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COMMITTEE D02 ON PETROLEUM PRODUCTS, LIQUID FUELS, AND LUBRICANTS

Issued: July 21, 2016

Reply to: Dan Worcester
Southwest Research Institute
6220 Culebra Rd.
San Antonio, TX 78238
Phone: 210.522.2405
Email: dworcester@swri.org

These are the unapproved minutes of the 07.19.2016 Sequence VI Conference Call.

The meeting was called to order at 8:05 AM Central Time by Nathan Moles.

Agenda

The Agenda is the included as Attachment 1.

1.0 Roll Call

The Attendance list is Attachment 2.

2.0 Approval of minutes

2.1 Approval of the minutes of the 07.12.2016 conference call.

ftp://ftp.astmtmc.cmu.edu/docs/gas/sequencevi/minutes/VIMinutes201600712ConferenceCall.pdf

MOTION: Approve the minutes from the 07.12.2016 conference call.

Nathan Moles, Dan Worcester second. The motion was unanimous.

3.0 Action Item Review

3.1 OHT to provide update on current VIE inventory –OHT
136 -002 version engines remain.

3.2 Update of VID engine inventory and expected depletion date of VID engines.
-Expected depletion of VID engines 2016 Q3
~70 test starts at independent labs remain
IAR has about 25 tests remaining, SwRI has about 18 tests left.

3.2 Send out acceptance limit spread sheet –Stats Group
This is complete.

3.3 What does Zi look like for VIE precision matrix vs 1st reference period for VIE –Rich Grundza See Attachment 3. This Excel will allow changes to see effects on reference pass rate and severity adjustment changes. There will be further review at the face to face.

ACTION: All labs review the LTMS sheet and provide input for the meeting in San Antonio.

3.5 Redo full analysis for VIE precision matrix for N=29
Initial discussion was on engine life. There was discussion on a cap or severity adjust values should other tests show a high sigma result similar to engine 128. There is no fast start to generate those adjustments with a single reference on a stand. See Attachment 4 for engine life analysis. Labs might choose not to continue with an engine that fails the first reference if there are 4 or 5 runs per engine. Different review options were considered. All 3 indicated the 4-5 tests per engine. This will be a decision for the Surveillance Panel. More data on RO 1010-1 for runs 5, 6 and 7 not included from the Precision Matrix will help with this decision. The drop in P values indicates reducing the number of runs per engine. The consensus was to make engine life the same for the VIE and VIF testing.

MOTION: Move forward with the VIF test allowing up to 4 full length tests with the 4th test starting with an engine hour of 900 or less. Y = 13, W = 1, N = 0. The motion passed.

4.0 Old Business

4.1 Update on precision matrix analysis. –Stats Group

~~Do we really need to run three RO tests to establish the new engine for LTMS?~~

~~Discussion of reducing the new reference requirement to two oils, then a third oil run after a defined number of candidates.~~

~~Discussion of using FEI 2 and FEI Sum for references to match candidate pass/fail criteria.~~

~~Discussion of evaluating 80/20 ratio of BL before to after for FEI 1 and 10/90 for FEI 2. Consider evaluating FEI 1 vs 100% BLB2 (or 3) and evaluating FEI 2 vs 100% BLA.~~

~~-Discussion of changing BLB1 to BLB2 delta acceptable limits.~~

~~-Determine engine calibration status of matrix engines and date of calibration~~

-Review impact of variable oil pressure of FEI (review prove out data to determine if it is stand or engine related)

-Should the acceptance bands value of 1.96 be rounded up? Due to the rounding on FEI 1 and 2 the actual pass limit is 1.91 and 1.92.

- Investigate what is needed to establish VID equivalent limits for VIE

-Review and Finalize LTMS Requirements

- Appendix K Template review –Todd Dvorak

These are on-going issues.

4.2 Update from task force, to investigate alternative test procedure Sequence "VIF" that would improve 0W-16. – Dan Worcester/Satoshi Hirano The matrix is complete. The Stat Group has begun review and this will be discussed along with the VIE Precision Matrix at the next Face to Face meeting.

4.3 Update from task force to investigate option to use short blocks to supplement engine inventory. –Adrian Alfonso/Bill Buscher GM will be able to supply more engines, but there are not enough right cylinder heads for the desired number of short blocks. All labs were asked to respond to the survey from TMC on the quantity of additional engine kits they would order. There are now about 950 requested. Rich will send an update before the next Build Task Force call on 07.21.2016. There are about 550 engines with both heads, so about 400 heads would need rebuild. Labs are to remove and save their cylinder heads for later rebuild.

4.4 Update from task force, to investigate engine cleaning procedure. –Dan Worcester

The matrix continues at SwRI. A second engine has been Ultra Sonic cleaned and additional measurements taken. IAR will also perform these measurements. Additional new engines available will lower the urgency for this method.

5.0 New Business

5.1 TBD

6.0 Next Meetings.

Upcoming schedule:

- 7/26 – 7/28 (noon) face to face meeting at IAR

The meetings adjourned at 10:13 AM.

Sequence VI Surveillance Panel Conference Call Agenda
July 19 @ 9:00-11:30AM EST

Call-in information is included below:

Call-in Number: 866-528-2256
Conference Code: 3744024
WebEx:

https://meetings.webex.com/collabs/#/meetings/detail?uuid=MBQN8T94JBLW6FI3BR9T19RZ3Q-20XT&rnd=343820.74569

DO NOT USE WEB EX CALL IN NUMBER

1.0) Roll Call

Do we have any membership changes or additions?

2.0) Approval of minutes

2.1 Approve the minutes from the July 12, 2016 Sequence VI Surveillance Panel.
ftp://ftp.astmtmc.cmu.edu/docs/gas/sequencevi/minutes/VIMinutes20160712ConferenceCallCorrected.pdf

3.0) Action Item Review

3.1 OHT to provide update on current VIE inventory –OHT

3.2 Update of VID engine inventory and expected depletion date of VID engines.

-Expected depletion of VID engines 2016 Q3
~70 test starts at independent labs remain

3.3 Send out acceptance limit spread sheet –Stats Group

3.4 What does Zi look like for VIE precision matrix vs 1st reference period for VIE –Rich Grundza

3.5 Redo full analysis for VIE precision matrix for N=29

4.) Old Business

4.1 Update on precision matrix analysis. –Stats Group

~~-Do we really need to run three RO tests to establish the new engine for LTMS?~~

~~-Discussion of reducing the new reference requirement to two oils, then a third oil run after a defined number of candidates.~~

~~-Discussion of using FEI 2 and FEI Sum for references to match candidate pass/fail criteria.~~

~~-Discussion of evaluating 80/20 ratio of BL before to after for FEI 1 and 10/90 for FEI 2. Consider evaluating FEI 1 vs 100% BLB2 (or 3) and evaluating FEI 2 vs 100% BLA.~~

~~-Discussion of changing BLB1 to BLB2 delta acceptable limits.~~

~~-Determine engine calibration status of matrix engines and date of calibration~~

-Review impact of variable oil pressure of FEI (review prove out data to determine if it is stand or engine related)

-Should the acceptance bands value of 1.96 be rounded up? Due to the rounding on FEI 1 and 2 the actual pass limit is 1.91 and 1.92.

- Investigate what is needed to establish VID equivalent limits for VIE

-Review and Finalize LTMS Requirements

-Update test procedure

- Appendix K Template review –Todd Dvorak

4.2 Update from task force, to investigate alternative test procedure Sequence “VIF” that would improve 0W-16. – Dan Worcester/Satoshi Hirano

4.3 Update from task force to investigate option to use short blocks to supplement engine inventory. –Adrian Alfonso/Bill Buscher

4.4 Update from task force, to investigate engine cleaning procedure. – Dan Worcester

5.) New Business

5.1 TBD

6.) Next Meeting

Upcoming schedule:

- 7/26 – 7/28 (noon) face to face meeting at IAR

7.) Meeting Adjourned

ASTM SEQUENCE VI

Name	Email/Phone	Company	Attend
Adrian Alfonso **Voting Member**	Phone: (210) 838-0431 adrian.alfonso@intertek.com	Intertek	ATTEND
Jason Bowden **Voting Member**	Phone: (440) 354-7007 jhbowden@ohtech.com	OHT	
Timothy Caudill **Voting Member**	Phone: (606) 329-5708 Tlcaudill@ashland.com	Ashland	
Tim Cushing **Voting Member**	Phone: (248) 881-3518 timothy.cushing@gm.com	General Motors	ATTEND
David Glaenzer **Voting Member**	Phone: (804) 788-5214 Dave.Glaenzer@aftonchemical.com	Afton	
Rich Grundza **Voting Member**	Phone: (412) 365-1034 reg@astmtmc.cmu.edu	TMC	ATTEND
Jeff Hsu **Voting Member**	Phone: (832) 419-3482 j.hsu@shell.com	Shell	ATTEND
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Dan Worcester **Voting Member**	Phone: (210) 522-2405 dan.worcester@swri.org	SwRI	ATTEND

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Chris Taylor	Chris.taylor@vpracingfuels.com	VP Racing Fuels	

Obs	TESTKEY	LTMSLAB	ENGNO	ENRUN	ENHREND	IND	FEI1	FEI1_OR	FEI2	FEI2_OR
	113244-VIE	**A**	**128**	**1**	**374**	**544**	**1.07**	**1.07**	**0.49**	**0.49**
	113247-VIE	**A**	**128**	**2**	**579**	**544**	**1.44**	**1.44**	**1.47**	**1.47**
	111451-VIE	**A**	**128**	**3**	**779**	**542-2**	**2.32**	**2.32**	**1.41**	**1.41**
	110726-VIE	**A**	**128**	**4**	**1003**	**1010-1**	**1.57**	**1.57**	**1.43**	**1.43**
1	110588-VIE	D	11	1	370	542-2	2.77	2.77	1.7	1.7
9	113293-VIE	D	11	2	571	542-2	2.53	2.53	1.74	1.74
18	113292-VIE	D	11	3	772	544	1.48	1.48	1.24	1.24
26	110589-VIE	D	11	4	973	1010-1	1.83	1.83	1.68	1.68
11	113300-VIE	C	31	2	570	1010-1	2.18	2.18	1.82	1.82
2	116040-VIE	C	29	1	358	544	1.81	1.81	1.53	1.53
10	113301-VIE	C	29	2	575	1010-1	2.49	2.49	1.69	1.69
19	114421-VIE	C	29	3	794	542-2	2.31	2.31	1.3	1.3
27	114422-VIE	C	29	4	1005	542-2	1.97	1.97	1.27	1.27
3	113224-VIE	G	55	1	363	544	1.36	1.36	1.83	1.83
12	105704-VIE	G	55	2	561	542-2	2.93	2.93	2.16	2.16
20	108989-VIE	G	55	3	758	1010-1	1.95	1.95	2.12	2.12
28	113234-VIE	G	55	4	956	1010-1	1.71	1.71	2	2
4	105705-VIE	G	60	1	390	542-2	2.34	2.34	1.7	1.7
13	113235-VIE	G	60	2	602	1010-1	1.67	1.67	1.51	1.51
21	113236-VIE	G	60	3	803	1010-1	1.59	1.59	1.49	1.49
29	113225-VIE	G	60	4	1002	544	1.1	1.1	1.04	1.04
5	110587-VIE	A	103	1	374	1010-1	1.6	1.6	1.74	1.74
14	110725-VIE	A	103	2	574	1010-1	1.84	1.84	1.59	1.59
22	111176-VIE	A	103	3	776	542-2	2.46	2.46	1.48	1.48
30	113243-VIE	A	103	4	978	544	1.24	1.24	1.11	1.11
6	110003-VIE	B	123	1	399	542-2	3	3	1.86	1.86
15	113258-VIE	B	123	2	597	544	1.48	1.48	1.64	1.64
23	110595-VIE	B	123	3	794	1010-1	1.77	1.77	1.99	1.99
31	113259-VIE	B	123	4	992	544	1.04	1.04	1.38	1.38
8	113223-VIE	F	136	1	364	1010-1	2.12	2.12	2.14	2.14

17	113220-VIE	F	136	2	569	544	0.84	0.84	1.51	1.51
25	113221-VIE	F	136	3	768	544	1.04	1.04	1.64	1.64
33	113222-VIE	F	136	4	968	542-2	2.86	2.86	2.13	2.13

Targets	FEI1
1010-1	1.90
542-2	2.56
544	1.30

R
Weight
SA Yi Cap
AL1
AL2
AL3

(Engine Hour Adj FEI)

FEISUM	CHART	FEI1 Adj	FEI2 Adj	Run	FEI1-Yi	Yi Cumalative Avg
1.56	**N**	0.91	0.38	1	-1.48	-1.48
2.91	**N**	1.39	1.43	2	0.35	-0.57
3.73	**N**	2.37	1.45	3	-0.60	-0.58
3	**N**	1.74	1.55	4	-0.59	-0.58
4.47	N	2.61	1.58	1	0.17	0.17
4.27	N	2.48	1.70	2	-0.27	-0.05
2.72	N	1.53	1.28	3	0.89	0.26
3.51	N	1.98	1.79	4	0.31	0.27
4	N	2.13	1.78	2	0.84	0.84
3.34	N	1.65	1.41	1	1.33	1.33
4.18	N	2.44	1.65	2	1.99	1.66
3.61	N	2.37	1.35	3	-0.61	0.91
3.24	N	2.14	1.40	4	-1.35	0.34
3.19	N	1.20	1.71	1	-0.39	-0.39
5.09	N	2.87	2.12	2	1.00	0.31
4.07	N	1.99	2.15	3	0.34	0.32
3.71	N	1.86	2.11	4	-0.16	0.20
4.04	N	2.19	1.59	1	-1.19	-1.19
3.18	N	1.63	1.48	2	-0.99	-1.09
3.08	N	1.66	1.54	3	-0.90	-1.03
2.14	N	1.27	1.16	4	-0.12	-0.80
3.34	N	1.44	1.63	1	-1.69	-1.69
3.43	N	1.79	1.55	2	-0.42	-1.05
3.94	N	2.51	1.52	3	-0.15	-0.75
2.35	N	1.40	1.23	4	0.37	-0.47
4.86	N	2.86	1.75	1	0.96	0.96
3.12	N	1.44	1.61	2	0.54	0.75
3.76	N	1.83	2.04	3	-0.25	0.41
2.42	N	1.20	1.50	4	-0.37	0.22
4.26	N	1.96	2.02	1	0.22	0.22

2.35	N	0.79	1.47	2	-1.98	-0.88
2.68	N	1.09	1.68	3	-0.81	-0.86
4.71	N	3.01	2.24	4	1.46	-0.28

FEI1	
Raw Stdev	Pooled s
0.27	0.28
0.31	
0.26	

	FEI2
FEI2	Raw Stdev
1.82	0.25
1.73	0.30
1.41	0.20

Input Limits for LTMS - Option 1

FEI1	FEI2
1.08	0.47
0.50	0.50
NA	NA
1.60	1.60
2.00	2.00
2.60	2.60

Optional Values for R: 1.08 for FEI1 & 0.47 for FEI2 to
Weight value applied to Yi result for SA calculation w
Cap for calculating SA when calibrating with one refe
Yi Limit for first test reference acceptance
Limit for comparing the difference between Y1 and Y
Average Yi limit to determine acceptance of second o

FEI1 SA	Add'l Ref Req'd?	FEI2-Yi	Yi Cumalative Avg	FEI2 SA
		-5.17	-5.17	
		0.12	-2.53	
		-0.93	-2.00	
0.16		-1.06	-1.76	0.44
-0.02		-0.49	-0.49	0.06
		-0.10	-0.29	
		-0.67	-0.42	
-0.08		-0.11	-0.34	0.08
-0.12		-0.16	-0.16	0.02
-0.19		0.00	0.00	0.00
		-0.67	-0.34	
		-1.28	-0.65	
-0.10		-1.11	-0.77	0.19
0.05		1.51	1.51	-0.19
		1.29	1.40	
		1.33	1.37	
-0.06		1.15	1.32	-0.33
0.17		-0.46	-0.46	0.06
		-1.35	-0.91	
		-1.12	-0.98	
0.22		-1.23	-1.04	0.26
	Run Add'l Ref	-0.78	-0.78	
0.29		-1.07	-0.93	0.23
		-0.71	-0.85	
0.13		-0.92	-0.87	0.22
-0.13		0.08	0.08	-0.01
		1.00	0.54	
		0.86	0.65	
-0.06		0.45	0.60	-0.15
-0.03		0.81	0.81	-0.10

	0.30	0.55	
	1.33	0.81	
0.08	1.71	1.03	-0.26

Pooled s
0.25

› account for differences in repeatability and reproducibility s
hen calibrating with one reference attempt.
rence only: FEI1 SA Max = NA and FEI2 SA Max = NA

2 or Y3 and the average of Y1 and Y2 for a second or third reference
r third reference

Add'l Ref Req'd?	Acceptable Reference?	FEI1 AC?	FEI2 AC?
Run Add'l Ref	0	1	0
Run Add'l Ref	0	1	0
Abandon Engine	0	1	0
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	0	0	0
	0	0	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	0	0	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1

0	0	1
1	1	1
0	0	1
25	28	29
76%	85%	88%

Obs	TESTKEY	LTMSLAB	ENGNO	ENRUN	ENHREND	IND	FEI1	FEI1_OR	FEI2	FEI2_OR
	113244-VIE	**A**	**128**	**1**	**374**	**544**	**1.07**	**1.07**	**0.49**	**0.49**
	113247-VIE	**A**	**128**	**2**	**579**	**544**	**1.44**	**1.44**	**1.47**	**1.47**
	111451-VIE	**A**	**128**	**3**	**779**	**542-2**	**2.32**	**2.32**	**1.41**	**1.41**
	110726-VIE	**A**	**128**	**4**	**1003**	**1010-1**	**1.57**	**1.57**	**1.43**	**1.43**
1	110588-VIE	D	11	1	370	542-2	2.77	2.77	1.7	1.7
9	113293-VIE	D	11	2	571	542-2	2.53	2.53	1.74	1.74
18	113292-VIE	D	11	3	772	544	1.48	1.48	1.24	1.24
26	110589-VIE	D	11	4	973	1010-1	1.83	1.83	1.68	1.68
11	113300-VIE	C	31	2	570	1010-1	2.18	2.18	1.82	1.82
2	116040-VIE	C	29	1	358	544	1.81	1.81	1.53	1.53
10	113301-VIE	C	29	2	575	1010-1	2.49	2.49	1.69	1.69
19	114421-VIE	C	29	3	794	542-2	2.31	2.31	1.3	1.3
27	114422-VIE	C	29	4	1005	542-2	1.97	1.97	1.27	1.27
3	113224-VIE	G	55	1	363	544	1.36	1.36	1.83	1.83
12	105704-VIE	G	55	2	561	542-2	2.93	2.93	2.16	2.16
20	108989-VIE	G	55	3	758	1010-1	1.95	1.95	2.12	2.12
28	113234-VIE	G	55	4	956	1010-1	1.71	1.71	2	2
4	105705-VIE	G	60	1	390	542-2	2.34	2.34	1.7	1.7
13	113235-VIE	G	60	2	602	1010-1	1.67	1.67	1.51	1.51
21	113236-VIE	G	60	3	803	1010-1	1.59	1.59	1.49	1.49
29	113225-VIE	G	60	4	1002	544	1.1	1.1	1.04	1.04
5	110587-VIE	A	103	1	374	1010-1	1.6	1.6	1.74	1.74
14	110725-VIE	A	103	2	574	1010-1	1.84	1.84	1.59	1.59
22	111176-VIE	A	103	3	776	542-2	2.46	2.46	1.48	1.48
30	113243-VIE	A	103	4	978	544	1.24	1.24	1.11	1.11
6	110003-VIE	B	123	1	399	542-2	3	3	1.86	1.86
15	113258-VIE	B	123	2	597	544	1.48	1.48	1.64	1.64
23	110595-VIE	B	123	3	794	1010-1	1.77	1.77	1.99	1.99
31	113259-VIE	B	123	4	992	544	1.04	1.04	1.38	1.38
8	113223-VIE	F	136	1	364	1010-1	2.12	2.12	2.14	2.14

17	113220-VIE	F	136	2	569	544	0.84	0.84	1.51	1.51
25	113221-VIE	F	136	3	768	544	1.04	1.04	1.64	1.64
33	113222-VIE	F	136	4	968	542-2	2.86	2.86	2.13	2.13

Targets	FEI1
1010-1	1.90
542-2	2.56
544	1.30

R
Weight
AL1 (Cap)
AL2
AL2.1
AL3

(Engine Hour Adj FEI)

FEISUM	CHART	FEI1 Adj	FEI2 Adj	Run	FEI1-Yi	Yi Cumalative Avg
1.56	**N**	0.91	0.38	1	-1.48	-1.48
2.91	**N**	1.39	1.43	2	0.35	-0.57
3.73	**N**	2.37	1.45	3	-0.60	-0.58
3	**N**	1.74	1.55	4	-0.59	-0.58
4.47	N	2.61	1.58	1	0.17	0.17
4.27	N	2.48	1.70	2	-0.27	-0.05
2.72	N	1.53	1.28	3	0.89	0.26
3.51	N	1.98	1.79	4	0.31	0.27
4	N	2.13	1.78	2	0.84	0.84
3.34	N	1.65	1.41	1	1.33	1.33
4.18	N	2.44	1.65	2	1.99	1.66
3.61	N	2.37	1.35	3	-0.61	0.91
3.24	N	2.14	1.40	4	-1.35	0.34
3.19	N	1.20	1.71	1	-0.39	-0.39
5.09	N	2.87	2.12	2	1.00	0.31
4.07	N	1.99	2.15	3	0.34	0.32
3.71	N	1.86	2.11	4	-0.16	0.20
4.04	N	2.19	1.59	1	-1.19	-1.19
3.18	N	1.63	1.48	2	-0.99	-1.09
3.08	N	1.66	1.54	3	-0.90	-1.03
2.14	N	1.27	1.16	4	-0.12	-0.80
3.34	N	1.44	1.63	1	-1.69	-1.69
3.43	N	1.79	1.55	2	-0.42	-1.05
3.94	N	2.51	1.52	3	-0.15	-0.75
2.35	N	1.40	1.23	4	0.37	-0.47
4.86	N	2.86	1.75	1	0.96	0.96
3.12	N	1.44	1.61	2	0.54	0.75
3.76	N	1.83	2.04	3	-0.25	0.41
2.42	N	1.20	1.50	4	-0.37	0.22
4.26	N	1.96	2.02	1	0.22	0.22

2.35	N	0.79	1.47	2	-1.98	-0.88
2.68	N	1.09	1.68	3	-0.81	-0.86
4.71	N	3.01	2.24	4	1.46	-0.28

FEI1	
Raw Stdev	Pooled s
0.27	0.28
0.31	
0.26	

	FEI2
FEI2	Raw Stdev
1.82	0.25
1.73	0.30
1.41	0.20

Input Limits for LTMS - Option 2

FEI1	FEI2
1.00	1.00
1.00	1.00
1.60	1.60
2.00	2.00
2.00	2.00
2.00	2.00

Optional Values for R: 1.08 for FEI1 & 0.47 for FEI2 to
Weight value applied to Yi result for SA calculation wh
Cap for calculating SA when calibrating with one refer
Yi Limit for first test reference acceptance
Limit for comparing the difference between Y1 and Y2
Average Yi limit to determine acceptance of second or

FEI1 SA	Add'l Ref Req'd?	FEI2-Yi	Yi Cumalative Avg	FEI2 SA
		-5.17	-5.17	
		0.12	-2.53	
0.16		-0.93	-2.00	0.50
0.16		-1.06	-1.76	0.44
-0.05		-0.49	-0.49	0.12
		-0.10	-0.29	
		-0.67	-0.42	
-0.08		-0.11	-0.34	0.08
-0.23		-0.16	-0.16	0.04
-0.37		0.00	0.00	0.00
		-0.67	-0.34	
		-1.28	-0.65	
-0.10		-1.11	-0.77	0.19
0.11		1.51	1.51	-0.38
		1.29	1.40	
		1.33	1.37	
-0.06		1.15	1.32	-0.33
0.33		-0.46	-0.46	0.12
		-1.35	-0.91	
		-1.12	-0.98	
0.22		-1.23	-1.04	0.26
0.45		-0.78	-0.78	0.19
		-1.07	-0.93	
		-0.71	-0.85	
0.13		-0.92	-0.87	0.22
-0.27		0.08	0.08	-0.02
		1.00	0.54	
		0.86	0.65	
-0.06		0.45	0.60	-0.15
-0.06		0.81	0.81	-0.20

	0.30	0.55	
	1.33	0.81	
0.08	1.71	1.03	-0.26

Pooled s
0.25

account for differences in repeatability and reproducibility s
en calibrating with one reference attempt.
ence only: FEI1 SA Max = 0.45 at 1.6 limit and FEI2 SA Max = 0.4 at 1.6 limit

or Y3 and the average of Y1 and Y2 for a second or third reference (can be the same as AL2)
third reference

Add'l Ref Req'd?	Acceptable Reference?	FEI1 AC?	FEI2 AC?
Run Add'l Ref	0	1	0
Run Add'l Ref	0	1	0
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	0	0	1
	0	0	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1
	1	1	1

0	0	1
1	1	1
0	0	1
27	29	31
82%	88%	94%

Engine Life Review

Industry Statistician Team

Date: 07-19-2016

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

Executive Summary

- Statistical analyses based on the 28 valid VIF matrix tests indicate that the effect of engine hours in FEI1 is not the same for all oils tested. This complicates the estimation of an engine hours correction that is applicable to all oils

- The panel may find that this rapid decrease in oil separation as engine hours increases requires limiting the VIF engine life

- Multiple statistical approaches have been taken to aid in the determination of engine life

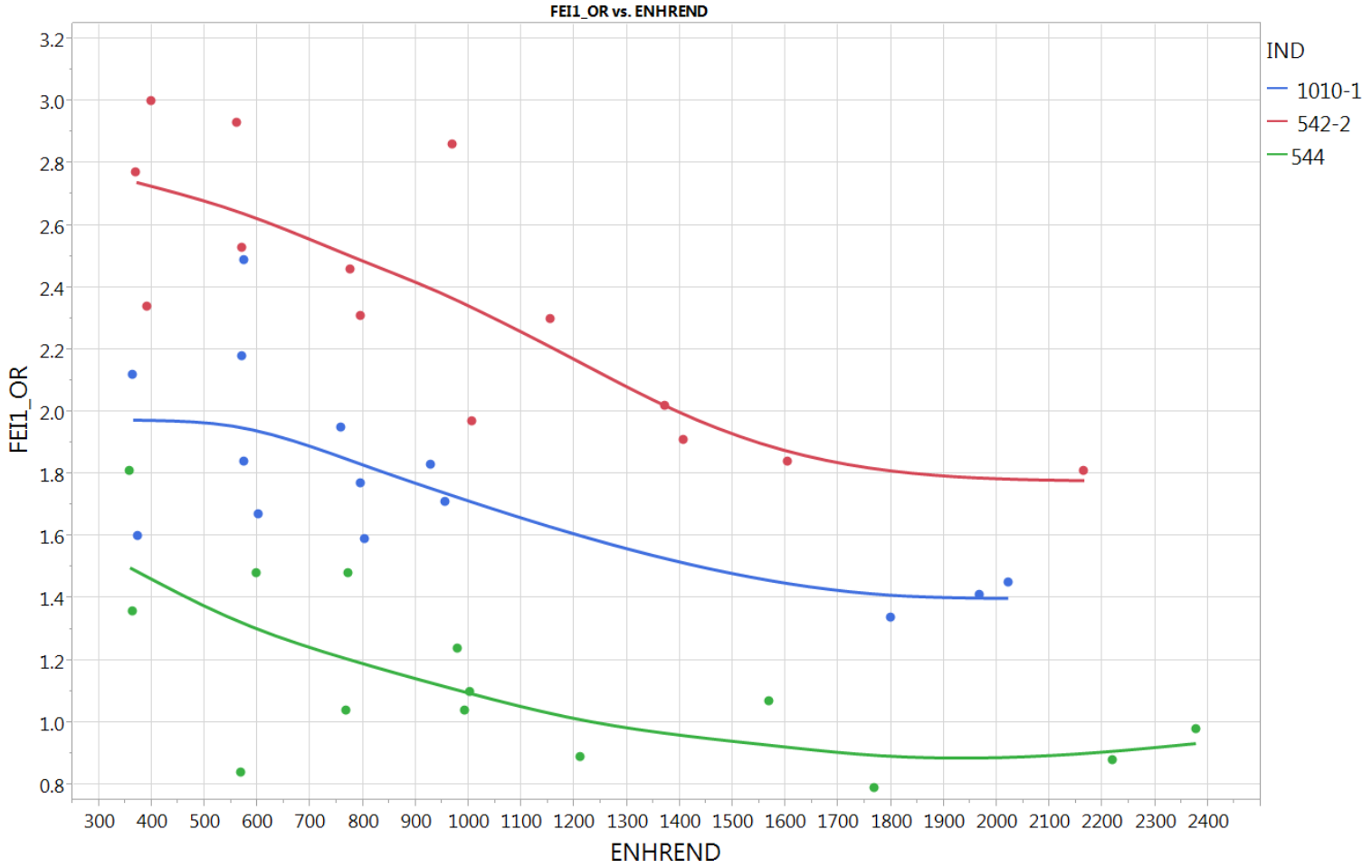
- Based on the results of these various approaches, which follow similar logic used in the VIE engine life determination, a VIF engine life of 4 to 5 tests is reasonable

VIE Engine Life (No A128, n=42)

Based on FEI1 Oil Discrimination

Assess Engine Life Based on Oil Discrimination

- FEI1 oil discrimination over the engine life
  - 542-2 > 1010-1 > 544 for the entire engine life



Assess Engine Life Based on Oil Discrimination

- Overall ANOVA Summary of FEI1 data:
  - Analysis indicates that there is a marginally significant difference in the slopes of the engine hour effect for the different oils in FEI1.

Summary of Fit

RSquare	0.880888
RSquare Adj	0.8316
Root Mean Square Error	0.249077
Mean of Response	1.761905
Observations (or Sum Wgts)	42

Analysis of Variance

Parameter Estimates

Term	Estimate	Prob>|t|	VIF
Intercept	2.2142123	<.0001*	.
IND[1010-1]	0.0123327	0.8304	1.4703228
IND[542-2]	0.5675208	<.0001*	1.4094118
LTMSLAB[A]	-0.120701	0.3005	3.4054905
LTMSLAB[B]	-0.011573	0.9000	3.2763778
LTMSLAB[C]	0.1795128	0.1681	4.5799605
LTMSLAB[D]	0.0542922	0.6461	3.5571025
LTMSLAB[F]	-0.013791	0.9055	3.4463237
LTMSLAB[C]:ENGNO[29]	-0.055426	0.7049	1.6196518
LTMSLAB[G]:ENGNO[55]	0.158561	0.0540	1.3900444
ENHREND	-0.00046	<.0001*	1.5999417
(ENHREND-1003.69)*IND[1010-1]	0.0000441	0.6754	1.7030227
(ENHREND-1003.69)*IND[542-2]	-0.000212	0.0565	1.6828208

Effect Tests

Source	Prob > F
IND	<.0001*
LTMSLAB	0.5797
ENGNO[LTMSLAB]	0.1372
ENHREND	<.0001*
ENHREND*IND	0.1084

Assess Engine Life Based on Oil Discrimination

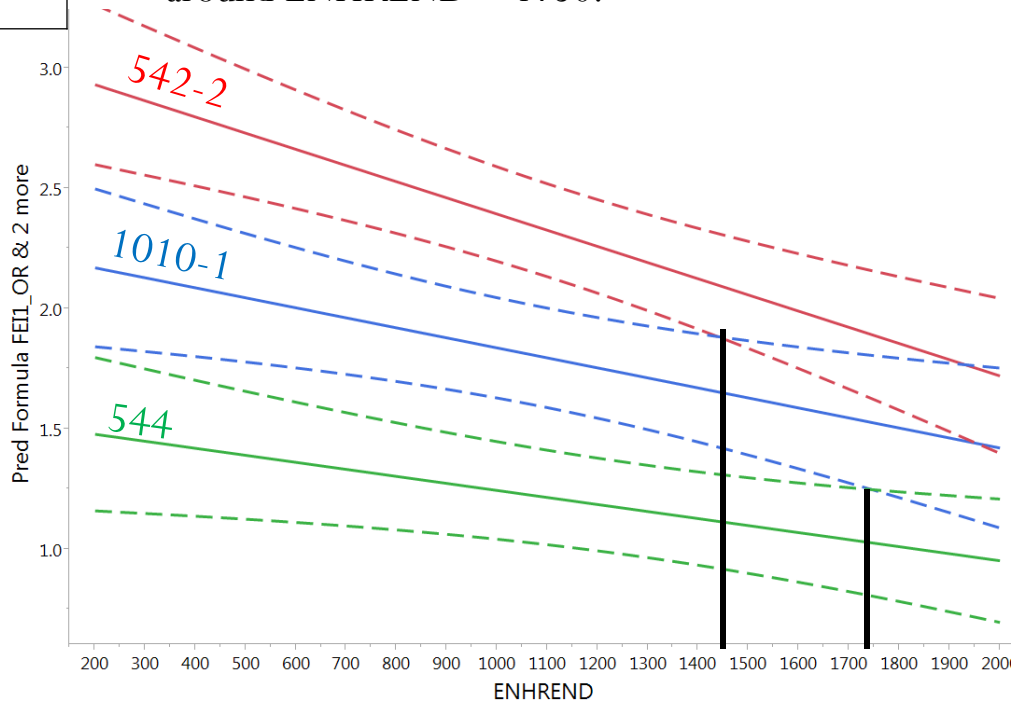
- FEI1 oil discrimination over the engine life
  - Using the prediction model we can obtain estimates for when oil discrimination is lost within each stand.
  - These estimates can be used to gauge VIE engine life based on FEI1

Lab-Engine	Predicted Hours at which 542-2 no longer discriminates from 1010-1	Predicted Hours at which 1010-1 no longer discriminates from 544
G 55	≈1450	≈1750
B 123	≈1400	≈1750

Refer to Appendix A for plots of other stands

Example: Using G 55

Notice how the 95% confidence interval for 542-2 begins to overlap the 95% confidence interval for 1010-1 at around ENHREND = 1450 and 1010-1 overlaps 544 at around ENHREND = 1750.



Assess Engine Life Based on Oil Discrimination

- FEI1 oil discrimination over the engine life
  - Another approach to determine VIF engine life would be to track the p-value of the oil*ENHREND term using various subsets of the valid matrix data. This significance of this term represents the point at which the same engine hour correction should no longer be used for all oils.

Data used	Number of test results	Overall p-value of oil*ENHREND term	Range of p-values by oil of oil*ENHREND term
ENHREND < 1100	29	.8069	.5351 to .9319
ENHREND < 1300	31	.9058	.7027 to .9504
ENHREND < 1450	33	.6579	.4080 to .8596
ENHREND < 1600	35	.4029	.3288 to .9134
ENHREND < 1800	37	.3681	.1769 to .6636
ENHREND < 2050	39	.2135	.0882 to .4016
All Valid Tests	42	.1084	.0565 to .6754

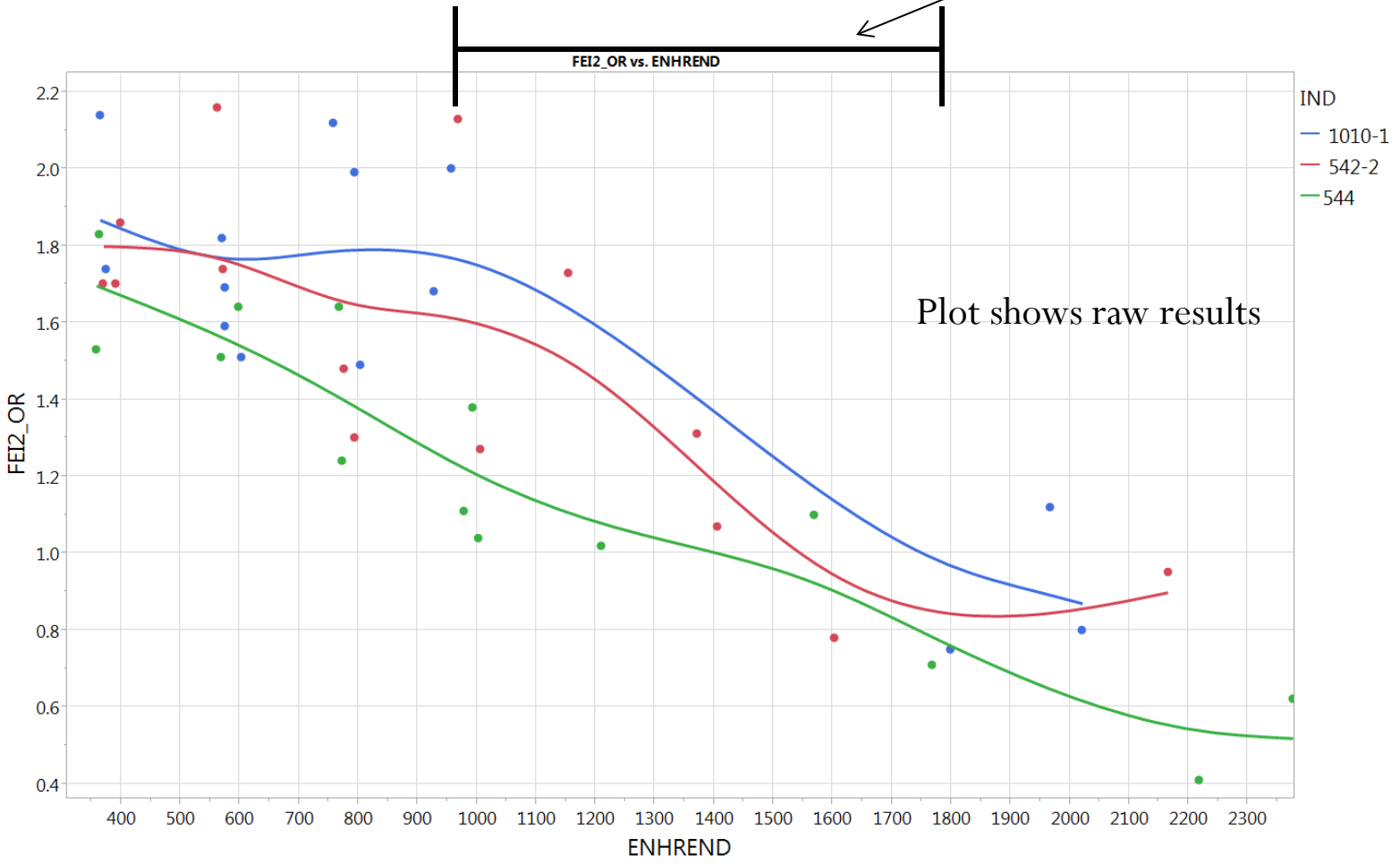
VIE Engine Life (No A128, n=42)

Based on FEI2 Oil Discrimination

Assess Engine Life Based on Oil Discrimination

- FEI2 oil discrimination over the engine life
  - Oil discrimination varies over the engine life

No 1010-1 results from ENHREND= 956 to ENHREND = 1799



Assess Engine Life Based on Oil Discrimination

- Overall ANOVA Summary of FEI2 data:
  - Analysis indicates that there is not a significant difference in the slopes of the engine hour effect for the different oils in FEI2.

Summary of Fit

RSquare	0.912417
RSquare Adj	0.876175
Root Mean Square Error	0.159432
Mean of Response	1.438095
Observations (or Sum Wgts)	42

Analysis of Variance

Parameter Estimates

Term	Estimate	Prob>|t|	VIF
Intercept	2.1282897	<.0001*	.
IND[1010-1]	0.1530283	0.0002*	1.4703228
IND[542-2]	0.0493566	0.1782	1.4094118
LTMSLAB[A]	-0.18992	0.0148*	3.4054905
LTMSLAB[B]	0.0342189	0.5626	3.2763778
LTMSLAB[C]	-0.112359	0.1774	4.5799605
LTMSLAB[D]	-0.06363	0.4025	3.5571025
LTMSLAB[F]	0.280212	0.0007*	3.4463237
LTMSLAB[C]:ENGNO[29]	-0.066602	0.4785	1.6196518
LTMSLAB[G]:ENGNO[55]	0.2694349	<.0001*	1.3900444
ENHREND	-0.000746	<.0001*	1.5999417
(ENHREND-1003.69)*IND[1010-1]	-2.237e-5	0.7399	1.7030227
(ENHREND-1003.69)*IND[542-2]	-0.000031	0.6537	1.6828208

Effect Tests

Source	Prob > F
IND	<.0001*
LTMSLAB	0.0066*
ENGNO[LTMSLAB]	<.0001*
ENHREND	<.0001*
ENHREND*IND	0.6871

Assess Engine Life Based on Oil Discrimination

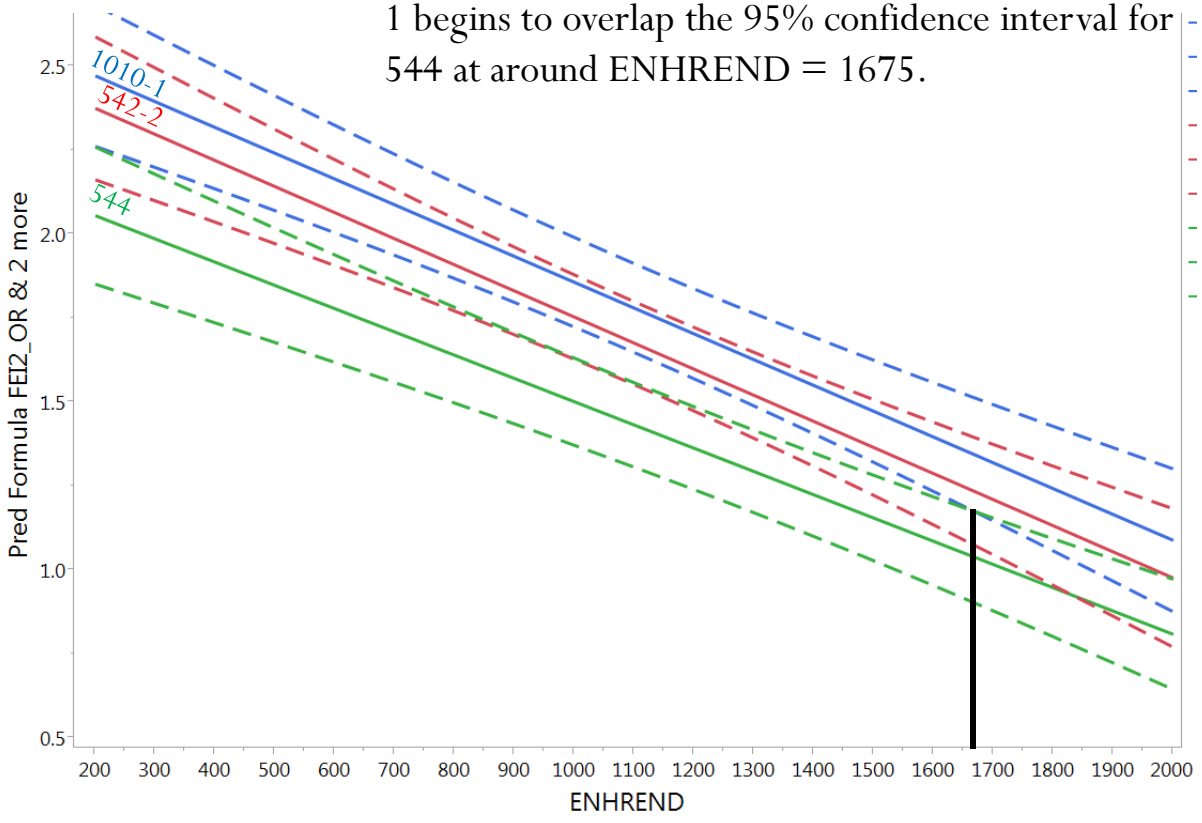
- FEI2 oil discrimination over the engine life
  - Using the prediction model we can obtain estimates for when oil discrimination is lost within each stand.
  - These estimates can be used to gauge VIE engine life based on FEI2

Lab-Engine	Predicted Hours at which 1010-1 no longer discriminates from 544
G 55	≈1675
B 123	≈1675

Refer to Appendix A for plots of other stands

Example: Using G 55

Notice how the 95% confidence interval for 1010-1 begins to overlap the 95% confidence interval for 544 at around ENHREND = 1675.



Assess Engine Life Based on Oil Discrimination

- FEI2 oil discrimination over the engine life
  - Another approach to determine VIF engine life would be to track the p-value of the oil*ENHREND term using various subsets of the valid matrix data. This significance of this term represents the point at which the same engine hour correction should no longer be used for all oils.

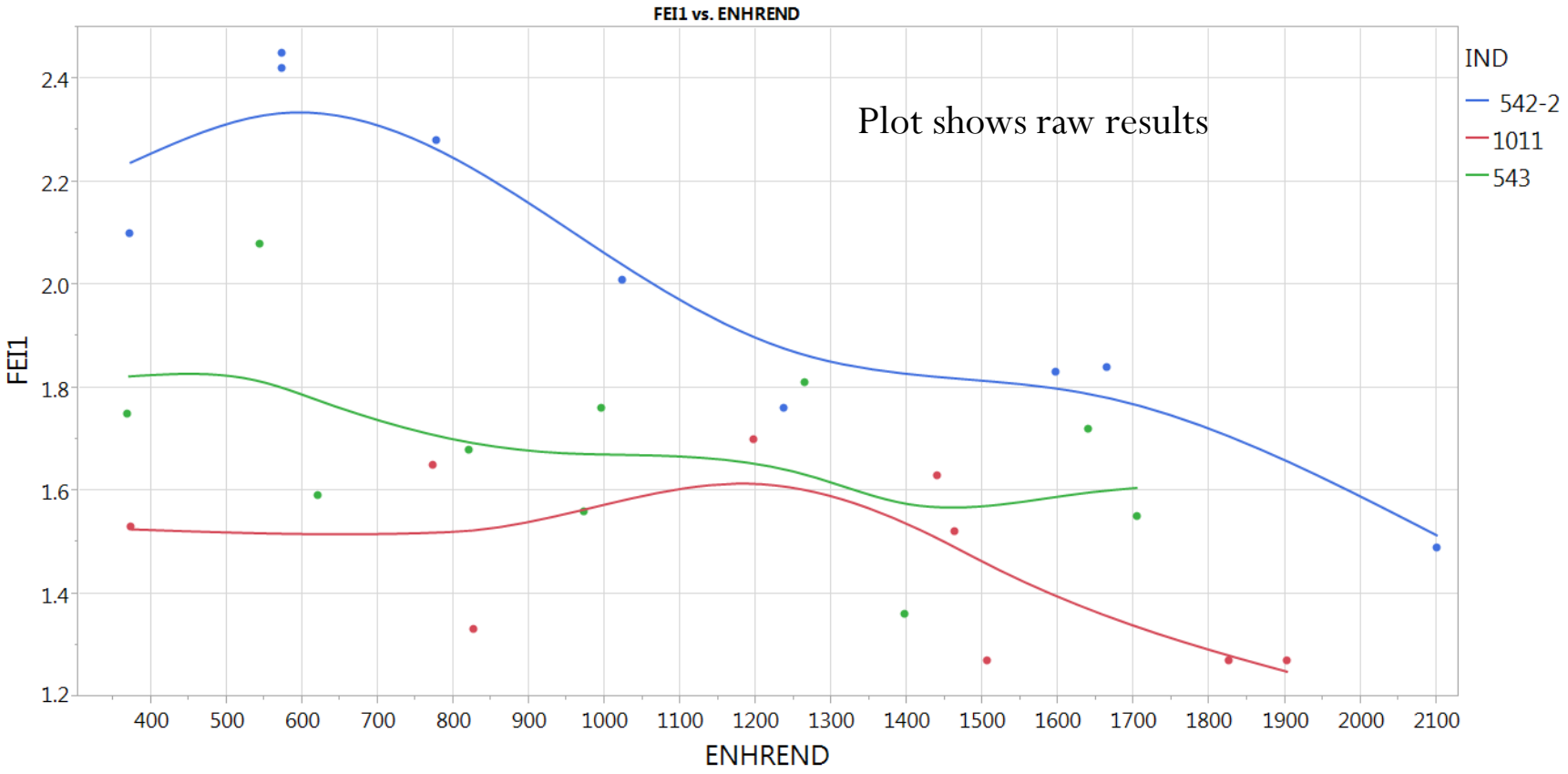
Data used	Number of test results	Overall p-value of oil*ENHREND term	Range of p-values by oil of oil*ENHREND term
ENHREND < 1100	29	.6932	.3995 to .7362
ENHREND < 1300	31	.2907	.1457 to .9725
ENHREND < 1450	33	.0963	.0530 to .5405
ENHREND < 1604	35	.0321	.0105 to .4557
ENHREND < 1800	37	.8998	.6722 to .9264
ENHREND < 2050	39	.8556	.5836 to .7673
All Valid Tests	42	.6871	.3910 to .7399

VIF Engine Life (n=28)

Based on FEI1 Oil Discrimination

Assess Engine Life Based on Oil Discrimination

- FEI1 oil discrimination over the engine life
  - Less oil discrimination occurs at higher hours



Assess Engine Life Based on Oil Discrimination

- Overall ANOVA Summary of FEI1 data:
  - Analysis indicates that the engine hours effect in FEI1 is not consistent across the oils tested

Summary of Fit

RSquare	0.841812
RSquare Adj	0.775207
Root Mean Square Error	0.15371
Mean of Response	1.721786
Observations (or Sum Wgts)	28

Analysis of Variance

Parameter Estimates

Term	Estimate	Prob>|t|	VIF
Intercept	1.9908417	<.0001*	.
IND[542-2]	0.3070791	<.0001*	1.4689633
IND[1011]	-0.263521	<.0001*	1.5751954
LTMSLAB[A]	0.0360773	0.2456	1.0689289
LTMSLAB[A]:ENGNO[122]	0.0333984	0.4443	1.1576671
LTMSLAB[G]:ENGNO[58]	-0.113188	0.0221*	1.1077156
ENHREND	-0.000235	0.0012*	1.1346756
(ENHREND-1126.5)*IND[542-2]	-0.000224	0.0125*	1.3256859
(ENHREND-1126.5)*IND[1011]	0.0001796	0.0671	1.4722341

Effect Tests

Source	Prob > F
IND	<.0001*
LTMSLAB	0.2456
ENGNO[LTMSLAB]	0.0603
ENHREND	0.0012*
ENHREND*IND	0.0333*

Assess Engine Life Based on Oil Discrimination

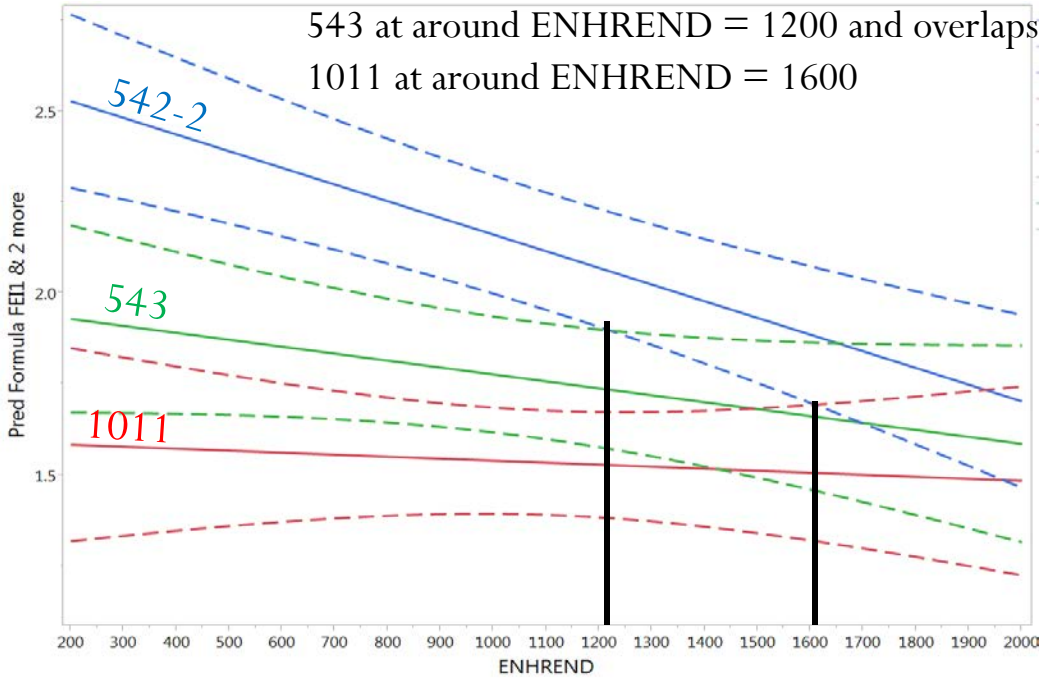
- FEI1 oil discrimination over the engine life
  - Using the prediction model we can obtain estimates for when oil discrimination is lost within each stand.
  - These estimates can be used to gauge VIF engine life

Lab-Engine	Predicted Hours at which 542-2 no longer discriminates from all other oils	Predicted Hours at which 542-2 no longer discriminates from any other oil
A 144	≈ 1300	≈ 1650
A 122	≈ 1200	≈ 1600
G 58	≈ 1300	≈ 1700
G 96	≈ 1150	≈ 1600

Refer to Appendix A for plots of other stands

Example: Using A 122

Notice how the 95% confidence interval for 542-2 begins to overlap the 95% confidence interval for 543 at around ENHREND = 1200 and overlaps 1011 at around ENHREND = 1600



Assess Engine Life Based on Oil Discrimination

- FEI1 oil discrimination over the engine life
  - Another approach to determine VIF engine life would be to track the p-value of the oil*ENHREND term using various subsets of the valid matrix data. This significance of this term represents the point at which the same engine hour correction should no longer be used for all oils.

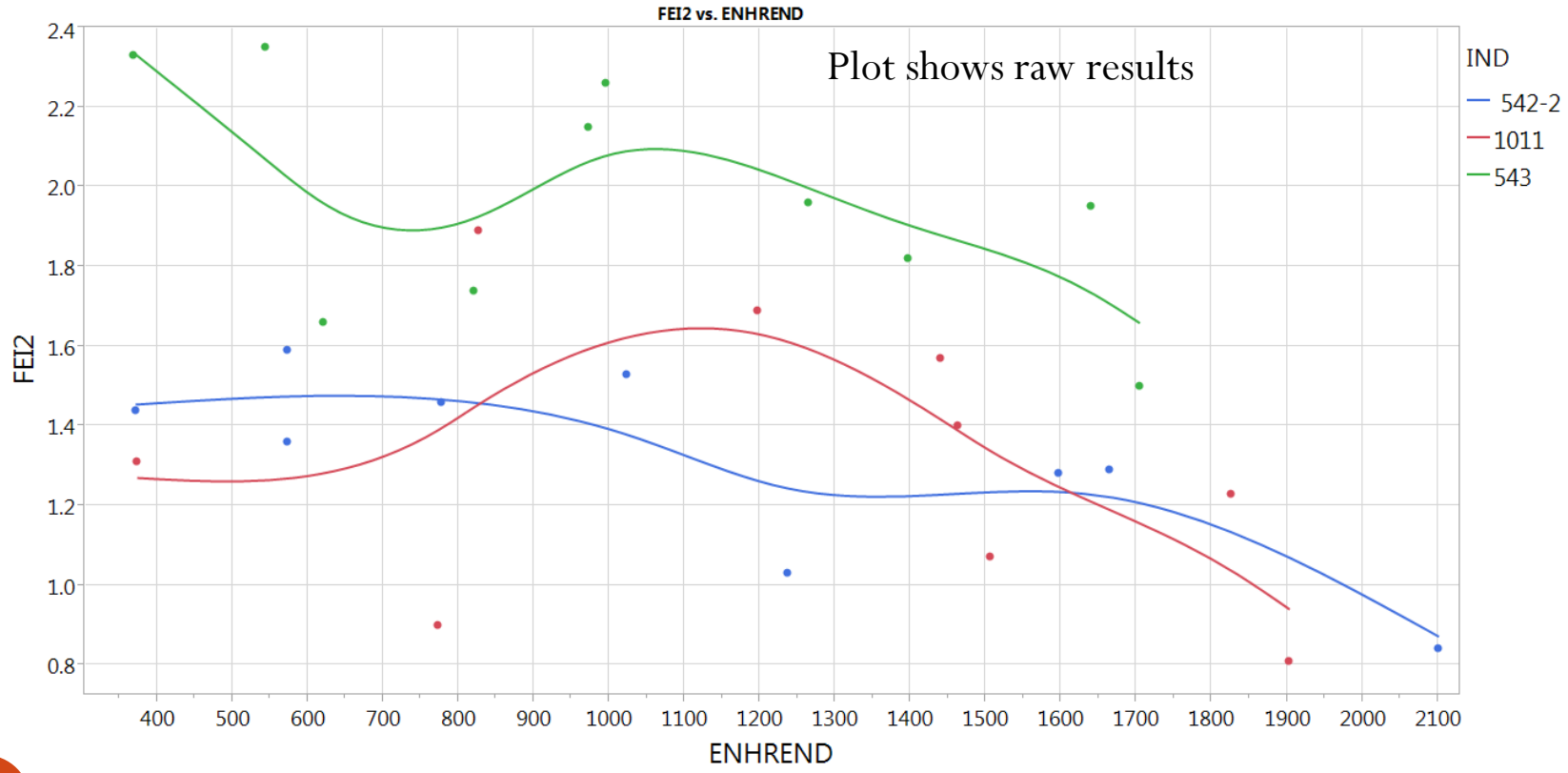
Data used	Number of test results	Overall p-value of oil*ENHREND term	Range of p-values by oil of oil*ENHREND term
ENHREND < 1100	14	.8321	.5872 to .9833
ENHREND < 1300	17	.2591	.1489 to .8258
ENHREND < 1450	19	.0648	.0228 to .2633
ENHREND < 1600	22	.0402	.0163 to .3575
ENHREND < 1800	25	.0392	.0147 to .8215
All Valid Tests	28	.0333	.0125 to .6322

VIF Engine Life (n=28)

Based on FEI2 Oil Discrimination

Assess Engine Life Based on Oil Discrimination

- FEI2 oil discrimination over the engine life
  - 543 discrimination from 542-2 and 1011 is consistent throughout the engine life



Assess Engine Life Based on Oil Discrimination

- Overall ANOVA Summary of FEI2 data:
  - Analysis indicates that the engine hours effect in FEI2 is consistent across the oils tested

Summary of Fit

Root Mean Square Error	0.178313
Mean of Response	1.550357
Observations (or Sum Wgts)	28

Analysis of Variance

Parameter Estimates

Term	Estimate	Prob>|t|	VIF
Intercept	1.8080271	<.0001*	.
IND[542-2]	-0.194258	0.0009*	1.4689633
IND[1011]	-0.214514	0.0005*	1.5751954
LTMSLAB[A]	0.0228922	0.5201	1.0689289
LTMSLAB[A]:ENGNO[122]	-0.076093	0.1414	1.1576671
LTMSLAB[G]:ENGNO[58]	-0.279961	<.0001*	1.1077156
ENHREND	-0.000227	0.0051*	1.1346756
(ENHREND-1126.5)*IND[542-2]	-0.000021	0.8261	1.3256859
(ENHREND-1126.5)*IND[1011]	0.0001242	0.2616	1.4722341

Effect Tests

Source	Prob > F
IND	<.0001*
LTMSLAB	0.5201
ENGNO[LTMSLAB]	<.0001*
ENHREND	0.0051*
ENHREND*IND	0.4947

Assess Engine Life Based on Oil Discrimination

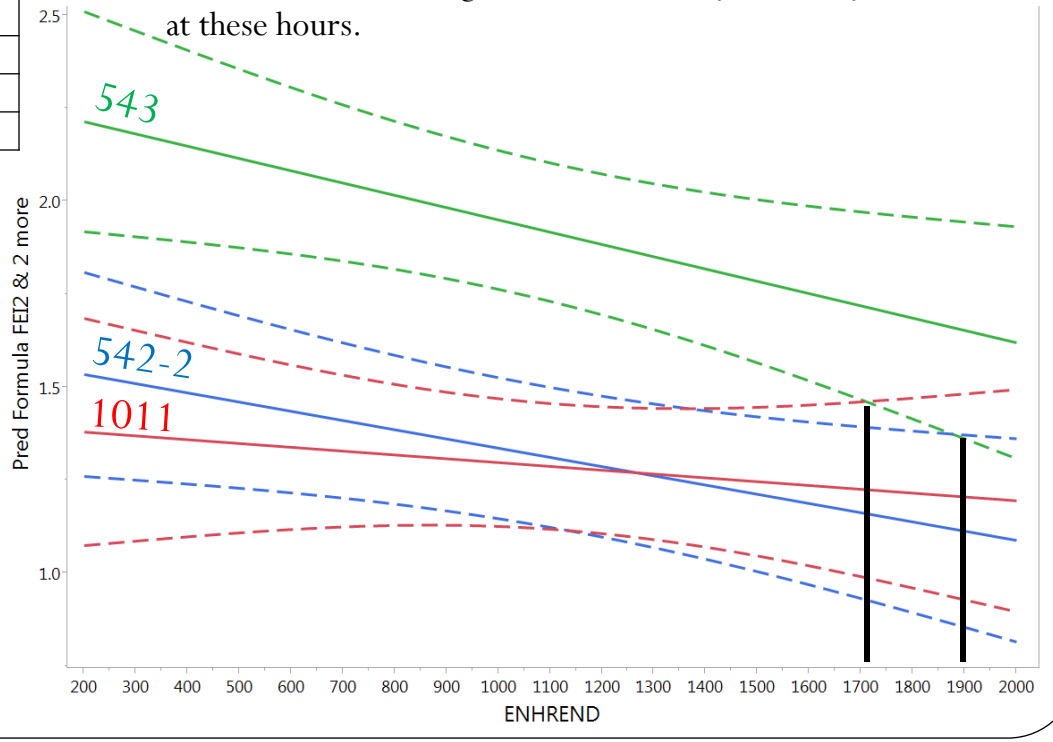
- FEI2 oil discrimination over the engine life
  - Using the prediction model we can obtain estimates for when oil discrimination is lost within each stand.
  - These estimates can be used to gauge VIF engine life based on FEI2

Lab-Engine	Predicted Hours at which 543 no longer discriminates from all other oils	Predicted Hours at which 543 no longer discriminates from any oil
A 144	≈ 1750	≈ 1900
A 122	≈ 1700	≈ 1900
G 58	≈ 1800	≈ 1950
G 96	≈ 1700	≈ 1825

Refer to Appendix A for plots of other stands

Example: Using A 122

Notice how the 95% confidence interval for 543 begins to overlap the 95% confidence interval for 1011 at around ENHREND = 1700 and overlaps 542-2 at around ENHREND = 1900. This loss of discrimination at higher hours is mostly driven by a lack of data at these hours.



Assess Engine Life Based on Oil Discrimination

- FEI2 oil discrimination over the engine life
  - Another approach to determine VIF engine life would be to track the p-value of the oil*ENHREND term using various subsets of the valid matrix data. This significance of this term represents the point at which the same engine hour correction should no longer be used for all oils.

Data used	Number of test results	Overall p-value of oil*ENHREND term	Range of p-values by oil of oil*ENHREND term
ENHREND < 1100	14	.1799	.1210 to .9242
ENHREND < 1300	17	.2870	.1293 to .6012
ENHREND < 1450	19	.5187	.3320 to .9908
ENHREND < 1600	22	.2498	.1325 to .7137
ENHREND < 1800	25	.1763	.0725 to .4185
All Valid Tests	28	.4947	.2616 to .8261

VIF Engine Life

Based on # of standard deviations of oil separation

Diminishing Oil Discrimination in VIE

FEI1	EngHr	542-2	1010-1	544	542-2-544	# of Sd
	350	2.75	2.02	1.36	1.39	5.34
	550	2.61	1.93	1.30	1.31	5.03
	750	2.47	1.84	1.24	1.23	4.72
	950	2.33	1.75	1.18	1.15	4.42
	1150	2.19	1.66	1.12	1.07	4.11
	1350	2.05	1.56	1.06	0.99	3.80
	1550	1.91	1.47	1.00	0.91	3.49
	1750	1.77	1.38	0.94	0.83	3.18
	1950	1.63	1.29	0.88	0.75	2.88
	2150	1.49	1.20	0.82	0.67	2.57
	2350	1.35	1.10	0.76	0.59	2.26
FEI2	EngHr	542-2	1010-1	544	1010-1-544	# of Sd
	350	2.20	2.30	1.87	0.43	2.70
	550	1.82	1.90	1.39	0.50	3.14
	750	1.61	1.65	1.25	0.40	2.49
	950	1.44	1.46	1.14	0.32	2.00
	1150	1.31	1.31	1.05	0.26	1.61
	1350	1.20	1.18	0.98	0.20	1.27
	1550	1.10	1.07	0.92	0.16	0.99
	1750	1.02	0.98	0.86	0.12	0.73
	1950	0.95	0.89	0.81	0.08	0.51
	2150	0.88	0.82	0.77	0.05	0.31
	2350	0.82	0.74	0.73	0.02	0.12

n=42	FEI1	FEI2
RMSE	0.26	0.16
LSMeans		
542-2	2.33	1.43
1010-1	1.77	1.54
544	1.19	1.18
Effect Size		
%	1.14	0.36
SD	4.38	2.25

Model: Oil, Lab, Engine(Lab), Enghr

Test discriminates FEI2 approximately 2 standard deviations up to around the 4th test.

Diminishing Oil Discrimination in VIF

FEI1	EngHr	542-2	1011	543	542-2-1011	# of Sd	543-1011	# of Sd
	350	2.41	1.51	1.84	0.90	5.31	0.33	1.97
	550	2.33	1.50	1.81	0.83	4.90	0.31	1.84
	750	2.25	1.49	1.78	0.76	4.49	0.29	1.71
	950	2.17	1.48	1.75	0.69	4.07	0.27	1.58
	1150	2.09	1.47	1.71	0.62	3.66	0.25	1.45
	1350	2.01	1.46	1.68	0.55	3.25	0.22	1.32
	1550	1.93	1.45	1.65	0.48	2.84	0.20	1.19
	1750	1.85	1.44	1.62	0.41	2.43	0.18	1.06
	1950	1.77	1.43	1.59	0.34	2.01	0.16	0.93
	2150	1.69	1.42	1.55	0.27	1.60	0.14	0.80
	2350	1.61	1.41	1.52	0.20	1.19	0.11	0.67
FEI2	EngHr	542-2	1011	543	543-542-2	# of Sd	543-1011	# of Sd
	350	1.56	1.42	2.23	0.67	3.71	0.81	4.50
	550	1.52	1.40	2.17	0.65	3.62	0.77	4.27
	750	1.47	1.38	2.11	0.64	3.53	0.73	4.05
	950	1.43	1.36	2.05	0.62	3.44	0.69	3.83
	1150	1.38	1.34	1.99	0.60	3.35	0.65	3.61
	1350	1.34	1.32	1.93	0.59	3.26	0.61	3.39
	1550	1.30	1.30	1.87	0.57	3.18	0.57	3.16
	1750	1.25	1.28	1.81	0.56	3.09	0.53	2.94
	1950	1.21	1.26	1.75	0.54	3.00	0.49	2.72
	2150	1.16	1.24	1.69	0.52	2.91	0.45	2.50
	2350	1.12	1.22	1.63	0.51	2.82	0.41	2.27

n=28	FEI1	FEI2
RMSE	0.17	0.18
LSMeans		
542-2	2.03	1.35
1011	1.49	1.36
543	1.67	1.97
Effect Size		
%	0.54	0.62
SD	3.18	3.44

Model: Oil, Lab, Engine(Lab), Enghr

Test discriminates FEI1 approximately 3 standard deviations up to around the 5th test.

Benchmarking: Oil Discrimination in Various GF-5 PCMO Tests

- Sequence IIIG ln(PVIS): oils separated by 2.0 standard deviations
- Sequence IIIG WPD: oils separated by 2.3 standard deviations
- Sequence IVA wear: oils separated by 1.2 standard deviations
- Sequence VID FEI2: oils separated by 2.9 standard deviations

Seq IIIG

PERCENT VISCOSITY INCREASE
Unit of Measure: LN(PVIS)

Reference Oil	Mean	Standard Deviation
434	4.7269	0.3859
435	5.1838	0.3096
435-2	5.1838	0.3096
438	4.5706	0.1768

Seq IIIG

WEIGHTED PISTON DEPOSITS
Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
434	4.80	0.96
435	3.59	0.58
435-2	3.59	0.58
438	3.20	0.33

Seq IVA

AVERAGE CAMSHAFT WEAR
Unit of Measure: micrometers

Reference Oil	Mean	Standard Deviation
1006-2	102.18	13.54
1007	84.76	15.40

Seq VID

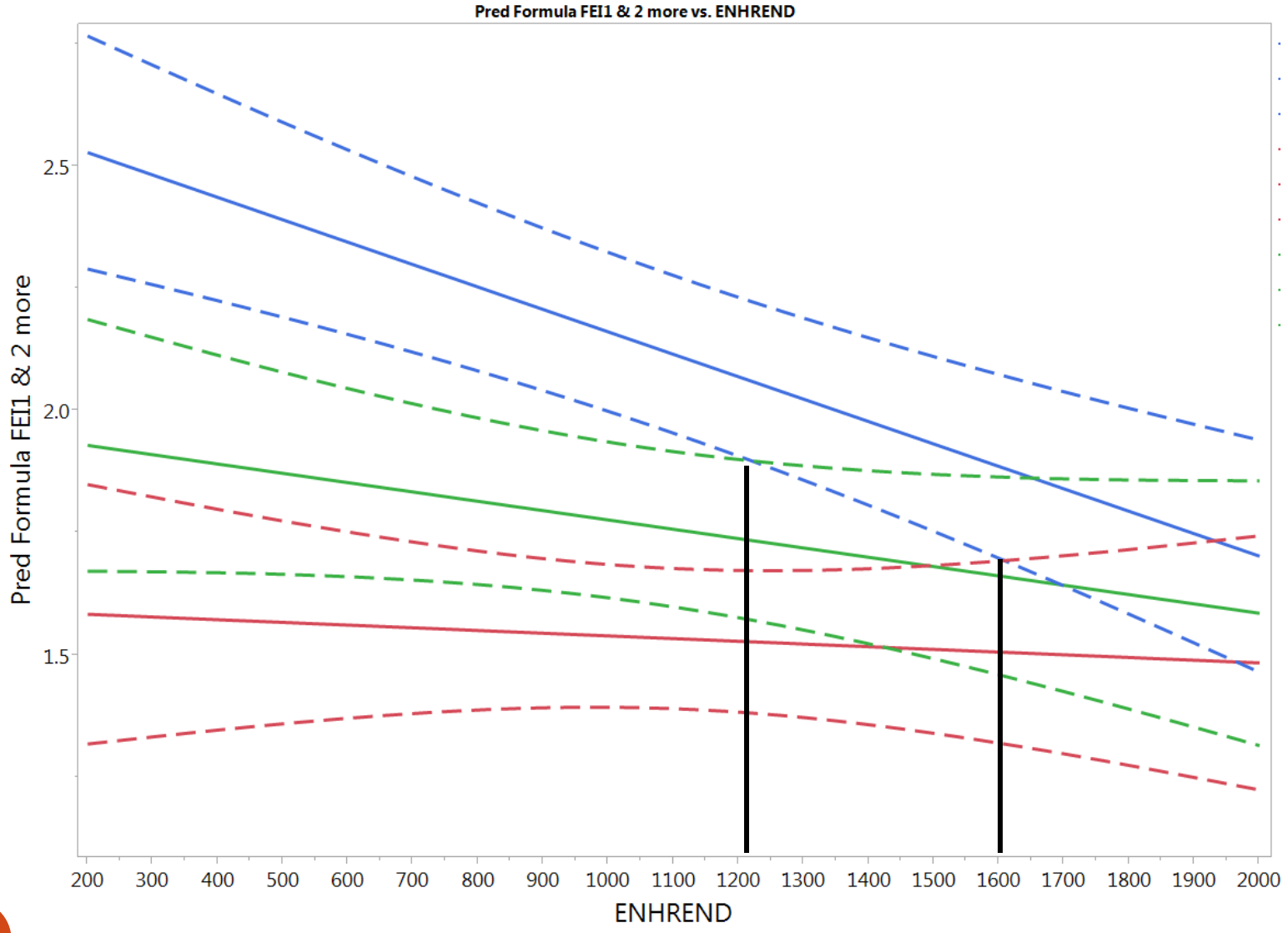
FUEL ECONOMY IMPROVEMENT at 100 Hours
Unit of Measure: Percent

Reference Oil	Mean	Standard Deviation
540 (GF5A)	1.04	0.14
541 (GF5D)	0.71	0.14
542 (GF5X)	0.80	0.14
1010	1.10	0.18

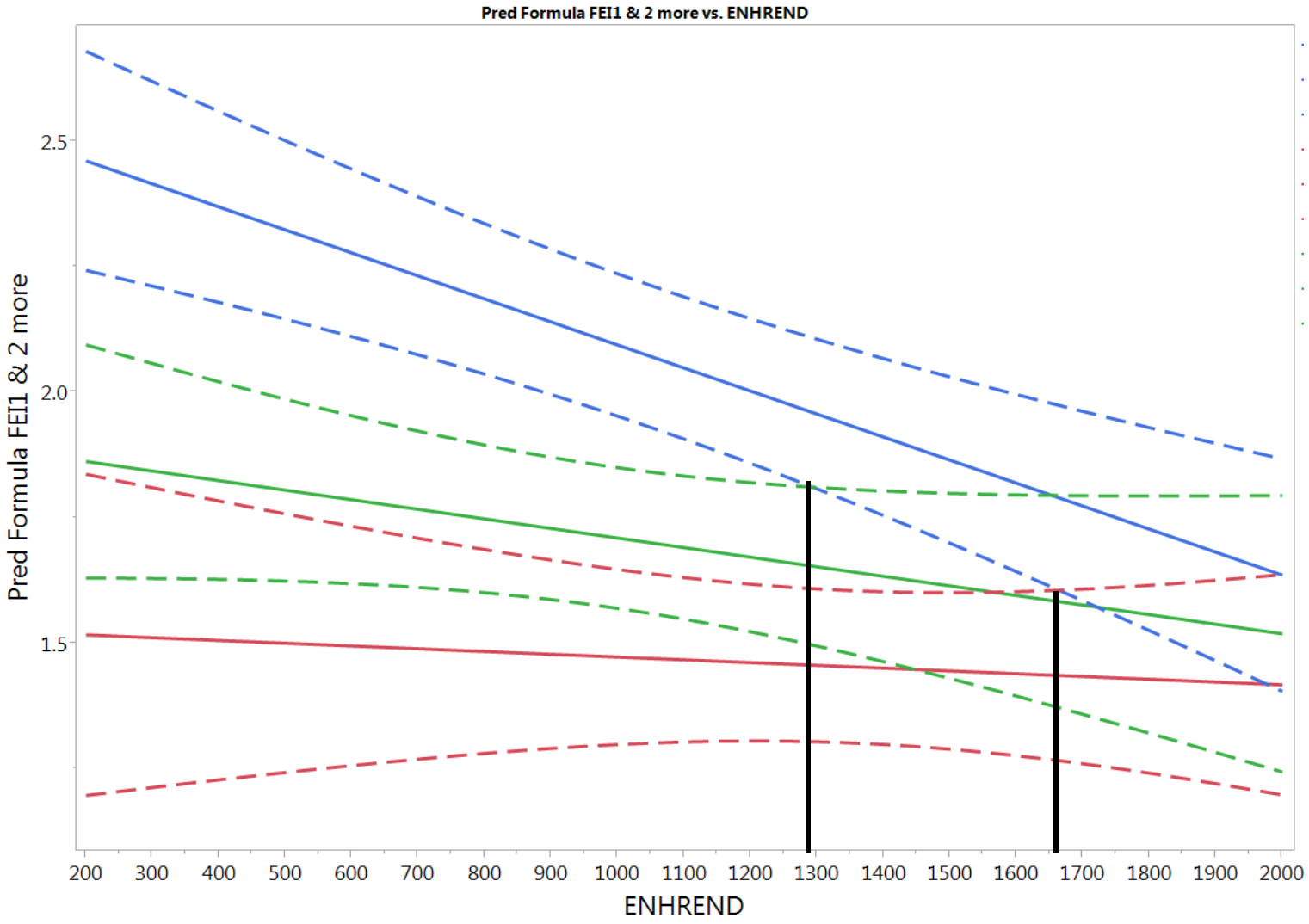
Appendix A

Additional Engine Plots

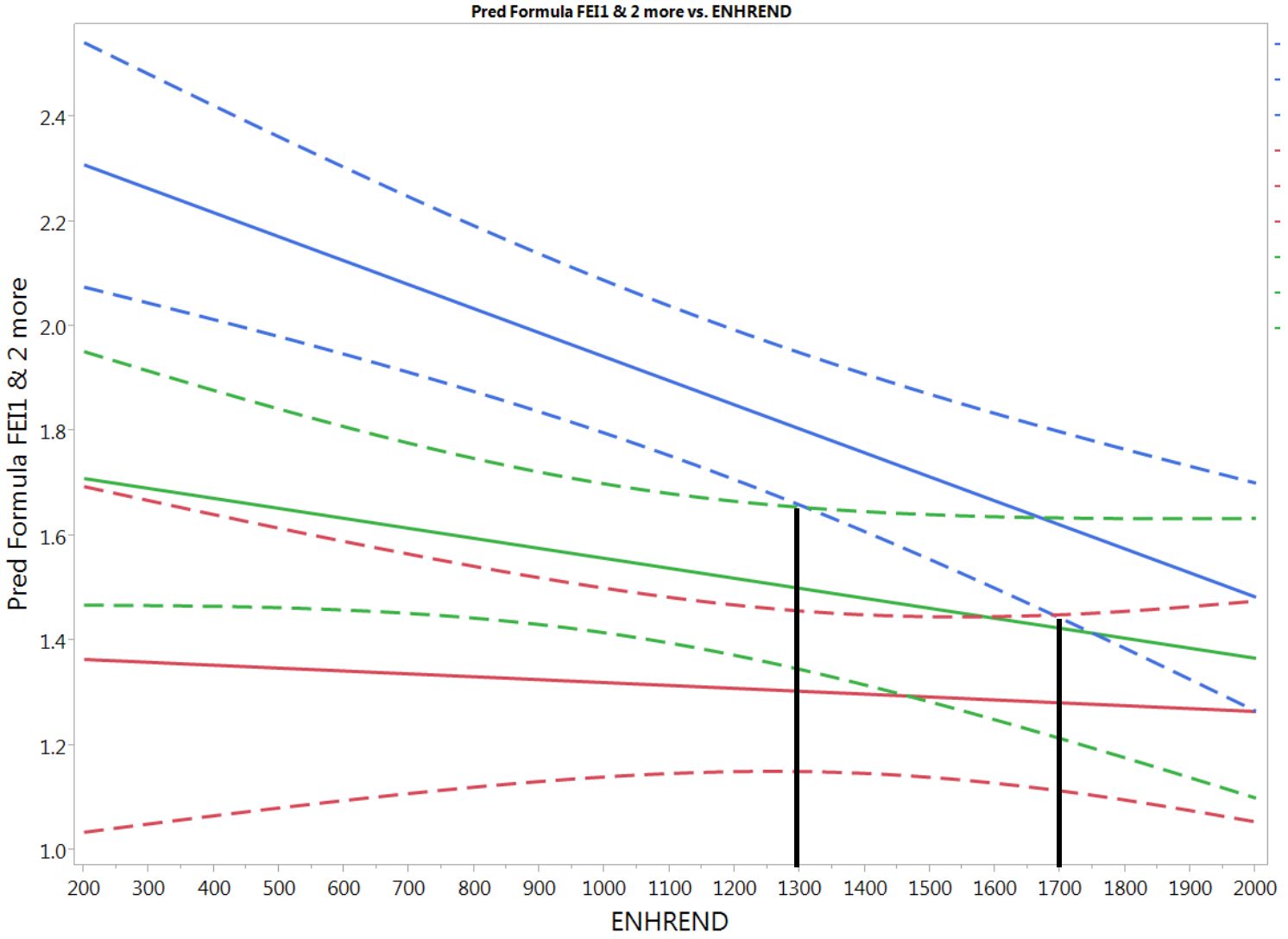
VIF Lab A Eng. 122 FEI1



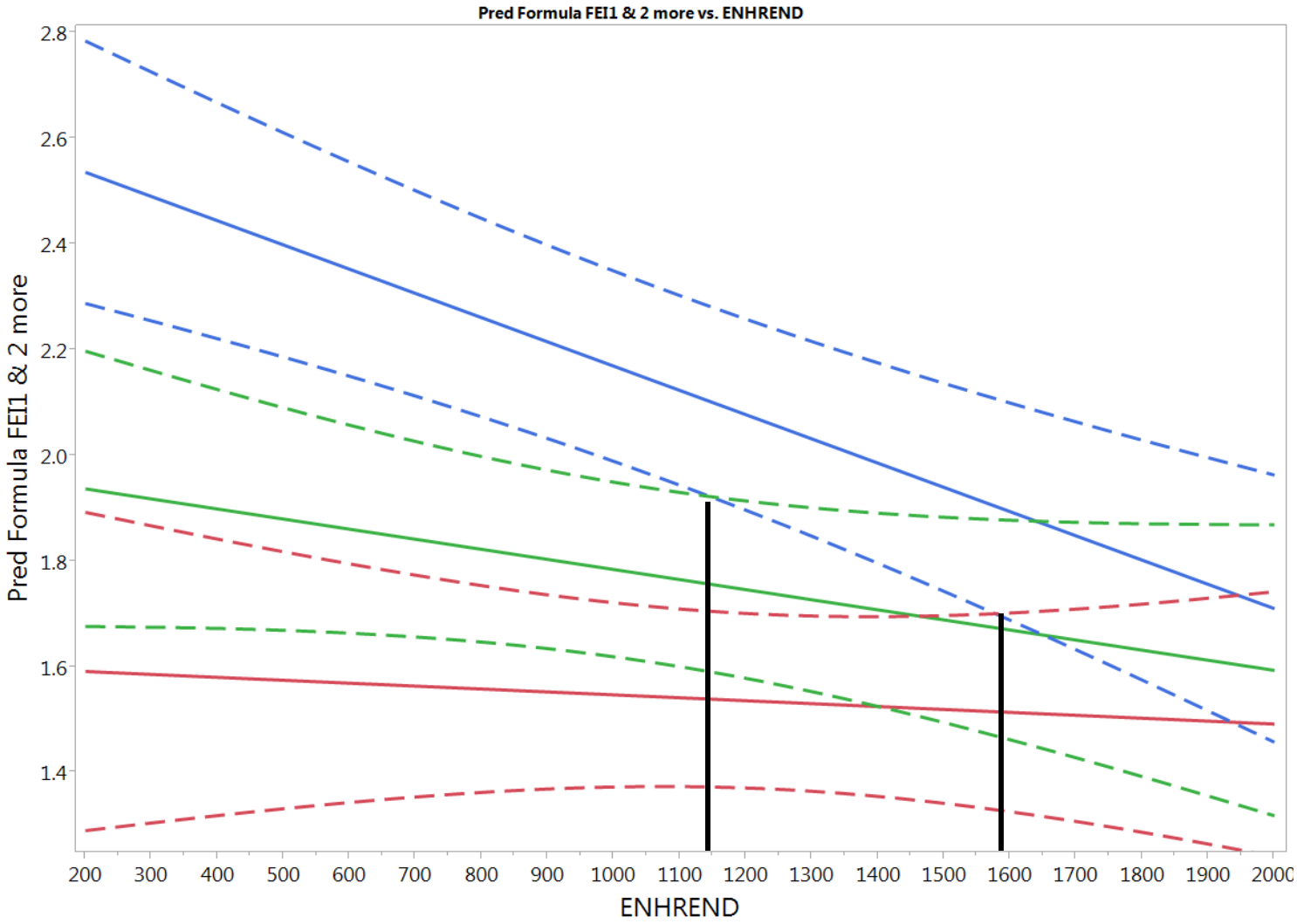
VIF Lab A Eng. 144 FEI1



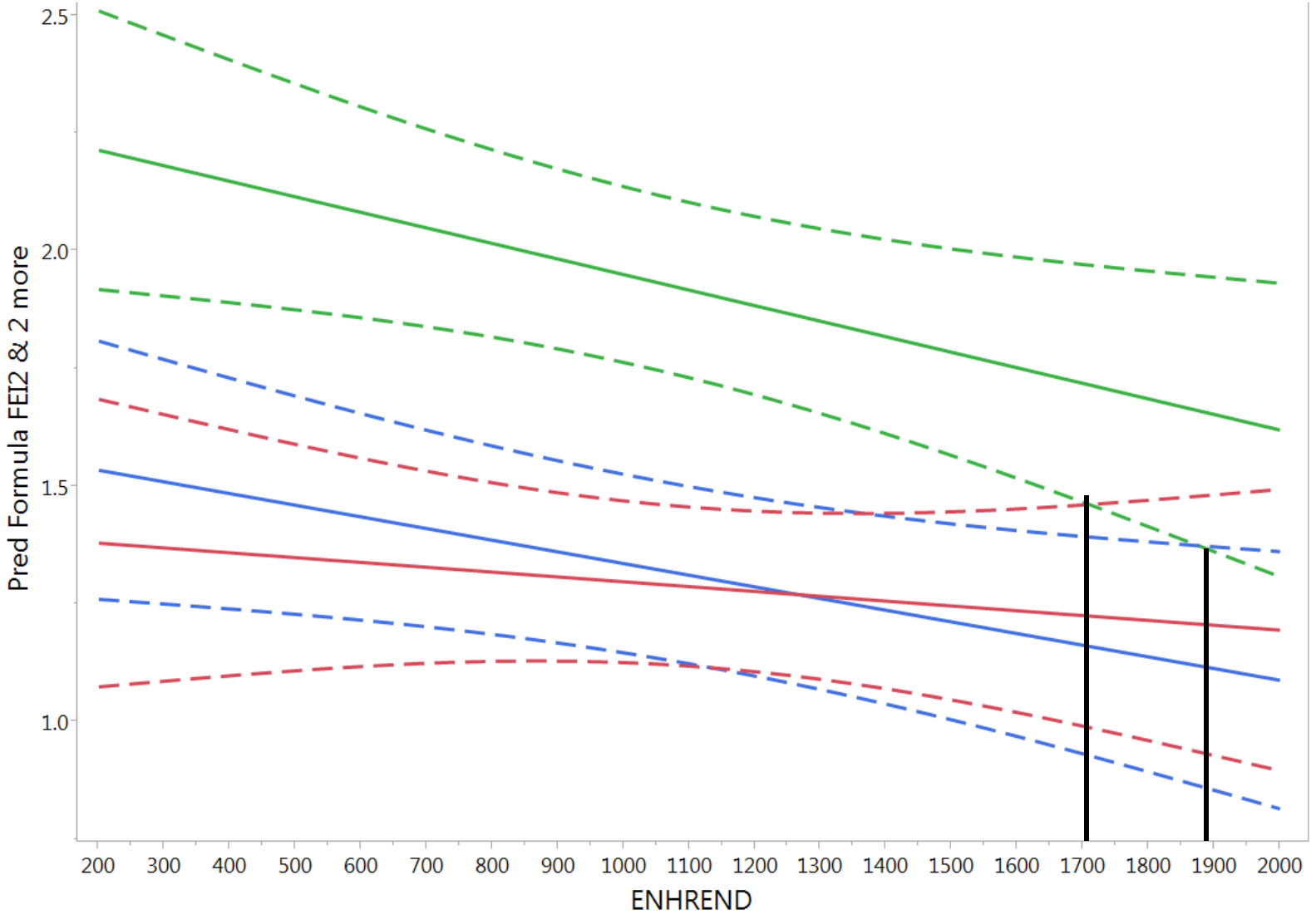
VIF Lab G Eng. 58 FEI1



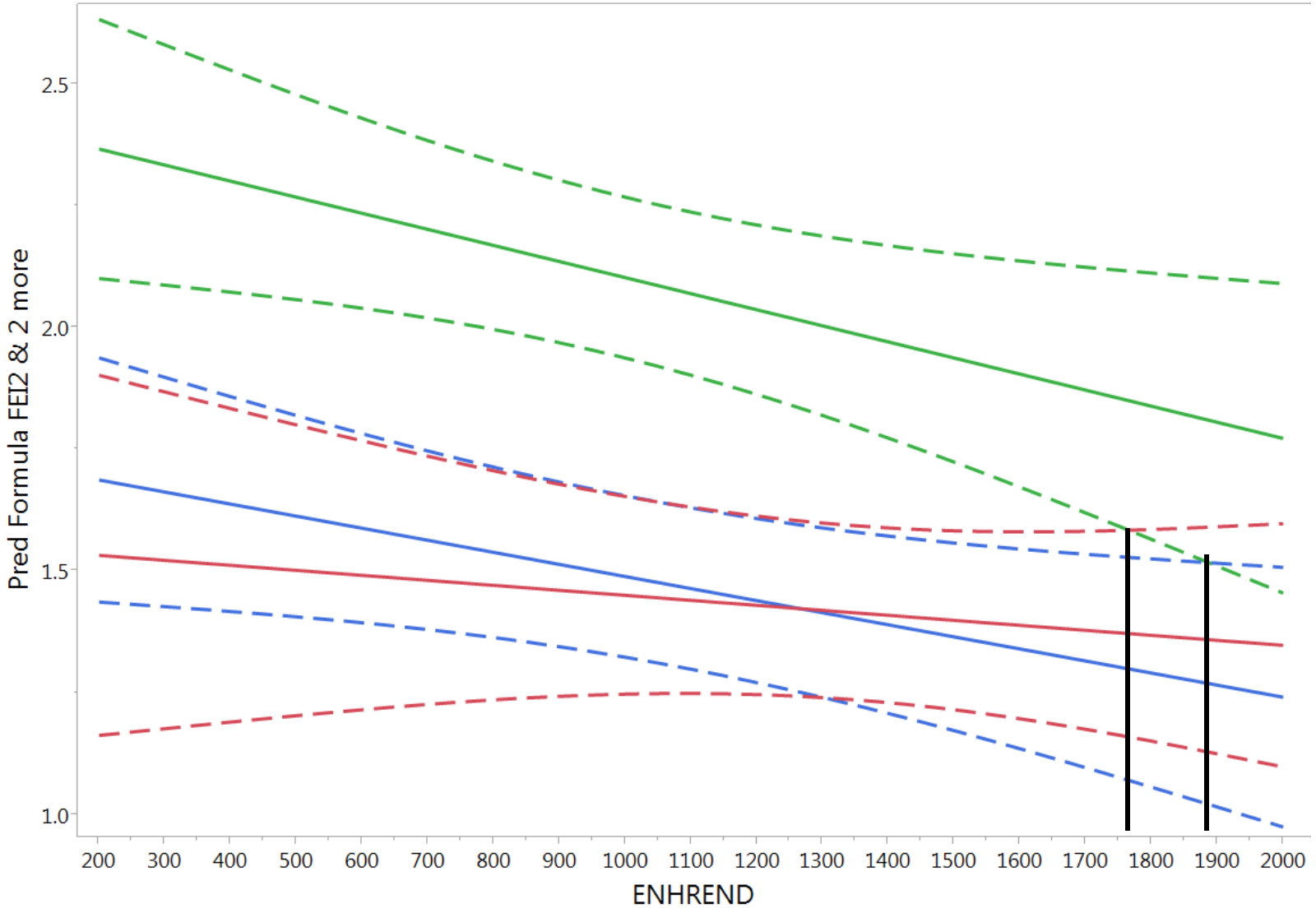
VIF Lab G Eng. 96 FEI1



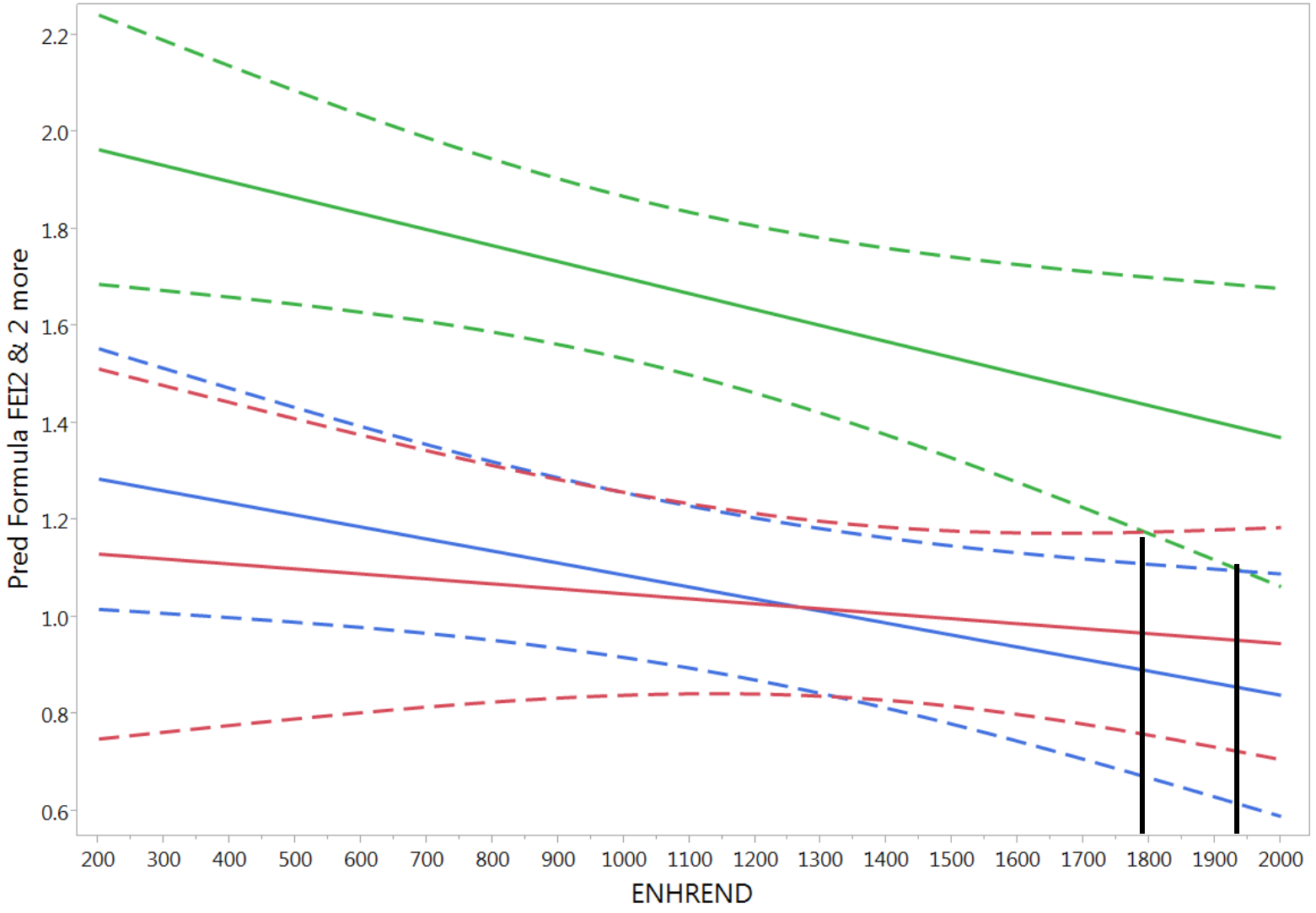
VIF Lab A Eng. 122 FEI2



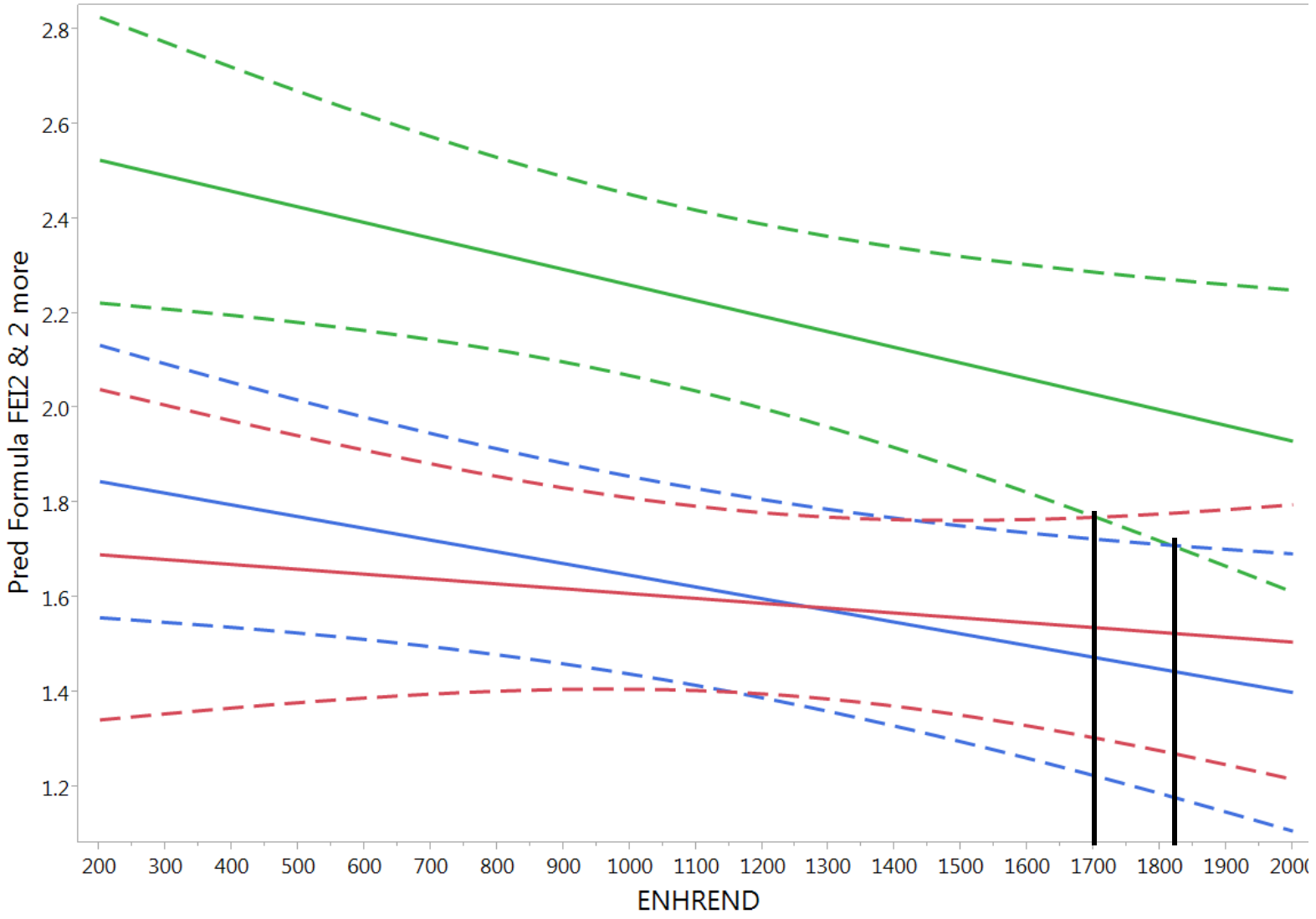
VIF Lab A Eng. 144 FEI2



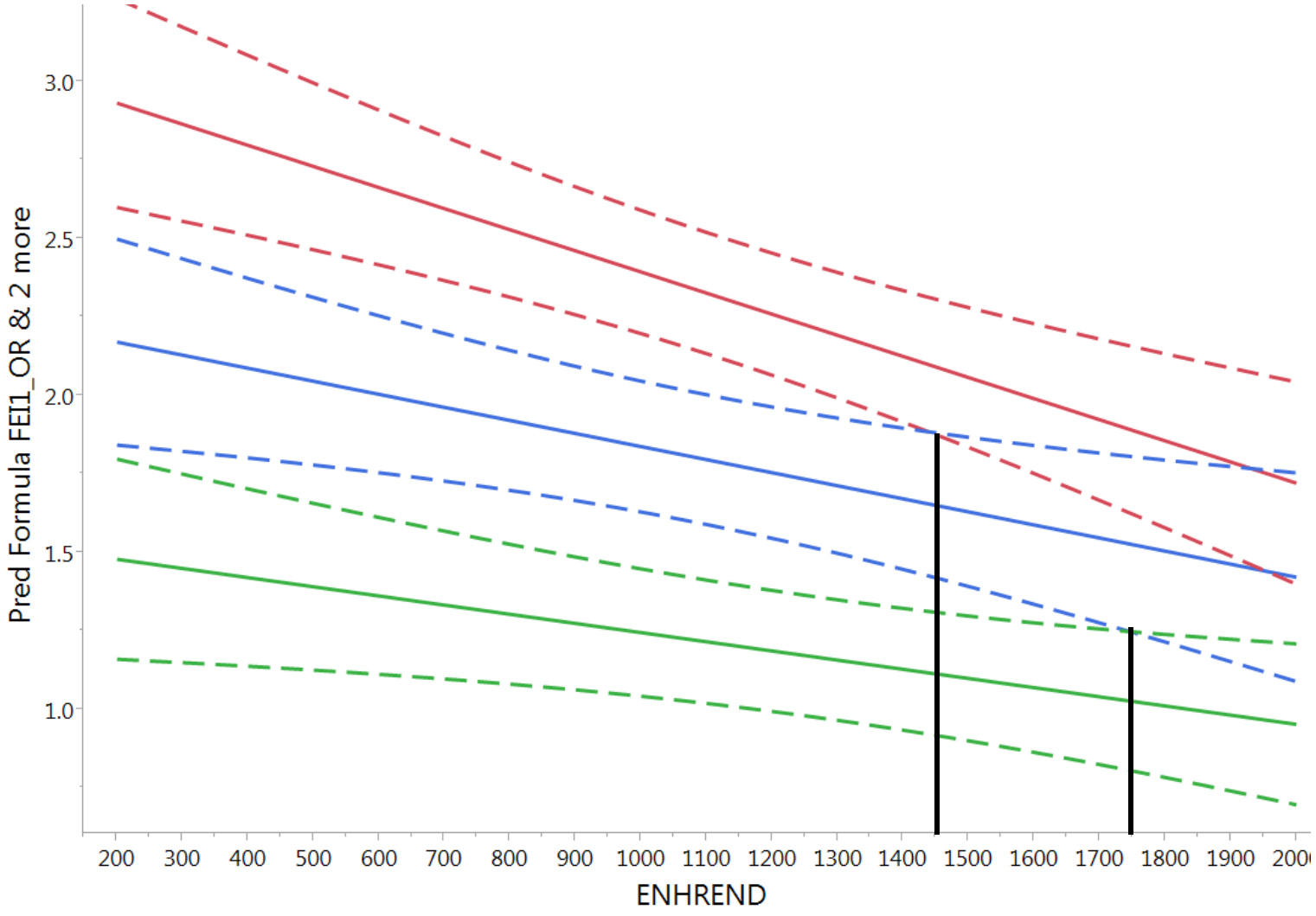
VIF Lab G Eng. 58 FEI2



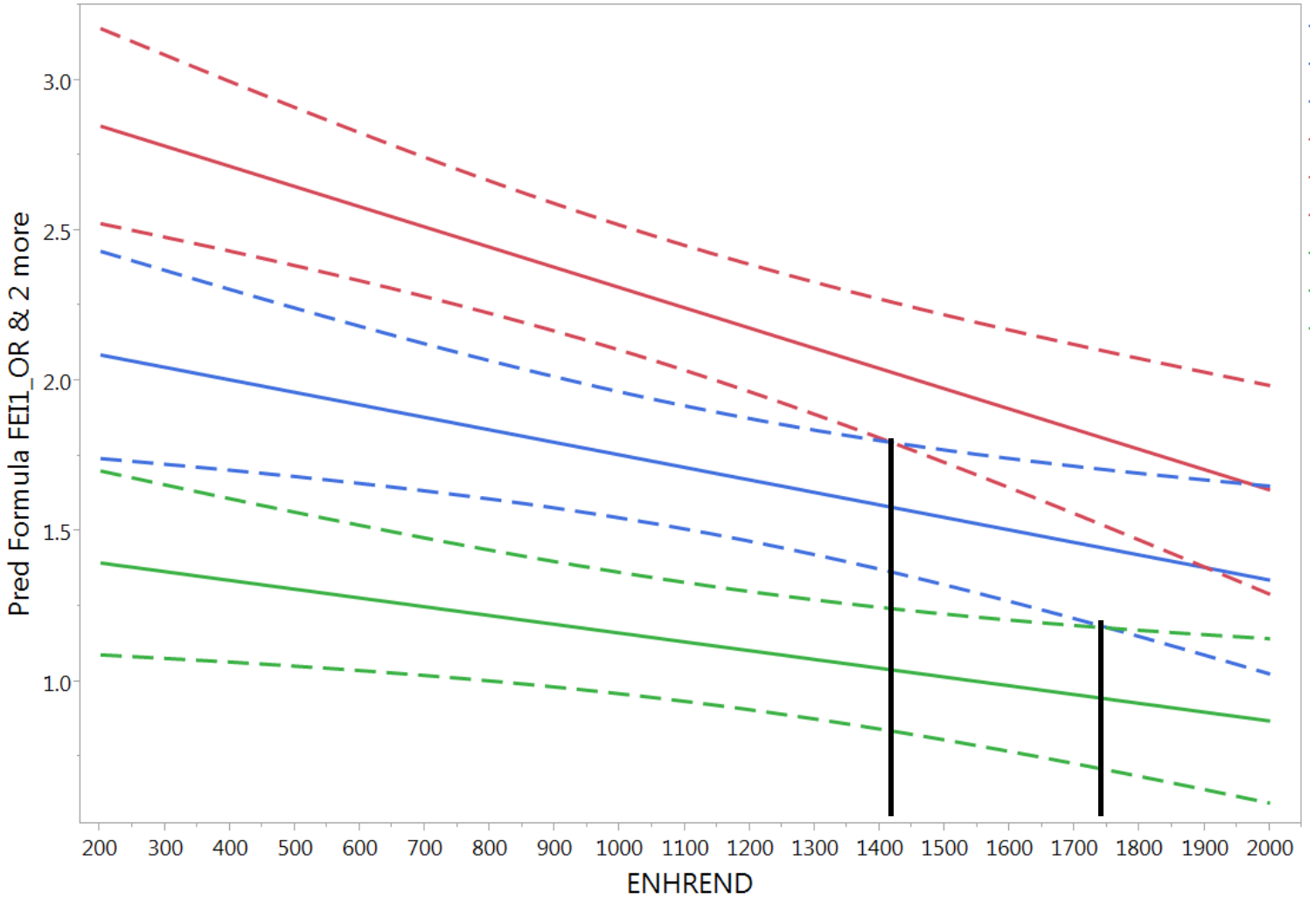
VIF Lab G Eng. 96 FEI2



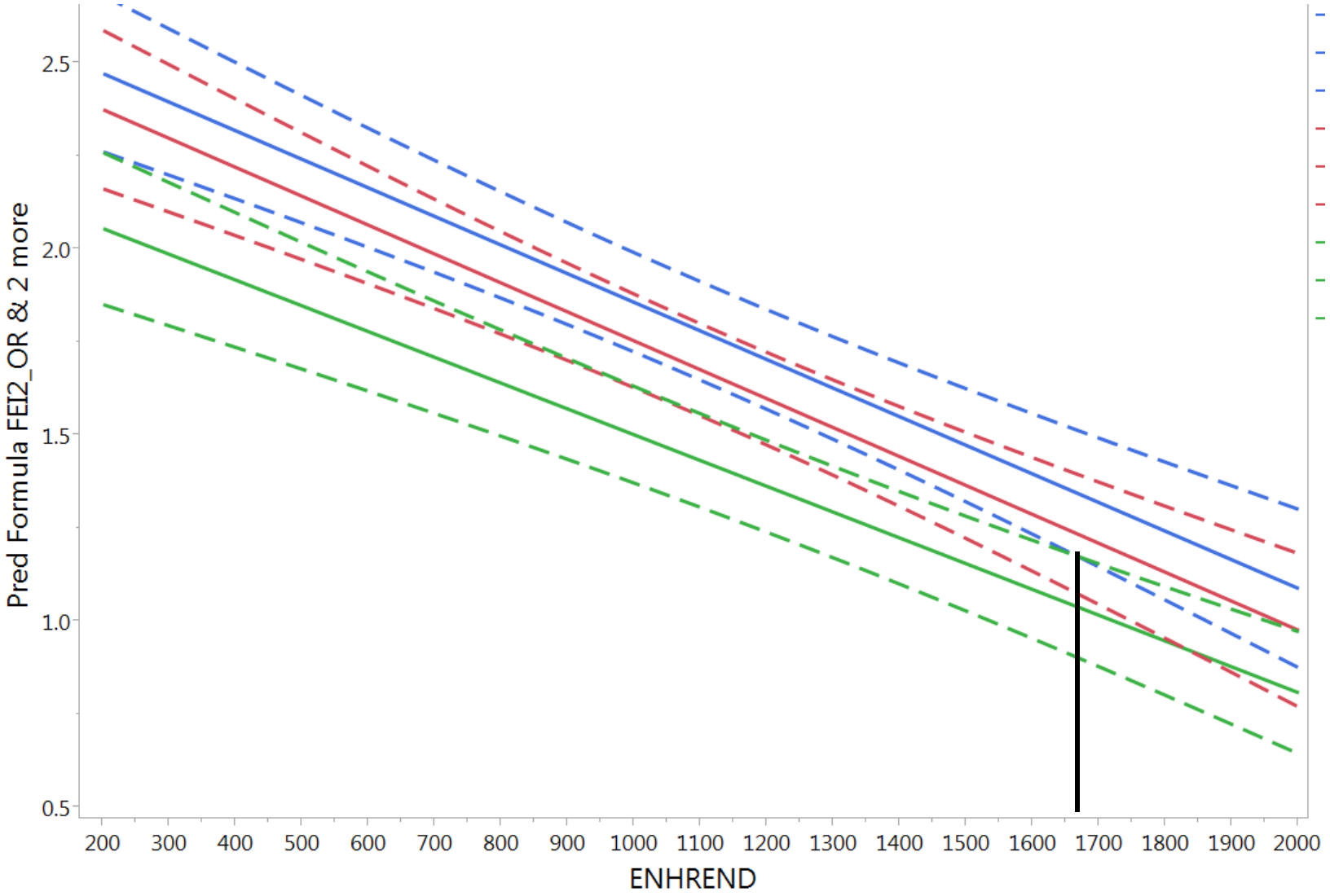
VIE Lab G Eng. 55 FEI1



VIE Lab B Eng. 123 FEI1



VIE Lab G Eng. 55 FEI2



VIE Lab B Eng. 123 FEI2