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COMMITTEE D02 ON PETROLEUM PRODUCTS, LIQUID FUELS, AND LUBRICANTS

Issued: June 1, 2016

Reply to: Dan Worcester
Southwest Research Institute
6220 Culebra Rd.
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These are the unapproved minutes of the 05.24-25.2016 Sequence VI Surveillance Panel meetings.

The meeting was called to order at 8:35 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 for 05.24 and Attachment 3 for 05.25.

2.0 Approval of minutes

2.1 Approval of the minutes of the 05.17.2016 meeting.

ftp://ftp.astmtmc.cmu.edu/docs/gas/sequencevi/minutes/VIMinutes201600517ConferenceCall.pdf

MOTION: Approve the minutes from the 05.17.2016 conference call.

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[Nathan Moles, Dan Worcester, second] Minutes were approved unanimously.

3.0 Action Item Review

3.1 OHT to provide update on current VIE inventory and service engine order. –OHT
There are 11 -001 and 144 -002 engines. SwRI has indicated they can only order 12 more from this total of 155.

ACTION: OHT will have a conference call to discuss options on the remaining engines.

3.2 Update of VID engine inventory and expected depletion date of VID engines.
-*Expected depletion of VID engines 2016 Q3* There are no new VID engines. Expected end of VID testing would be October 2016.

4.0 Old Business

4.1	8:55-9:10	Update from task force, to investigate alternative test procedure Sequence "VIF" that would improve 0W-16. – Dan Worcester/Satoshi Hirano SwRI and IAR will complete the VIF Matrix in mid-June. There will be a meeting with the Surveillance Panel in July to work on moving forward. See Attachment 4 and Attachment 5 for updated test results for the VIF Matrix. Work will need to begin on a separate VIF test procedure. Oil 1011 does not show a shift with engine hours.
4.2	9:10-9:15	Update from task force to investigate option to use short blocks to supplement engine inventory. –Adrian Alfonso/Bill Buscher The kits are being finalized.
4.3	9:15-9:45	Data validity discussion –Rich G. and Dan W. The test validity items were reviewed. See Attachment 6 for validity comments.
4.4		List of items to be reviewed after the Precision Matrix -All This will be an on-going effort.
4.4.1	9:45-10:30	Preliminary Analysis on Oil Discrimination over Engine Life (Stat Group Addendum presentation) See Attachment 7 for the initial analysis for the meeting. There was concern that the initial test on an engine after break in shows a different response than later in the engine life. This may indicate more break in or a different break in method would affect response early in engine life. The FEI 2 response shifts after 1000 hours of engine life. BL After has a wider range than the VID, and engine 128 showed a much greater BL After

		shift while completing the matrix. SwRI tore down engine 128 and found a burned valve on #2 cylinder. The last two tests in the Precision Matrix were invalidated. See Attachment 8 where all data from engine 128 and all engines with greater than 1000 test hours were removed for analysis. This would move to 4 runs plus break in for each engine. One option considered was to have the 5th run be on reference oil 1010-1 to get more tests on an engine [out to 1200 hours]. MOTION: Remove all data for SwRI engine 128 and use only the first 4 runs on each engine, for 29 data points for Precision Matrix analysis. Rich Grundza, Andy Ritchie second. 11 yes, 1 waive, 1 no. The motion passed.
4.4.2	10:45-11:30	Finalize engine hours correction transformation Two versions were presented: a modified Ln version similar to the VID and a linear version with an "Ice Hockey Stick" that would flatten the correction above a selected number of test hours. The reduced data set shows oil separation and a sigma of 0.12 for FEI 2. With the decision to get 4 runs per engine, the hockey stick was no longer required. These are the engine hour equations presented: FEI1 Adj= 0.000518*(EngHr–675) FEI2 Adj= 0.000381*(EngHr–675)
4.4.3	11:30-Noon	Test precision discussion
4.4.4	1-2	Number of RO tests to establish the new engine for LTMS? Reference Period? MOTION: Move forward with 4 full length tests per engine pending additional data on a reference oil on the 5th test on each engine. The group will decide a test plan for 5th run testing. Angela Willis, Nathan Moles second. 12 yes, 1 waive. The motion passed.
4.4.5	2-3	Other Items NOT listed???
4.4.6	3:15-3:30	Discussion of using FEI 2 and FEI Sum for references to match candidate pass/fail criteria. The consensus was to stay with the current VID type reference oil pass criteria of FEI 1 and FEI 2.
4.4.7	3:30-4	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. The consensus was to continue with the existing weighting.
4.4.8	4-4:30	Discussion of changing BLB1 to BLB2 delta acceptable limits. Add BLA shift limits? The consensus was to stay with the existing limits of -0.2 to 0.4.
4.4.9	4:30-5	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. This will be an on-going effort due to the reduced number of reference runs on a new engines.
DAY 2		**********
4.4.10	8-9:15AM	Review and Finalize LTMS Requirements Discussion was on the number of references to run on a new engine.

		MOTION: Proceed to develop Sequence VIE LTMS requirements for one reference oil calibration test per engine. Dave Glaenzer, Andy Ritchie 2nd. 9 yes, 1 waive, 4 no. Discussion continued on how to track references on the engines. A dead band limit system was discussed.
4.4.11	9:15-9:45AM	Review impact of variable oil pressure of FEI (review prove out data to determine if it is stand or engine related) This will be an on-going effort.
4.3.12	9:45-10:15AM	Investigate what is needed to establish VID equivalent limits for VIE This will be an on-going effort. This will be an on-going effort.
4.3.13	10:15-10:30AM	Determine engine calibration status of matrix engines and date of calibration This will be an on-going effort. ACTION: There will be a Task Force to develop procedures for cleaning engines. Dan Worcester, Jerry Brys and Jason Bowden volunteered for this effort. Lubrizol will supply the presentation they did on cleaning and continued use of a VIE engine. MOTION: Every 5th run will be a donated reference oil test on oil 1010-1 to gather data on running the engines out to 1200 hours. This motion passed unanimously.

5.0 New Business

5.1 Appendix K Template review –Todd Dvorak This will be reviewed at a later meeting.

5.2 VID test performance – Bob Campbell/Dave Glaenzer See Attachment 9 for a review of VID tests run, pass rates, and FEI 1 early termination numbers. The pass rate has dropped to single digits. There is concern the test is out of control. Further data was supplied back to 2010. See Attachment 10.

6.0 Next Meetings.

To be determined. The meeting on 05.31 is cancelled.

The meetings adjourned at 5:00 PM on Tuesday and 11:06 AM on Wednesday.

Sequence VI Surveillance Panel Conference Call Agenda
May 24 @ 8:30-5:00PM EST
May 25 @ 8:00-12:00PM EST

Call-in information is included below:

Call-in Number: 866-528-2256
Conference Code: 3744024
WebEx:
https://meetings.webex.com/collabs/meetings/join?uuid=M5N3FDHOYW6LAICWAKTC7NKSVO-20XT

1.0) Roll Call (8:30-8:40AM)

Do we have any membership changes or additions?

2.0) Approval of minutes (8:40:8:45AM)

2.1 Approve the minutes from the May 17, 2016 Sequence VI Surveillance Panel.

3.0) Action Item Review (8:45-8:55AM)

3.1 OHT to provide update on current VIE inventory and service engine order. –OHT

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

-Expected depletion of VID engines 2016 Q3

4.) Old Business

4.1	8:55-9:10	Update from task force, to investigate alternative test procedure Sequence "VIF" that would improve 0W-16. – Dan Worcester/Satoshi Hirano
4.2	9:10-9:15	Update from task force to investigate option to use short blocks to supplement engine inventory. –Adrian Alfonso/Bill Buscher
4.3	9:15-9:45	Data validity discussion –Rich G. and Dan W.
4.4		List of items to be reviewed after the Precision Matrix -All

4.4.1	9:45-10:30	Preliminary Analysis on Oil Discrimination over Engine Life (Stat Group Addendum presentation)
BREAK	10:30-10:45	**********
4.4.2	10:45-11:30	Finalize engine hours correction transformation
4.4.3	11:30-Noon	Test precision discussion
LUNCH	Noon-1	**********
4.4.4	1-2	Number of RO tests to establish the new engine for LTMS? Reference Period?
4.4.5	2-3	Other Items NOT listed???
BREAK	3-3:15	**********
4.4.6	3:15-3:30	Discussion of using FEI 2 and FEI Sum for references to match candidate pass/fail criteria.
4.4.7	3:30-4	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.
4.4.8	4-4:30	Discussion of changing BLB1 to BLB2 delta acceptable limits. Add BLA shift limits?
4.4.9	4:30-5	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.
DAY 2		**********
4.4.10	8-9:15AM	Review and Finalize LTMS Requirements
4.4.11	9:15-9:45AM	Review impact of variable oil pressure of FEI (review prove out data to determine if it is stand or engine related)
4.3.12	9:45-10:15AM	Investigate what is needed to establish VID equivalent limits for VIE
4.3.13	10:15-10:30AM	Determine engine calibration status of matrix engines and date of calibration

5.) New Business (10:30-Noon 5/25)

5.1 Appendix K Template review –Todd Dvorak

5.2 VID test performance – Bob Campbell/Dave Glaenzer

6.) Next Meeting

TBD

7.) Meeting Adjourned

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Tom Smith		Valvoline	
Hap Thompson	Hapjthom@aol.com	VIE Facilitator	
Chris Taylor	Chris.taylor@vpracingfuels.com	VP Racing Fuels	

SEQUENCE VIF RESULTS WITH NO HOUR ADJUSTMENT

SW 1 (Lab A)				SW2 (Lab A)				IAR 1 (Lab G)				IAR 2 (Lab G)			
	FEI 1	FEI 2	EOT hr		FEI 1	FEI 2	EOT hr		FEI 1	FEI 2	EOT hr		FEI 1	FEI 2	EOT hr
543	1.75	2.33	369	1011	1.53	1.31	373	542-2	2.10	1.44	371	1011	Invalid (BLB1/2 Shift)		
												1011	**1.37**	**1.4**	**350**
542-2	2.42	1.59	572	542-2	2.45	1.36	573	543	1.59	1.66	621	543	2.08	2.35	544
542-2	2.28	1.46	777	1011	1.65	0.90	773	543	1.68	1.74	820	1011	1.33	1.89	827
543	1.76	2.26	995	543	1.56	2.15	972	542-2	Invalid (EBP issue)			542-2	2.01	1.53	1023
								542-2	1.76	1.03	1236				
1011	1.70	1.69	1197	543	1.81	1.96	1264	1011	1.27	1.07	1505	542-2	1.78	1.33	1223
543	1.36	1.82	1397	1011	1.52	1.40	1462	543	1.55	1.50	1704	1011	1.63	1.57	1439
542-2	1.83	1.28	1596	542-2				1011				543			
1011								542-2							

Stage 1 Sense Check runs will be tested in 2 engines/2 labs

Stage 2 Sense Check runs will be tested in the other two engines/2labs

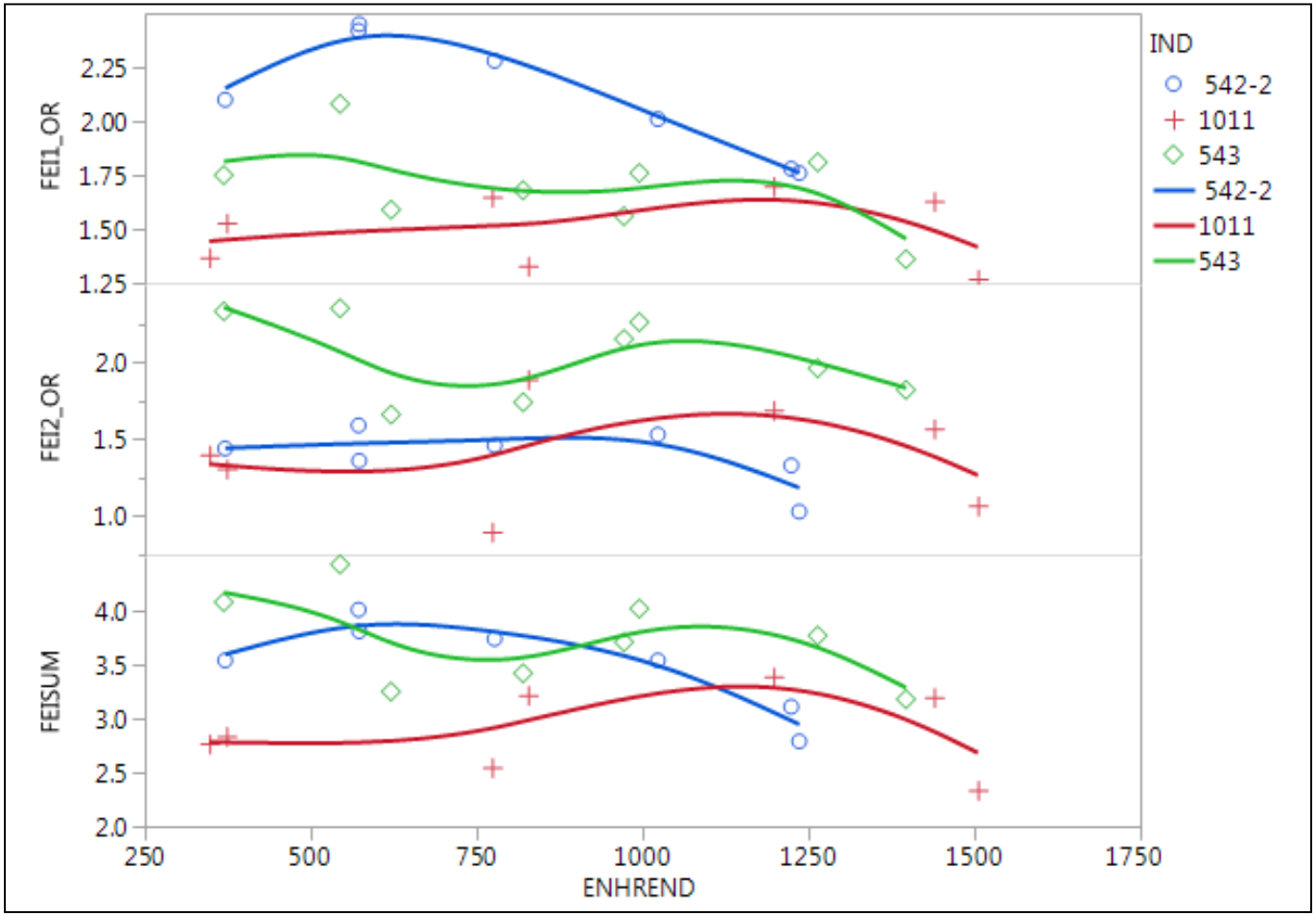
VIF – Preliminary Data Analysis Check of Oil Discrimination vs. Engine Hrs

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
- Amanda Miller, Afton
- Abaigeal Ritzenthaler, Afton

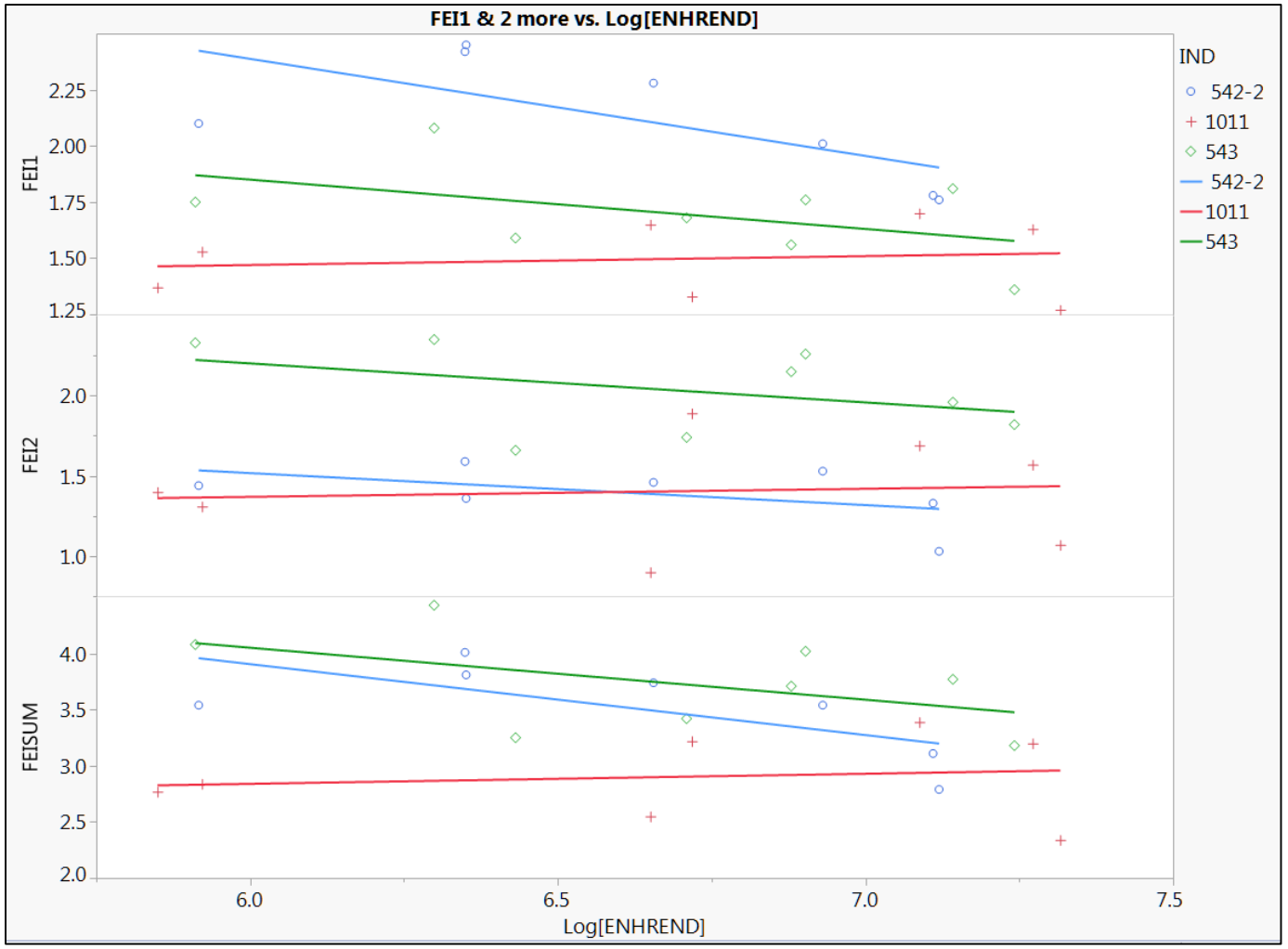
Raw VIF FEI by Engine Hour

- Completed 22 of the 30 PM reference tests
- Curve fit of FEI1, FEI2, and FEISum vs. EngHr data shown below



Raw VIF FEI by Ln(EngineHour)

- Linear fit of the FEI1, FEI2, and FEISum data shown below



VIF Main Effects Model

- Model Factors: *EngHrEnd, Lab, Eng(Lab), IND*
  - Reference oil significant at the $p = 0.05$ threshold

FEI 1

Response FEI1

Whole Model

Summary of Fit

Root Mean Square Error	0.207182
Mean of Response	1.766818
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	1.7186140	0.286436	6.6731
Error	15	0.6438633	0.042924	Prob > F
C. Total	21	2.3624773		0.0014*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.9538495	0.115493	16.92	<.0001*
ENHREND	-0.000212	0.000122	-1.74	0.1030
LTMSLAB[A]	0.0829958	0.045266	1.83	0.0866
LTMSLAB[A]:ENGNO[122]	0.0005895	0.064188	0.01	0.9928
LTMSLAB[G]:ENGNO[58]	-0.050205	0.064659	-0.78	0.4496
IND[542-2]	0.3475501	0.064435	5.39	<.0001*
IND[1011]	-0.263331	0.066745	-3.95	0.0013*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
ENHREND	1	1	0.1293754	3.0140	0.1030
LTMSLAB	1	1	0.1442987	3.3617	0.0866
ENGNO[LTMSLAB]	2	2	0.0259049	0.3018	0.7439
IND	2	2	1.3185670	15.3592	0.0002*

FEI 2

Response FEI2

Whole Model

Actual by Predicted Plot

Summary of Fit

RSquare	0.812355
RSquare Adj	0.737297
Root Mean Square Error	0.209538
Mean of Response	1.629091
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	2.8511900	0.475198	10.8231
Error	15	0.6585918	0.043906	Prob > F
C. Total	21	3.5097818		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.7243821	0.116806	14.76	<.0001*
ENHREND	-0.000151	0.000124	-1.22	0.2412
LTMSLAB[A]	0.0210115	0.045781	0.46	0.6528
LTMSLAB[A]:ENGNO[122]	-0.134959	0.064918	-2.08	0.0552
LTMSLAB[G]:ENGNO[58]	-0.222355	0.065394	-3.40	0.0040*
IND[542-2]	-0.224704	0.065167	-3.45	0.0036*
IND[1011]	-0.222049	0.067505	-3.29	0.0050*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
ENHREND	1	1	0.0653809	1.4891	0.2412
LTMSLAB	1	1	0.0092483	0.2106	0.6528
ENGNO[LTMSLAB]	2	2	0.7260689	8.2684	0.0038*
IND	2	2	2.1261195	24.2121	<.0001*

VIF Main Effects Model

- Model Factors: *Ln(EngHrEnd), Lab, Eng(Lab), IND*
  - Reference oil significant at the $p = 0.05$ threshold

FEI 1

Summary of Fit

RSquare	0.714862
RSquare Adj	0.600806
Root Mean Square Error	0.211917
Mean of Response	1.766818
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	1.6888443	0.281474	6.2677
Error	15	0.6736330	0.044909	Prob > F
C. Total	21	2.3624773		0.0019*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.7312082	0.647822	4.22	0.0007*
IND[542-2]	0.3534266	0.065642	5.38	<.0001*
IND[1011]	-0.272306	0.067912	-4.01	0.0011*
LnENHREND	-0.14434	0.096919	-1.49	0.1571
LTMSLAB[A]	0.0857939	0.046198	1.86	0.0830
LTMSLAB[A]:ENGNO[122]	0.0047129	0.065486	0.07	0.9436
LTMSLAB[G]:ENGNO[58]	-0.053001	0.066109	-0.80	0.4352

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	1.3878080	15.4514	0.0002*
LnENHREND	1	1	0.0996057	2.2180	0.1571
LTMSLAB	1	1	0.1548781	3.4487	0.0830
ENGNO[LTMSLAB]	2	2	0.0289334	0.3221	0.7295

FEI 2

Summary of Fit

RSquare	0.81073
RSquare Adj	0.735022
Root Mean Square Error	0.210443
Mean of Response	1.629091
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	2.8454857	0.474248	10.7086
Error	15	0.6642961	0.044286	Prob > F
C. Total	21	3.5097818		0.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.3377691	0.643317	3.63	0.0024*
IND[542-2]	-0.220956	0.065185	-3.39	0.0040*
IND[1011]	-0.228204	0.06744	-3.38	0.0041*
LnENHREND	-0.111724	0.096245	-1.16	0.2639
LTMSLAB[A]	0.0227078	0.045877	0.49	0.6278
LTMSLAB[A]:ENGNO[122]	-0.132539	0.06503	-2.04	0.0596
LTMSLAB[G]:ENGNO[58]	-0.224309	0.065649	-3.42	0.0038*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	2.1444307	24.2109	<.0001*
LnENHREND	1	1	0.0596765	1.3475	0.2639
LTMSLAB	1	1	0.0108500	0.2450	0.6278
ENGNO[LTMSLAB]	2	2	0.7276865	8.2157	0.0039*

VIF Interaction Effects Model

- **Model Factors: *Ln(EngHr), Lab, Eng(Lab), IND, IND*Lab, IND*Ln(EngHr)***
  - **All factors significant at the $p = 0.10$ threshold**

FEI 1

Summary of Fit

RSquare	0.921046
RSquare Adj	0.84927
Root Mean Square Error	0.130219
Mean of Response	1.766818
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	10	2.1759511	0.217595	12.8322
Error	11	0.1865261	0.016957	Prob > F
C. Total	21	2.3624773		0.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.6260048	0.433719	6.05	<.0001*
IND[542-2]	0.350232	0.041139	8.51	<.0001*
IND[1011]	-0.306846	0.042394	-7.24	<.0001*
LnENHREND	-0.12669	0.065221	-1.94	0.0781
LTMSLAB[A]	0.0948582	0.030356	3.12	0.0097*
LTMSLAB[A]:ENGNO[122]	0.0369785	0.043306	0.85	0.4114
LTMSLAB[G]:ENGNO[58]	-0.132698	0.045845	-2.89	0.0146*
IND[542-2]*LTMSLAB[A]	0.0865403	0.043758	1.98	0.0736
IND[1011]*LTMSLAB[A]	0.0656249	0.045471	1.44	0.1768
(LnENHREND-6.67105)*IND[542-2]	-0.252726	0.106627	-2.37	0.0371*
(LnENHREND-6.67105)*IND[1011]	0.2975686	0.089786	3.31	0.0069*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	1.4112792	41.6137	<.0001*
LnENHREND	1	1	0.0639811	3.7732	0.0781
LTMSLAB	1	1	0.1655784	9.7646	0.0097*
ENGNO[LTMSLAB]	2	2	0.1533537	4.5219	0.0369*
IND*LTMSLAB	2	2	0.2107483	6.2142	0.0156*
LnENHREND*IND	2	2	0.1984808	5.8525	0.0186*

FEI 2

Summary of Fit

RSquare	0.873066
RSquare Adj	0.757672
Root Mean Square Error	0.201248
Mean of Response	1.629091
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	10	3.0642728	0.306427	7.5660
Error	11	0.4455091	0.040501	Prob > F
C. Total	21	3.5097818		0.0012*

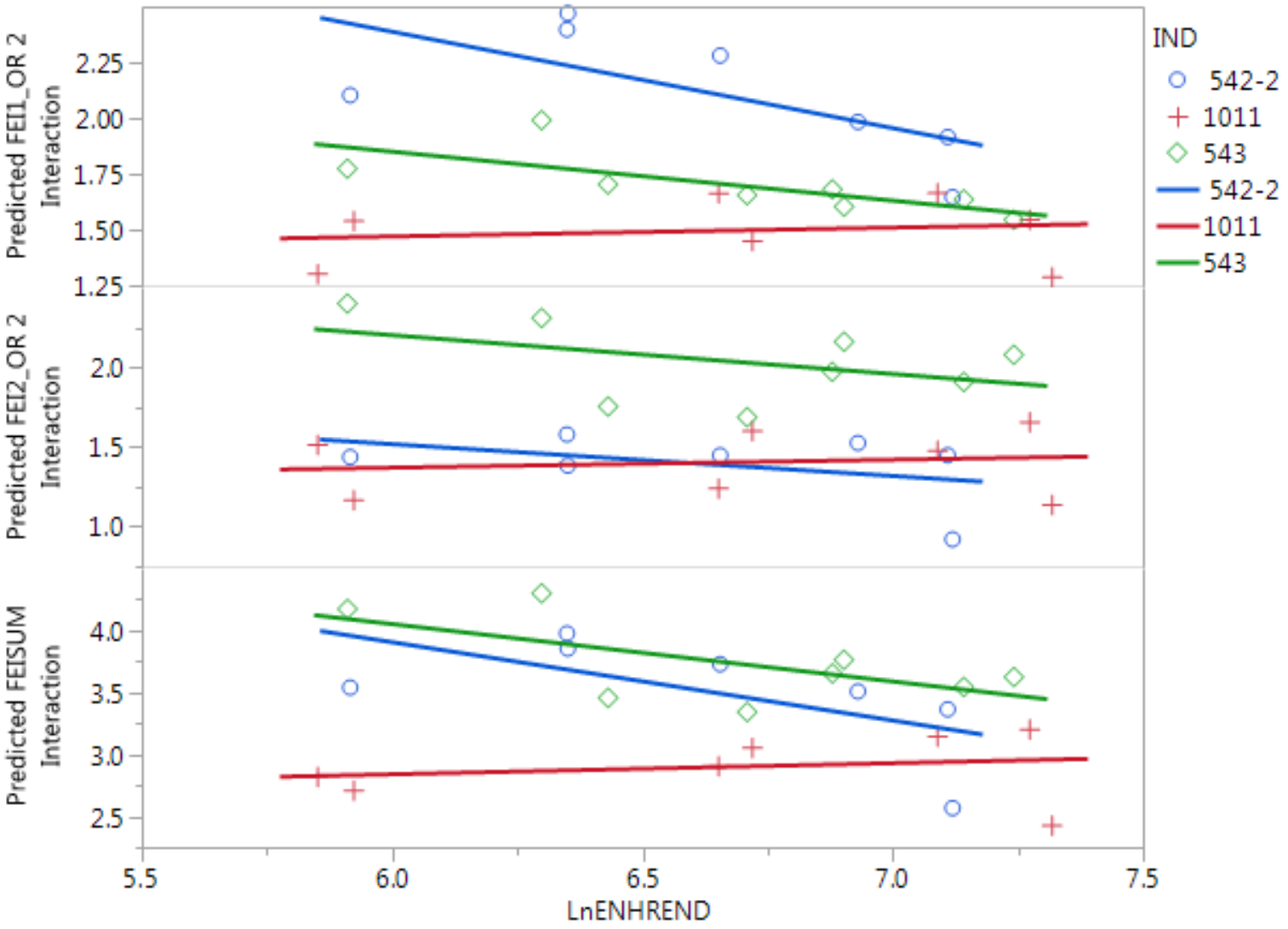
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.8502632	0.670297	4.25	0.0014*
IND[542-2]	-0.220867	0.063579	-3.47	0.0052*
IND[1011]	-0.237817	0.065519	-3.63	0.0040*
LnENHREND	-0.190434	0.100797	-1.89	0.0855
LTMSLAB[A]	0.022494	0.046914	0.48	0.6410
LTMSLAB[A]:ENGNO[122]	-0.097427	0.066928	-1.46	0.1734
LTMSLAB[G]:ENGNO[58]	-0.261762	0.070852	-3.69	0.0035*
IND[542-2]*LTMSLAB[A]	-0.038045	0.067626	-0.56	0.5850
IND[1011]*LTMSLAB[A]	-0.020326	0.070273	-0.29	0.7778
(LnENHREND-6.67105)*IND[542-2]	-0.238674	0.164788	-1.45	0.1754
(LnENHREND-6.67105)*IND[1011]	0.2900476	0.138761	2.09	0.0606

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	2.1362287	26.3727	<.0001*
LnENHREND	1	1	0.1445625	3.5694	0.0855
LTMSLAB	1	1	0.0093108	0.2299	0.6410
ENGNO[LTMSLAB]	2	2	0.6444671	7.9562	0.0073*
IND*LTMSLAB	2	2	0.0319663	0.3946	0.6831
LnENHREND*IND	2	2	0.1863723	2.3008	0.1463

VIF Interaction Model Predictions



VIF Preliminary Analysis Summary

- The reference oil factor appears to be significant - regardless of the modeling approach
- Preliminary review of the data suggests that there is a reference oil * engine hour age interaction effect
  - Refence oil 1011 appears to have more of a constant effect for FEI1 and FEI2 with respect to EngHrEnd
- The significance of engine age, reference oil, lab, eng(Lab) effect will be determined – when precision matrix has been completed. (8 more tests left in the VIF precision matrix)

From TMC:

When a test is reported to the TMC, the flatfile data is screened for:

1) Controlled parameters (Forms 16, 17, 18) with in limits specified (invalidation Criteria)
2) Monitored parameters during aging within limits (no invalidation criteria)
3) BLB1, 2 or 3 where applicable are within limits.
4) Shutdowns and downtime limits not exceeded
5) Data corrected for engine hours properly
6) BLA is also screened to BLB limits, beyond BLbefore limits mostly on first engine reference.
7) Coolant in – coolant out delta > 0 (looking for misplaced T/c's)

Bottom line, anything that has a plus or minus or is a validity criteria is checked by computer program and I also due a visual on most data.
There are usually minimal to no excursions on average data for most tests on the non-validity parameters, and I believe that is the case with all these matrix tests.
None had validity criteria exceeded and minimal deviations on the monitored parameters.

From the VIE procedure:

11.6.19 *Diagnostic Review Procedures*—To ensure test operational validity, conduct a critical review of the data at frequent intervals during the test.
The final review after the test is completed is only partially effective in identifying problems since the indicated data cannot be cross examined by first hand observation.
Early detection of instrumentation errors is essential and often the record for information parameters (dependent variables) indicate problem areas involving the primary control parameters.
The following parameter response characteristics are significant:

11.6.19.1 Stabilization trends.
11.6.19.2 Air fuel ratio stability.
11.6.19.3 Fuel flow stability.
11.6.19.4 Intake manifold absolute pressure.
11.6.19.5 Speed.
11.6.19.6 Torque.
11.6.19.7 Exhaust back pressure.
11.6.19.8 Fuel rail temperature.

13.3 *Deviations from Test Operational Limits*—Report all deviations from specified test operational limits.

13.5 In the space provided, note the time, date, test hour, and duration of any shutdown or off-test condition.

And from SwRI for a VID review equivalent:

I have two Excel sheets, one where the actual test data is imported and compared, and I then compare those values to the printed report, and one that looks at the test stand/engine [and has all data for all VID-E-F tests run at this lab].

1. How many tests on the calibration period and number of test hours [10 tests and max of 1750 hours].
2. BLB Delta – I have the operations program calculate and then compare that to the Excel for each test to ensure it is [-0.2 to +0.4]. I also have the operations program E stop in the candidate oil flush stage should it ever exceed those limits.
3. I have a critical parameter sheet for each stage. Any parameter outside the limits will turn red. I also have that for secondary parameter values and make a note in the comments section. Please note so the question does not get asked, the few values below are examples from the Excel, not the full set reviewed for each test.

Stage 1

	Spec	BLB1	BLB2	FEI1	FEI2	BLA
Speed, rpm	2000+/-5	2000.0	2000.0	2000.0	2000.0	2000.0
Torque, NM	105+/-0.1	105.00	105.00	105.00	105.00	105.00
Oil Temp, °C	115+/-2	115.0	115.0	115.0	115.0	115.0

16 hr Aging Conditions, Phase 1				
	Spec	Average	Min	Max
Speed, rpm	2250+/-5	2250.0	2250.0	2250.0
Torque, NM	110+/-0.1	110.00	110.00	110.00

4. I record shutdowns and calculate total downtime. The manual data logs say to call me with the 3rd test for VID and 4th test shutdown for VIE and VIF.
5. I confirm and enter oil consumption.
6. I verify operational stability.
7. I verify C.V.% by stage.

Intake Air Temp, °C	29+/-2	29.0	29.0	29.0	29.0	29.0
Fuel Rail Temp, °C	22+/-2	22.0	22.0	22.0	22.0	22.0
EBP, kPa	105+/-0.17	105.00	105.00	105.00	105.00	105.00
Fuel Flow, kg/h	Rec	6.559	6.530	6.342	6.377	6.583
AFR	14.00-15.00	14.47	14.47	14.47	14.47	14.47
Delta AFR	<.50	0.04	0.04	0.04	0.04	0.04
BSFC, Standard Deviation	Rec	0.00016	0.00018	0.00010	0.00010	0.00008
BSFC, C.V.%	Rec	0.05%	0.06%	0.03%	0.04%	0.03%

Preliminary Analysis on Oil Discrimination over Engine Life (Addendum to the VIE PM Analysis)

Statistics Group

May 19, 2016

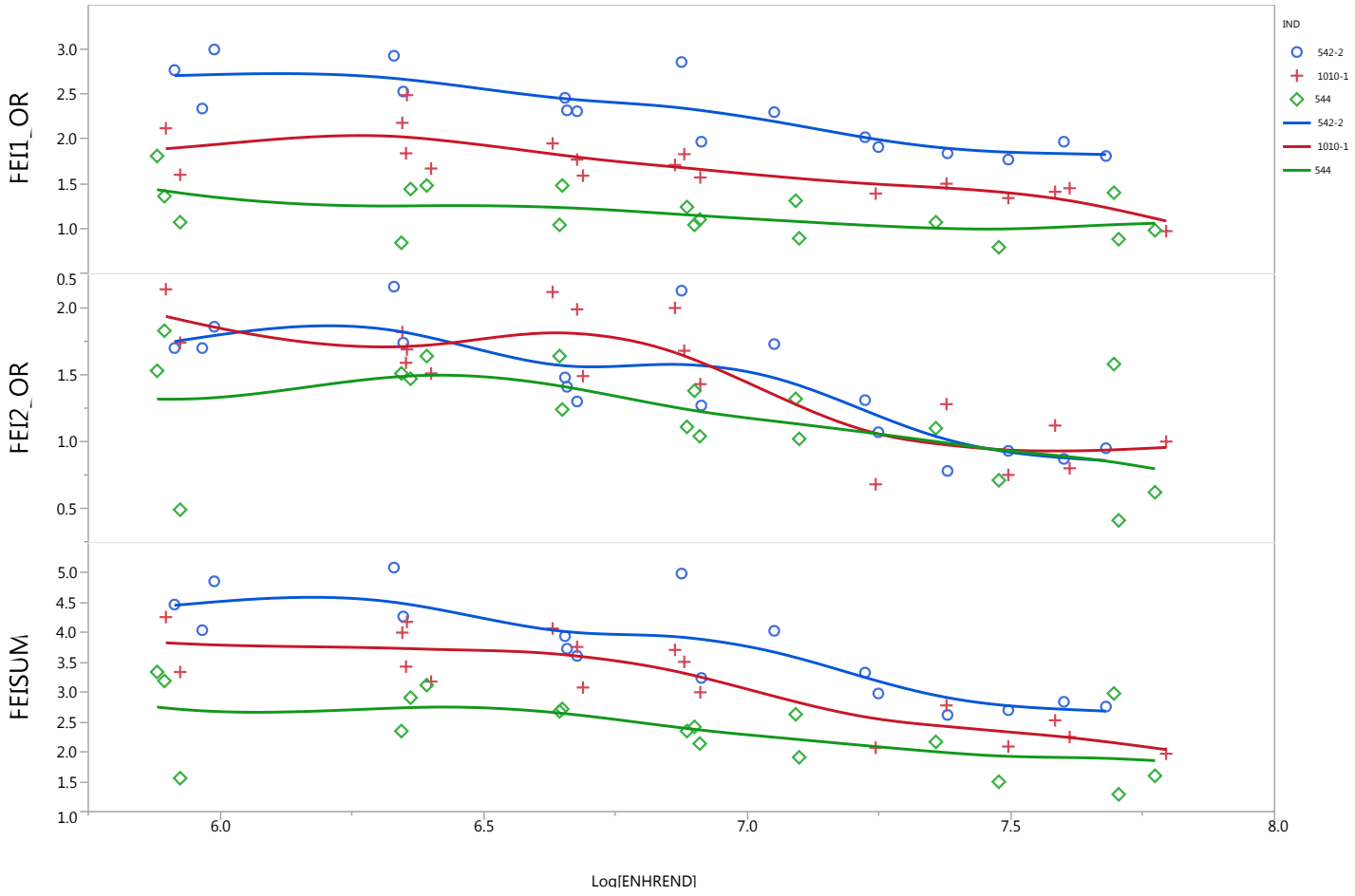
Statistics Group

- 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

Summary

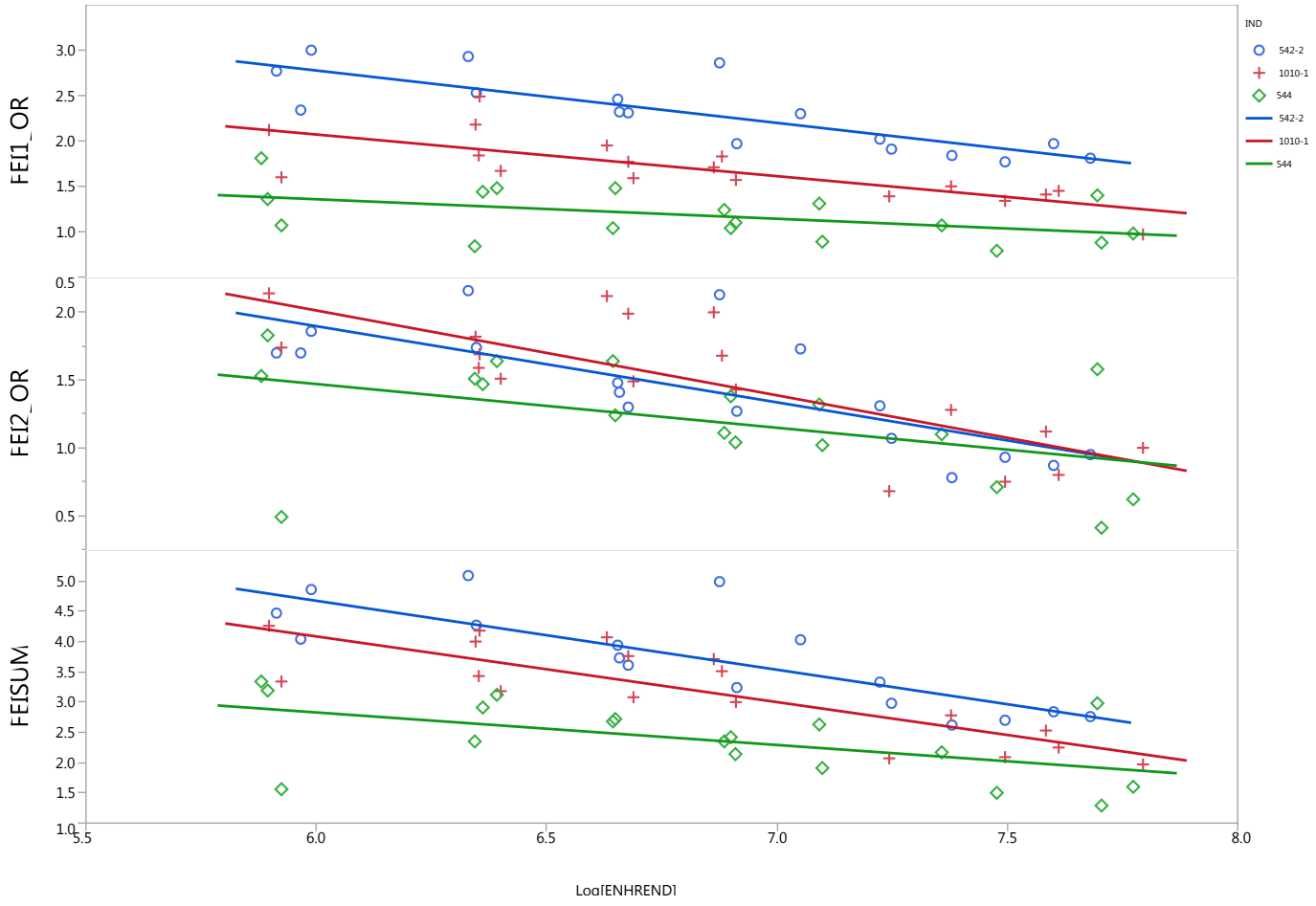
- Significant change in FEI1 discrimination as engine ages but test still discriminates at end of engine hour tested (2400hrs)
- Though change in FEI2 discrimination as engine ages is marginally significant, the test only discriminate up to approximately the 4^{th} test or 1000 hours.

Raw FEI by Ln Engine Hour



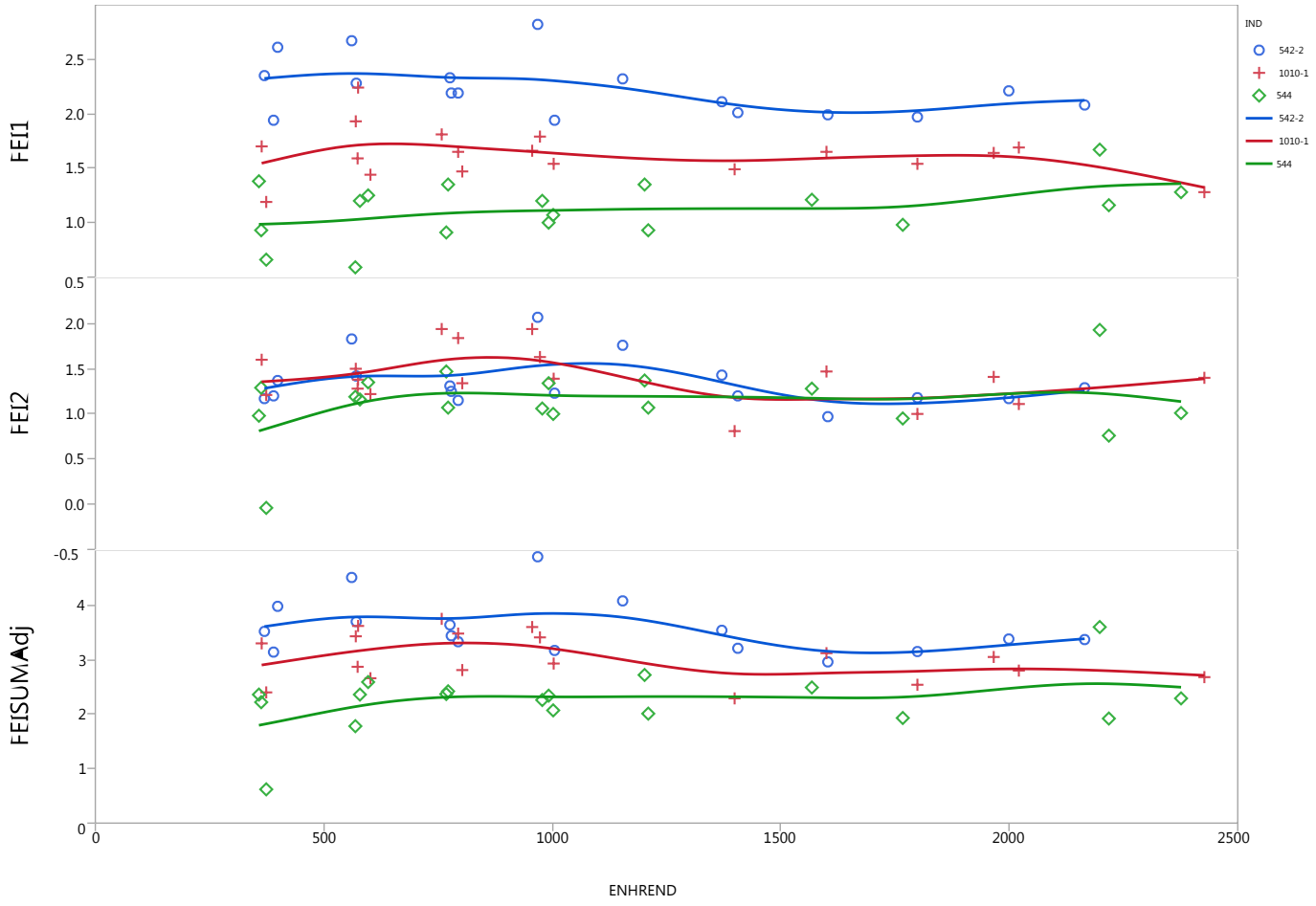
Raw data suggests diminishing oil differentiation towards higher engine hours.

Raw FEI by Ln Engine Hour



Raw data suggests diminishing oil differentiation towards higher engine hours.

FEI Ln Adj by Engine Hour



Interaction Effects Models

FEI1

Summary of Fit

RSquare	0.943567
RSquare Adj	0.89881
Root Mean Square Error	0.182488
Mean of Response	1.711509
Observations (or Sum Wgts)	53

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	23	16.147525	0.702066	21.0819
Error	29	0.965754	0.033302	Prob > F
C. Total	52	17.113279		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	1.0210907	15.3308	<.0001*
LTMSLAB	5	5	0.2560614	1.5378	0.2090
ENGNO[LTMSLAB]	3	3	0.2624177	2.6267	0.0692
Log[ENHREND]	1	1	1.5782034	47.3908	<.0001*
Log[ENHREND]*IND	2	2	0.5871054	8.8149	0.0010*
LTMSLAB*IND	10	10	1.3710040	4.1169	0.0013*

FEI2

Summary of Fit

RSquare	0.693929
RSquare Adj	0.451182
Root Mean Square Error	0.333068
Mean of Response	1.374717
Observations (or Sum Wgts)	53

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	23	7.293829	0.317123	2.8587
Error	29	3.217092	0.110934	Prob > F
C. Total	52	10.510921		0.0041*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	0.5947465	2.6806	0.0855
LTMSLAB	5	5	0.5062845	0.9128	0.4865
ENGNO[LTMSLAB]	3	3	0.5271050	1.5838	0.2146
Log[ENHREND]	1	1	3.0509481	27.5023	<.0001*
Log[ENHREND]*IND	2	2	0.4859681	2.1903	0.1300
LTMSLAB*IND	10	10	0.6849399	0.6174	0.7865

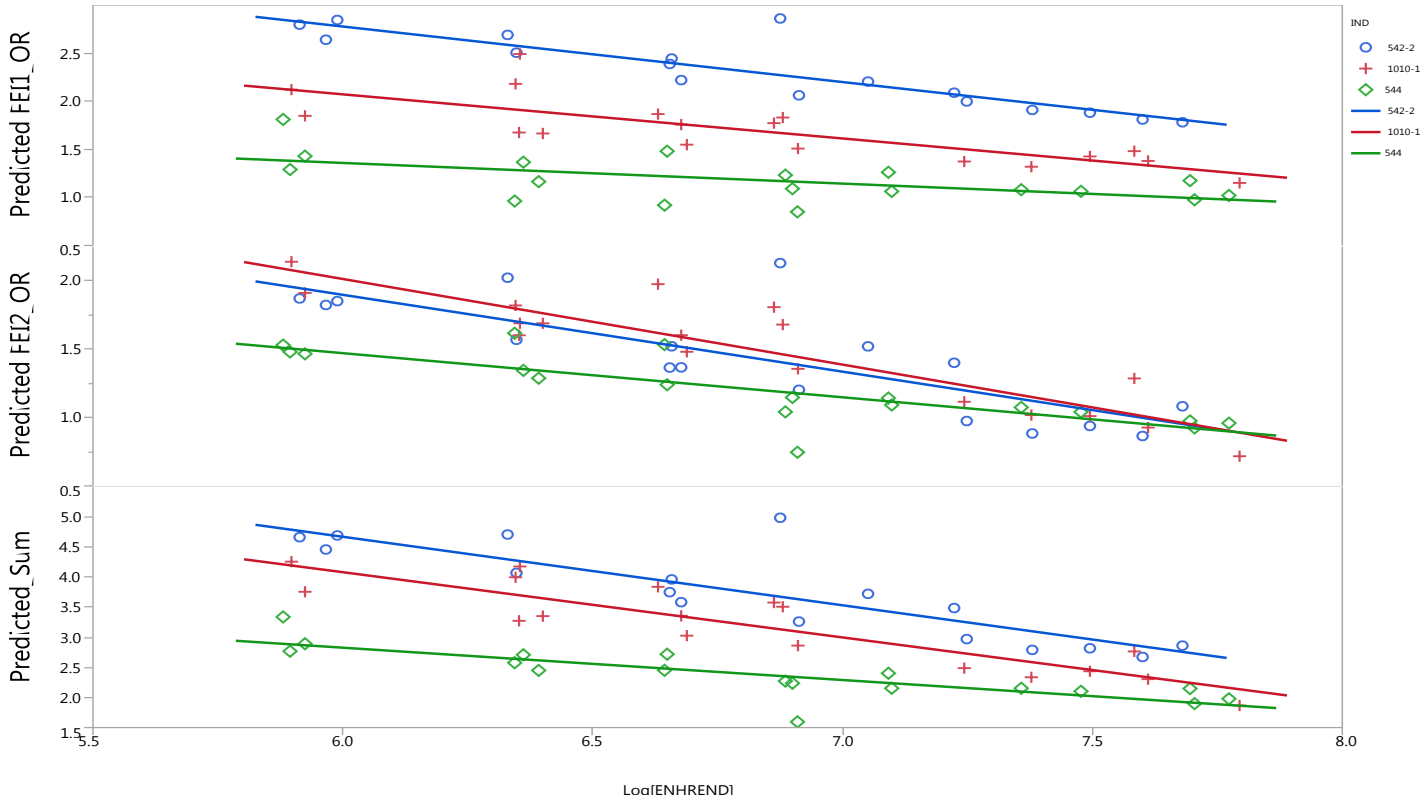
Models indicate marginal to significant oil and engine hour interaction effect.

Impact of Engine Hour Adjustment

FEI1	EngHr	LnEngHr	542-2	1010-1	544	542-2-544	#of Sd
	350	5.9	2.96	2.16	1.35	1.61	8.94
	550	6.3	2.65	1.97	1.28	1.37	7.61
	750	6.6	2.44	1.85	1.24	1.21	6.70
	950	6.9	2.28	1.75	1.20	1.08	6.01
	1150	7.0	2.16	1.67	1.18	0.98	5.44
	1350	7.2	2.05	1.61	1.15	0.90	4.97
	1550	7.3	1.95	1.55	1.13	0.82	4.57
	1750	7.5	1.87	1.50	1.12	0.76	4.21
	1950	7.6	1.80	1.46	1.10	0.70	3.89
	2150	7.7	1.73	1.42	1.09	0.65	3.61
	2350	7.8	1.68	1.39	1.07	0.60	3.35
FEI2	EngHr	LnEngHr	542-2	1010-1	544	544-1010-1	#of Sd
	350	5.9	2.14	2.21	1.49	0.72	2.19
	550	6.3	1.82	1.88	1.36	0.52	1.57
	750	6.6	1.61	1.66	1.27	0.38	1.16
	950	6.9	1.44	1.48	1.21	0.28	0.84
	1150	7.0	1.31	1.35	1.16	0.19	0.58
	1350	7.2	1.20	1.23	1.11	0.12	0.36
	1550	7.3	1.10	1.13	1.07	0.06	0.17
	1750	7.5	1.02	1.04	1.04	0.00	0.01
	1950	7.6	0.94	0.96	1.01	-0.05	-0.14
	2150	7.7	0.87	0.89	0.98	-0.09	-0.27
	2350	7.8	0.81	0.83	0.96	-0.13	-0.39

Engine hour coefficients indicate diminishing oil differentiation towards higher engine hours.

Interaction Model Predictions



- FEI1 oil means are significantly different over engine age but test still discriminates around 3 standard deviations around 2400 hours.
- FEI2 oil means are marginally different over engine age but test discriminates around 1 standard deviation only up to approximately the 4th run or 1000 hours in an engine. Beyond that, the test cannot discriminate FEI2.

Models at > 1000 Hours

FEI1

Summary of Fit

RSquare	0.866583
RSquare Adj	0.804321
Root Mean Square Error	0.1893
Mean of Response	1.462609
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	3.4913263	0.498761	13.9185
Error	15	0.5375171	0.035834	Prob > F
C. Total	22	4.0288435		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	2.6983438	37.6501	<.0001*
LTMSLAB	3	3	0.0586471	0.5455	0.6586
ENGNO[LTMSLAB]	1	1	0.0146909	0.4100	0.5316
Log[ENHREND]	1	1	0.1487738	4.1517	0.0596

Level		Least Sq Mean
542-2	A	1.89
1010-1	B	1.33
544	C	1.02

Levels not connected by same letter are significantly different.

Level	- Level	Difference	p-Value
542-2	544	0.87	<.0001*
542-2	1010-1	0.56	0.0002*
1010-1	544	0.31	0.0246*

FEI2

Summary of Fit

RSquare	0.464493
RSquare Adj	0.21459
Root Mean Square Error	0.284281
Mean of Response	1.033478
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	1.0514837	0.150212	1.8587
Error	15	1.2122381	0.080816	Prob > F
C. Total	22	2.2637217		0.1484

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	0.02334086	0.1444	0.8667
LTMSLAB	3	3	0.35672613	1.4714	0.2623
ENGNO[LTMSLAB]	1	1	0.08103698	1.0027	0.3325
Log[ENHREND]	1	1	0.52205644	6.4598	0.0226*

Level		Least Sq Mean
542-2	A	1.01
1010-1	A	0.95
544	A	0.93

Levels not connected by same letter are significantly different.

Level	- Level	Difference	p-Value
542-2	544	0.08	0.87
542-2	1010-1	0.06	0.92
1010-1	544	0.02	0.99

Models confirm significant oil discrimination for FEI1 but not for FEI2 at > 1000 hours.

Conclusions and Recommendations

Conclusions:

- Significant change in FEI1 discrimination as engine ages but test still discriminates at end of engine hour tested (2400hrs)
- Though change in FEI2 discrimination as engine ages is marginally significant, the test only discriminate up to approximately the 4th test or 1000 hours.

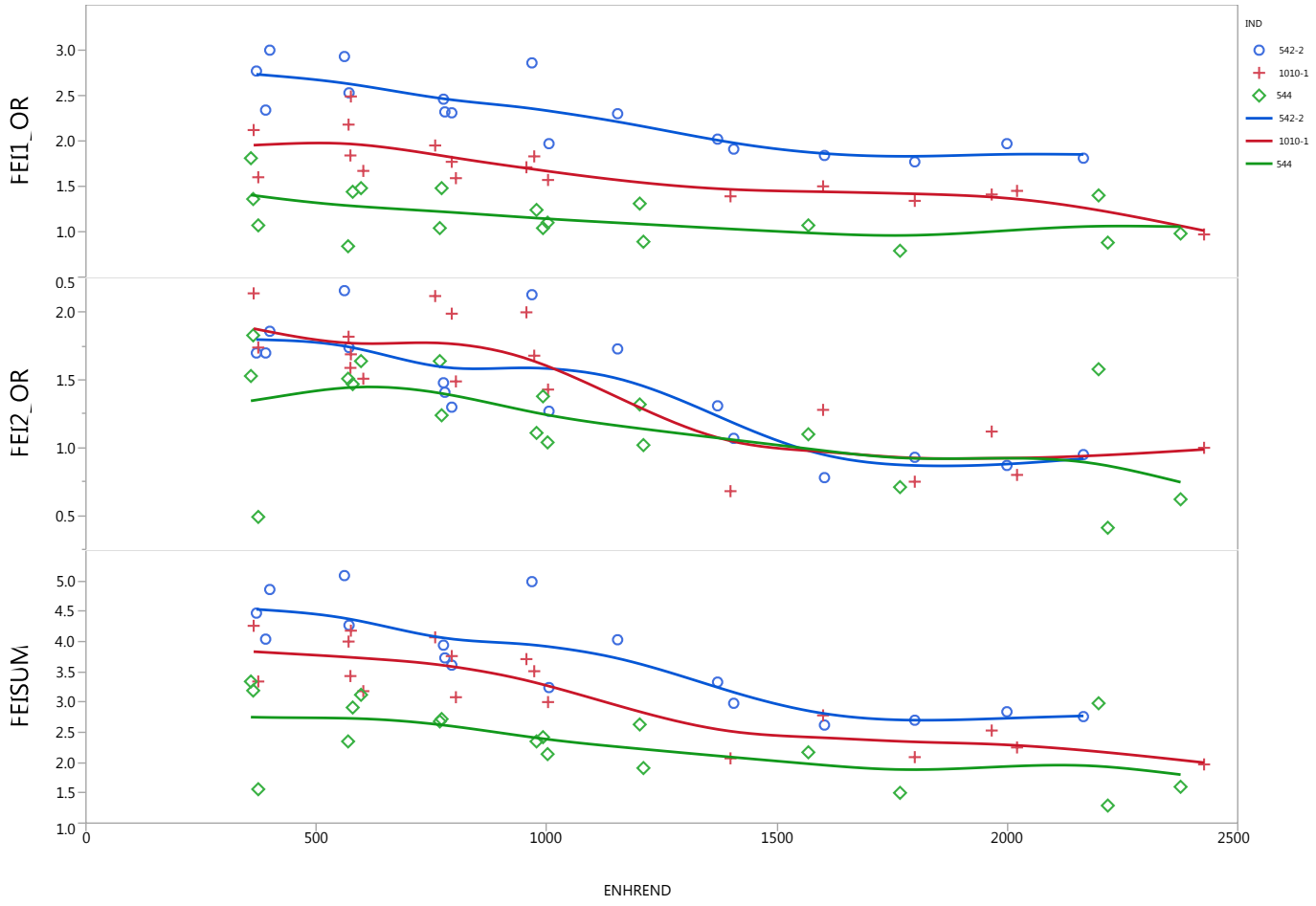
Recommendations:

- No 1010-1 oil was tested on the 5th run in the matrix. To determine engine life can be extended to 1200 hours (due to lack of FEI2 discrimination), additional tests on 1010-1 on engines that only had 4 runs are recommended.
- An LTMS that uses one or two reference tests per engine is being explored.

Appendix

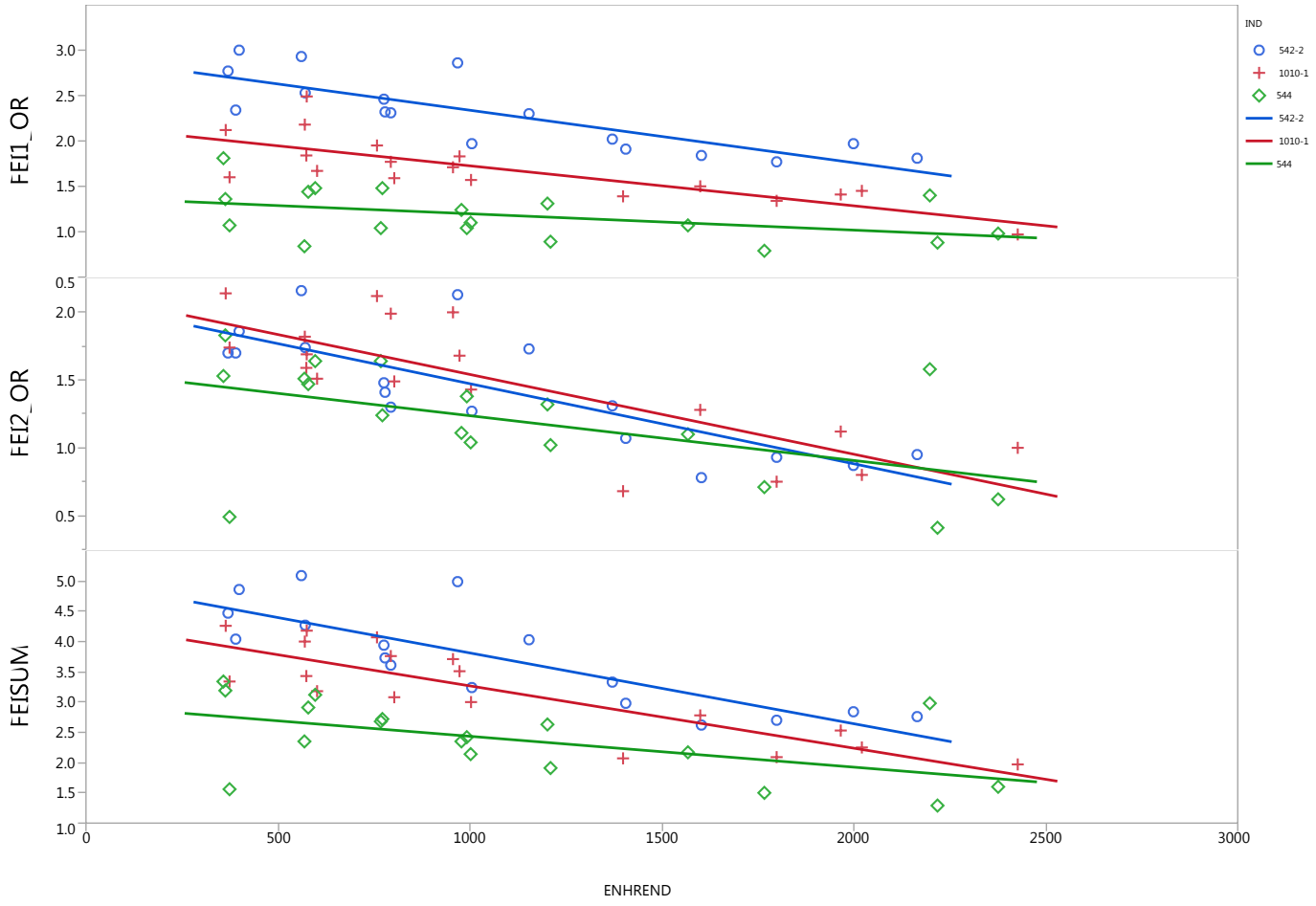
Ice Hockey Stick Engine Hour Adjustment

Raw FEI by Engine Hour



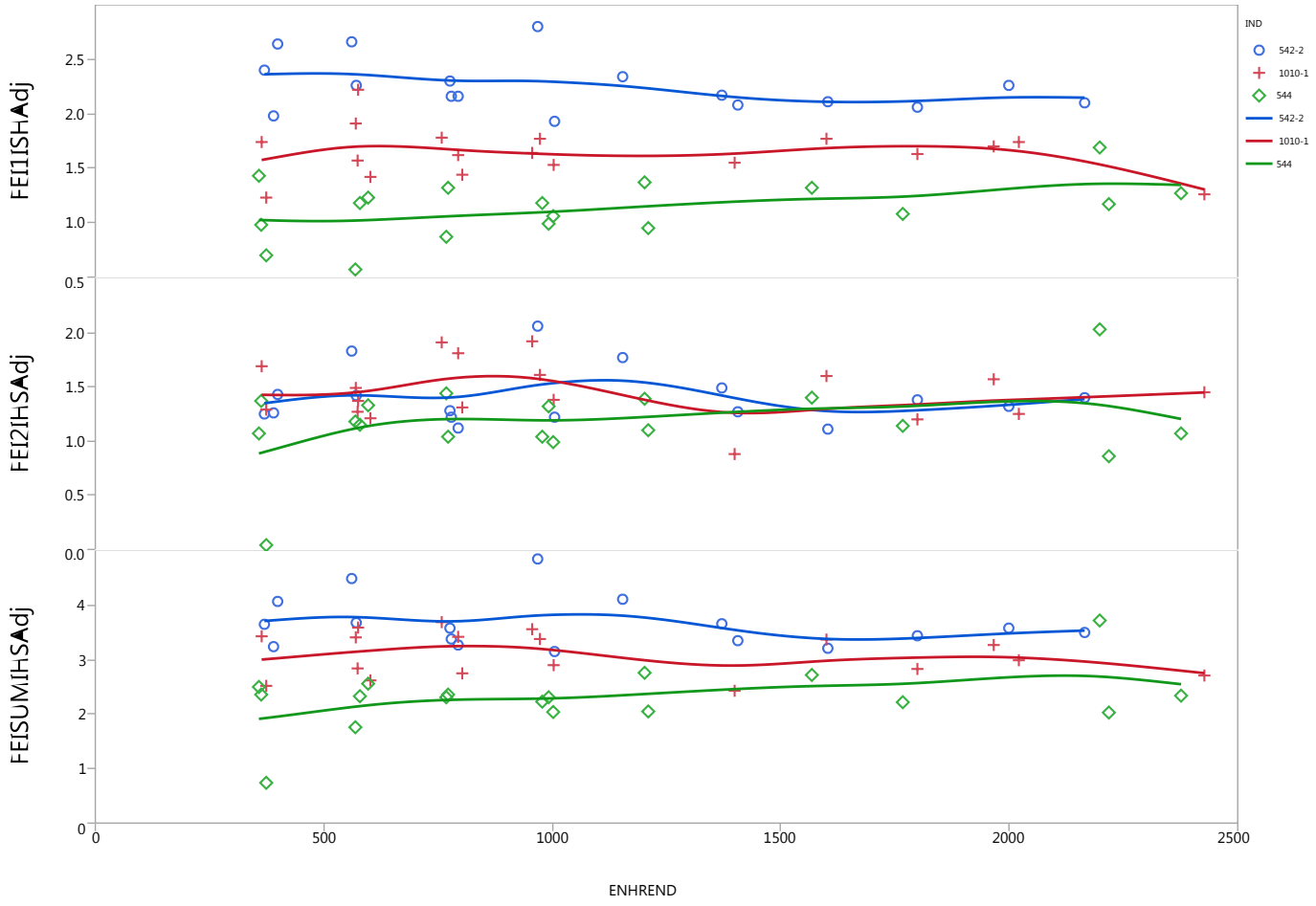
Raw data suggests diminishing oil differentiation towards higher engine hours.

Raw FEI by Engine Hour



Raw data suggests diminishing oil differentiation towards higher engine hours.

FEI IHS Adj by Engine Hour



Interaction Effects Models

FEI1

Summary of Fit

RSquare	0.948009
RSquare Adj	0.906774
Root Mean Square Error	0.175159
Mean of Response	1.711509
Observations (or Sum Wgts)	53

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	23	16.223536	0.705371	22.9906
Error	29	0.889744	0.030681	Prob > F
C. Total	52	17.113279		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	7.0439007	114.7932	<.0001*
LTMSLAB	5	5	0.2298268	1.4982	0.2210
ENGNO[LTMSLAB]	3	3	0.2448488	2.6602	0.0668
EngHr1	1	1	1.6223632	52.8787	<.0001*
EngHr1*IND	2	2	0.4982961	8.1206	0.0016*
LTMSLAB*IND	10	10	1.3659171	4.4520	0.0008*

FEI2

Summary of Fit

RSquare	0.731588
RSquare Adj	0.51871
Root Mean Square Error	0.311905
Mean of Response	1.374717
Observations (or Sum Wgts)	53

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	23	7.689669	0.334333	3.4367
Error	29	2.821252	0.097285	Prob > F
C. Total	52	10.510921		0.0010*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	0.5407925	2.7794	0.0786
LTMSLAB	5	5	0.5124691	1.0535	0.4059
ENGNO[LTMSLAB]	3	3	0.5622787	1.9266	0.1473
EngHr2	1	1	3.4362024	35.3212	<.0001*
EngHr2*IND	2	2	0.3768453	1.9368	0.1624
LTMSLAB*IND	10	10	0.4639428	0.4769	0.8913

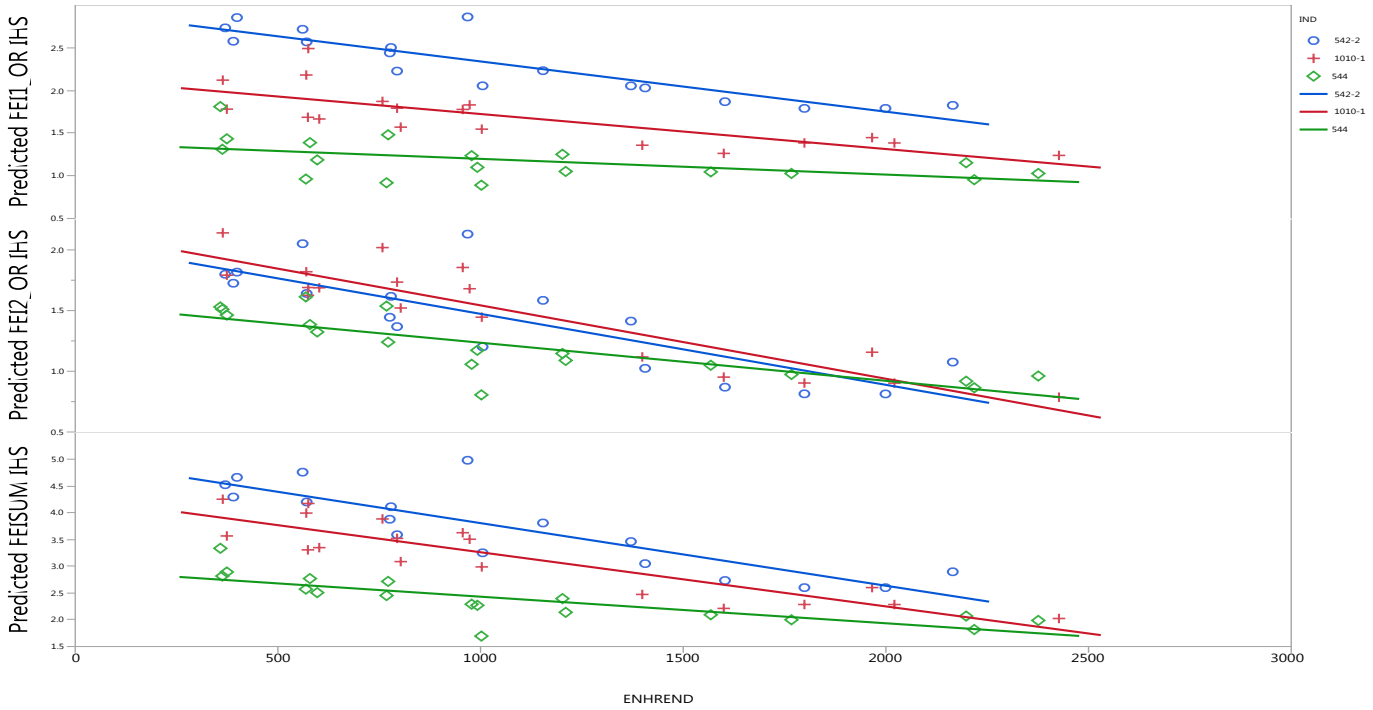
Models indicate marginal to significant oil and engine hour interaction effect.

Impact of Engine Hour Adjustment

FEI1	EngHr	542-2	1010-1	544	542-2-544	# of Sd
	350	2.83	2.05	1.34	1.49	8.28
	550	2.67	1.95	1.30	1.37	7.61
	750	2.51	1.84	1.26	1.25	6.95
	950	2.34	1.73	1.21	1.13	6.28
	1150	2.18	1.63	1.17	1.01	5.62
	1350	2.01	1.52	1.12	0.89	4.95
	1550	1.85	1.41	1.08	0.77	4.29
	1750	1.69	1.31	1.04	0.65	3.62
	1950	1.52	1.20	0.99	0.53	2.96
	2150	1.36	1.09	0.95	0.41	2.29
	2350	1.20	0.99	0.90	0.29	1.62
FEI2	EngHr	542-2	1010-1	544	544-1010-1	#of Sd
	350	1.98	2.07	1.46	0.61	1.86
	550	1.83	1.91	1.38	0.53	1.59
	750	1.67	1.74	1.30	0.44	1.32
	950	1.51	1.57	1.23	0.35	1.05
	1150	1.35	1.41	1.15	0.26	0.78
	1350	1.20	1.24	1.07	0.17	0.51
	1550	1.04	1.08	1.00	0.08	0.24
	1750	0.88	0.91	0.92	-0.01	-0.03
	1950	0.73	0.75	0.85	-0.10	-0.30
	2150	0.57	0.58	0.77	-0.19	-0.57
	2350	0.41	0.42	0.69	-0.28	-0.84

Engine hour coefficients indicate diminishing oil differentiation towards higher engine hours.

Interaction Model Predictions



- FEI1 oil means are significantly different over engine age but test still discriminates around 3 standard deviations up to approximately 1950 hours. Beyond that discrimination is only around 2 standard deviations.
- FEI2 oil means are marginally different over engine age but test discriminates around 1 standard deviation only up to approximately the 4th run or 1000 hours in an engine. Beyond that, the test cannot discriminate FEI2.

Models at > 1000 Hours

FEI1

Summary of Fit

RSquare	0.865841
RSquare Adj	0.803234
Root Mean Square Error	0.189825
Mean of Response	1.462609
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	3.4883380	0.498334	13.8297
Error	15	0.5405055	0.036034	Prob > F
C. Total	22	4.0288435		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	2.8580581	39.6581	<.0001*
LTMSLAB	3	3	0.0595406	0.5508	0.6553
ENGNO[LTMSLAB]	1	1	0.0193744	0.5377	0.4747
EngHr1	1	1	0.1457854	4.0458	0.0626

Level		Least Sq Mean
542-2	A	1.89
1010-1	B	1.32
544	C	1.00

Levels not connected by same letter are significantly different.

Level	- Level	Difference	p-Value
542-2	544	0.89	<.0001*
542-2	1010-1	0.57	0.0002*
1010-1	544	0.32	0.0202*

FEI2

Summary of Fit

RSquare	0.496332
RSquare Adj	0.261286
Root Mean Square Error	0.275701
Mean of Response	1.033478
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	1.1235566	0.160508	2.1116
Error	15	1.1401651	0.076011	Prob > F
C. Total	22	2.2637217		0.1063

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
IND	2	2	0.03963645	0.2607	0.7739
LTMSLAB	3	3	0.32521422	1.4262	0.2743
ENGNO[LTMSLAB]	1	1	0.09795679	1.2887	0.2741
EngHr2	1	1	0.59412941	7.8164	0.0136*

Level		Least Sq Mean
542-2	A	1.01
1010-1	A	0.94
544	A	0.90

Levels not connected by same letter are significantly different.

Level	- Level	Difference	p-Value
542-2	544	0.11	0.76
542-2	1010-1	0.07	0.91
1010-1	544	0.04	0.96

Models confirm significant oil discrimination for FEI1 but not for FEI2 at > 1000 hours.

VIE Precision Matrix Analysis

Industry Statistician Team

Date: 05-24-2016

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

Agenda

- Analyzing Reduced PM Data Set
  - Data Set for Analysis
  - FEI1 Analysis
  - FEI2 Analysis
  - Reference Oil Standard Deviations

Agenda

- Analyzing Reduced PM Data Set
  - Data Set for Analysis
  - FEI1 Analysis
  - FEI2 Analysis
  - Reference Oil Standard Deviations

Data Set for Analysis

- Data set includes the following:
  - 1st, 2nd, 3rd, and 4th Run Test Run data, exclusively
  - No engine 128 from Lab A (A1)
  - N = 29

Step	Run Order	A 1	A 2	G 1	G 2	B	D	C	F	Eng. Hrs
	SOT Engine Hours	150	150	150	150	150	150	150	150	
1	1	544 113244-VIE	1010-1 110587-VIE	542-2 105705-VIE	544 113224-VIE	542-2 110003-VIE	542-2 110588-VIE	544 113298-VIE 544 116040-VIE (new engine)	1010-1 113223-VIE	350
	2	544 113247-VIE	1010-1 110725-VIE	1010-1 113235-VIE	542-2 105704-VIE	544 113258-VIE	542-2 113293-VIE	1010-1 113300-VIE 1010-1 113301-VIE (new engine)	544 113220-VIE	550
	3	542-2 111451-VIE	542-2 111176-VIE	1010-1 113236-VIE	1010-1 108989-VIE	1010-1 110595-VIE	544 113292-VIE	542-2 113299-VIE Oil Con. Engine Abandoned 542-2 114421-VIE (new engine)	544 113221-VIE	750
	4	1010-1 110726-VIE	544 113243-VIE	544 113225-VIE	1010-1 113234-VIE	544 113259-VIE	1010-1 110589-VIE	542 114422-VIE (new engine)	542-2 113222-VIE	950
2	5	544 113246-VIE	544 113245-VIE Failed Eng.		542-2 113229-VIE	544 113260-VIE				1150
	6	1010-1 110727-VIE	1010-1		542-2 113230-VIE	542-2 110004-VIE				1350
	7	1010-1 113252-VIE	544		544 113226-VIE	542-2 113261-VIE				1550
	8	542-2 113248-VIE	542-2		544	544 113263-VIE				1750
	9	542-2 113249-VIE	542-2		113238-VIE	1010-1 113266-VIE				1950
	10	544			542-2 113232-VIE	544 116027-VIE				2150
	11	113254-VIE	1010-1		544 113228-VIE					2350
	EOT Engine Hours	950	2350	950	2350	2150	950	950	950	Total Runs
	Runs/ Engine	4	11	4	11	10	4	4	4	52

Excluded from Analysis

Test Reported Invalid

Data Set for Analysis

- Raw FEI1 plot of data for analysis:

Data Set for Analysis

- Raw FEI2 plot of data for analysis:

Agenda

- Analyzing Reduced PM Data Set
  - Data Set for Analysis
  - FEI1 Analysis
  - FEI2 Analysis
  - Reference Oil Standard Deviations

FEI1 Analysis

- Overall ANOVA Summary of FEI1 data:
  - Reference Oils are statistically Significant
  - Linear EngHr Adj is marginally significant at the 0.05 threshold
  - VIE PM Test Precision: 0.30 *(contrast w/ VID PM test precision of 0.12)*

Class Level Information		
Class	Levels	Values
IND	3	1010-1 542-2 544
LTMSLAB	6	A B C D F G
ENGNO	8	11 29 31 55 60 103 123 136

Number of Observations Read	29
Number of Observations Used	29

R-Square	Coeff Var	Root MSE	FEI1_OR Mean
0.843489	15.56382	0.296840	1.907241

Source	DF	Type III SS	Mean Square	F Value	Pr > F
ENHREND	1	0.38095840	0.38095840	4.32	0.0522
IND	2	6.69349851	3.34674926	37.98	<.0001
LTMSLAB	5	0.23394770	0.04678954	0.53	0.7500
ENGNO(LTMSLAB)	2	0.18732786	0.09366393	1.06	0.3661

FEI1 Analysis

- Difference between reference oil LsMeans for FEI1:
  - All oil contrasts are significantly different
  - {544 < 1010-1 < 542-2}

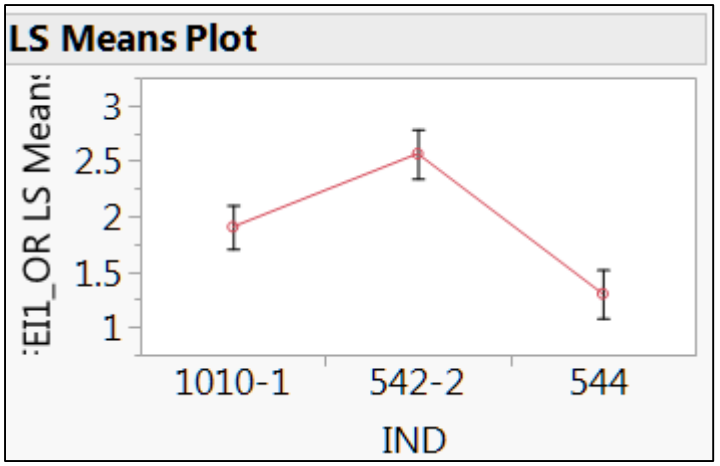
FEI1 Response Model

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

IND	FEI1_OR LSMEAN	LSMEAN Number
1010-1	1.90484847	1
542-2	2.56388817	2
544	1.30134339	3

Least Squares Means for effect IND
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: FEI1_OR

i/j	1	2	3
1		0.0005	0.0013
2	0.0005		<.0001
3	0.0013	<.0001	



RefOil	VID FEI1 Target	VID FEI2 Target
542	1.49	0.8
1010	1.34	1.1

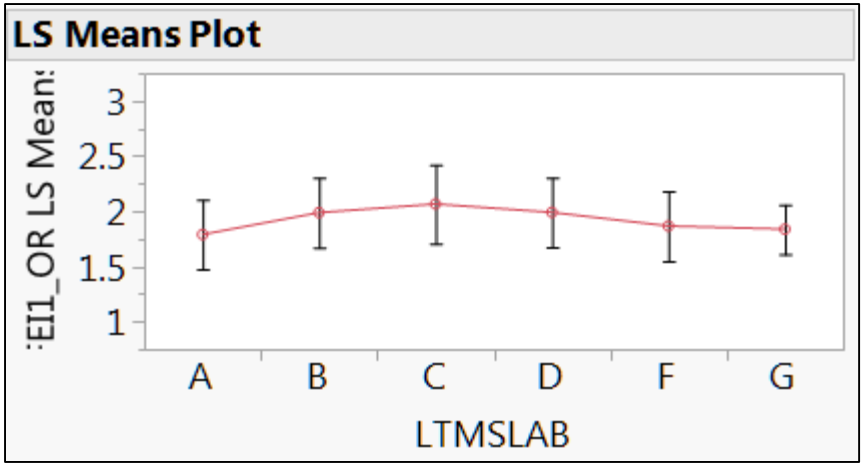
FEI1 Analysis

- Difference between test Lab LSMeans for FEI1
  - No significant difference between Labs

LTMSLAB	FEI1_OR LSMEAN	LSMEAN Number
A	1.78986900	1
B	1.98860430	2
C	2.06655125	3
D	1.99053727	4
F	1.86647217	5
G	1.83812606	6

Least Squares Means for effect LTMSLAB
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: FEI1_OR

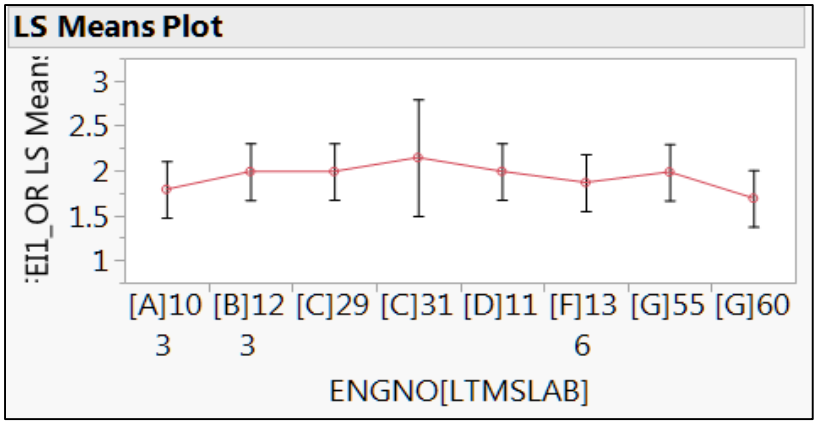
i/j	1	2	3	4	5	6
1		0.9324	0.8132	0.9298	0.9991	0.9998
2	0.9324		0.9993	1.0000	0.9910	0.9614
3	0.8132	0.9993		0.9993	0.9480	0.8511
4	0.9298	1.0000	0.9993		0.9910	0.9593
5	0.9991	0.9910	0.9480	0.9910		1.0000
6	0.9998	0.9614	0.8511	0.9593	1.0000	



FEI1 Analysis

- LSMean difference between engines within the same Lab
  - Contrasts: {C-29 vs. C-31}, {G-55 vs. G-60}
  - Conclusion: No Significant[1] difference between engines within a Lab

ENGNO	LTMSLAB	FEI1_OR LSMEAN	LSMEAN Number
103	A	1.78986900	1
123	B	1.98860430	2
29	C	1.98899371	3
31	C	2.14410879	4
11	D	1.99053727	5
136	F	1.86647217	6
55	G	1.98408178	7
60	G	1.69217035	8



Least Squares Means for Effect ENGNO(LTMSLAB)
t for H0: LSMean(i)=LSMean(j) / Pr > |t|
Dependent Variable: FEI1_OR

i/j	1	2	3	4	5	6	7	8
		-0.93367	-0.93544	-1.04692	-0.94283	-0.35985	-0.92511	0.465275
1		0.9782	0.9780	0.9600	0.9771	0.9999	0.9793	0.9997
	0.933672		-0.00183	-0.44973	-0.00908	0.581539	0.021238	1.392641
2	0.9782		1.0000	0.9998	1.0000	0.9987	1.0000	0.8492
	0.935436	0.001829		-0.4485	-0.00735	0.574916	0.023063	1.394548
3	0.9780	1.0000		0.9998	1.0000	0.9988	1.0000	0.8484
	1.046919	0.449732	0.4485		0.444339	0.804148	0.473339	1.333661
4	0.9600	0.9998	0.9998		0.9998	0.9907	0.9997	0.8742
	0.942827	0.009076	0.007353	-0.44434		0.582401	0.030323	1.401483
5	0.9771	1.0000	1.0000	0.9998		0.9987	1.0000	0.8453
	0.359847	-0.58154	-0.57492	-0.80415	-0.5824		-0.55259	0.818025
6	0.9999	0.9987	0.9988	0.9907	0.9987		0.9991	0.9897
	0.925109	-0.02124	-0.02306	-0.47334	-0.03032	0.552586		1.38919
7	0.9793	1.0000	1.0000	0.9997	1.0000	0.9991		0.8507
	-0.46527	-1.39264	-1.39455	-1.33366	-1.40148	-0.81803	-1.38919	
8	0.9997	0.8492	0.8484	0.8742	0.8453	0.9897	0.8507	

[1] *Familywise error rate critical t of 2.45 selected for 2 contrasts*

FEI1 Analysis

- FEI1 EngHr Adjustment:

$$FEI1\ Adj = 0.000518*(EngHr - 675)$$

Agenda

- Analyzing Reduced PM Data Set
  - FEI1 Analysis
  - FEI2Analysis
  - Reference Oil Standard Deviations

FEI2 Analysis

- ANOVA Summary of FEI2 data
  - EngHrs, Oil, and Lab factors are statistically Significant
  - VIE PM Test Precision: 0.12 *(contrast w/ VID PM test precision: 0.14)*

Class Level Information		
Class	Levels	Values
IND	3	1010-1 542-2 544
LTMSLAB	6	A B C D F G
ENGNO	8	11 29 31 55 60 103 123 136

Number of Observations Read	29
Number of Observations Used	29

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	2.33520394	0.23352039	15.81	<.0001
Error	18	0.26587882	0.01477105		
Corrected Total	28	2.60108276			

R-Square	Coeff Var	Root MSE	FEI2_OR Mean
0.897781	7.338225	0.121536	1.656207

Source	DF	Type III SS	Mean Square	F Value	Pr > F
ENHREND	1	0.20566015	0.20566015	13.92	0.0015
IND	2	0.78711581	0.39355790	26.64	<.0001
LTMSLAB	5	0.58102866	0.11620573	7.87	0.0004
ENGNO(LTMSLAB)	2	0.69037148	0.34518574	23.37	<.0001

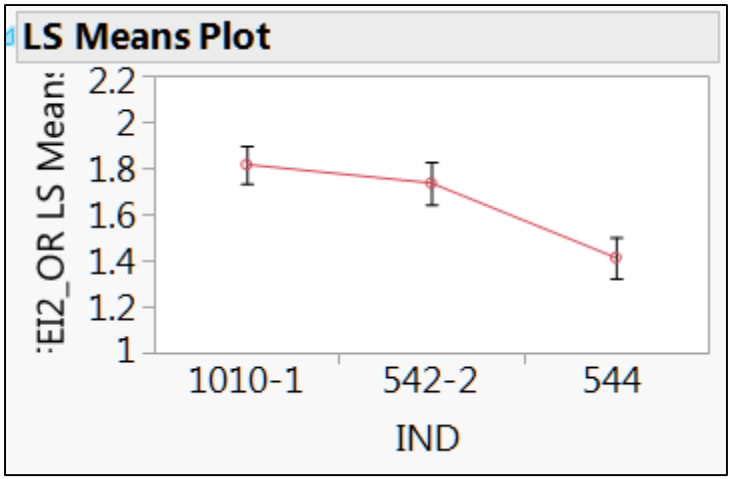
FEI2 Analysis

- Difference between reference oil LSmeans for FEI2
  - Significant Oil Contrasts: 544 < 1010-1 & 544 < 542-2

IND	FEI2_OR LSMEAN	LSMEAN Number
1010-1	1.81510674	1
542-2	1.73477556	2
544	1.41205531	3

Least Squares Means for effect IND
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: FEI2_OR

i/j	1	2	3
1		0.3668	<.0001
2	0.3668		0.0001
3	<.0001	0.0001	



RefOil	VID FEI1 Target	VID FEI2 Target
542	1.49	0.8
1010	1.34	1.1

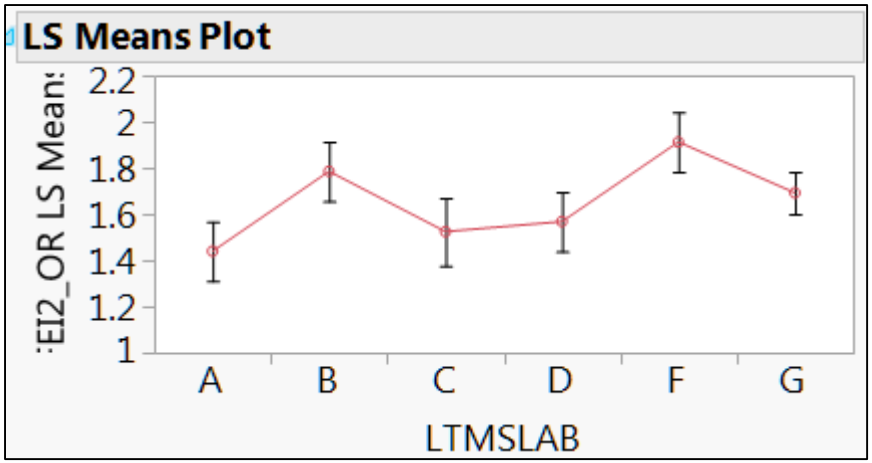
FEI2 Analysis

- Difference between test Lab LSMeans for FEI2
  - Significant difference between labs
    - Lab A < B, F, G; Lab C < F; Lab D < F,

LTMSLAB	FEI2_OR LSMEAN	LSMEAN Number
A	1.43989527	1
B	1.78576937	2
C	1.52461631	3
D	1.56845582	4
F	1.91251850	5
G	1.69261995	6

Least Squares Means for effect LTMSLAB
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: FEI2_OR

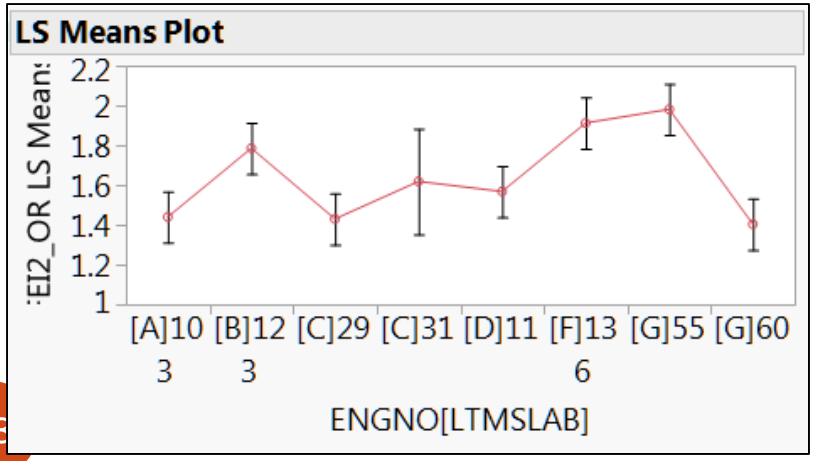
i/j	1	2	3	4	5	6
1		0.0099	0.9347	0.6832	0.0005	0.0323
2	0.0099		0.1066	0.1781	0.6839	0.8175
3	0.9347	0.1066		0.9967	0.0069	0.3410
4	0.6832	0.1781	0.9967		0.0104	0.5860
5	0.0005	0.6839	0.0069	0.0104		0.0857
6	0.0323	0.8175	0.3410	0.5860	0.0857	



FEI2 Analysis

- LSMeans difference between engines within the same Lab
  - Contrasts: {C-29 vs. C-31}, {G-55 vs. G-60}
  - Conclusion: [1]Significant Difference between engines within Lab (G)
    - Stand based LTMS system is appropriate given the data analysis

ENGNO	LTMSLAB	FEI2_OR LSMEAN	LSMEAN Number
103	A	1.43989527	1
123	B	1.78576937	2
29	C	1.43033228	3
31	C	1.61890034	4
11	D	1.56845582	5
136	F	1.91251850	6
55	G	1.98130628	7
60	G	1.40393362	8



Least Squares Means for Effect ENGNO(LTMSLAB)
t for H0: LSMean(i)=LSMean(j) / Pr > |t|
Dependent Variable: FEI2_OR

i/j	1	2	3	4	5	6	7	8
		-3.96875	0.109723	-1.2921	-1.47529	-5.42254	-6.29881	0.418289
1		0.0162	1.0000	0.8904	0.8104	0.0008	0.0001	0.9998
	3.968749		4.076365	1.1787	2.492208	-1.47404	-2.24275	4.381308
2	0.0162		0.0130	0.9280	0.2591	0.8110	0.3734	0.0069
	-0.10972	-4.07637		-1.33166	-1.60708	-5.52616	-6.31853	0.302924
3	1.0000	0.0130		0.8750	0.7407	0.0006	0.0001	1.0000
	1.292103	-1.1787	1.331658		0.356479	-2.0771	-2.61813	1.549365
4	0.8904	0.9280	0.8750		0.9999	0.4633	0.2119	0.7722
	1.475289	-2.49221	1.607077	-0.35648		-3.94481	-4.73643	1.887461
5	0.8104	0.2591	0.7407	0.9999		0.0171	0.0033	0.5751
	5.422542	1.474044	5.526157	2.077104	3.94481		-0.78938	5.829675
6	0.0008	0.8110	0.0006	0.4633	0.0171		0.9916	0.0003
	6.298805	2.242751	6.31853	2.618126	4.736433	0.789377		6.710933
7	0.0001	0.3734	0.0001	0.2119	0.0033	0.9916		<.0001
	-0.41829	-4.38131	-0.30292	-1.54936	-1.88746	-5.82967	-6.71093	
8	0.9998	0.0069	1.0000	0.7722	0.5751	0.0003	<.0001	

[1]*Familywise error rate critical t of 2.45 selected for 2 contrasts*

FEI2 Analysis

- FEI2 EngHr Adjustment:

$$FEI2\ Adj = 0.000381*(EngHr - 675)$$

Agenda

- Analyzing Reduced PM Data Set
  - FEI1 Analysis
  - FEI2 Analysis
  - Reference Oil Standard Deviations

Reference Oil Standard Deviations

- Listed below are the model based standard deviations by reference oil *(Based on model fit residuals with factors EngHrEnd, Lab, Eng(Lab), and IND)*

	Std Dev					
	Residual FEI1_OR			Residual FEI2_OR		
	IND			IND		
	1010-1	**542-2**	**544**	**1010-1**	**542-2**	**544**
	0.1930396049	0.3007094748	0.2474860092	0.0549477127	0.1304689823	0.1115286193

Appendix

Appendix

- Summary of Lsmeans and standard deviations for FEI1 and FEI2

	Std Dev					
	Residual FEI1_OR			Residual FEI2_OR		
	IND			IND		
	1010-1	542-2	544	1010-1	542-2	544
	0.1930396049	0.3007094748	0.2474860092	0.0549477127	0.1304689823	0.1115286193

FEI1 RMSE: 0.30

FEI1 Response Model

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

IND	FEI1_OR LSMEAN	LSMEAN Number
1010-1	1.90484847	1
542-2	2.56388817	2
544	1.30134339	3

Least Squares Means for effect IND
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: FEI1_OR

i/j	1	2	3
1		0.0005	0.0013
2	0.0005		<.0001
3	0.0013	<.0001	

FEI2 RMSE = 0.12

IND	FEI2_OR LSMEAN	LSMEAN Number
1010-1	1.81510674	1
542-2	1.73477556	2
544	1.41205531	3

Least Squares Means for effect IND
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: FEI2_OR

i/j	1	2	3
1		0.3668	<.0001
2	0.3668		0.0001
3	<.0001	0.0001	

VID Candidate Data

2012 - Present

Passion for Solutions®

ACC MA data – 2010 to 2016

	Sequence VID 0W-20 and 5W-20				Sequence VID 0W-30 and 5W-30			
Six Month	Registered	Valid	GF-5	Percent	Registered	Valid	GF-5	Percent
Period Ending	Tests	Tests	Pass	Pass	Tests	Tests	Pass	Pass
April, 2010	100	79	17	17.0%	110	84	22	20.0%
October, 2010	76	59	15	19.7%	80	58	12	15.0%
April, 2011	80	58	12	15.0%	44	39	8	18.2%
October, 2011	25	17	7	28.0%	20	14	4	20.0%
April, 2012	36	28	10	27.8%	23	15	6	26.1%
October, 2012	26	20	3	11.5%	37	28	10	27.0%
April, 2013	12	9	2	16.7%	46	37	5	10.9%
October, 20213	29	24	2	6.9%	36	34	9	25.0%
April, 2014	31	27	3	9.7%	23	17	2	8.7%
October, 2014	27	19	6	22.2%	12	12	3	25.0%
April, 2015	28	23	4	14.3%	15	14	0	0.0%
October, 2015	50	23	3	6.0%	51	31	4	7.8%
April, 2016	60	36	1	1.7%	43	24	1	2.3%

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Passion for Solutions®

ACC MA Data

	Sequence VID 0W-20 and 5W-20				Sequence VID 0W-30 and 5W-30			
Six Month Period Ending	Registered Tests	Valid Tests	GF-5 Pass	Percent Pass	Registered Tests	Valid Tests	GF-5 Pass	Percent Pass
April, 2012	36	28	10	27.8%	23	15	6	26.1%
October, 2012	26	20	3	11.5%	37	28	10	27.0%
April, 2013	12	9	2	16.7%	46	37	5	10.9%
October, 20213	29	24	2	6.9%	36	34	9	25.0%
April, 2014	31	27	3	9.7%	23	17	2	8.7%
October, 2014	27	19	6	22.2%	12	12	3	25.0%
April, 2015	28	23	4	14.3%	15	14	0	0.0%
October, 2015	50	23	3	6.0%	51	31	4	7.8%
April, 2016	60	36	1	1.7%	43	24	1	2.3%

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Passion for Solutions®

VID Candidate Data

2012 - Present

Passion for Solutions®

ACC MA data – 2010 to 2016

	Sequence VID 0W-20 and 5W-20				Sequence VID 0W-30 and 5W-30			
Six Month	Registered	Valid	GF-5	Percent	Registered	Valid	GF-5	Percent
Period Ending	Tests	Tests	Pass	Pass	Tests	Tests	Pass	Pass
April, 2010	100	79	17	17.0%	110	84	22	20.0%
October, 2010	76	59	15	19.7%	80	58	12	15.0%
April, 2011	80	58	12	15.0%	44	39	8	18.2%
October, 2011	25	17	7	28.0%	20	14	4	20.0%
April, 2012	36	28	10	27.8%	23	15	6	26.1%
October, 2012	26	20	3	11.5%	37	28	10	27.0%
April, 2013	12	9	2	16.7%	46	37	5	10.9%
October, 20213	29	24	2	6.9%	36	34	9	25.0%
April, 2014	31	27	3	9.7%	23	17	2	8.7%
October, 2014	27	19	6	22.2%	12	12	3	25.0%
April, 2015	28	23	4	14.3%	15	14	0	0.0%
October, 2015	50	23	3	6.0%	51	31	4	7.8%
April, 2016	60	36	1	1.7%	43	24	1	2.3%

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ACC MA Data

	Sequence VID 0W-20 and 5W-20				Sequence VID 0W-30 and 5W-30			
Six Month Period Ending	Registered Tests	Valid Tests	GF-5 Pass	Percent Pass	Registered Tests	Valid Tests	GF-5 Pass	Percent Pass
April, 2012	36	28	10	27.8%	23	15	6	26.1%
October, 2012	26	20	3	11.5%	37	28	10	27.0%
April, 2013	12	9	2	16.7%	46	37	5	10.9%
October, 20213	29	24	2	6.9%	36	34	9	25.0%
April, 2014	31	27	3	9.7%	23	17	2	8.7%
October, 2014	27	19	6	22.2%	12	12	3	25.0%
April, 2015	28	23	4	14.3%	15	14	0	0.0%
October, 2015	50	23	3	6.0%	51	31	4	7.8%
April, 2016	60	36	1	1.7%	43	24	1	2.3%

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