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Committee D02 on PETROLEUM PRODUCTS AND LUBRICANTS

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Issued: August 26, 2014

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These are the unapproved minutes of the 08.12.2014 Sequence VI Surveillance Panel call.

The meeting was called to order at 10:00 AM by Chairman Charlie Leverett.

Agenda

The Agenda is the included as Attachment 1.

1.0 Roll Call

The Attendance list Attachment 2. Mark Adams was added to the guest list.

2.0 Approval of minutes

2.1 Approval of the minutes of the 07.01.2014 meeting.

2.1.1 A request was made to add a note that reference oil 541-1 was in limited supply and would not be assigned for VIE test development.

Motion – Accept the minutes of the 07.01.2014 VID SP CC.
Dan Worcester, Dave Glaenzer, second. Unanimous.

3.0 Action Item Review

3.1 OHT to report VIx engine usage and depletion date of VID engines.
There are 21 2009 and 105 2012 engines in inventory.

3.2 VIE Draft - This is waiting for the Precision Matrix.

3.3 How was BL Shift determined for the VID? Charlie Leverett has completed this action item, included as Attachment 3.

3.4 What is the status of the OHT VIE displacement block? Those will be in stock on 08.13.2014 and OHT will contact the labs for order information.

3.5 Notify ILSAC that reference oil 541-1 will not be available for the VIE Precision Matrix. Charlie Leverett has completed this action item.

4.0 Old Business

4.1 Haltermann EEE and Additized EEE Data Base

ACTION: Tracey King will get a status of the latest batch of EEE and Additized EEE fuels.

4.2 There will be a PCEOCP meeting that will provide further direction/actions.
Charlie asked for guidelines from PCEOCP but has not got a response.

5.0 New Business

5.1 There was a presentation by Lubrizol included as Attachment 4.
There are higher pass targets for GF-6. Newer Friction Modifier [FM] tend to attach to the surfaces. There is also a change in BLA shift. The existing flush methods do not improve this. A new engine hour correction will be needed for the VIE tests. More engines will likely be needed for the life of the VIE.

5.2 There was a presentation by Afton on fuel temperature included at Attachment 5.
There is variation of fuel temperature control going to the Micromotion. Lab A had consistent control but at two different setpoints. Lab B had more variation. Options would be to make this a critical parameter or tighten the existing range.

ACTION: This will receive more study. Todd Dvorak will do a presentation for the next meeting.

5.3 There was a Break In history review presented by Afton included as Attachment 6.
Looking at historical break in procedures for fuel economy testing indicate possible areas for improvement.

ACTION: Afton will try a break in to the existing VIE method but running out to 200 hours.

5.4 There was Precision Estimate data presented by TMC included at Attachment 7.
Currently the precision for FEI 1 and 2 are about twice the VID values.

5.5 Is the industry ready for the Precision Matrix?
ILSAC has recommended oils for the Precision Matrix. They will be 542, 1010 and Tech 1. Ron Romano has some VID data on the Tech 1 oil. Labs are to contact Charlie Leverett if they want to donate a Tech 1 VIE test.
ACTION: Both 542 and 1010 will need new blends to be available for GF-6.
At this time the group feels the VIE is not ready to begin the Precision Matrix due to issues with FM carryover, engine life and number of engines left, and clarification of the break in procedure.
Action: Bruce will see if "Service Engines" of this model year are available.

6.0 Next Meeting or Conference Call

At the call of the Chairman

Meeting Adjourned

The meeting adjourned at 11:17 AM.

Sequence VI Surveillance Panel Conference Call Agenda
August 12 @ 10:00 CDT

Call-in information is included below:

Call-in Number: 800-391-9177
Conference Code: 4875645502

1.0) Roll Call

Do we have any membership changes or additions?
Mark Adams mark@tribologytesting.com has asked to be included on the distribution list

2.0) Approval of minutes

2.1) Approve the minutes from the 07/01/14 Sequence VI Surveillance Panel CC.

*Comment: I believe the SP determined we would not assign 541-1 going forward for **VIE testing** due to the lack of it's availability?*

3.0) Action Item Review

3.1 OHT to report VID & VIE engine usage and expected depletion date of VID engines. - OHT

3.2 VIE Draft - Table 5 information which cannot be generated until sufficient testing/precision matrix has taken place (stats group).

3.4 Determine how the range for BL Shift was determined in the VID. Charlie Completed, see attachment.

3.5 Update from OHT on the availability of the new oil pan displacement block.

3.6 Inform ILSAC that 541-1 will not be available for the VIE Precision Matrix – Done

3.7 VIE Draft Procedure Updates – Procedure has been updated as of the changes made at the 7/1/14 conference call and is posted on the TMC web site.

4.) Old Business

4.1 Requested Database from Haltermann – Tracy King will supply TMC the latest batch data on EEE and Additized EEE Fuels?

4.2 PCEOCP - ?

Discussion – The PCEOCP this week (6/24) and I expect we will get further questions and instructions following this meeting. I will update this panel on the outcome once received.

5.) New Business

5.1 Review Lubrizol presentation sent out to SP 8/5/14

5.2 Review Fuel Temp Study from Dave sent out to SP 8/5/14

5.3 Review Seq. VI New Engine Break-in history from Dave sent out 8/6/14.

5.4 Review Precision Estimates from Rich sent out to SP 7/28/14

5.5 Discussion – Are we ready for the Precision Matrix???

6.) Next Meeting

Call of the chairman

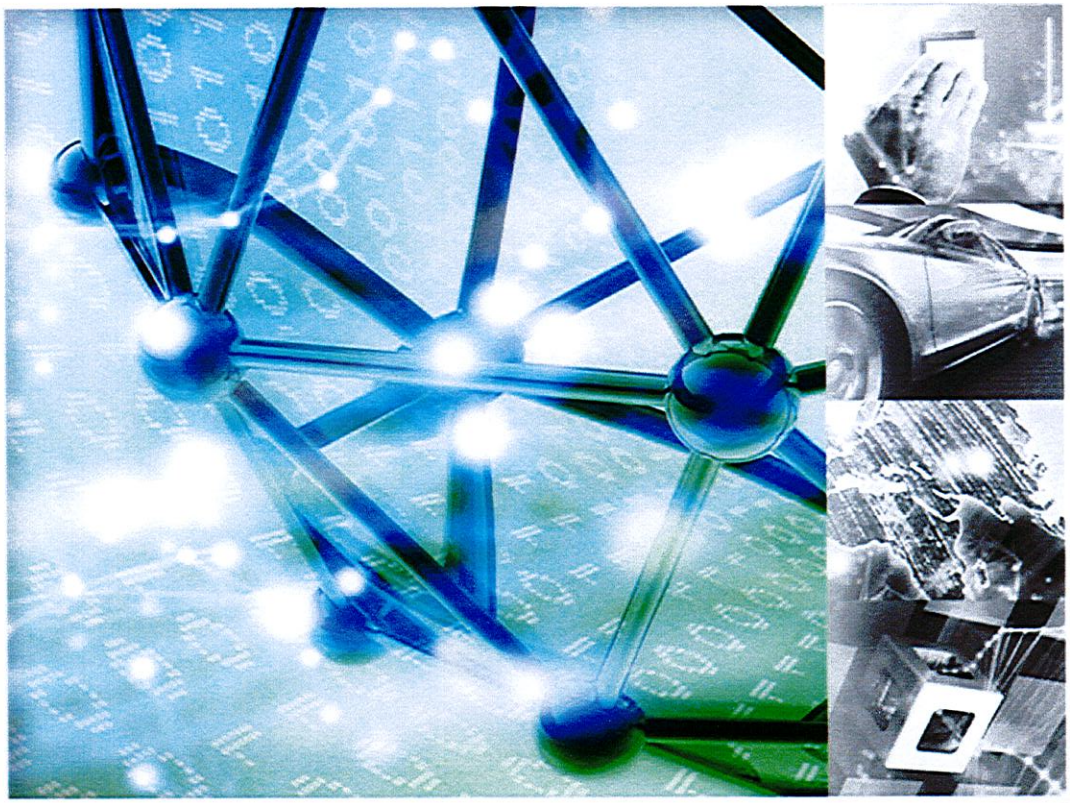
7.) Meeting Adjourned

Analysis Excluding High Baseline Shift Data

- Starting with the Precision Matrix, the Statisticians Group recommended an additional baseline be run until the FC shift of consecutive BLBs is between -0.2 and 0.4%.
- This range was exceeded four times in the Prove Out Matrix:
  - IAR: Test 1 (Oil A)
  - SwRI: Test 5 (Oil B)
  - SwRI: Test 6 (Oil E)
  - SwRI: Test 8 (Oil A)
- The data exceeding the limits were omitted from the following analysis. The improvements noted are likely optimistically high.
- Main improvement is decrease in Phase 1 RMSE from 0.268 to 0.204 FEI% (24%).

Analysis With and Without Baseline Shift Data

		Full Data Set		Abbreviated Data Set	
		Phase 1	Phase 2	Phase 1	Phase 2
B - A	Coefficient	0.398	0.244	0.488	0.163
	p-Value	0.020	0.104	0.007	0.373
A - E	Coefficient	0.364	0.555	0.356	0.604
	p-Value	0.036	0.002	0.035	0.008
RMSE		0.268	0.247	0.204	0.251



Sequence VI / GF-6 – Initial Testing Observations

Nathan Moles

8/12/2014

Outline

SUCCESS TOGETHER

- High FM Carry Over Effect
  - VID test observations
  - Implications/solutions
- Sequence VIE Responsiveness
  - Decreasing response over the lifetime of VIE engine
  - Impact on potential engine hour correction factor
  - BLA shift over the lifetime of VIE engine
  - Implications/solutions

Lubrizol

FM Carry Over

General Overview

SUCCESS TOGETHER

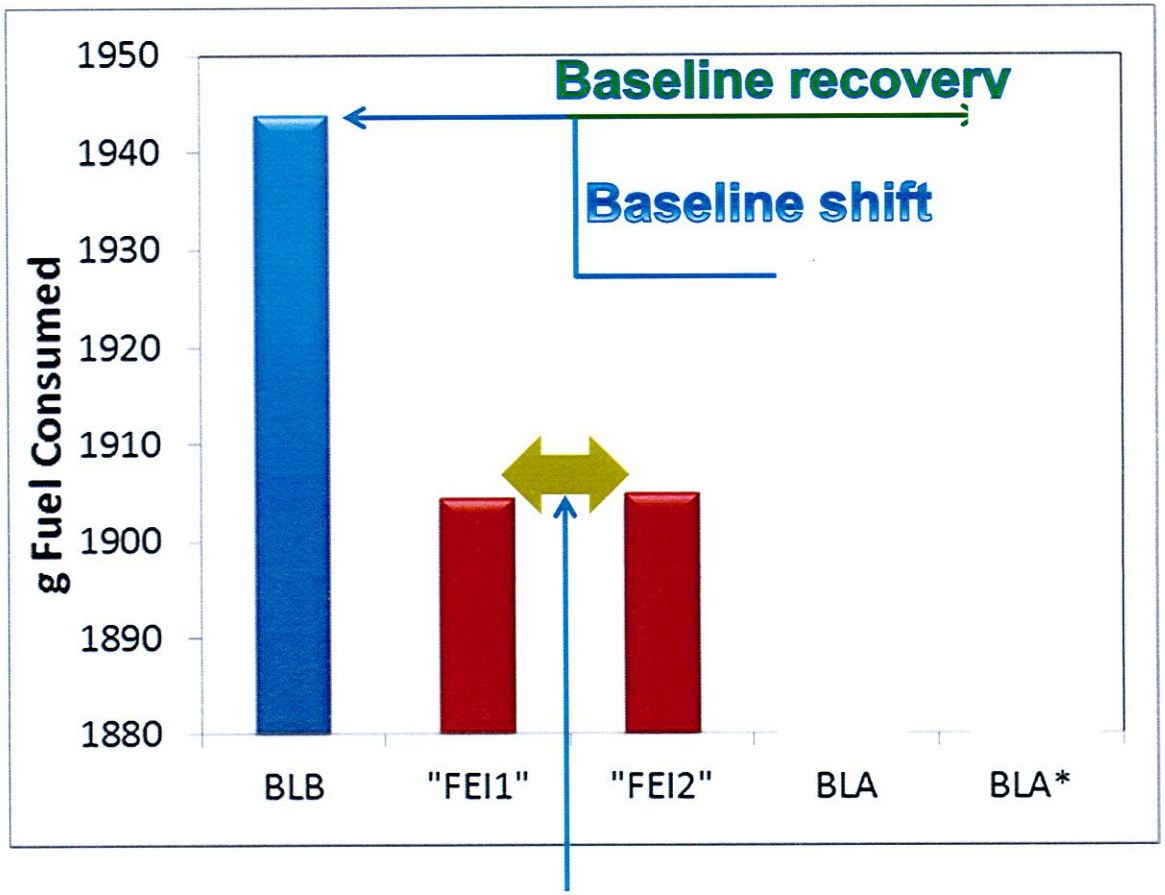
- Increased FEI targets for GF-6 require more/better FM's
- LZ ran a series of formulas in both the VID and VIE
  - Experimental GF-6 prototype additive packages
  - Formulas designed from the ground up to deliver good FE
- Several repeat runs resulted in unusually high BLA shifts

Lubrizol

VID Observations

SUCCESS TOGETHER

- Carefully analyzed weighted fuel consumption of baseline and candidate oils
- In cases where high levels of FM and/or certain type of FM were used, potential carryover effects were observed



Virtual parity between "FEI1" and "FEI2" on amount of fuel consumed

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Engine Life BL Fuel Consumption

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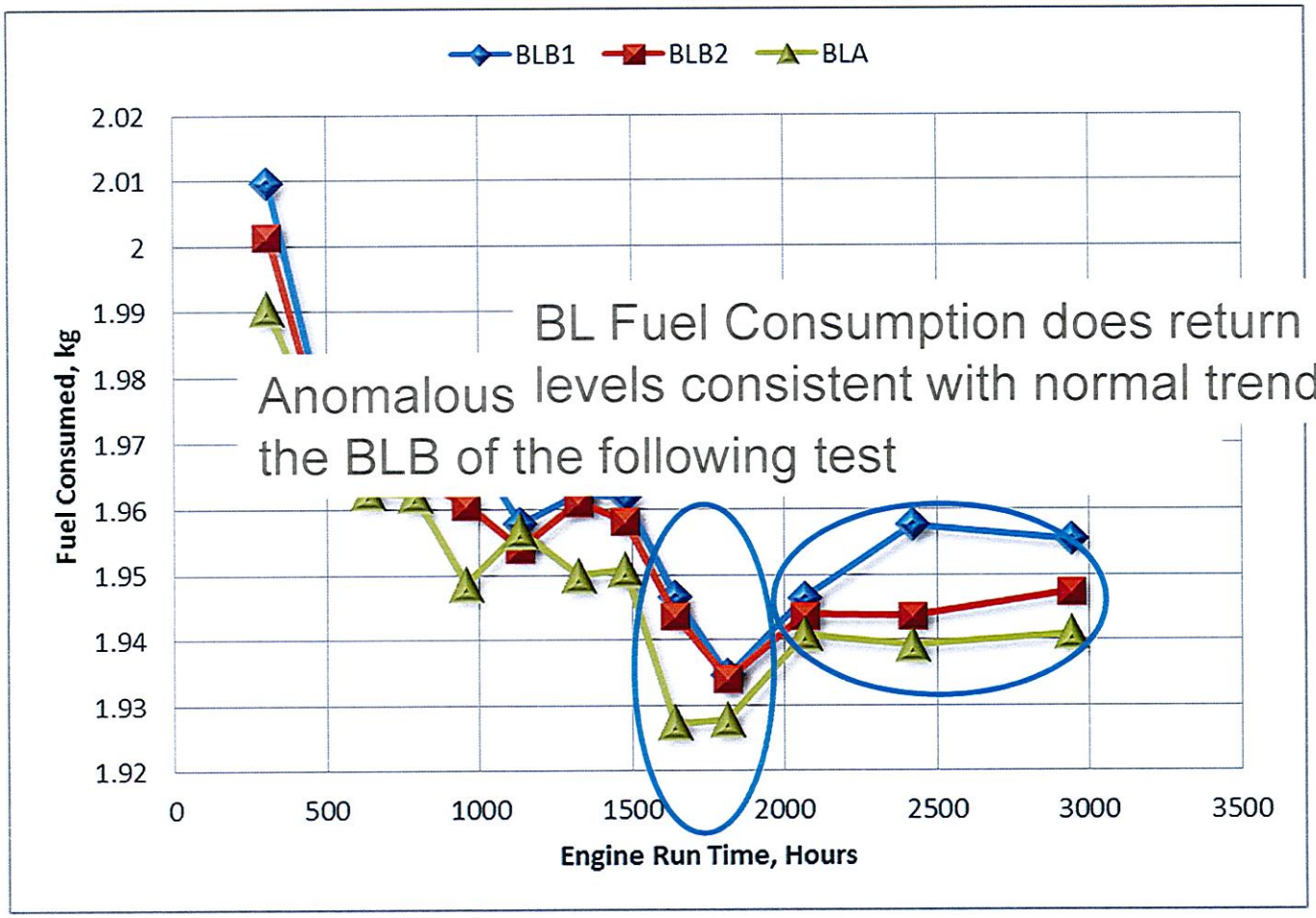

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FM Carry Over Implications

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- Sequence VI Fuel Economy test is actually penalizing stronger/more durable FM formulations
- We continue to investigate if there are substantial FM carryover effects in the VIE – If there are, several options for addressing it come to mind:
  - More flushing (unsuccessful on VID)
    - Flush oil and double BL flushes performed twice following completion of VID test with minimal impact on high BLA shift
  - Reformulation of the flush (unsuccessful to date on VID)
    - 0W-20 version of current flush oil was ran 12 and 24hrs with minimal impact on high BLA shift
  - Just use BLB and forget about BLA (still an issue on subsequent test BLB on VID)
  - Just use BLA and forget about BLB (still need effective/efficient way to remove carry over FM)

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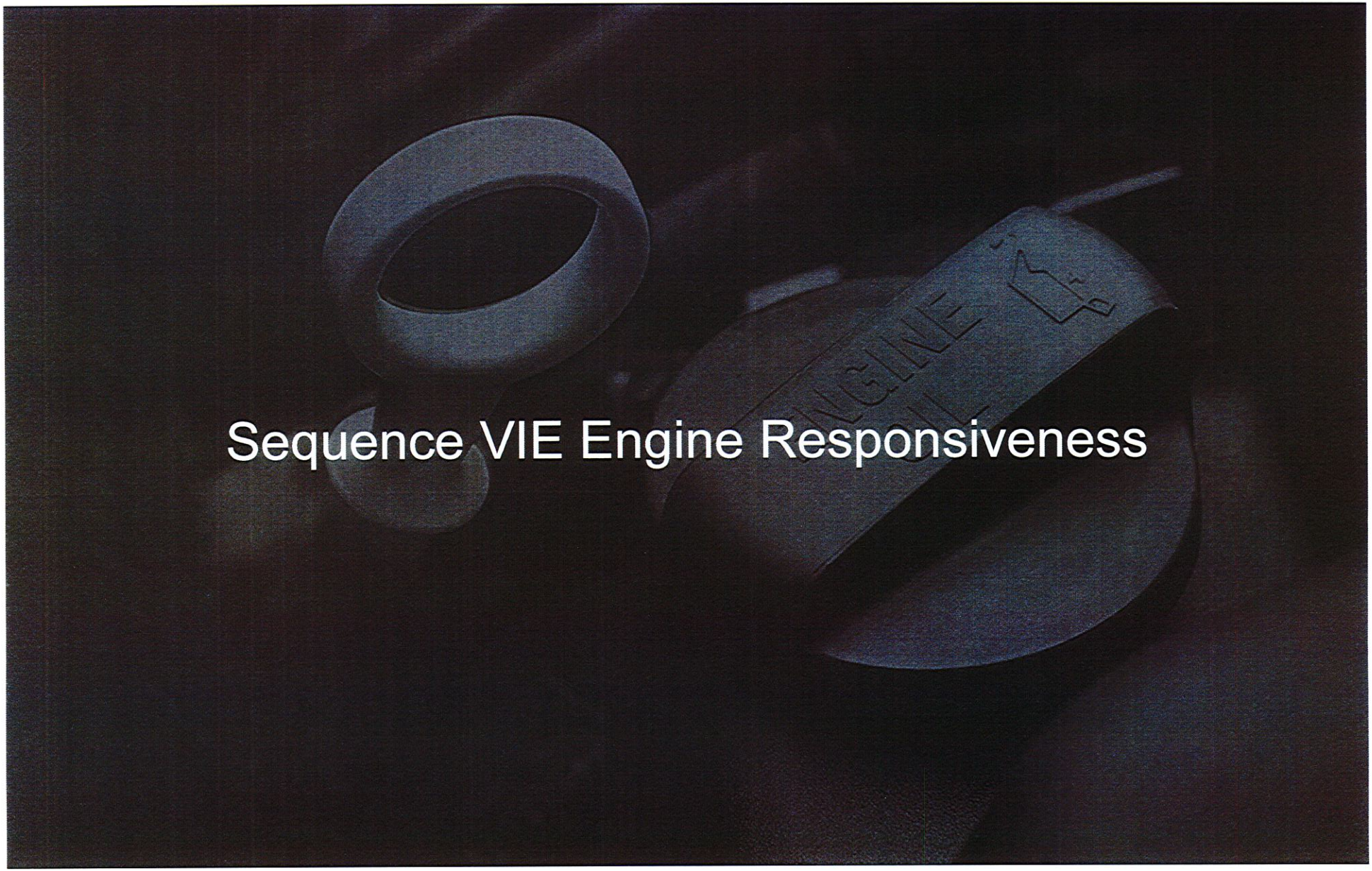
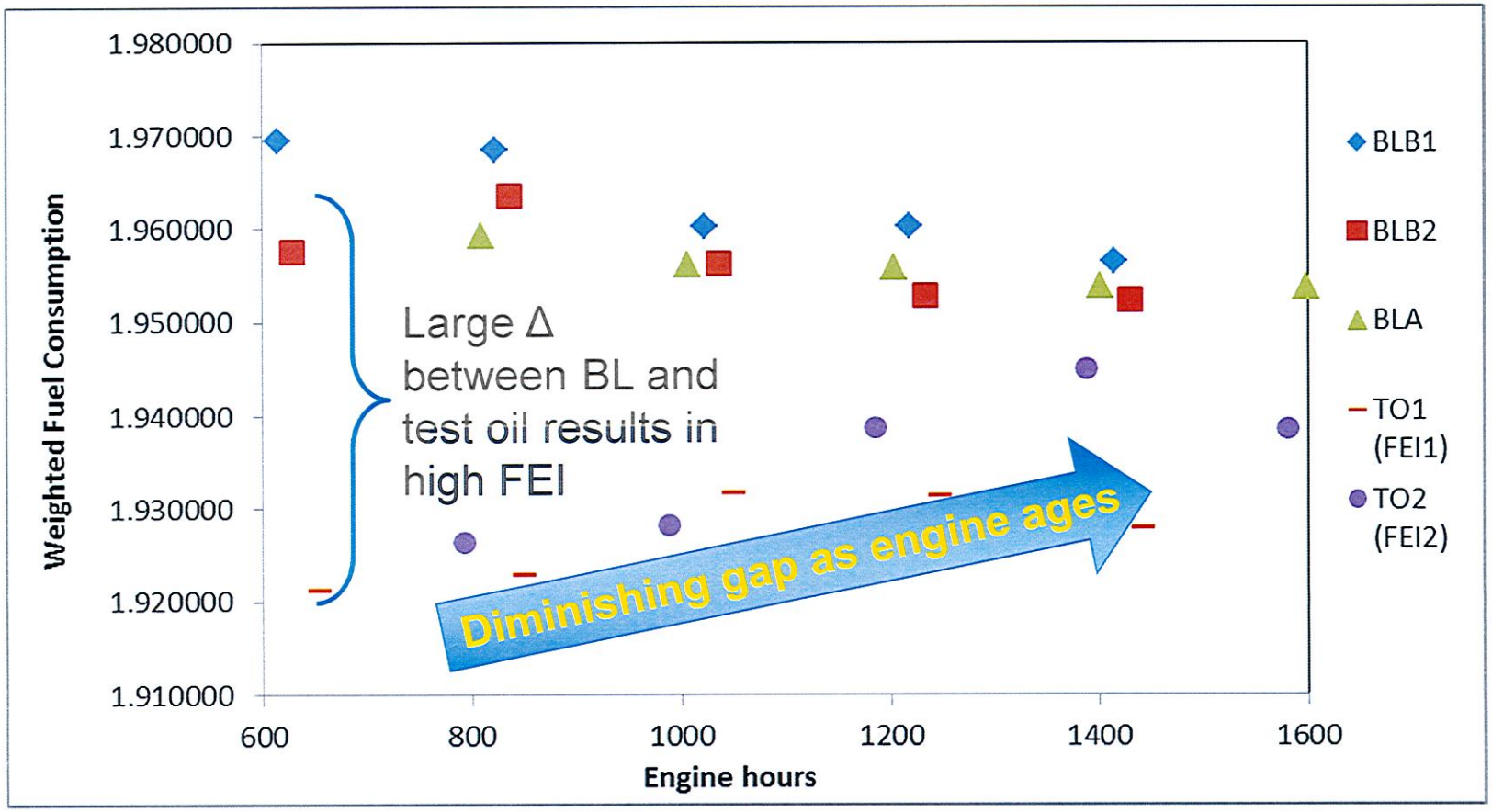


VIE Engine Stand Case Study

SUCCESS TOGETHER



- Recent VIE Test Stand running a matrix of oils
- In general, gap between test oil and BL shrinks with engine hours resulting in lower calculated FEI
- Responsiveness of the engine is an area of intense interest

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Lubrizol Analysis of Reference Oils

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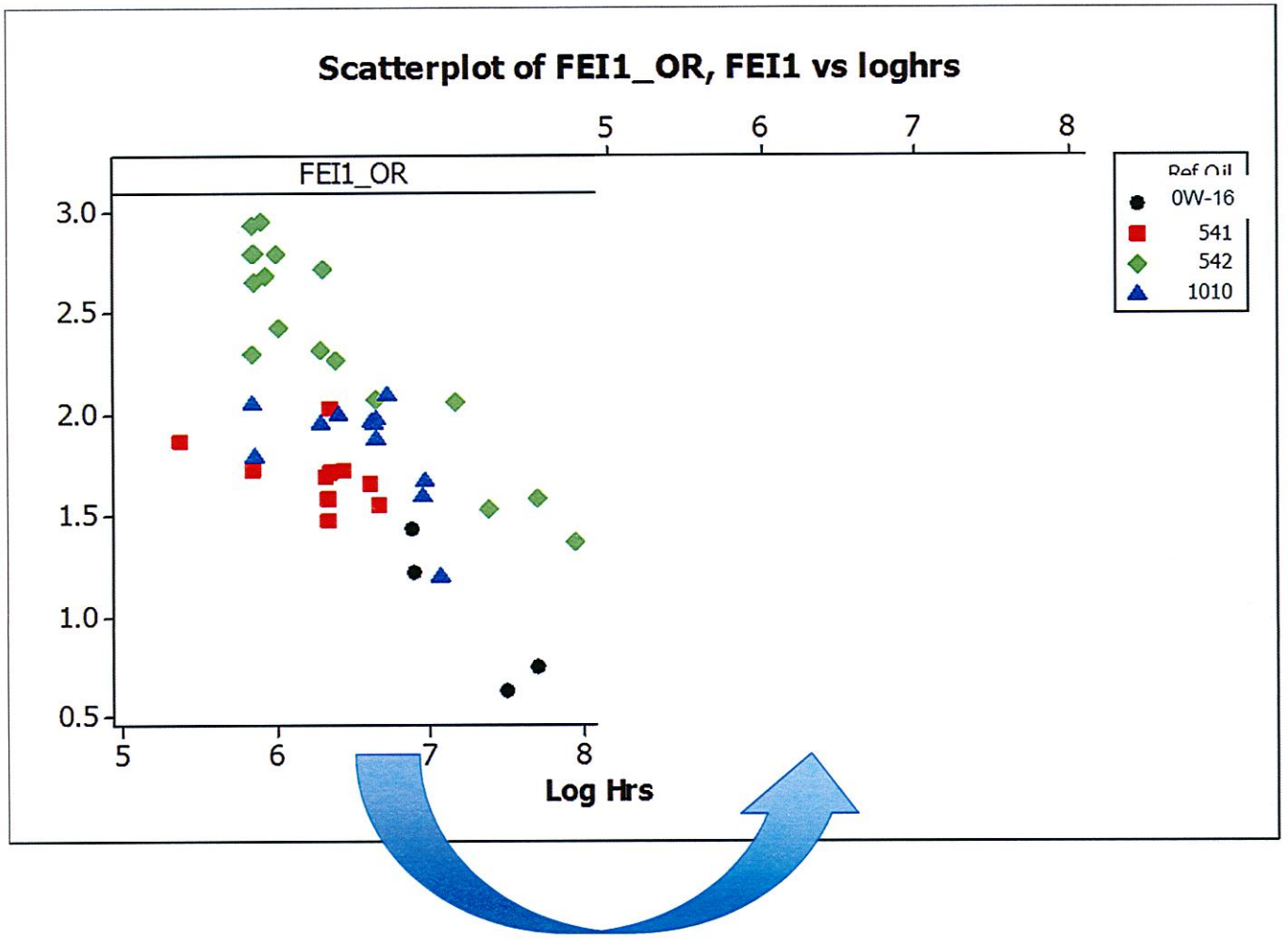

- VID correction does not adequately correct the VIE data

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New Correction Factor

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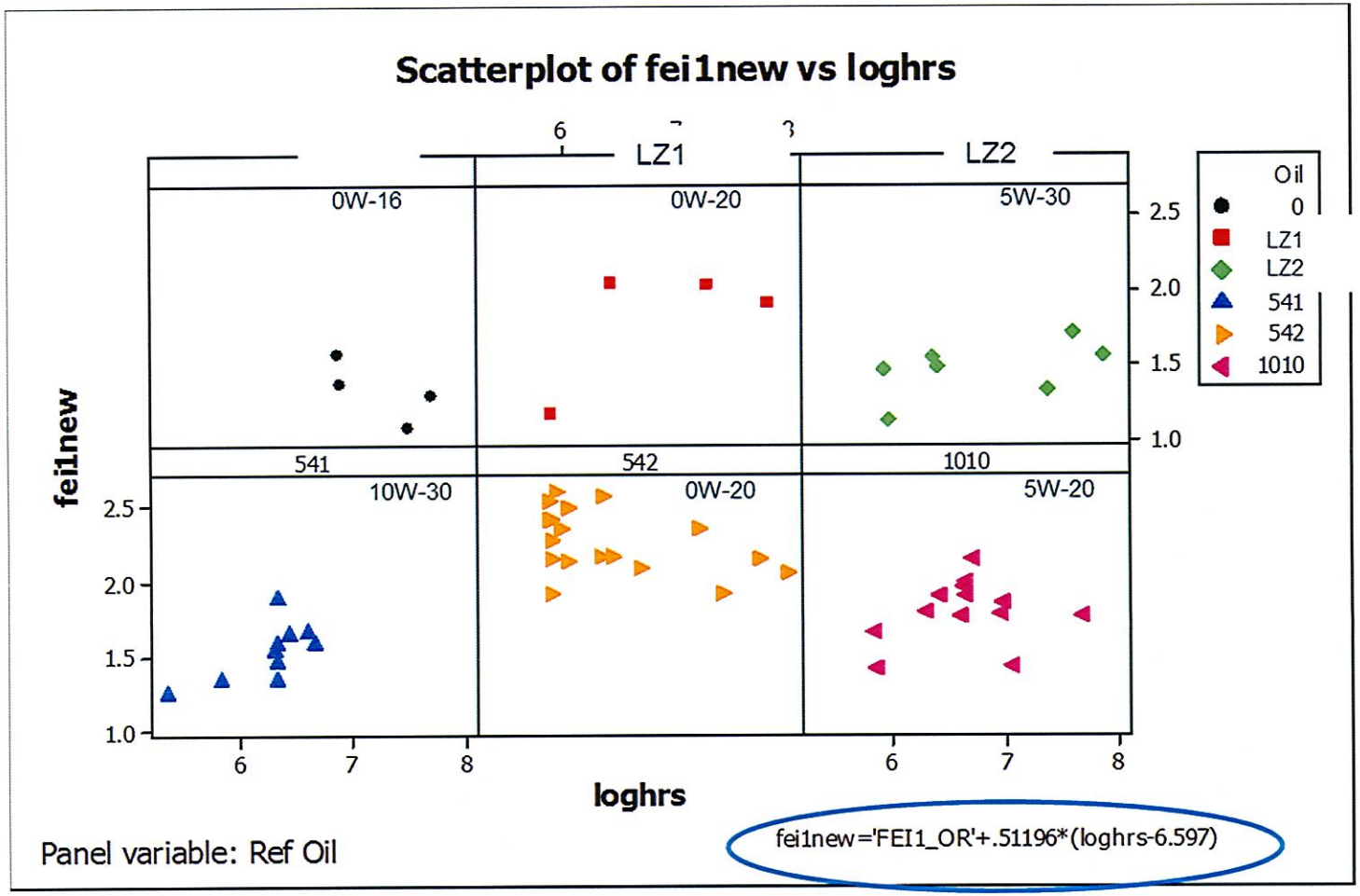

- New correction factor marginally better than the VID
- Based on additized fuel test data for industry RO's and LZ RO's
- Not nearly rigorous enough yet

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Plot of Correction

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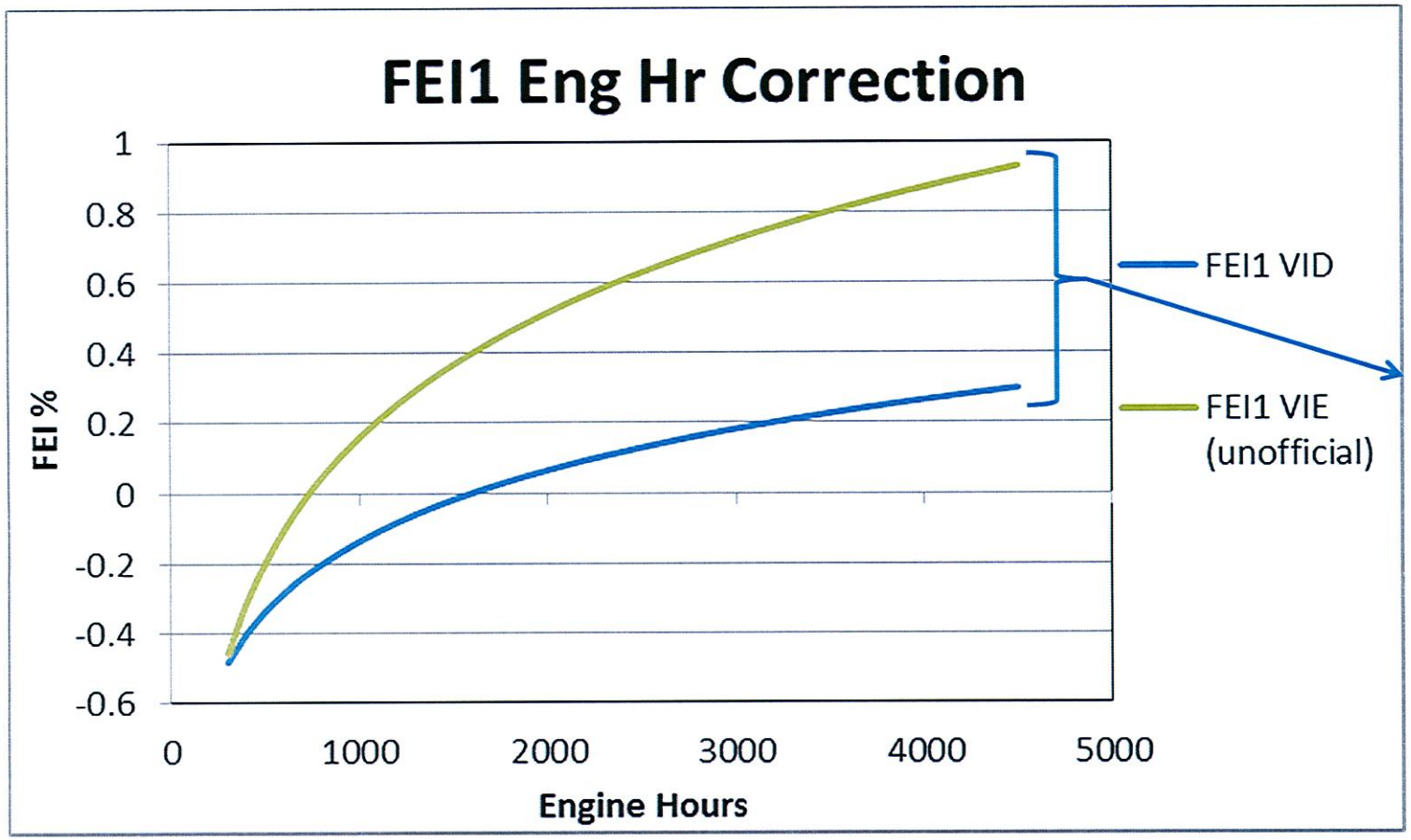

A manifestation of the responsiveness issue?

- The two correction factors look quite different

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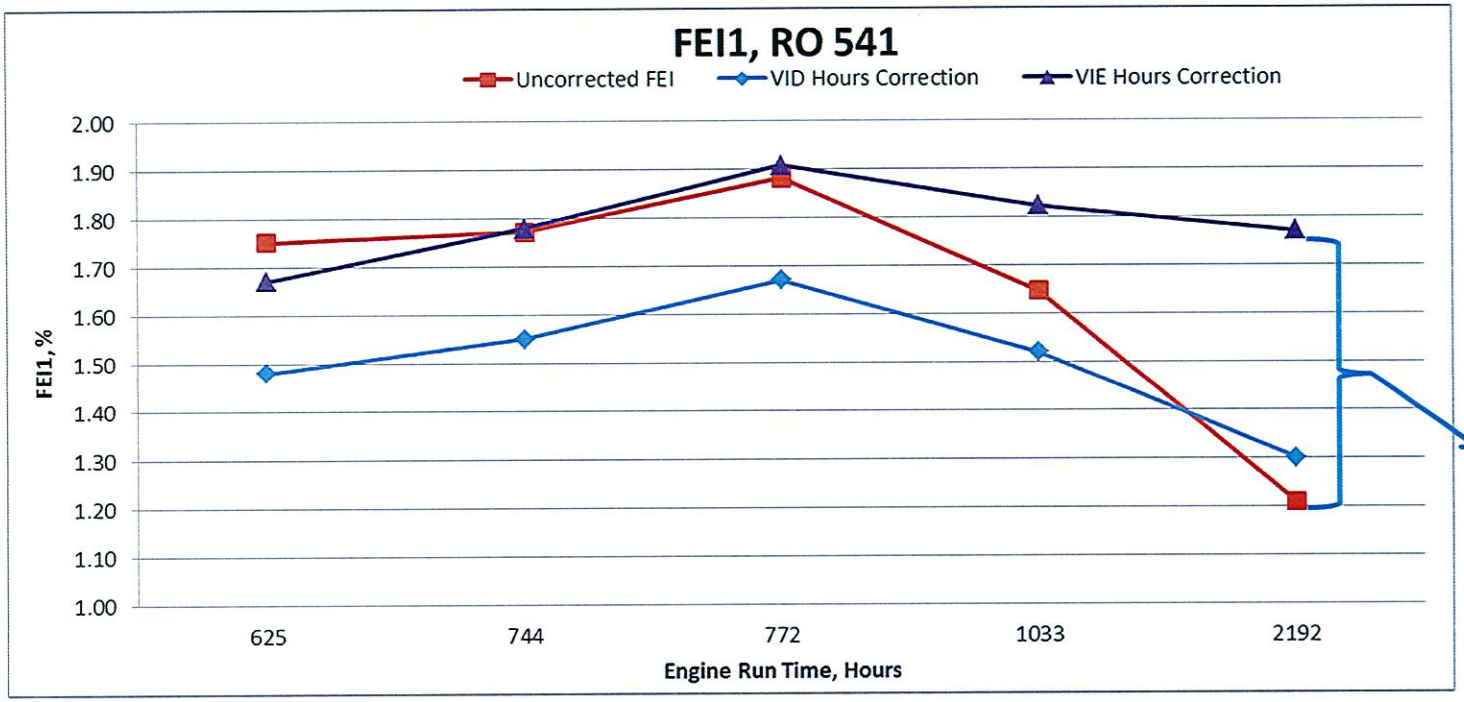
SEQ VIE TEST DATA

SUCCESS TOGETHER

- Example of the correction factor "linearizing" the results



Approximately 1/3 of FEI at 2200 hours is from the correction factor

- VID Correction Average = 1.48
- VIE Correction Average = 1.67

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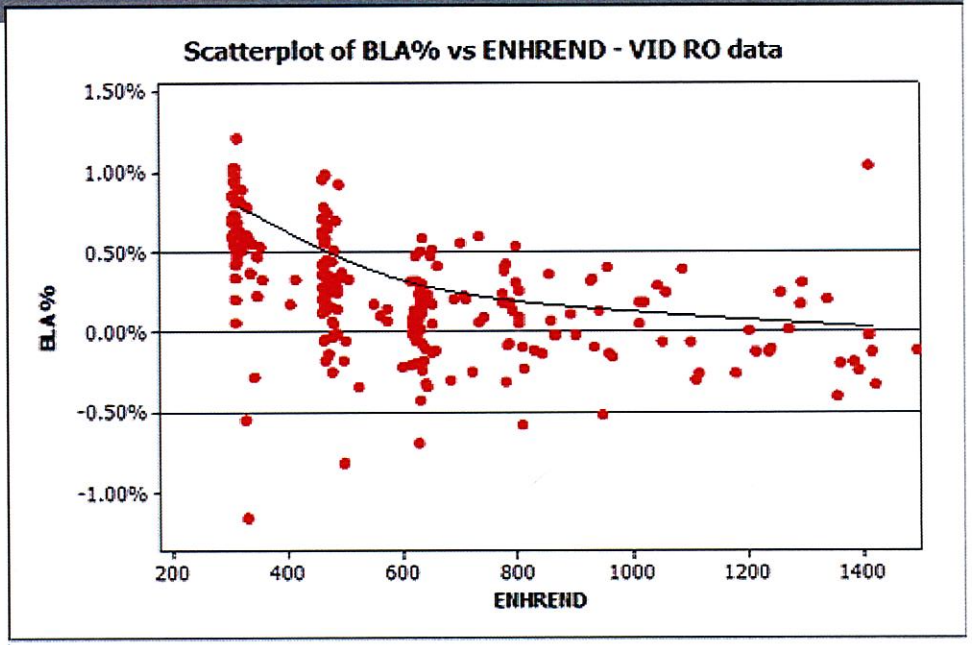
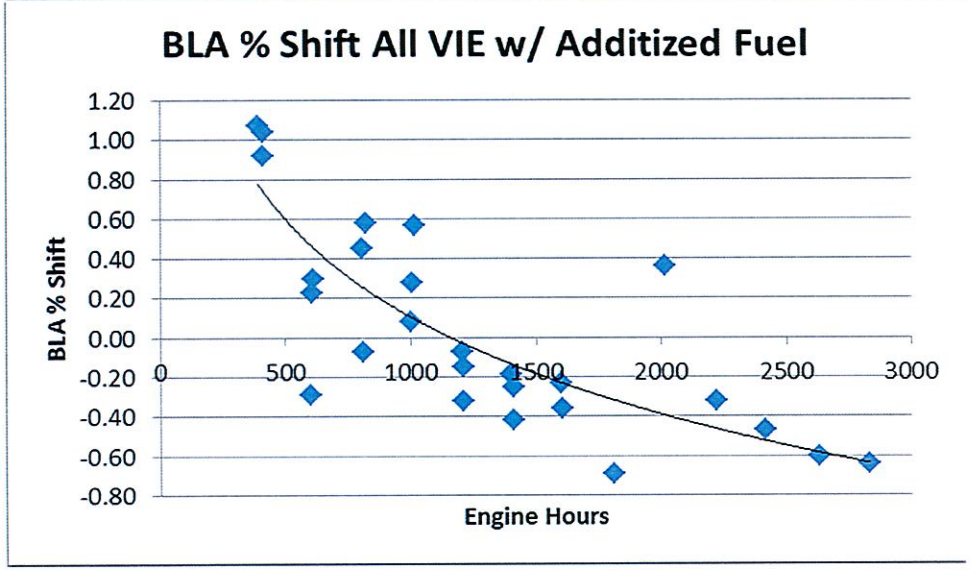
BLA Shift Over Engine Life

SUCCESS TOGETHER

- BLA over time trends from a large positive shift to a large negative shift
- Limited data at extended hours
- Effect is reversible as seen in a "saw tooth" pattern in the BLA fuel consumption data
- Do not see a positive impact in FEI% indicates it affects test oil as well





Responsiveness Implications

SUCCESS TOGETHER

- Potential muting of responsiveness late in life could have large effect on the ultimate VIE engine hours correction factor
- Resulted in removing engines before hitting OC limits around 1,500 hours
- What is actually causing the drop in responsiveness?
- How much of an correction factor impact on final FEI numbers is acceptable and still have meaningful test results?
- Should more engines be acquired for GF-6?
- Should the number of reference test be reduced?

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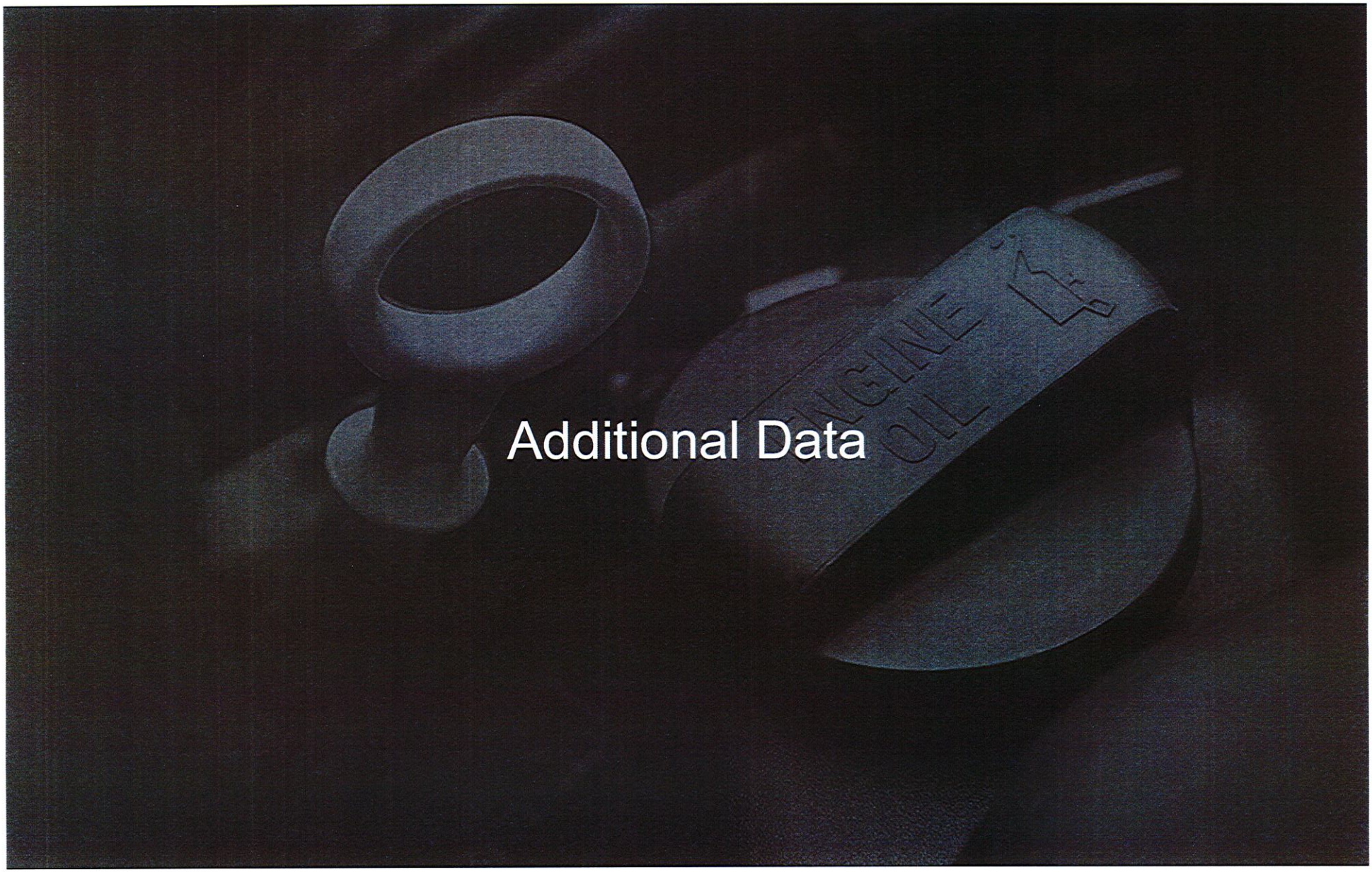

Additional Data

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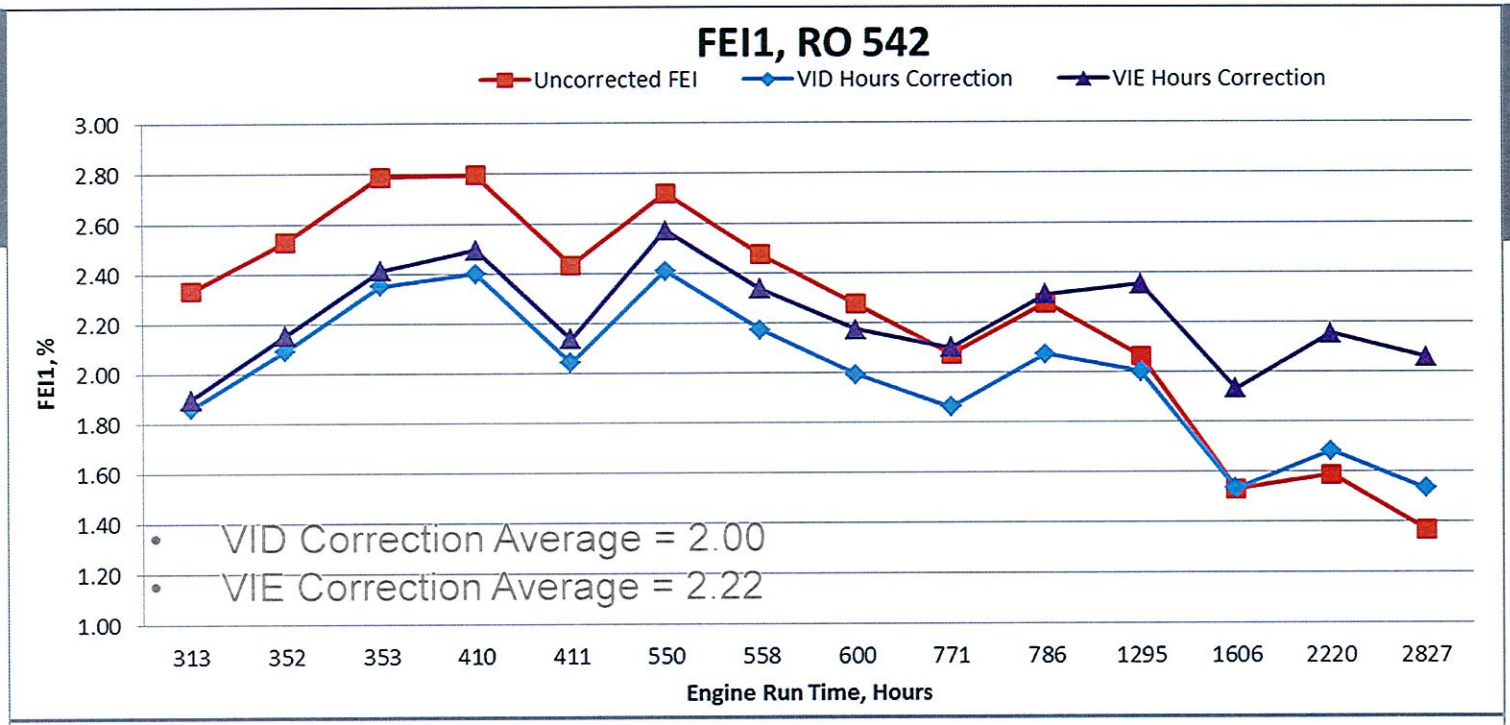
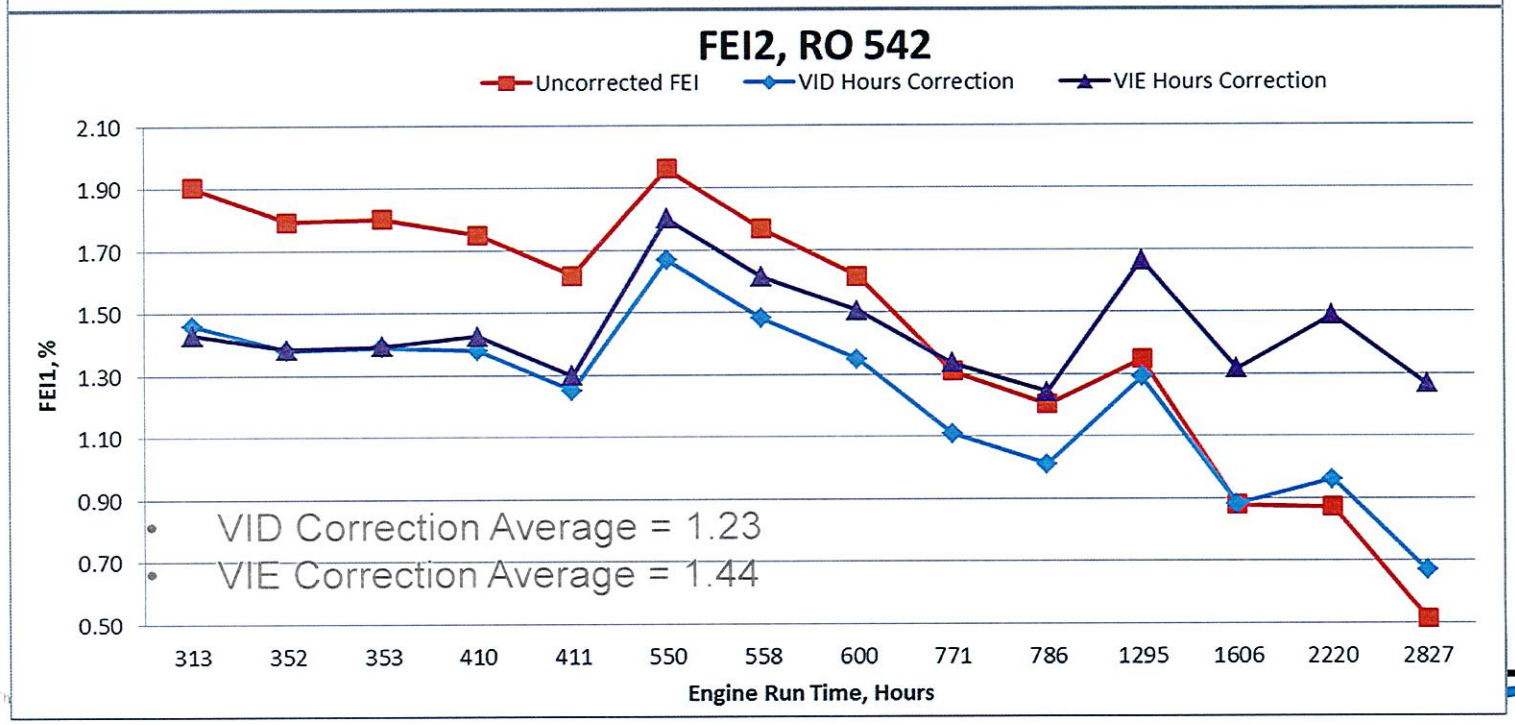
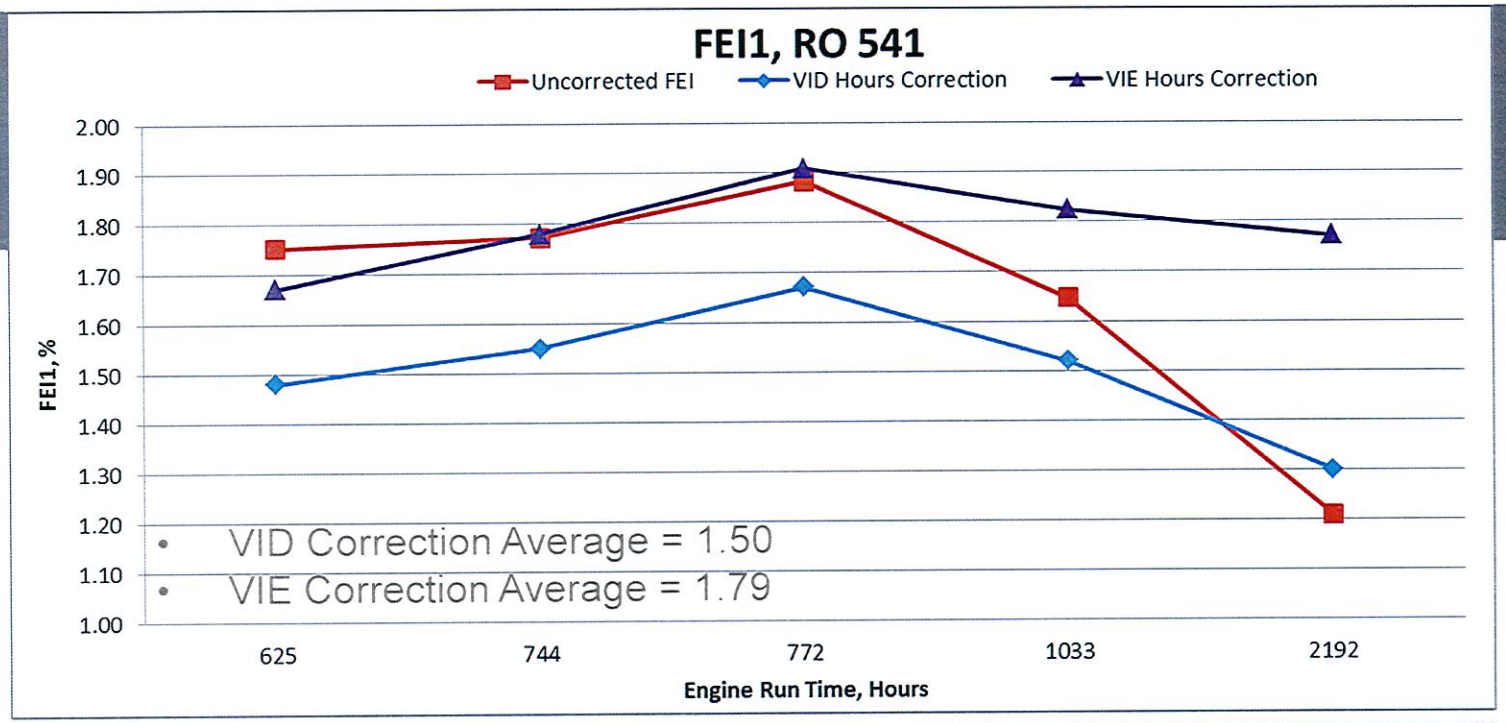
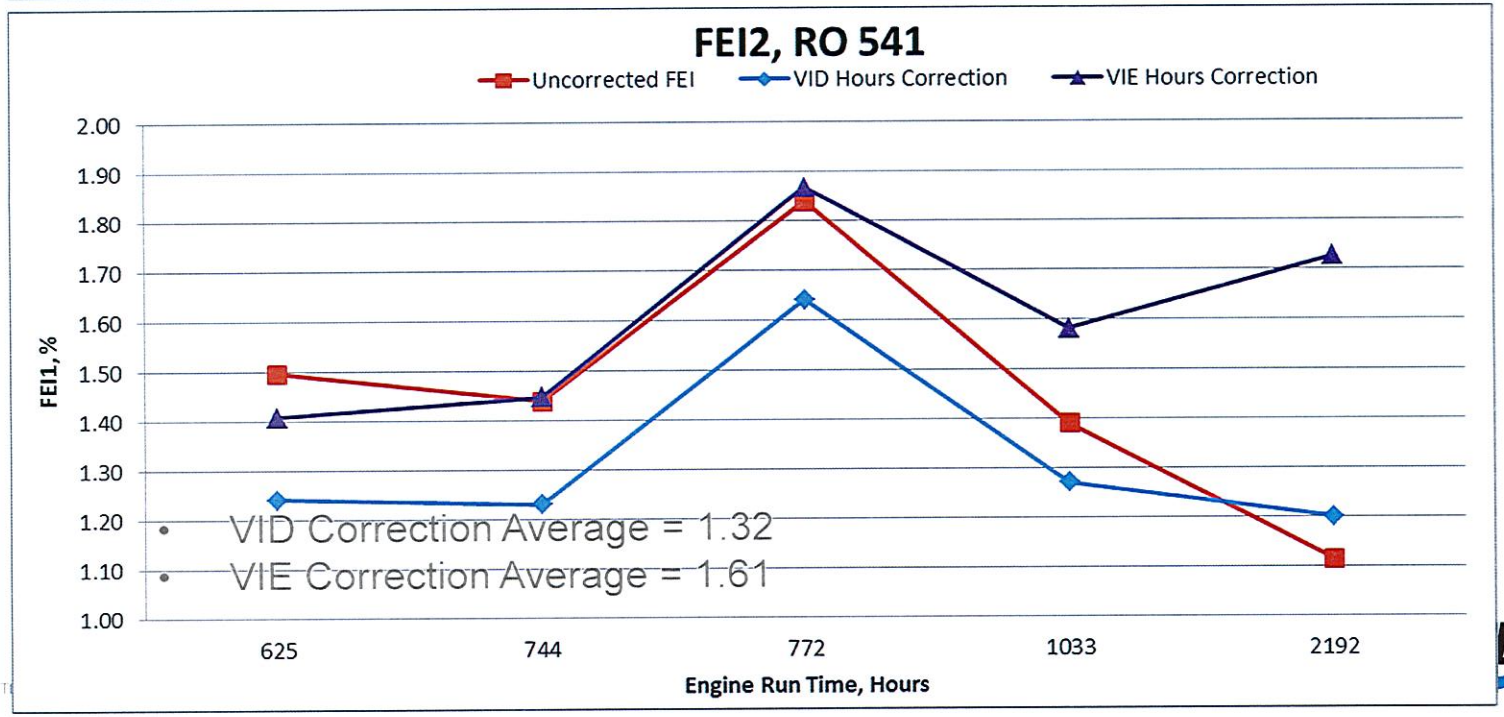
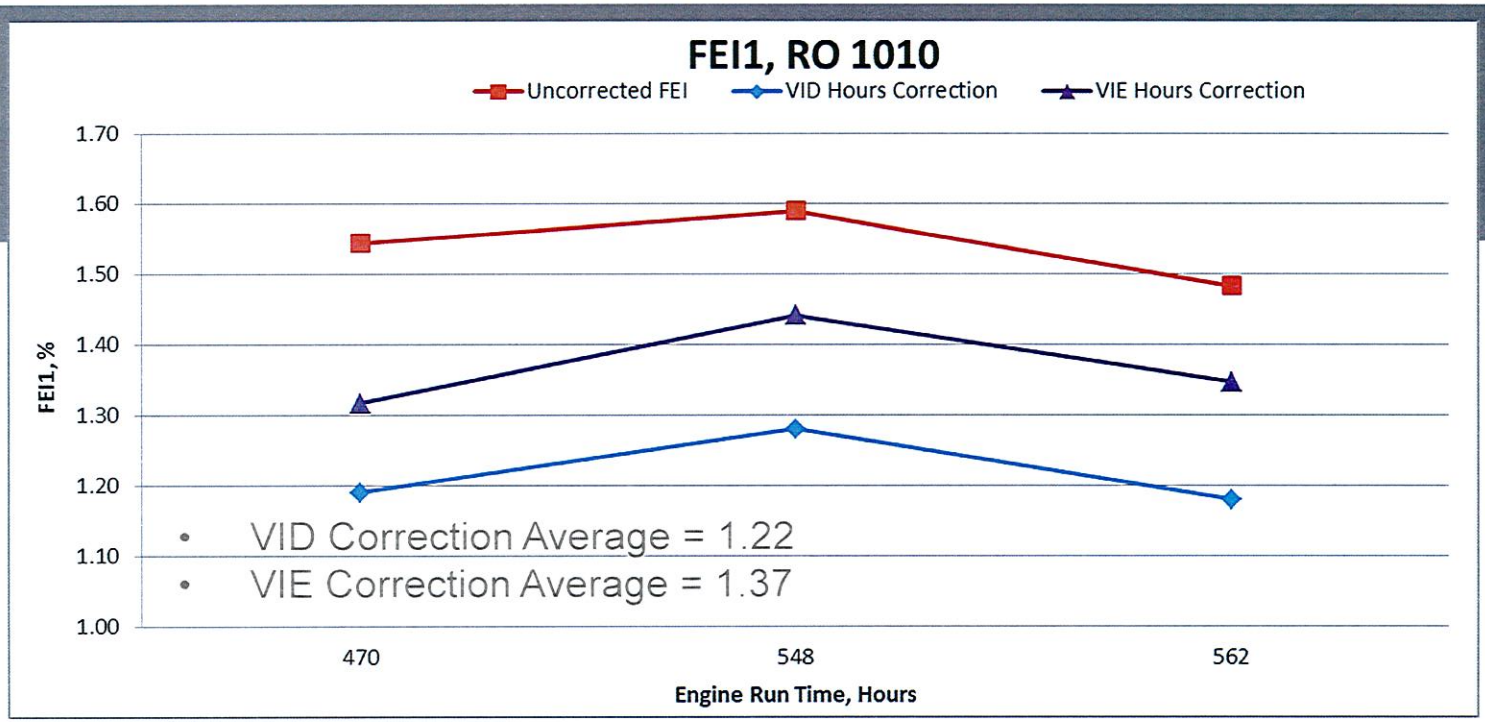
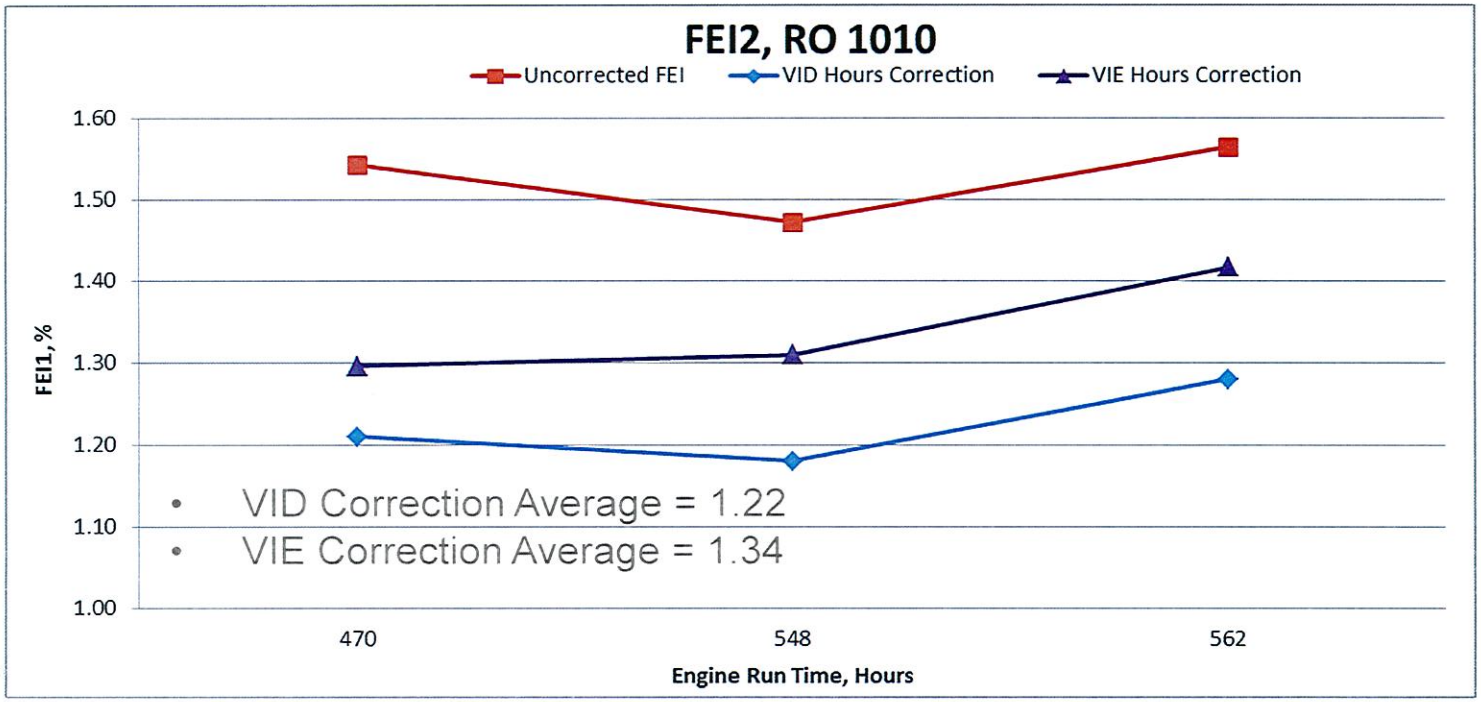

FEI1, RO 542
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
FEI1, %
VID Correction Average = 2.00
VIE Correction Average = 2.22
313
352
353
410
411
550
558
600
771
786
1295
1606
2220
2827
Engine Run Time, Hours


FEI2, RO 542
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
2.10
1.90
1.70
1.50
1.30
1.10
0.90
0.70
0.50
FEI1, %
VID Correction Average = 1.23
VIE Correction Average = 1.44
313
352
353
410
411
550
558
600
771
786
1295
1606
2220
2827
Engine Run Time, Hours

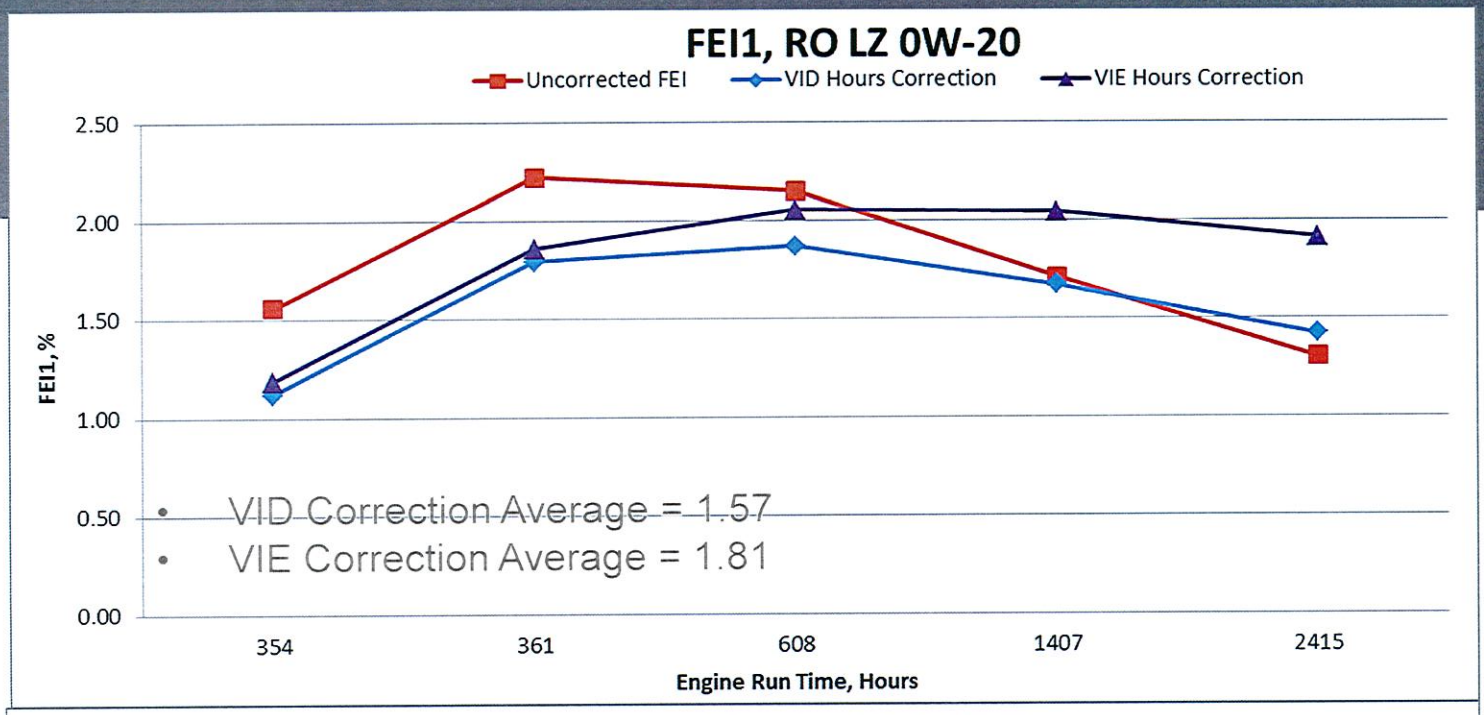

FEI1, RO 541
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
FEI1, %
VID Correction Average = 1.50
VIE Correction Average = 1.79
625
744
772
1033
2192
Engine Run Time, Hours

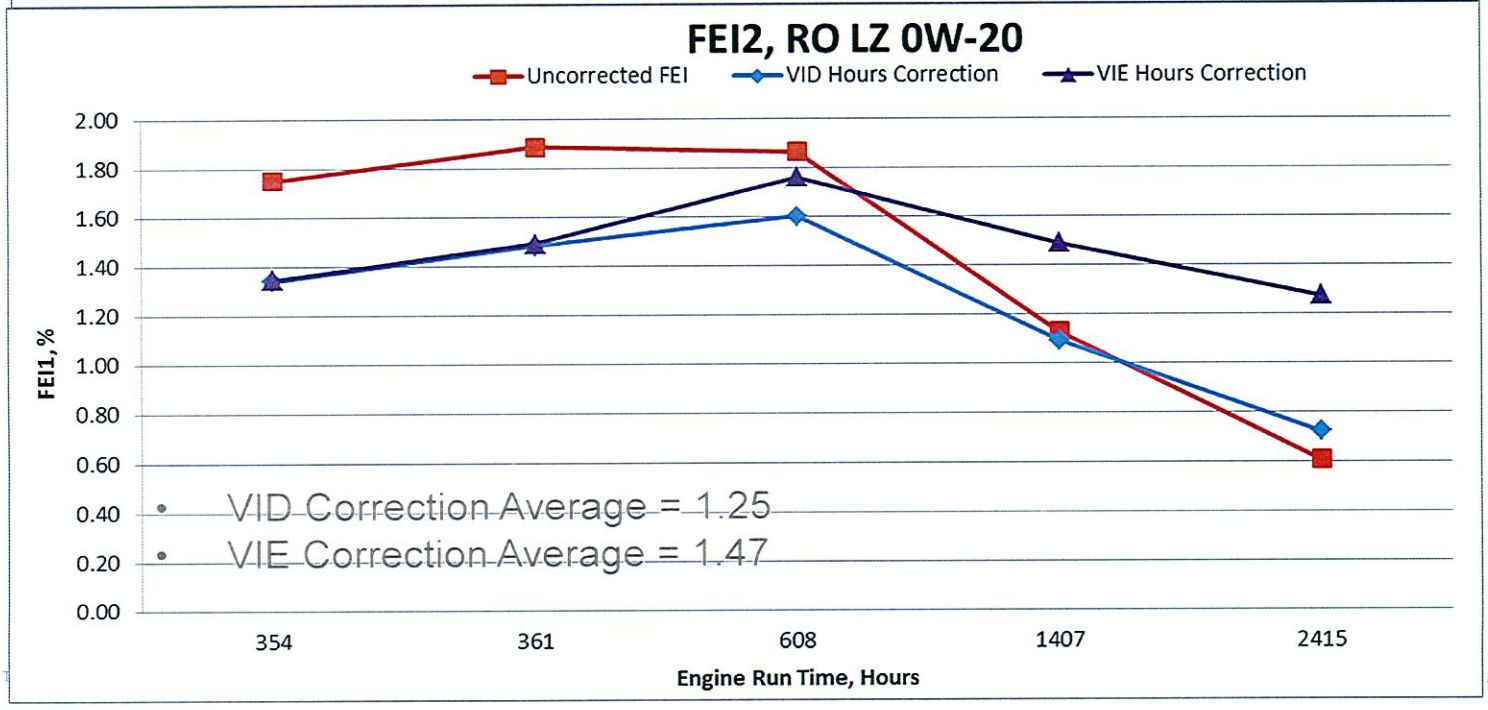

FEI2, RO 541
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
FEI1, %
VID Correction Average = 1.32
VIE Correction Average = 1.61
625
744
772
1033
2192
Engine Run Time, Hours


FEI1, RO 1010
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
FEI1, %
• VID Correction Average = 1.22
• VIE Correction Average = 1.37
470
548
562
Engine Run Time, Hours


FEI2, RO 1010
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
1.60
1.50
1.40
1.30
1.20
1.10
1.00
FEI1, %
• VID Correction Average = 1.22
• VIE Correction Average = 1.34
470
548
562
Engine Run Time, Hours

Lubrizol





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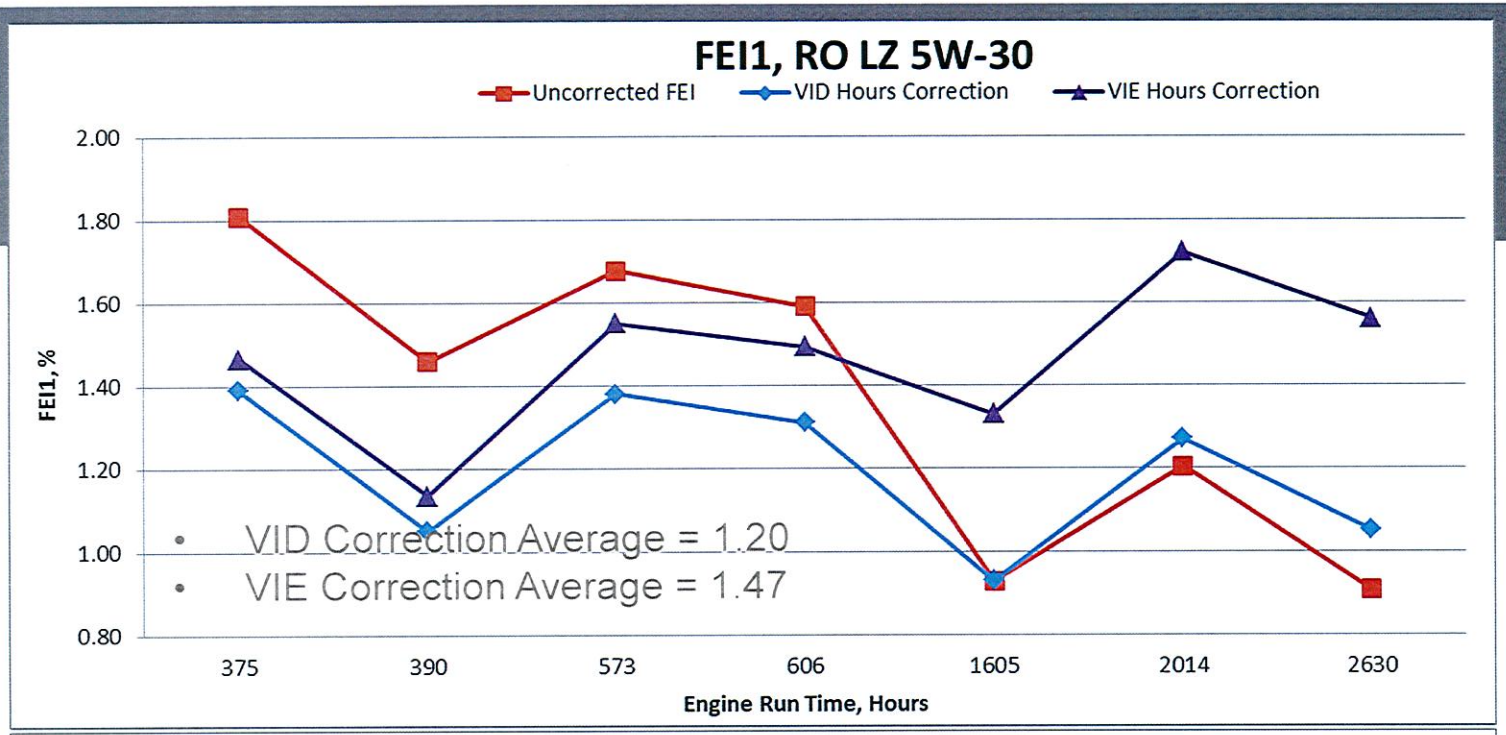

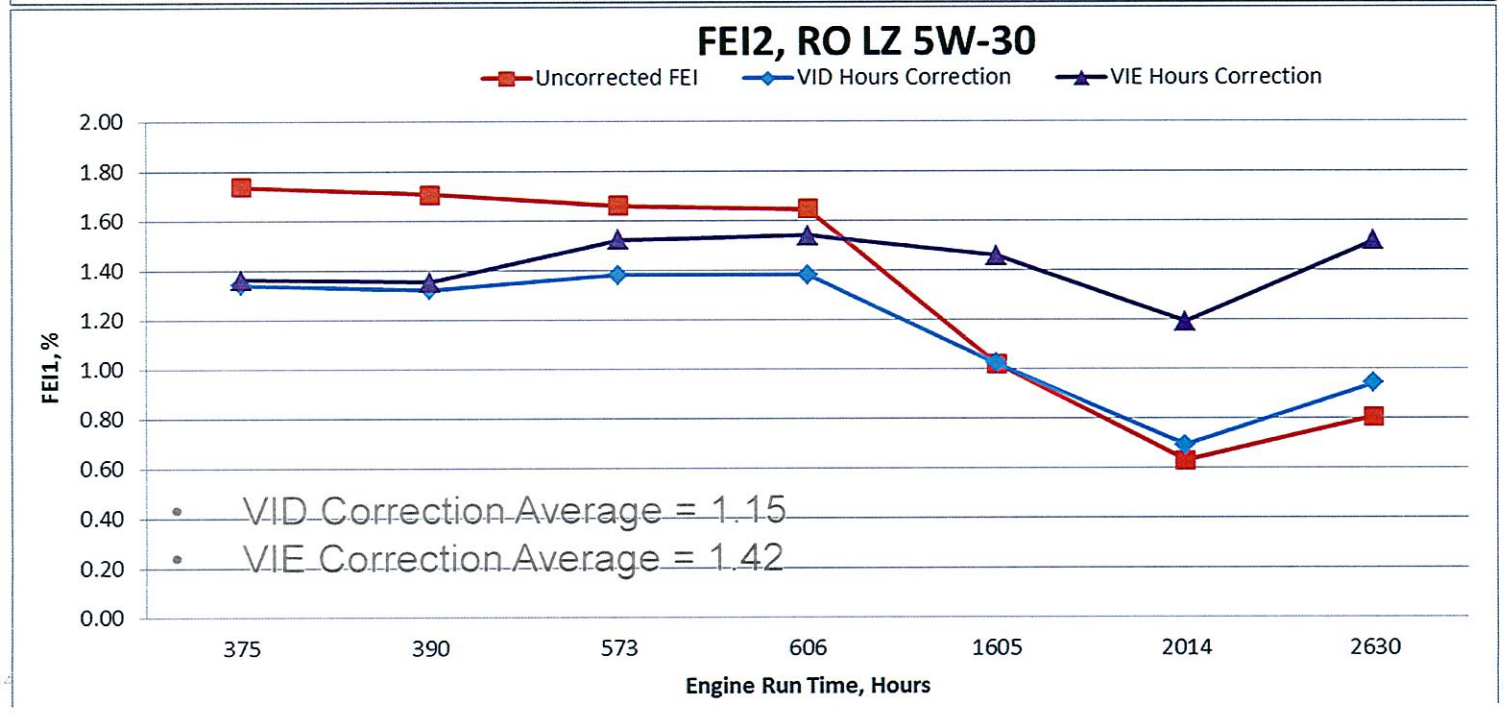

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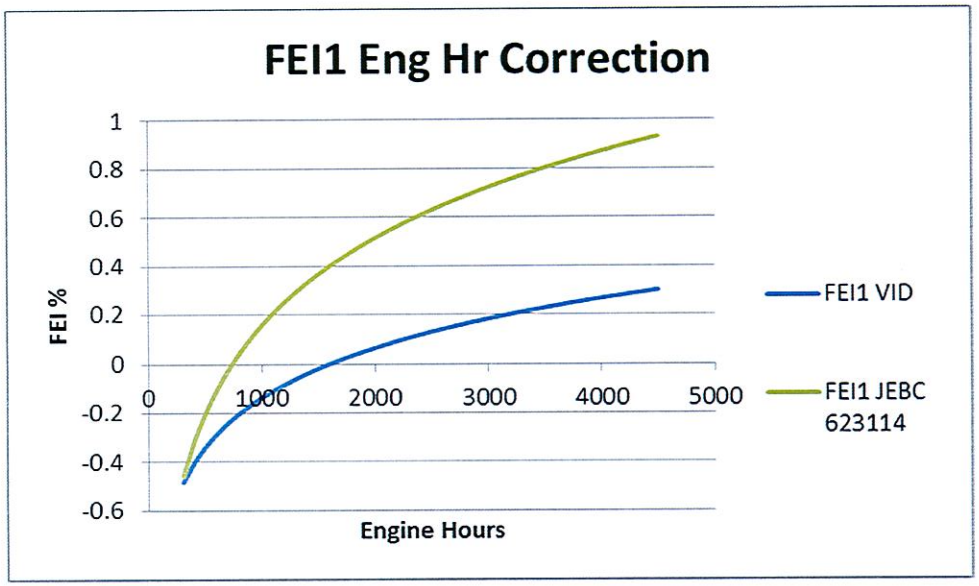

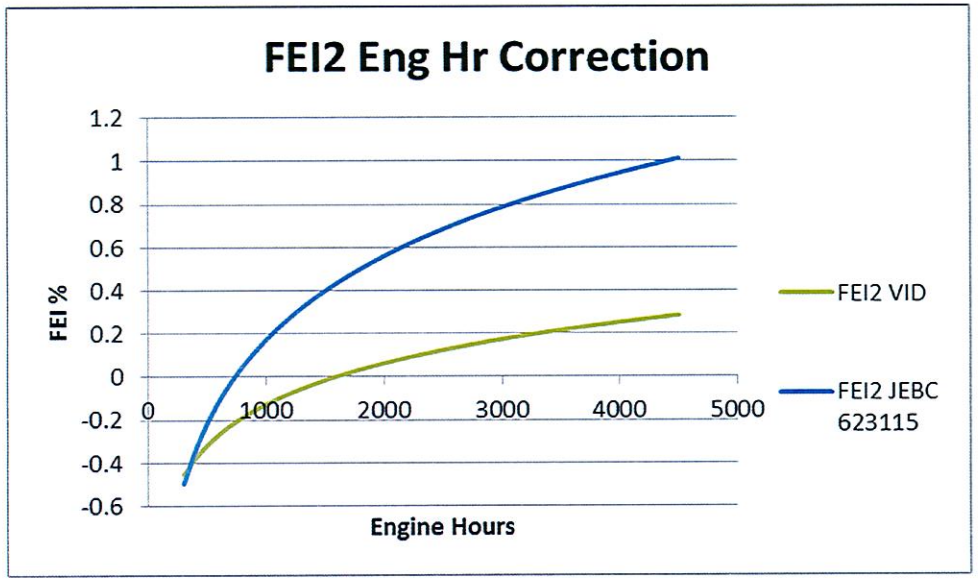

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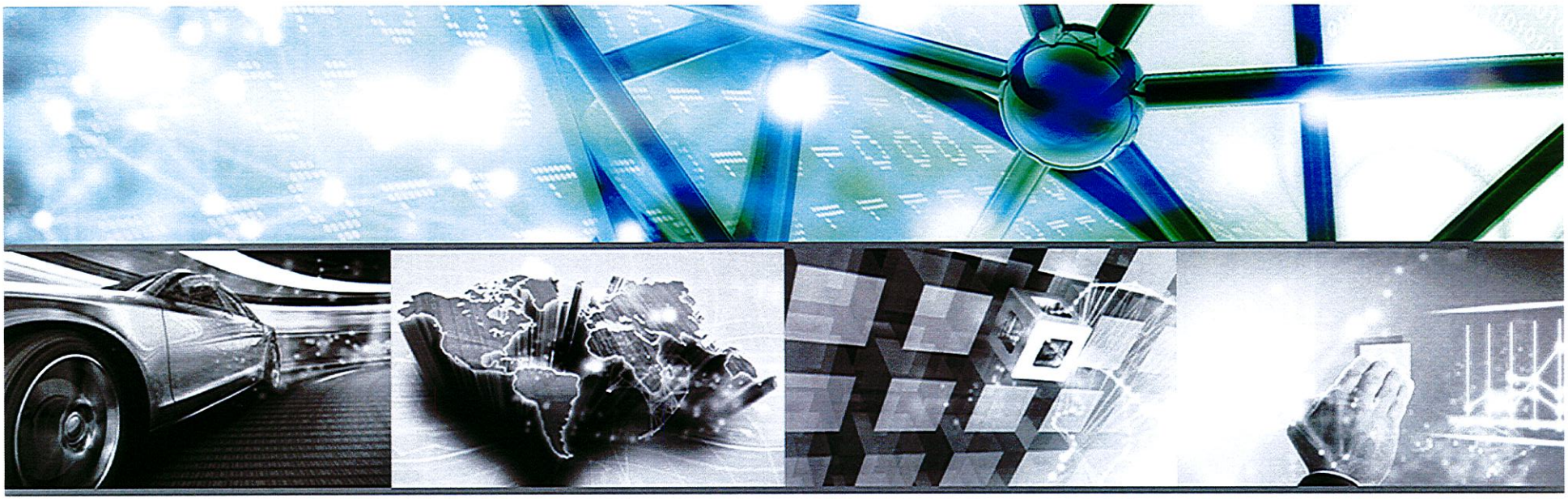

SUCCESS TOGETHER

Working together, achieving great things

When your company and ours combine energies, great things can happen. You bring ideas, challenges and opportunities. We'll bring powerful additive and market expertise, unmatched testing capabilities, integrated global supply and an independent approach to help you differentiate and succeed.

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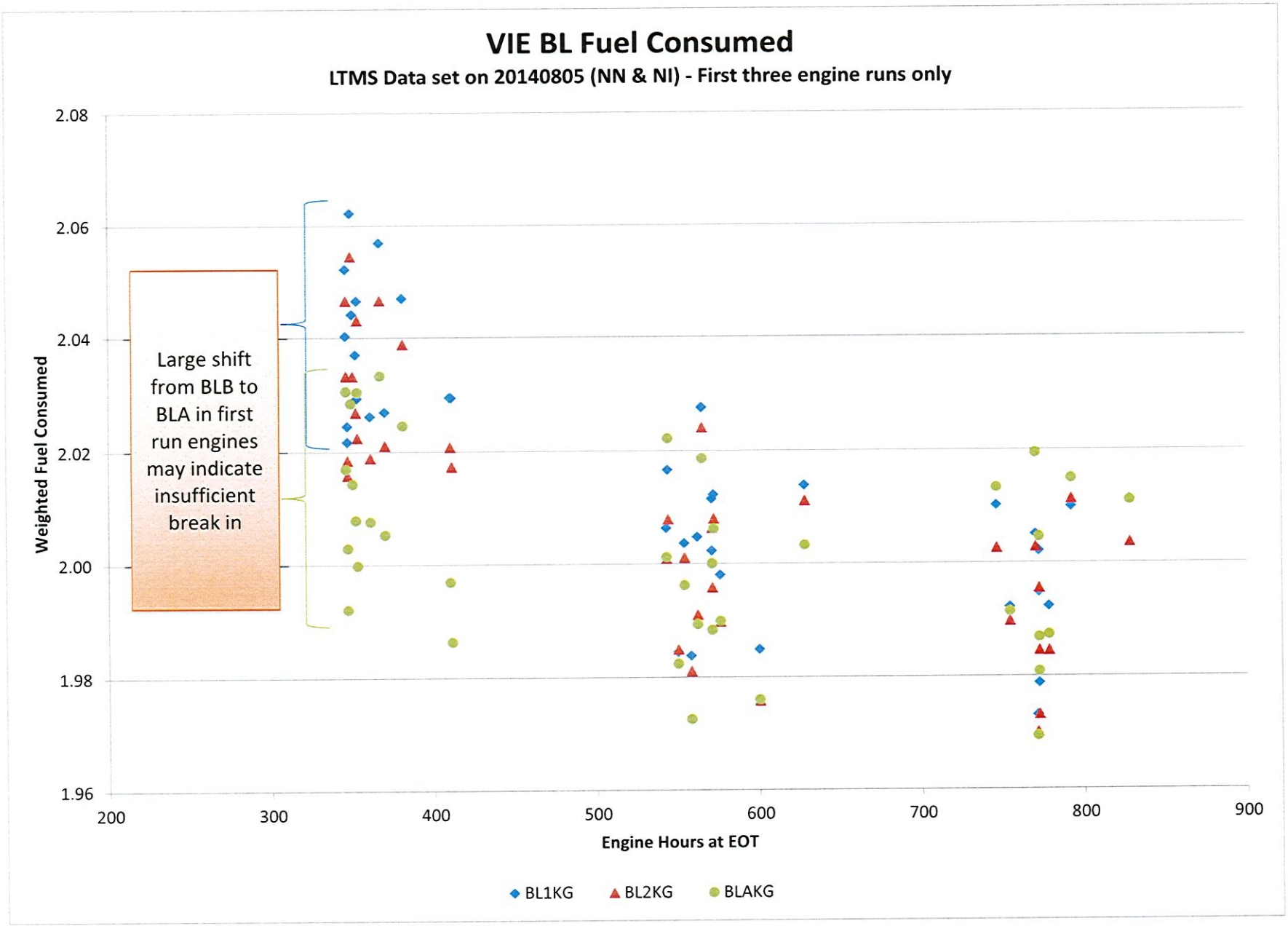

VIE BL Fuel Consumed
LTMS Data set on 20140805 (NN & NI) - First three engine runs only
Weighted Fuel Consumed
2.08
2.06
2.04
2.02
2.00
1.98
1.96
200
300
400
500
600
700
800
900
Engine Hours at EOT
Large shift from BLB to BLA in first run engines may indicate insufficient break in
BL1KG
BL2KG
BLAKG

Sequence VI New Engine Break-In

"Those who cannot remember the past are condemned to repeat it." -Santayana 1905

David Glaenzer

August, 2014

Passion for Solutions™

A Little Sequence VI History to Aid New Engine Break-In Discussions

ASTM D6202 (Sequence VIA)

- 4.6L V-8
- 5.68L BC Oil
- No specified oil make-up (lab discretion)
- Cyclical Operation for minimum of 100 hours
- Stability check after every 10 hours of cyclical operation
- Step A 4 minutes at 1500 rpm/48 Nm (7.5kW)
- Step B 1 minute at 3500 rpm / 57 Nm (20.9 kW)
- Acceleration from A to B in 4-5 seconds
- Deceleration from B to A in 15 seconds
- Coolant Inlet Temperature 95°C
- Oil Gallery Temperature 105°C

ASTM D6837 (Sequence VIB)

- 4.6L V-8
- 6.0L BC Oil
- No specified oil make-up (lab discretion)
- Cyclical Operation for minimum of 200 hours
- Stability check eliminated from procedure
- Step A 4 minutes at 1500 rpm/48 Nm (7.5kW)
- Step B 1 minute at 3500 rpm / 57 Nm (20.9 kW)
- Acceleration from A to B in 15 seconds maximum
- Deceleration from B to A in 15 seconds maximum
- Coolant Inlet Temperature 95°C
- Oil Gallery Temperature 105°C

ASTM D7589 (Sequence VID)

- 3.6L V-6
- 5.4L BC Oil (actually >5.4L due to test full being set at flush conditions)
- Initially no specified oil make-up (lab discretion), later changed to addition if oil pan is 400 ml low
- Cyclical Operation for minimum of 150 hours
- No stability check
- Step A 4 minutes at 1500 rpm/38 Nm (6.0kW)
- Step B 1 minute at 3500 rpm / 45 Nm (16.5 kW)
- Acceleration from A to B in 15 seconds maximum
- Deceleration from B to A in 15 seconds maximum
- Coolant Inlet Temperature 80°C
- Oil Gallery Temperature 80°C

ASTM DXXXX (Sequence VIE)

- 3.6L V-6
- 5.9L BC Oil (actually >5.9L due to test full being set at flush conditions)
- Oil addition if oil pan is 400 ml low
- Cyclical Operation for minimum of 150 hours
- No stability check
- Step A 4 minutes at 1500 rpm/38 Nm (6.0kW)
- Step B 1 minute at 3500 rpm / 45 Nm (16.5 kW)
- Acceleration from A to B in 15 seconds maximum
- Deceleration from B to A in 15 seconds maximum
- Coolant Inlet Temperature 80°C
- Oil Gallery Temperature 80°C

Fuel Temperature Inconsistencies in Sequence VIE Engine Oil Test

Review of ASTM RO Data
Fuel to Flow Meter Temperature
Fuel to Engine Fuel Rail Temperature

David L. Glaenzer
June, 2014

Passion for Solutions™

ASTM Sequence VIE Draft Procedure

Table 3 Sequence VIE Test Operating Conditions

- Temperatures, All Stages
  - Fuel-to-Flow Meter Temperature (D)

    20 to 32°C All Stages (delta from max stage reading shall be ≤ 4)
  - Fuel-to-Fuel Rail Temperature (B)

    22 ± 2°C

D Difference between the maximum stage average reading of the entire test and the individual stage average readings.

B Critical measurement and controlled parameter.

A Little History

- **D7589, Table 3 Sequence VID Test Operating Conditions**
  - Reads the same as VIE Draft Procedure
- **D6837, Table 3 Sequence VIB Test Operating Conditions**
  - Reads the same as VIE Draft Procedure
- **D6202, Table 3 Sequence VIA Test Operating Conditions**
  - Temperatures, All Stages
    - Fuel-to-Flow Meter Temperature (C)
      68 to 89.6°**F** All Stages (delta from max stage reading shall be ≤ **4**)
    - Fuel-to-Fuel Rail Temperature (A)
      68 ± 3.6°**F**

  C Difference between the maximum stage average reading of the entire test and the individual stage average readings.

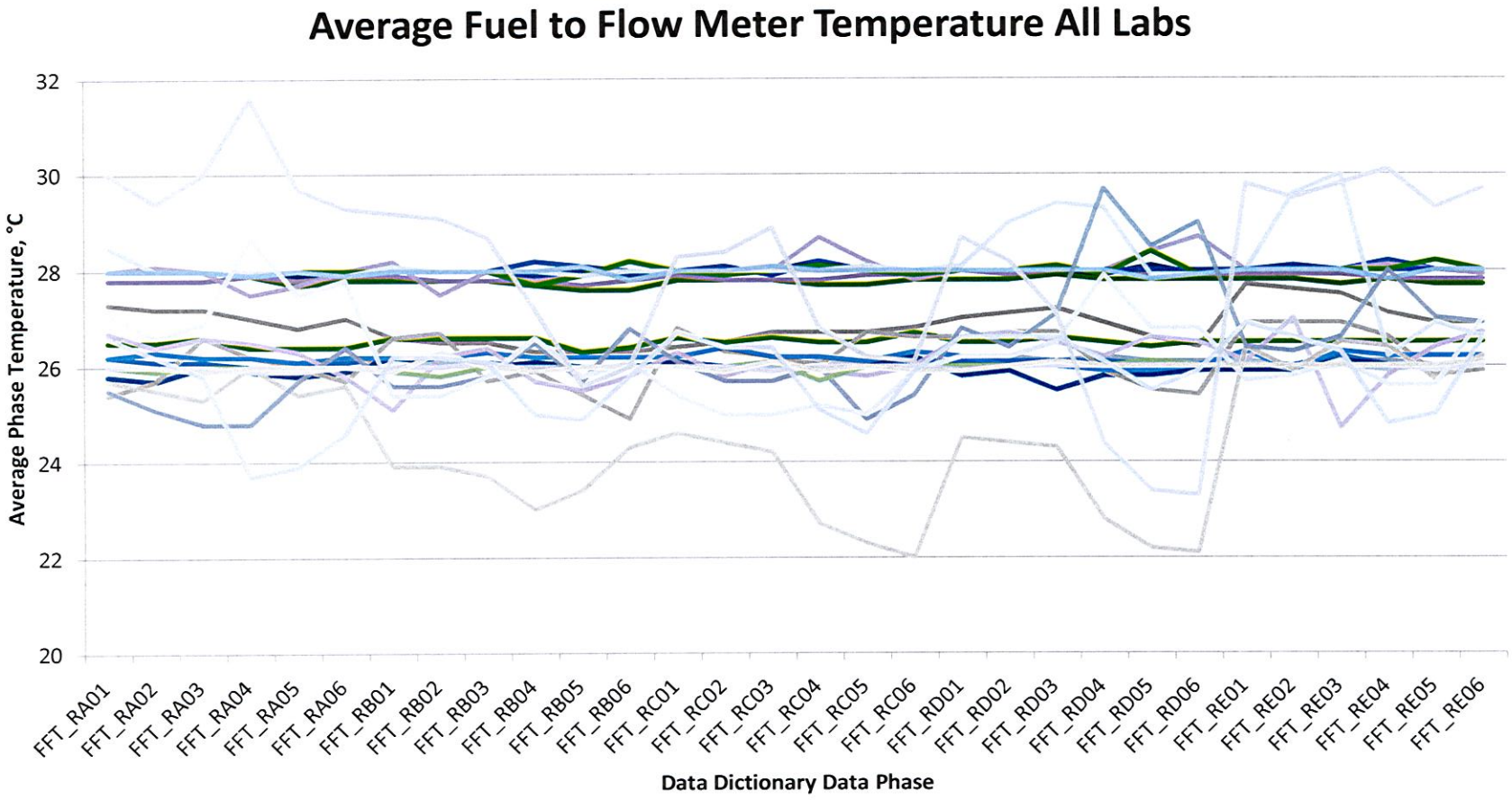
  A Critical measurement and controlled parameter targeted for middle of specification range.

  Conversion on delta from max not made from °F to °C when transitioning for VIA to VIB.

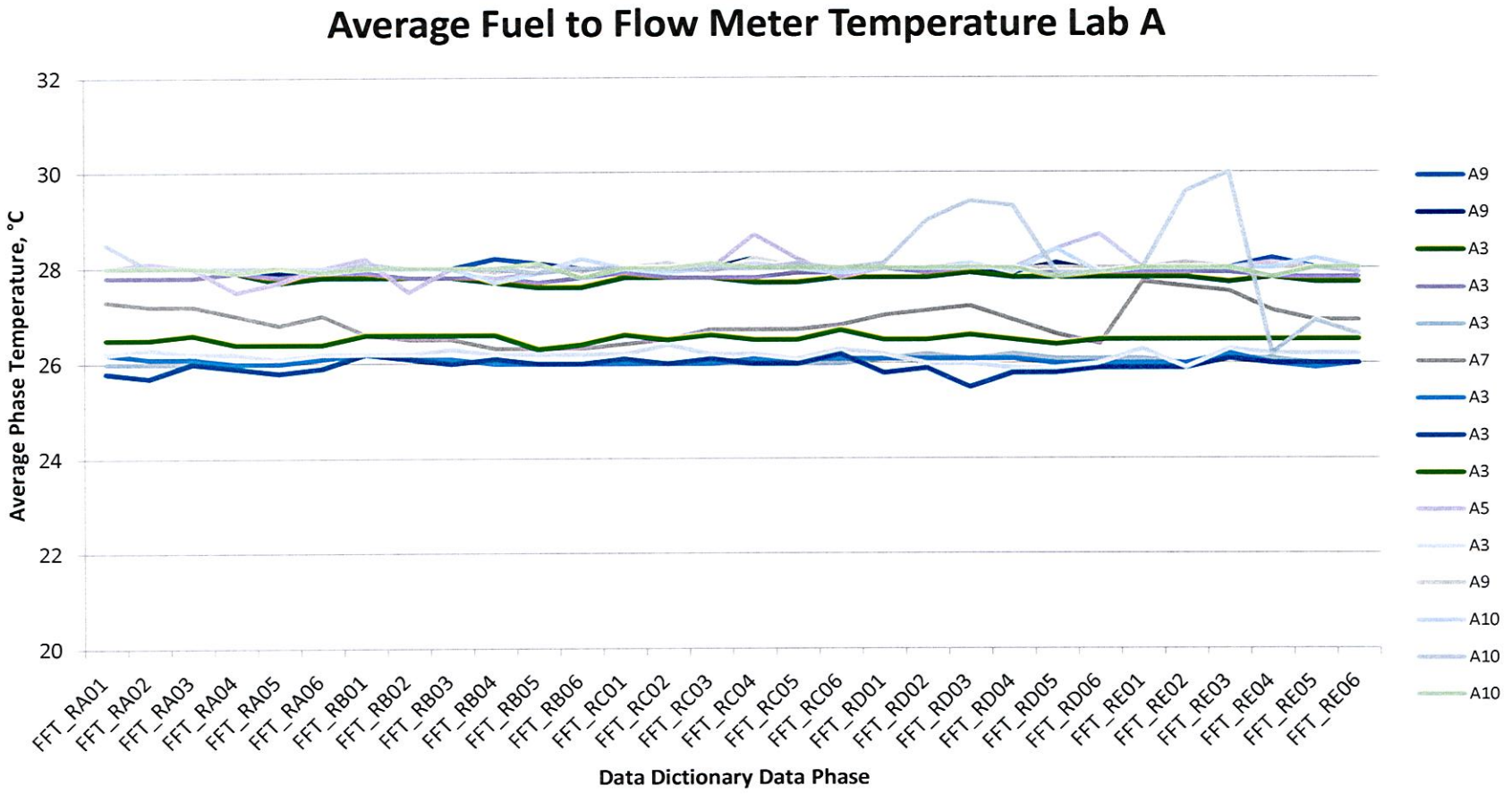
Data Examined

- ASTM-TMC Data
- At time of analysis, 42 Tests reported with current "VIE" configuration
- Only 26 of 42 tests show complete Fuel-to-Flow Meter temperature data
- Only 23 of 42 tests show complete Fuel-to-Fuel Rail temperature data
- Data are arranged by ASTM Data Dictionary nomenclature and are not in order with test procedure

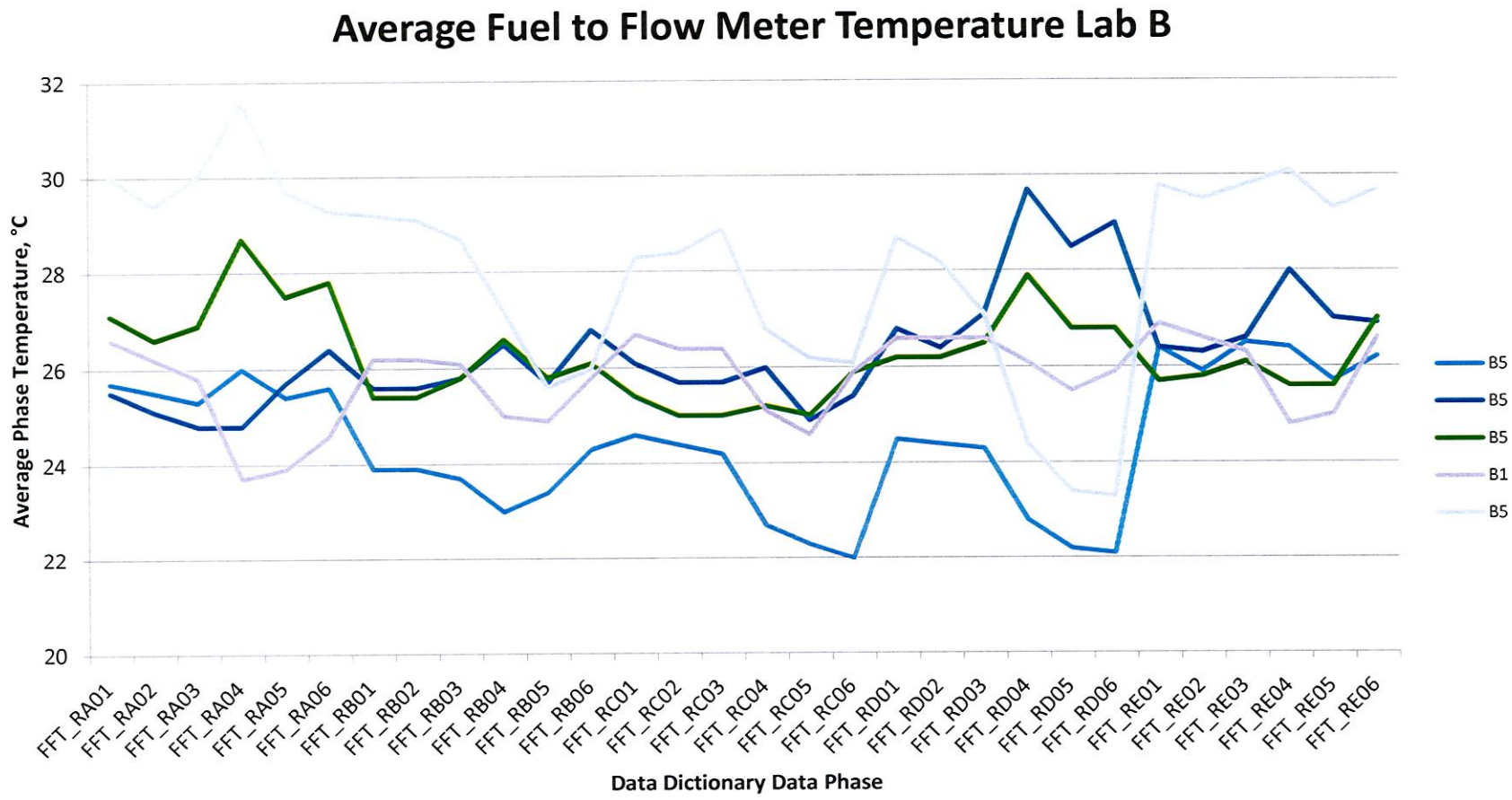
Fuel to Flow Meter Temperature



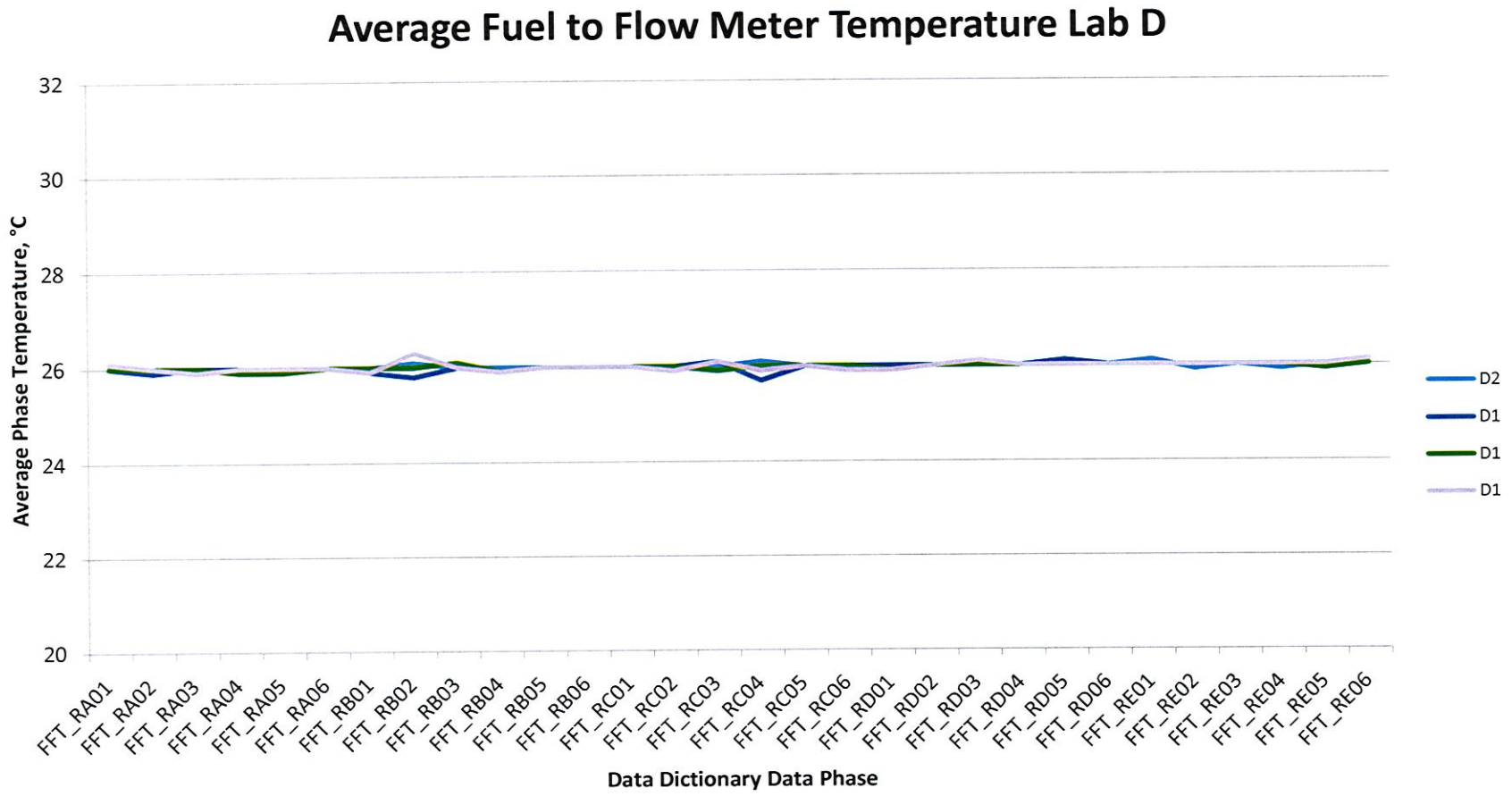
Fuel to Flow Meter Temperature



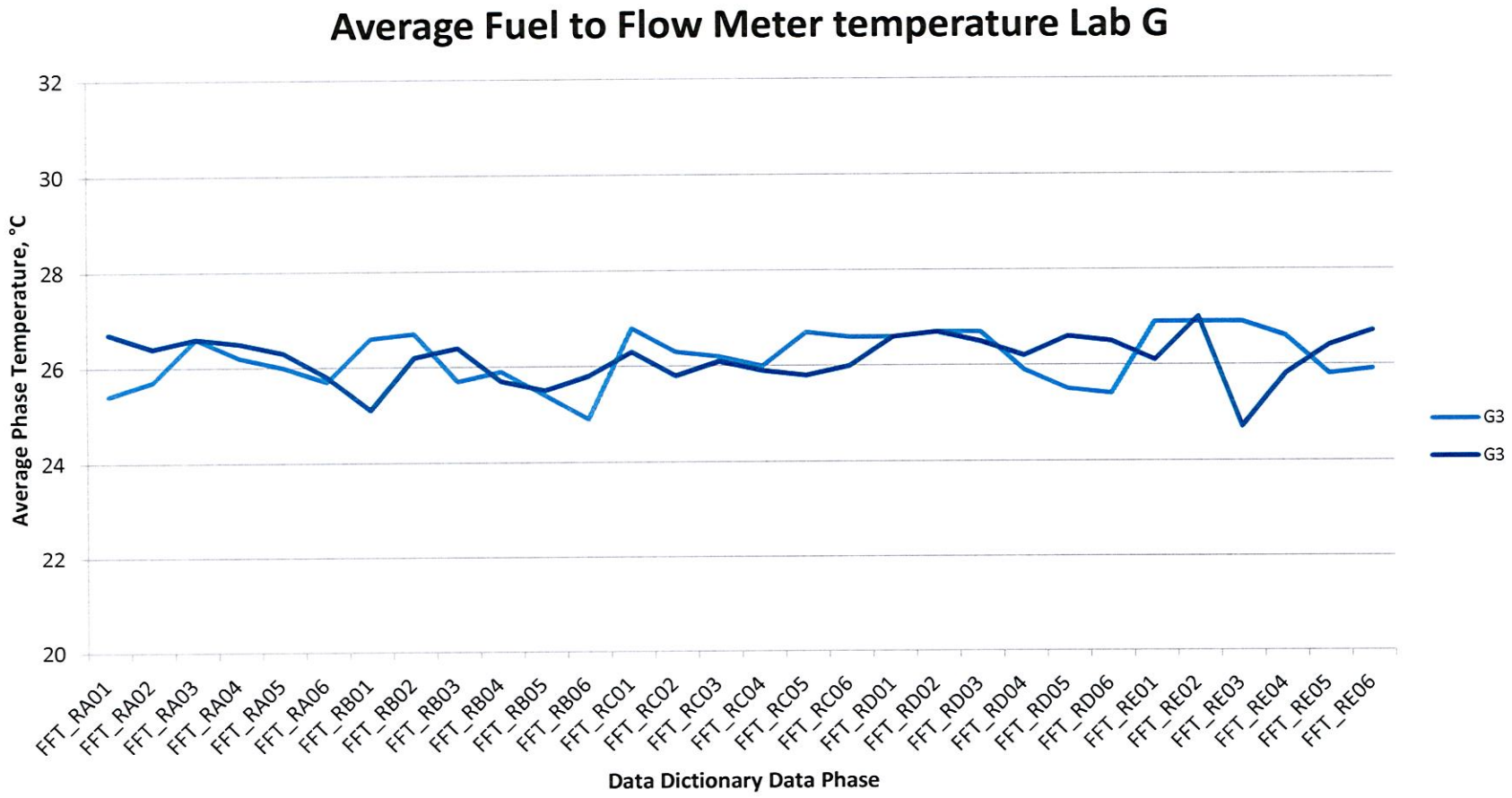
Fuel to Flow Meter Temperature



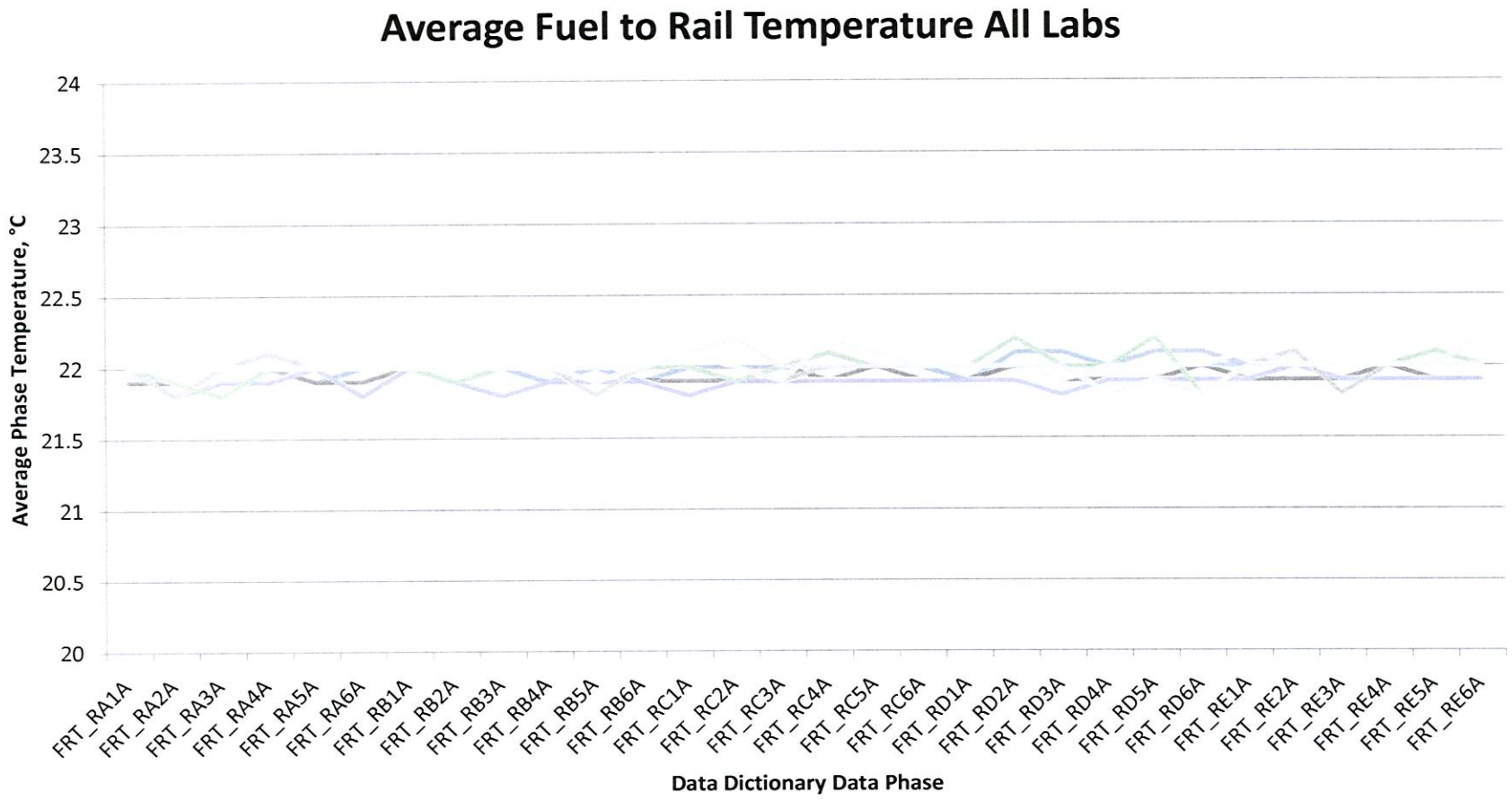
Fuel to Flow Meter Temperature



Fuel to Flow Meter Temperature



Fuel to Fuel Rail Temperature



Conclusions and Recommendation

- **Not all labs are doing a good job of controlling Fuel to Flow Meter temperature.**
- **One lab may have different Fuel to Flow Meter control set-points on different stands.**
- **Several tests appear to have Fuel to Flow Meter data exceeding the test validity criteria.**
- **Fuel to Fuel Rail is tightly controlled across all labs and stands.**

- **Recommend that Fuel to Flow Meter be moved to "critical measurement and control parameter" with hard specification; i.e. XX° C ± X° C specified. If not critical, return to VIA specification (± 4° F, 2.2° C).**

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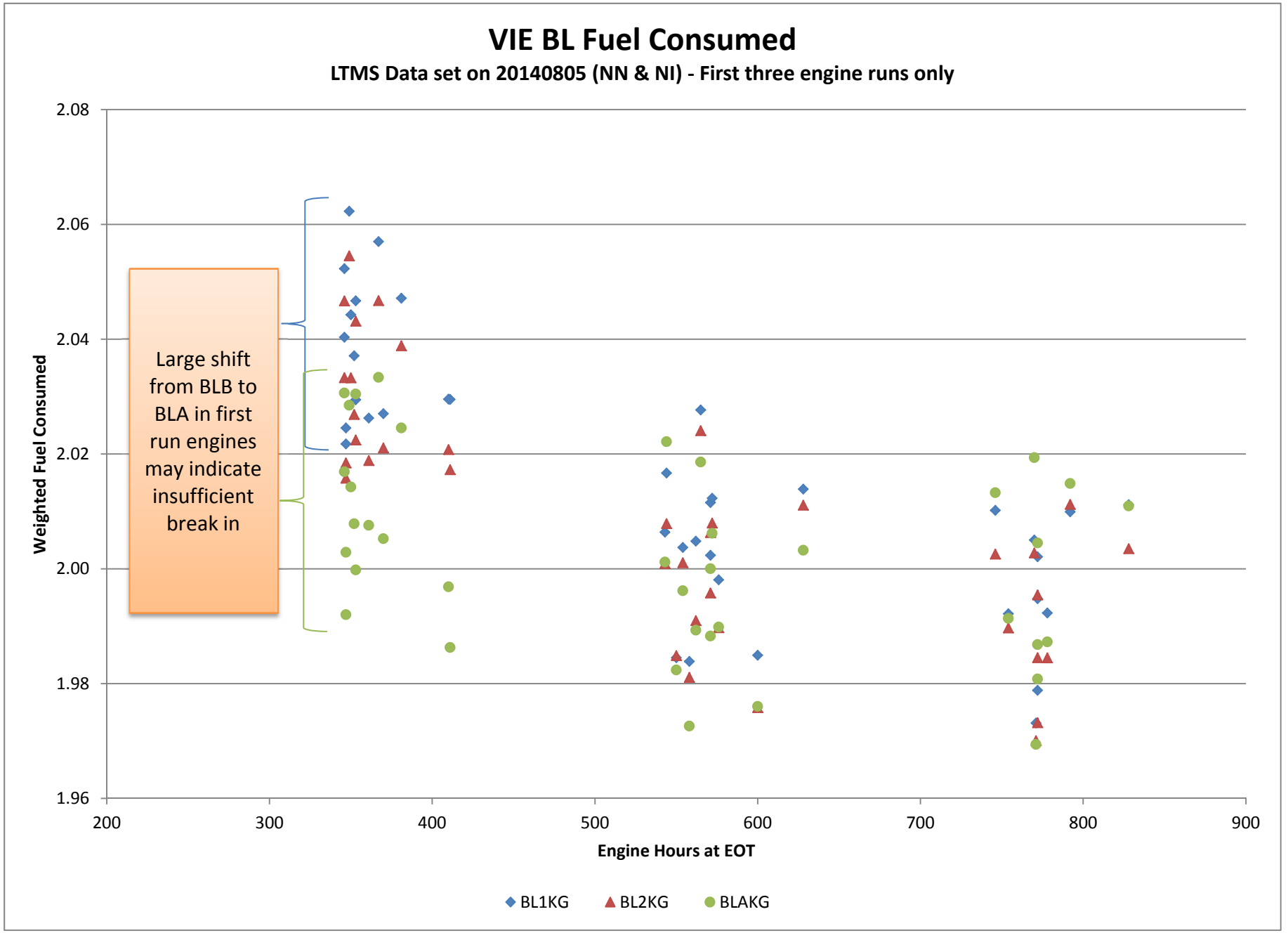
Mark Adams	mark@tribologytesting.com		attend

ASTM SEQUENCE VI

Name	Address	Phone/Fax/Email	Attendance


VIE BL Fuel Consumed
LTMS Data set on 20140805 (NN & NI) - First three engine runs only
Weighted Fuel Consumed
2.08
2.06
2.04
2.02
2.00
1.98
1.96
200
300
400
500
600
700
800
900
Engine Hours at EOT
Large shift from BLB to BLA in first run engines may indicate insufficient break in
BL1KG
BL2KG
BLAKG

Sequence VI / GF-6 – Initial Testing Observations

Nathan Moles

8/12/2014

Lubrizol

Outline

SUCCESS TOGETHER

- High FM Carry Over Effect
  - VID test observations
  - Implications/solutions
- Sequence VIE Responsiveness
  - Decreasing response over the lifetime of VIE engine
  - Impact on potential engine hour correction factor
  - BLA shift over the lifetime of VIE engine
  - Implications/solutions

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FM Carry Over

General Overview

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- Increased FEI targets for GF-6 require more/better FM's
- LZ ran a series of formulas in both the VID and VIE
  - Experimental GF-6 prototype additive packages
  - Formulas designed from the ground up to deliver good FE
- Several repeat runs resulted in unusually high BLA shifts

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VID Observations

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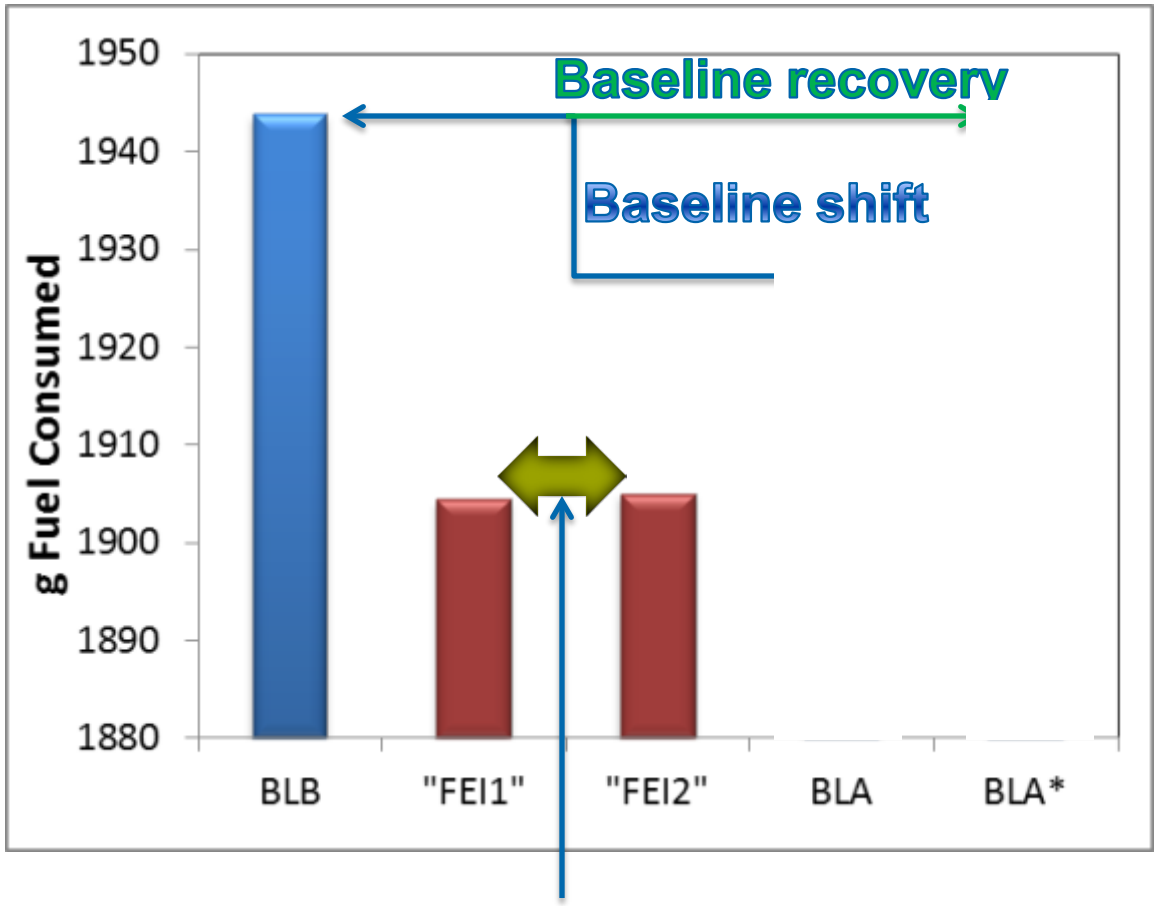
- Carefully analyzed weighted fuel consumption of baseline and candidate oils
- In cases where high levels of FM and/or certain type of FM were used, potential carryover effects were observed



Virtual parity between “FEI1” and “FEI2” on amount of fuel consumed

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Engine Life BL Fuel Consumption

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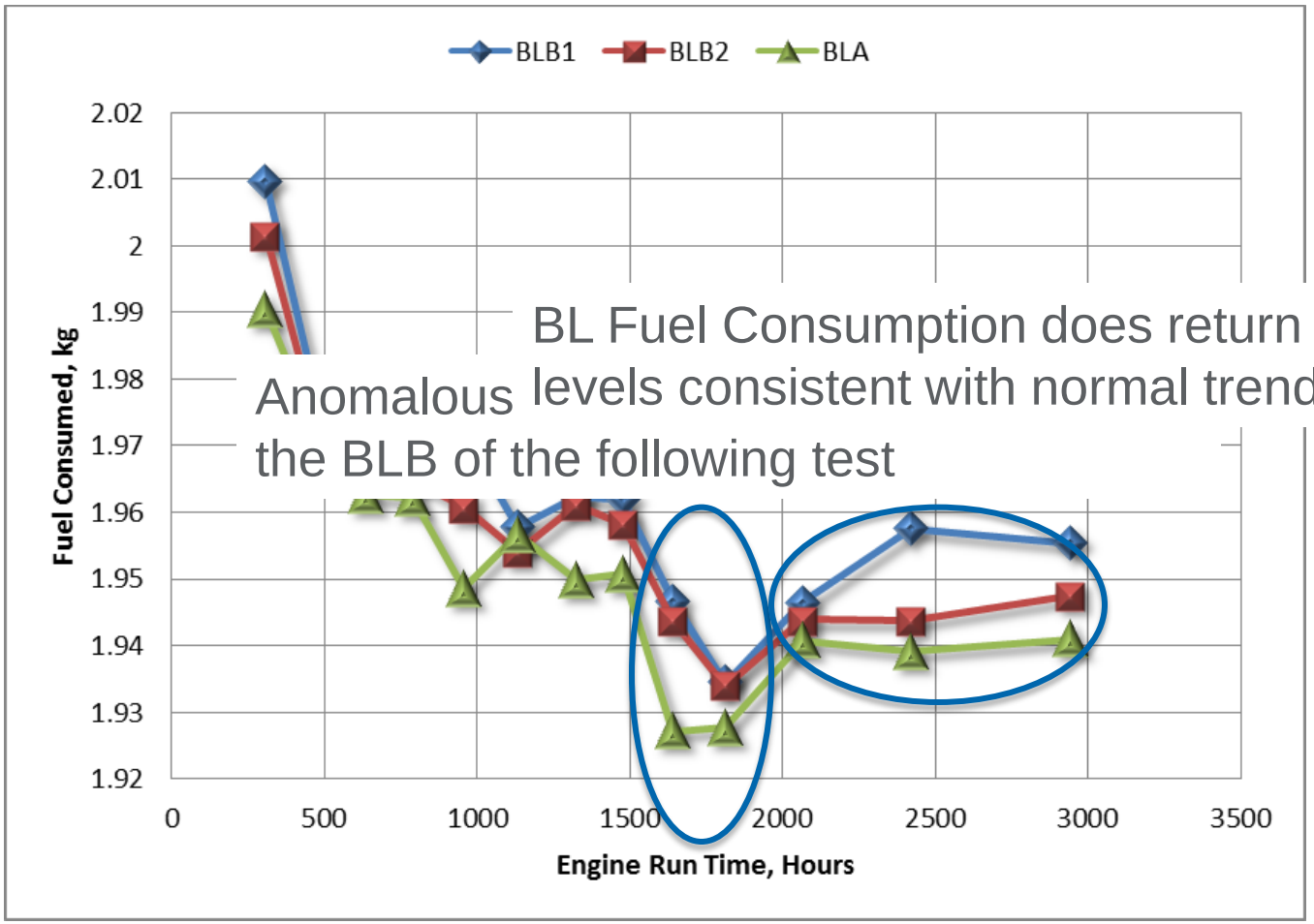

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FM Carry Over Implications

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- Sequence VI Fuel Economy test is actually penalizing stronger/more durable FM formulations
- We continue to investigate if there are substantial FM carryover effects in the VIE – If there are, several options for addressing it come to mind:
  - More flushing (unsuccessful on VID)
    - Flush oil and double BL flushes performed twice following completion of VID test with minimal impact on high BLA shift
  - Reformulation of the flush (unsuccessful to date on VID)
    - 0W-20 version of current flush oil was ran 12 and 24hrs with minimal impact on high BLA shift
  - Just use BLB and forget about BLA (still an issue on subsequent test BLB on VID)
  - Just use BLA and forget about BLB (still need effective/efficient way to remove carry over FM)

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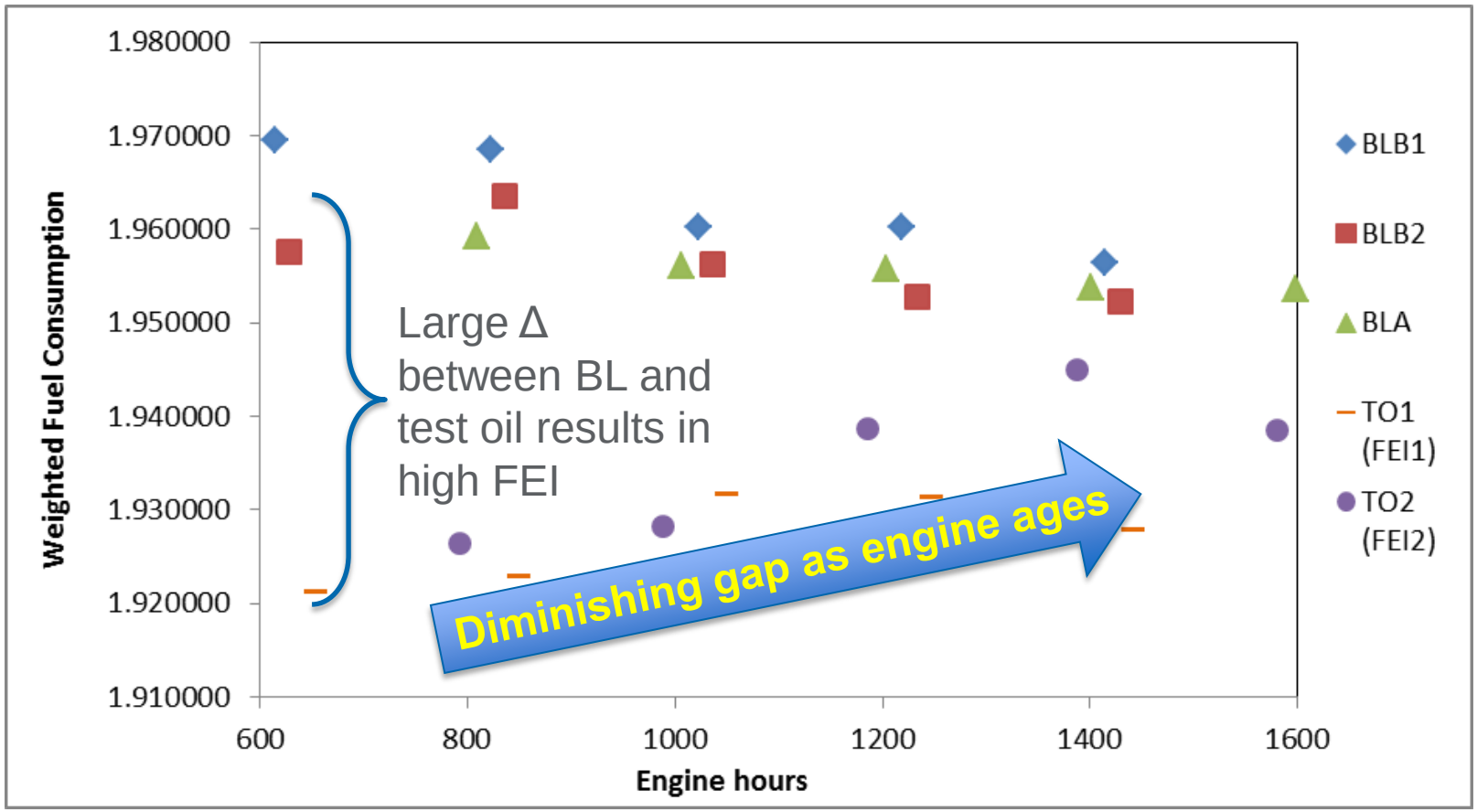
Sequence VIE Engine Responsiveness

VIE Engine Stand Case Study

SUCCESS TOGETHER



- Recent VIE Test Stand running a matrix of oils
- In general, gap between test oil and BL shrinks with engine hours resulting in lower calculated FEI
- Responsiveness of the engine is an area of intense interest

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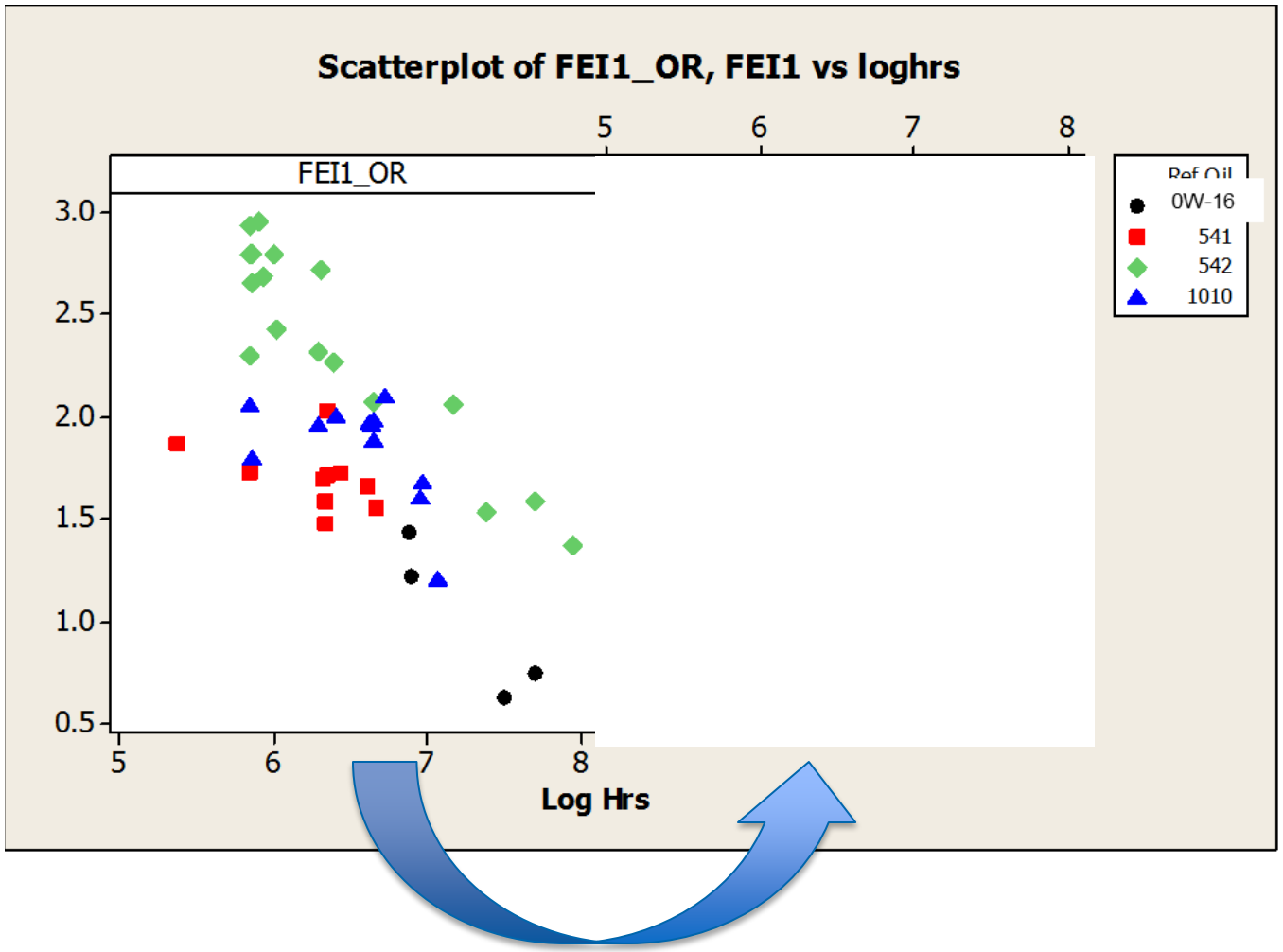
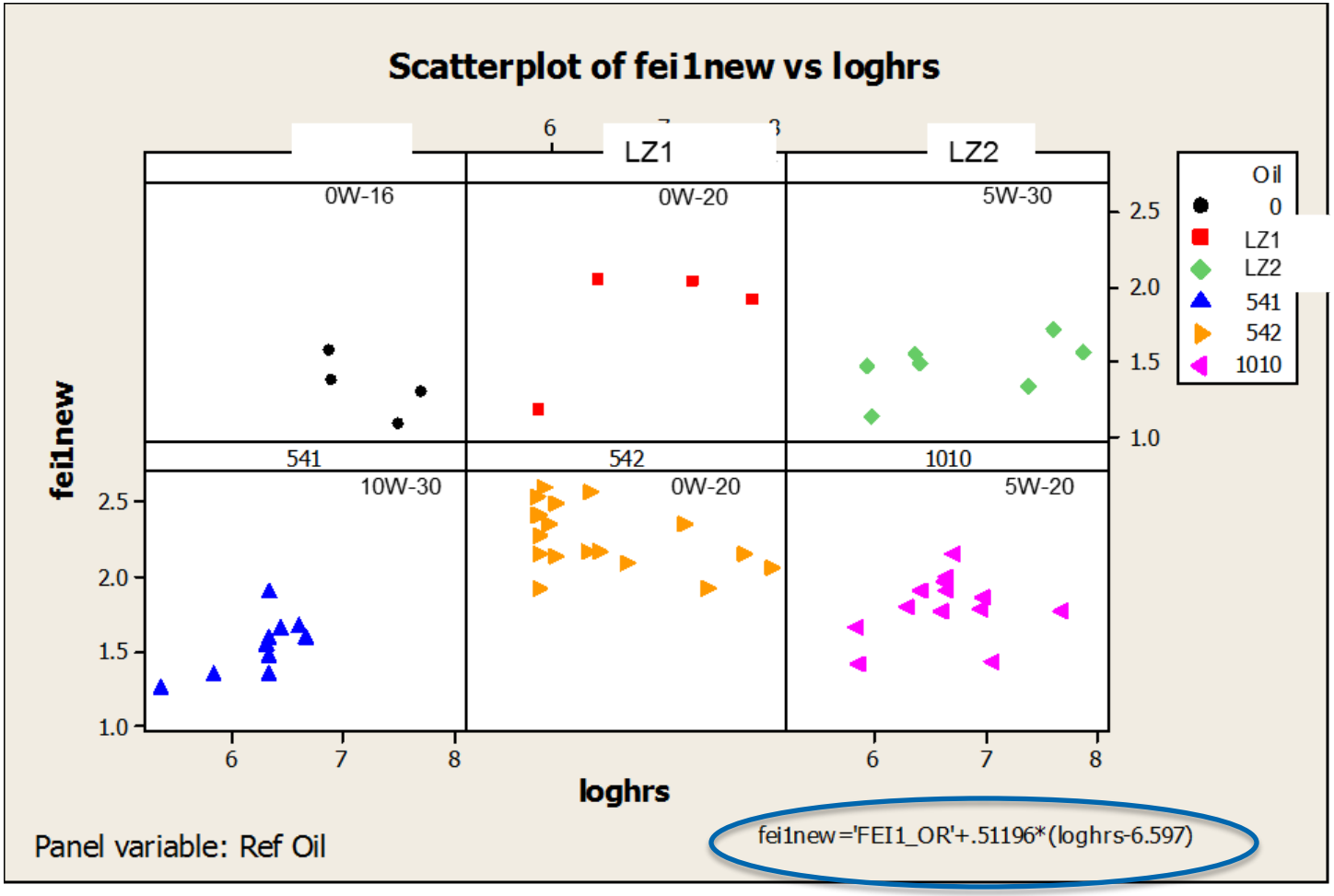
Lubrizol Analysis of Reference Oils



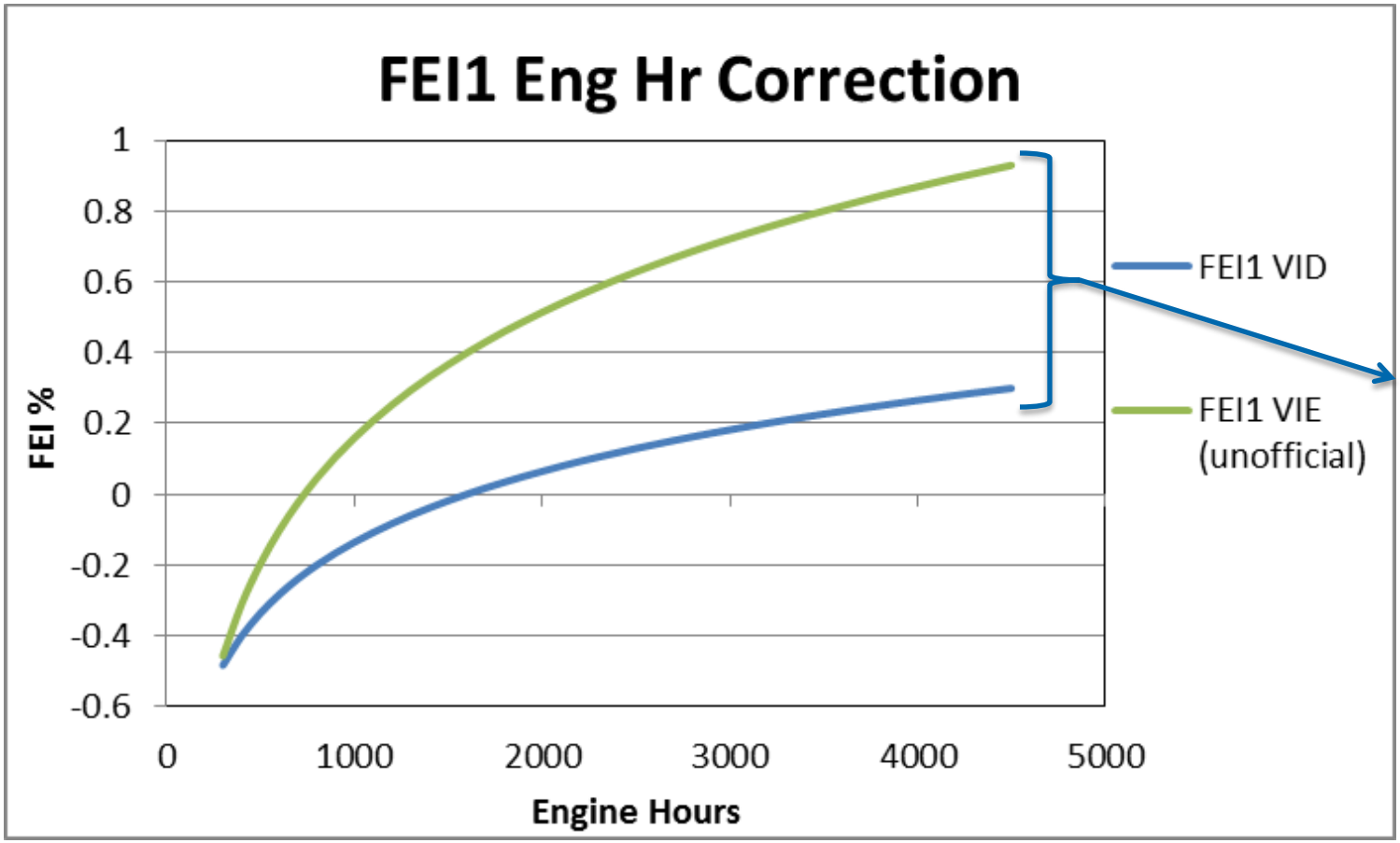
- VID correction does not adequately correct the VIE data

New Correction Factor



- New correction factor marginally better than the VID
- Based on additized fuel test data for industry RO's and LZ RO's
- Not nearly rigorous enough yet

Plot of Correction



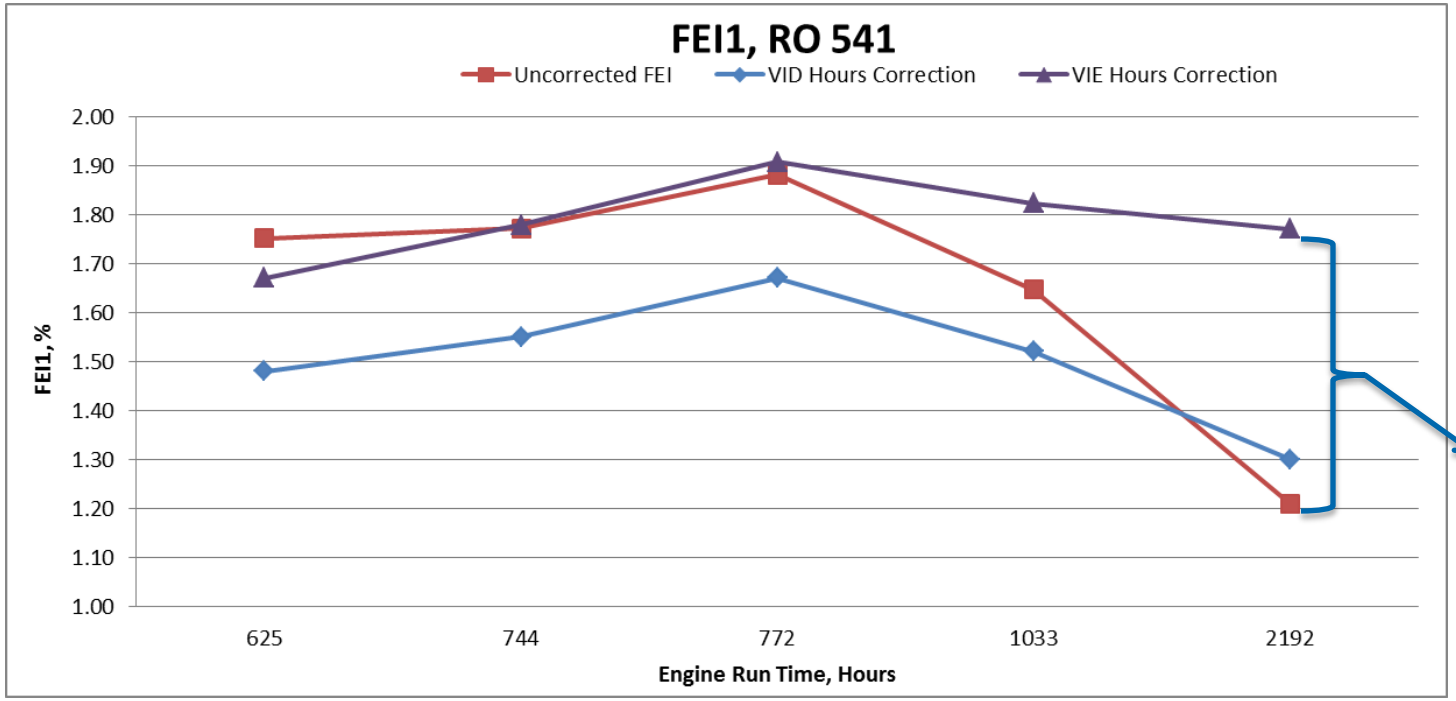
A manifestation of the responsiveness issue?

- The two correction factors look quite different

SEQ VIE TEST DATA

SUCCESS TOGETHER

- Example of the correction factor “linearizing” the results



Approximately 1/3 of FEI at 2200 hours is from the correction factor

- VID Correction Average = 1.48
- VIE Correction Average = 1.67

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BLA Shift Over Engine Life

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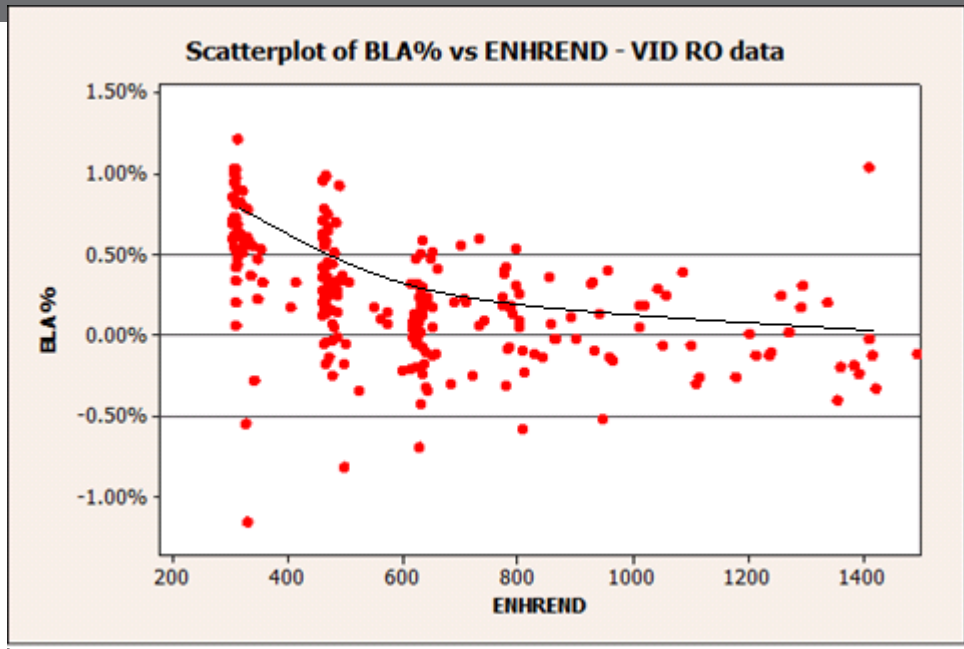
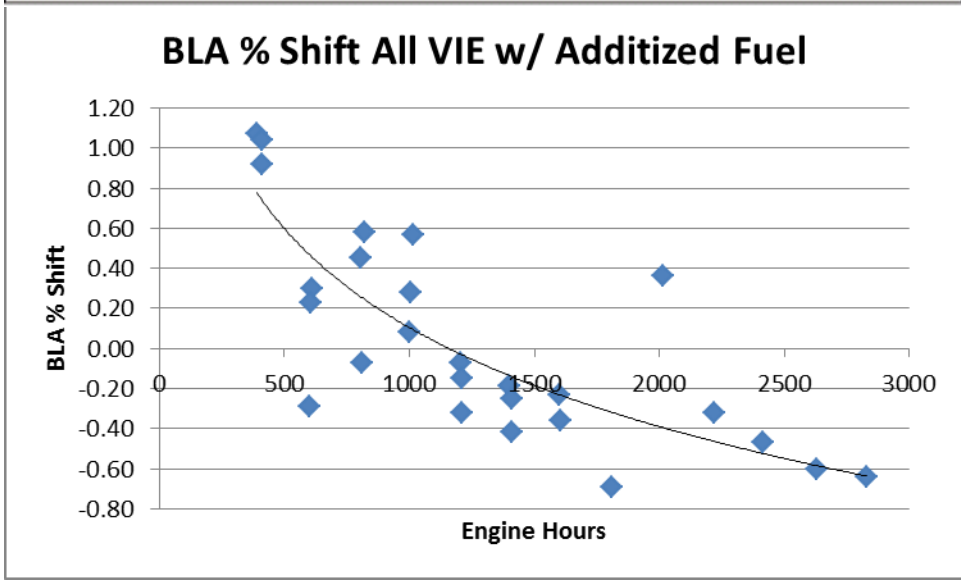
- BLA over time trends from a large positive shift to a large negative shift
- Limited data at extended hours
- Effect is reversible as seen in a “saw tooth” pattern in the BLA fuel consumption data
- Do not see a positive impact in FEI% indicates it affects test oil as well





Responsiveness Implications

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- Potential muting of responsiveness late in life could have large effect on the ultimate VIE engine hours correction factor
- Resulted in removing engines before hitting OC limits around 1,500 hours
- What is actually causing the drop in responsiveness?
- How much of an correction factor impact on final FEI numbers is acceptable and still have meaningful test results?
- Should more engines be acquired for GF-6?
- Should the number of reference test be reduced?

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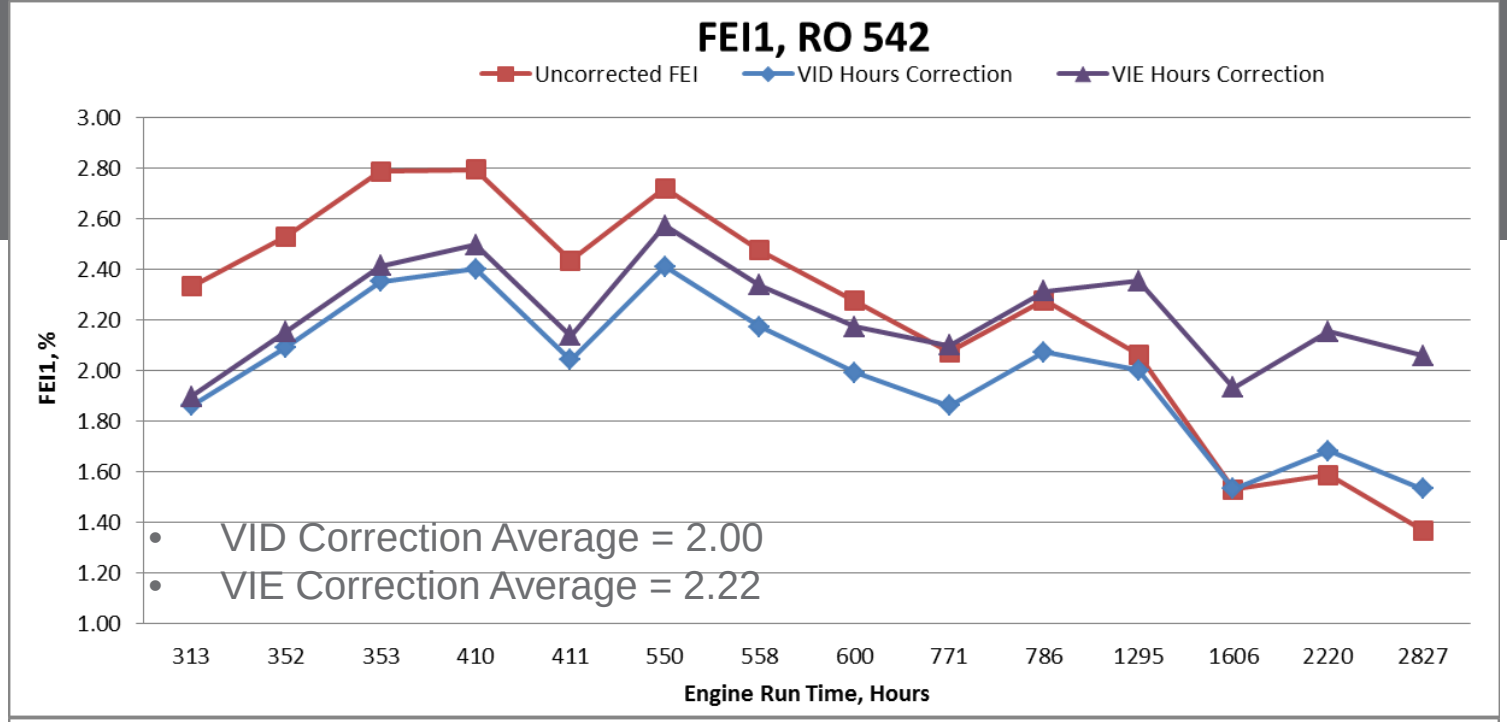
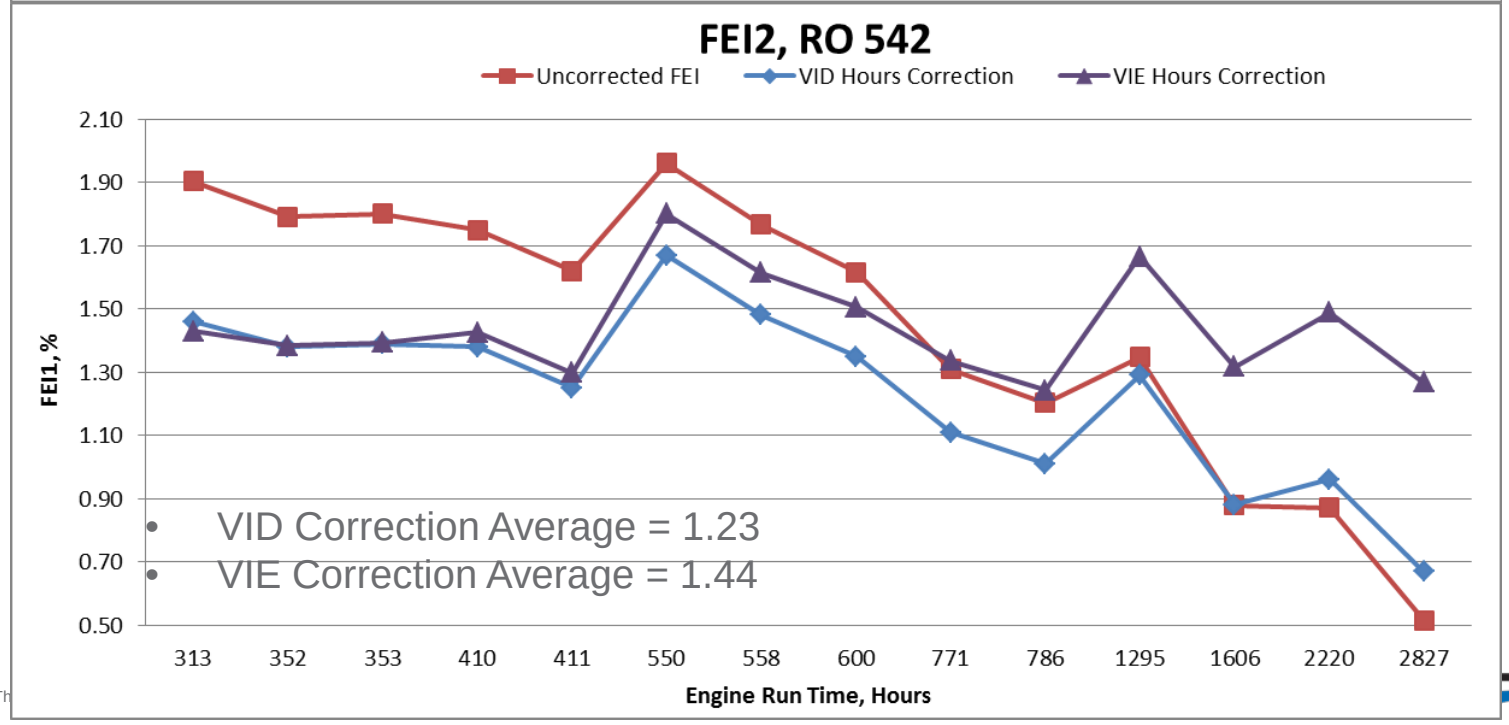
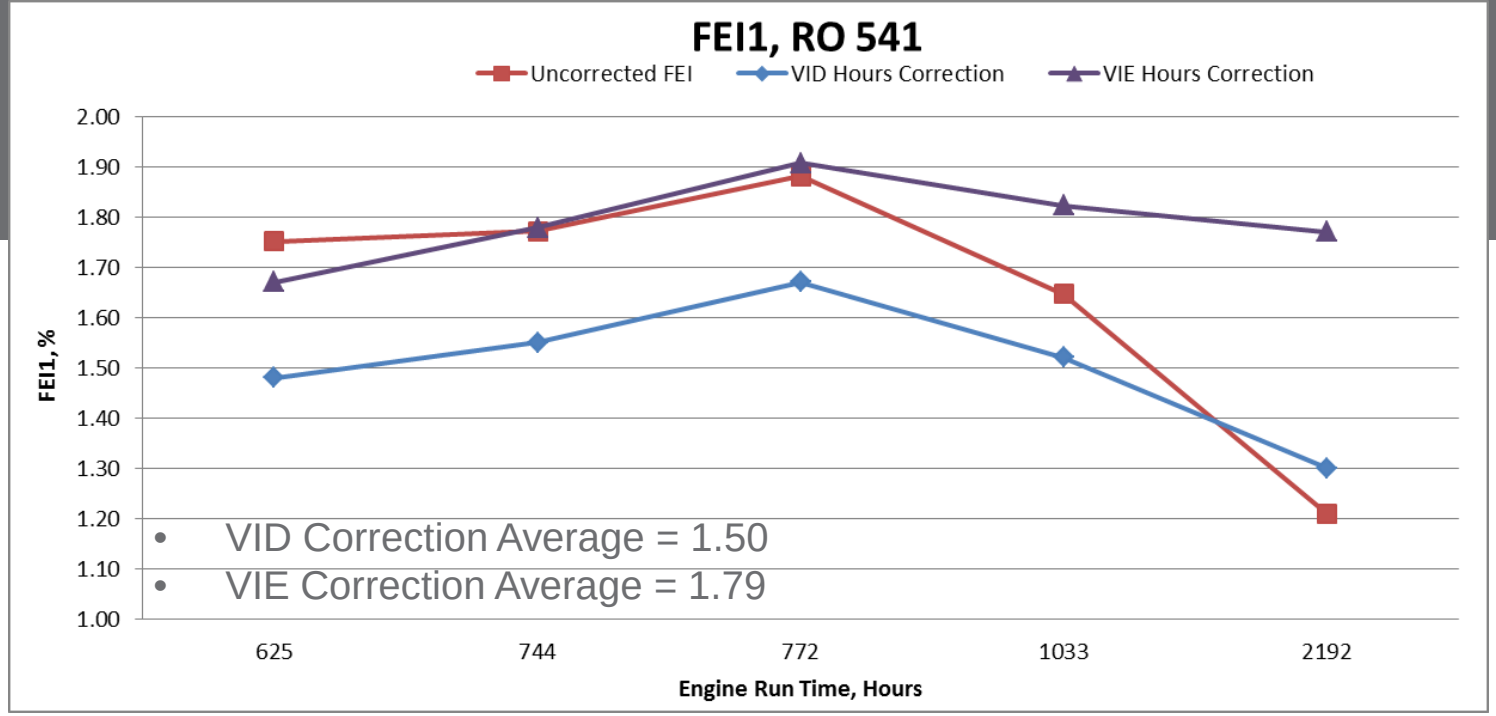
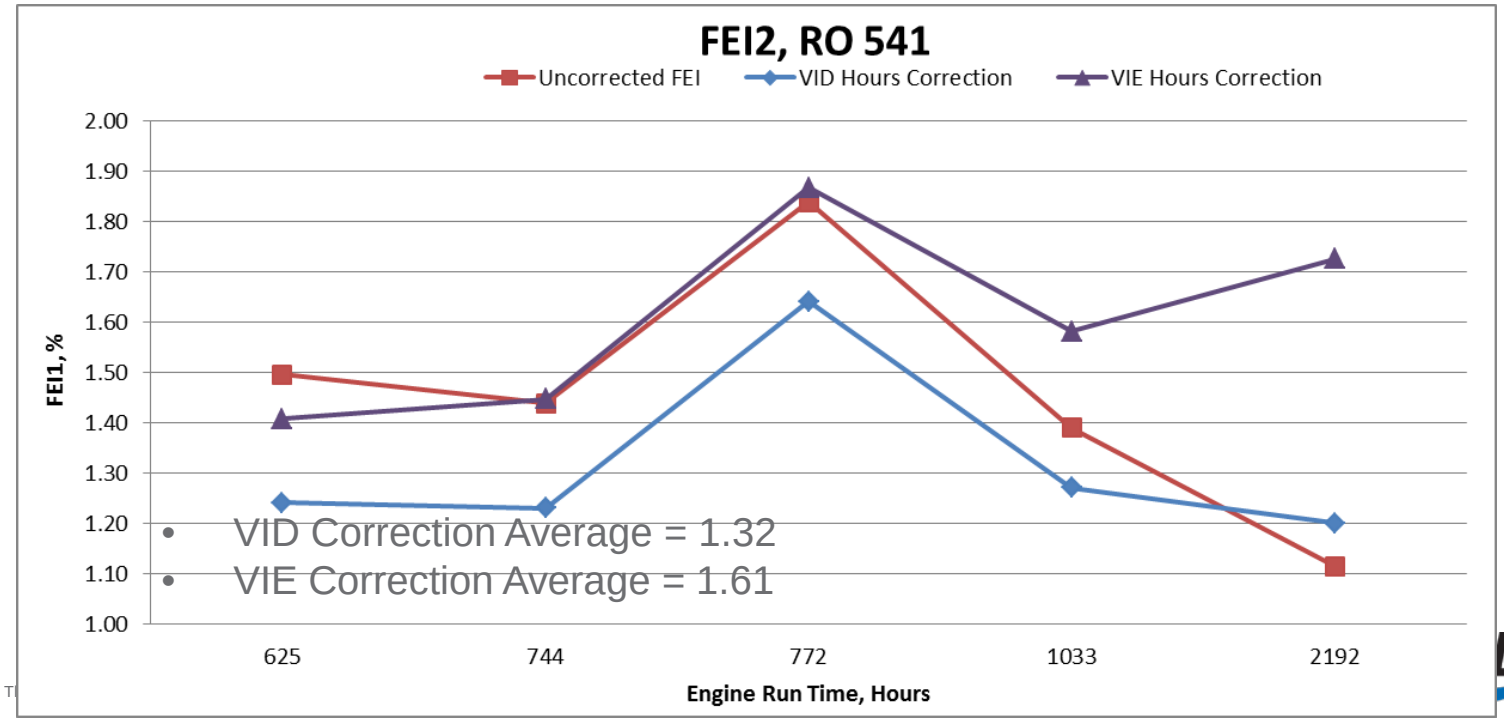
Additional Data


FEI1, RO 542
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
FEI1, %
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
313
352
353
410
411
550
558
600
771
786
1295
1606
2220
2827
Engine Run Time, Hours
VID Correction Average = 2.00
VIE Correction Average = 2.22


FEI2, RO 542
Uncorrected FEI
VID Hours Correction
VIE Hours Correction
FEI1, %
2.10
1.90
1.70
1.50
1.30
1.10
0.90
0.70
0.50
313
352
353
410
411
550
558
600
771
786
1295
1606
2220
2827
Engine Run Time, Hours
VID Correction Average = 1.23
VIE Correction Average = 1.44





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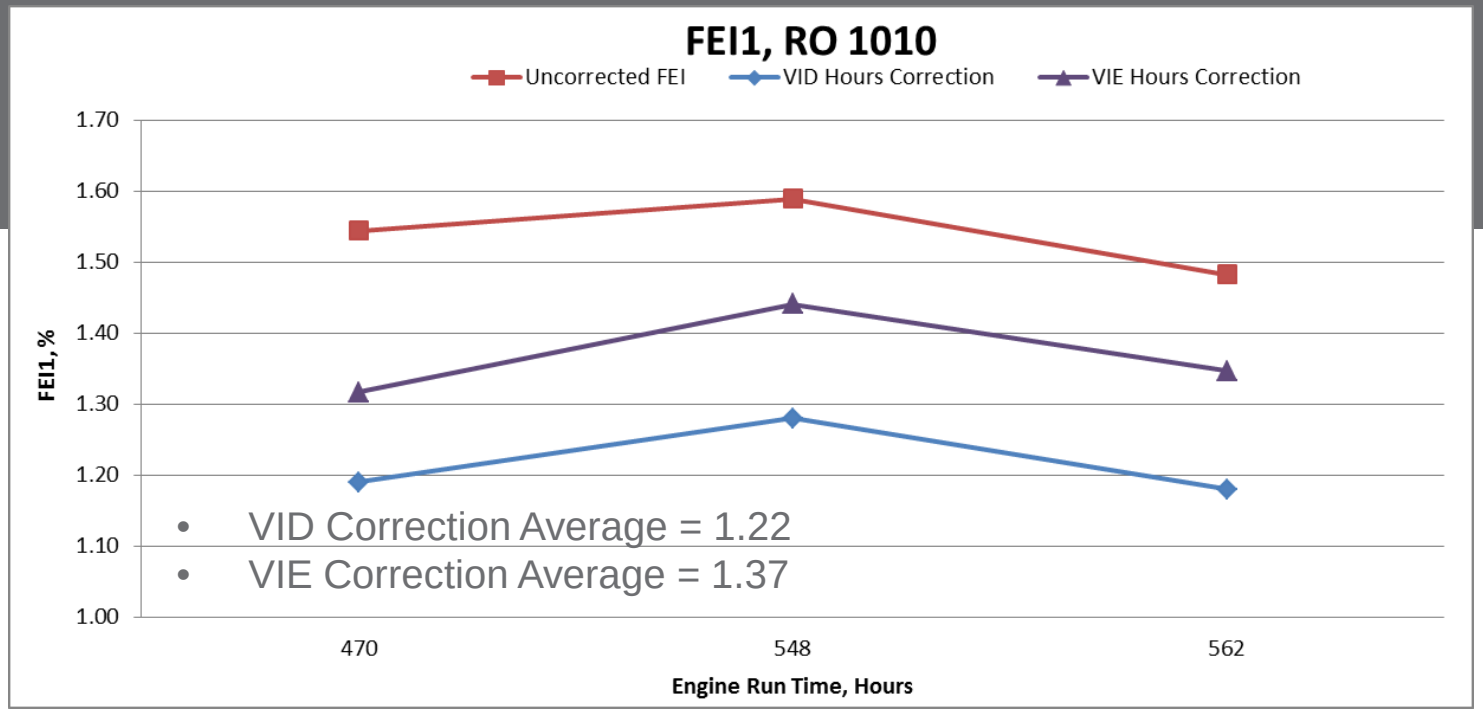

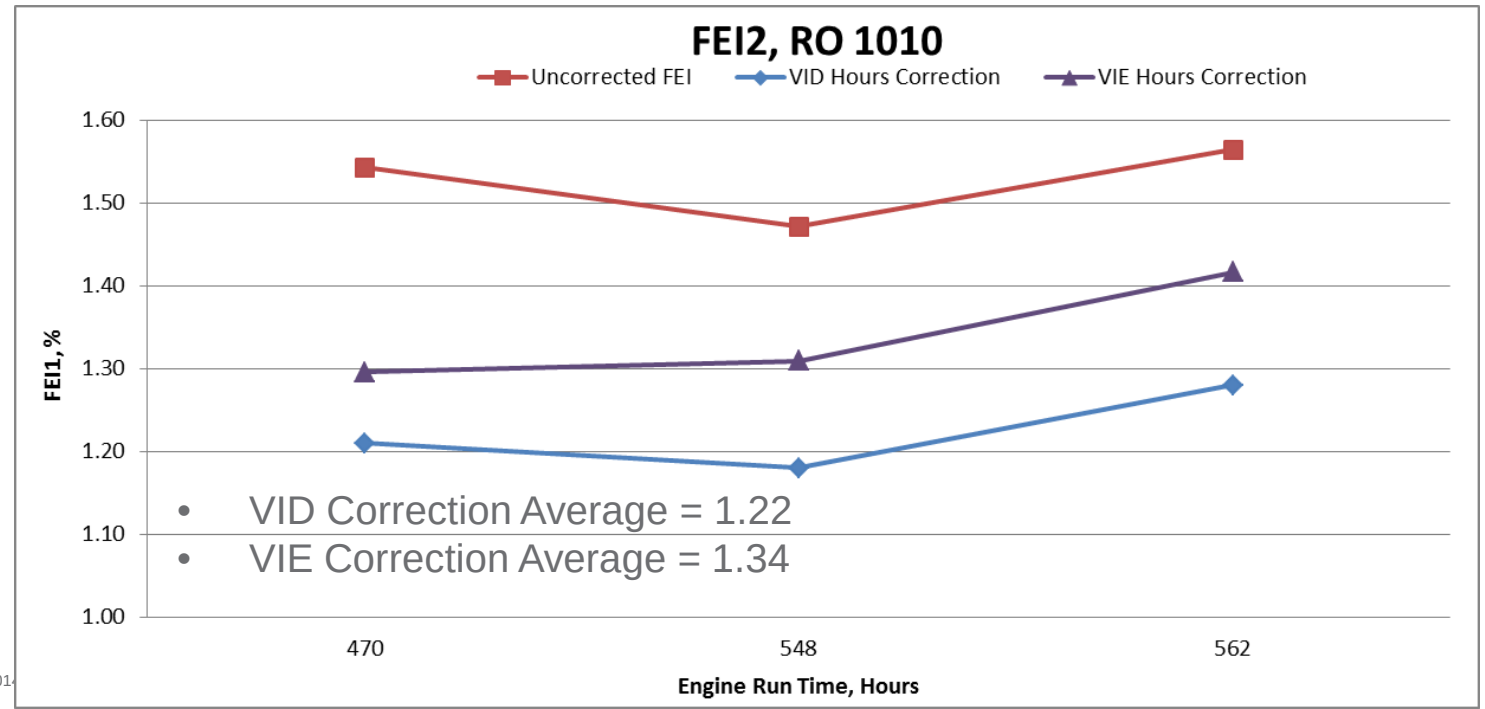

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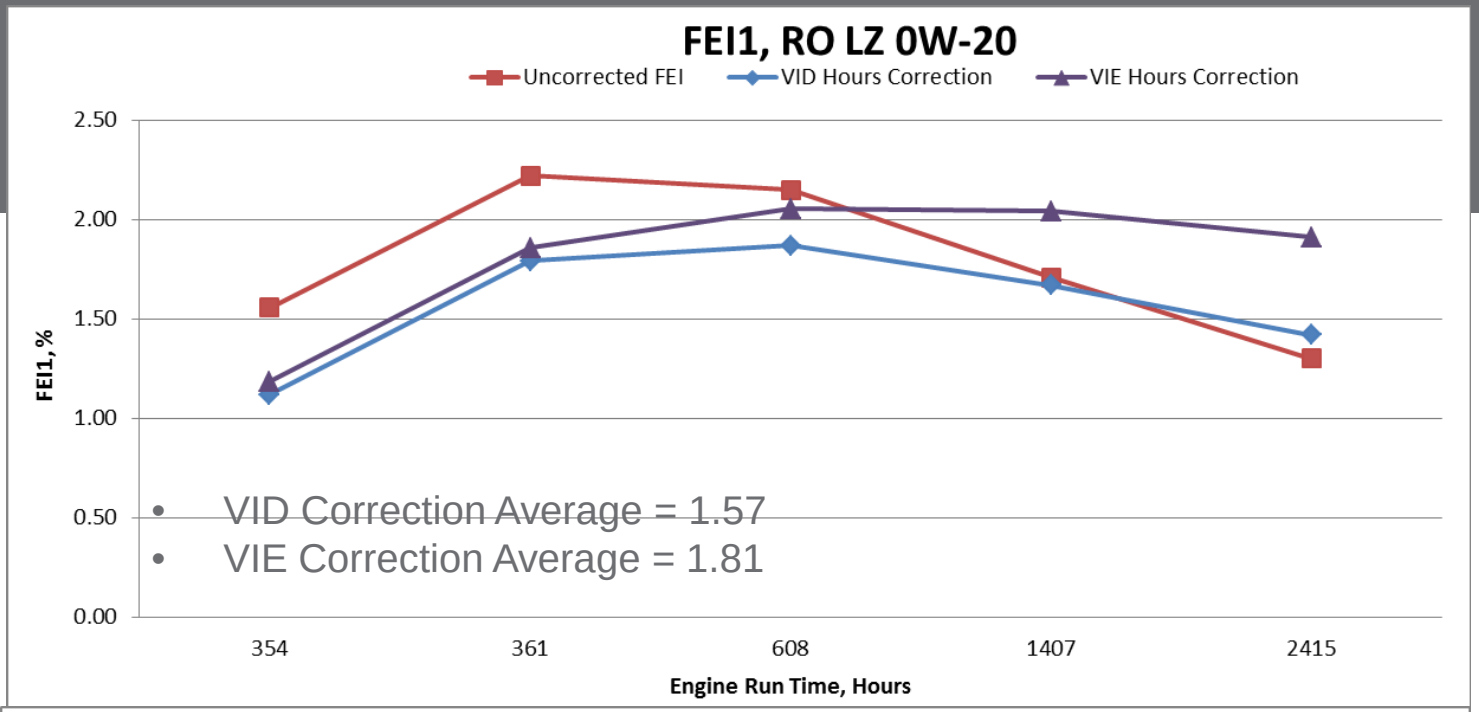

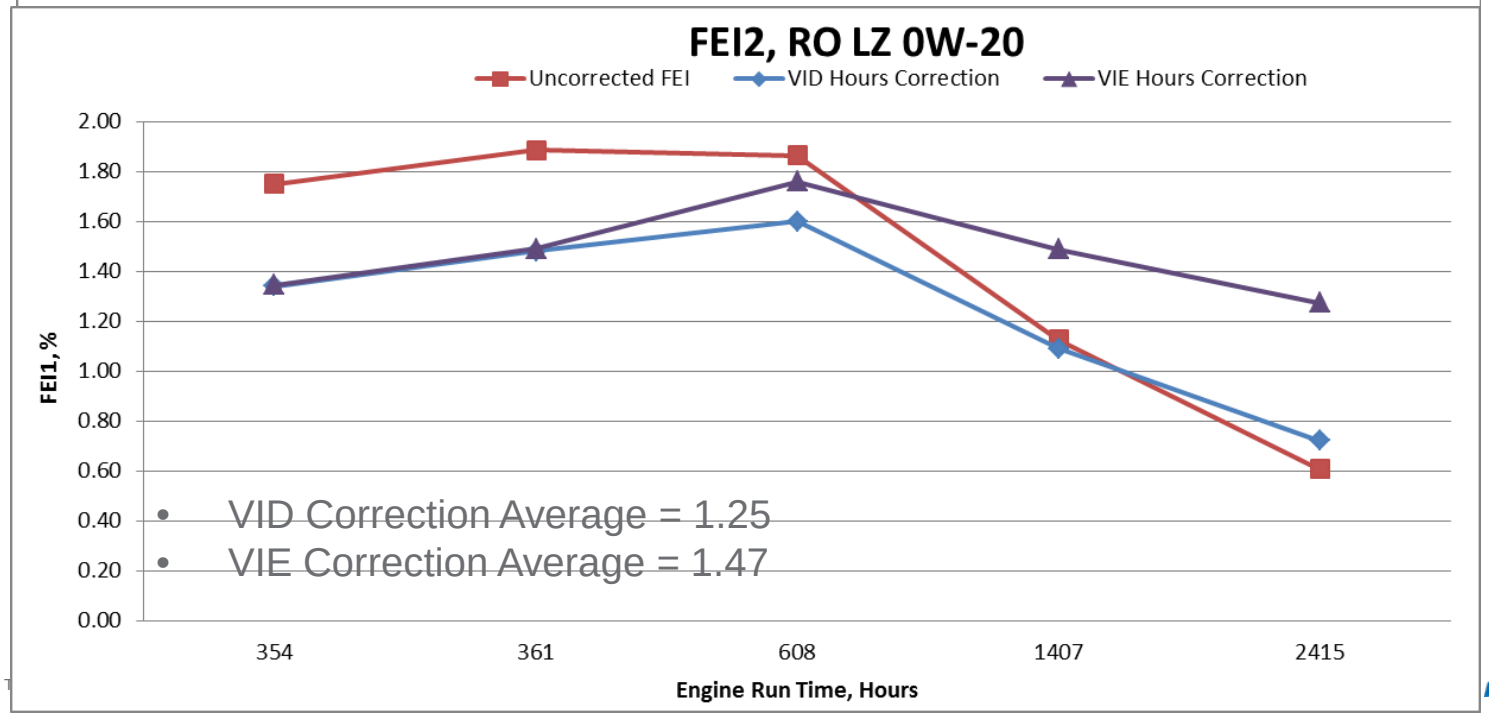

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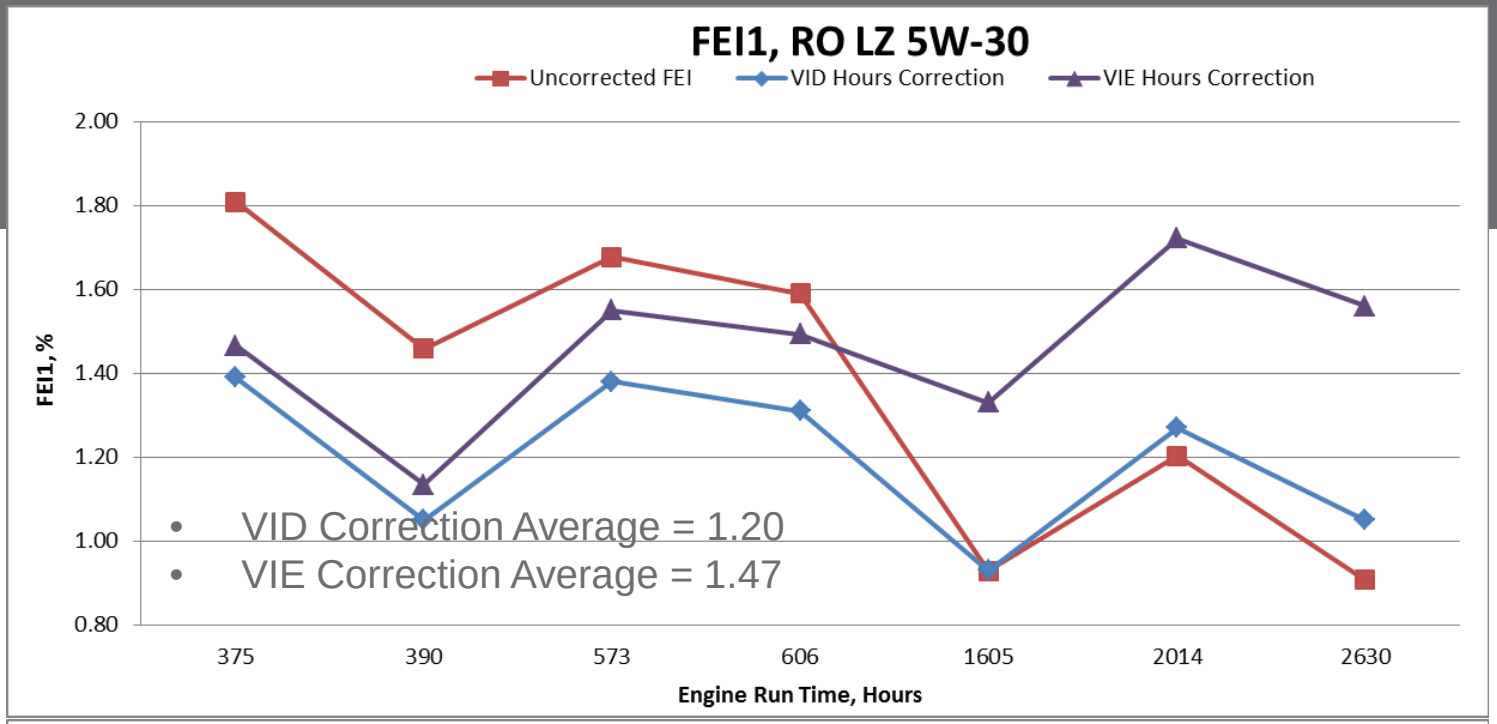

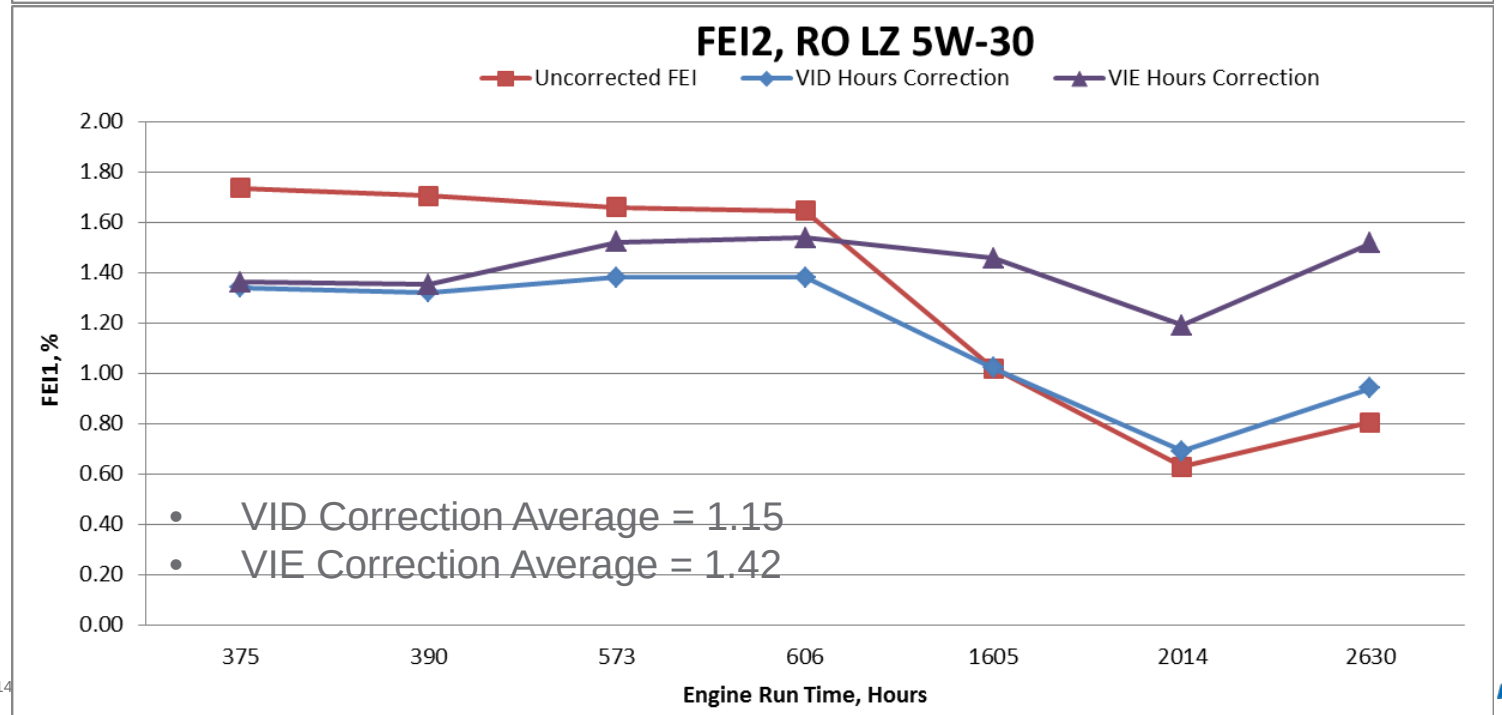

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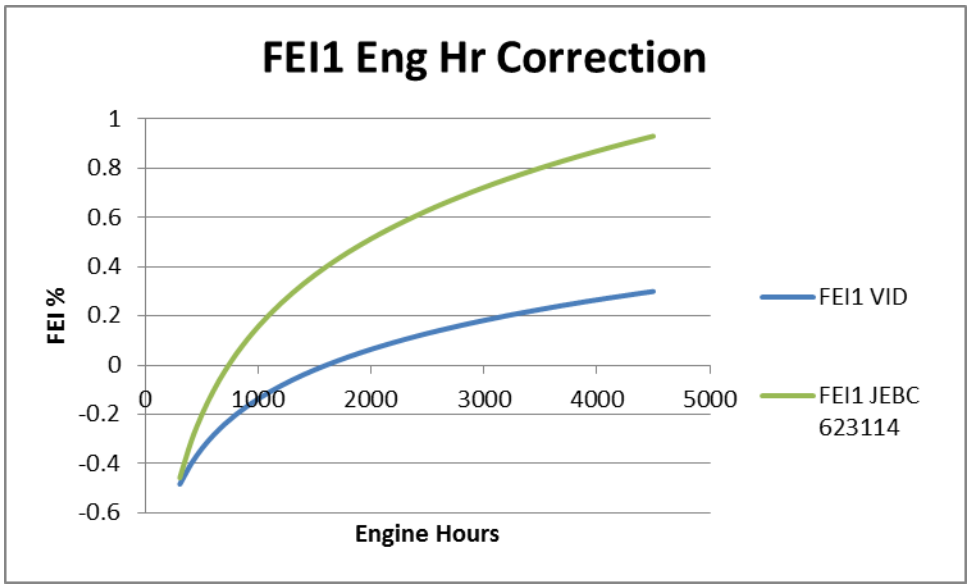

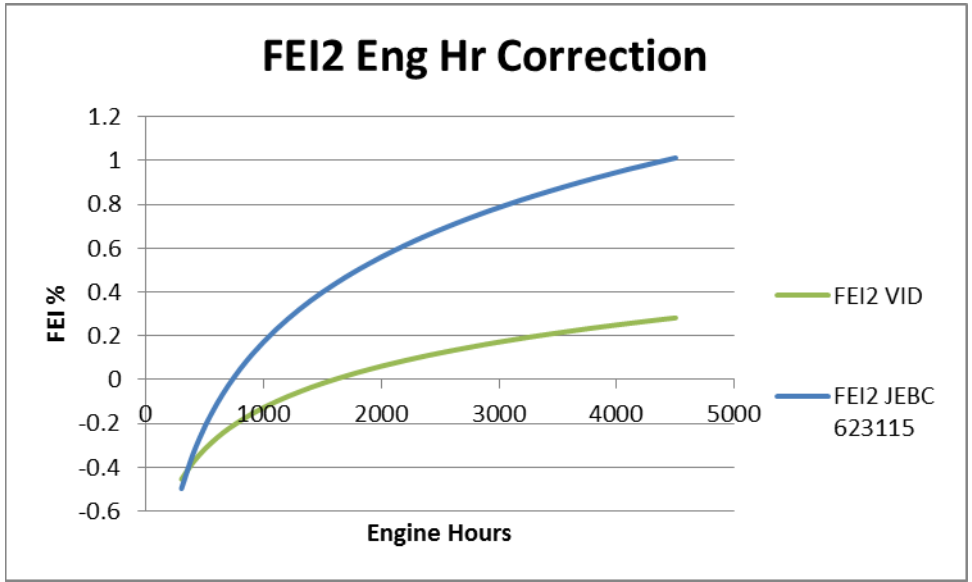

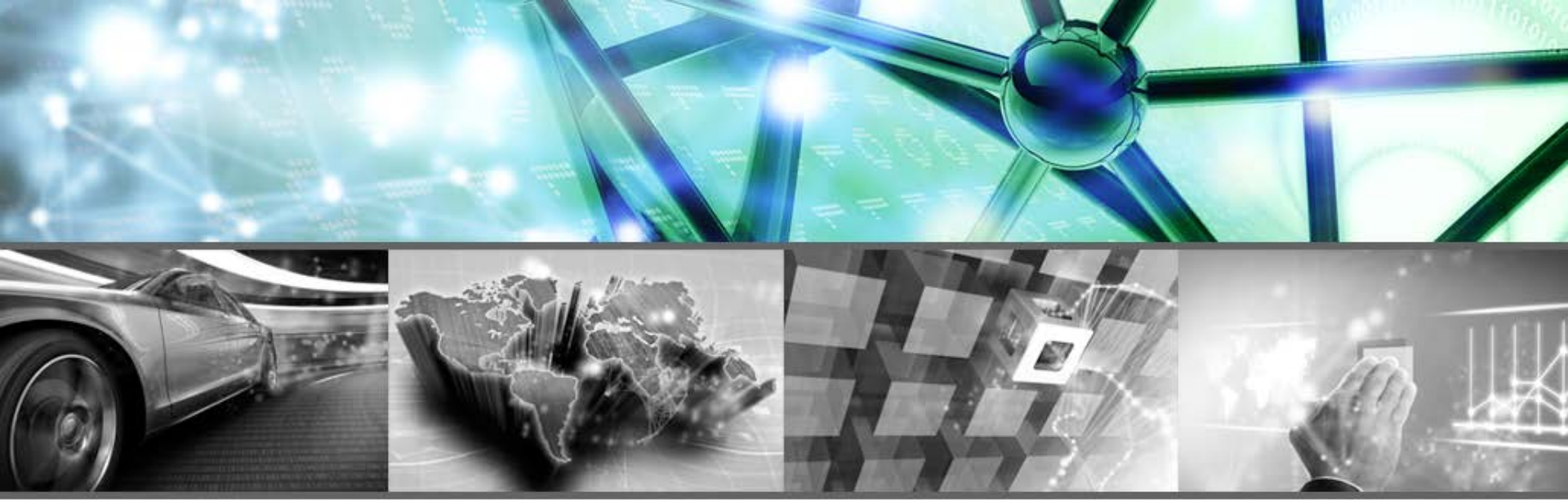

SUCCESS TOGETHER

Working together, achieving great things

When your company and ours combine energies, great things can happen. You bring ideas, challenges and opportunities. We'll bring powerful additive and market expertise, unmatched testing capabilities, integrated global supply and an independent approach to help you differentiate and succeed.

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David L. Glaenzer

June, 2014

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- **D6837, Table 3 Sequence VIB Test Operating Conditions**
  - Reads the same as VIE Draft Procedure
- **D6202, Table 3 Sequence VIA Test Operating Conditions**
  - Temperatures, All Stages
    - Fuel-to-Flow Meter Temperature (C)

      68 to 89.6°**F** All Stages (delta from max stage reading shall be ≤ **4**)
    - Fuel-to-Fuel Rail Temperature (A)

      68 ± 3.6°**F**

    C Difference between the maximum stage average reading of the entire test and the individual stage average readings.

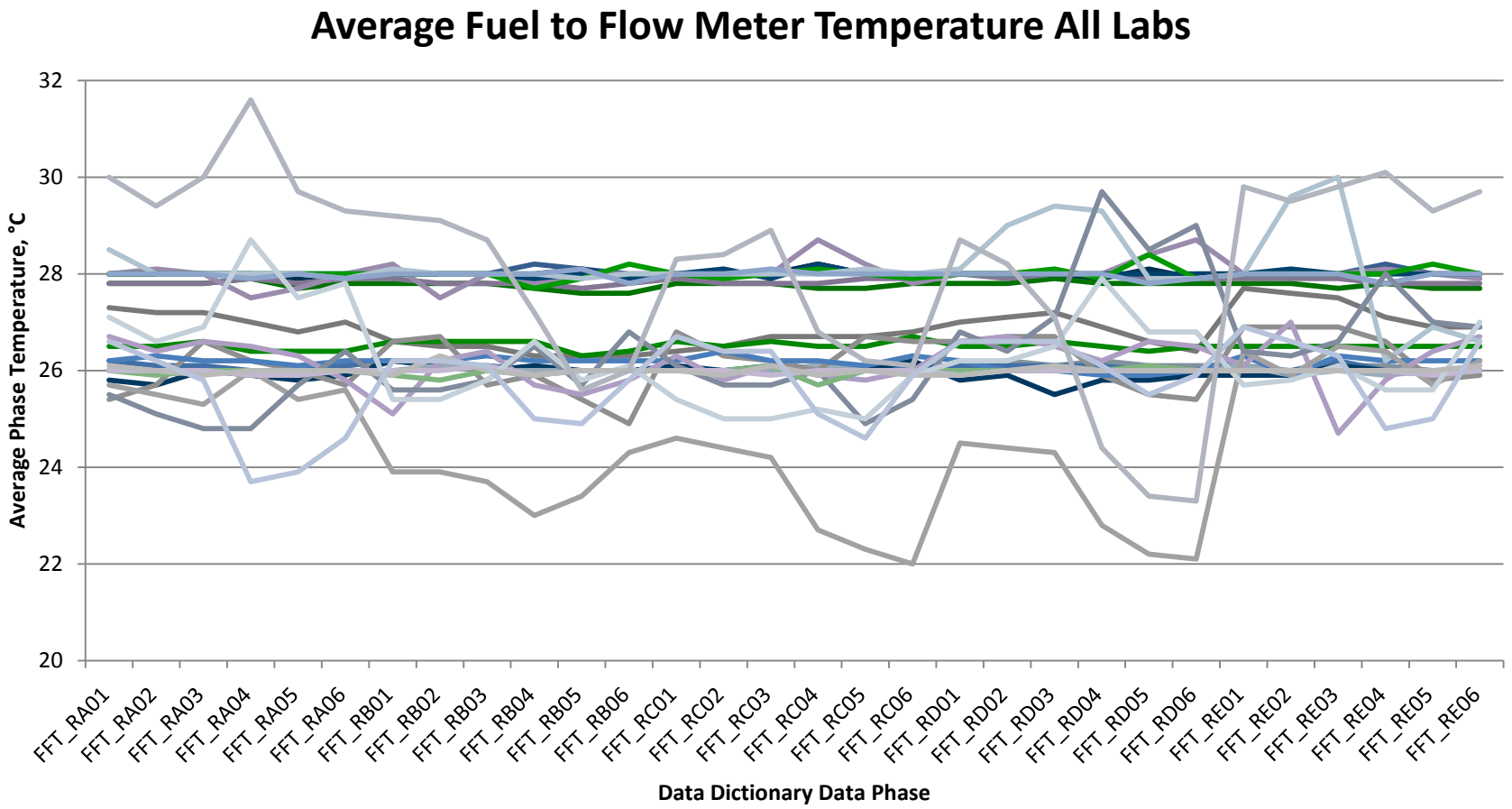
    A Critical measurement and controlled parameter targeted for middle of specification range.

    Conversion on delta from max not made from °F to °C when transitioning for VIA to VIB.

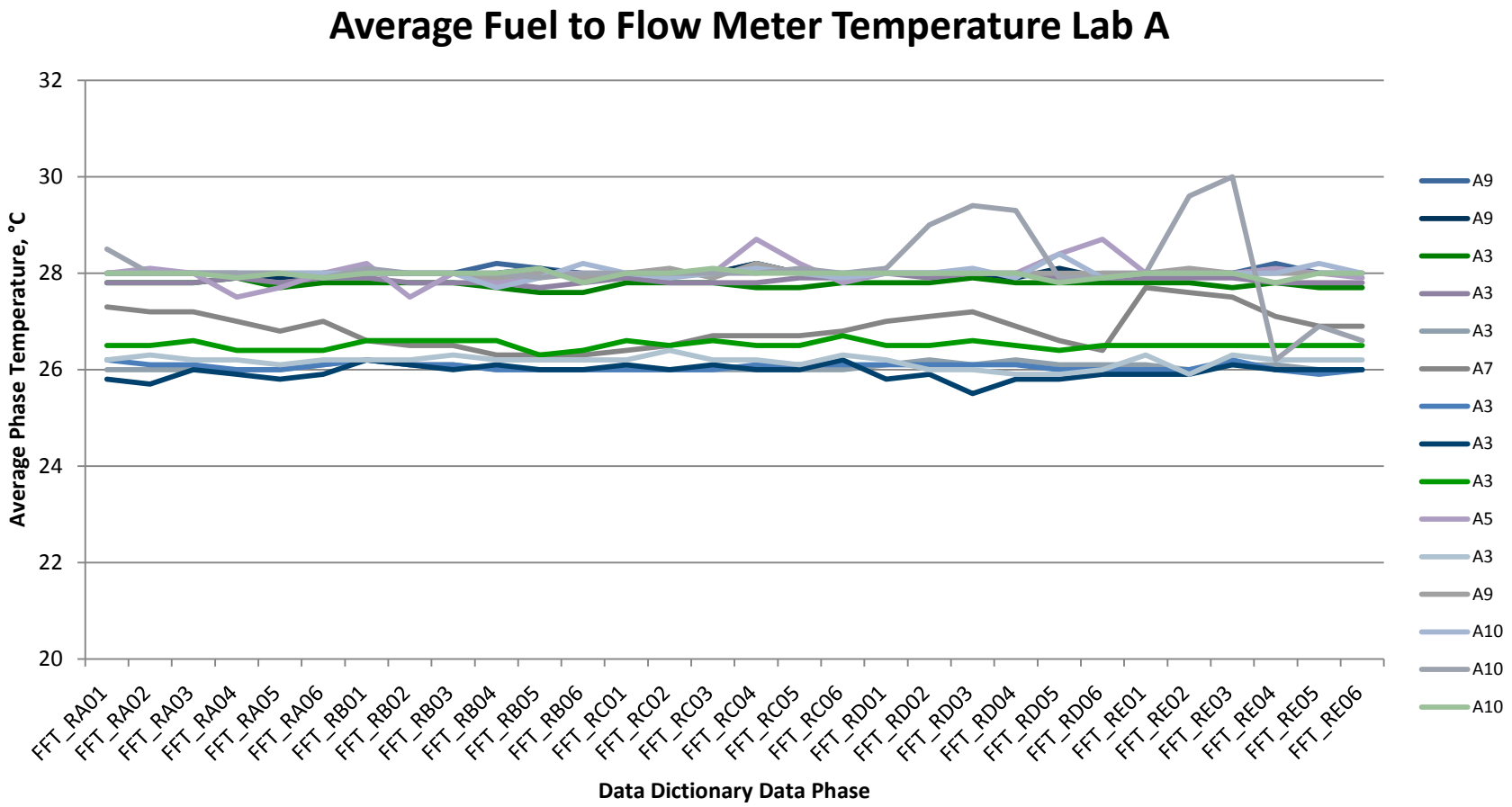
Data Examined

- **ASTM-TMC Data**
- **At time of analysis, 42 Tests reported with current “VIE” configuration**
- **Only 26 of 42 tests show complete Fuel-to-Flow Meter temperature data**
- **Only 23 of 42 tests show complete Fuel-to-Fuel Rail temperature data**
- **Data are arranged by ASTM Data Dictionary nomenclature and are not in order with test procedure**

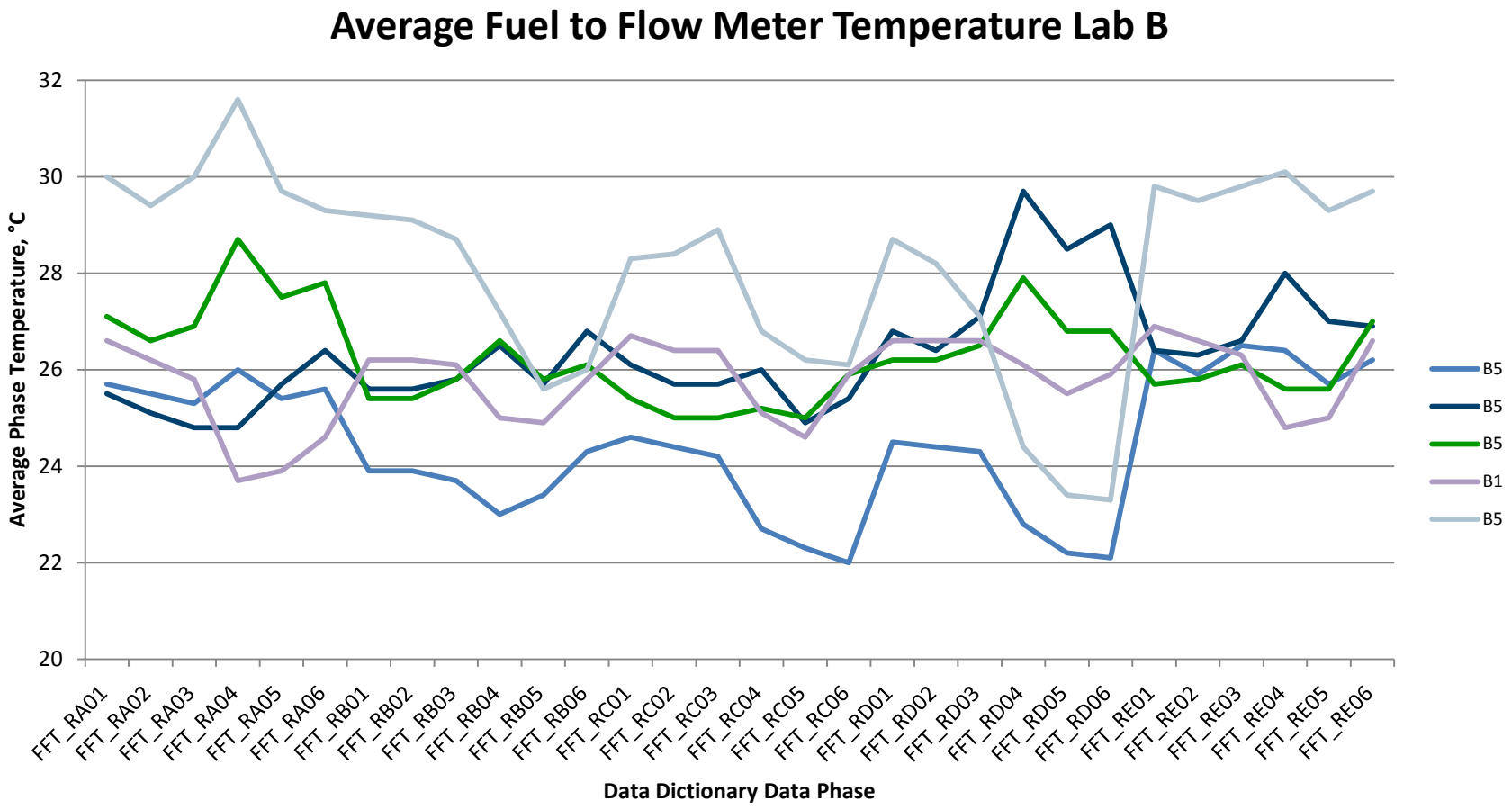
Fuel to Flow Meter Temperature



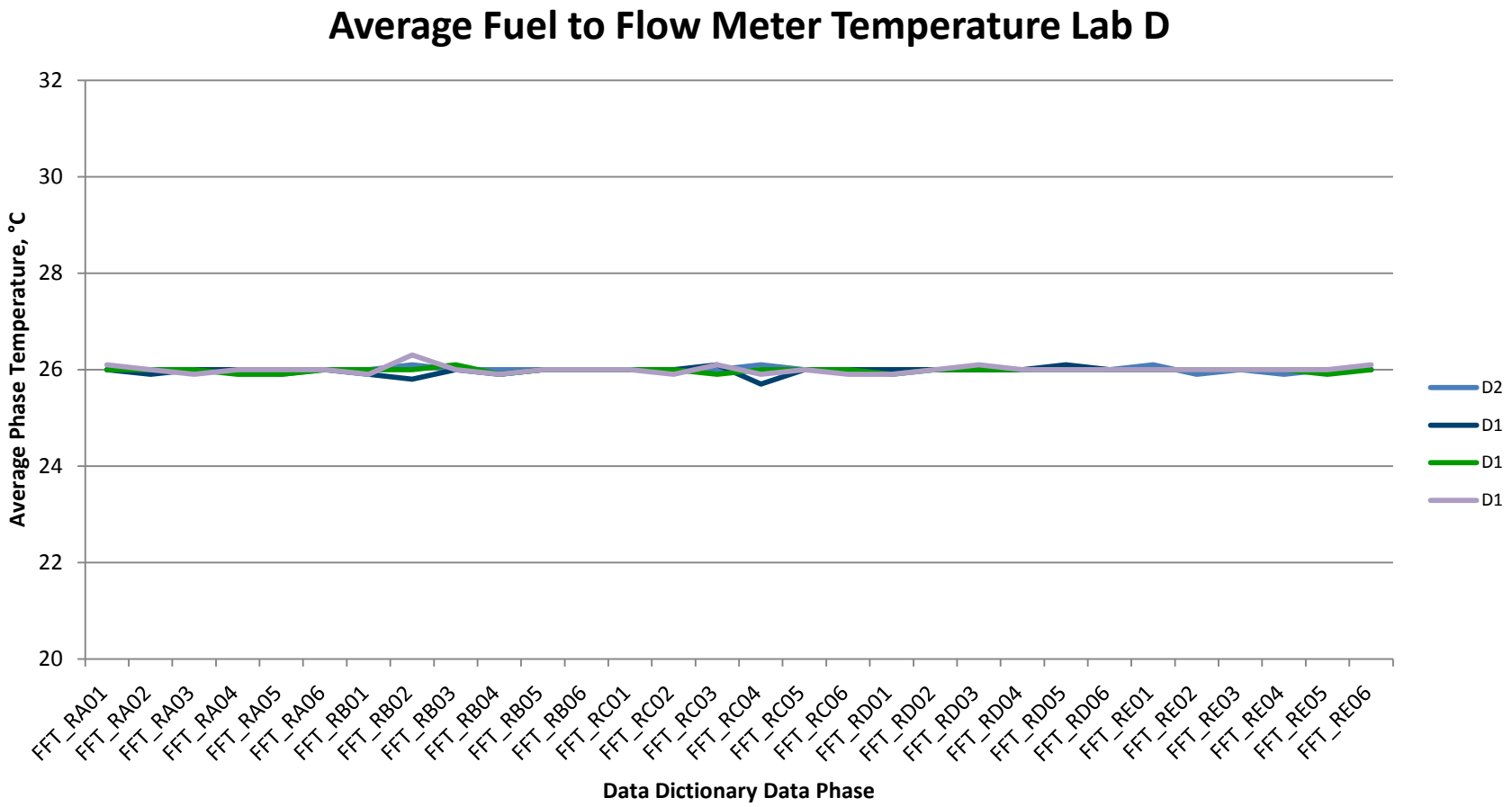
Fuel to Flow Meter Temperature



Fuel to Flow Meter Temperature



Fuel to Flow Meter Temperature



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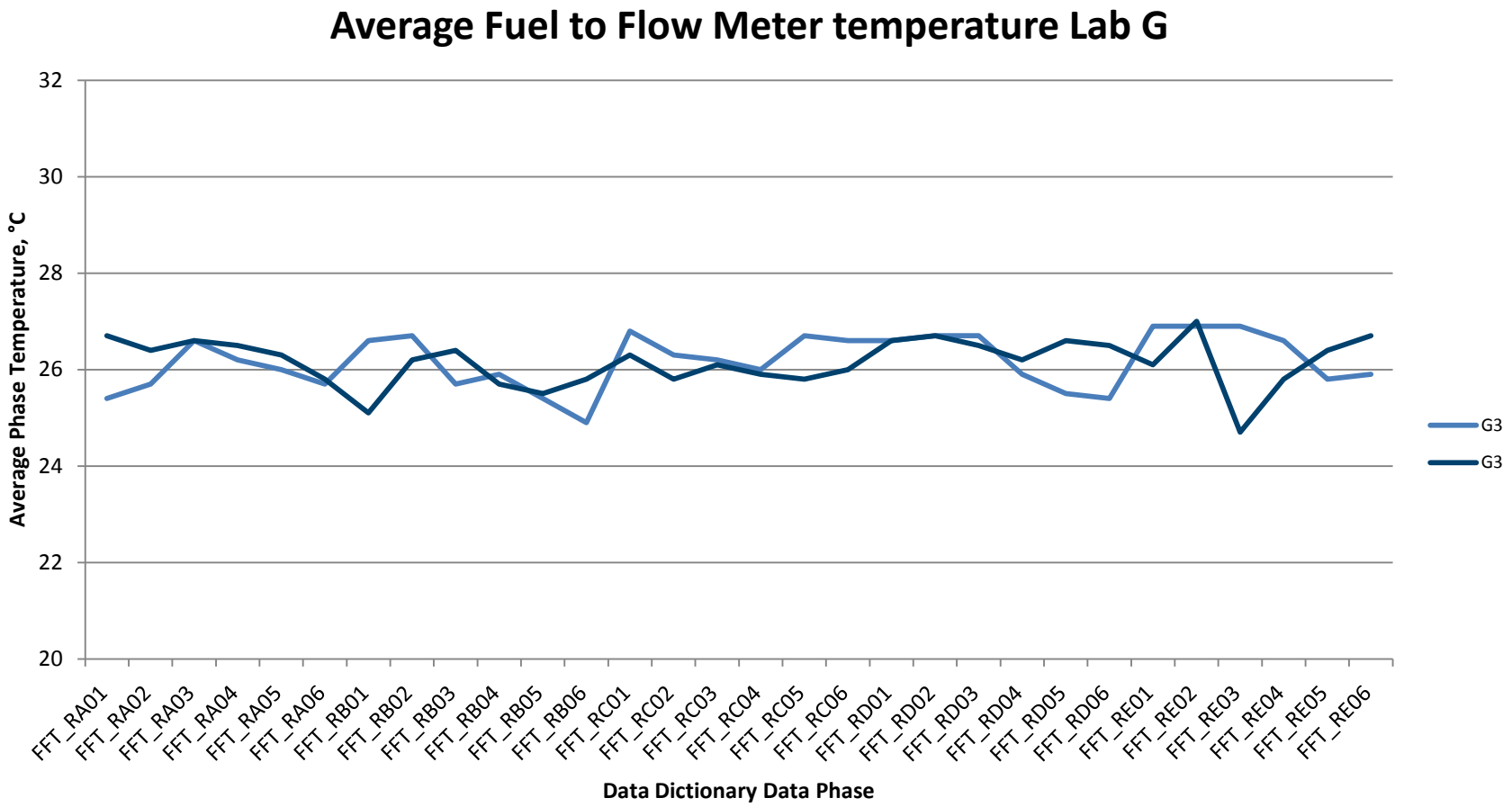
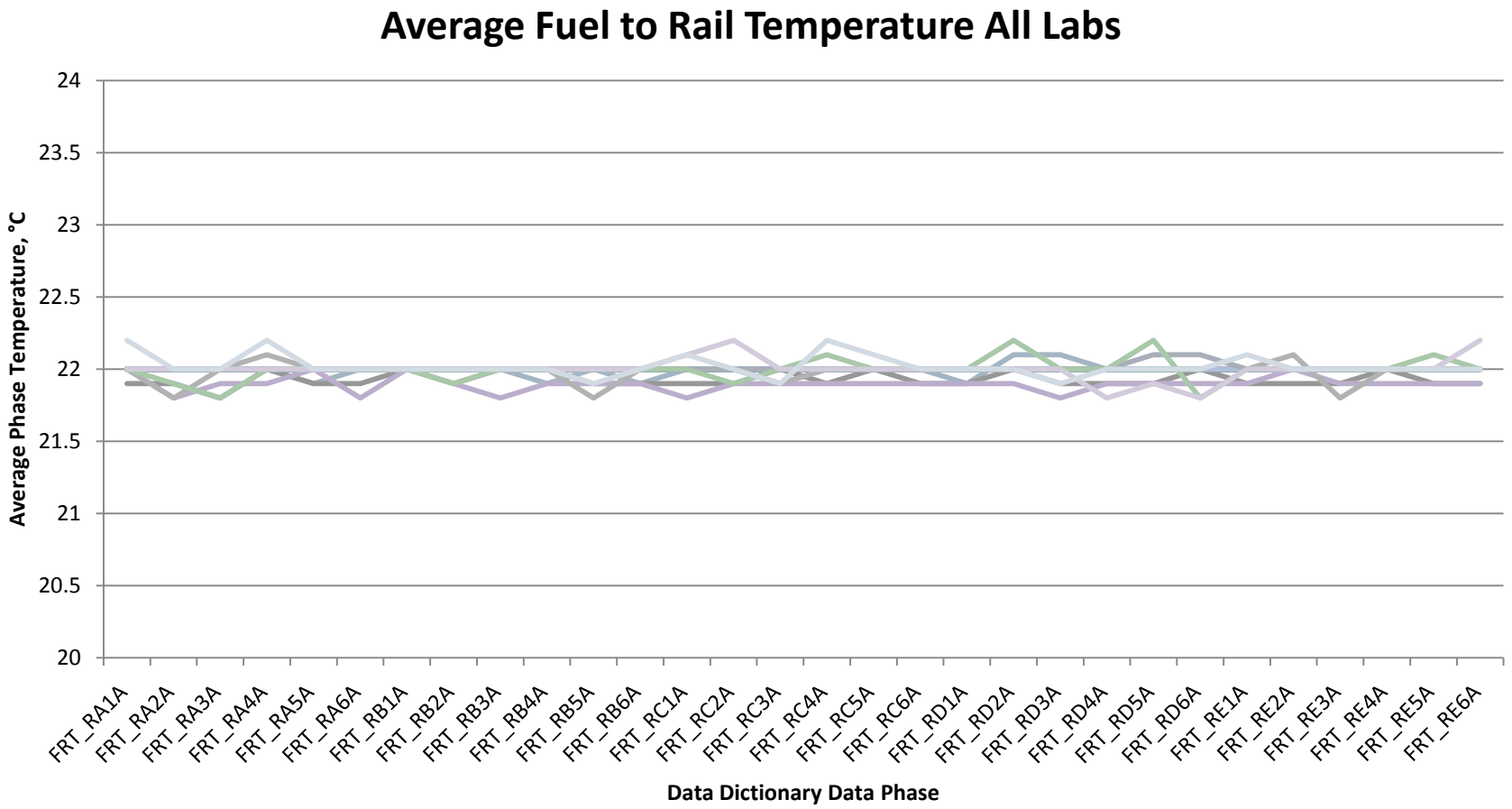
Fuel to Flow Meter Temperature



Fuel to Fuel Rail Temperature

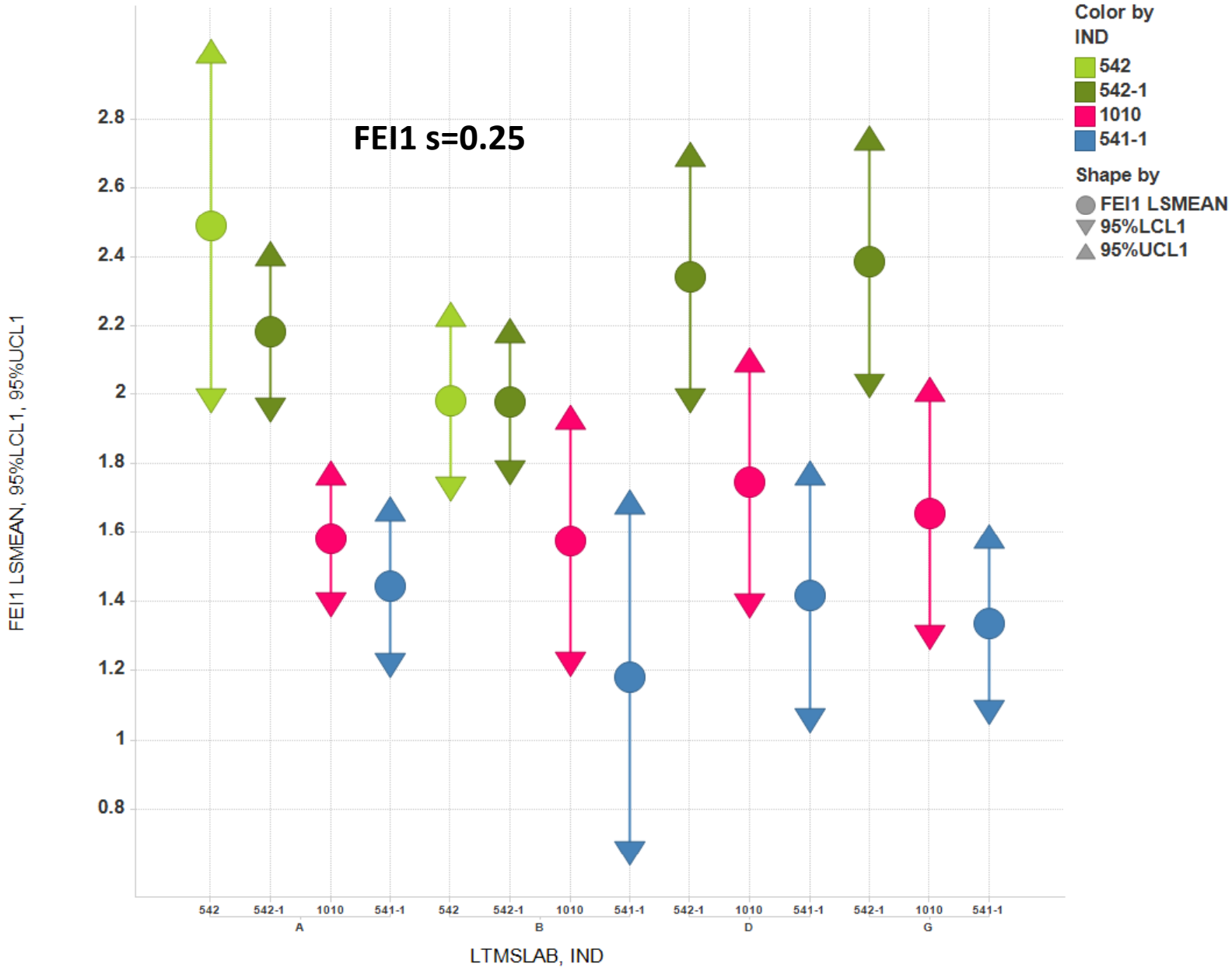


Conclusions and Recommendation

- **Not all labs are doing a good job of controlling Fuel to Flow Meter temperature.**
- **One lab may have different Fuel to Flow Meter control set-points on different stands.**
- **Several tests appear to have Fuel to Flow Meter data exceeding the test validity criteria.**
- **Fuel to Fuel Rail is tightly controlled across all labs and stands.**

- **Recommend that Fuel to Flow Meter be moved to “critical measurement and control parameter” with hard specification; i.e. XX° C ± X° C specified. If not critical, return to VIA specification (± 4° F, 2.2° C).**

VIE FEI1 Discrimination, Reproducibility, Repeatability



VIE FEI2 Discrimination, Reproducibility, Repeatability