

IVB Metrology Sub-Group | MINUTES

REVISION DATE: 7/25/2018 11:04:00 AM

Relevant Test:	Sequence IVB
Note Taker:	Chris Mileti
Meeting Date:	07-19-2018
Comments:	2 nd conference call for the Sequence IVB Metrology Sub-Group.

1. REVIEW OF STATISTICAL PRESENTATION FOR 3RD ROUND ROBIN (KEVIN O'MALLEY):

1.1. Background:

- 1.1.1. Three Keyence round-robins were previously conducted by Intertek, Southwest and Lubrizol.
- 1.1.2. Kevin O'Malley reviewed the "IVB Keyence Round Robin 3 Analysis" PowerPoint file with the Metrology Sub-Group.
- 1.1.3. This presentation was originally given to the full Sequence IV Surveillance Panel in April 2016.
- 1.1.4. The presentation reviews the results of the 3rd Keyence round-robin that was conducted by the original three laboratories.

1.2. Slide #2:

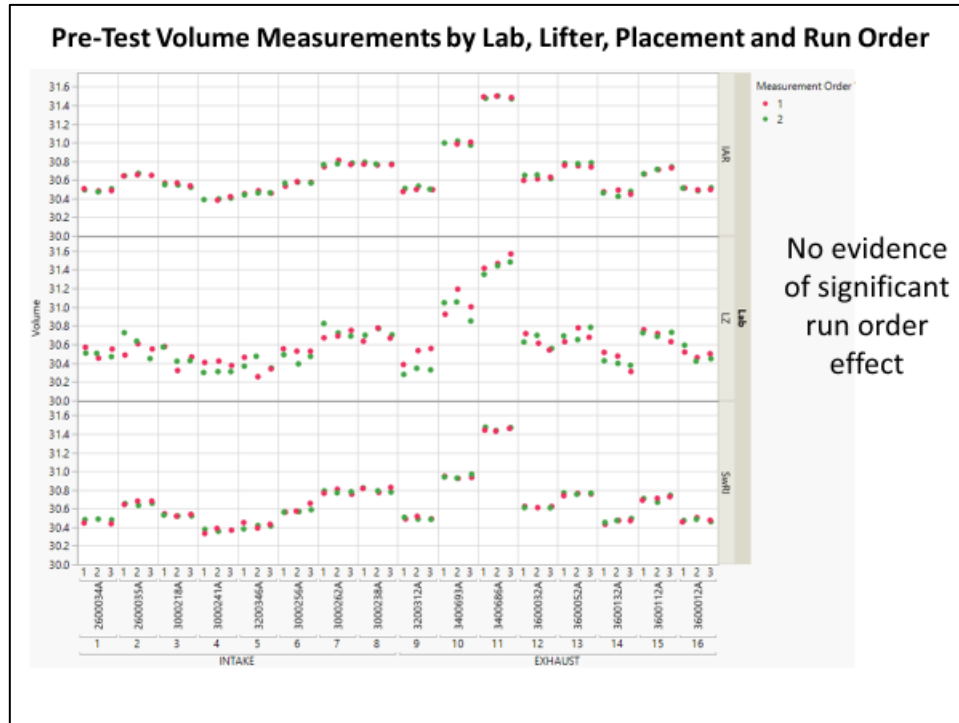
Round Robin Methodology

- 16 pre-test lifters (8 exhaust, 8 intake) were measured at each of the three labs (SwRI, IAR, and LZ). Labs measured the volume of the lifters using the following procedure:
 - Place the lifter on the Keyence unit and take two consecutive measurements.
 - Remove the lifter.
 - Place the lifter on the Keyence unit for a second time and take two consecutive measurements.
 - Remove the lifter.
 - Place the lifter on the Keyence unit for a third time and take two consecutive measurements.
- It is planned that these lifters will be utilized in a single precision matrix test so post-test measurements can be gathered for direct comparison.

- 1.2.1. This slide lists the data collection protocols.

1.2.2. These protocols include how the lifter is placed on the Keyence stage and the number of repeat measurements that were taken.

1.3.Slide #3:



- 1.3.1. This chart shows the pre-test lifter measurements.
- 1.3.2. Each row contains data from a different lab.

1.4.Slide #4:

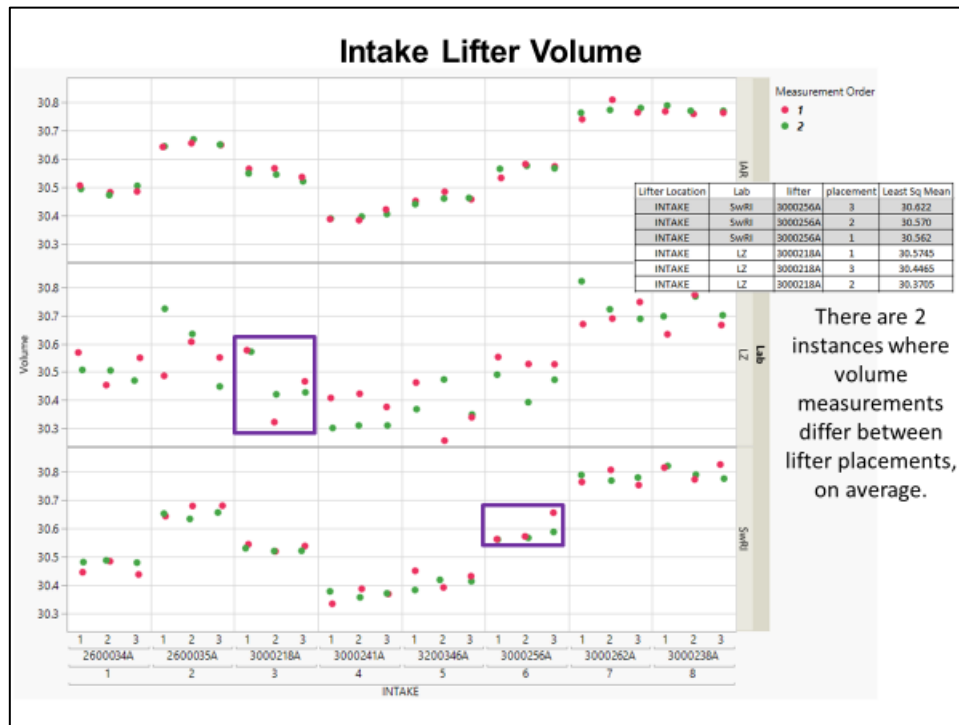
Test Variation

Lab	Round Robin 2 Estimated Standard Deviation	Round Robin 3 Estimated Standard Deviation
LZ	0.0234	0.0716
IAR	0.0128	0.0164
SwRI No Talc	0.0156	0.0189
SwRI Talc	0.0157	

- The estimated standard deviation represents the expected standard deviation of volume measurements taken at the same lab on the same lifter in the same placement.
- The measurement variation in Round Robin 3 measurements at LZ is higher than the measurement variation observed at the other labs as well as in Round Robin 2 measurements at this lab.
- SwRI and IAR exhibit similar measurement variation to each other as well as between Round Robin 2 and 3.

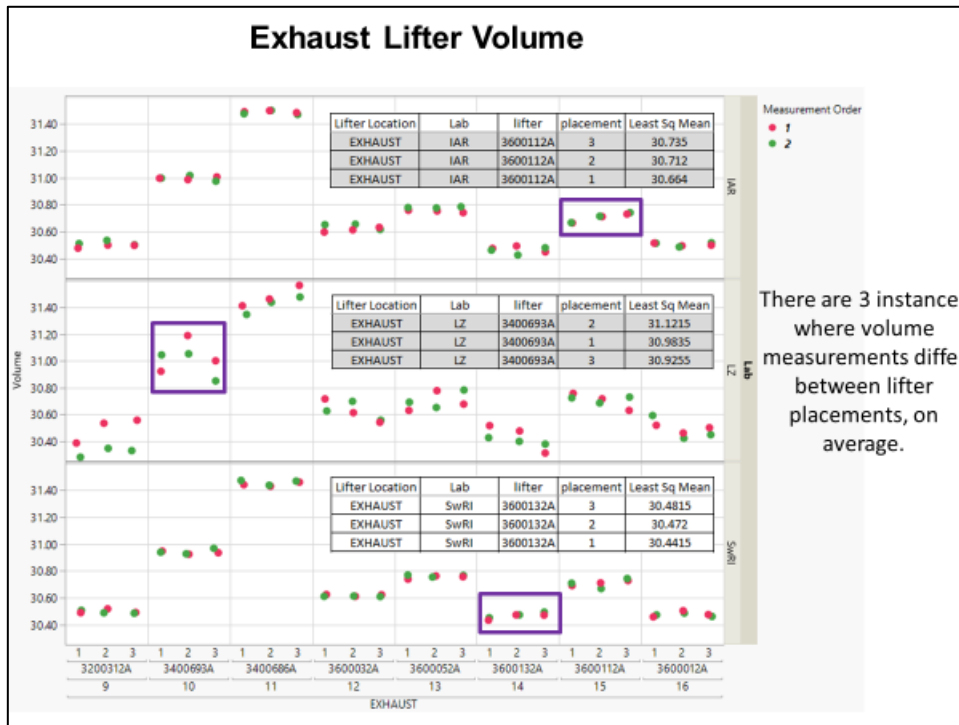
- 1.4.1. This slide compares the estimated standard deviations between the 2nd and 3rd round robins.
- 1.4.2. There is a notable increase in Lubrizol's standard deviation.
- 1.4.3. Talc was not used to collect any of the measurements for the 3rd round robin.
- 1.4.4. Comments from Intertek:**
 - 1.4.4.1. Talc was not implemented in the procedure until after the 3rd round robin.
 - 1.4.4.2. Southwest collected supplemental data with talc during the 2nd round robin because they were the lab responsible for initially evaluating this technique.
 - 1.4.4.3. Southwest later concluded that talc helped improve precision and reduce high spots.

1.5. Slide #5:



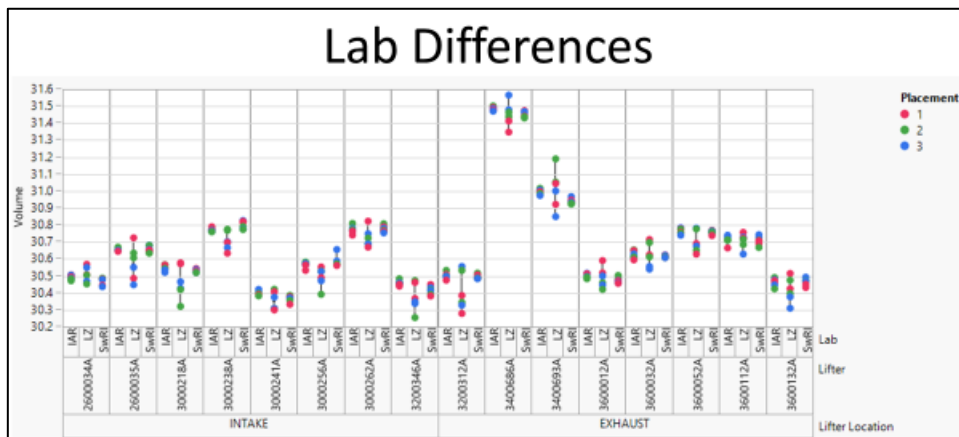
- 1.5.1. This chart shows the intake lifter measurements.
- 1.5.2. The table at the right of the slide shows the measurements that are highlighted within the two purple boxes.
- 1.5.3. In general, lifter placement did not have an impact on the overall data.
 - 1.5.3.1. However, the data within the two purple boxes are exceptions.
- 1.5.4. O'Malley questioned whether the lifter sizes (or grades) could have an impact on the measurements.

1.6. Slide #6:



- 1.6.1. This chart shows the exhaust lifter measurements.
- 1.6.2. The table in each row shows the measurements highlighted by the corresponding purple box.
- 1.6.3. These three purple boxes show instances where the volume measurements differ between lifter placement.
 - 1.6.3.1. The purple box for Lubrizol has the biggest measurement difference.

1.7.Slide #7:



On average, IAR and SwRI measurements differ by 0.0121 units (IAR > SwRI). Upon closer inspection, a significant difference is only observed in the measurements of 2 of the lifters (3400693A & 3200346A). So, this difference may not be of practical importance.

Given the variability observed in LZ measurements, we cannot claim that there are significant differences, on the average, between the measurements from LZ and the other labs.

- On average, LZ measurements are 0.0434 units lower than IAR; 0.0313 units less than SwRI.

- 1.7.1. The lab difference between Intertek and Southwest is being driven by two lifters.

1.7.2. Lubrizol had the most variability during the 3rd round robin.

1.7.2.1. This variability made it difficult to determine if Lubrizol was statistically different than Intertek or Southwest.

1.8. Slide #8:

Comments/Conclusions

1. In general there is no significant difference between average volume measurements taken at the various labs. Keep in mind there were a couple of lifters in which IAR and SwRI differed in their average measurements.
2. In general lifter placement on the Keyence can change without a significant effect on the volume. However, there are 5 instances (of 48) where volume measurements differ between lifter placements.
3. The measurement variation at LZ is higher compared to the other labs. It is also higher than the measurements variation observed at this lab in Round Robin 2 results.
4. 95% of measurements taken at either IAR or SwRI on the same lifter in the same lifter position are estimated to span a range of 0.0693.
5. 95% of measurements taken at LZ on the same lifter in the same lifter position are estimated to span a range of 0.2806.
6. Test measurement variation can be evaluated by lifter grade. A direct link between lifter grade and lifter ID would be needed.

1.8.1. On average, lifter placement was not a statistically significant factor in the round robin.

1.8.2. Lubrizol displayed the most variability out of all three labs.

1.8.3. Bullets #4 and #5 contain estimates for the Keyence's variability.

1.8.4. Bullet #6 introduces the idea of adding lifter grades as a variable during the next round robin.

1.8.5. Comments from Intertek:

1.8.5.1. Selecting specific lifter grades will be very difficult.

1.8.5.2. The lifter grades are dictated by the engine.

1.8.6. Response from Kevin O'Malley:

1.8.6.1. If specific lifters cannot be selected, then the next best option is to use an engine with lifter grades that span the range of lifter grades from the 2nd Precision Matrix.

1.8.6.2. It would also be useful to utilize an oil that will generate lifter volume losses that span the range of volume losses from the 2nd Precision Matrix.

1.8.7. Comments from Southwest:

1.8.7.1. Is data available that shows the distribution of lifter grades being used in the Industry?

1.8.7.2. This will help address O'Malley's recommendation to use an appropriate range of lifter grades.

1.8.8. Response from Intertek:

1.8.8.1. Lifter grade usage has been consistent since 2016.

1.8.8.2. Grade-20 is on the low end of the range, and Grade-48 is on the high end of the range.

1.8.8.3. Intake lifter grades are usually smaller than exhaust lifter grades.

1.8.9. Comments from Lubrizol:

- 1.8.9.1. Under normal circumstances, the sub-group should select an engine for this round robin that offers the widest range of lifter grades.
- 1.8.9.2. Unfortunately, time is an issue because the Industry wants many of the critical action items completed by September 2018.
- 1.8.9.3. As a result, the sub-group will need to use the first engine that is available for this effort (regardless of the grades that it requires).

1.8.10. Comments from Intertek:

- 1.8.10.1. They have 8-9 Sequence IVB engines in service.
- 1.8.10.2. They are willing to donate one of these engines to the 4th round robin.
- 1.8.10.3. Unfortunately, all their test stands have recently been referenced.
- 1.8.10.4. They could use an engine for the upcoming BOI/VGRA matrix.
 - 1.8.10.4.1. But this matrix requires new engines.

1.8.11. Comments from Southwest:

- 1.8.11.1. They are bringing a new stand online, which requires two consecutive reference tests.
- 1.8.11.2. They have just completed the first test, and are selecting lifter grades for the second test.
- 1.8.11.3. They could offer this engine for the round robin.
- 1.8.11.4. Lubrizol cautioned that doing so would force Southwest to delay the completion of their reference testing by a month.

2. FORWARD ACTION PLAN FOR 4TH ROUND ROBIN:

2.1. Proposal for IAR101:

- 2.1.1. IAR101 was used during the 2nd Precision Matrix.
- 2.1.2. This stand was recently referenced using REO1012.
- 2.1.3. Even though the stand was successfully calibrated, the result inexplicably shifted severe.
 - 2.1.3.1. As a result, the stand now has an unfavorable severity adjustment.
- 2.1.4. Intertek may be willing to donate an REO300 industry information run that can be used for the round robin.
 - 2.1.4.1. This will help them better understand the recent severity shift.
 - 2.1.4.2. REO300, which is a failing reference oil, should also generate a wide range of lifter volume losses.
- 2.1.5. Intertek will follow-up with this sub-group as soon as possible to confirm whether they can make this engine and stand available for the round robin.

2.2. High Spots:

- 2.2.1. Several members of the sub-group brought up the issue of high spots.

2.2.2. Response from Intertek and Lubrizol:

- 2.2.2.1. High spots were originally caused by areas of high reflectivity on E.O.T. lifters.
- 2.2.2.2. This reflectivity would result in anomalies in the Keyence measurements.
- 2.2.2.3. This phenomenon was effectively eliminated with the introduction of talc.

2.3. Lifter Batch:

- 2.3.1. Lubrizol speculated whether the round robin could use lifters from the same batch.
- 2.3.2. Intertek believes that this will be tricky because each grade has different consumption rates.

2.3.2.1. As a result, there are a mixture of Batch-A, Batch-B and Batch-C lifters being used.

2.3.3. Lubrizol will contact OHT to see if they have the capability to supply Batch-C lifters for all the required grades.

2.4. Lifter Placement:

2.4.1. Lubrizol inquired whether the sub-group wants to keep lifter placement as a variable in the next round robin.

2.4.2. Comments from O'Malley:

2.4.2.1. Ideally, the 4th round robin should be conducted the same as the 3rd round robin.

2.4.2.2. However, he understands that timing constraints may prevent this.

2.4.2.3. One option to save time would be to do two lifter placements instead of the original three.

2.4.2.4. Another option would be to maintain the three lifter placements but eliminate the repeat measurements.

2.4.3. Comments from Exxon:

2.4.3.1. They would prefer to mimic the 3rd round robin in its entirety.

2.4.3.2. The extra measurement time is justified.

2.4.3.3. This will result in the most comprehensive data set for the statisticians, and it will reduce the likelihood that this effort will need to be repeated.

2.4.3.4. Intertek concurs with Exxon's comments.

2.5. Back-Up Lifters:

2.5.1. Lubrizol questioned whether back-up lifters should be added in case Intertek needs to make a last-minute adjustment to their clearances.

2.5.2. Intertek offered to check their clearances with lifters from their inventory so that they are completely confident that the specified grades will be sufficient.

2.6. Measurement Order:

2.6.1. Lubrizol will start the pre-test measurements because they are the closest to OHT.

2.6.2. Lubrizol will send the lifters to the other east coast labs (Exxon and Afton) after they are done.

2.6.3. Intertek should be the last lab to get the lifters.

Action Items	Person responsible	Completion Date

Follow-up Notes/Updates	Initials	Date Added
Representatives from each of the (5) Sequence IVB laboratories participated in this conference call.	CHTM	07-24-2018

Attendees	Organization	Contact Information