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COMMITTEE D02 ON PETROLEUM PRODUCTS, LIQUID FUELS, AND LUBRICANTS

Issued: 03.02.2018

Reply to: Dan Worcester
Southwest Research Institute
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San Antonio, TX 78238
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These are the unapproved minutes of the 02.28.2018 Sequence VI Conference Call.

The meeting was called to order at 1:03 PM Central Time by Chair Andrew Stevens.

Agenda

The Agenda is the included as Attachment 1. Only 3.1 was discussed at this meeting.

1.0 Roll Call

The Attendance list is Attachment 2. There were no membership changes.

2.0 Approval of Meeting minutes from 12.13.2017 Seq. VI SP meeting.

2.1 Andrew Stevens made the motion and Dan Worcester seconded.

2.2 The minutes were approved unanimously.

3.0 Old Business

3.1 Monitoring of the Sequence VIE Procedure Stats Group

3.1.1 Test Severity & Engine Hour Adjustment

The meeting focused on this topic. Background is covered, including how many runs per engine, and the severity shift over time. See Attachment 3. Slide 4 is the Executive Summary. The severity shift started at the end of the Precision Matrix. The VIF has a "hill effect" and two reference tests were chosen. This was discussed for the VIE, see Slide 8. New oil standard deviations are discussed, based on one reference run per engine. The Zi would be updated to use 40% from historical testing at each stand.

$$Z_i = 0.6Y_i + 0.4*Z_{i-1}$$

There would be an FEI 1 Industry correction of 0.21 and 0.22 for FEI 2. The Yi bands would widen to ±2.5 to cover an unequal severity shift in the three reference oils. There was a question by Bob Campbell about changing the reference oil assignments, currently 1/3 for each oil. 45, 45, 10% was discussed, then the following motion made and approved.

Motion #1 –Move to 40, 40 and 20% reference oil assignments for 1010, 542 and 544.
Bob Campbell, Robert Stockwell, second. Passed unanimous.

There was then discussion on Slide 37 to apply for VIE reference runs. Most of the discussion was on when this would apply to the labs.

Motion #2 –Recommend to the Surveillance Panel:
Bob Campbell, Robert Stockwell, second. Passed with two waives.

Per slide 37 of the Stat Group presentation, Items 1 and 2 will apply. Re-report the last 3 runs on each stand, then implement the changes on the next reference on each new engine. If less than 3 runs on a stand at a lab, report what reference tests have been completed on the stand. If no references on a stand, report it as a new stand and use $Z_{0.}$

1. Update LTMS to include stand based Zi with capped Yi effect, new Yi limits, new standard deviations, new severity adjustment standard deviations, and new R as below.
    1. Yi Limits set to +/-2.500 and Zi impact capped atYi limits
    2. New standard deviations per table below.
    3. New SA s: FEI1=0.235, FEI2=0.281
    4. New R: FEI1=0.919, FEI2 = 0.904
2. Adopt an Industry correction factor of 0.21 for FEI1 and 0.22 for FEI2

3. Move to the following standard deviations for each oil:

		FEI 1 Proposed	FEI 2 Proposed
542 Blends	Std. Dev	0.280	0.260
	N	45	45
1010-1	Std. Dev	0.199	0.327
	N	39	39
544	Std. Dev	0.214	0.256
	N	43	43

4.0 Meeting Adjourned

The meeting adjourned at 3:05 PM Central Time.

Sequence VI Surveillance Panel Call Meeting Agenda
February 28, 2018 @ 2:00-4:00 EST

Webex Meeting Details Below Agenda

1. **Roll Call (start 2:05 EST)**

   1.1. SP Membership changes and additions

2. **Approval of Meeting minutes from December 13, 2017 Seq. VI SP meeting**

3. **Old Business**

3.1	3.1. Monitoring of the Sequence VIE Procedure 3.1.1. Test Severity & Engine Hour Adjustment	Stats Group
3.2	Review of Action Items from 12/13/17 SP Meeting - **Action Item #1 –** Haltermann to report to the Sequence VI surveillance panel on details of building large batch of Lube Cert EEE fuel + DCA - **Action Item #2**– Progress Report: Laboratories to inspect their stands and report to Rich Grundza on what valves they have installed on each stand for 150C in Section 6.5.3 of the Sequence VIE and Sequence VIF ASTM test procedures - **Action Item #3 –** Progress Report: Add Section 11.6.5.1 from the Sequence VID (D7589) ASTM test procedure to the Sequence VIE (D8114) and Sequence VIF ASTM test procedures. - **Action Item #4 –** Progress Report: Rich Grundza to review the Sequence VIE and Sequence VIF ASTM test procedures for inclusion of the necessary sole source statements and to make recommendations, if needed, to the Sequence VI surveillance panel	Andrew Stevens

	- **Action Item #7** – Progress Report: Laboratories to re-upload their Sequence VIE and VIF precision matrix tests (29 VIE and 18 VIF tests) with the engine hour adjustment applied. - **Action Item #7 –** Progress Report: Greg Miranda/Andrew Stevens and Rich Grundza to provide all of the necessary information, to update the Sequence VIF test procedure draft, to Hap Thompson for the next and final procedure draft - **Action Item #8** – Progress Report: Seq. VIF/VIE Procedure Review: Prepare for balloting in new year - Build manual replaces Annex A17 - Fixed timing sprockets 9.4.20 revision - Section 6.2 not allowing revision of short block	
3.3	Seq. VIE Severity Task Force Update 3.3.1 Results of Scott Stap review of photos of ring deposits seen at Valvoline.	Dan Worcester

4. New Business

4.1. Seq VIE BOI/VGRA Matrix Details Discussion
4.1.1. Progress Report

5. Next Meeting

5.1. SP Meeting: TBD

6. Meeting Adjourned

Hi,

 Lubrizol is inviting you to this WebEx meeting:

Seq VI SP Meeting
Wed, Feb 28, 2:00 pm | 2 hr
New York (Eastern Standard Time, GMT-05:00)
Host: Lubrizol

Join

Add the attached iCalendar (.ics) file to your calendar.

Agenda

This meeting does not have an agenda.

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VOTES				

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Dan Worcester **Voting Member**				
VOTES				

VIE Severity Review and Recommendations

Statistics Group

February 20, 2018

Statistics Group

- Arthur Andrews, ExxonMobil
- Doyle Boese, Infineum
- Jo Martinez, Chevron Oronite
- Kevin O'Malley, Lubrizol
- Martin Chadwick, Intertek
- Richard Grundza, TMC
- Lisa Dingwell, Afton
- Todd Dvorak, Afton
- Travis Kostan, SwRI

Background

- 2/29/17: statistics group informed the Surveillance Panel that the VIE test had been averaging 0.5 to 1 standard deviations severe on FEI1 and just over 1 standard deviation severe for FEI2 for all data post precision matrix (industry in alarm for FEI2).
  - Action (from meeting minutes) was for "test sponsors to provide data/feeling for VIE test severity."
- 3/28/17: data was still severe, but 5 calibration tests in a row on all 3 reference oils passed. Recommendation was made continue to monitor. (Industry still in alarm for FEI2).
- Severity Task force formed on 7/7/17, but to date, no significant causes for the shift have been found.
- 9/12/17: Short blocks approved for use
  - Stat's group commented there is not enough evidence to completely change the engine hours adjustment (but could be updated); if changes are pursued, then changes to the RO oil targets may be needed.
  - Stat's group also agreed that we could better understand test performance with additional reference tests in the form of additional short block matrix testing or performing two references per engine
- 11/16/17: Stat's group does not recommend use of 5th runs

- During the course of these analyses the Stat's Group noticed various potential reasons why a severity shift could be perceived: severity changed; oil targets misrepresent oil performance coming out of precision matrix; "hill effect"

Executive Summary

After reviewing the severity of the VIE test, the statistics group recommends to the Sequence VI Surveillance Panel that the following actions be taken:

1. Update oil standard deviations
   - There is evidence post precision matrix indicating FEI1 oil standard deviations are lower; similar or higher for FEI2. If other changes are made at this time it seems appropriate to include changes to the SDs since it is not uncommon to update estimates over time
2. Adopt a stand Z_i for use in severity adjustment calculations (60% Y_i; 40% stand Z_i)
   - Evidence exists that stand bias exists independent of engine differences. The current system assumes engine differences exist with little or no stand bias (SA = 60% of Yi). Incorporating stand history at a lower percentage than the current result incorporates stand bias while still accounting for potentially large differences between engines.
3. Adopt an Industry correction factor of 0.21 for FEI1 and 0.22 for FEI2
   - When severity shifts occur in the industry, correction factors have been implemented to adjust results back to target performance
4. Widen Yi Acceptance limits from ± 2.0 to ± 2.5.
   - There is an unequal shift in the severity among the oils. Widening the Yi limits will accommodate oils that are expected to not give on targets results.

Note: The surveillance panel should keep in mind that a correction factor does not correct for the unequal severity shift in reference oils or labs and the resulting implications. This includes engine severity adjustments being somewhat correlated to reference oil assignment.

Risk: This approach assumes that the disproportionate amount of negative Yi's is caused by a severity shift. If the appearance of severity is actually a manifestation of a "hill effect" in which 2nd runs are higher than 1st runs (like what was seen in VIF FEI1), or some other effect, then we could be implementing a solution that is not appropriate for references, and more importantly, candidate oils.

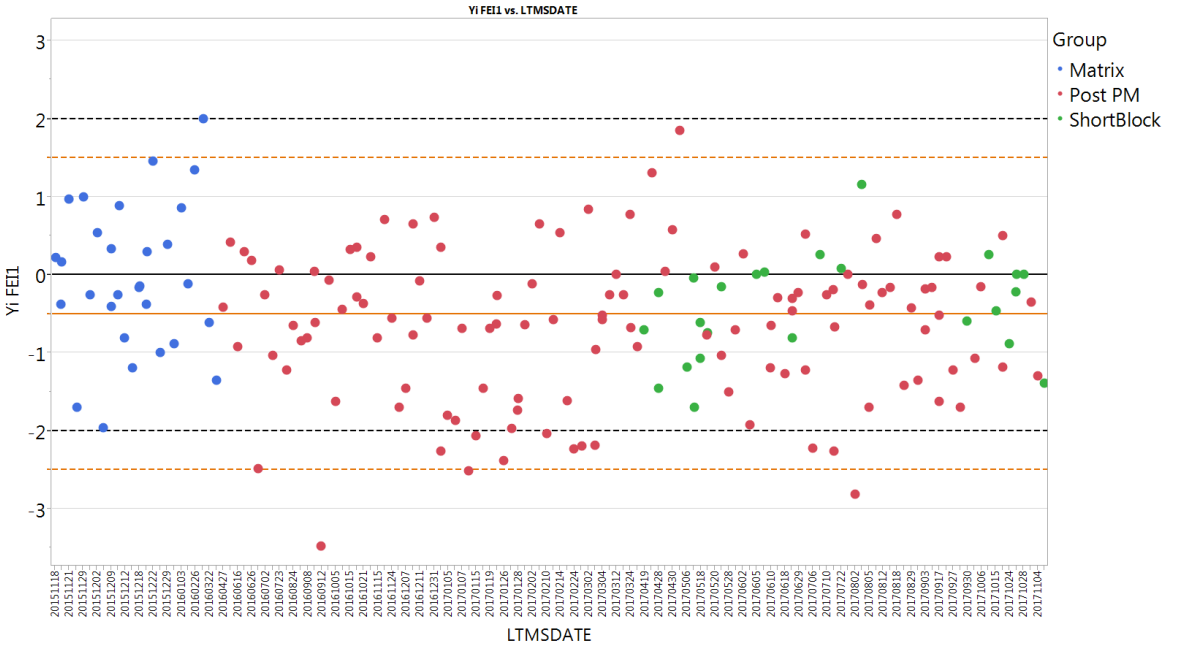
Comments

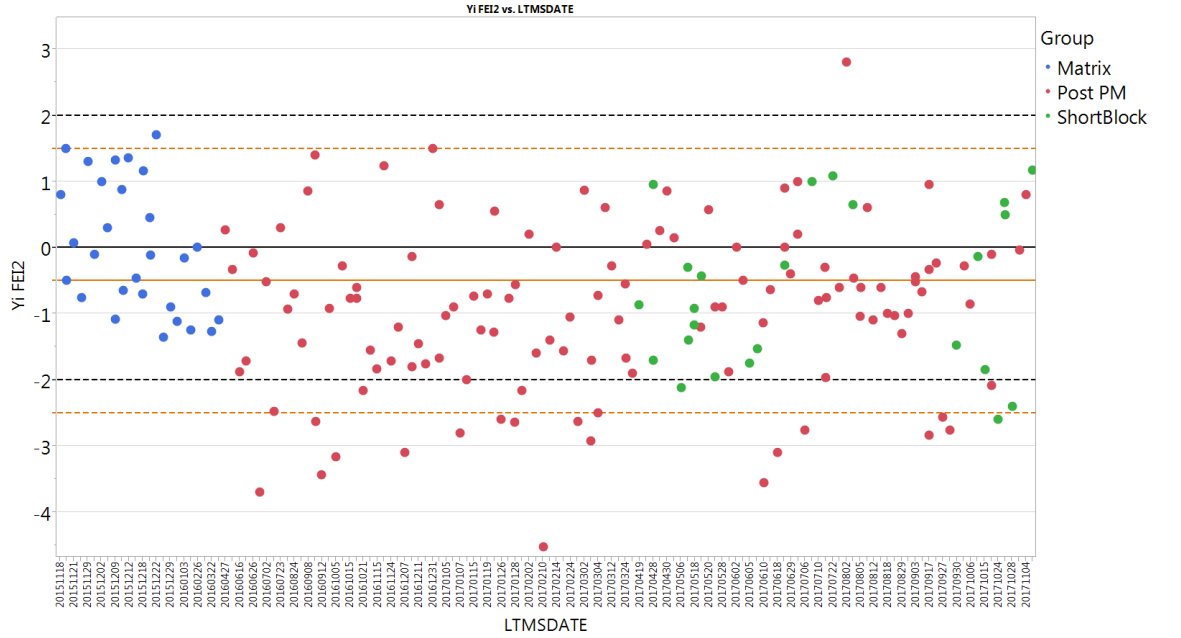
Yi plot of FEI2 suggests a possible shift in severity towards the end of the precision matrix.

Oil targets were established based on all matrix data and were not weighted based on when the tests were run.

Also, the oil targets are based on 8 engines and there is no guarantee those 8 represent the majority

If this is the cause of the perceived shift, then the issue lies with how the oil targets were set up.





Graph includes operationalyl valid 1st-4th run tests through 11/04/17.

Comments

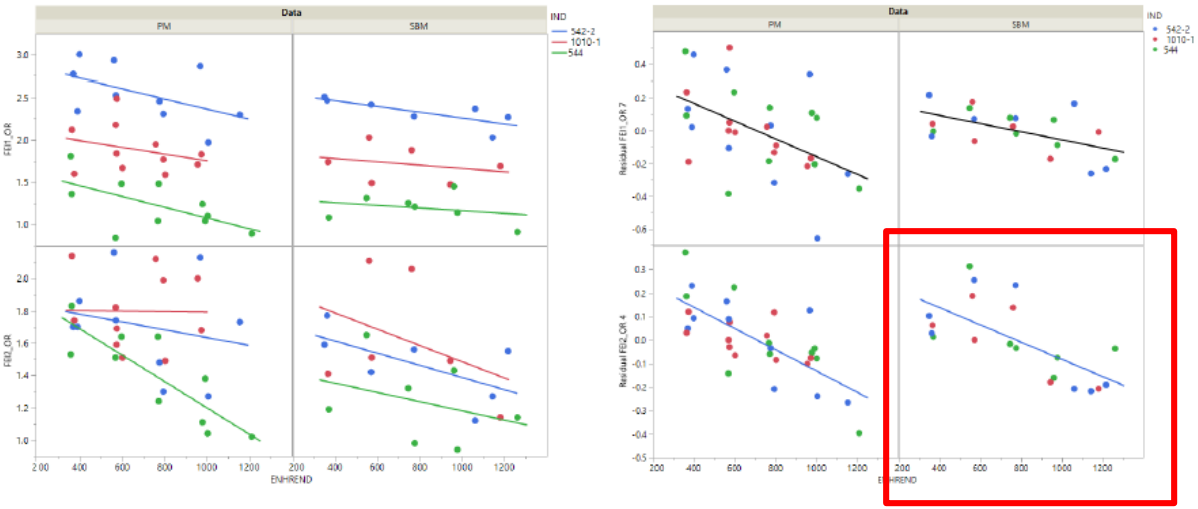
The analysis of the short block data suggests a "hill effect" similar to what was seen in the VIF.

If this is real, then we would expect the 1st run calibration tests to appear severe. Since this makes up the majority of chartable data, it would manifest as a perceived severity shift in the Yi plots

Hill Effect

The "hill effect" was part of the reason why a 2 test calibration was pursued in the VIF

Evaluating Engine Hour Adjustment



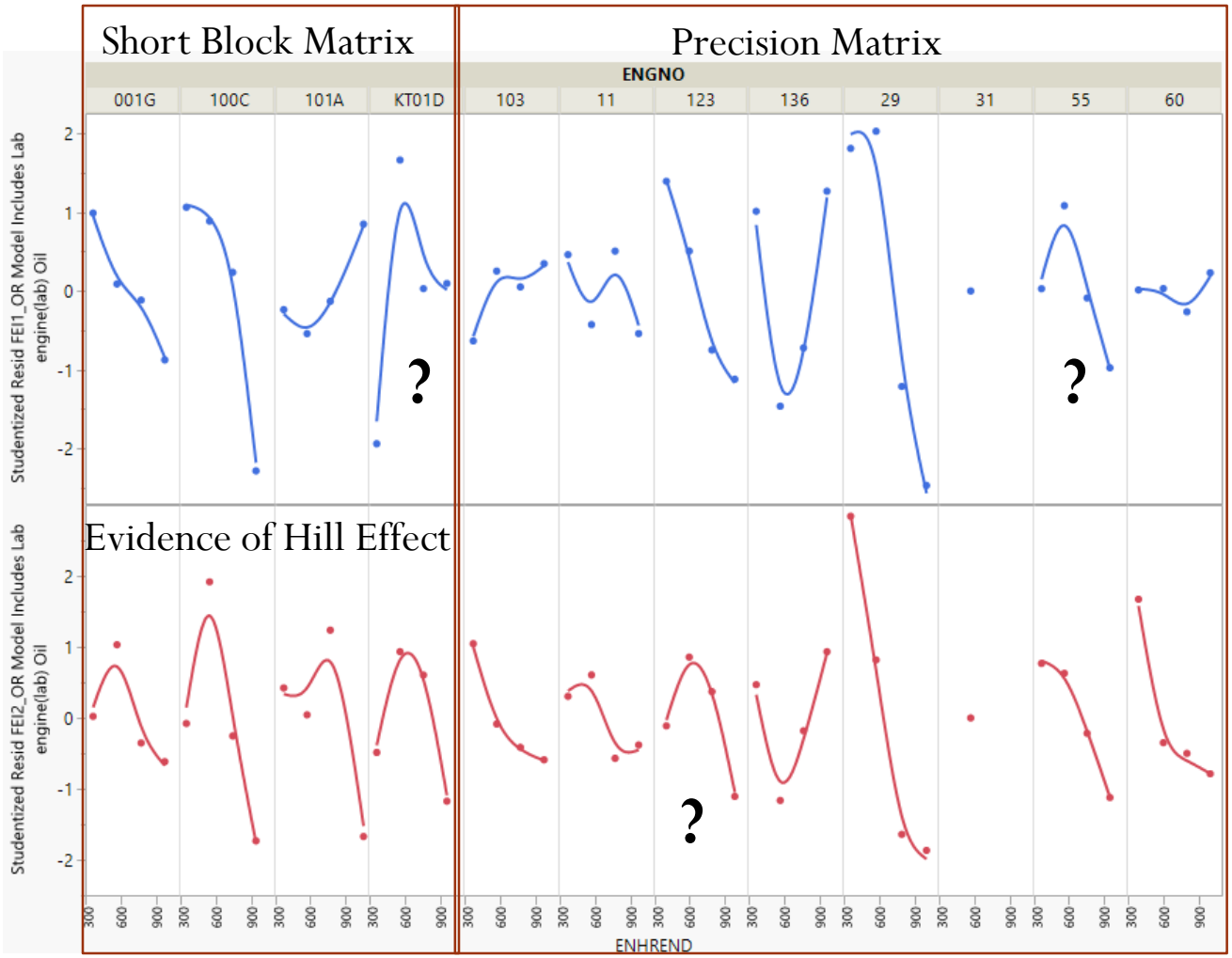
- Appears that engine hour adjustment between PM and SBM may be different
- FEI2 appears to show higher 2nd runs than 1st runs, a phenomenon seen in VIF FEI1
- Since SBM has limited data (4 engines) to establish engine hour adjustment, evaluating engine hour adjustment using PM and SBM data is more appropriate

11

Slide taken from presentation Stat Group shared with the panel on 11/16/17 titled *Evaluating VIE Oil Discrimination in 5-run Engine Life*

Comments

Further comparisons by engine show evidence of "hill effect" in short block matrix engines (FEI2) and minor evidence in FEI and precision matrix data



Comments

ALTERNATIVE APPROACH:

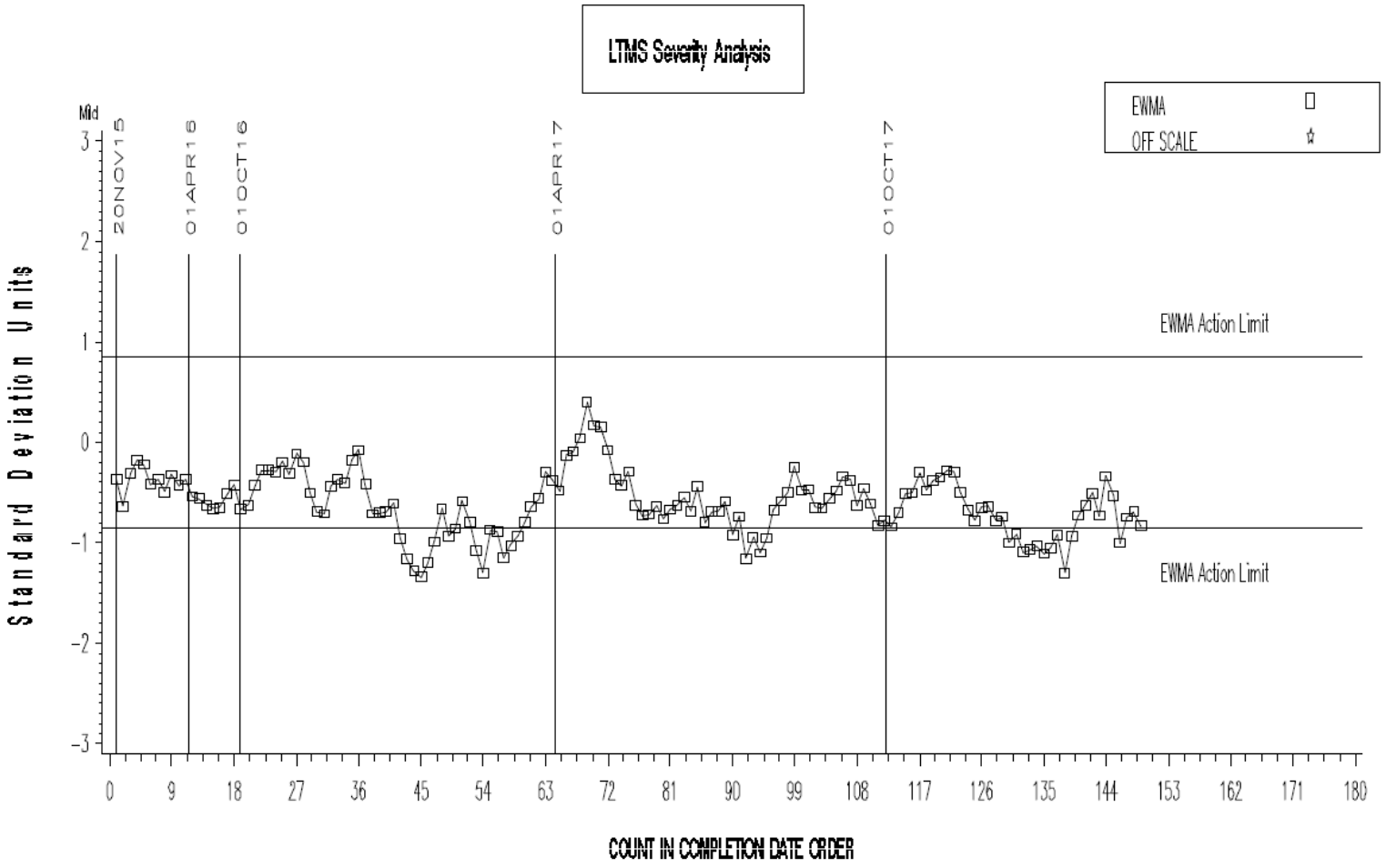
Temporarily, or permanently, perform two reference tests at the beginning of each engine's life.

- Benefits:
  - Better assess whether a severity shift is truly present or a manifestation of the "hill effect"
  - Judge whether the current engine hours adjustment is reasonable early in the life of the engines
- Possible outcomes:
  - 1st runs appear severe and 2nd runs appear near target or mild: supports "hill effect"
  - Both 1st and 2nd runs are severe: indicates need for CF or is a manifestation of oil targets not being appropriate for post precision matrix engines
- Note: A permanent change to the VIE could be handled by mimicking the VIF LTMS; this approach would allow us to better handle this situation and future test severity concerns.

FEI 1 Industry EWMA

FEI1 industry severity has recently come out of the alarm action limit.

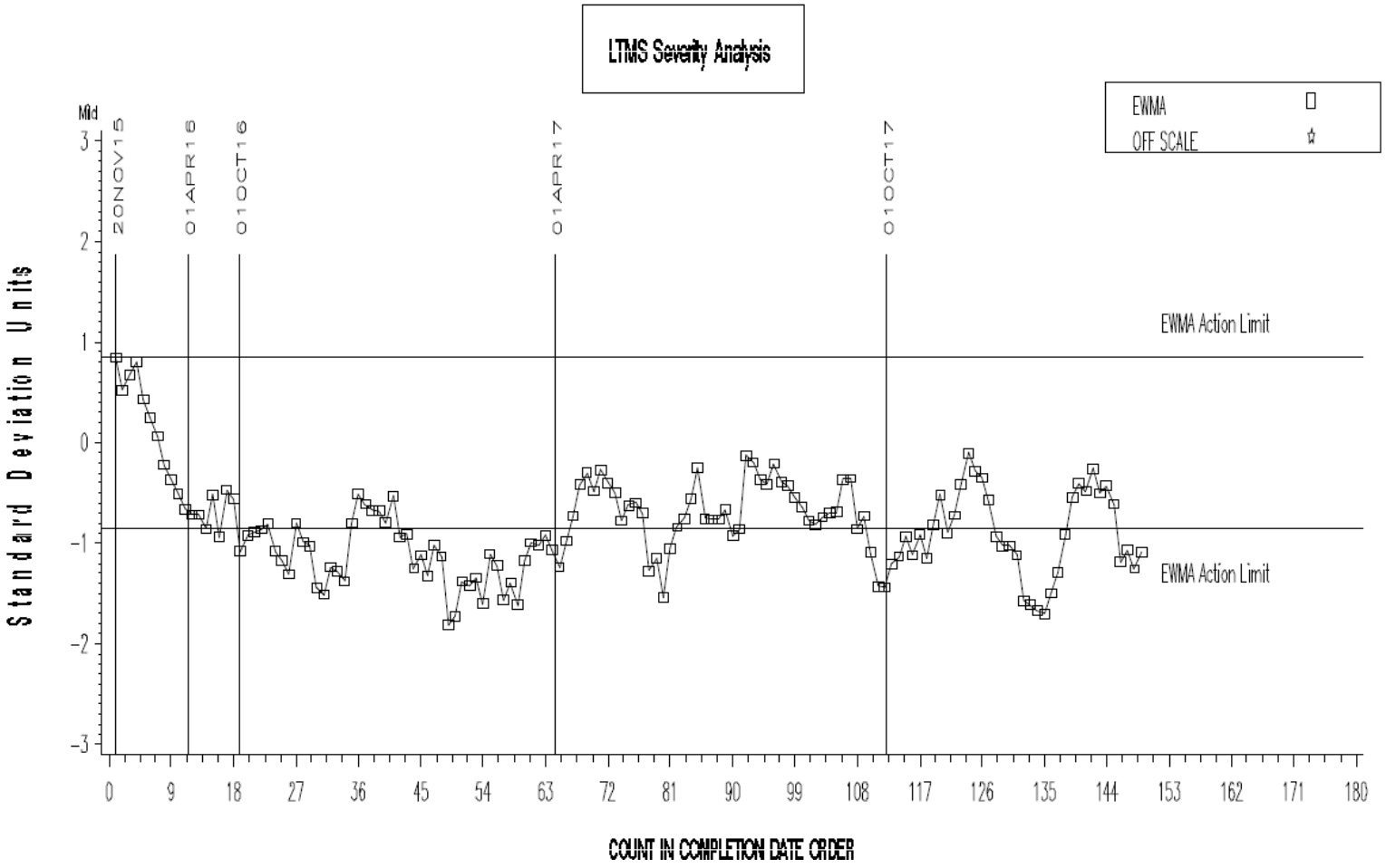
Updated 02/14/18



FEI 2 Industry EWMA

FEI 2 severity has drifted in and out of action alarm, and just recently exceeded the action limit again.

Updated 02/14/18



Recommendation #1

Update Oil Standard Deviations

Update Oil Standard Deviations

The oil standard deviations can be improved upon with the larger data set available. The statistics group recommends that following updates be applied, which represents the raw standard deviations of the oils using post-matrix 1st run data:

FEI 1

		FEI 1 Current	FEI 1 Proposed
542 Blends	Std. Dev	0.31	0.280
	N	9	45
1010-1	Std. Dev	0.27	0.199
	N	11	39
544	Std. Dev	0.26	0.214
	N	9	43

FEI 2

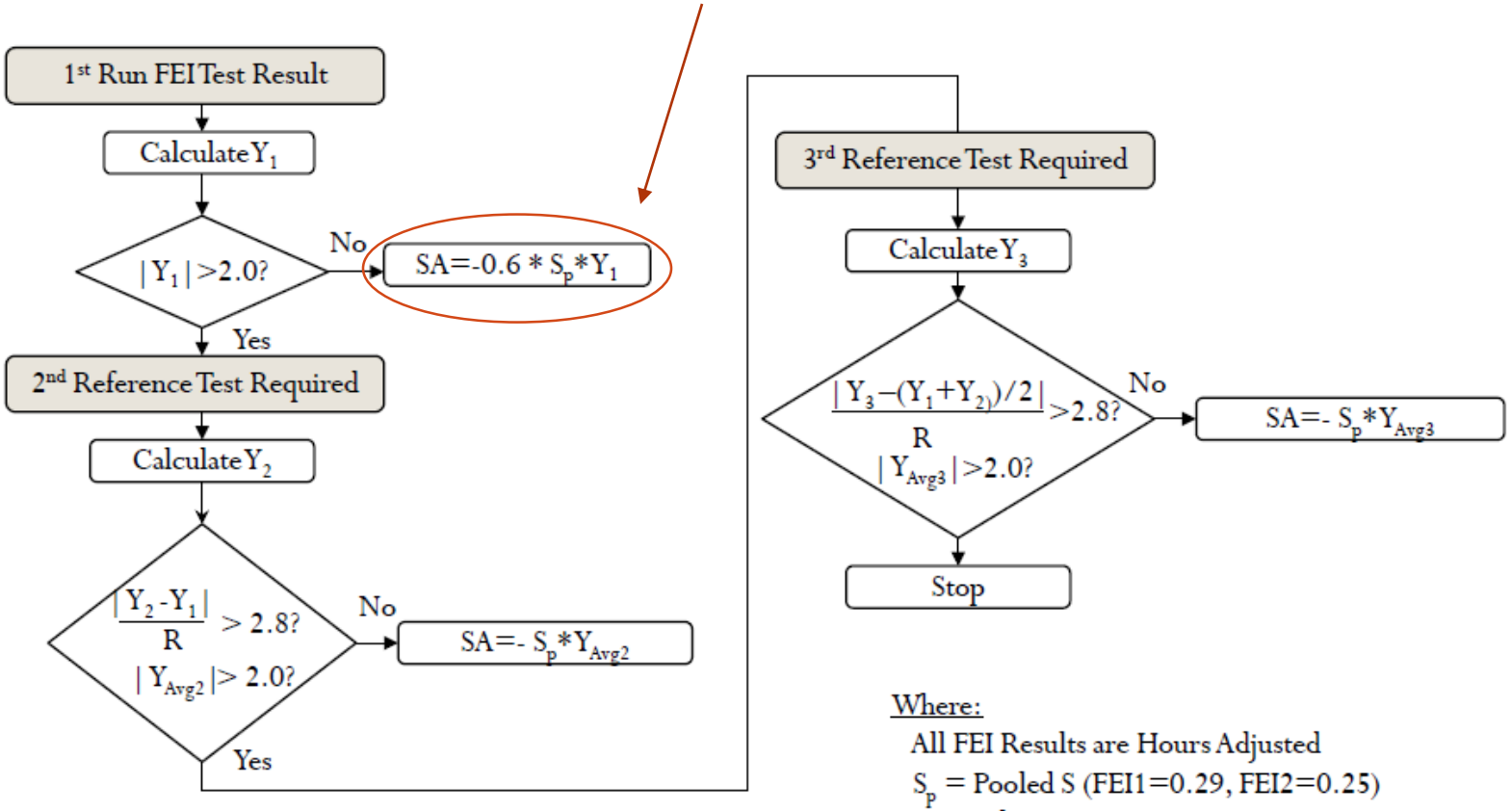
		FEI 2 Current	FEI 2 Proposed
542 Blends	Std. Dev	0.30	0.260
	N	9	45
1010-1	Std. Dev	0.25	0.327
	N	11	39
544	Std. Dev	0.20	0.256
	N	9	43

Recommendation #2

Adopt a stand-based Zi for use in SA calculations

Adopt a stand-based Zi for use in SA calculations

- Current VIE LTMS severity adjustment (SA) for a single run calibration is based on a weight factor of $(0.6 * Y_i * -S_p)$.



Where:

All FEI Results are Hours Adjusted

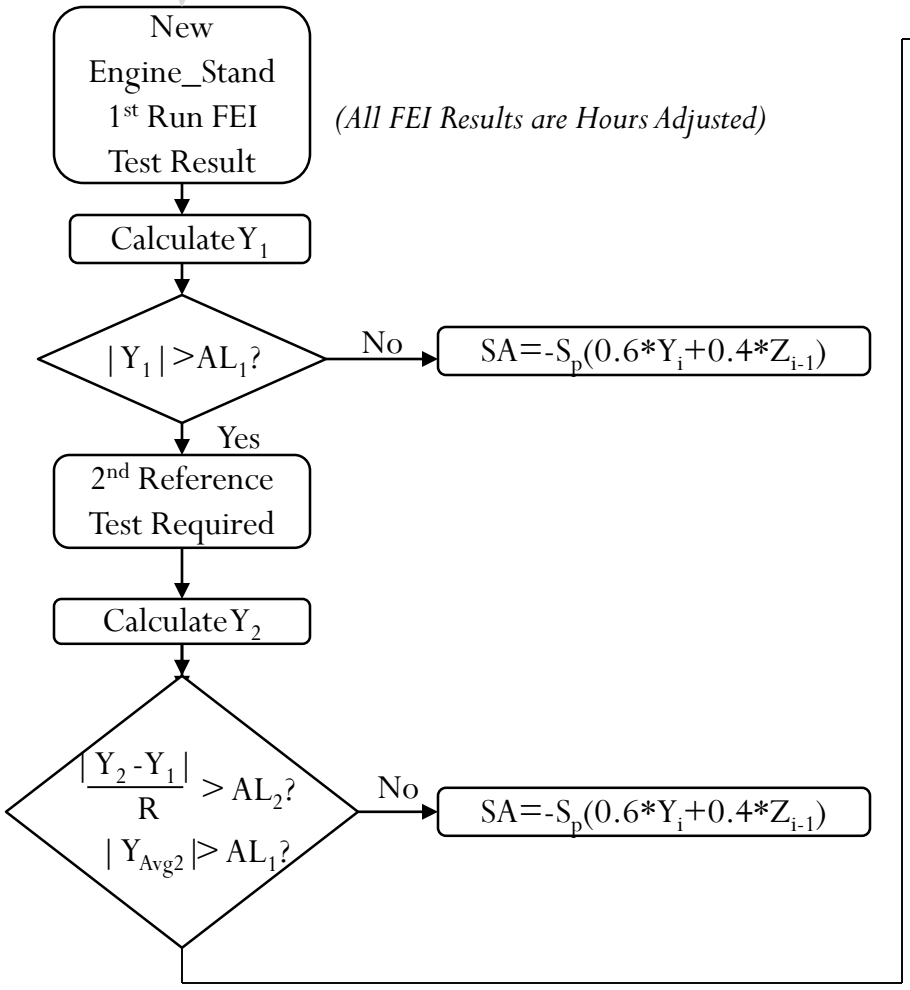
S_p = Pooled S (FEI1=0.29, FEI2=0.25)

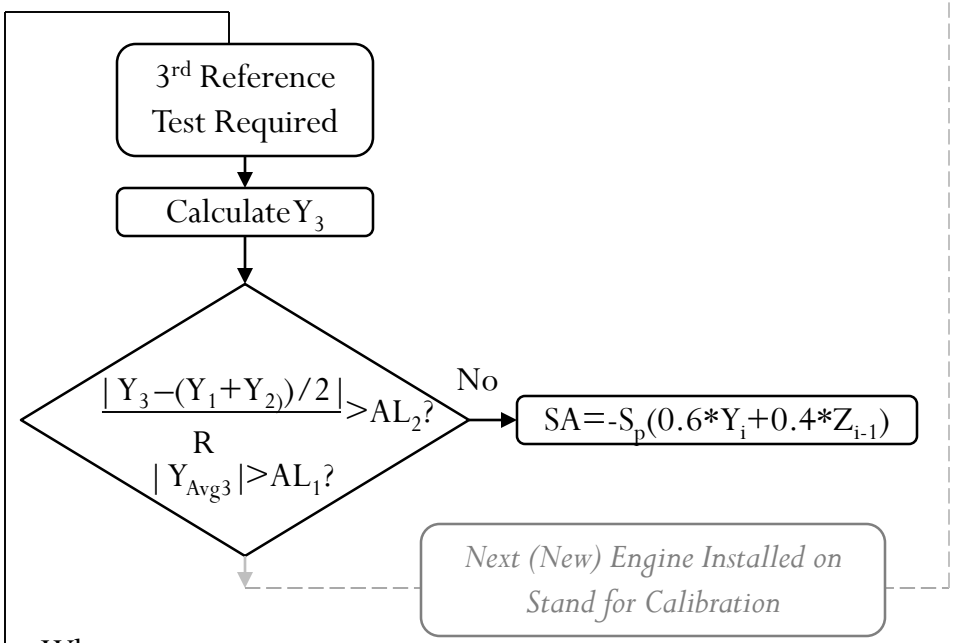
R = Stdev Ratio (FEI1=1.00, FEI2 = 0.48)

Adopt a stand-based Zi for use in SA calculations

- The selection of the 0.6 weight factor was a compromise due the fact that the stand-engine calibration was based on 1 result rather than the traditional 3 results.
- For the single run calibration, the inclusion of the stand based exponentially weighted moving average in the Severity Adjustment (SA) is an option to better estimate the severity of the stand and adjust Candidates accordingly.
- The proposal is to include an additional 0.4 weight factor that is based on the exponential weighted moving average (EWMA) Z_i of the stand.
  - Current:
    - $SA = (0.6 * Y_i) * -S_p$
  - Proposed:
    - Stand Based LTMS Charting for Severity Adjustment
      - $Z_i = 0.6Y_i + 0.4*Z_{i-1}$ $(\lambda = 0.6)$
      - $SA=-Z_i*S_p$
      - $Z_o=0$

Flow Chart for Proposed Stand-based LTMS





Where:

$AL_1 = 2.5$

$AL_2 = 2.8$

$\lambda = 0.6$

$Z_i = 0.6*Y_i + 0.4*Z_{i-1}$

S_p = Pooled S (FEI1=0.235, FEI2=0.281)

R = Stdev Ratio (FEI1=0.919, FEI2 = 0.904)

$Z_0 = 0$

$Y^*_{Avg2} = (Y_1 + Y_2)/2$

$Y^*_{Avg3} = (Y_1 + Y_2 + Y_3)/3$

Y_i results will be capped at ± 2.5

*Where Y_1, Y_2, and Y_3 corresponds to 1st, 2nd, and 3rd engine-stand run

Adopt a stand-based Zi for use in SA calculations

- Calculation method for EWMA for stand based severity:
  - Z_i = EWMA of the standardized test result at test order i.
  - $Z_i = \lambda * Y_i + (1 - \lambda) * Z_{i-1}$ (where $\lambda = 0.6$)

- Example of EWMA calculations for Lab-Stand entity:

Lab-Stand	*Ref Test Number*	*Engine Num*	*Lab-Stand-Eng*	*Yi*	*Yi (Capped)*	*Z_i*	*Severity Adj*	*Notes*
X-1	0					0.00		
X-1	1	1234	X-1-1234	0.50	0.50	0.30	$-S_p*0.30$	*Engine "1234" calbrated on 1st attempt*
X-1	2	2468	X-1-2468	-1.00	-1.00	-0.48	$S_p*0.48$	*Engine "2468" calbrated on 1st attempt*
X-1	3	3579	X-1-3579	-2.60	-2.50	-1.69		*Engine "3579" failed 1st calibration attempt*
X-1	4	3579	X-1-3579	-1.75	1.75	-1.73	$S_p*1.73$	*Engine "3579" Calibrated on 2nd attempt*

Recommendation #3 & #4

Industry Correction Factor

FEI1 = +0.21

FEI2 = +0.22

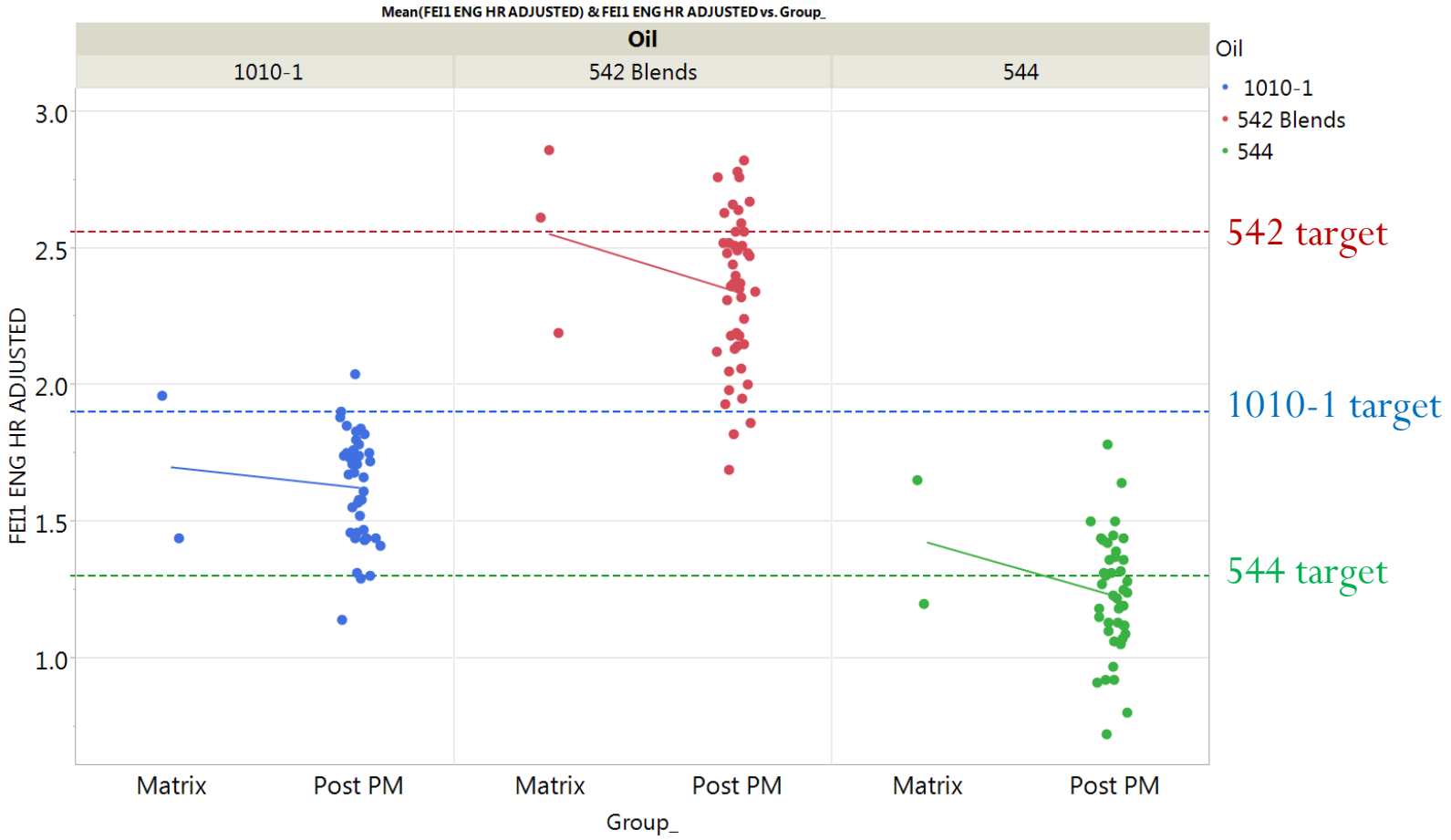
Widen Yi Acceptance Bands from ±2.0 to ± 2.5

Industry Correction Factor

FEI 1

FEI1 Matrix vs. Post-matrix

Post PM data is generally severe, but to varying degrees. Least severe for 544.



Reference Oil	Mean	Standard Deviation
542-2	2.56	0.31
544	1.30	0.26
1010-1	1.90	0.27

FEI1(EngHrAdj.) Model

The model shown below was used to calculate the target means for the reference oils during the post precision matrix period.

Summary of Fit

RSquare	0.870109
RSquare Adj	0.832277
Root Mean Square Error	0.217525
Mean of Response	1.756866
Observations (or Sum Wgts)	134

Analysis of Variance

Lack Of Fit

Parameter Estimates

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Oil	2	2	5.2384742	55.3552	<.0001*
Lab Stand	25	25	2.4660574	2.0847	0.0054*
Group_	1	1	0.1682490	3.5558	0.0622
Group_*Oil	2	2	0.0061415	0.0649	0.9372

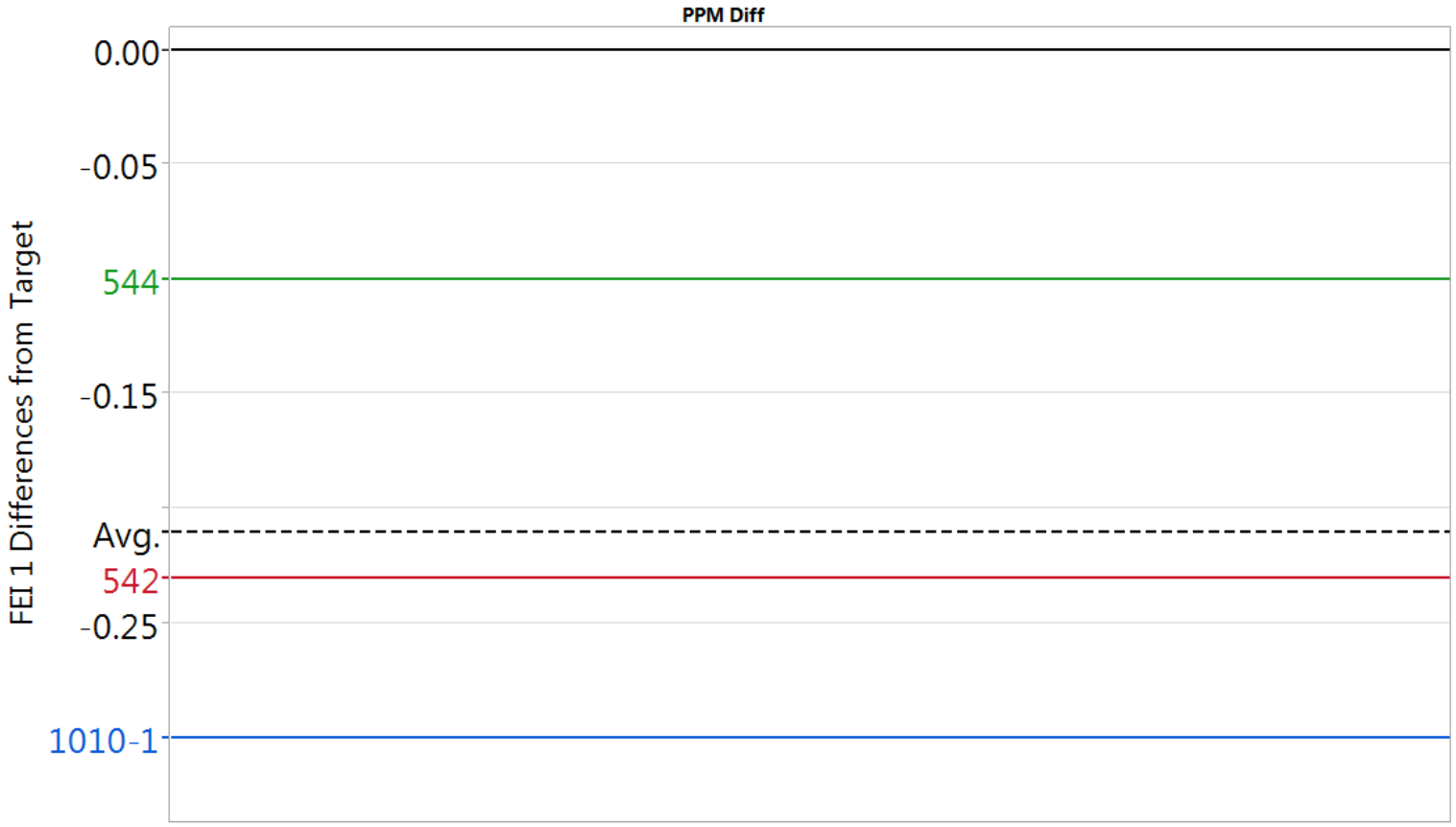
Least Squares Means Table

Level	Least Sq Mean
Matrix, 1010-1	1.8539759
Matrix,542 Blends	2.5125172
Matrix,544	1.3563378
Post PM, 1010-1	1.6013532
Post PM,542 Blends	2.3325380
Post PM,544	1.2054137

Reference Oil	Mean	Standard Deviation
542-2	2.56	0.31
544	1.30	0.26
1010-1	1.90	0.27

FEI1 Differences from Target

- The shift in the reference oils is different by oil.
- The suggested option is a correction factor of +0.21. This is the average difference across all 3 oils for post-precision matrix data.
- This will bring 544 on average above target, 542 will be close to target, and 1010-1 will on average be below target.

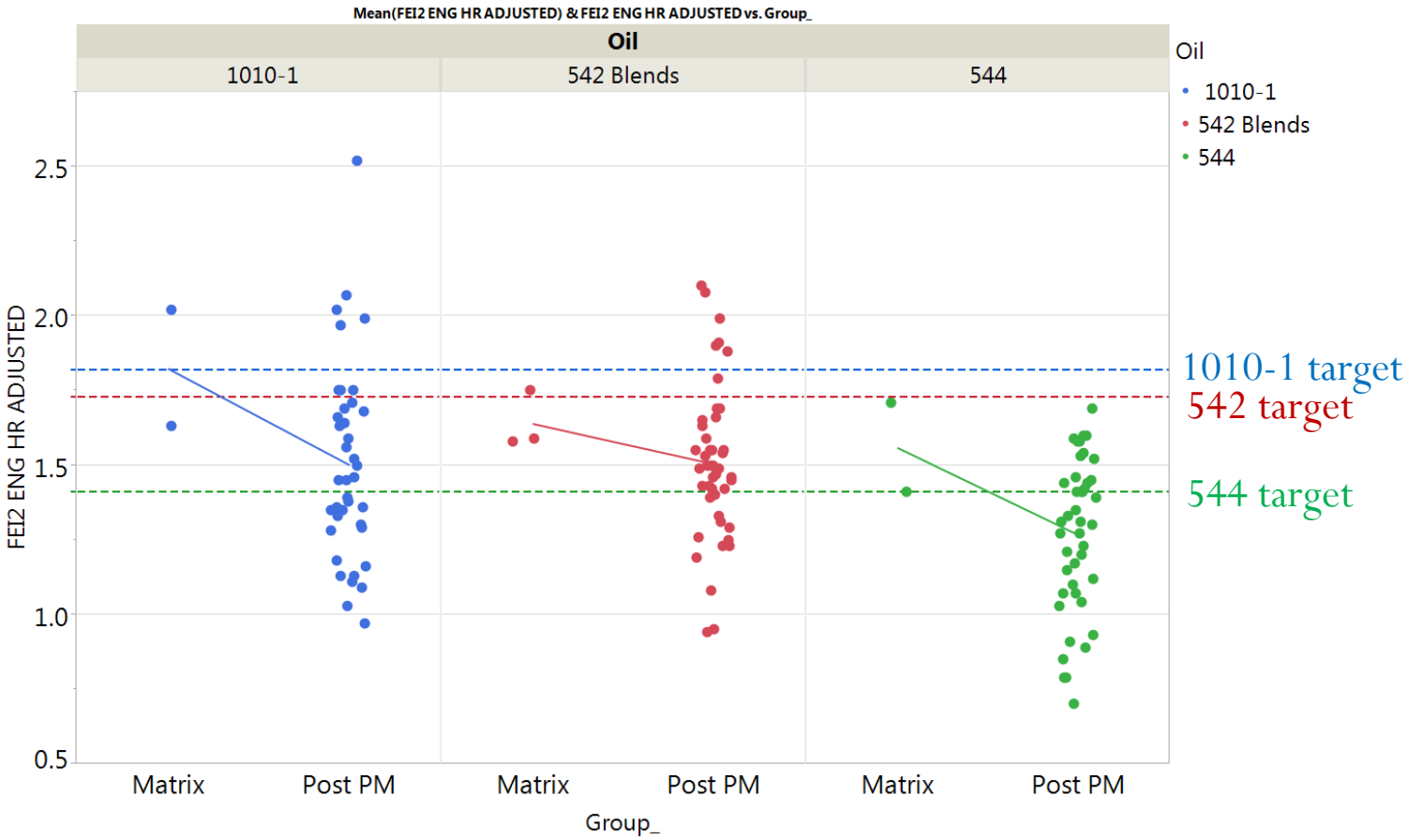


Industry Correction Factor

FEI 2

FEI2 Matrix vs. Post-matrix

Post precision matrix data is severe to varying degrees by oil. Least severe for 544.



Reference Oil	Mean	Standard Deviation
542-2	1.73	0.30
544	1.41	0.20
1010-1	1.82	0.25

FEI2(EngHrAdj.) Model

The model shown below was used to calculate the target means for the reference oils during the post precision matrix period.

Summary of Fit

RSquare	0.445702
RSquare Adj	0.284255
Root Mean Square Error	0.254092
Mean of Response	1.435746
Observations (or Sum Wgts)	134

Analysis of Variance

Lack Of Fit

Parameter Estimates

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Oil	2	2	0.2699671	2.0907	0.1288
Lab Stand	25	25	3.2732421	2.0279	0.0072*
Group_	1	1	0.1977175	3.0624	0.0831
Group_*Oil	2	2	0.0414474	0.3210	0.7262

Least Squares Means Table

Level	Least Sq Mean
Matrix, 1010-1	1.8607360
Matrix,542 Blends	1.6269226
Matrix,544	1.4321817
Post PM, 1010-1	1.4958013
Post PM,542 Blends	1.4984254
Post PM,544	1.2930467

Reference Oil	Mean	Standard Deviation
542-2	1.73	0.30
544	1.41	0.20
1010-1	1.82	0.25

FEI2 Differences from Target

- The shift in the reference oils is different by oil.
- The suggested option is a correction factor of +0.22. This is the average difference across all 3 oils for post-precision matrix data.
- This will bring 544 on average above target, 542 will be close to target, and 1010-1 will on average be below target.

Note about Model Selection

The industry statisticians elected to use a model which weighs severity equally across all stands in the industry. An alternative approach would have been to average equally across lab severity levels. This approach was not recommended because:

1) Tendency for observed stand differences within a lab.
2) There are 3 labs with 2,3, and 10 total data points. These labs should not receive the same weight as the labs with 34, 36, and 49 total data points, due to the large uncertainty in the true lab average with such a small sample size.

Under the alternative approach, the ICF would have been:

FEI1 – 0.13 (versus 0.21 recommended)

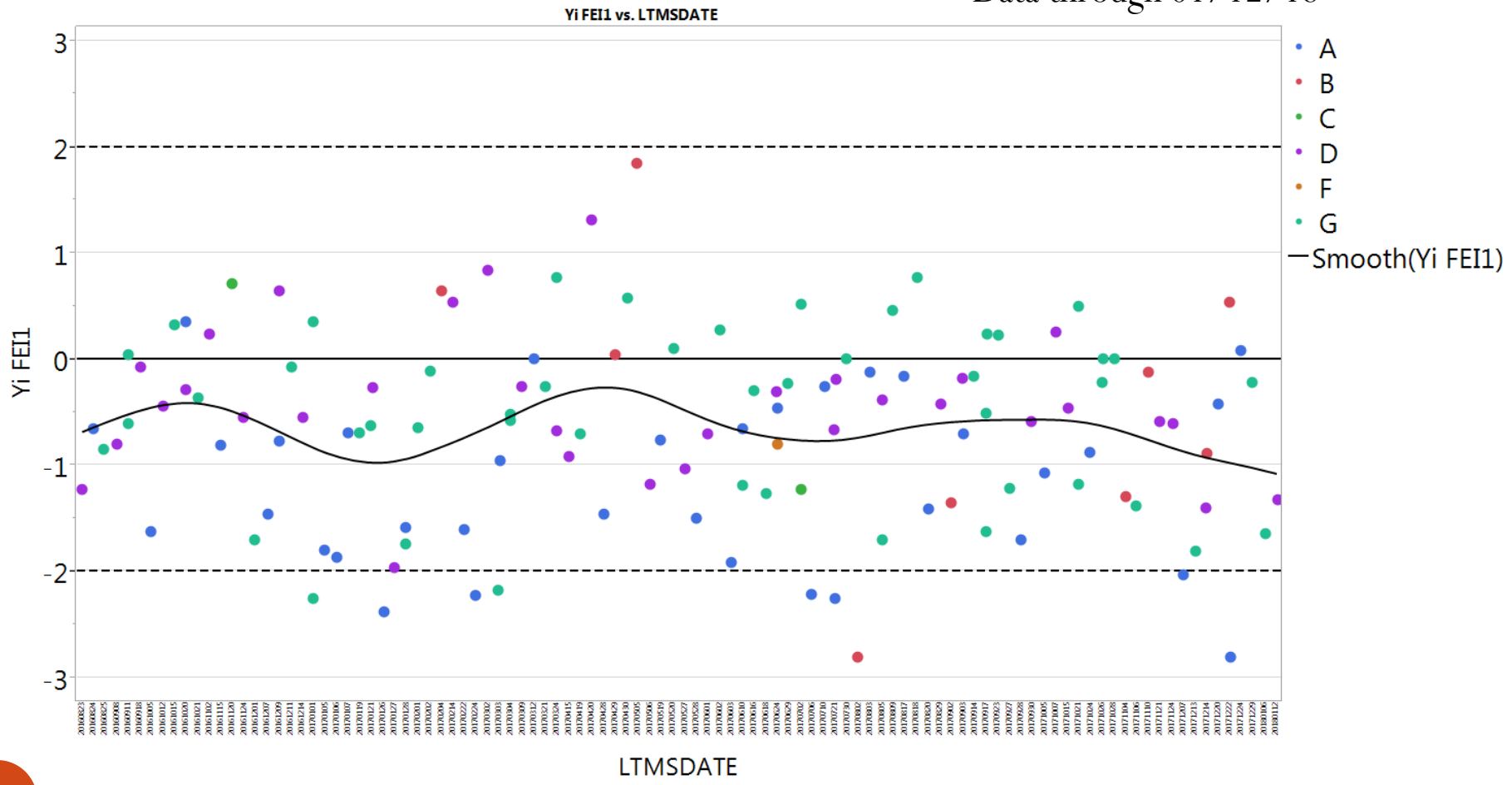
FEI2 – 0.12 (versus 0.22 recommended)

Impact of ICF and New s

Post-PM Historical FEI 1 Yis Ordered by Date

FEI1 Yi shows 9 results outside of the acceptance bands out of 127 (7%), though this reasonable number of failures appears to be due more to the small standard deviations than to being on target.

Data through 01/12/18

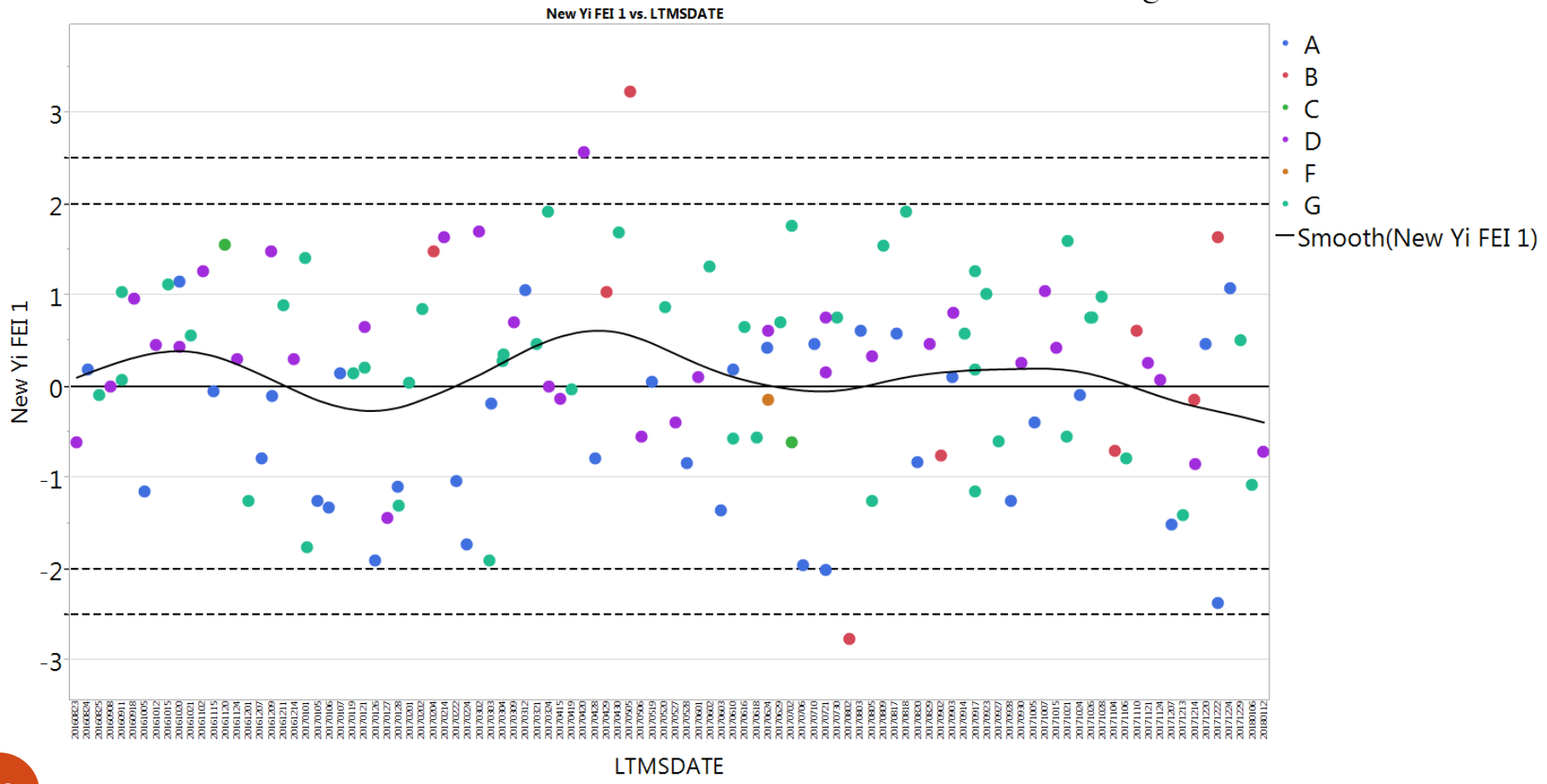


*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

FEI 1 Historical Yis with ICF and New s

The graph shows what the historical Yi values would have looked like with a correction factor and the updated standard deviations.

Data through 01/12/18

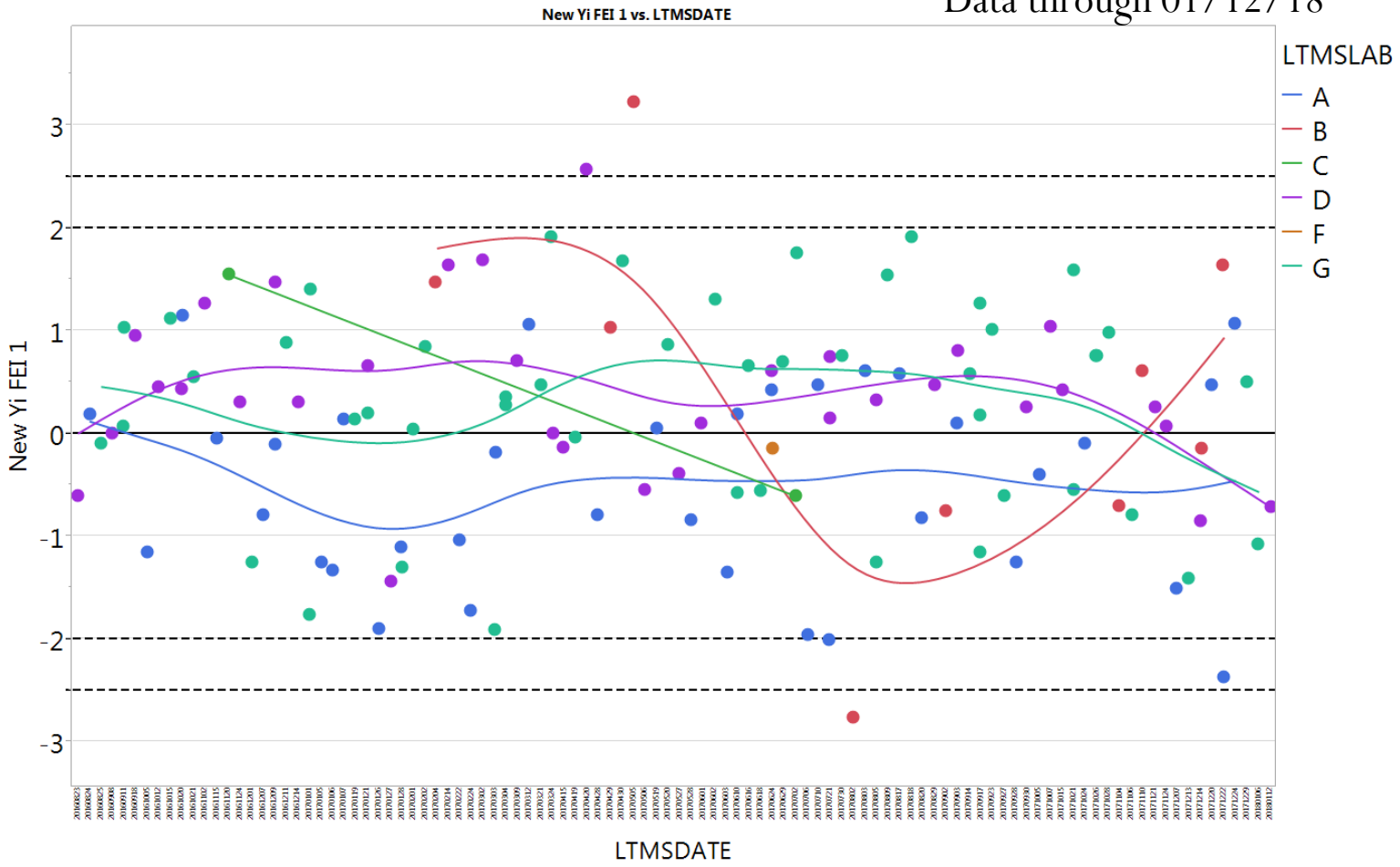


*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

FEI 1 Historical Yis with ICF and New s -By Lab

The lines below shows lab severity levels had the correction factors and new standard deviations been in place.

Data through 01/12/18

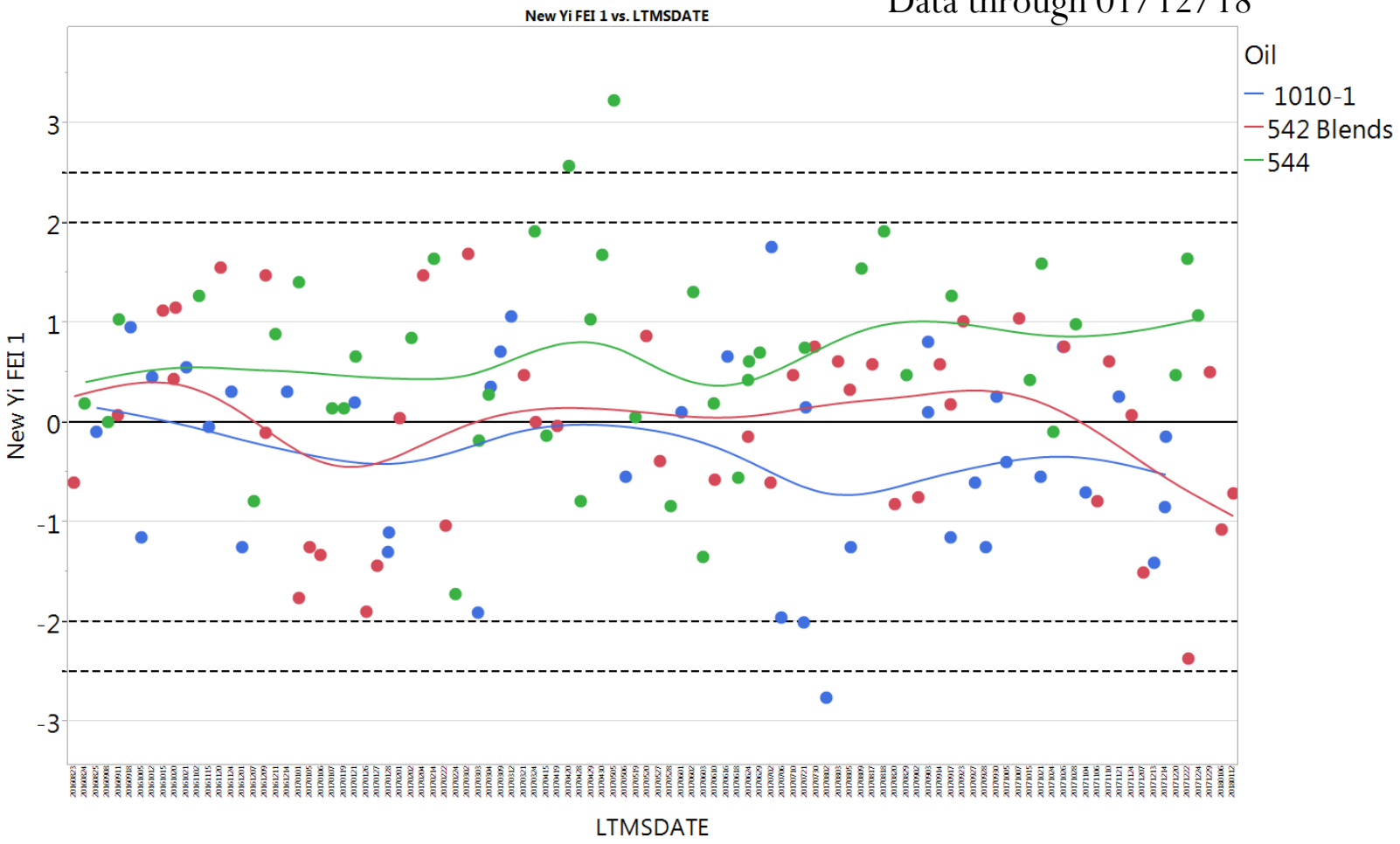


*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

FEI 1 Historical Yis with ICF and New s -By Oil

The lines below shows oil severity levels had the correction factors and new standard deviations been in place.

Data through 01/12/18

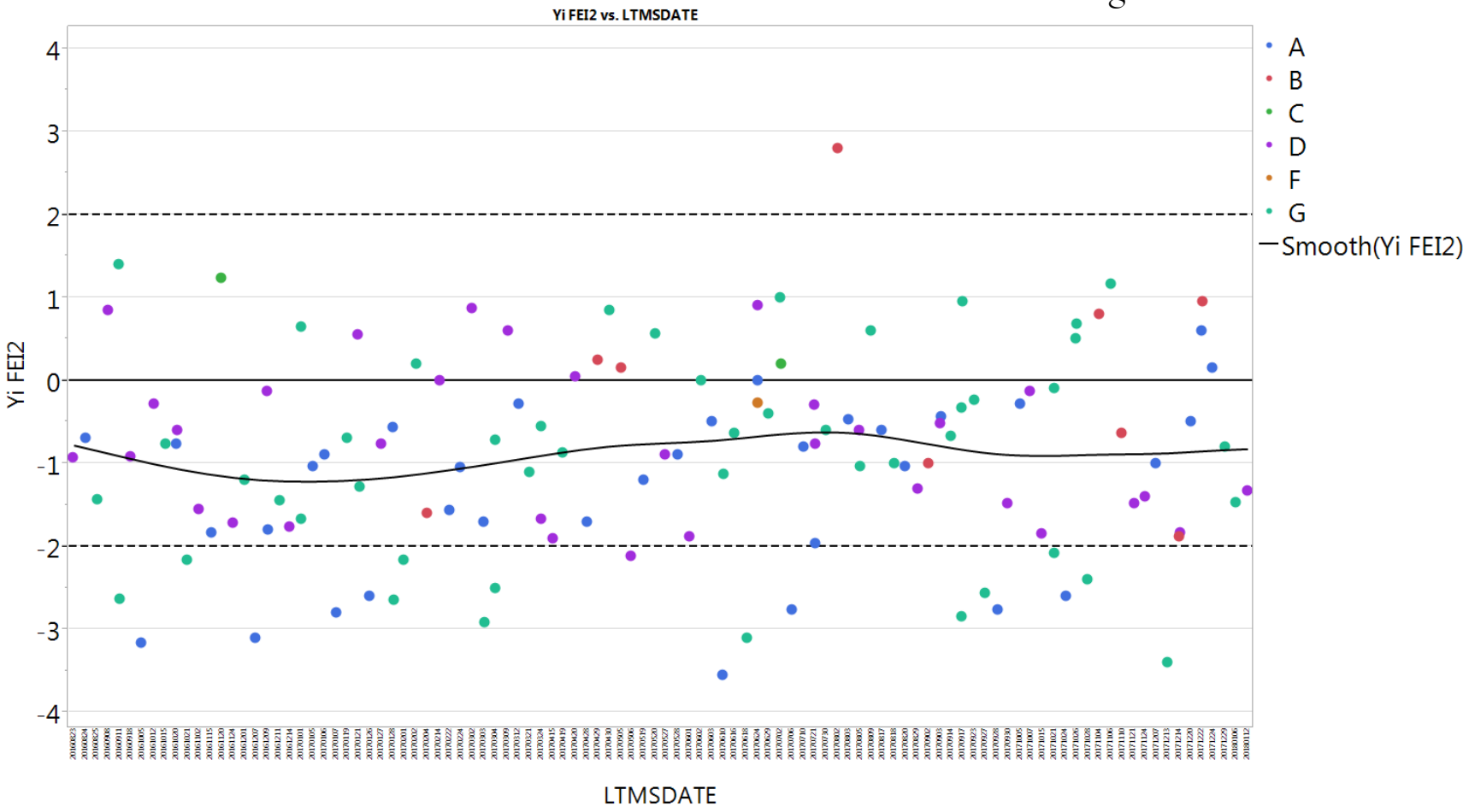


*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

Historical FEI 2 Yis Ordered by Date

FEI2 has 22 failures (17%), with all but one of these being on the severe side.

Data through 01/12/18

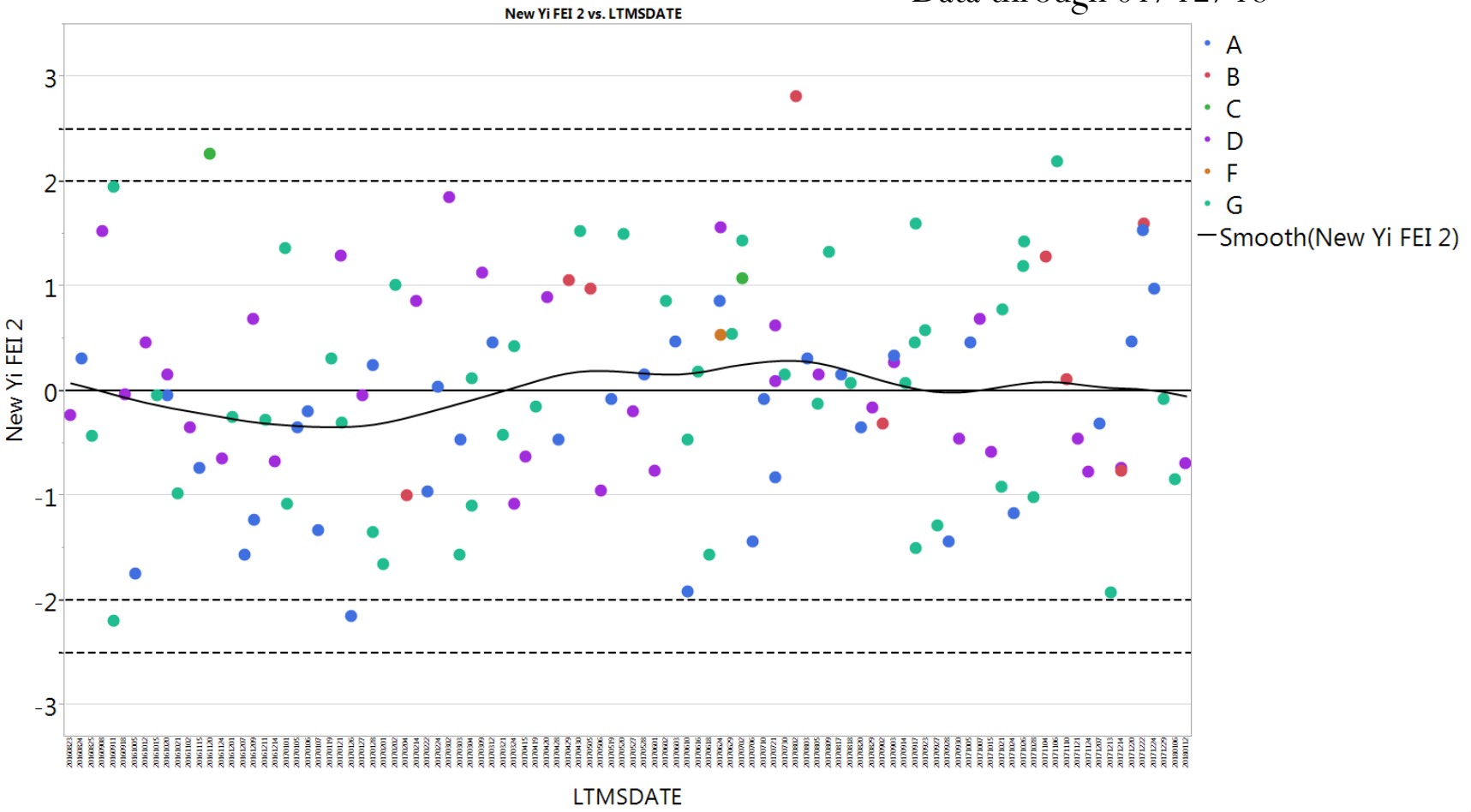


*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

FEI 2 Historical Yis with ICF and New s

The graph shows what the historical Yi values would have looked like with a correction factor and the updated standard deviations.

Data through 01/12/18

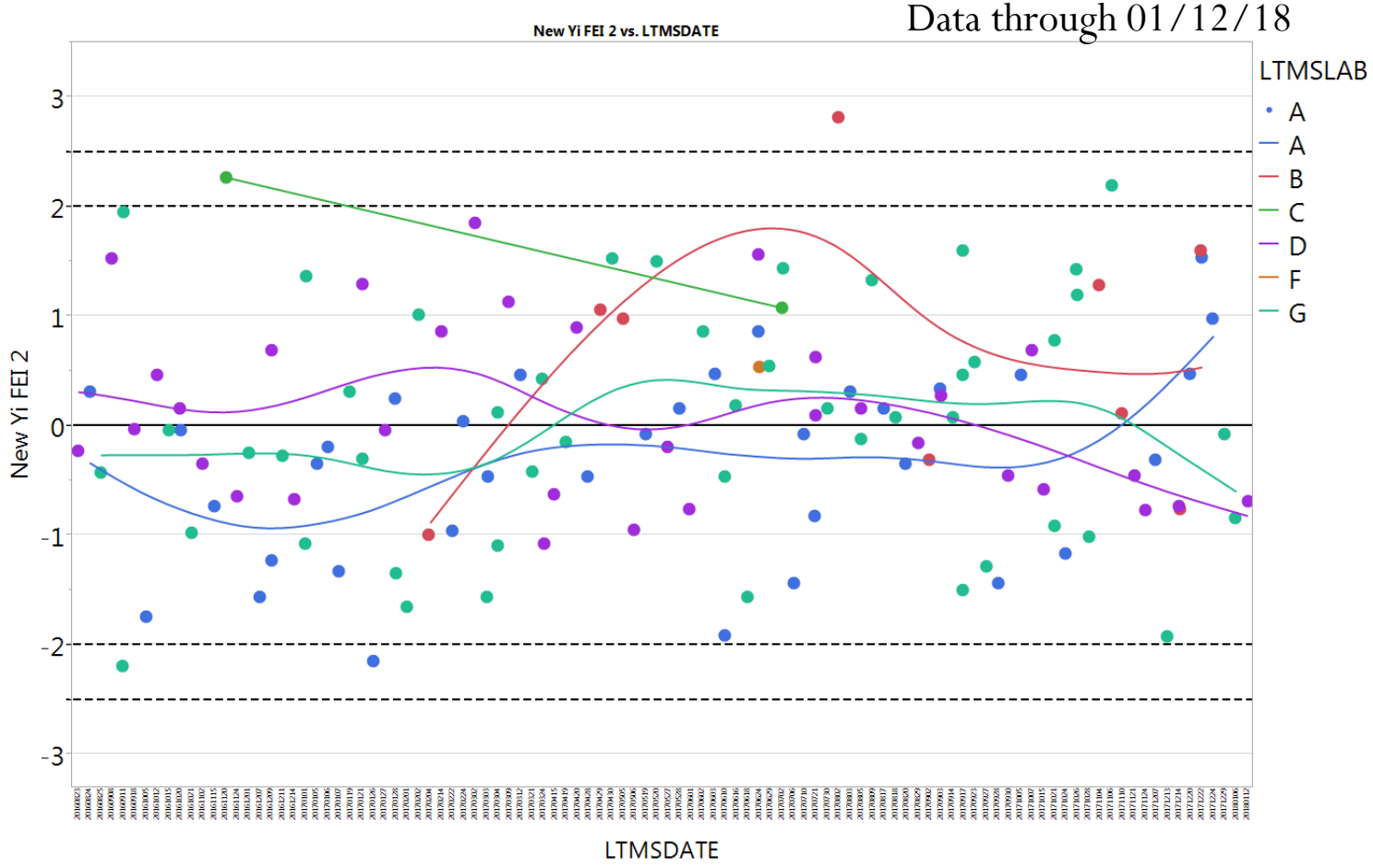


*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

FEI 2 Historical Yis with ICF and New s -By Lab

The lines below shows lab severity levels had the correction factors and new standard deviations been in place.

Data through 01/12/18

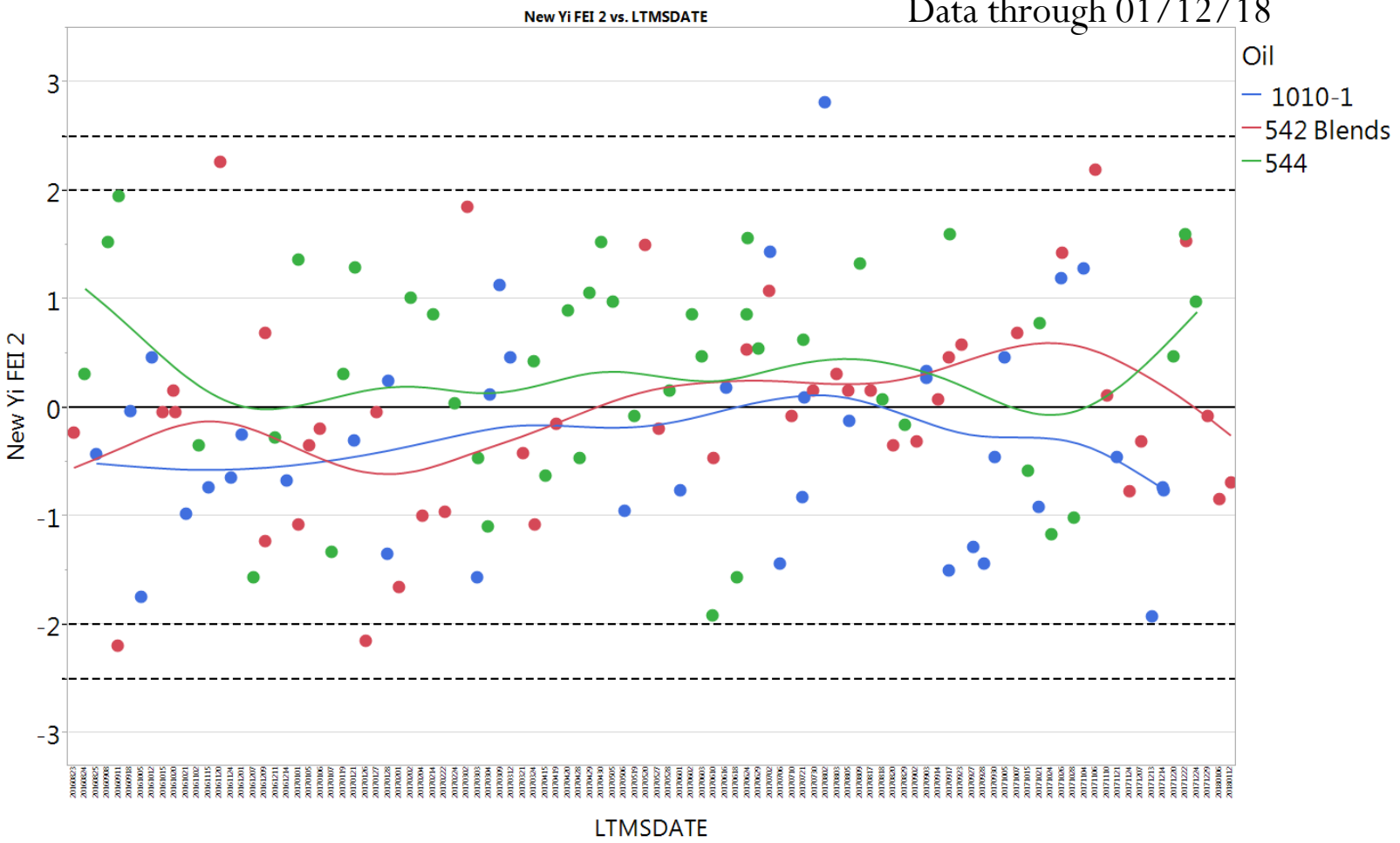


*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

FEI 2 Historical Yis with ICF and New s -By Oil

The lines below shows oil severity levels had the correction factors and new standard deviations been in place.

Data through 01/12/18



*Not all chartable data included. Only 1st runs with EOT engine hours less than 500 hours.

Recommendations

1. Update LTMS to include stand based Zi with capped Yi effect, new Yi limits, new standard deviations, new severity adjustment standard deviations, and new R as below.
    1. Yi Limits set to +/-2.500 and Zi impact capped at Yi limits
    2. New standard deviations per table below.
    3. New SA s: FEI1=0.235, FEI2=0.281
    4. New R: FEI1=0.919, FEI2 = 0.904
2. Adopt an Industry correction factor of 0.21 for FEI1 and 0.22 for FEI2

		FEI 1 Proposed	FEI 2 Proposed
542 Blends	Std. Dev	0.280	0.260
	N	45	45
1010-1	Std. Dev	0.199	0.327
	N	39	39
544	Std. Dev	0.214	0.256
	N	43	43

Note: After discussion, statistics group is comfortable beginning these changes with the next reference in each stand.

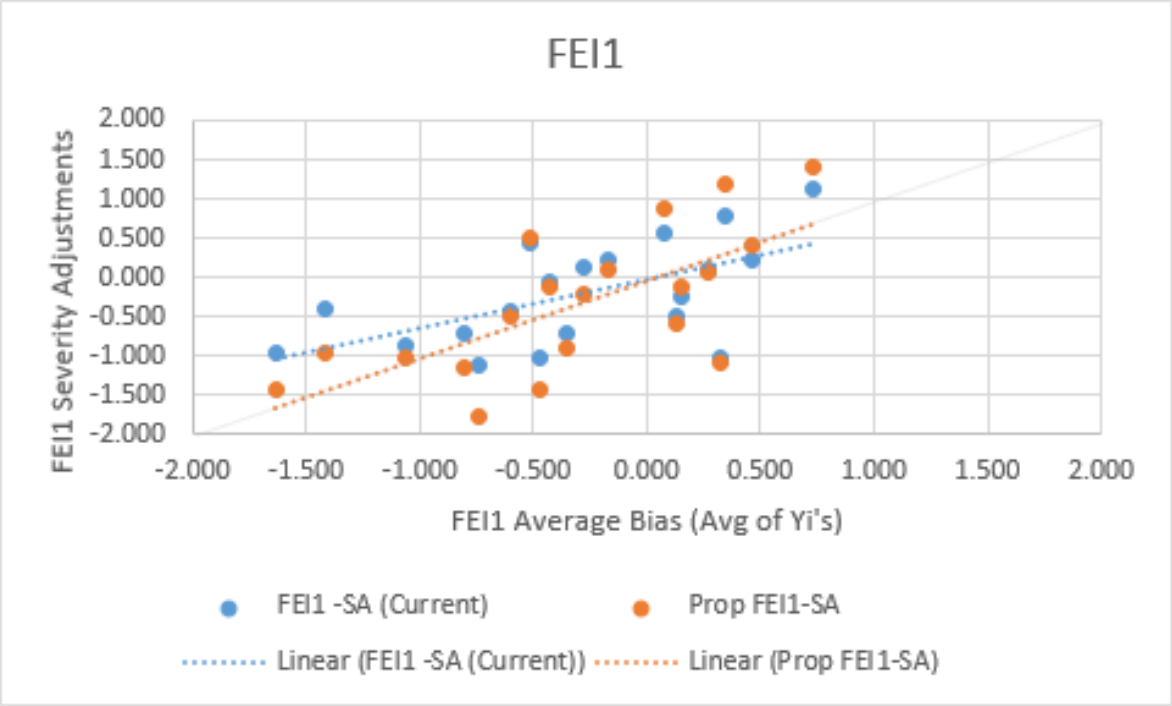
Appendix

Data Set

- Data used in this analysis was limited to 1st run data only with engine hours less than 500 hours.
- Data was divided into precision matrix, post precision matrix OHT engines, and post precision matrix short block engines.
- Validity codes were AC, MC, AG, and AC. Data immediately following precision matrix with validity codes NN was not included.
- The engine hour adjusted FEI1 and FEI2 values were used in the modeling.
- Final data point for data used in CF calculation was reported on 01/12/2018.

Adopt a stand-based Zi for use in SA calculations

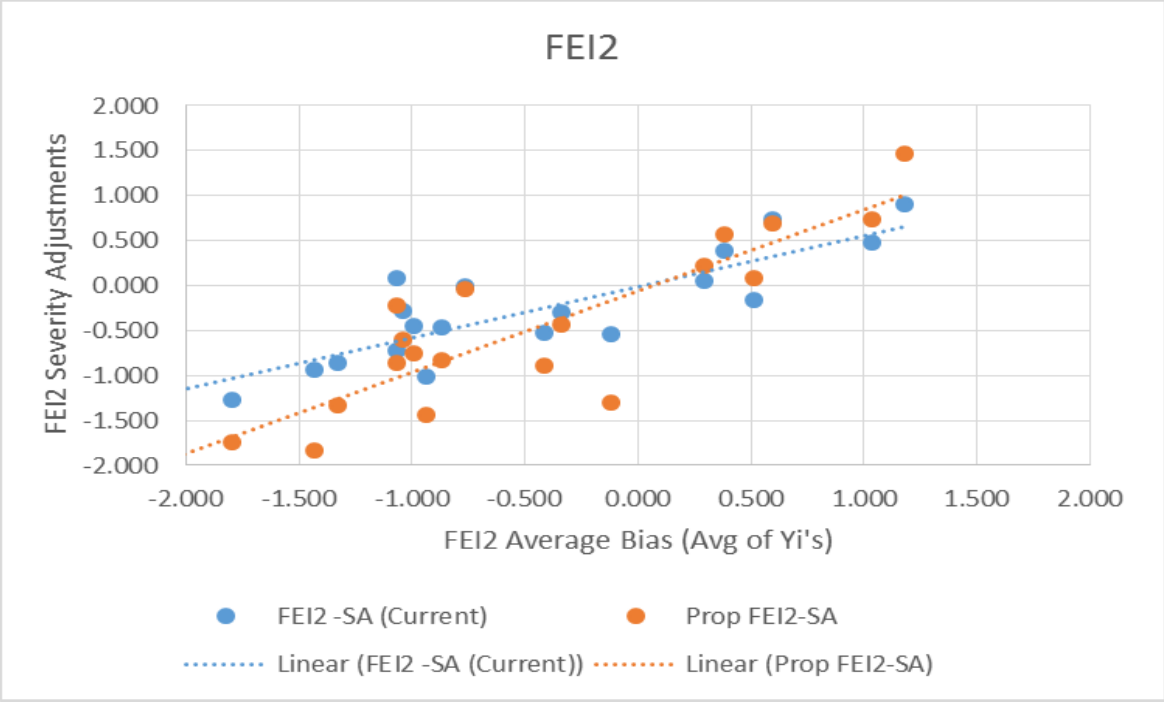
- The below chart summarizes the current vs. proposed method of Severity Adjustments* for FEI1
  - Proposed SA method results in improved correlation with average FEI1 bias



*To increase the size of the data set for comparison of the existing with the proposed SAs, 5th run data was used to calculate the Y_i and Z_i results.

Adopt a stand-based Zi for use in SA calculations

- The below chart summarizes the current vs. proposed method of Severity Adjustments* for FEI2
  - Proposed SA method results in improved correlation with average FEI2 bias



*To increase the size of the data set for comparison of the existing with the proposed SAs, 5th run data was used to calculate the Y_i and Z_i results.