

# Sequence IV Surveillance Panel | MINUTES

REVISION DATE: 11/5/2017 4:04:00 PM

|                       |   |
|-----------------------|---|
| <b>Relevant Test:</b> | Sequence IVA and IVB  |
| <b>Note Taker:</b>    | Chris Mileti  |
| <b>Meeting Date:</b>  | 10-25-2017  |
| <b>Comments:</b>      | Conference call to review the status of the 2 <sup>nd</sup> Precision Matrix. |

## 1. ACTION ITEM REVIEW:

### 1.1. OHT Update:

- 1.1.1. OHT has completed the computer modeling of its upcoming clutch alignment tool.
- 1.1.2. The new OHT coolant adaptor plates will have "IN" and "OUT" stamping.
- 1.1.3. OHT is modifying [1<sup>st</sup> generation] oil pans (that were returned from the labs) with slotted pick-up tubes.

### 1.2. Lubrizol Update:

#### 1.2.1. Oil Sample Valve:

- 1.2.1.1. Lubrizol replaced the original oil sample valve on its Golden Stand with a valve supplied by Swagelok.
- 1.2.1.2. This Swagelok valve was evaluated to determine if it can reduce foam in the oil samples.
- 1.2.1.3. Lubrizol believes that the valve is marginally better (in terms of foam mitigation) than the stock sample valve.
  - 1.2.1.3.1. However, the improvement is not significant enough to recommend a change to the Golden Stand.

#### 1.2.2. Screening Lifter Profiles:

- 1.2.2.1. Lubrizol has identified two Keyence parameters that can be used to screen lifter profiles.
- 1.2.2.2. Chris Mileti sent an email yesterday that summarizes Lubrizol's thoughts on this issue.

### 1.3. Southwest Update:

#### 1.3.1. Oil Sample Round-Robin:

- 1.3.1.1. Southwest and Intertek have exchanged oil samples.
- 1.3.1.2. Southwest has not yet supplied their measurements.

#### 1.3.2. Rockwell Hardness Testing of Intake Camshafts:

- 1.3.2.1. Southwest is still working on this action item.
- 1.3.2.2. They expect to have results soon.

#### 1.3.3. Revisit Oil Gallery Temperature Quality Index Calculation:

- 1.3.3.1. Southwest is waiting for more data to become available before it makes a recommendation on this action item.

### 1.4. Exxon Update:

- 1.4.1. Exxon is still investigating the spike in coolant flow near the end of each test cycle.
- 1.4.2. The hardware in Exxon's coolant flow system is oriented in the same way as the legacy Golden Stands.
  - 1.4.2.1. However, the plumbing lengths are likely very different.

## 2. UPDATE ON PROVE-OUT TESTING:

### 2.1. Lubrizol's Prove-Out Test with REO1012:

- 2.1.1. This test is almost finished.
  - 2.1.1.1. Lubrizol improved its oil temperature control strategy during the first few hours of the test.
- 2.1.2. Lubrizol's previous prove-out test with REO300 delivered an unexpectedly mild result.
- 2.1.3. The iron content of the REO1012 test was 75ppm at 175HRS.
- 2.1.4. **Intertek's Comments:**
  - 2.1.4.1. It will be interesting to see if the oil temperature control improvements made by Lubrizol allow it to generate more expected results with REO1012.
  - 2.1.4.2. The iron content at 175HRS (75ppm) is very close to that of the two recent Intertek tests with REO1012.
  - 2.1.4.3. Lubrizol may need to change its Precision Matrix run order to guarantee that it gets another data point with REO300.
  - 2.1.4.4. Intertek will get Lubrizol the information on the oil system blower and booster pump upgrades today.

### 2.2. Baffle on Blowby Heat Exchanger (Intertek):

- 2.2.1. Intertek has not yet discussed this issue with the Surveillance Panel.
- 2.2.2. **Test Stand #165:**
  - 2.2.2.1. This cell experiences relatively large changes in ambient conditions.
  - 2.2.2.2. There is a large volume of air that flows through the cell, and this made it difficult to control the temperature of the blowby gas.
  - 2.2.2.3. They placed a cardboard box around the heat exchanger which significantly improved their ability to control the temperature.
- 2.2.3. Intertek eventually replaced the cardboard box with a more formal "baffle box".
- 2.2.4. They will distribute engineering prints of their baffle box to the other laboratories.
  - 2.2.4.1. They recommend including these prints in the procedure as an optional upgrade for the Golden Stand.

### 2.3. Exxon's Prove-Out Testing:

- 2.3.1. They are running their 2<sup>nd</sup> prove-out test now.
- 2.3.2. They appear to have lost 10HRS of test data because of a network problem.
- 2.3.3. However, this network issue did not impact the test itself.
  - 2.3.3.1. The stand still collected 6-second test data (even though the 1-second data was lost).
  - 2.3.3.2. Exxon will work with TMC to calculate the quality index values.
- 2.3.4. The test is expected to end this Friday.
- 2.3.5. **Forward Action Plan:**
  - 2.3.5.1. Exxon plans to install a "mule" motor in the stand for 2-3 days to troubleshoot the data acquisition problem.
  - 2.3.5.2. Once this troubleshooting is complete, they will run the break-in and aging cycle for their Precision Matrix engine.

### **2.3.6. Exxon's Oil Analysis Data:**

- 2.3.6.1. Intertek stated that the Exxon oil analysis data looked very good and correlates well with the data from the other laboratories.
- 2.3.6.2. Exxon is currently using an external lab to run their subtests.
  - 2.3.6.2.1. The only disadvantage of using the external lab is that it takes longer to get results.
- 2.3.6.3. Their internal lab would require an 80mL oil sample instead of the current 60mL sample volume.
- 2.3.6.4. Exxon expects to start their Precision Matrix test on November 7<sup>th</sup>.

### **2.4. Southwest's Precision Matrix Testing:**

- 2.4.1. REO300 is scheduled to run on Stand #19.
- 2.4.2. They are investigating the recent mild test results on Stand #18.
  - 2.4.2.1. The next test on this stand may start near the end of the week.
- 2.4.3. They have installed the baffle box, booster pump and oil heat exchanger blower on all their test stands.

### **2.5. Intertek's Precision Matrix Testing:**

- 2.5.1. Stand #100 is running REO1012, and the test is expected to complete this Thursday.
- 2.5.2. Stand #101 is running REO300, and the test is expected to complete this Friday.
- 2.5.3. Stand #102 is running REO1011, and the test is expected to complete this Saturday.
- 2.5.4. There is no discrimination between REO1011 and REO1012 in terms of iron.
  - 2.5.4.1. This is like the iron results from the 1<sup>st</sup> Precision Matrix.
- 2.5.5. The QI values for these tests are good.
  - 2.5.5.1. The real-time QI reporting for the engine coolant outlet temperature is not yet active.
- 2.5.6. Intertek created a spreadsheet that allows for an easy comparison between 30-second test cycles.
  - 2.5.6.1. They will make this spreadsheet available to the other laboratories.

### **2.6. Next Operational Data Review:**

- 2.6.1. The next operational data review will be delayed to accommodate the on-site inspection of Afton's Golden Stand next week.
- 2.6.2. The next operational data review will be scheduled in two weeks.
  - 2.6.2.1. Data from 101-102HRS will be examined.
- 2.6.3. This review will include data from the Precision Matrix tests at Intertek and Southwest and the prove-out matrix tests at Lubrizol and Exxon.

### **2.7. Sequence IVB Report Forms:**

- 2.7.1. The TMC will accept test results issued with the old report forms.
- 2.7.2. The current/old report forms do not have provisions for lab severity adjustments or industry correction factors.
- 2.7.3. The TMC is willing to reduce the amount of time beta testing the new form.
  - 2.7.3.1. The Surveillance Panel agreed to the reduced beta testing time.
  - 2.7.3.2. The Surveillance Panel would also like to make the new report form a priority for the TMC.

## **3. STATISTICAL ANALYSIS OF PROVE-OUT DATA (J. MARTINEZ):**

### 3.1. Summary Slide:

## Summary

- Conclusions are based on 13 tests completed from the IVB precision matrix in May 2017. Discrimination may not translate to the new procedure.
  
- Oil 300 discriminates with oil 1012 for both Keyence Volume Loss and Mass Loss.
- Oil 1011 discriminates with oil 1012 for Keyence Volume Loss but not for Mass Loss.
  - Should these two oils discriminate?
  
- Recommend to measure Mass Loss during the precision matrix.

- 3.1.1. The Keyence and mass loss data does show discrimination between REO300 and REO1012.
- 3.1.2. The Keyence data does show discrimination between REO1011 and REO1012.
  - 3.1.2.1. However, the mass loss does not show discrimination.
- 3.1.3. They recommend continuing the mass loss measurements at least through the Precision Matrix.
- 3.1.4. Intertek's Comments:**
  - 3.1.4.1. Mass loss clearly provides information that is different than volume loss.
  - 3.1.4.2. Maintaining the mass loss measurements will not be an issue because they do not take a lot of time.

## 4. TIMELINE:

### 4.1. Timeline Review:

- 4.1.1. The 2<sup>nd</sup> Precision Matrix is running.
- 4.1.2. Row 1 should be completed by October 30<sup>th</sup>.
- 4.1.3. An operational data review of the Row 1 data will be conducted on November 6<sup>th</sup> or 7<sup>th</sup>.
- 4.1.4. The Precision Matrix will not be paused for the operational data review.
- 4.1.5. Most of the Precision Matrix testing should be completed by the end of November.
- 4.1.6. The statisticians can start reviewing the data in the middle of December.

| Action Items | Person responsible | Completion Date |
|--------------|--------------------|-----------------|
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| Action Items | Person responsible | Completion Date |
|--------------|--------------------|-----------------|
|              |                    |                 |

| Follow-up Notes/Updates | Initials | Date Added |
|-------------------------|----------|------------|
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|                         |          |            |

| Attendees       | Organization | Contact Information |
|-----------------|--------------|---------------------|
| See attachment. |              |                     |
|                 |              |                     |
|                 |              |                     |

# **Sequence IV Surveillance Panel**

Conference Call

October 25, 2017

8:30 a.m. - 10:30 a.m.

## **A G E N D A**

1. Previous action item review
2. Prove-out testing update
3. Precision matrix testing update
4. Keyence versus mass loss discrimination analysis review
5. Sequence IVB timeline review
6. Motion and action item review
7. Next meeting
8. Adjourn

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| Matasic, James    | Lubrizol Corporation<br>29400 Lakeland Blvd.<br>Wickliffe, OH 44092<br>Phone No.: 440-347-2487<br>Fax No.:<br>Email: <a href="mailto:James.Matasic@Lubrizol.com">James.Matasic@Lubrizol.com</a>  |           |
| McMillan, Mike    | 5019 Deer Creek Cir N<br>Washington, MI 48094<br>Phone No.: 586-677-9198<br>Fax No.:<br>Email: <a href="mailto:mmcmillan123@comcast.net">mmcmillan123@comcast.net</a>  |           |
| Meier, Adam       | ExxonMobil<br><br>Phone No.:<br>Fax No.:<br>Email: <a href="mailto:adam.r.meier@exxonmobil.com">adam.r.meier@exxonmobil.com</a>  |           |
| O'Malley, Kevin   | Lubrizol Corporation<br>29400 Lakeland Blvd.<br>Wickliffe, OH 44092<br>Phone No.: 440-347-4141<br>Fax No.:<br>Email: <a href="mailto:Kevin.OMalley@lubrizol.com">Kevin.OMalley@lubrizol.com</a>  | ✓         |
| Pastor, Jofran    | Infineum<br><br>Phone No.:<br>Fax No.:<br>Email: <a href="mailto:jofran.pastor@infineum.com">jofran.pastor@infineum.com</a>  |           |
| Porter, Christian | Afton Chemical Corporation<br>500 Spring Street<br>P.O. Box 2158<br>Richmond, VA 23217-2158<br>Phone No.: 804-788-5837<br>Fax No.: 804-788-6358<br>Email: <a href="mailto:christian.porter@aftonchemical.com">christian.porter@aftonchemical.com</a> |           |
| Ritchie, Andrew   | Infineum USA L.P.<br>1900 E. Linden Avenue<br>Linden, NJ 07036-0536<br>Phone No.: 908-474-2097<br>Fax No.: 908-474-3637<br>Email: <a href="mailto:andrew.ritchie@infineum.com">andrew.ritchie@infineum.com</a>                                       | ✓         |

**NON-MEMBER MAILING LIST  
SEQUENCE IV SURVEILLANCE PANEL**

October 25, 2017

| NAME              | COMPANY-ADDRESS-PHONE-FAX-EMAIL   | SIGNATURE |
|-------------------|---|-----------|
| Smolenski, Don    | Evonik<br><br>Phone No.:<br>Fax No.:<br>Email:  |           |
| Stockwell, Robert | Chevron Oronite Company LLC<br><br>Phone No.:<br>Fax No.:<br>Email: <a href="mailto:Robert.Stockwell@chevron.com">Robert.Stockwell@chevron.com</a>  | ✓         |
| Sutherland, Mark  | Test Engineering, Inc.<br>12718 Cimarron Path<br>San Antonio, TX 78249<br>Phone No.: 210-867-8357<br>Fax No.: 210-690-1959<br>Email: <a href="mailto:msutherland@tei-net.com">msutherland@tei-net.com</a> |           |
| Taylor, Chris     | VP Racing Fuels<br><br>Phone No.: 210-710-4627<br>Fax No.:<br>Email: <a href="mailto:chris.taylor@vpracing-fuels.com">chris.taylor@vpracing-fuels.com</a>   |           |
| Thompson, Hap     | ASTM Facilitator<br><br>Phone No.: 904-287-9596<br>Fax No.:<br>Email: <a href="mailto:Hapjthom@aol.com">Hapjthom@aol.com</a>  |           |
| Tumati, Prasad    | Haltermann<br><br>Phone No.:<br>Fax No.:<br>Email: <a href="mailto:ptumati@jhaltermann.com">ptumati@jhaltermann.com</a>   |           |
| Huan<br>Huan      | Phone No.:<br>Fax No.:<br>Email:  | ✓         |
|                   | Phone No.:<br>Fax No.:<br>Email:  |           |

**NON-MEMBER MAILING LIST  
SEQUENCE IV SURVEILLANCE PANEL**

October 25, 2017

| NAME | COMPANY-ADDRESS-PHONE-FAX-EMAIL  | SIGNATURE |
|------|----------------------------------|-----------|
|      | Phone No.:<br>Fax No.:<br>Email: |           |
|      | Phone No.:<br>Fax No.:<br>Email: |           |
|      | Phone No.:<br>Fax No.:<br>Email: |           |
|      | Phone No.:<br>Fax No.:<br>Email: |           |
|      | Phone No.:<br>Fax No.:<br>Email: |           |
|      | Phone No.:<br>Fax No.:<br>Email: |           |
|      | Phone No.:<br>Fax No.:<br>Email: |           |
|      | Phone No.:<br>Fax No.:<br>Email: |           |





## Sequence IV Surveillance Panel

October 3, 2017

9:00AM – 5:00PM

Intertek

San Antonio, TX

### Motions and Action Items

As Recorded at the Meeting by Bill Buscher

1. Action Item – Perform a sectional Rockwell hardness test on a test intake camshaft.  
**In process.**
2. Action Item – Ask the supplier of IVB-LFO-1 if the directional performance between prove-out tests, of the intake lifter wear, can be shared with the surveillance panel.  
**In process.**
3. Action Item – Update the operational data review Excel template to include the extra blowby temperature parameters.  
**Completed.**
4. Action Item – Lab to provide 1 hour, test hour 101 to 102 (NOTE: if an unscheduled shutdown occurred between test hour 101 and 102, then obtain data from the next full hour of test time without any scheduled or unscheduled shutdowns), of operational data, using the updated operational data review Excel template, from all of the prove-out tests, to the TMC for posting, so that a thorough operational data analysis can be performed Rich Grundza and Kevin OMalley. A total of 12 prove-out tests to be included. Labs to have data uploaded by 10/9/17. A follow-up conference call to be scheduled for 10/12/17.  
**Completed.**
5. Action Item – Travis Kostan to obtain the engine coolant out temperature data from the operational data files indicated in the above action item, to calculate QI target and limits.  
**Completed.**
6. Action Item – Surveillance panel chair to collect the Intake Lifter Average Volume Loss results from the two ASTM REO 1012 and the seven ASTM REO 300 prove-out tests and forward to the industry statisticians group for statistical analysis.  
**Completed.**



## Sequence IV Surveillance Panel

October 12, 2017

8:30AM – 11:30AM

Conference Call

### Motions and Action Items

As Recorded at the Meeting by Bill Buscher

1. Action Item – Surveillance panel chair to collect the individual Intake Lifter Average Volume Loss results from the two ASTM REO 1012 and the seven ASTM REO 300 prove-out tests and forward to the industry statisticians group for statistical analysis by individual lifter.  
**In process.**
2. Action Item – Labs to compare intake lifter profile traces to volume loss results from their ASTM REO 1012 and ASTM REO 300 prove-out tests.  
**In process.**
3. Action Item – SwRI and Intertek to share their PDI profile traces from their ASTM REO 1012 and ASTM REO 300 prove-out tests for comparison and review.  
**In process.**
4. Action item – Lubrizol metrology technician to draft a Keyence intake lifter crown profile screening procedure.  
**Completed.**
5. Action item – Resume using old intake lifter crown profile rejection criteria, replacing the PDI with the Keyence and update test procedure accordingly.  
**Completed.**



## Sequence IV Surveillance Panel

October 16, 2017

8:30AM – 11:30AM

Conference Call

### Motions and Action Items

As Recorded at the Meeting by Bill Buscher

1. Action Item – Intertek to provide a procedure for adding a chilled water booster pump and a blower to the engine oil temperature control system.  
**In process.**
2. Action Item – Re-evaluate the engine oil gallery temperature Qi targets and limits using the operational data from the latest prove-out and precision matrix tests.  
**In process.**
3. Action Item – Labs to review and confirm component orientation for their engine and RAC coolant systems.  
**Completed.**
4. Action item – Afton to provide operational data plots of their engine coolant flow and RAC coolant flow for comparison to the operational data plots from the other labs.  
**In process.**
5. Motion – Set separate stage 1 and stage 2 Qi targets and windows for Engine Coolant Out Temperature, with a Qi target of 51.50°C and a Qi window of  $\pm 0.75^\circ\text{C}$  for stage 1 and Qi target of 52.75°C and a Qi window of  $\pm 0.75^\circ\text{C}$  for stage 2. Transition data will not be included in the Engine Coolant Out Temperature Qi calculation.  
Chris Mileti / Bill Buscher / Passed 9 – 0 – 3  
**Completed.**
6. Action Item – Industry statisticians group to perform a statistical analysis, evaluating oil discrimination capabilities and differences between volume loss and mass loss.  
**Completed.**
7. Motion – Surveillance panel agrees to eliminate PDI area loss and z diff as lifter wear measurement requirements from the Sequence IVB test procedure, based on the statistical correlation analysis between the Keyence volume loss and the PDI area loss and z diff wear measurement parameters. Effective 10/16/17.  
Bill Buscher / Chris Mileti / Passed 9 – 0 – 3  
**Completed.**



## Sequence IV Surveillance Panel

October 25, 2017

8:30AM – 10:30AM

Conference Call

### Motions and Action Items

As Recorded at the Meeting by Bill Buscher

1. Action Item – Lab to provide 1 hour, test hour 101 to 102 (NOTE: if an unscheduled shutdown occurred between test hour 101 and 102, then obtain data from the next full hour of test time without any scheduled or unscheduled shutdowns), of operational data, using the updated operational data review Excel template, from any additional prove-out tests and the Row 1 precision matrix tests, to the TMC for posting, so that an additional operational data analysis can be performed by Rich Grundza and Kevin OMalley. A total of 3 additional prove-out tests and 5 precision matrix tests to be included. Labs to have data uploaded by 11/1/17. A follow-up conference call to be scheduled for 11/7/17.
2. Action Item – Lab to complete and submit test reports to the TMC for any previously or recently completed Sequence IVB reference oil tests.





**Sequence IVB Timeline/Deadlines**

| <b>Task</b>   | <b>5-Stand Precision Matrix</b> |
|---|---------------------------------|
| Complete Test Fuel Blending                           | DONE                            |
| Complete Test Hardware Procurement and Preparation    | DONE                            |
| Complete Preparation for Prove-out Testing            | DONE                            |
| Complete Row 1 Prove-out Tests                        | DONE                            |
| Complete Row 2 Prove-out Tests                        | DONE                            |
| Complete Procedure Update                             | DONE                            |
| Complete Precision Matrix Lab Audits                  | DONE                            |
| Seq. IV Surveillance Panel Meeting                    | DONE                            |
| Complete 5 ASTM REO 300 Prove-out Tests               | DONE                            |
| Complete Preparation for Precision Matrix             | DONE                            |
| Seq. IV Surveillance Panel Conference Call - 10/12/17 | DONE                            |
| Seq. IV Surveillance Panel Conference Call - 10/16/17 | DONE                            |
| Restart Precision Matrix (Start Row 1 Tests)          | 10/18/2017                      |
| Complete Row 1 Precision Matrix Tests                 | 10/30/2017                      |
| Complete Row 1 Precision Matrix Operational Review    | 11/6/2017                       |
| Complete Precision Matrix                             | 11/29/2017                      |
| Complete Final Precision Matrix Operational Review    | 12/6/2017                       |
| Start Statistical Analysis of Precision Matrix        | 12/7/2017                       |
| Complete Statistical Analysis of Precision Matrix     | 1/7/2018                        |
| Complete Development and Approve LTMS                 |                                 |
| <b>PCEOCP/AOAP Vote for Test Acceptance</b>           | <b>1/11/2018</b>                |
| Stand Calibration Starts                              | 1/12/2018                       |

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Intertek is done. SwRI?

IAR stands 1,2 and 3 and SwRI stand 2 complete by  $\approx$  10/30/17. SwRI stand 1 delayed.

accounts for 1 week to compile test results and complete review

accounts for 10 days to complete each test (3 tests on each stand)

accounts for 1 week to compile test results from last row and complete review

accounts for 1 month to complete statistical analysis for 5-stand timeline, in order to vote at January 2018 PCEOC

**P/AOAP meeting**

# Comparison of IVB Intake Lifter Average Volume Loss and Average Mass Loss Discrimination

Statistics Group

Oct. 18, 2017

# 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

- Conclusions are based on 13 tests completed from the IVB precision matrix in May 2017. Discrimination may not translate to the new procedure.
- Oil 300 discriminates with oil 1012 for both Keyence Volume Loss and Mass Loss.
- Oil 1011 discriminates with oil 1012 for Keyence Volume Loss but not for Mass Loss.
  - Should these two oils discriminate?
- Recommend to measure Mass Loss during the precision matrix.

# Data Completed before Termination

- Labs
  - IAR: 2 stands
  - SwRI: 2 stands
- Oils
  - 1012 (5W-20): 5 tests
  - 300 (5W-30): 3 tests
  - 1011 (0W-16): 5 tests
- Total number of tests = 13



# IVB PM Data

Precision Matrix Data Table from Frank Farber's 20170524 IVB Matrix Test Status update.

| Run Order | B1                 | B2   | A1                 | A2                 |
|-----------|--------------------|--|--------------------|--------------------|
| 1         | 300<br>123246-IVB  | 1012<br>125167-IVB                           | 300<br>123243-IVB  | 1011<br>109199-IVB |
| 2         | 1011<br>109203-IVB | 1011<br>109204-IVB<br>Terminated 157<br>hrs. | 1012<br>125175-IVB | 1011<br>109200-IVB |
|           |                    | 1011<br>125878-IVB                           |                    |                    |
| 3         | 1011<br>120737-IVB | 300<br>125171-IVB                            | 1012<br>125177-IVB | 1012<br>125176-IVB |
| 4         | 1012<br>125168-IVB | 300  | 1011               | 300                |
| 5         | 300                | 1012   | 1011               | 300                |

Reported Invalid

# ANOVA Models

## Intake Lifter Average Volume Loss

- Oil and Stand within Lab are significant while Lab is marginal.

**Summary of Fit**

|                            |          |
|----------------------------|----------|
| RSquare                    | 0.86932  |
| RSquare Adj                | 0.775977 |
| Root Mean Square Error     | 0.221794 |
| Mean of Response           | 2.284598 |
| Observations (or Sum Wgts) | 13       |

**Analysis of Variance**

| Source   | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|----------|----|----------------|-------------|---------|----------|
| Model    | 5  | 2.2906887      | 0.458138    | 9.3132  |          |
| Error    | 7  | 0.3443472      | 0.049192    |         | 0.0053*  |
| C. Total | 12 | 2.6350359      |             |         |          |

**Parameter Estimates**

| Term                           | Estimate  | Std Error | t Ratio | Prob >  t |
|--------------------------------|-----------|-----------|---------|-----------|
| Intercept                      | 2.3265117 | 0.054026  | 36.34   | <.0001*   |
| Reference Oil[300]             | 0.2666303 | 0.102974  | 2.59    | 0.0360*   |
| Reference Oil[1011]            | 0.1221913 | 0.098081  | 1.25    | 0.2529    |
| Lab[AR]                        | 0.1250882 | 0.063598  | 1.97    | 0.0899    |
| Lab[AR]:Matrix Stand[Stand 1]  | -0.136708 | 0.085582  | -1.60   | 0.1542    |
| Lab[SWR]:Matrix Stand[Stand 1] | 0.4332313 | 0.102974  | 4.21    | 0.0040*   |

**Effect Tests**

| Source            | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|-------------------|-------|----|----------------|---------|----------|
| Reference Oil     | 2     | 2  | 0.94610815     | 9.6164  | 0.0098*  |
| Lab               | 1     | 1  | 0.19030218     | 3.8685  | 0.0899   |
| Matrix Stand[Lab] | 2     | 2  | 0.95558553     | 9.7127  | 0.0096*  |

## Intake Lifter Average Mass Loss

- Oil is significant while Lab and Stand within Lab are marginal.

**Summary of Fit**

|                            |          |
|----------------------------|----------|
| RSquare                    | 0.825963 |
| RSquare Adj                | 0.701651 |
| Root Mean Square Error     | 3.59459  |
| Mean of Response           | 21.77115 |
| Observations (or Sum Wgts) | 13       |

**Analysis of Variance**

| Source   | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|----------|----|----------------|-------------|---------|----------|
| Model    | 5  | 499.25570      | 85.8511     | 5.6443  |          |
| Error    | 7  | 90.44755       | 12.9211     |         | 0.0137*  |
| C. Total | 12 | 519.70325      |             |         |          |

**Parameter Estimates**

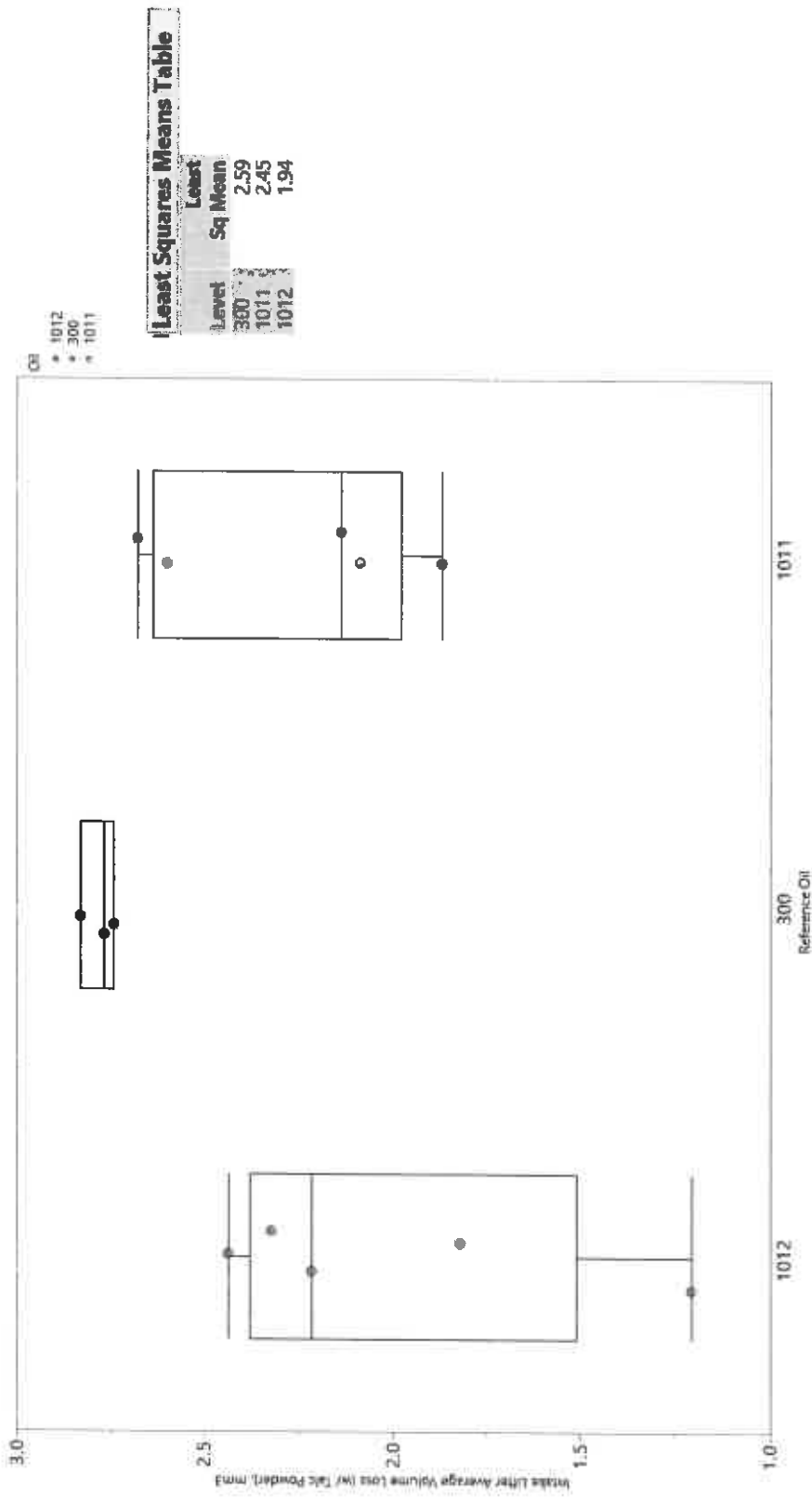
| Term                           | Estimate  | Std Error | t Ratio | Prob >  t |
|--------------------------------|-----------|-----------|---------|-----------|
| Intercept                      | 22.582917 | 1.037669  | 21.76   | <.0001*   |
| Reference Oil[300]             | 5.6964722 | 1.668895  | 3.41    | 0.0112*   |
| Reference Oil[1011]            | -1.229278 | 1.589588  | -0.77   | 0.4646    |
| Lab[AR]                        | 2.0389722 | 1.030728  | 1.98    | 0.0884    |
| Lab[AR]:Matrix Stand[Stand 1]  | -1.198944 | 1.387013  | -0.86   | 0.4160    |
| Lab[SWR]:Matrix Stand[Stand 1] | 4.1603611 | 1.668895  | 2.49    | 0.0414*   |

**Effect Tests**

| Source            | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|-------------------|-------|----|----------------|---------|----------|
| Reference Oil     | 2     | 2  | 184.82298      | 7.1520  | 0.0203*  |
| Lab               | 1     | 1  | 50.56307       | 3.9132  | 0.0884   |
| Matrix Stand[Lab] | 2     | 2  | 86.55599       | 3.3494  | 0.0954   |

# Intake Average Volume Loss

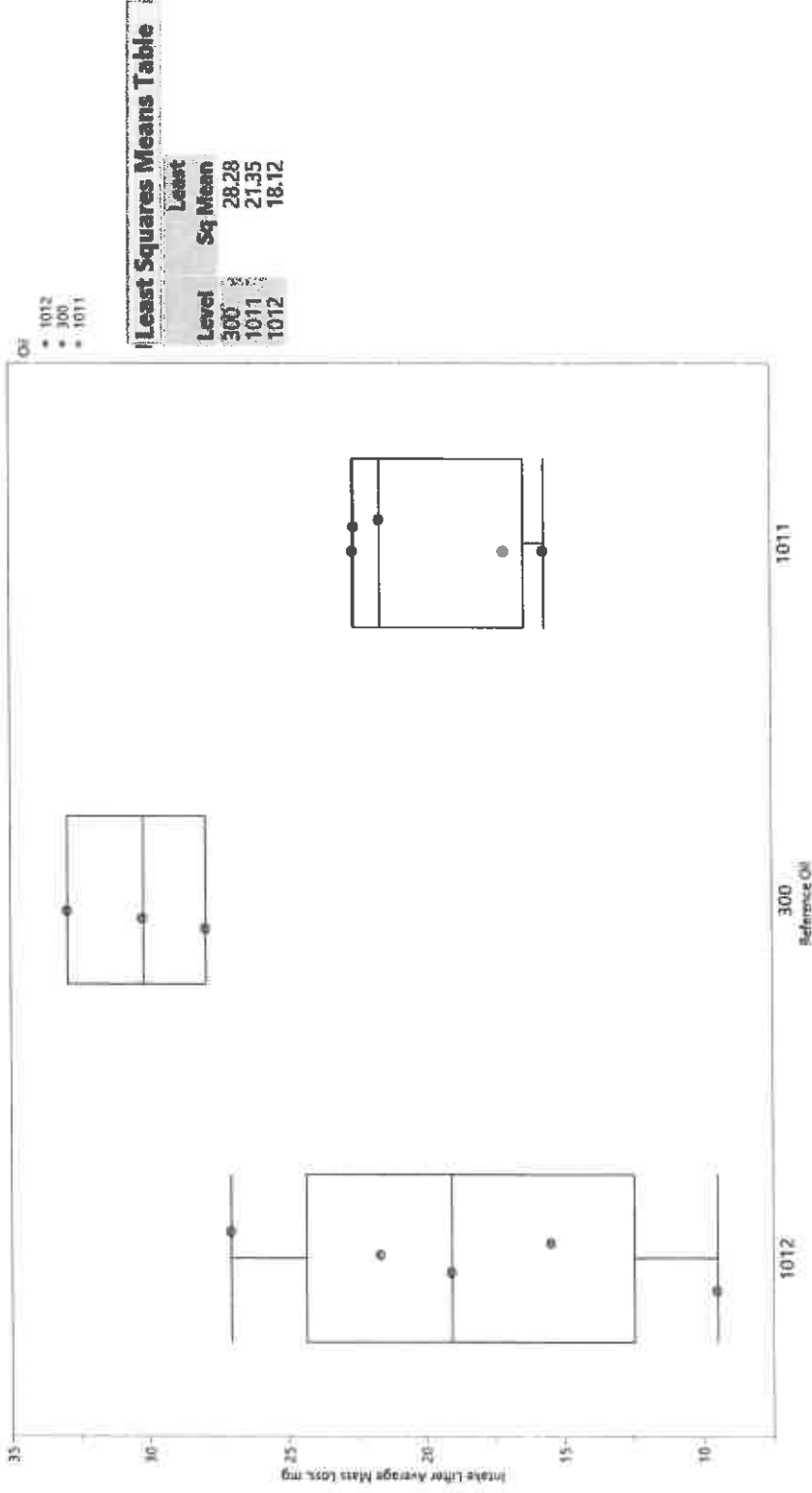
IVB can discriminate Volume Loss of 3 standard deviations between oils 300 and 1012 and 2.3 standard deviations between oils 1011 and 1012.



300, 1011 > 1012 (p=0.01 or 0.03)

# Intake Average Mass Loss

IVB can discriminate Mass Loss of 2.8 standard deviations between oils 300 and 1012 but not between 1011 and 1012.



**300 > 1012 (p=0.02)**

# Sequence IVB Precision Matrix Design

Statistics Group  
October 9, 2017

# Statistics Group

- 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

# Sequence IVB Precision Matrix Design

| Run Order | Precision Matrix |               |             |              |              |      | Supplemental |       |  |
|-----------|------------------|---------------|-------------|--------------|--------------|------|--------------|-------|--|
|           | IAR - Stand1     | IAR - Stand 2 | IAR Stand 3 | SwRI Stand 1 | SwRI Stand 2 | LZ   | XOM          | Afton |  |
| 1         | 1012             | 300           | 1011        | 300          | 1012         | 1012 | 300          | 1011  |  |
| 2         | 1011             | 1012          | 1012        | 1011         | 300          | 1012 | 300          | 1011  |  |
| 3         | 300              | 1011          | 300         | 1012         | 1011         | 300  | 1011         | 1012  |  |
| 4         | 1012             | 300           | 1011        | 300          | 1012         |      |              |       |  |

## Recommendations:

1. Each supplemental lab runs a minimum of 3 tests
2. Order of supplemental tests is subject to change