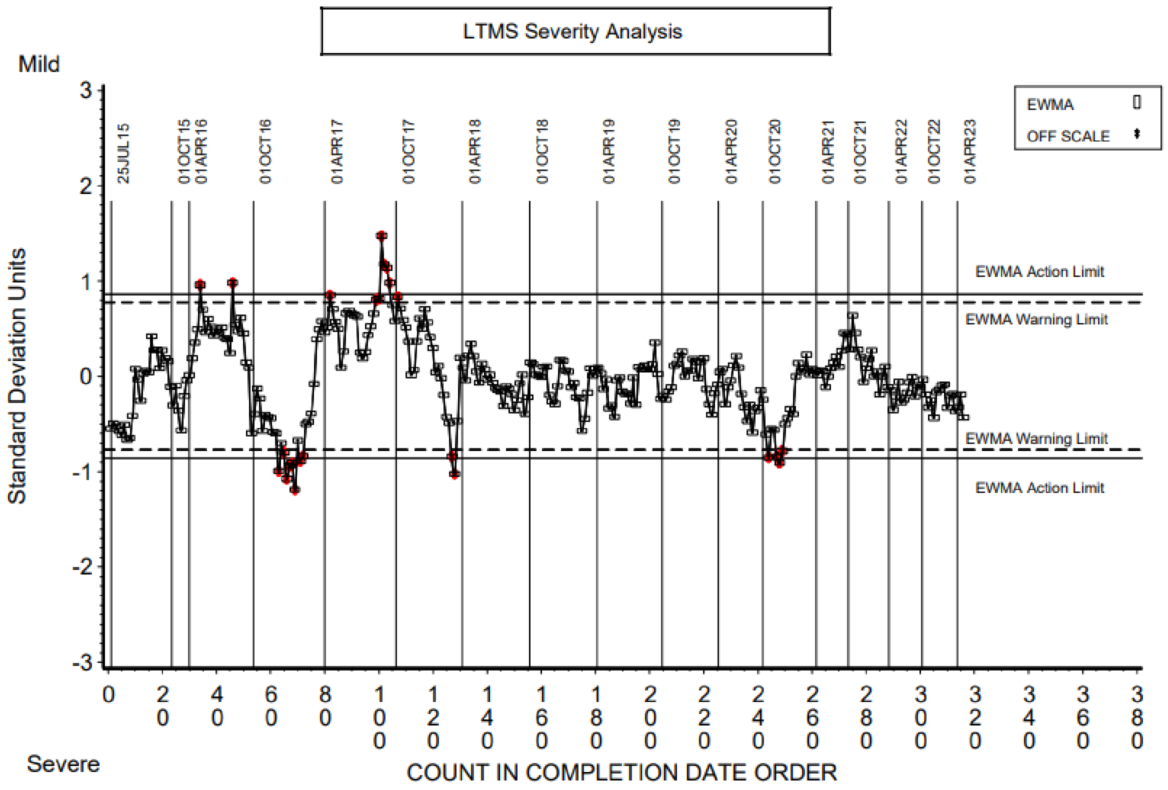
Industry Status

Industry data suggest about a one standard deviation mild PVIS problem, with WPD in control.

PVIS



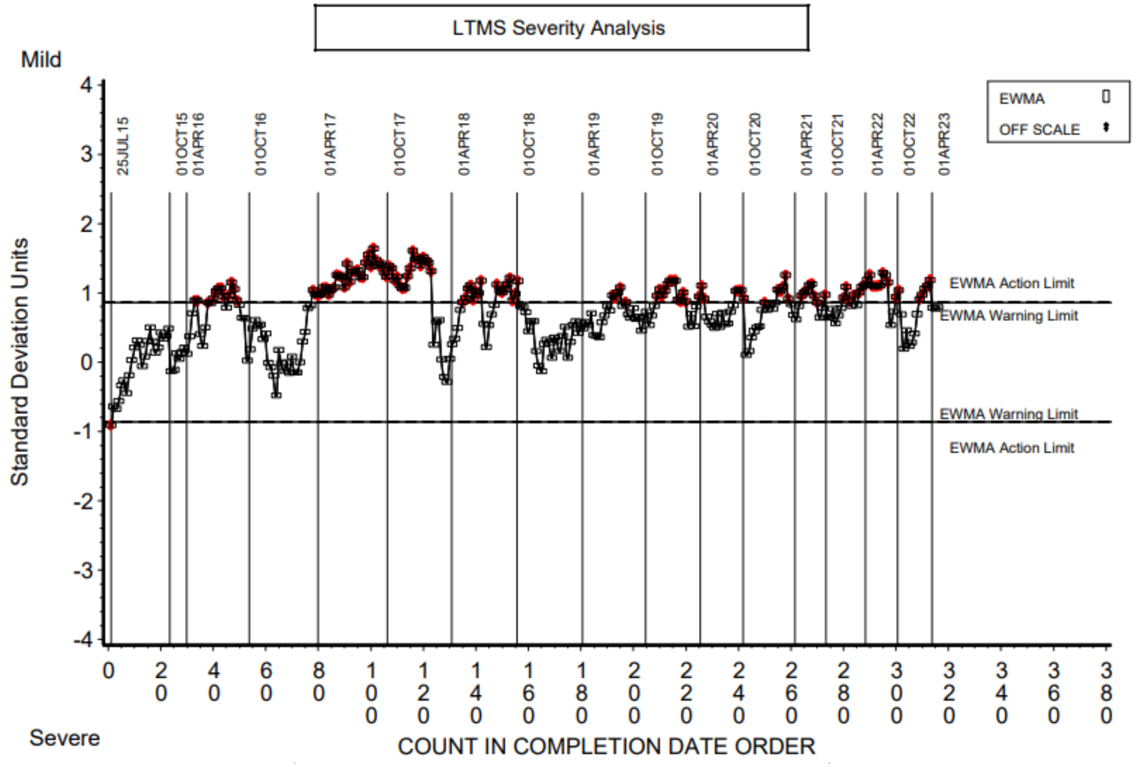
WPD



Industry Status

APV has trended similar to PVIS on average, though with less variability and more consistently mild.

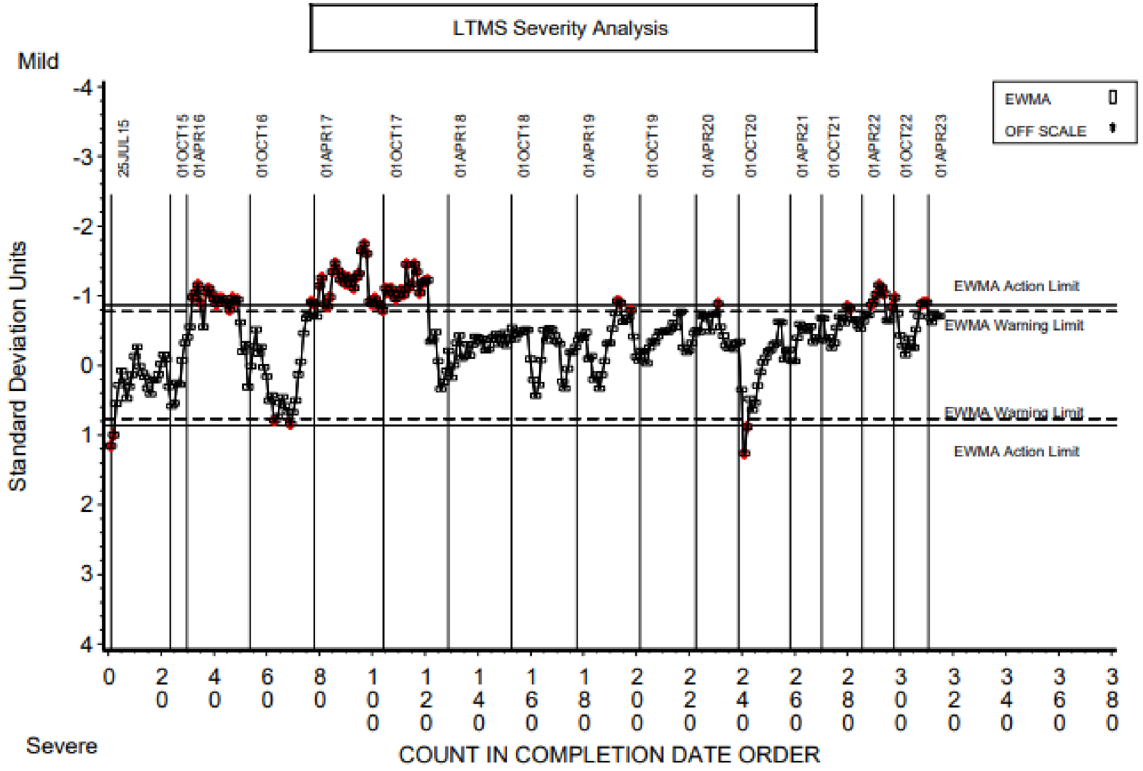
APV



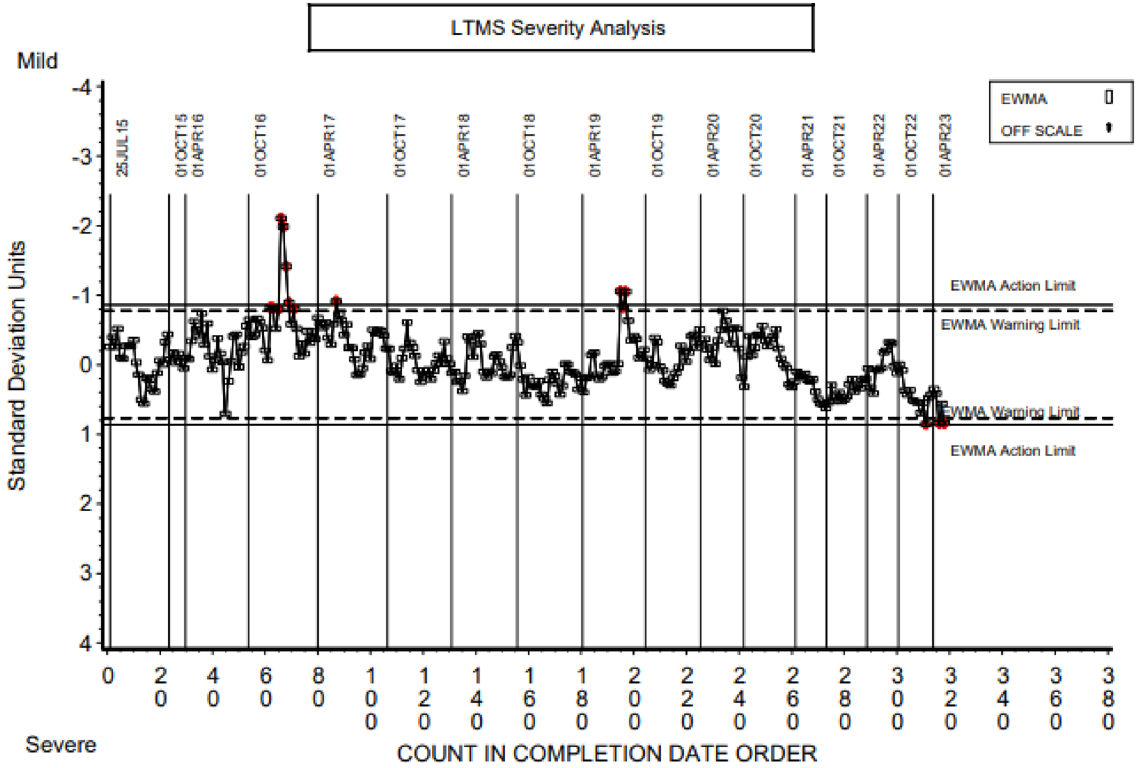
Industry Status

MRV similar to PVIS and APV, while phosphorus retention has been mostly under control, with a recent move near the EWMA severe action alarm limit.

MRV



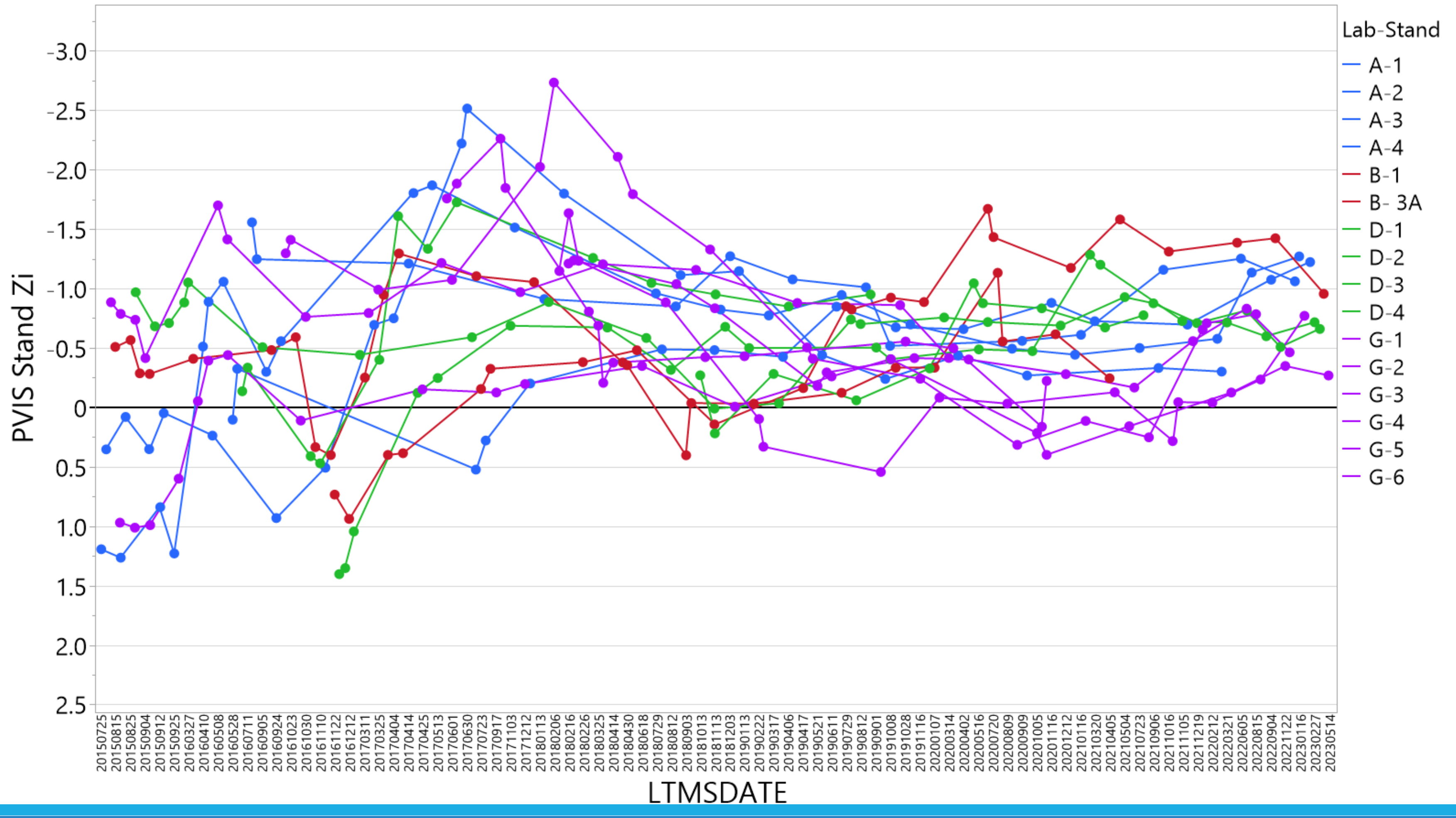
PHOS



PVIS

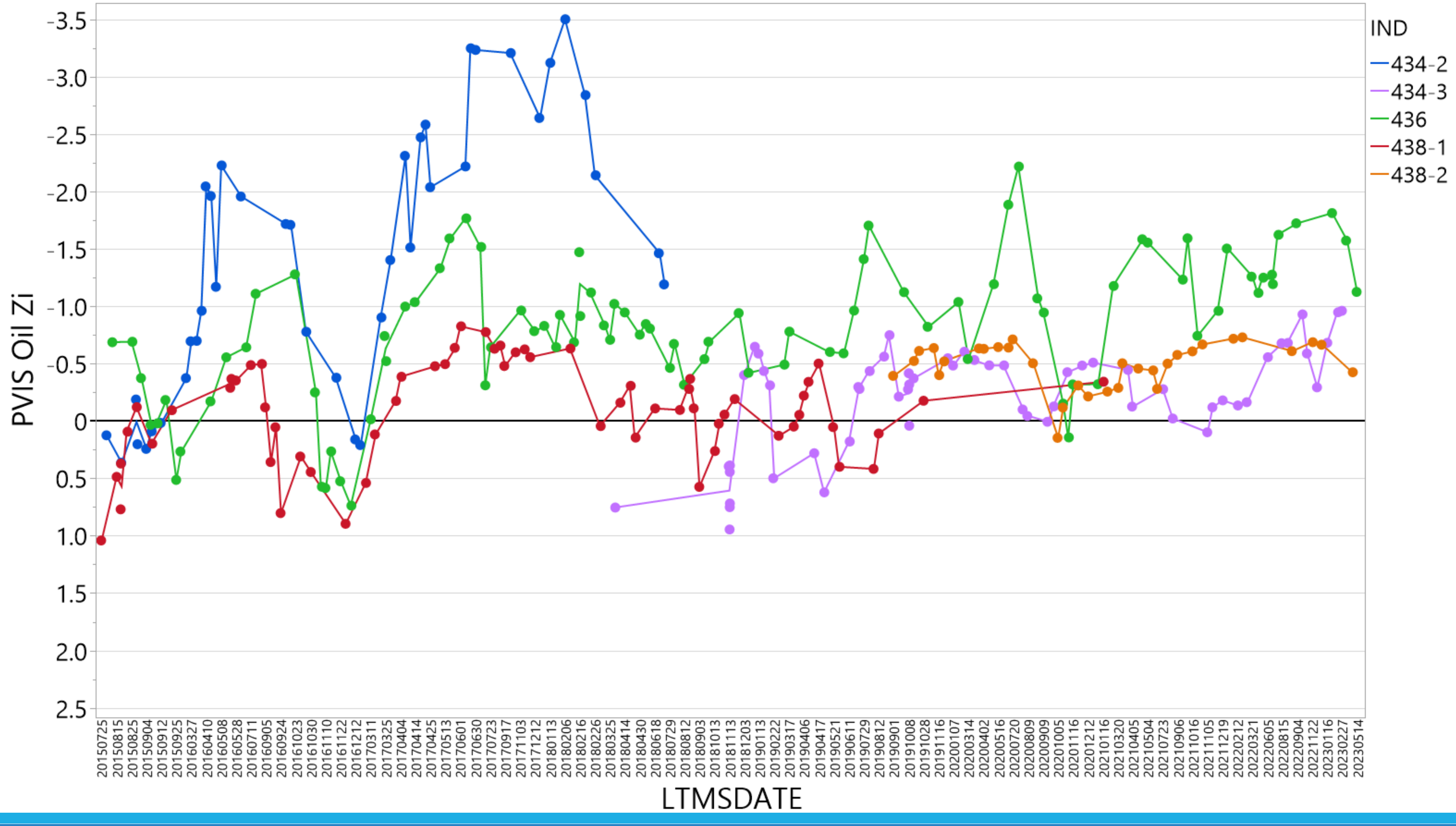
PVIS Zi by Lab-Stand

EWMA plot by stand suggests that all stands in the industry are mild, between 0.25 to 1.25 standard deviations mild.



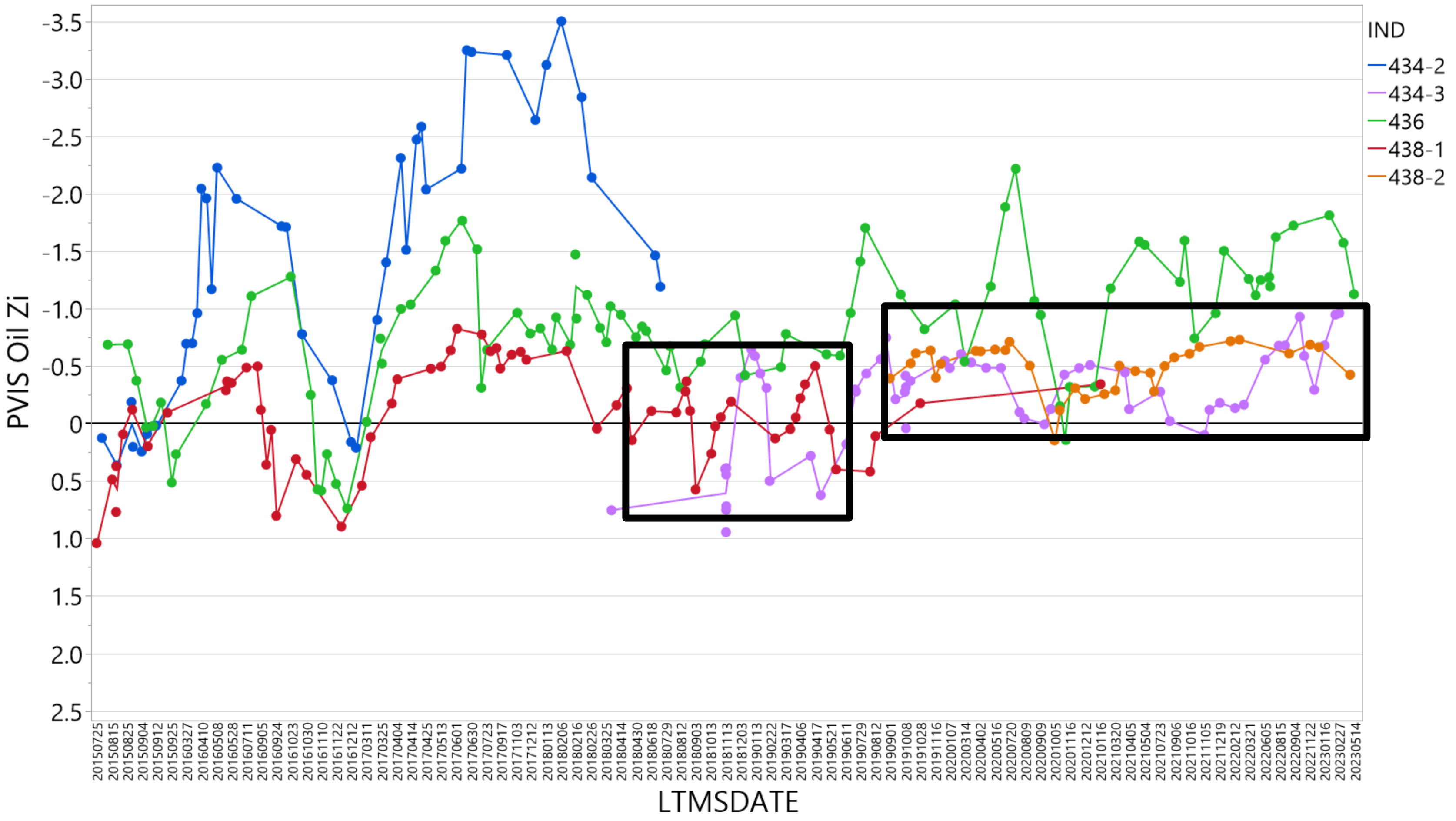
PVIS EWMA by Oil

436 has trended mild for a long time now.   438-2 appears to have been introduced at a similar time to when 434-3 and 436 were shifting milder, around summer/early fall of 2019.



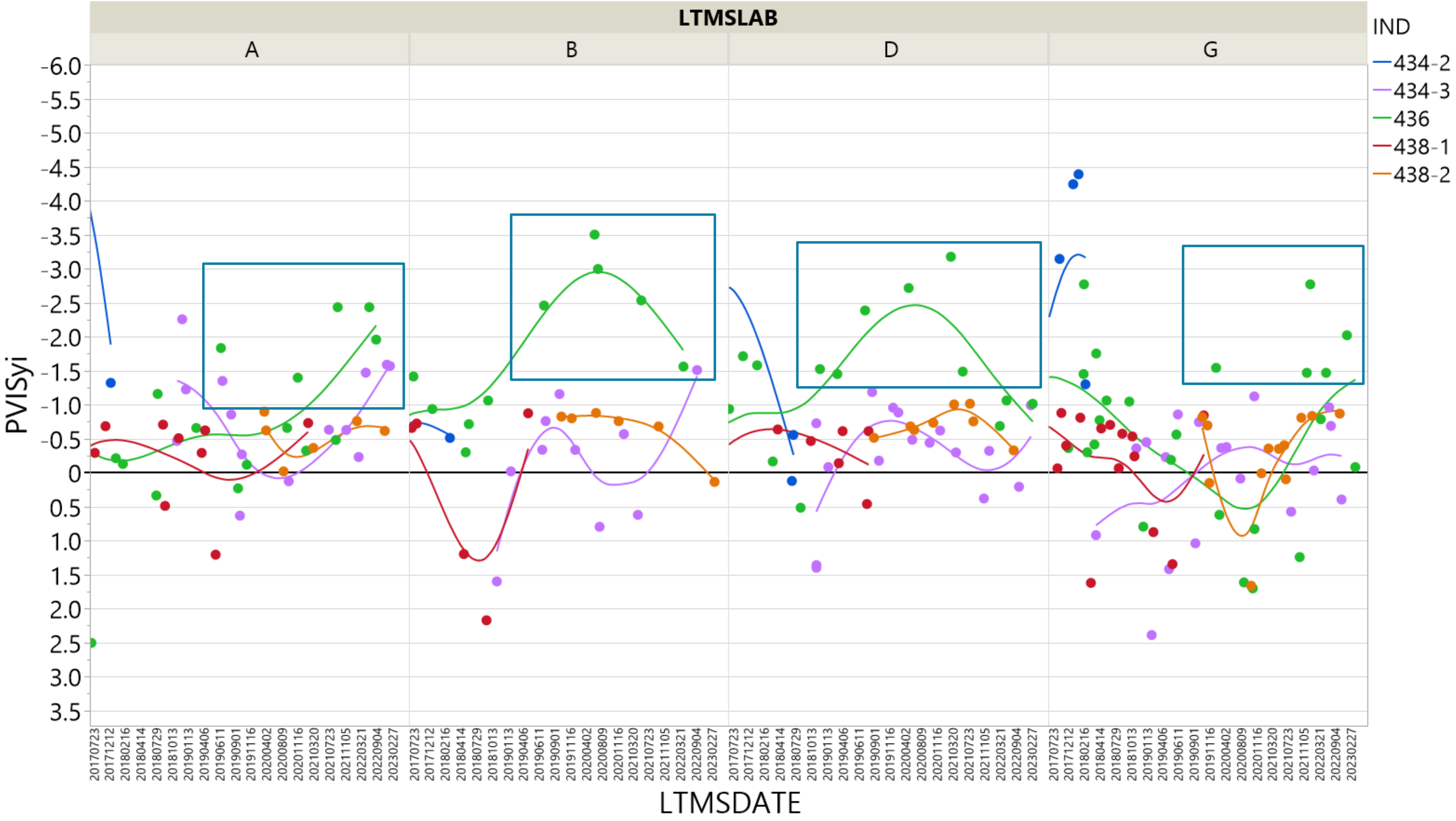
Oil 438 Re-blend Target

Both 438-1 and 438-2 line up fairly well with 434-3 severity, indicating that that difference in the re-blend may be due do the industry severity shift which lines up with the time of the re-blend introduction.



PVIS Yi by Oil and Lab

A majority of the mild data in recent history appears to be on reference oil 436.



Targets +/- 2 Sigma by Oil

2 standard deviations mild on Oil 436 is only 13% below target. Oil 438-2 can actually get a result as low as 8% and still be within 2 standard deviations.

Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	5.7602 (317%)	0.6598	4.4406 (85%)	7.0798 (1,188%)
438-2	3.9754 (53%)	0.9558	2.0638 (8%)	5.887 (360%)
436	3.3289 (28%)	0.3138	2.7013 (15%)	3.9565 (52%)

Choosing a Time Period for Standard Deviation Calculations

This slide explains how the data set was selected for calculating the standard deviation of each of the reference oils.

<u>434-3:</u>

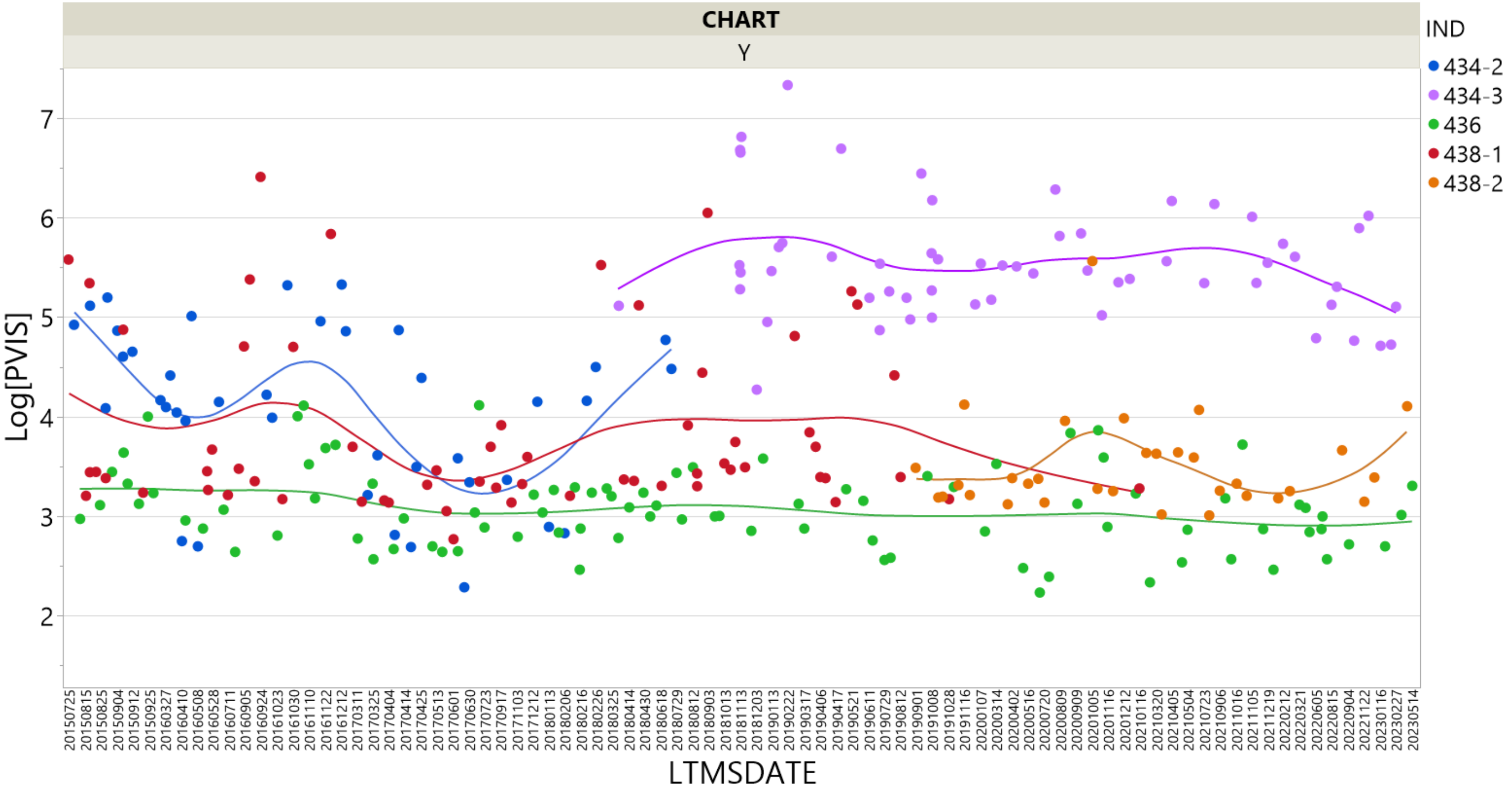
- Reasonably stable, except for most recent mild data.
- Will use all data raw standard deviation.

<u>436:</u>

- Downward drift over time.
- Linear drift correct all data, use residual standard deviation.

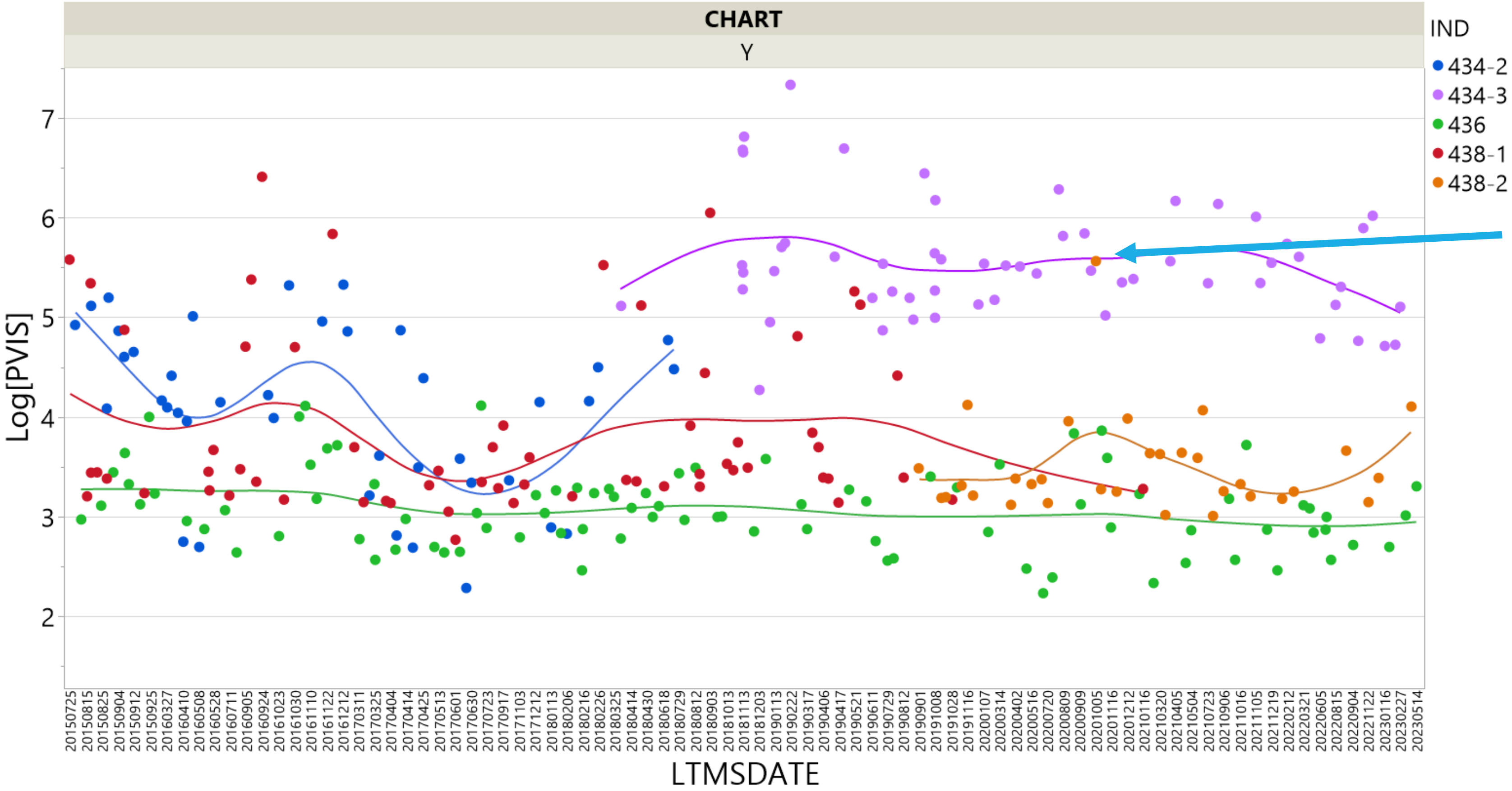
<u>438-2:</u>

- Reasonably stable.
- Will use all data raw standard deviation.



One 438-2 Potential Outlier

The inclusion/exclusion of this data point has a large impact on the estimated standard deviation. It is recommended to retain this point in the calculation, as this level of severity has been seen often on the original blend in the past.



Potential Outlier

<u>438-2 standard deviation</u>

- With point: 0.4950
- Without: 0.3259

Estimated Standard Deviations

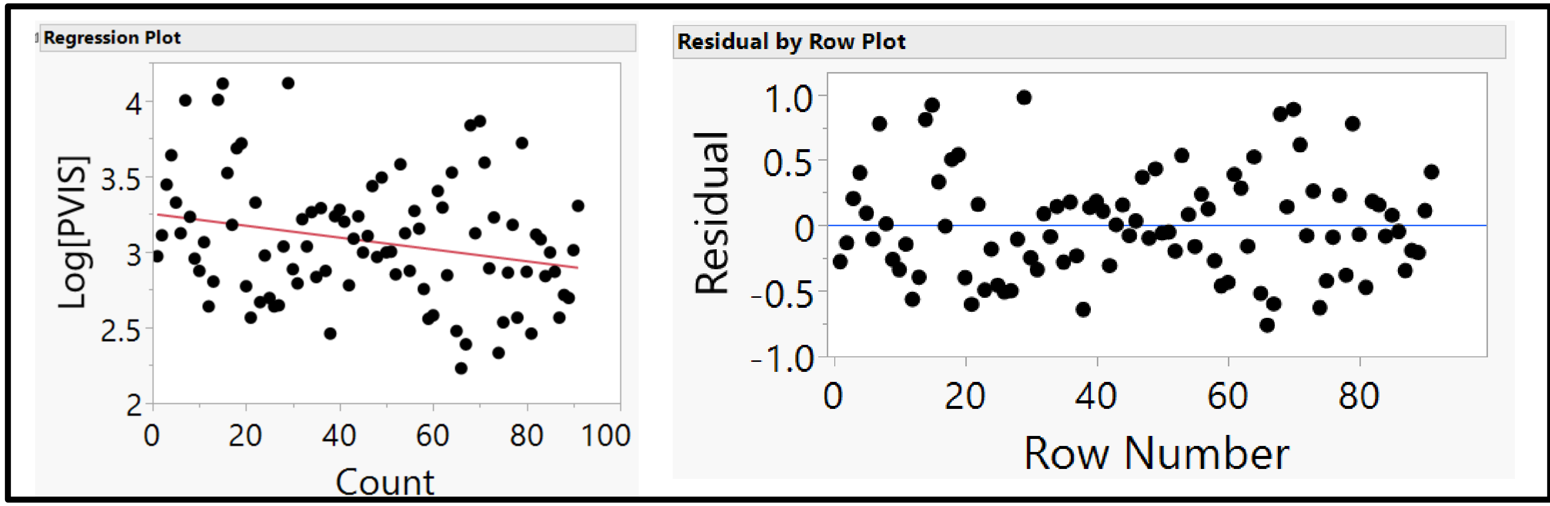
Using the data sets and methodology from the previous slide, the table to the right shows the recommended updates to the standard deviations.

Oil	LTMS Standard Deviation	Recommended New Standard Deviation
434-3	0.6598	0.5845
438-2	0.9558	0.4950
436	0.3138	0.4005

Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
0.4641	0.4933

Average of 3 Ref. Oil Standard Deviations

Oil 436 Model: Ln(PVIS) ~ Count



Updated +/- 2 Standard Deviations by Oil

The tables to the right compares +/- 2 standard deviations for each of the oils before and after the standard deviation update.

<u>Current</u>

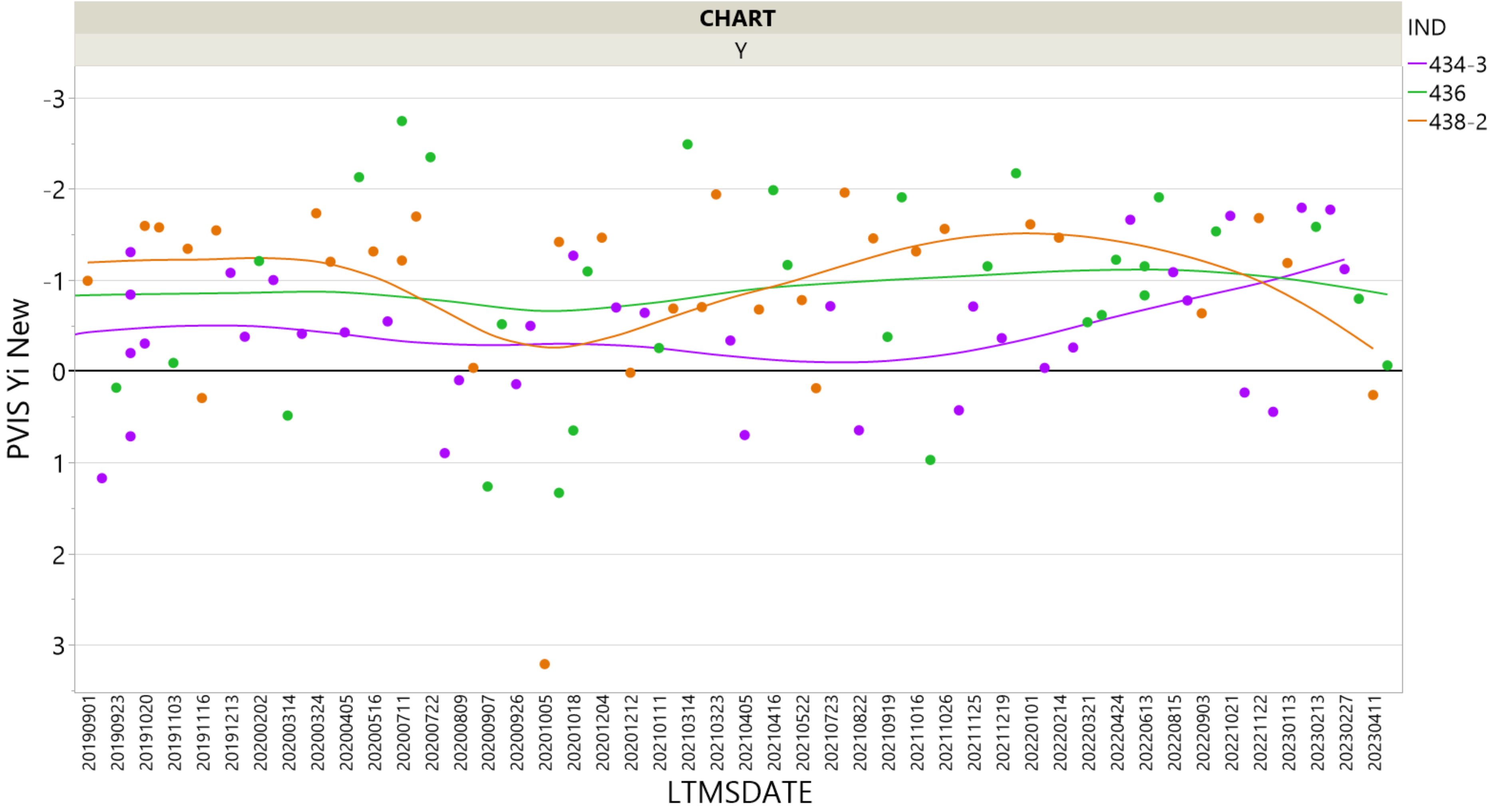
Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	5.7602 (317%)	0.6598	4.4406 (85%)	7.0798 (1,188%)
438-2	3.9754 (53%)	0.9558	2.0638 (8%)	5.887 (360%)
436	3.3289 (28%)	0.3138	2.7013 (15%)	3.9565 (52%)

<u>With Proposed Changes</u>

Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	5.7602 (317%)	0.5845	4.5912 (99%)	6.9292 (1,022%)
438-2	3.9754 (53%)	0.4950	2.9854 (20%)	4.9654 (143%)
436	3.3289 (28%)	0.4005	2.5279 (13%)	4.1299 (62%)

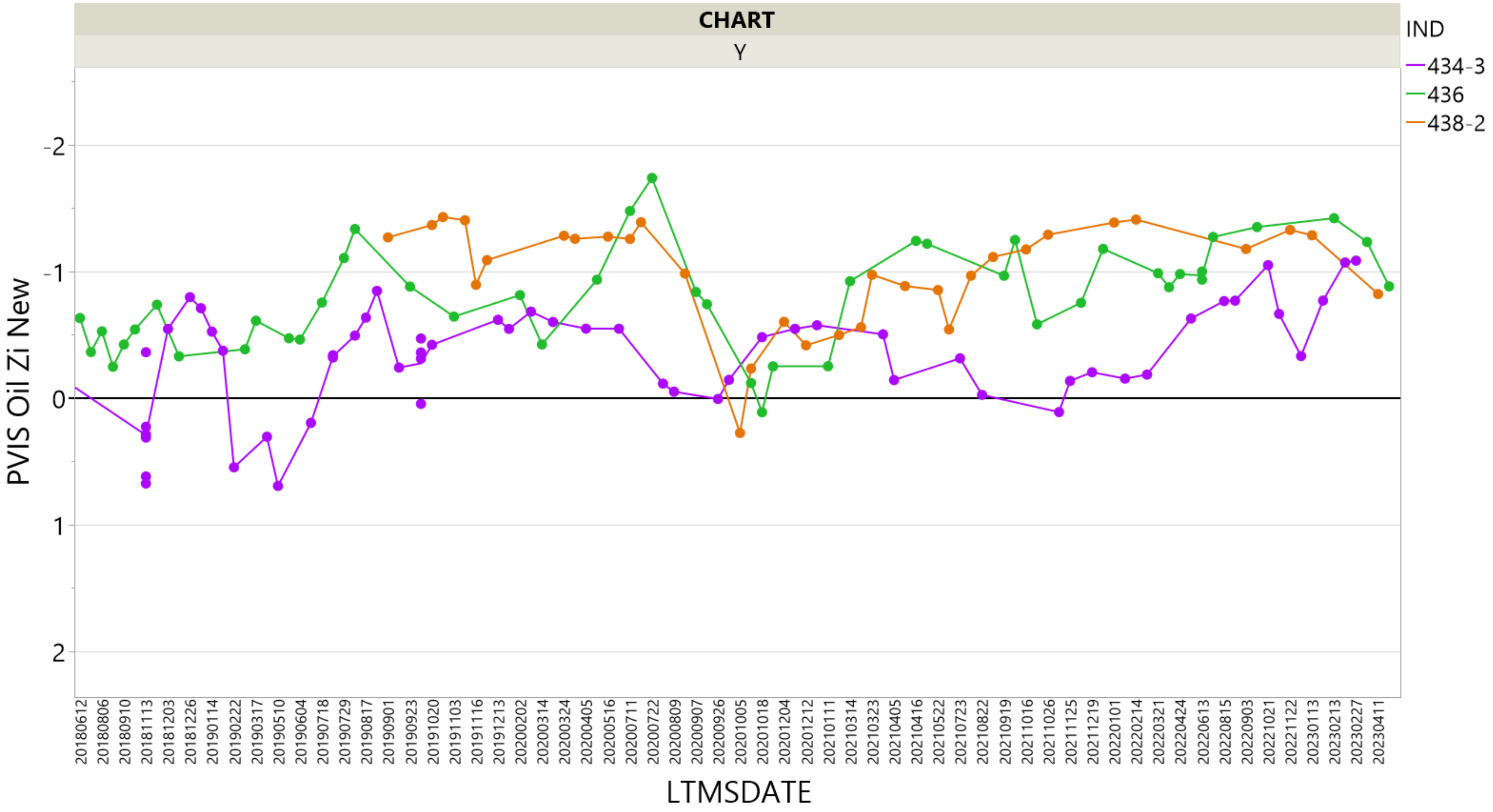
Updated PVIS Yi Plot by Oil

With the updated standard deviations, the scatter of the reference oil results is more reasonably similar



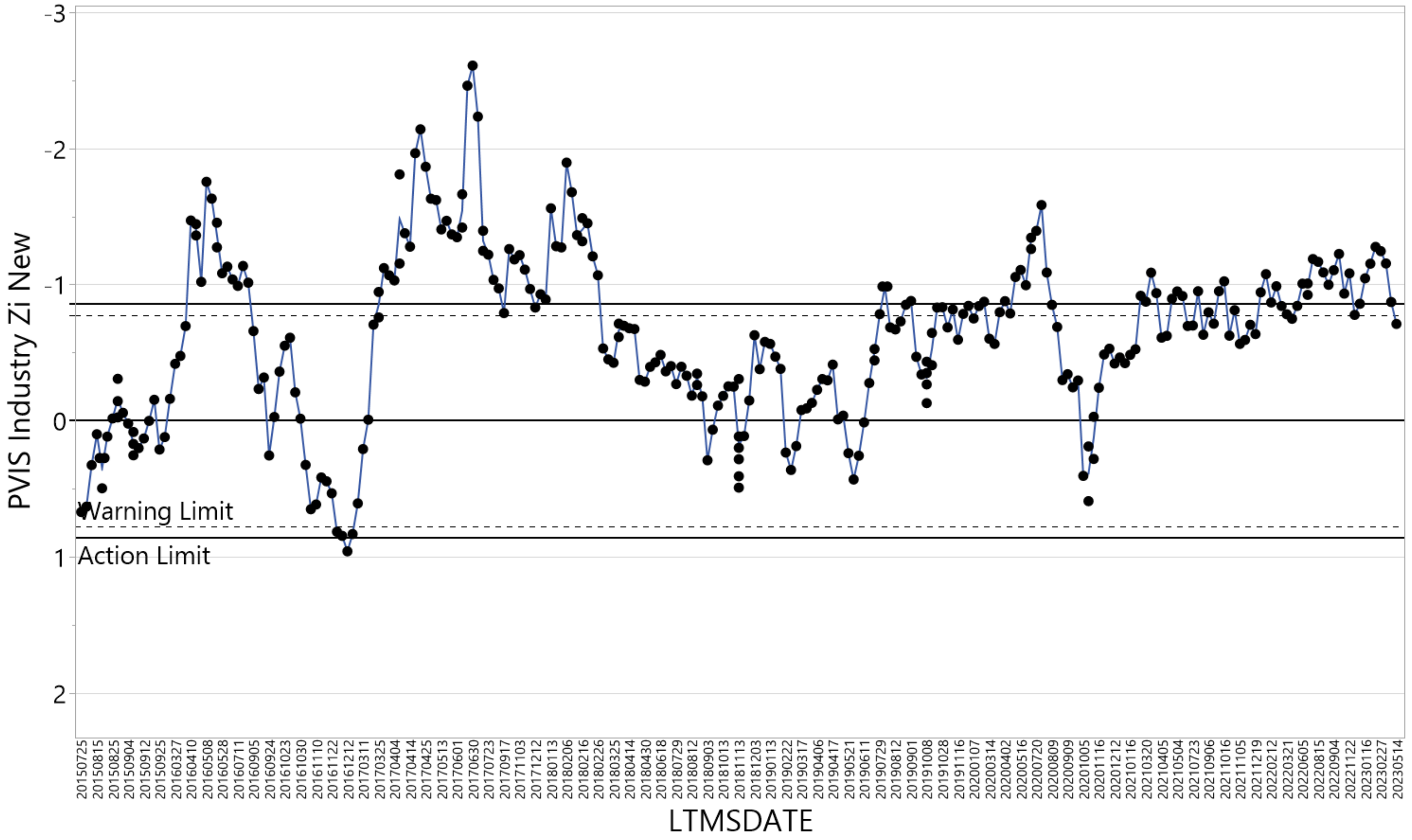
Updated PVIS Oil EWMA Plot

Using the updated standard deviations, all 3 reference oils currently are right around 1 standard deviation mild, though oil 434-3 just recently reached this severity level.



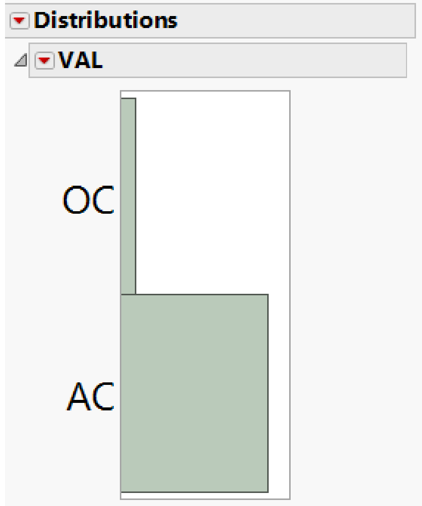
Updated PVIS Industry EWMA

Updating the standard deviations does not fix the severity problem, but it removes the oil dependency for calibration probability and severity adjustments.



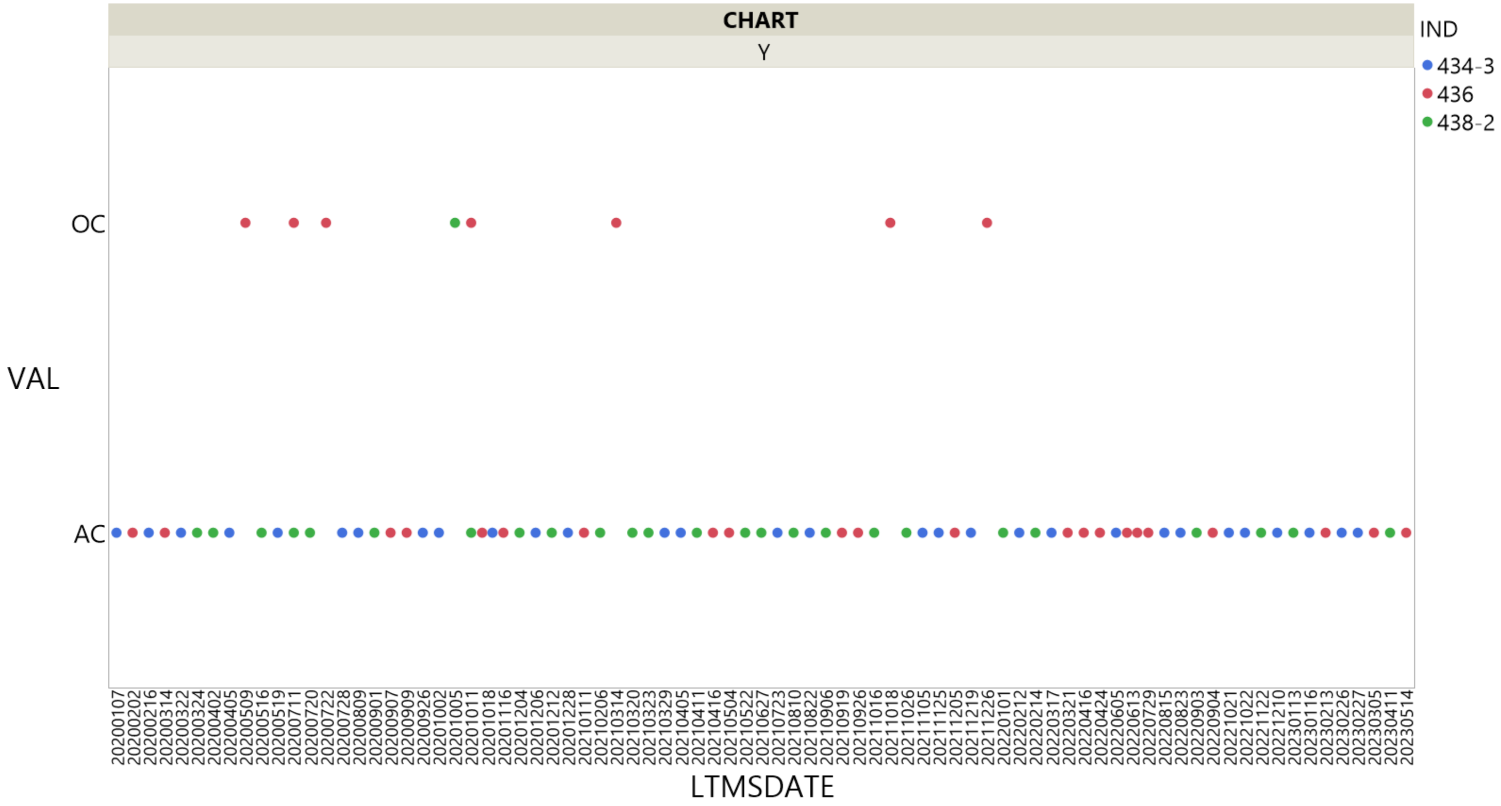
Correction Factor?

Since 2020, there has been a 91% calibration success rate, with all but 1 being on oil 436. With the updated standard deviations, this problem should go away. Therefore, with labs able to calibrate and all reference oils behaving similarly, it is recommended to do nothing mathematically about severity at this time and continue to monitor or look for further engineering explanations.



Frequencies

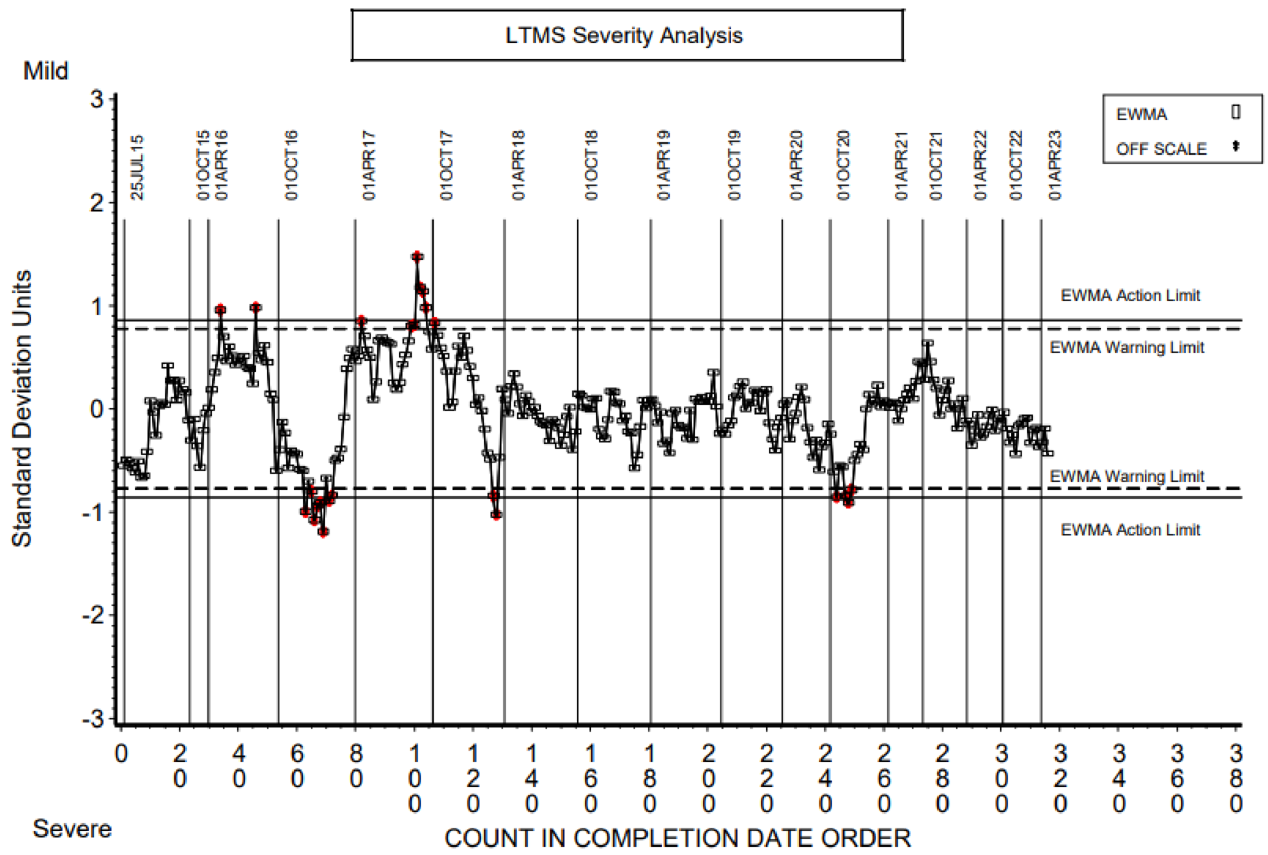
Level	Count	Prob
AC	77	0.90588
OC	8	0.09412
Total	85	1.00000

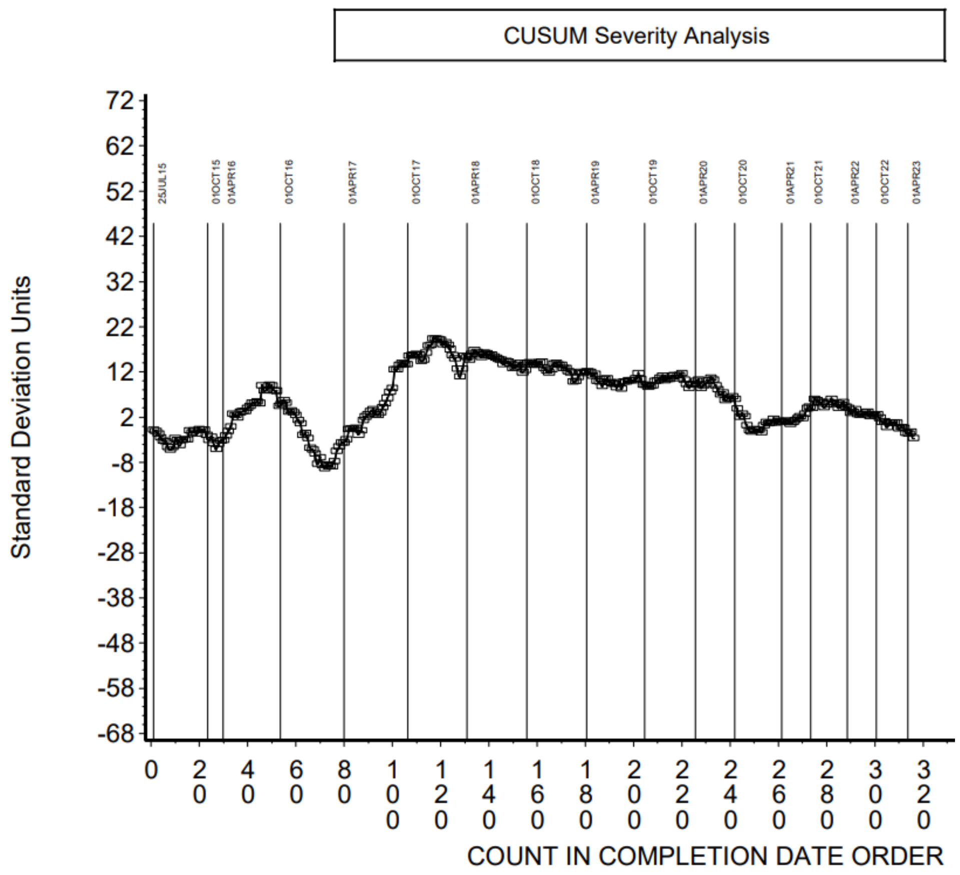


WPD

WPD Industry EWMA

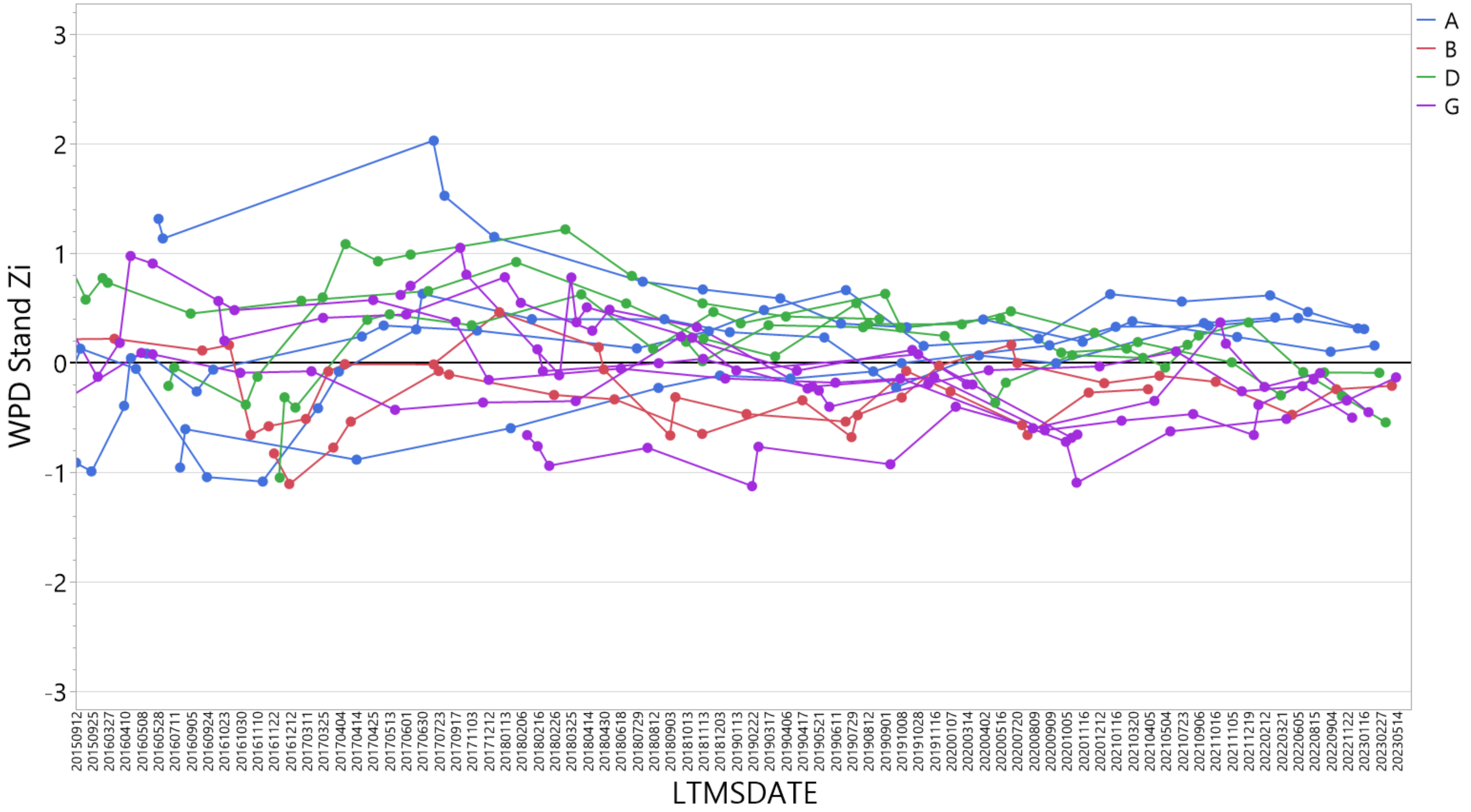
WPD is pretty well in control, though slightly on the severe side for the past year.





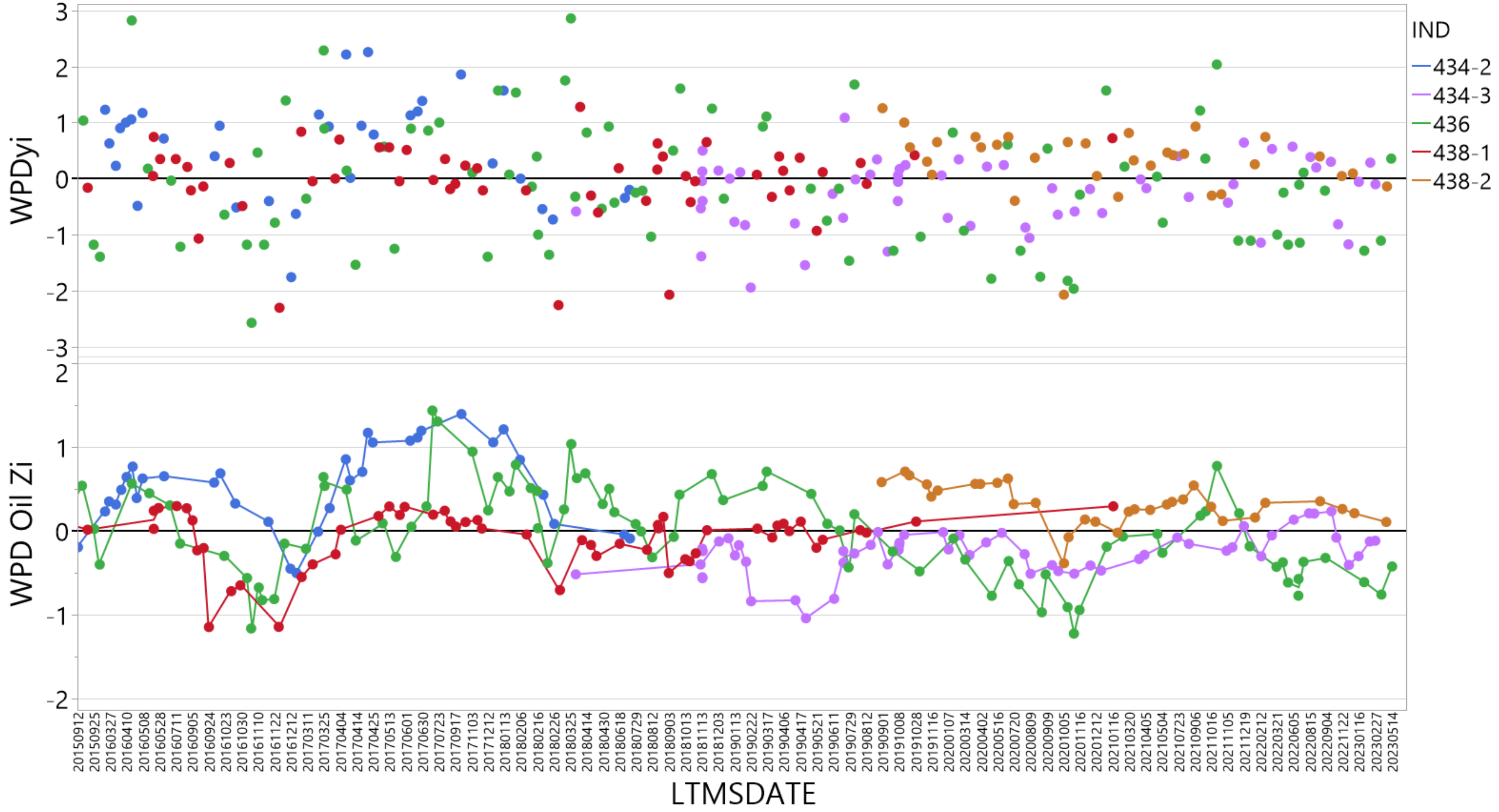
WPD EWMA by Lab-Stand

EWMA plot by stand suggests that all stands in the industry are close to target, within +/- 0.5 standard deviations.



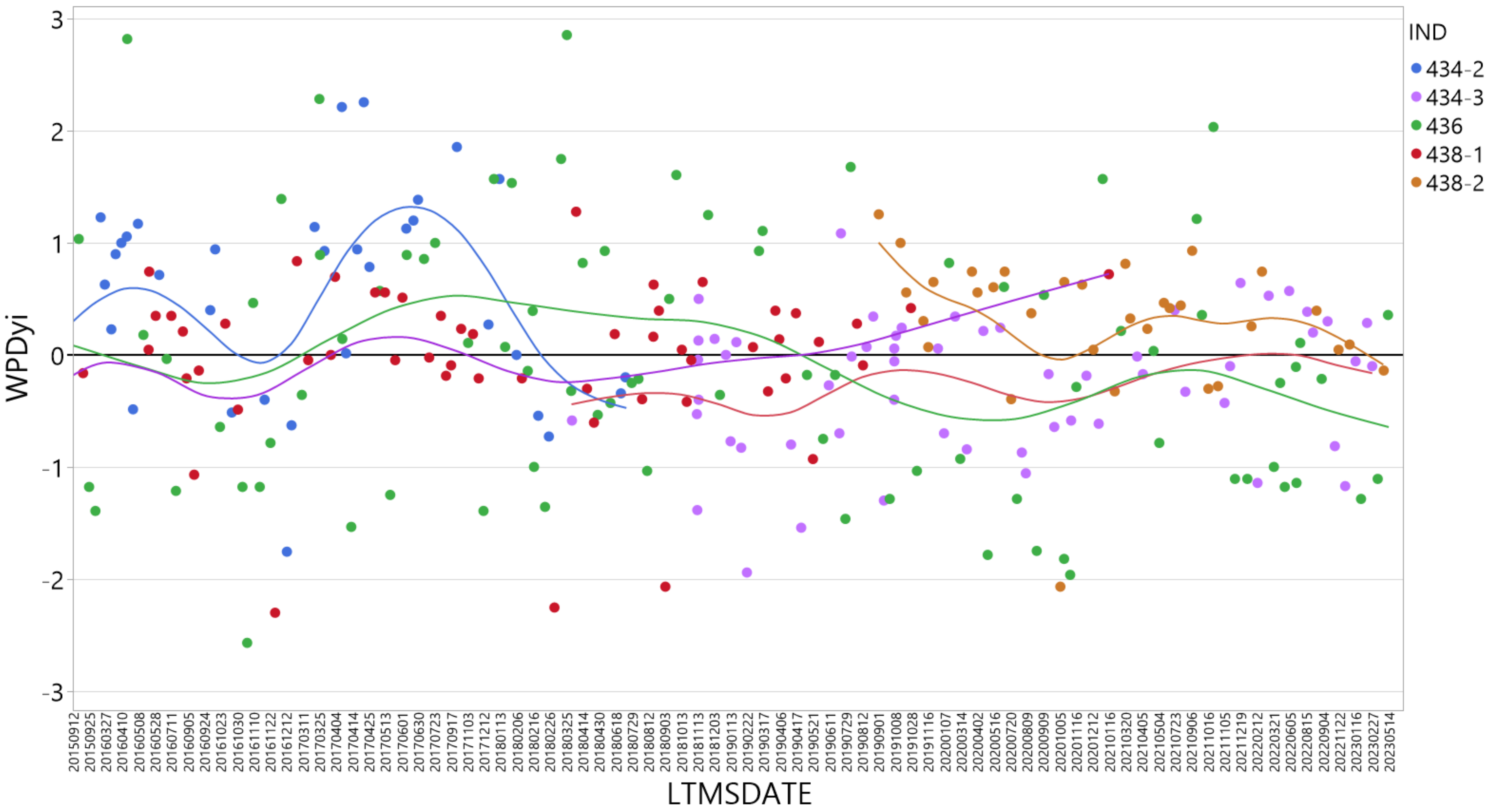
WPD Yi and EWMA by Oil

438-2 has been slightly mild since the introduction (may have gotten target wrong). 434-3 is currently pretty close to target, while 436 has been averaging 0.5 standard deviations severe.



WPD Yi by Oil, All Labs Combined

436 clearly has the most variability, but it may be because the other oil standard deviations are too small and that its spread is more the desired result of +/- 2 sigma.



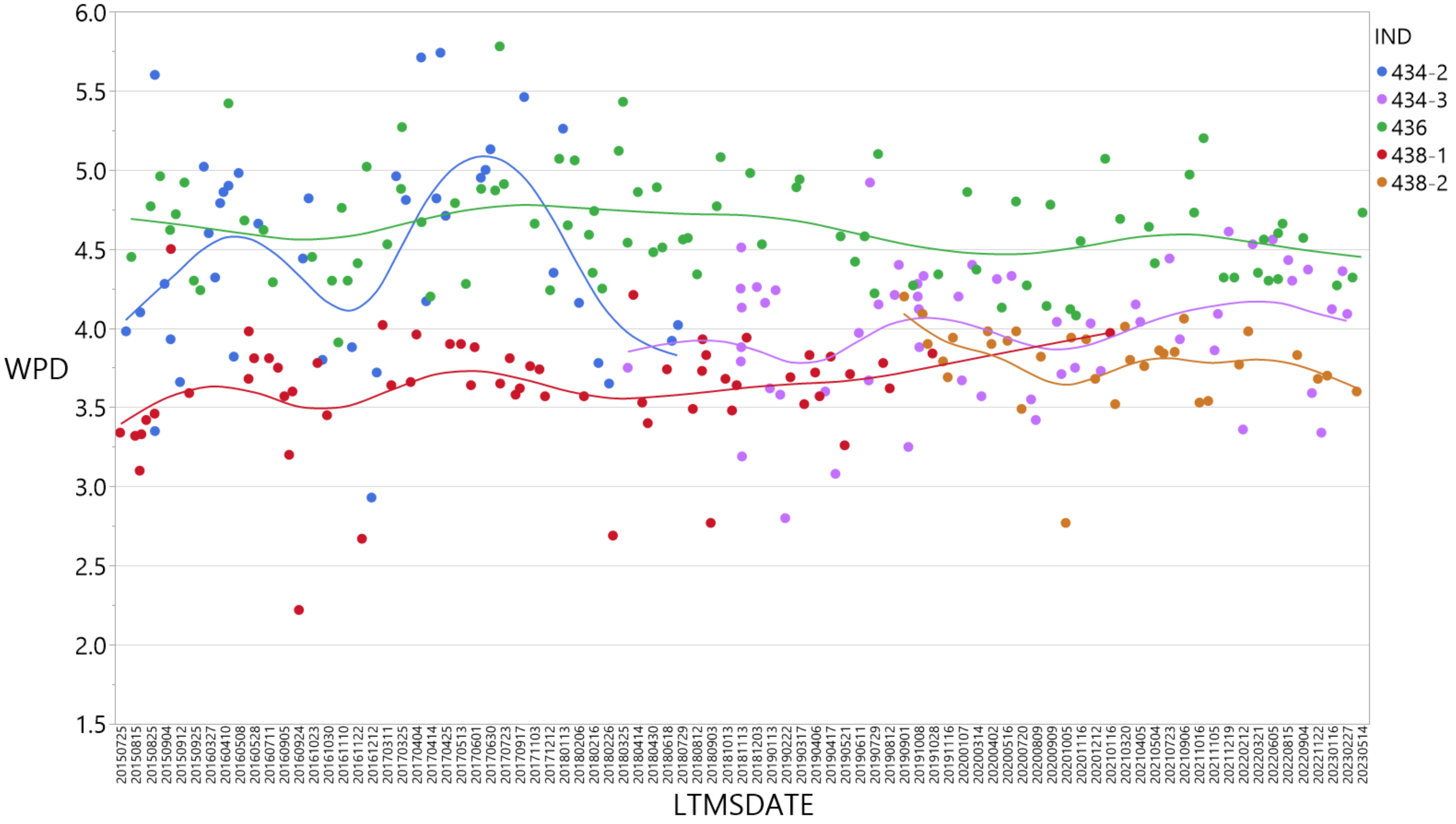
Targets +/- 2 Sigma by Oil

There are major difference in the standard deviations of these oils.

Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	4.16	0.70	2.76	5.56
438-2	3.66	0.43	2.80	4.52
436	4.63	0.28	4.07	5.19

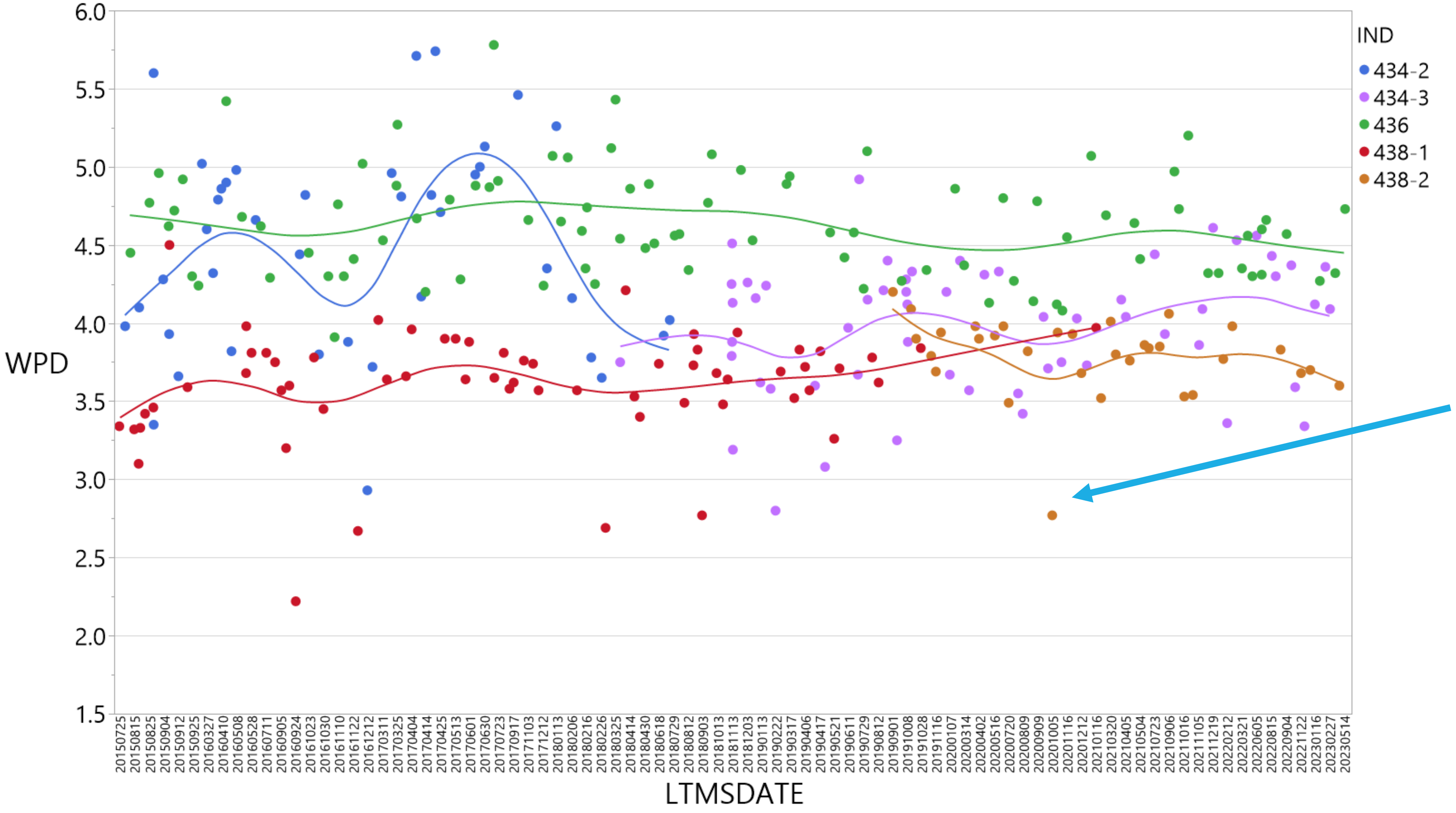
Choosing a Time Period for Standard Deviation Calculations

Though there appears to be a small downward trend for 436 and a small upward trend for oil 434-3, these are not statistically significant in either case. Therefore, the raw standard deviation appears appropriate for all 3 oils using all data.



One 438-2 Potential Outlier

The same outlier that was seen for PVIS is also seen for WPD, and it is again recommended to retain this value.



Potential Outlier

<u>438-2 standard deviation</u>

- With point: 0.26
- Without: 0.18

Estimated Standard Deviations

Using the data sets and methodology from the previous slide, the table to the right shows the recommended updates to the standard deviations.

Oil	LTMS Standard Deviation	Raw Standard Deviation
434-3	0.70	0.42
438-2	0.43	0.26
436	0.28	0.34

Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
0.47	0.34

Updated +/- 2 Standard Deviations by Oil

The tables to the right compares +/- 2 standard deviations for each of the oils before and after the standard deviation update.

Current

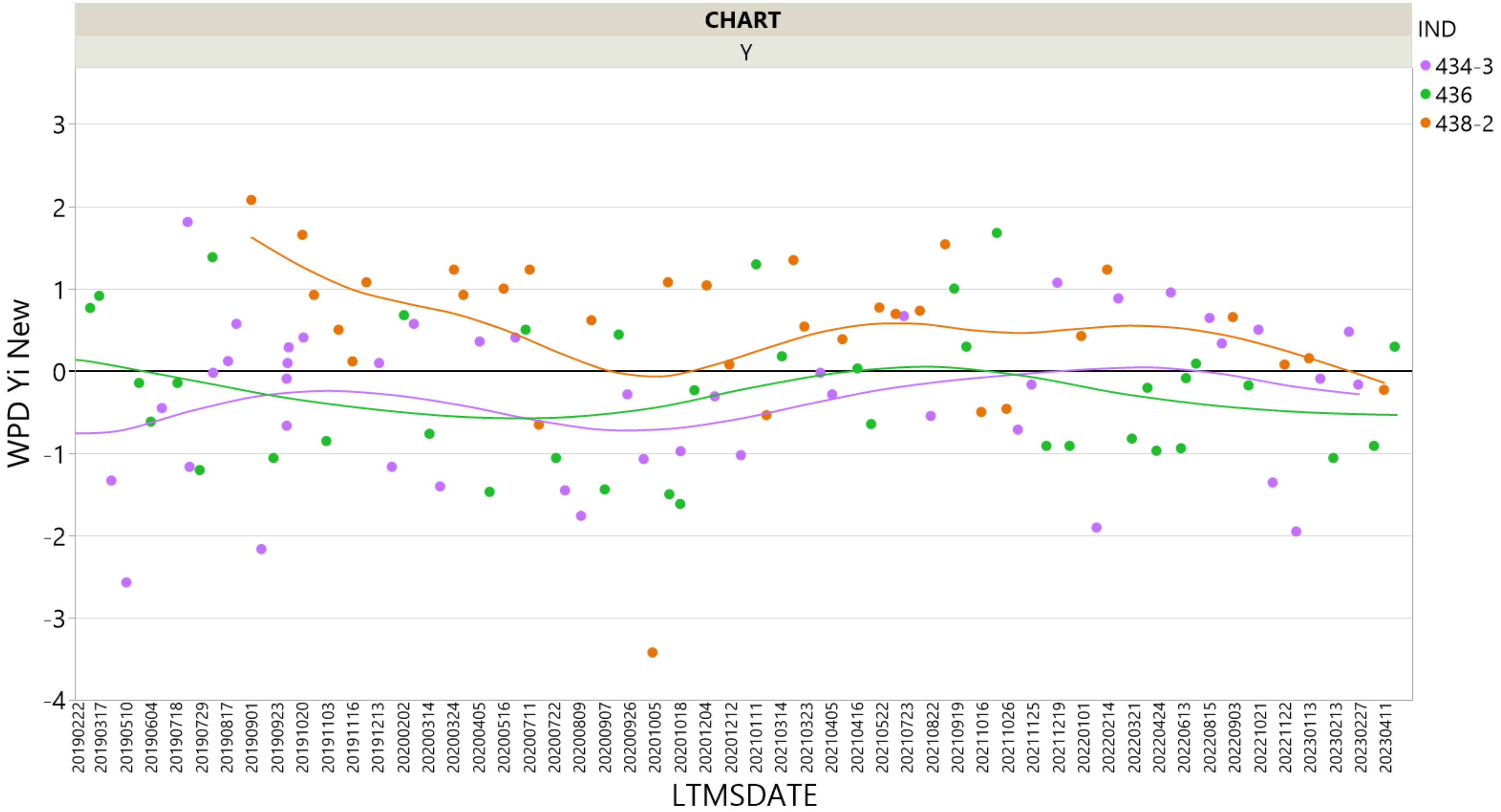
Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	4.16	0.70	2.76	5.56
438-2	3.66	0.43	2.80	4.52
436	4.63	0.28	4.07	5.19

With Proposed Changes

Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	4.16	0.42	3.32	5.00
438-2	3.66	0.26	3.14	4.18
436	4.63	0.34	3.95	5.31

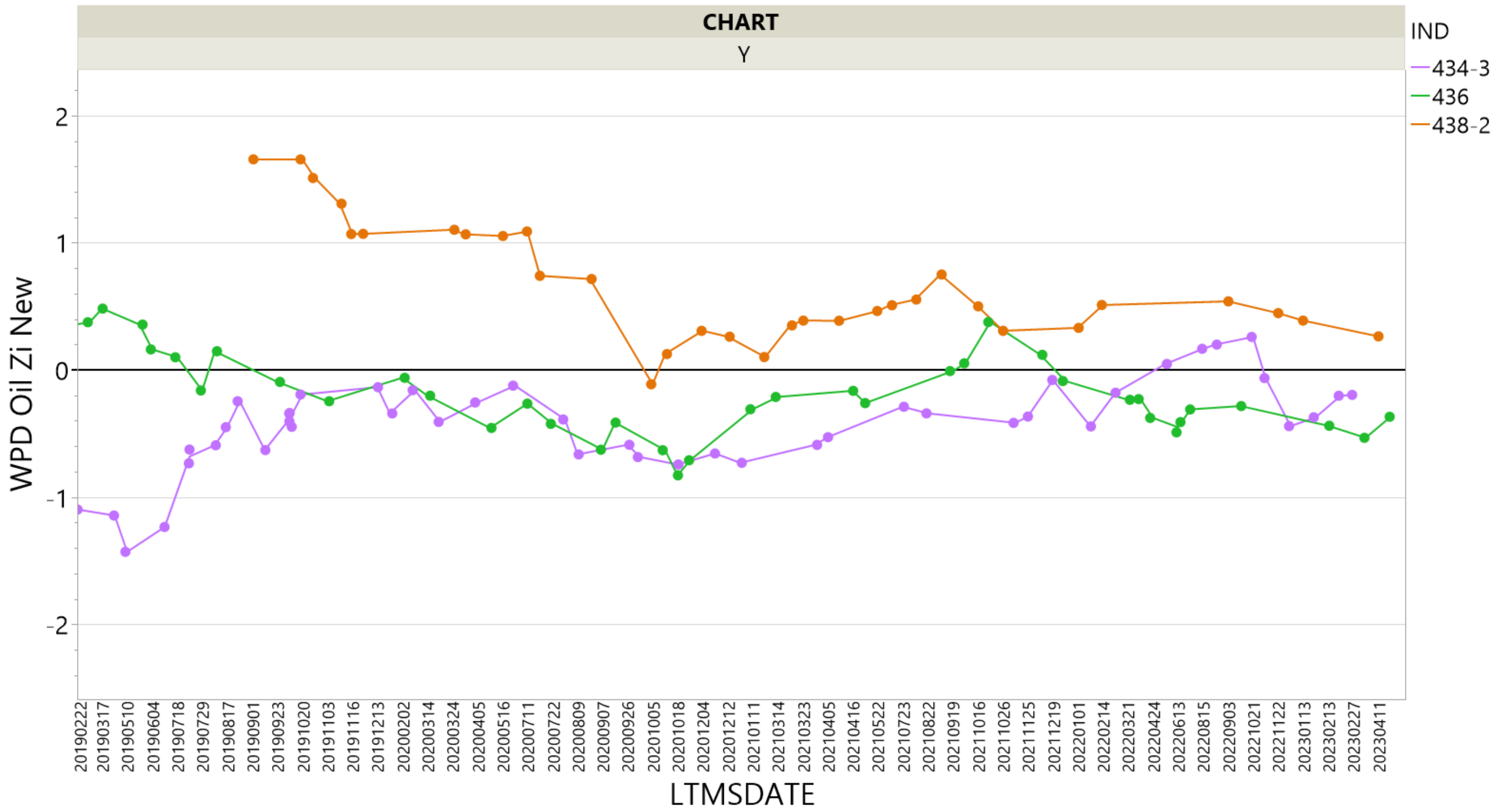
Updated WPD Yi Plot by Oil

With the updated standard deviations, the scatter of the reference oil results is more reasonably similar.



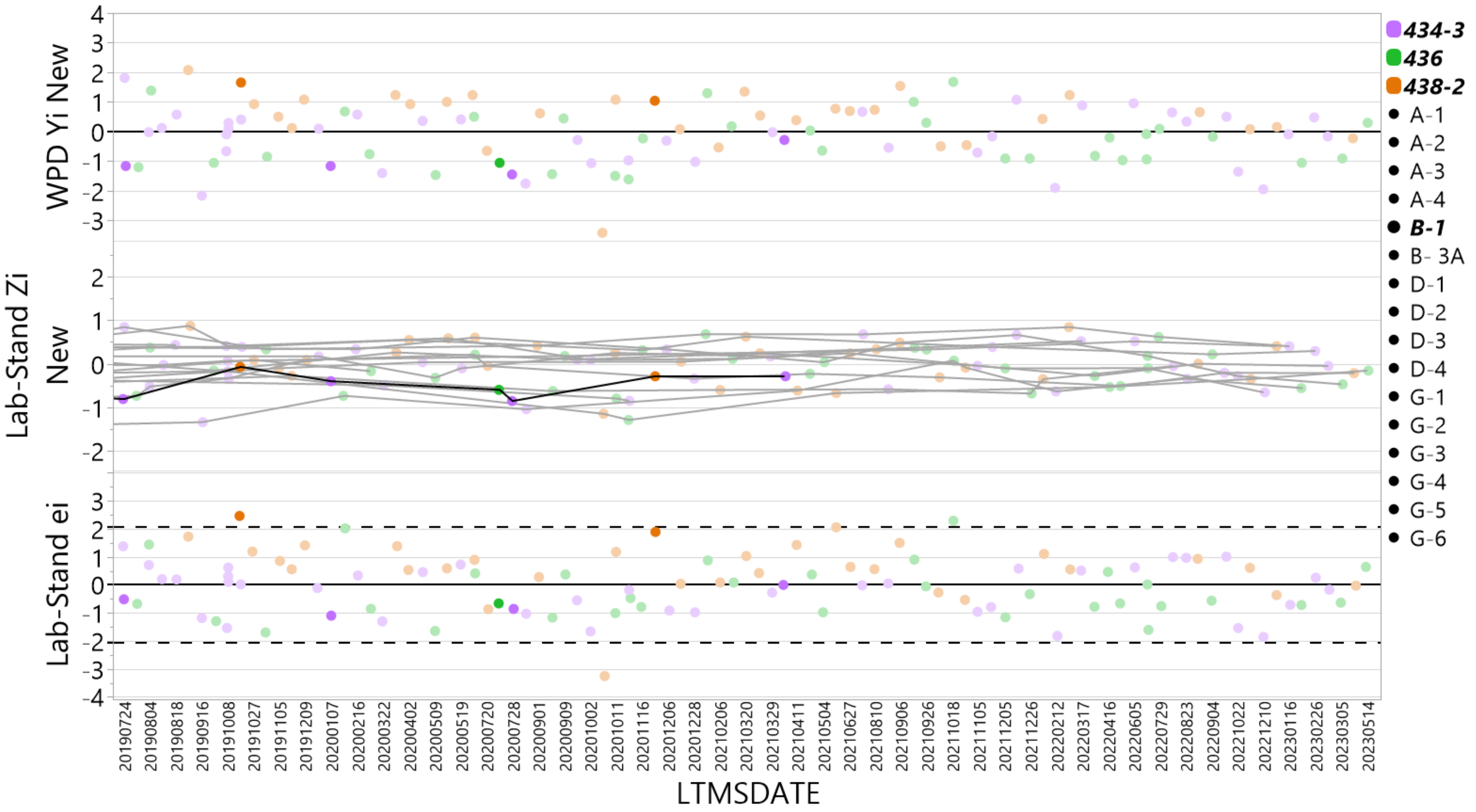
Updated WPD Oil EWMA Plot

Oil 438-2 is just mild of target, while the other two reference oils are just severe of target.



Calibration Failures

Looking back at how the updated standard deviations would have impacted calibration success, there appears to be 3 ei failures. Only the first one, shown below, would be a new failure, as the others already were.



An alternative Std. Dev. for 438-2

Since 438-2 appears to include an expected bias, the raw standard deviation may not capture the expected variability in Yi results, since this standard deviation only considers variability from the sample mean, not deviation from target. Using an alternative standard deviation formula which considers deviations from target may provide some relief for the expected bias for this oil.

$$S.D.\ (Normal) = \sqrt{\frac{\sum_{i=1}^{n}(Result_i - \overline{x})^2}{n-1}}$$

$$S.D.\ (Alt) = \sqrt{\frac{\sum_{i=1}^{n}(Result_i - Target)^2}{n-1}}$$

Oil	LTMS Standard Deviation	Raw Standard Deviation
434-3	0.70	0.42
438-2	0.43	~~0.26~~ 0.29
436	0.28	0.34

What would Target Update be for 438-2?

Based on a model with oil, lab, and lab[stand], the contrast between 438-1 and 438-2 suggests that the re-blend 438-2 is 0.21 merits milder. Based on the current LTMS target for 438-1 of 3.66, a target update for this oil would be recommended to be 3.87.

Though updating targets always has an impact on candidate pass/fail probability, there are several reasons this update could be considered appropriate in this case.

- Updates for re-blends are necessary when they are different to keep the test the same. They only reason it may not be desired here is that this change has gone unnoticed for several years and therefore upcoming candidates will have a different playing field than candidates run over this time period. However, this would return the test to original severity prior to the introduction of this re-blend.
- This test is fortunate to have three reference oils, so the impact over the past few years of not updating the re-blend target is very minimal given the size of the difference and the 1/3 average weighting of this oil in severity adjustments.

Least Squares Means Table

Level	Least Sq Mean	Std Error
434-2	4.4619323	0.06670675
434-3	3.9837165	0.05416943
436	4.6250643	0.04351713
438-1	3.6049812	0.05296073
438-2	3.8170508	0.07352510

Contrast

Test Detail

434-2	0
434-3	0
436	0
438-1	-1
438-2	1
Estimate	0.2121
Std Error	0.0908
t Ratio	2.3368
Prob>|t|	0.0202
SS	0.9024
Lower 95%	0.0334
Upper 95%	0.3908

Candidate Impact?

Consider an on-target stand (Zi = 0) running a calibration test for the first time on Oil 438-2. Without the updated target, the stand is expected to get a result of 3.87. This would result in a Yi value of 0.49, a Zi value of 0.15, and a severity adjustment of -0.07. The next two reference oil tests would be expected to be on target, diluting the effect, and the sequence continues as follows:

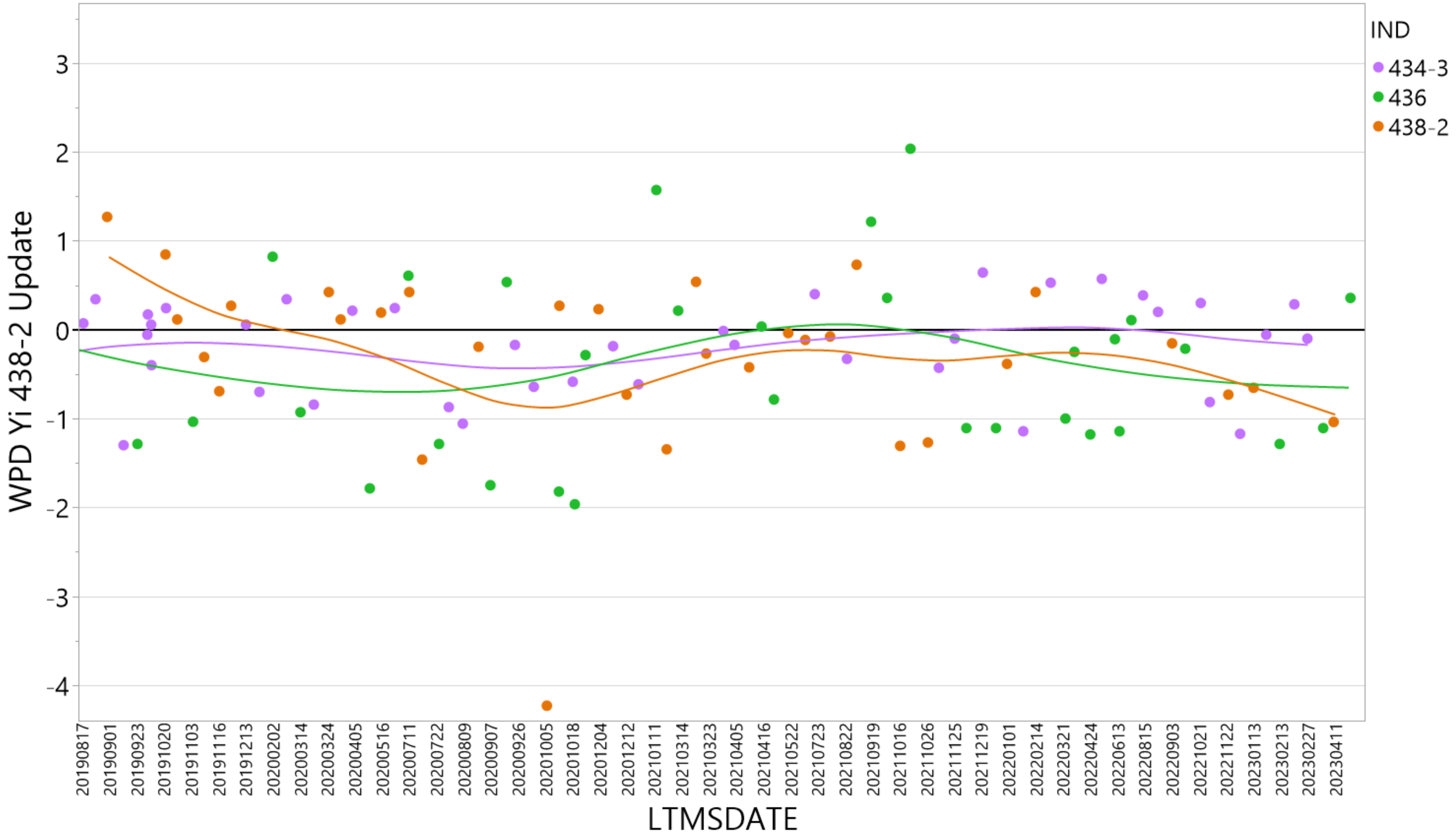
Expected Yi	Expected Zi	Expected SA
0.488	0.147	-0.069
0.000	0.103	-0.048
0.000	0.072	-0.034
0.488	0.197	-0.092
0.000	0.138	-0.065
0.000	0.096	-0.045
0.488	0.214	-0.101
0.000	0.150	-0.070
0.000	0.105	-0.049
0.488	0.220	-0.103
0.000	0.154	-0.072
0.000	0.108	-0.051
0.488	0.222	-0.104
0.000	0.155	-0.073
0.000	0.109	-0.051

Average Yi	SA
0.163	**-0.077**

Updating the target simply returns the expected severity adjustment to zero for an on-target stand.

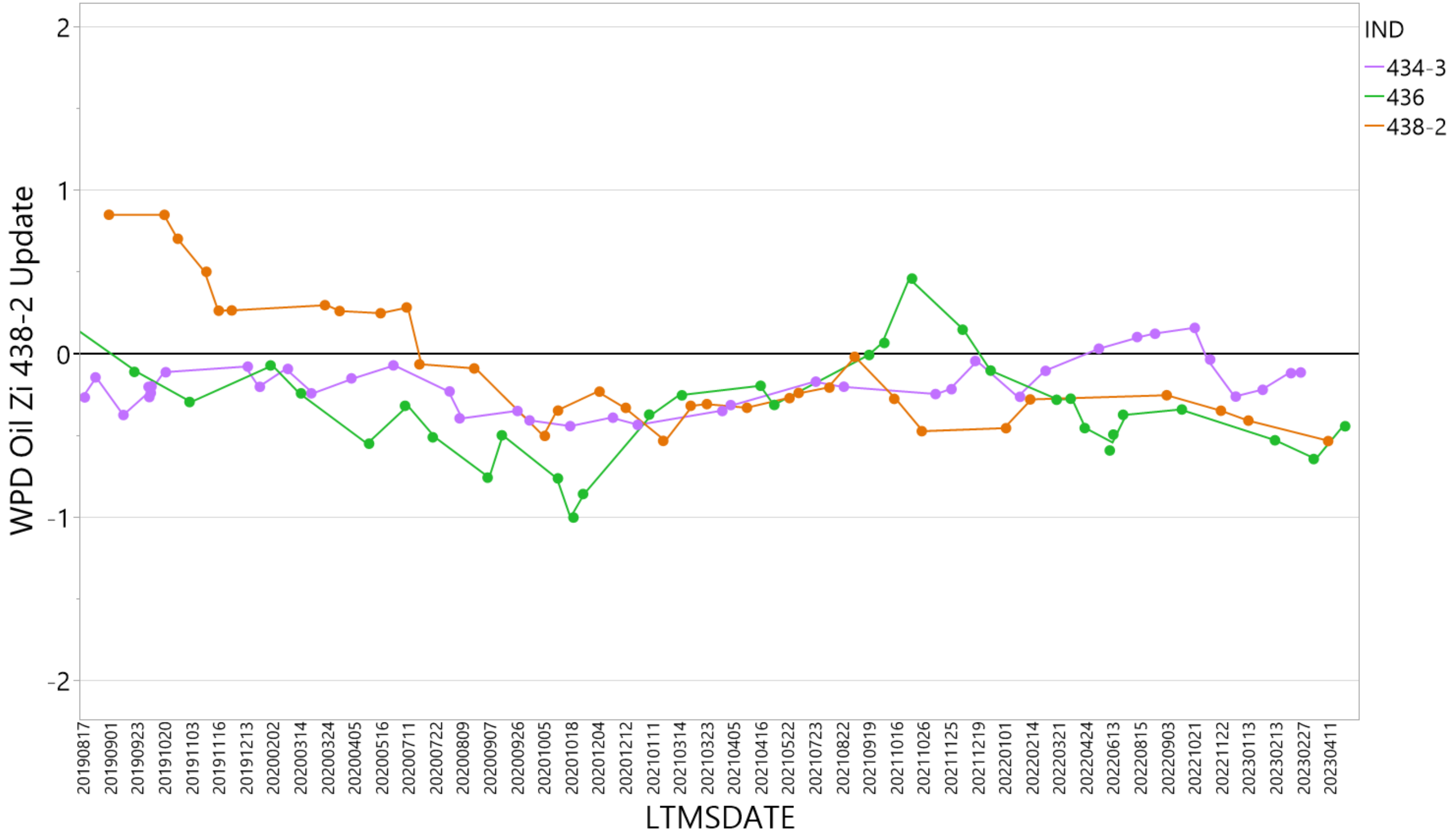
Updated WPD Yi Plot by Oil

Below is a plot of the industry Yi values with the standard deviation update and the 438-2 target update.



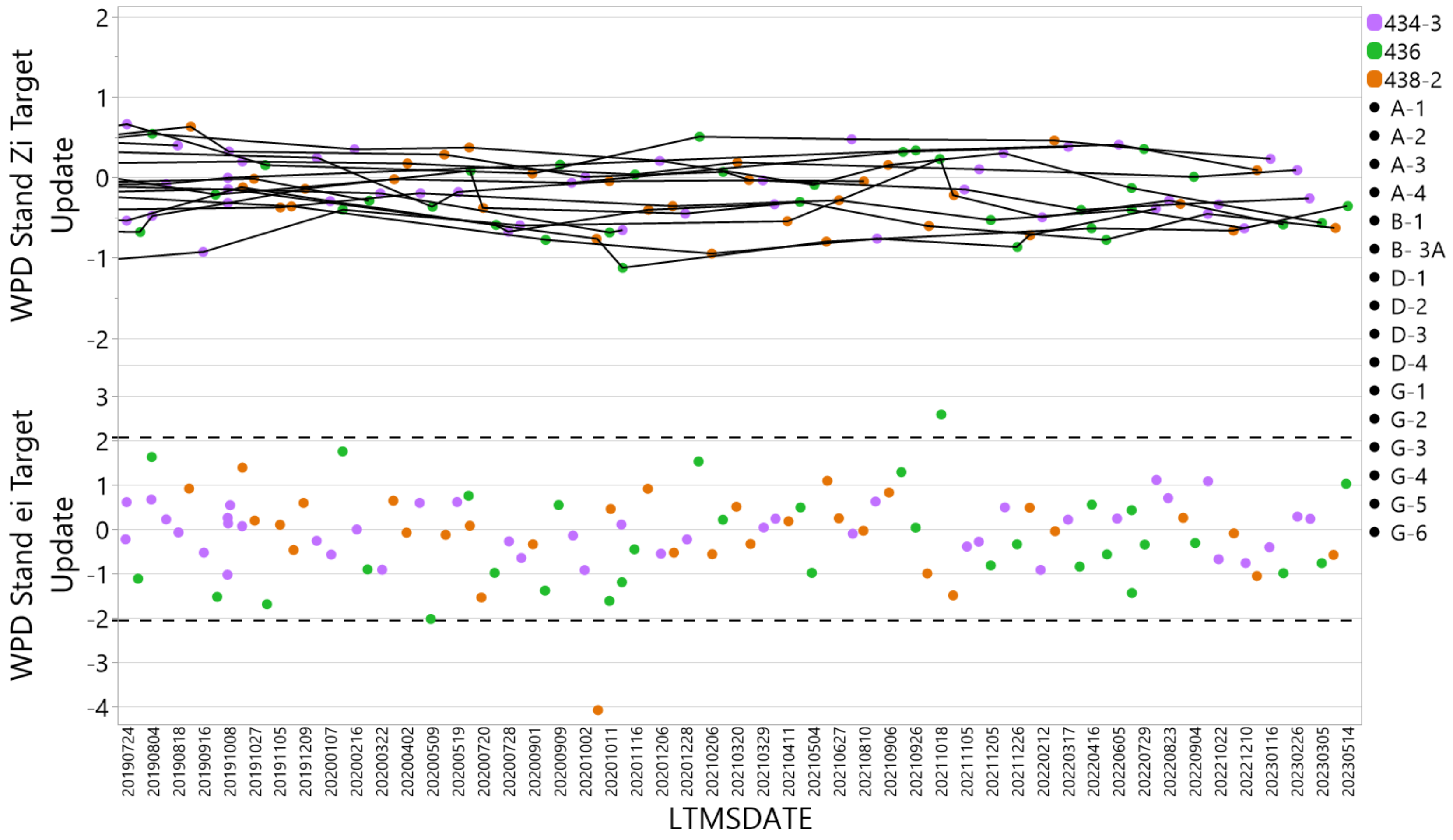
Updated WPD Oil EWMA Plot

With the 438-2 target update, all 3 oils are indicating that WPD is in control but slightly severe by 0 to 0.5 standard deviations.



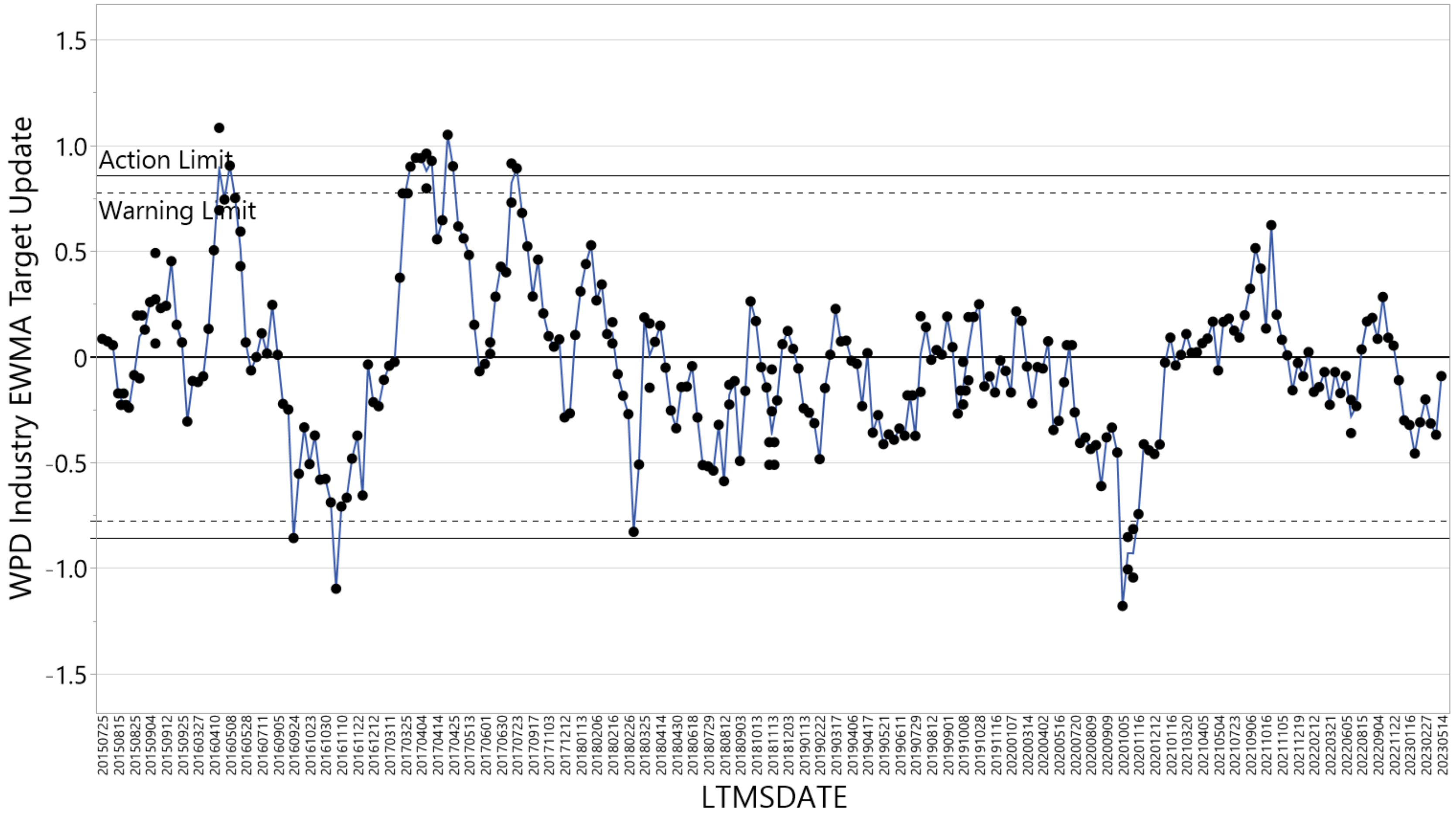
Calibration Failures

Looking back at how the updated standard deviations would have impacted calibration success, there appears to be 3 ei failures, with 2 of those being new failures. The second is shown below and appears appropriate.



Updated WPD Industry EWMA

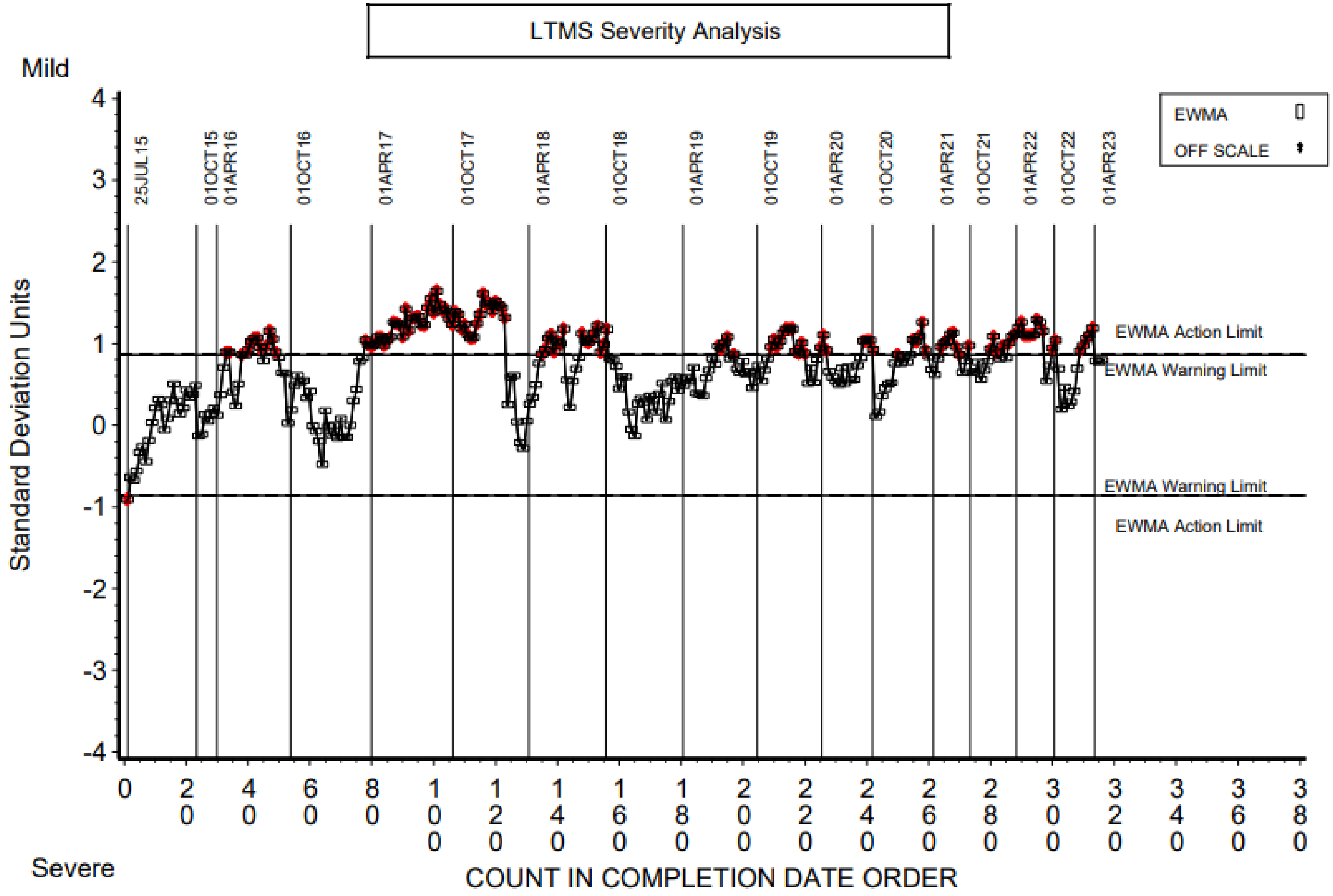
Below is the estimated updated Industry EWMA with the 438-2 target update and the updated standard deviations.



APV

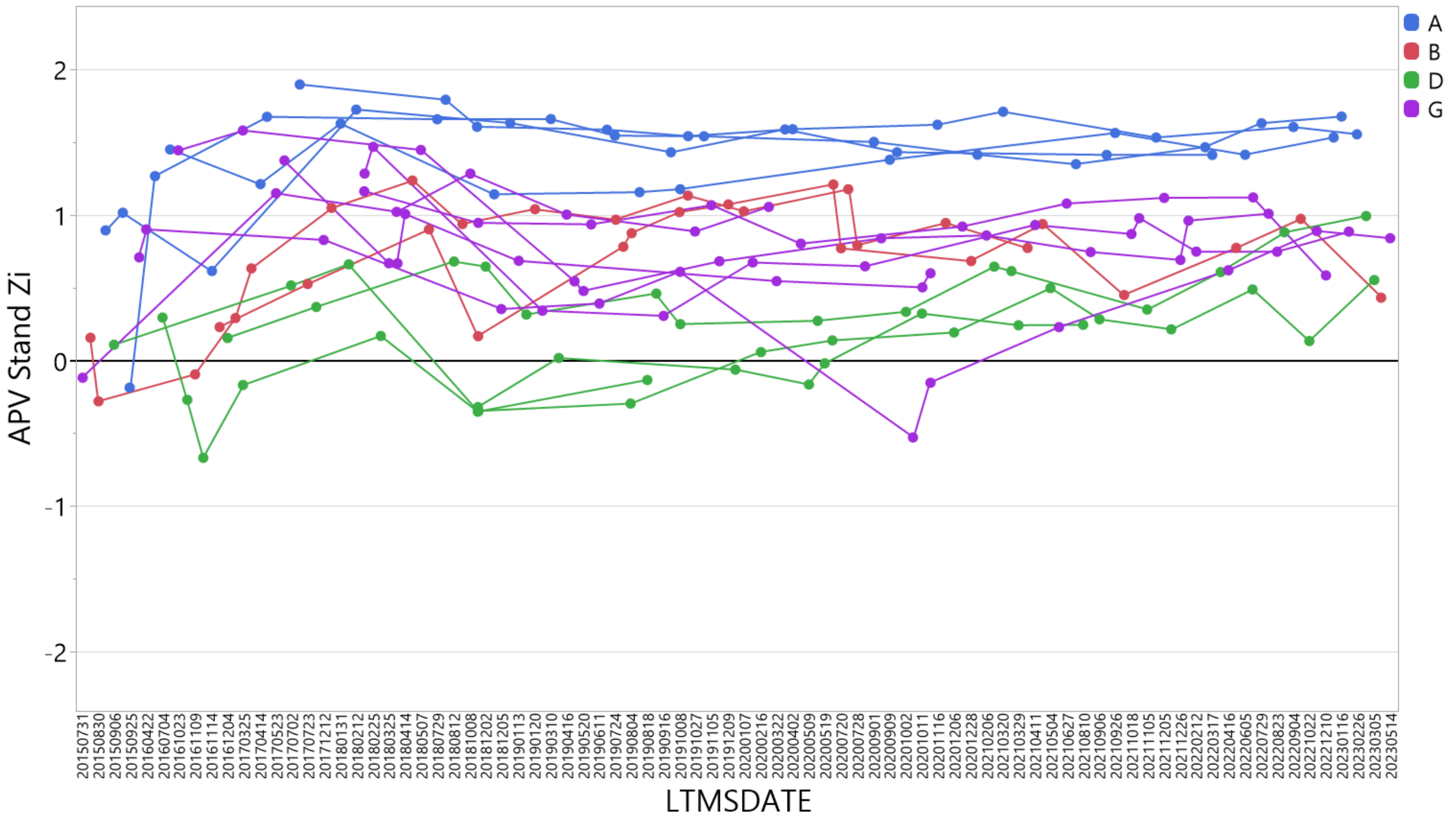
APV Industry EWMA

APV is trending similar to PVIS currently, just less than one standard deviation mild, but has been more consistently mild, rarely dipping below the zero line.



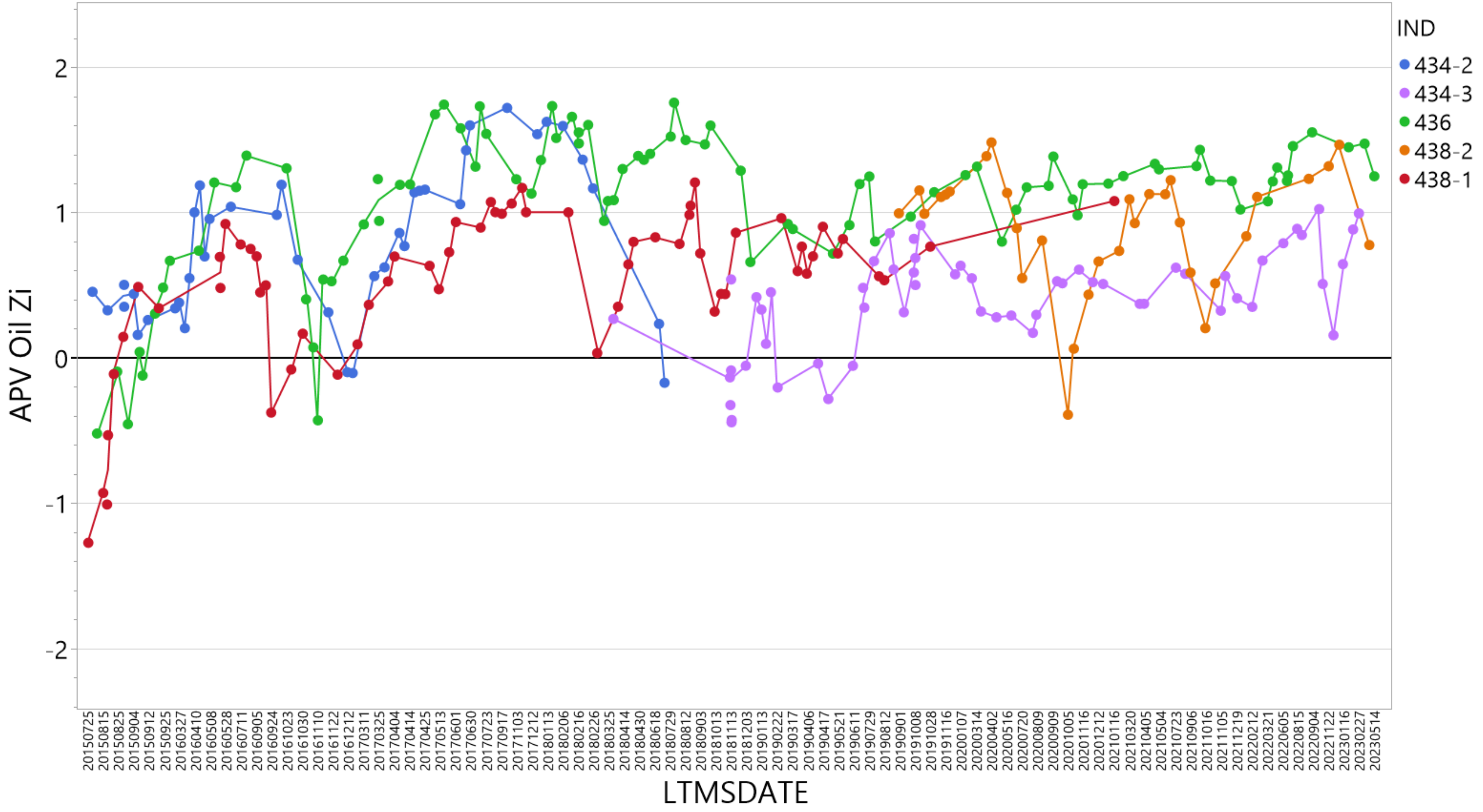
APV Zi by Lab-Stand

Lab A appears to have stands running milder than the rest of the industry.



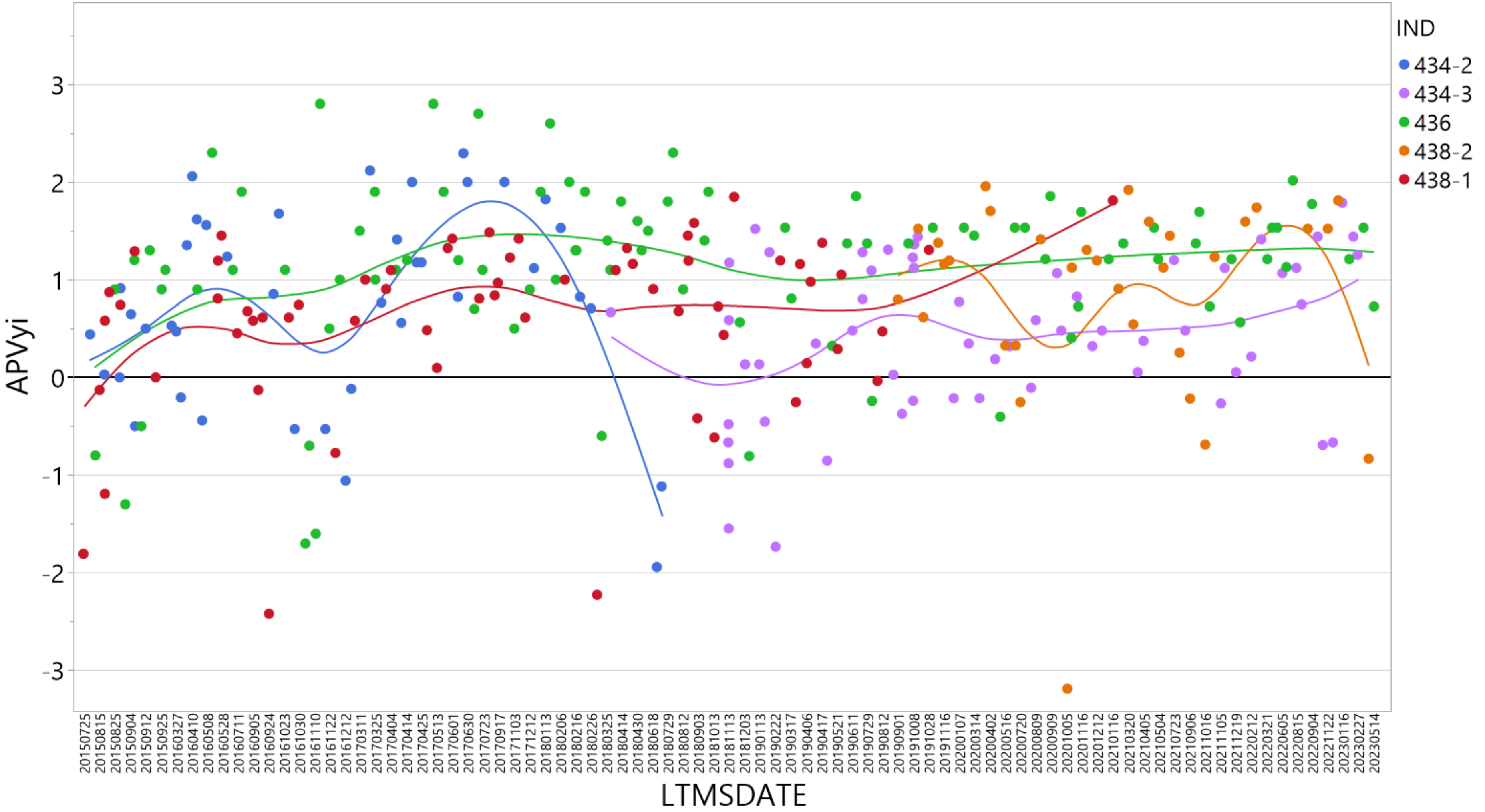
APV EWMA by Oil

436 has trended mild for a long time now.   438-2 appears to have been introduced at a similar time to when 434-3 and 436 were shifting milder, around summer/early fall of 2019.



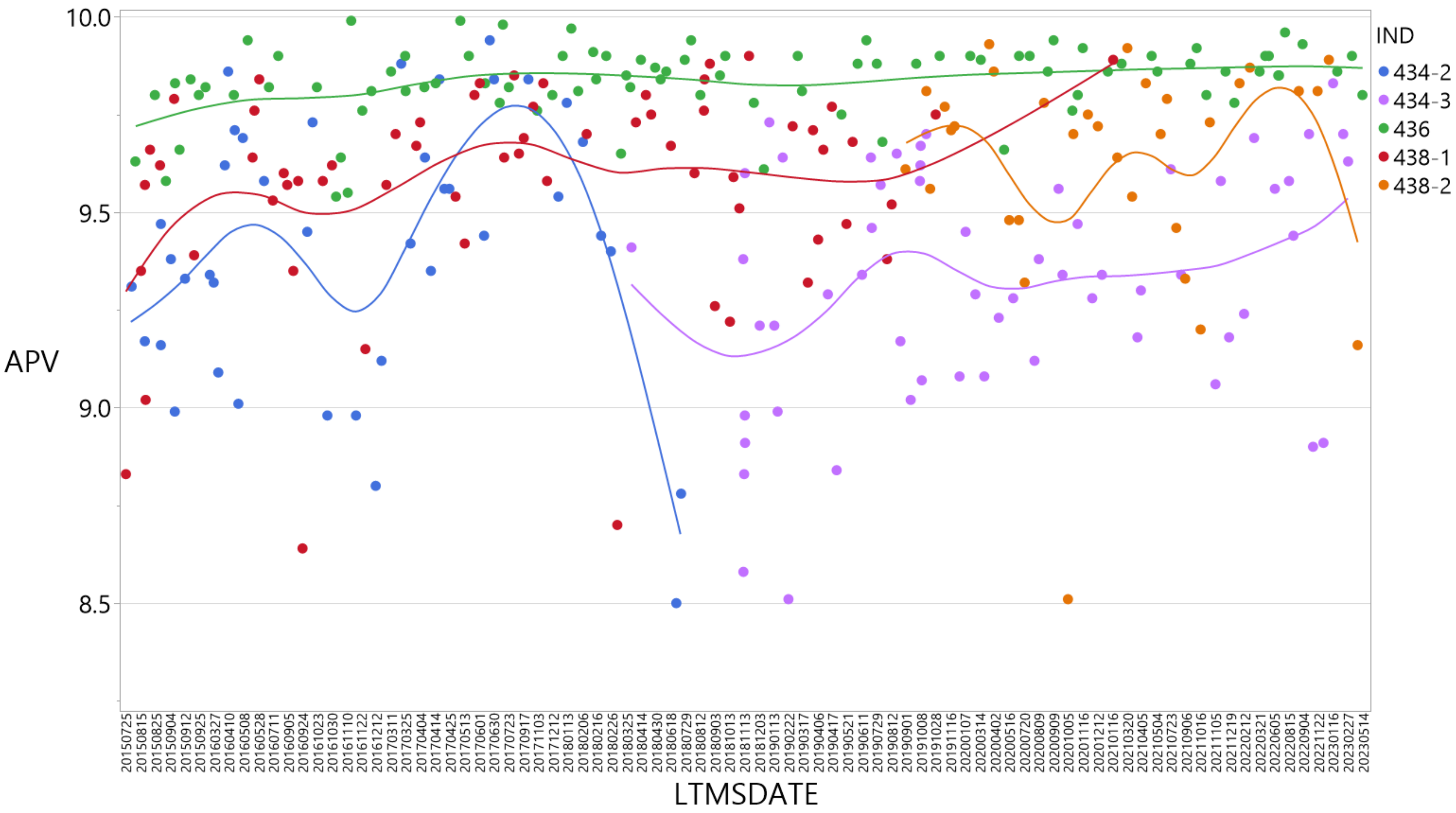
APV Yi by Oil, All Labs Combined

All oils are mild to some degree for the majority of the time since inception of this test, with 434-3 closest to target.



Choosing a Time Period for Standard Deviation Calculations

Standard deviations were calculated using all data for each of the reference oils.



Estimated Standard Deviations

The table to the right shows the recommended updates to the standard deviations.

Oil	LTMS Standard Deviation	Recommended New Standard Deviation
434-3	0.375	0.3000
438-2	0.276	0.2889
436	0.124	~~0.0941~~ 0.124

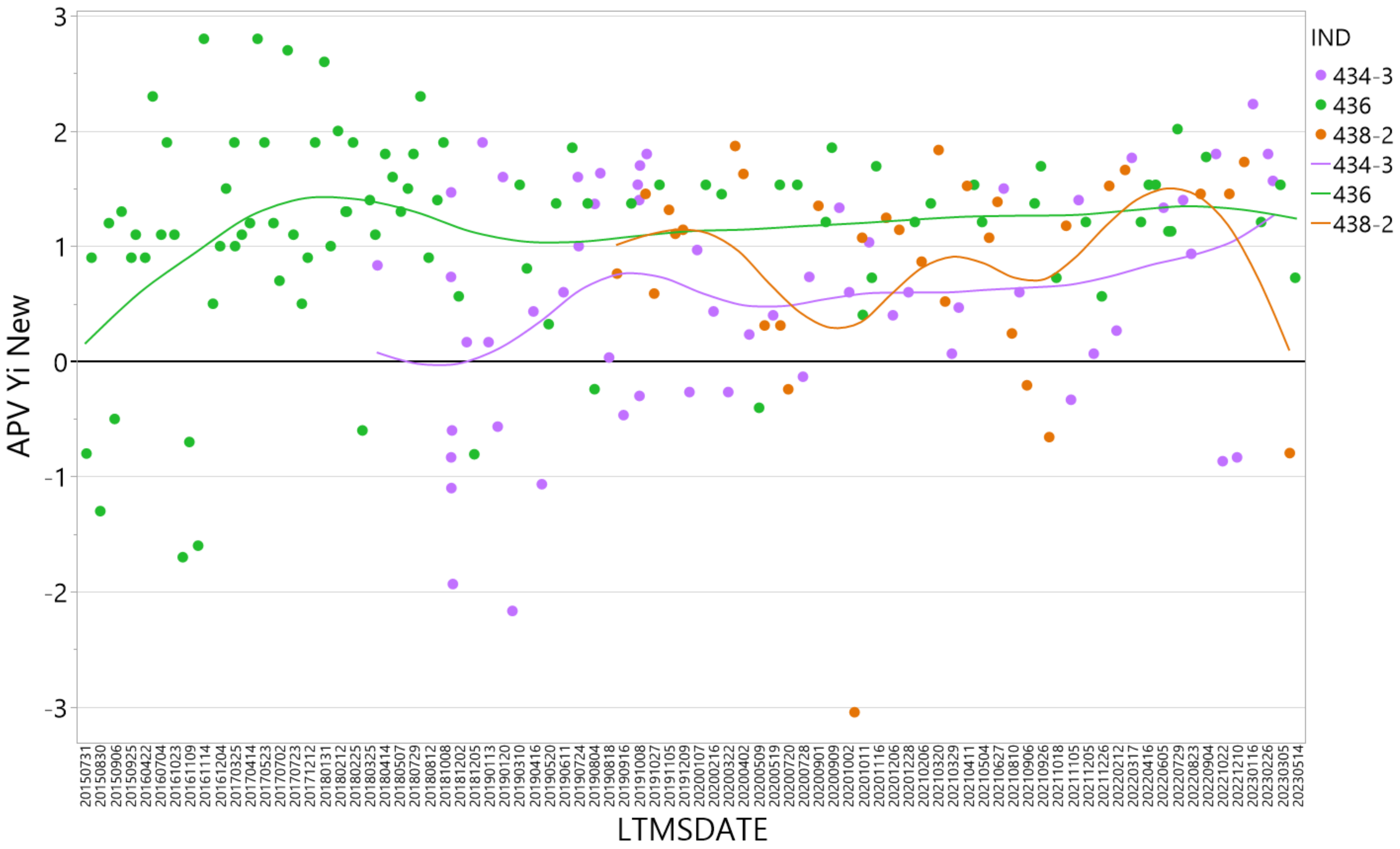
Leave 436 alone in case of shift toward target.

Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
0.327	0.2376

Average of 3 Ref. Oil Standard Deviations

Updated APV Yi Plot by Oil

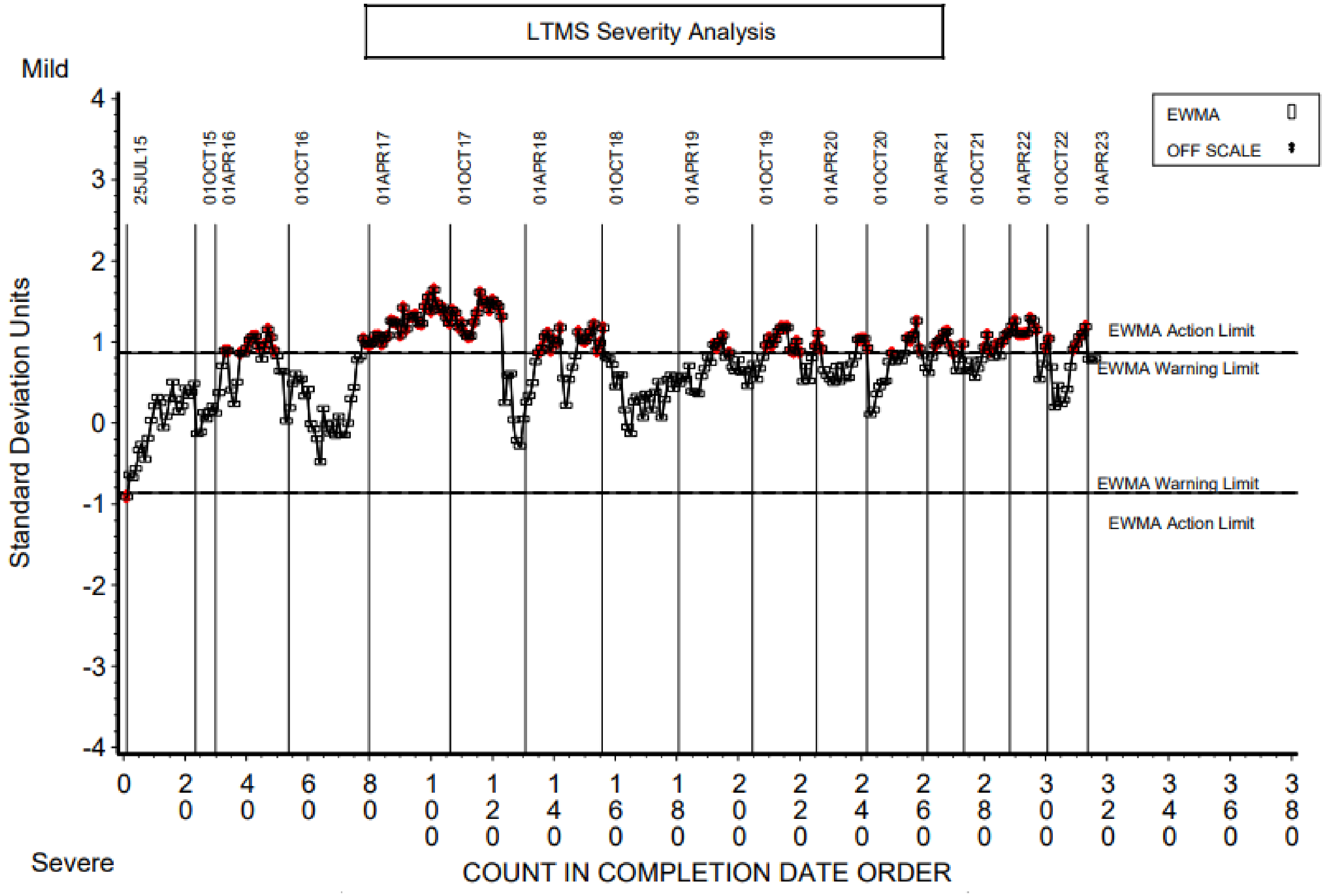
With the updated standard deviations, the scatter of the reference oil results is more reasonably similar



MRV

MRV Industry EWMA

MRV is trending similarly mild to PVIS and APV.



MRV LTMS Targets

The MRV parameter uses Yi values from PVIS for oil 434-3. LTMS updates are therefore only considered here for 436 and 438-2.

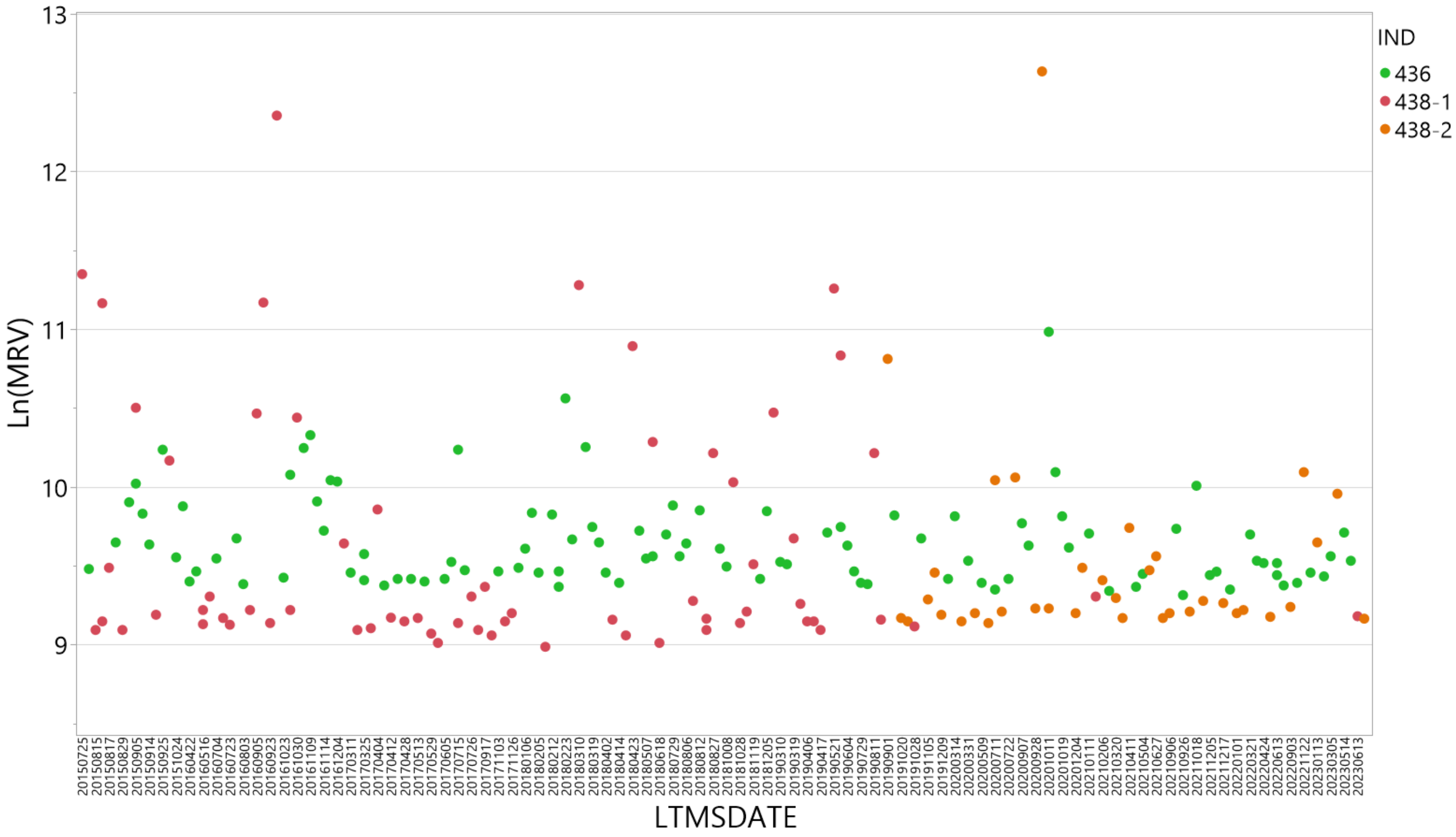
MRV Viscosity
Unit of Measure: ln(MRV)

Reference Oil	Mean	Standard Deviation
434-2	11.1107	0.5220
434-3[A]	---	---
436	9.7854	0.2423
438-1	9.8189	0.9132

[A] For oil 434-3, use Sequence IIIH PVIS Yi value as MRV Yi value

Ln(MRV) by LTMS Date

Below is a plot of Ln(MRV) by date. With 438-2 seeming milder, standard deviations will be calculated separately for this re-blend, similar to what was done for PVIS.



MRV LTMS Standard Deviation Updates

Using the raw standard deviation, the below summary statistics show the recommended updates.

MRV Viscosity
Unit of Measure: ln(MRV)

Reference Oil	Mean	Standard Deviation
434-2	11.1107	0.5220
434-3[A]	---	---
436	9.7854	0.2423
438-1	9.8189	0.9132

[A] For oil 434-3, use Sequence IIIH PVIS Yi value as MRV Yi value

There would be no new calibration failures as a result of the 438-2 standard deviation decrease.

Distributions Oil=436

Ln(MRV)

Summary Statistics

Mean	9.6468216
Std Dev	0.2864332
N	104

Distributions IND=438-2

Ln(MRV)

Summary Statistics

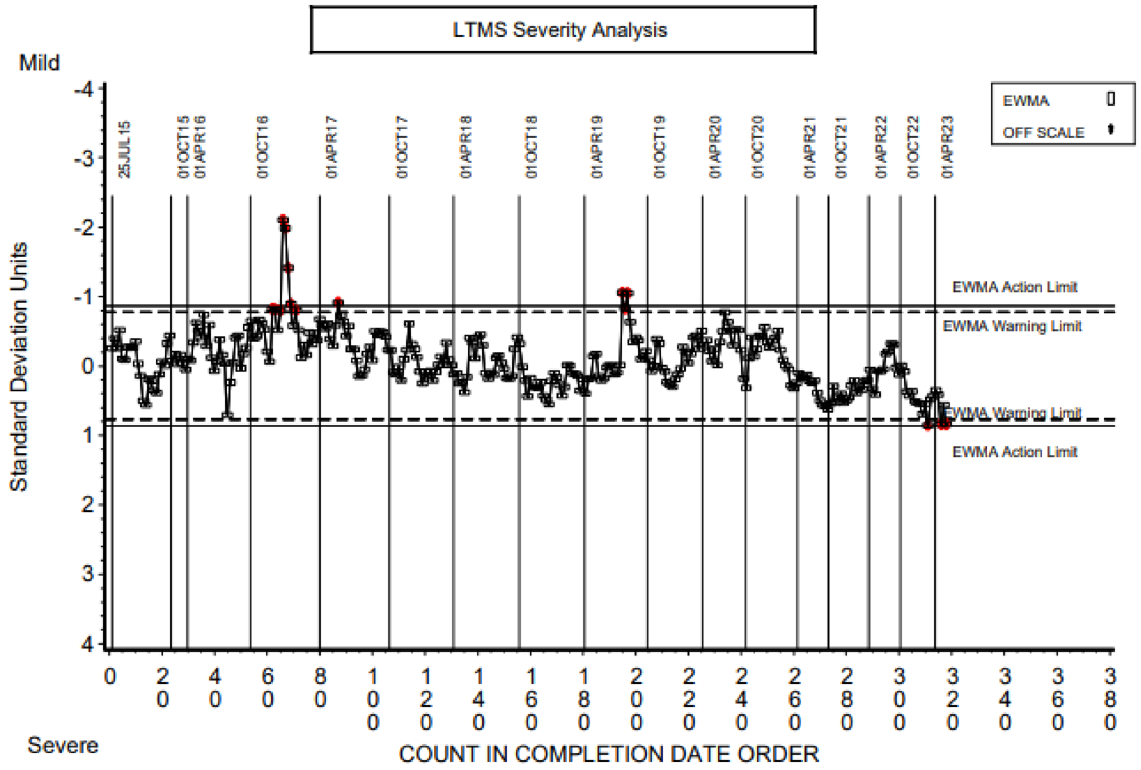
Mean	9.5034151
Std Dev	0.6511145
N	36

Severity adjustment standard deviation 0.4725 → 0.4538.

Phosphorus Retention

PHOS Industry EWMA

Phos retention has been mostly under control but moved near the severe alarm limit recently.



PHOS LTMS Targets

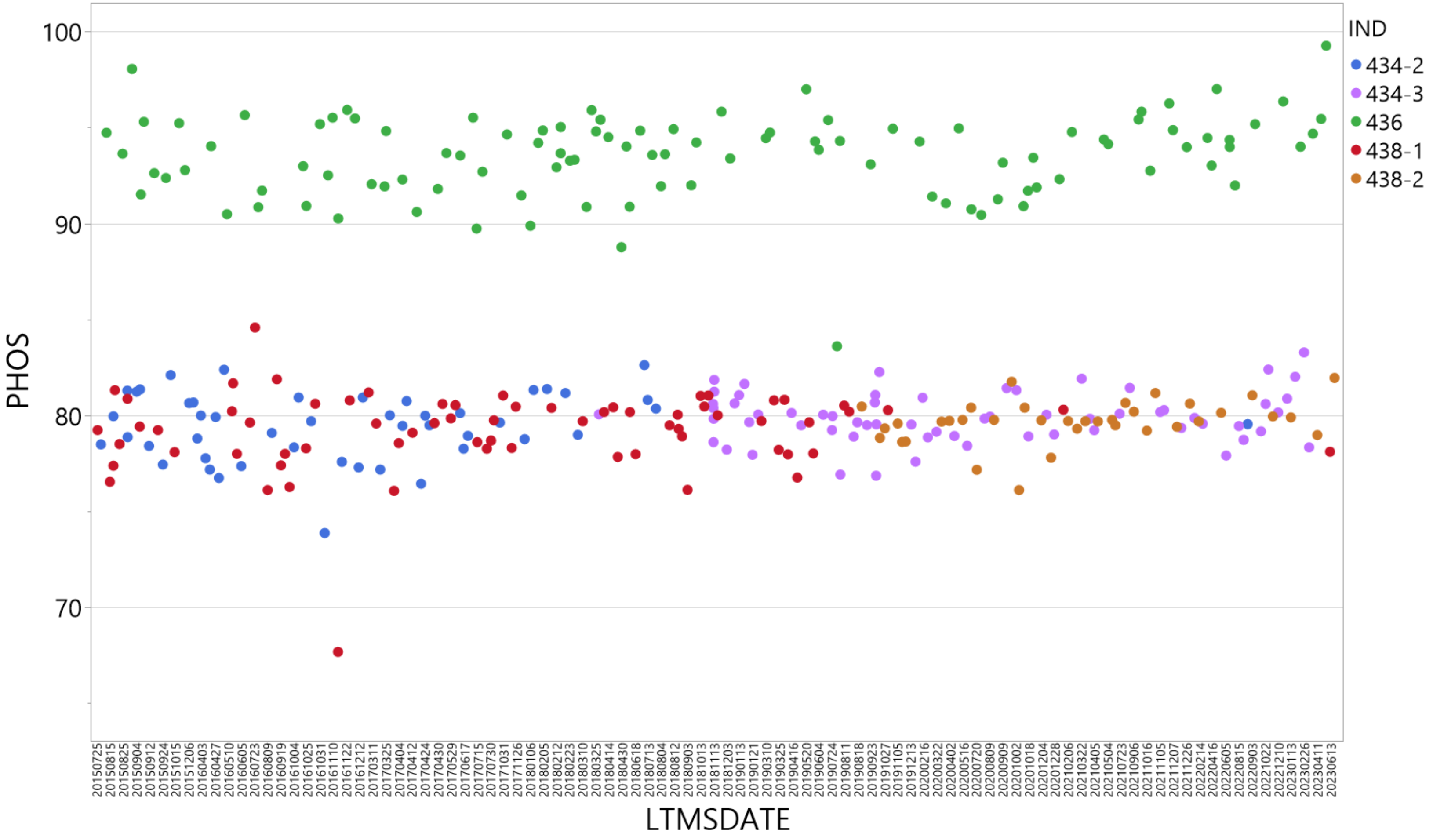
Below are the LTMS means and standard deviations.

PHOSPHOROUS RETENTION
Unit of Measure: Percent

Reference Oil	Mean	Standard Deviation
434-2	79.95	1.58
434-3	79.95	1.58
436	94.15	2.02
438-1	78.92	1.54

PHOS by LTMS Date

Below is a plot of PHOS by date. The data seems consistent over time and re-blends, with a couple of outliers.



PHOS LTMS Standard Deviation Updates

The following steps were followed to obtain the standard deviations:

1. Filtered to Chartable = Y
2. Combined re-blends into single oil and ran a model with PHOS ~ Oil.
3. Filtered out studentized residuals greater than +/- 3 (four points removed).
4. Calculated raw standard deviations with outliers removed and re-blends combined.

PHOSPHOROUS RETENTION
Unit of Measure: Percent

Reference Oil	Mean	Standard Deviation
434-2	79.95	1.58
434-3	79.95	1.58
436	94.15	2.02
438-1	78.92	1.54

There would only be one additional calibration failure with these changes, which would be the most recent run on stand A-3, which was the most mild result to date on oil 434-3 at 83.27%.

Distributions Oil=434-X
PHOS
Summary Statistics

Mean	79.745872
Std Dev	1.4275362
N	109

Distributions Oil=436
PHOS
Summary Statistics

Mean	93.543824
Std Dev	1.850338
N	102

Distributions Oil=438-X
PHOS
Summary Statistics

Mean	79.467282
Std Dev	1.4437717
N	103

Summary

Summary of Recommended Changes, PVIS and WPD

Below is a summary of the recommended changes for PVIS and WPD.

PVIS

Oil	LTMS Standard Deviation	Recommended New Standard Deviation
434-3	0.6598	0.5845
438-2	0.9558	0.4950
436	0.3138	0.4005

Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
0.4641	0.4933

WPD

Oil	LTMS Mean	Recommended New LTMS Mean	LTMS Standard Deviation	Recommended New Standard Deviation
434-3	4.16	---	0.70	0.42
438-2	3.66	3.87	0.43	0.26
436	4.63	---	0.28	0.34

Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
0.47	0.35

Summary of Recommended Changes, APV, MRV, PHOS

Below is a summary of the recommended changes for APV, MRV, and PHOS.

APV

Oil	LTMS Standard Deviation	Recommended New Standard Deviation
434-3	0.375	0.3000
438-2	0.276	0.2889
436	0.124	0.124

Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
0.327	0.2376

MRV

Oil	LTMS Standard Deviation	Recommended New Standard Deviation
434-3	---	---
438-2	0.9132	0.6511
436	0.2423	0.2864

Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
0.4725	0.4538

PHOS

Oil	LTMS Standard Deviation	Recommended New Standard Deviation
434-3	1.58	1.43
438-2	1.54	1.44
436	2.02	1.85

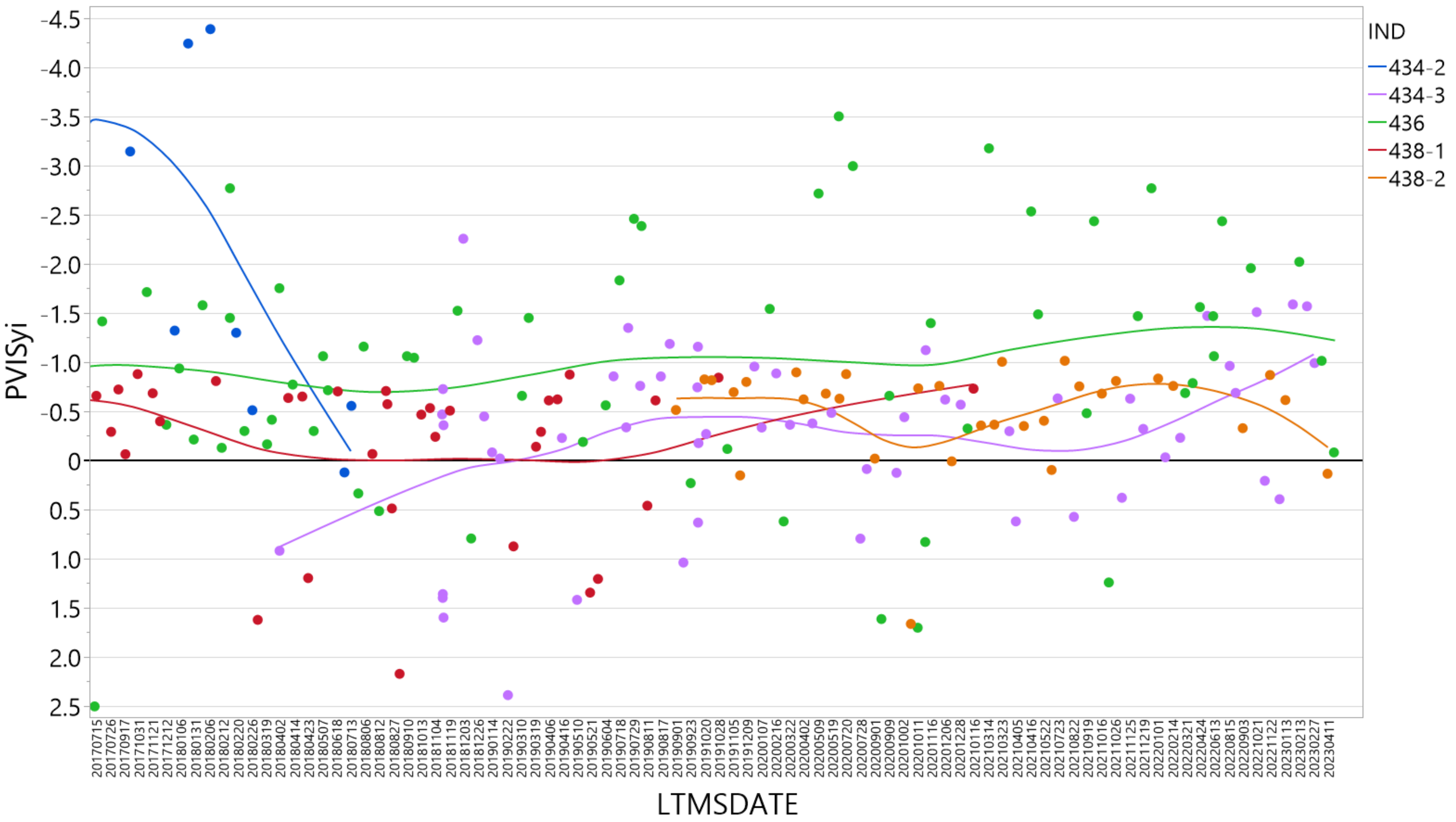
Current S.A. Std. Dev.	Recommended S.A. Std. Dev.
1.53	1.57

Appendix
Additional Slides

PVIS Yi by Oil, All Labs Combined

Though the biggest problem is clearly 436, there are a handful of recent 434-3 results which have been milder than normal as well.

The total spread of all 436 results is about 5 standard deviations wide (approx. +/- 2.5 from average), and much smaller for other two oils.



Average and Standard Deviation Since 2020

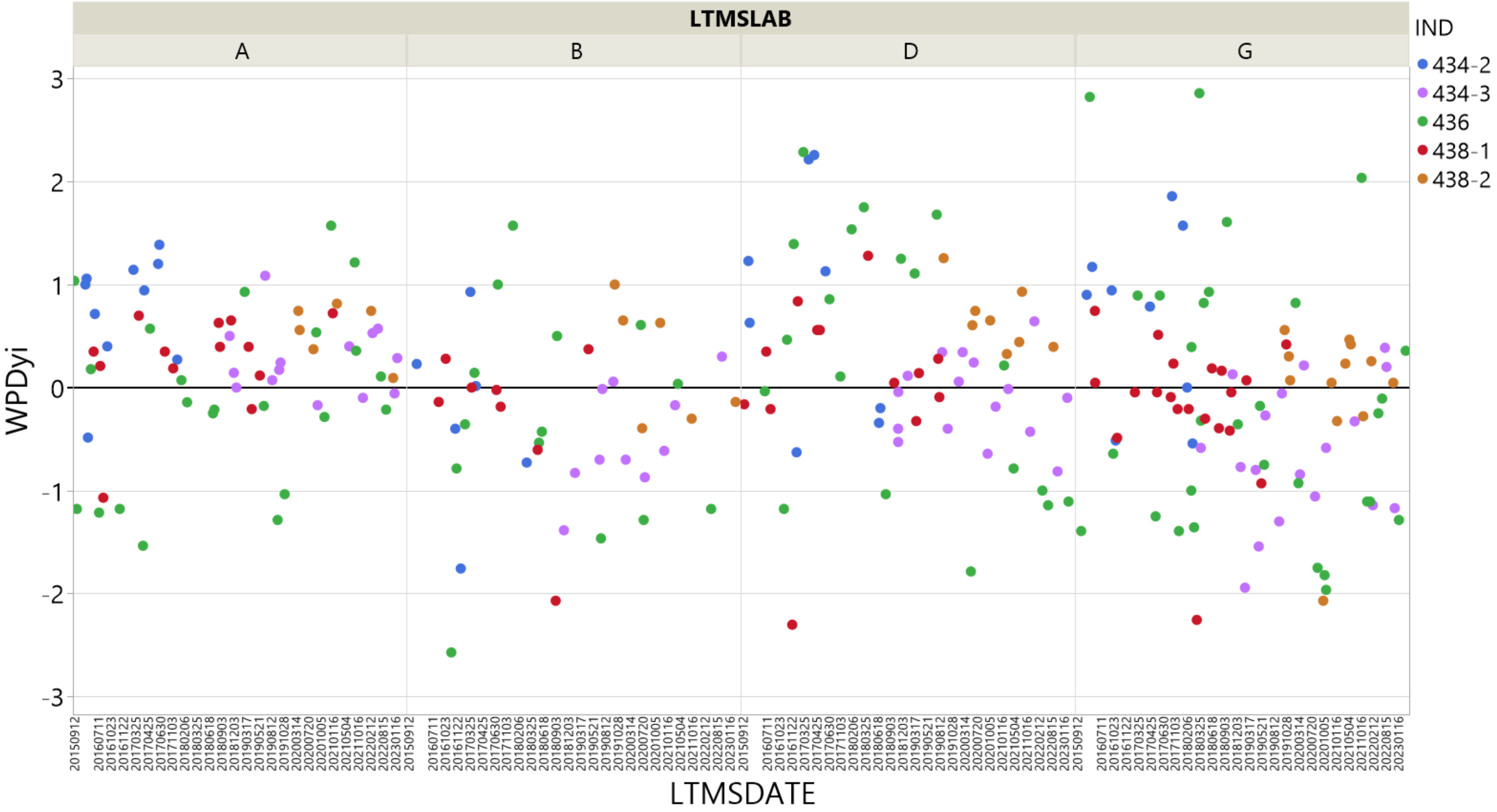
The realized standard deviation of Yi results for Oil 436 since 2020 is almost 3 times higher than the other two oils. The target Yi standard deviation should be a value of one. The data indicates that the standard deviations are too large for 434-3 and 438-2, but too small for oil 436.

Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	5.7602 (317%)	0.6598	4.4406 (85%)	7.0798 (1,188%)
438-2	3.9754 (53%)	0.9558	2.0638 (8%)	5.887 (360%)
436	3.3289 (28%)	0.3138	2.7013 (15%)	3.9565 (52%)

Oil	Yi Average	Yi Std. Dev.	n
434-3	-0.43 (239%)	0.66	30
438-2	-0.48 (34%)	0.55	26
436	-1.19 (19%)	1.42	29

WPD Yi by Oil and Lab

Oil 436 again appears to be much more variable than the other oils at all labs.



Average and Standard Deviation Since 2020

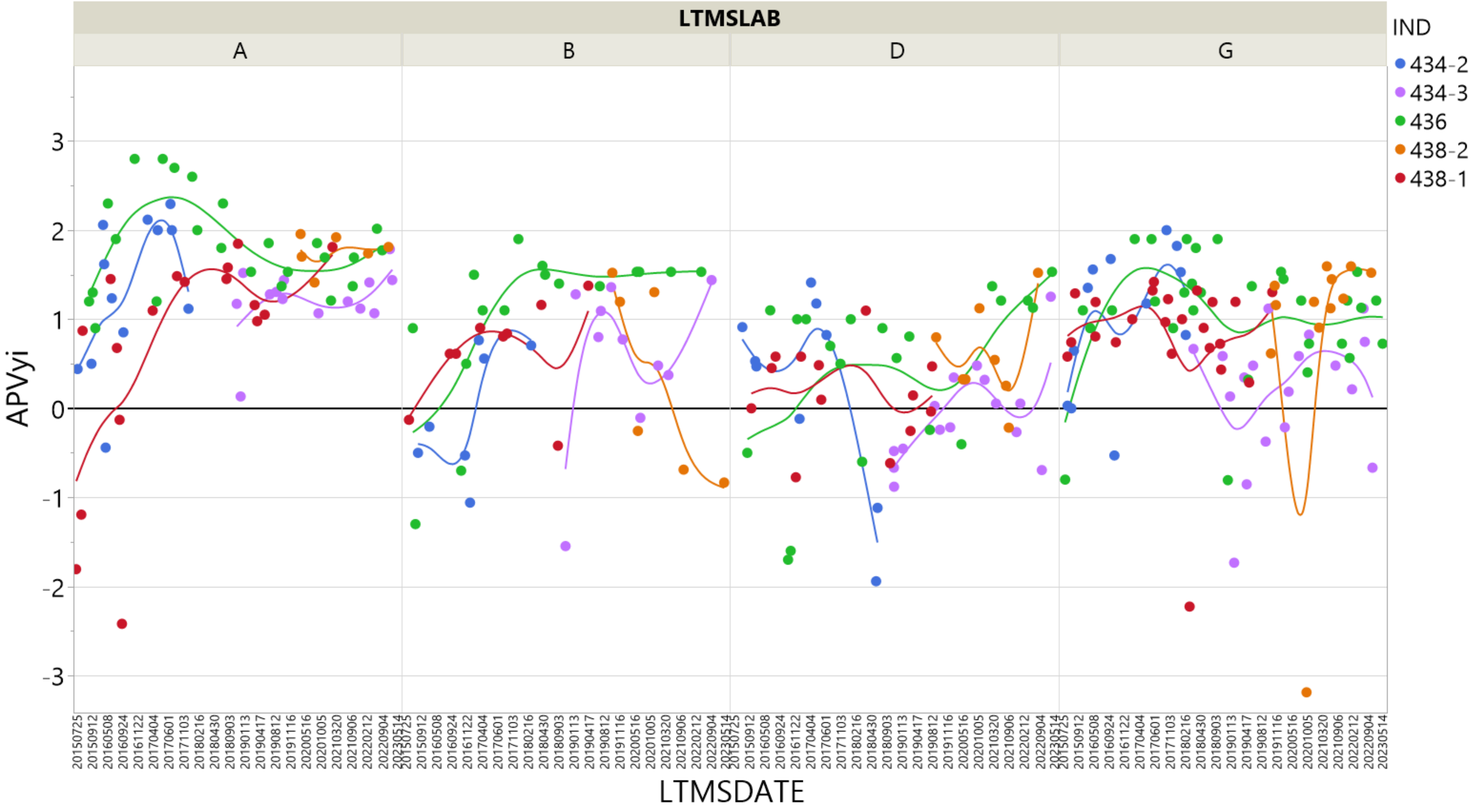
The realized standard deviation of Yi results for Oil 436 since 2020 is almost 3 times higher than the other two oils. The target Yi standard deviation should be a value of one. The data indicates that the standard deviations are too large for 434-3 and 438-2, and just slightly too small for oil 436.

Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	4.16	0.70	2.76	5.56
438-2	3.66	0.43	2.80	4.52
436	4.63	0.28	4.07	5.19

Oil	Yi Average	Yi Std. Dev.	n
434-3	-0.19	0.54	30
438-2	0.23	0.61	26
436	-0.39	1.05	29

APV Yi by Oil and Lab

APV is mild to varying degrees at all labs.



Average and Standard Deviation Since 2020

Yi standard deviations are less than one for 2/3 of the oils. 436 standard deviation likely smaller due to its proximity to the upper end of the scale.

Reference Oil	LTMS Mean	LTMS Standard Deviation	Mean – 2 Std. Dev.	Mean + 2 Std. Dev.
434-3	9.16	0.375	8.41	9.91
438-2	9.39	0.276	8.84	9.94
436	9.71	0.124	9.46	9.96

Oil	Yi Average	Yi Std. Dev.	n
434-3	0.57 (9.37)	0.64	30
438-2	0.82 (9.61)	1.15	26
436	1.25 (9.87)	0.50	29