Seq. VI New Supplier Entry Procedure Task Force Minutes 5/10/2019

Scope:

The ASTM Sequence VI Surveillance Panel requested a Task Force be formed to develop a procedure containing the requirements a new supplier shall fulfill before becoming a viable supplier.

Objectives:

The Task Force will:

- Review previous analysis of data regarding fuel batches changes.
    - When and why changing fuel batches were allowed?
    - Was there a stats analysis completed to see the impact of changing fuel batches?
        - If yes, was the significance of the change comparable to what was observed between batches from Texas and Michigan?
        - Will the variability of the previously mentioned be used for the new supplier?

  Fuel batches changes were not allowed until approximately 5 years ago. The fuel economy test sponsor preferred not to change batches. Approximately 5 years ago data was generated to and presented for the approval of changing batches at any time needed. Batch change effect has been analyzed multiple times finding no significant variations in result (see presentations attached to the minutes). For the most part, Haltermann fuel blended in Michigan is distributed to the labs closer to it, fuel blended in Texas is distributed to labs in Texas.
  Will changing fuel from supplier A to B within a test be acceptable? The answer to this question may depend on what data shows for the new fuel, but, for other test types such as the Seq. V, mixing a new batch once the current batch has been depleted down to 10% is allowed. The Seq. VI used Baseline Before and Baseline After to calculate FE and this could help absorb the effect of changing fuels within a test.

- Review current procedure to introduce new batches of Baseline and reference oils, hardware.

  SwRI presented a proposal for the introduction of new fuel/supplier:

  The following test plan eliminates concerns about engine, stand, and lab severity differences by obtaining direct A/B paired comparisons.

  - New engine
  Break in and 542 ref on alternate fuel
  Switch to Haltermann Solutions fuel, run 542 reference oil again (2nd run).
  Engine can be used for two candidates

  - New engine
  Break in and 1010 ref on Haltermann Solutions fuel

Switch to alternate fuel, run 1010 reference oil again (2nd run)
Engine can be used for two candidates

- New Engine
Break in and 544 ref on alternate fuel,
Switch to Haltermann Solutions fuel, run 544 reference oil again (2nd run)
Engine can be used for two candidates

The above gives 3 direct comparison points. Statistical power can be calculated for n = 3, 4, 5, etc. and determine the appropriate number of tests needed to detect differences of size 0.5 sigma, 1.0 sigma, etc.

Action Item: All members to review the above proposal and review the procedures to introduce new hardware and new batches of BL, compare those to the proposal above and be prepared to discuss next time.

Meeting adjourned. 5/2/2019

- Develop a procedure containing the requirements a new supplier shall fulfill before becoming a viable supplier.
    - Could different fuels age the engines differently?
    - What is the difference between different suppliers vs. different batches?

Prasad: I would like to add the following:

1. Changing fuel batches involve no change in raw material blend component source, generally speaking.
2. Each supplier has different raw material source.
3. C of A does not adequately describe the fuel fully well particularly in reference to Deposit (IVD) behavior.
4. Not all additives work equally on various components of the fuel.
5. Deposits do cause fuel economy degradation that need to be tested
6. Fuels with same C of A can produce very different deposit quantities.

My point here is that extensive testing is required before we establish equivalency particularly regarding performance degradation measurements from lab to lab and run to run.

- How often large batches for other test types adjusted to stay in compliance?
- Statistically, what is the most efficient way to evaluate equivalency for new suppliers?
- Based on previous input, should it be different than introducing a new batch?
- Outline cost responsibilities for introducing a new supplier.

Please refer to the attached power point presentation from SwRI presented by Travis. The comments to follow refer to the presentation.

Most of the group favored option 2 is a good starting point of discussion for next call. Option 2 or a modified version of it, could test for equivalency but will not provide data for engine aging effect. There were comments about running option 2 as ABA or running BA instead so that if the stand calibrates it would be with the currently approved fuel. The discussion will continue next call. An option was presented to determine engine aging effect by analyzing the baseline fuel consumption, this will further discuss next call as well.

Meeting adjourned. 5/10/2019

- Submit TF recommendation to the Seq. VI Surveillance Panel.

Seq. VI New Supplier Entry Procedure ATTENDANCE 20190510

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Sequence VI Alternate Fuel Supplier Testing Ideas

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Goal

- To provide testing options to the Sequence VI Surviellance Panel for consideration in how to determine if a new fuel supplier is acceptable for consideration in the VIE and VIF test methods.

- The following slides cover 3 different testing options with varying number of tests.

Some Options

Three options below are listed in order from least amount of testing to most testing.

1. No Testing - Introduce through normal referencing
2. AB paired testing
3. Full Engine Life Test Matrix

Option #1 – No Testing - Introduce w/ Normal Referencing

- Under this option the surveillance panel is fairly confident any in-spec fuel will behave similar to current fuel. The surveillance panel believes the fuel is highly likely to have no impact on the engine hour adjustment, and that any differences in severity can be handled by severity adjustments.

- This option would be similar to how hardware batch changes are often handled.

Option #2 – AB Paired Testing

Under this option, the potential supplier would run side-by-side testing next to the current supplier on identical reference oils.

Example

- Engine #1
  Break in and 542 ref on Haltermann Solutions fuel
  Switch to alternate fuel, run 542 reference oil again (2nd run).
  Engine can be used for two candidates, using the severity adjustment from run #1.

  - Engine #2
  Break in and 1010 ref on Haltermann Solutions fuel
  Switch to alternate fuel, run 1010 reference oil again (2nd run)
  Engine can be used for two candidates, using the severity adjustment from run #1.

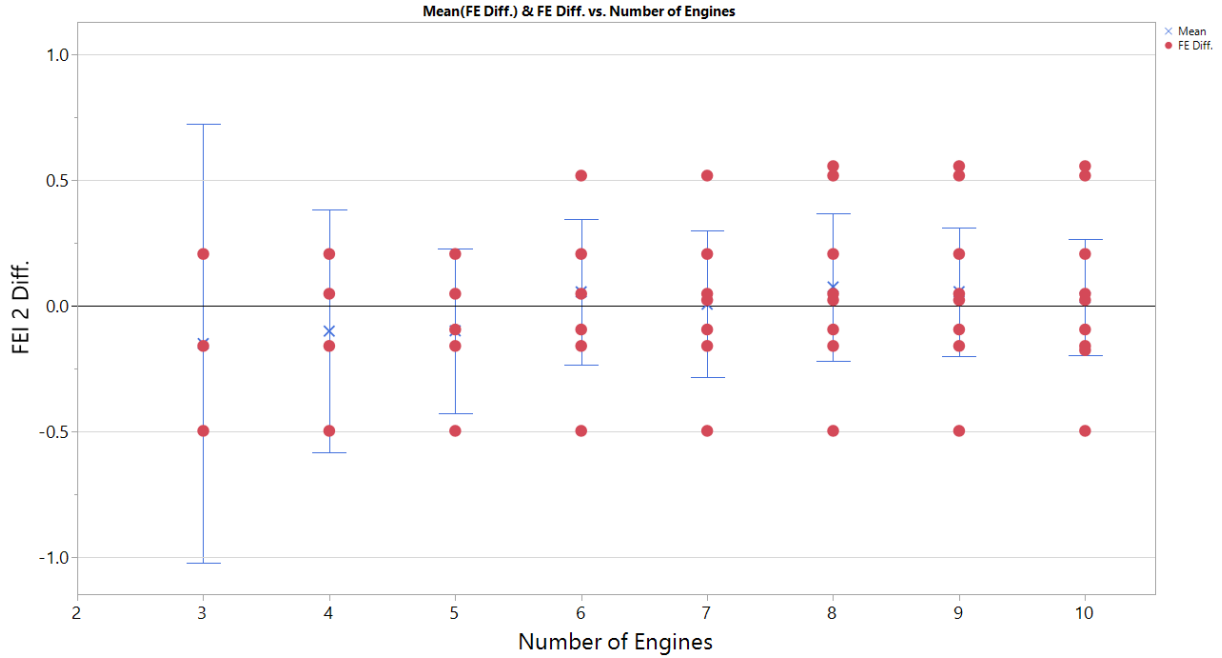
  - Engine #3
  Break in and 544 ref on Haltermann Solutions fuel,
  Switch to alternate fuel, run 544 reference oil again (2nd run)
  Engine can be used for two candidates, using the severity adjustment from run #1.

The above process can be continued until a stopping criteria is met (discussed on the following slides).

Option #2 – AB Paired Testing

-A Hypothetical Outcome of 10 Pairs

Each data point was a simulated difference between two results which were sampled from the same normal distribution (to simulate no fuel difference). The repeatability standard deviation for FEI2 of 0.281 was used.



Option #2 – AB Paired Testing

-Expected 95% C.I. Width

- The below table shows the expected 95% confidence interval width, based on the number of data pairs obtained and the VIE FEI2 repeatability.

Number of Pairs	Expected 95% C.I. Width for VIE FEI2
3	+/- 0.986
4	+/- 0.632
5	+/- 0.493
6	+/- 0.417
7	+/- 0.367
8	+/- 0.332
9	+/- 0.305
10	+/- 0.284
15	+/- 0.220

Statistical Notes

95% C.I. on the mean difference is

$$\overline{x}_d \pm t_{.05,n-1}\frac{s_d}{\sqrt{n}}$$

, where

$$s_d = \sqrt{2} * s_{repeatability}$$

$$s_{repeatability} = 0.281$$

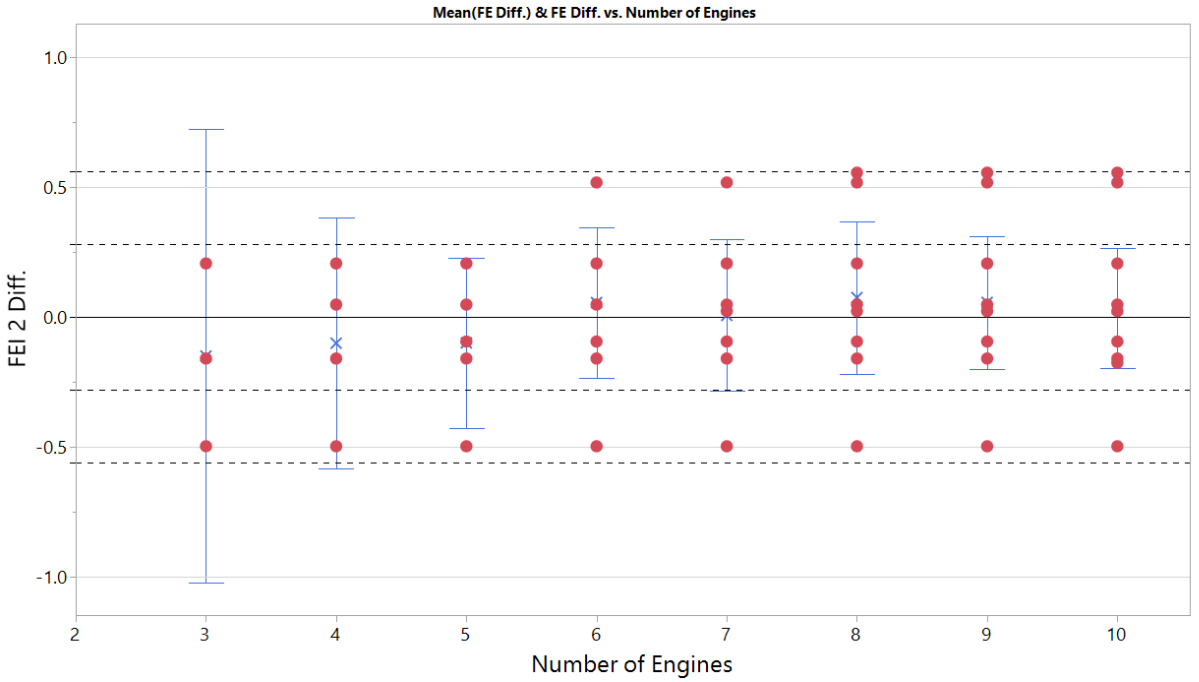
$$s_d = 0.397$$

Option #2 – AB Paired Testing

Stopping Conditions

An Example of a Stopping Criteria

- Minimum 3 tests (1 per oil)
- Mean difference C.I. overlaps zero.
- No part of 95% C.I. is outside +/- 2 sigma



$2\ s_r = 0.562$

$1\ s_r = 0.281$

$-1\ s_r = -0.281$

$-2\ s_r = -0.562$

Option #2 – AB Paired Testing

-Some Thoughts for Consideration

- Under this option, testing in labs is able to continue as usual.
- The potential supplier is given clear criteria on what needs to be accomplished to be considered, and can therefore cease testing at any time if results do not look hopeful.
- If this route is chosen, the surveillance panel is willing to assume that the new fuel would not impact engine aging, since this aspect will not be evaluated.

Option #3 – Full Engine Life Test Matrix

A test matrix can be designed for testing fuel similarity across various conditions. In order to properly design a test matrix, the surveillance panel would need to decide which of the following variables should be tested, and which can be assumed to be the same:

- Labs (1, 2, or All?)
- Stands within a Lab (Single or Multiple?)
- Engine Aging

A test matrix would likely be 4-5 engines, or 16-20 tests. Less variables would give more power to detect smaller differences between fuels, but may take more time to complete.

A model would be run at the completion of the matrix, and the variables "fuel" and "fuel*enginehours" will be examined for statistical significance.

Option #3 – Full Engine Life Test Matrix

-Some Thoughts for Consideration

- The full engine life and multiple engine test matrix approach allows for variables such as engine life to be tested, along with showing that the fuel is similar across engine life, labs, stands, etc.

- A 20 test matrix run at 2 labs with stands in each lab would have similar probability of detecting a one sigma difference in the fuel about 7 data pairs obtained by option #2.

- It is somewhat more difficult to evaluate how similarly the fuel is performing mid-testing due to the other variables being varied simultaneously.