IVB Metrology Sub-Group | MINUTES

REVISION DATE: 9/19/2018 8:55:00 AM

Relevant Test:	Sequence IVB
Note Taker:	Chris Mileti
Meeting Date:	09-14-2018
Comments:	Conference call for the Sequence IVB Metrology Sub-Group.

1. AGENDA ITEM #1 - USING KEYENCE TO SCREEN LIFTER PROFILES:

1.1. Opening Comments from Lubrizol:

1.1.1. The first agenda item for this meeting was to discuss using the Keyence to screen lifter profiles.

1.1.1.1. Intake lifters with unacceptable profiles should be discarded or used on the exhaust-side of the engine.

1.1.2. ***Summary of Previous Toyota Comments on this Issue:***

1.1.2.1. Toyota commented on this issue during a recent IVB sub-group conference call.

1.1.2.2. Their requirement is that all intake lifters have a flat or crowned profile.

1.1.2.3. Lifters with concavity should not be used on the intake-side of the engine.

1.1.2.4. Toyota always envisioned using the Keyence as a quick way to screen lifters for profile acceptability.

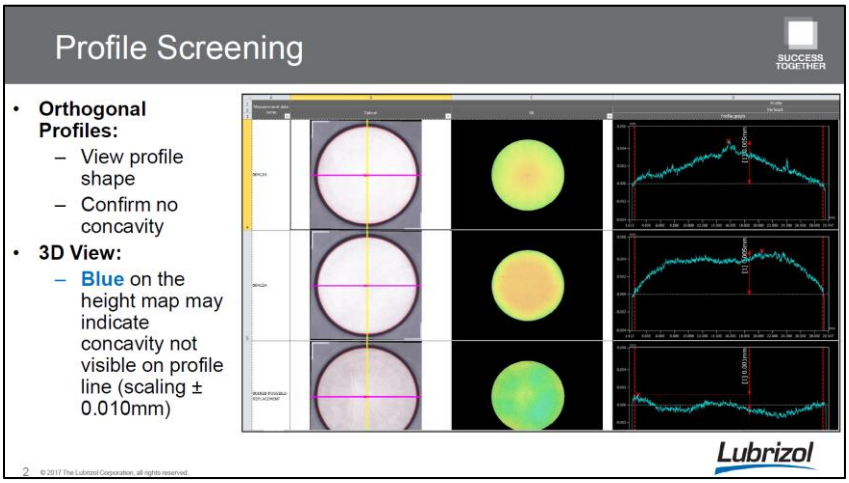
1.1.3. ***Feedback from Other Labs:***

1.1.3.1. Lubrizol distributed a presentation to this sub-group a few weeks ago that summarized its thoughts on this issue.

1.1.3.2. Lubrizol also received documents from Southwest and Afton.

1.2. Review of Lubrizol Lifter Profile Screening Proposal:

1.2.1. ***Slide #2:***



1.2.1.1. A tab can be set-up in the Keyence software to display both a height map and orthogonal profile for each lifter.

1.2.1.1.1. The orthogonal profile replicates a trace from the PDI instrument.

1.2.1.2. *Color Scale:*

1.2.1.2.1. Extensive areas of blue on the height map, especially near the center of the lifter, indicate regions of concavity.

1.2.1.2.2. The color scale is set in relation to the assigned reference plane.

1.2.1.2.3. It is not uncommon for a lifter to have some blue coloration around its edge.

1.2.1.2.4. The TMC noted that an orange coloration indicates a domed profile in Lubrizol's color scale.

1.2.1.3. *Lifter at Bottom of Slide:*

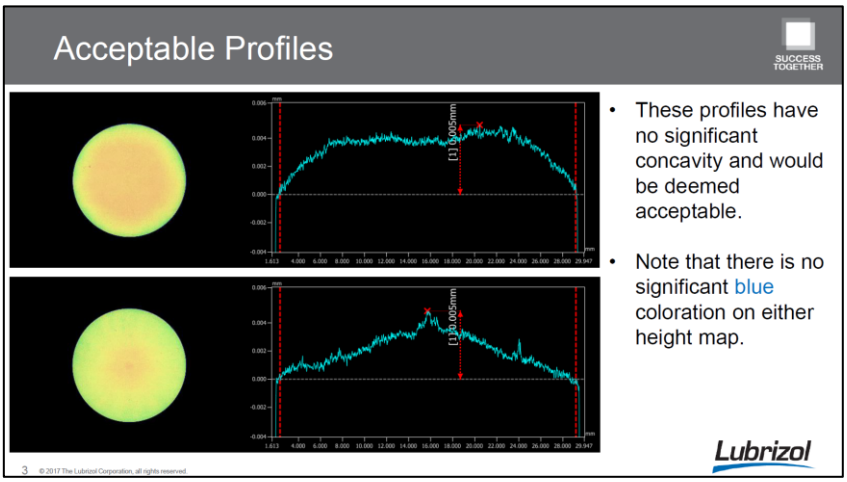
1.2.1.3.1. The lifter shown at the bottom of the slide has a concave profile.

1.2.1.3.2. Lubrizol believes that this is a Batch-C lifter.

1.2.1.3.3. Intertek has not seen any concavity in their lifters, so they are surprised that Lubrizol found one.

1.2.1.4. Even though flat profiles are acceptable, Intertek likes to use lifters that have some sort of dome.

1.2.2. ***Slide #3:***



1.2.2.1. This slide shows acceptable profiles.

1.2.2.2. *Comments from Intertek:*

1.2.2.2.1. The original lifter acceptability criteria required a uniform dome.

1.2.2.2.2. This requirement was relaxed after a Metrology Workshop that was hosted by Lubrizol in August 2017.

1.2.2.2.3. Test variability seemed to increase after the profile acceptability requirements were made less stringent.

1.2.2.2.4. As a result, strict profile acceptability requirements were reintroduced.

1.2.2.2.5. This did not reduce test variability, so Intertek supports returning to the more relaxed screening criteria.

1.2.2.3. *Comments from Lubrizol:*

1.2.2.3.1. Lubrizol's proposal is to use qualitative (color scale) and not quantitative (crown height) screening criteria.

1.2.2.3.2. There has been no evidence to suggest that the degree of lifter crown impacts lifter wear.

1.2.2.3.3. Also, stringent lifter crown criteria can be very expensive.

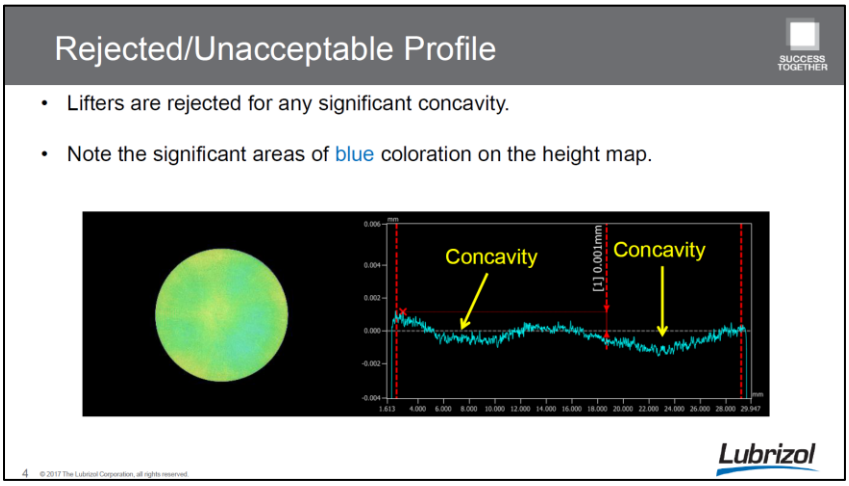
1.2.2.3.4. It is difficult to use rejected intake lifters on the exhaust-side of the engine because the range of grades is different.

1.2.2.4. *Lifter Crown and Lifter Rotation (Intertek):*

1.2.2.4.1. The lifter's crown has a small contribution to the lifter's rotation.

1.2.2.4.2. Toyota has said in the past that the valve spring is the primary driver of lifter rotation in this engine.
1.2.2.4.3. The IVB camshaft lobes are flat.
1.2.2.4.4. In contrast, the IIIF/G camshaft lobes are tapered and offset.
1.2.2.4.4.1. A combination of this taper, offset and lifter crown drives IIIF/G lifter rotation.
1.2.2.4.5. Toyota has also stated that their manufacturing tolerance for lifters requires a flat or domed profile.
1.2.2.4.5.1. Concave profiles are not acceptable.

1.2.3. ***Slide #4:***



1.2.3.1. This slide shows an example of an unacceptable lifter profile.
1.2.3.2. *Blue Coloration Around Edges:*
1.2.3.2.1. Afton asked if blue coloration around the edges of the lifter is acceptable.
1.2.3.2.2. Intertek believes it is acceptable, especially since the edges of the intake lifter do not contact the camshaft lobes.
1.2.3.2.3. The TMC noted that blue coloration around the edges is an indication of a convex profile.
1.2.3.3. *Offset Dome:*
1.2.3.3.1. Intertek said that it is not uncommon to have a lifter with an offset dome.
1.2.3.3.2. The group agreed that this type of profile should be acceptable.
1.2.3.3.3. The shape of the dome can be dropped from lifter profile acceptability criteria.
1.2.3.4. *History of Lifter Profile Screening (Intertek):*
1.2.3.4.1. Fred Gerhart identified lifter profile irregularities when this test was being developed at Southwest a few years ago.
1.2.3.4.2. Profiles were being measured via x-axis and y-axis traces using a PDI.
1.2.3.4.3. Gerhart found that profile irregularities could look different in each of these two traces.
1.2.3.4.4. As a result, he felt the need to establish stringent profile acceptability criteria.
1.2.3.4.5. The 3D imaging capability of the Keyence eliminates the shortcomings of the PDI, so the stringent criteria may no longer be needed.
1.2.3.5. *Grade-30 Lifters:*
1.2.3.5.1. Intertek believes that the Grade-30 lifters have the highest rejection rate.

1.3. Review of Southwest Document:

1.3.1. Southwest agrees with Intertek and Lubrizol regarding relaxing the profile acceptability criteria.

1.3.2. The Keyence is quicker and provides more comprehensive data than the PDI.
1.3.3. The five labs just need to confirm that they have standardized the Keyence settings.
1.3.4. ***Comments from Lubrizol:***
1.3.4.1. All the labs should be using the "official" Sequence IVB Keyence template that is located on the TMC website.
1.3.4.2. The Keyence settings are dictated by the template.
1.3.5. ***Explanation of Document:***

1.0 Checking for Concavity, Flatness or Crowning

No.	Action	Expected Result	Pass/Fail
1	Open .ZON lifter file in Keyence Analyzer program	☐ File is open and 3 images (optical, height, 3D) are displayed.	
2	Click the "ref plane" button in the tool bar	☐ A window opens with an optical image of the lifter and a list of reference plane method choices on the right.	
3	Click the "continuous plane" button from the list of choices.	☐ Another window opens with a list of parameters on the right.	
4	Under the "Extract Method" heading, choose "Con Plane".	☐ The active method changes from "Plane" to "Con Plane".	
5	Under the "Acceptable Level" heading, reduce the slider from the default of 4 to 2.	☐ Acceptable Level is set to 2.	
6	Click anywhere on the surface of the lifter until almost the entire lifter surface is highlighted blue.	☐ Nearly all of the lifter face is highlighted blue.	

1.3.5.1. Southwest reviewed the document that they use to check for lifter concavity, flatness or crowning.
1.3.5.2. This document provides step-by-step instructions for their Keyence operators to check a lifter's profile.
1.3.5.3. Lubrizol noted that this document aligns perfectly with what it proposed earlier.

1.4. Review of Afton Presentation:
1.4.1. Afton chose not to review their presentation during this meeting.
1.4.2. They felt that most of what was included in their document had already been discussed by the other labs.

1.5. Infineum:
1.5.1. Buscher asked Infineum if they had any feedback or questions for this sub-group.
1.5.1.1. Infineum was the only test-user on the conference call.
1.5.2. Infineum requested clarification on whether the PDI was still being used to collect lifter wear measurements.
1.5.3. ***Response from Lubrizol:***
1.5.3.1. Prior to the 2nd Precision Matrix, the Sequence IVB laboratories were using both the PDI and the Keyence to collect lifter wear measurements.
1.5.3.2. This was extremely time consuming.
1.5.3.3. The Statistics Group analyzed the PDI and Keyence measurements and determined that they were statistically equivalent.
1.5.3.4. As a result, the Surveillance Panel voted to discontinue to the PDI measurements.

2. AGENDA ITEM #2 – ANOMALY IN EXXON'S ROUND ROBIN DATA:

2.1. Comments from Lubrizol (Chris Mileti):
2.1.1. An anomaly was discovered in Exxon's pre-test round robin data.

2.1.1.1. Two of their "repeat" measurements had a difference of approximately 1.6mm^3.
2.1.1.2. The lifter was not repositioned between measurements.

2.1.2. ***Cause of Anomaly:***

2.1.2.1. Exxon sent Lubrizol the Keyence measurement files (associated with this anomaly) for analysis.
2.1.2.2. Lubrizol determined that there was no problem in the measurement itself.
2.1.2.3. Instead, the problem appeared to be related to the template.
2.1.2.4. Lubrizol was able to replicate the anomaly using Exxon's measurement file and its own Keyence software.
2.1.2.5. This was concerning because it proved that the anomaly could occur at any of the five labs.

2.2. Detailed Explanation of the Anomaly (Lubrizol, Mike Kinzel):

2.2.1. This is essentially a positioning error.
2.2.2. The software's "edge-detect" circle is not following the perimeter of the lifter.
2.2.2.1. This caused problems when applying the reference plane.
2.2.3. Expanding the edge detect range of the template should resolve this problem.
2.2.3.1. This will not impact test results.
2.2.3.2. This option was reviewed with a Keyence representative, and she agreed that this is an appropriate solution.
2.2.4. It is not known what is unique about the Exxon measurement file that triggered this problem.
2.2.5. Lubrizol will revise the IVB template and provide it to the TMC so that they can post it on their website.
2.2.6. ***Comments from Southwest:***
2.2.6.1. Southwest has experienced the exact same problem over the years.
2.2.6.2. It appears to be random, and probably occurred about 3-4 times.
2.2.6.3. They found that reapplying the template to the raw data file does not correct the problem.
2.2.6.4. The only way to correct the problem is to re-scan the lifter.

3. AGENDA ITEM #3 – LAB VARIABILITY IN ABSOLUTE KEYENCE MEASUREMENTS:

3.1. Comments from Lubrizol (Chris Mileti):

3.1.1. The three original Sequence IVB laboratories (Intertek, Southwest and Lubrizol) have conducted three prior Keyence round-robins in addition to the one that is currently underway.
3.1.2. It was established during this previous work that there is a magnitude shift between the absolute measurements taken at each lab.
3.1.2.1. Fortunately, it is believed that this shift is eliminated when the volume loss is calculated (the shift "washes out" when the difference is calculated between the pre-test and post-test measurements).
3.1.3. Lubrizol now believes that it can explain what is causing this difference in the absolute measurements.

3.2. Detailed Explanation of the Shift (Lubrizol, Mike Kinzel):

3.2.1. There are small discrepancies in the "circle equivalent diameter" parameter on each Keyence unit.

3.2.2. For example, the "circle equivalent diameter" values on the Lubrizol and Exxon machines differ by 0.1mm.
3.2.3. These small discrepancies can translate into significant differences in the absolute measurements.
3.2.4. Lubrizol determined that reassigning the "circle equivalent diameter" to match what is being used at another lab will eliminate the difference in absolute measurements.
3.2.5. ***Calibration:***
3.2.5.1. The small discrepancies are the result of different x-y calibrations for each machine.
3.2.5.2. Calibration impacts how the Keyence handles pixel size.
3.2.5.3. This, in turn, can impact measurement areas/volumes.
3.2.6. ***Data for Current Round-Robin:***
3.2.6.1. There are clearly lab-to-lab differences in the pre-test absolute measurements collected for the 4th Round-Robin.
3.2.6.2. Fortunately, these differences can be eliminated without having to repeat the scans or change the template.
3.2.6.3. Lubrizol created a video that shows how to batch-process existing scans to standardize the "circle equivalent diameter" between all the labs.
3.2.6.4. Lubrizol will post this video on a collaboration SharePoint site that the other four labs will be able to access.

3.3. Lifter Deposits:

3.3.1. Afton stressed that the lifters need to be extremely clean prior to Keyence measurements.
3.3.2. They have recently had lifters with heavy deposits.
3.3.2.1. Any residue that remains on the lifter after cleaning can impact the Keyence scans.
3.3.3. Lubrizol will review the IVB metrology procedure to confirm that it contains instructions to clean the lifters with heptane prior to scanning.

3.4. Update on 4th Keyence Round Robin (Intertek):

3.4.1. The test with the round-robin lifters completed at Intertek early in the week.
3.4.2. Intertek expects the average intake lifter volume loss to be around 2.5-3.0mm^3.
3.4.3. Intertek will measure the end-of-test round-robin lifters and then send them to Southwest.

Action Items	Person responsible	Completion Date

Follow-up Notes/Updates	Initials	Date Added
Representatives from Lubrizol, Intertek, Southwest and Afton participated in the conference call.	CHTM	09-17-2018

Attendees	Organization	Contact Information