VH Operational Data Review | MINUTES

Revision Date *12/20/2016 3:21:00 PM*

Relevant Test:	Sequence VH
Note Taker:	Chris Mileti
Meeting Date:	12-19-2016
Lubrizol Attendees:	Mileti
Comments:	Operational data review in advance of Sequence VH Precision Matrix. This review focused on transition data.

1. OPERATIONAL DATA REVIEW:

a) Background:

i) The data discussed in this meeting was distributed by Rich Grundza via email on 12-12-2016 at 8:45AM EST.

ii) This email contained the following files:

(1) Transitions.pptx
(2) Transitions 2-3.pptx
(3) Transitions 3-1.pptx

b) Release of Funds to Cover Industry Testing:

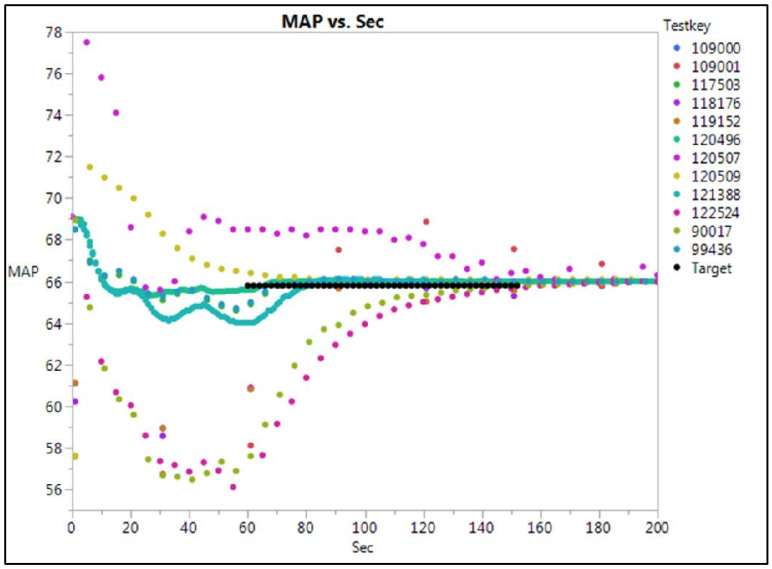
i) The TMC will review all QI calculations.
ii) Each lab will also need to send the TMC representative transition plots.
iii) The labs can bill for these tests once the TMC confirms that they are valid.

2. STAGE 1→2 TRANSITION:

a) Speed:

i) No changes will be made to the speed "window" for this parameter.
ii) All of the labs appear to be able to achieve the speed set-point within the required amount of time.

b) Intake Manifold Absolute Pressure (MAP):



i) There are drastic differences between labs with the MAP parameter.
ii) The MAP parameter can be affected by both the speed and load.
iii) Different labs approach the "window" from different directions.
   (1) The MAP does not change significantly during the Stage 1→2 transition for some labs.
   (2) Some labs approach the MAP set-point from relatively high absolute pressures.
   (3) Some labs approach the MAP set-point from relatively low absolute pressures.

iv) Lubrizol comments:

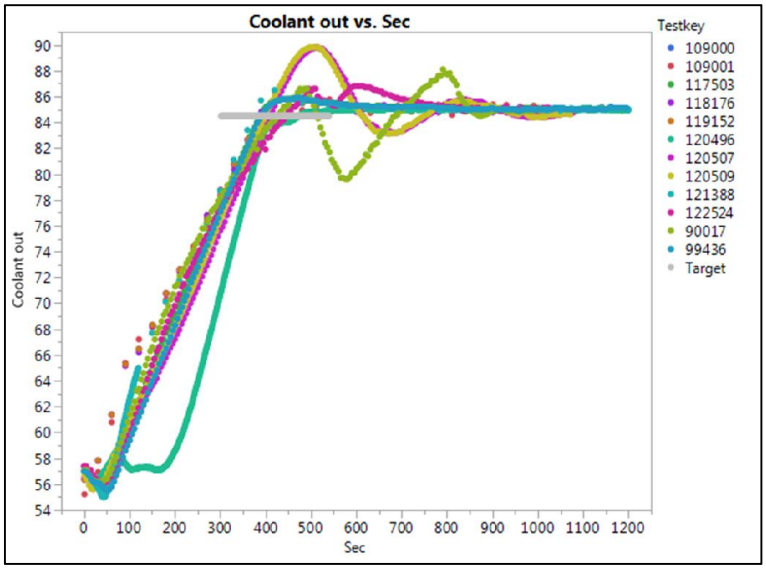
   (1) The differences in MAP control during the Stage 1→2 transition can definitely impact how the PCV valve operates during this time.
   (2) This could, in turn, result in different levels of crankcase evacuation at different labs.

v) Afton acknowledged that they have the fastest speed ramp.
vi) The two [blue-green] tests that have the smoothest MAP transition are also the last tests to achieve the speed set-point.
   (1) One of these two tests was from Lubrizol.
   (2) Lubrizol has the capability to modify its PID settings for each stage and transition.
   (3) Lubrizol has tuned its dyno PID controller to apply power slowly yet steadily during this time.
   (4) This makes both the speed and MAP transitions very smooth.
   (5) The only downside is that Lubrizol must periodically review its transition data to confirm that it is still achieving the speed set-point within the required window of time.
vii) The software at some of the labs does not allow the PID coefficients to be customized for different stages and transitions.
viii) The group agreed that all of the labs need to collect data during the transitions at a minimum sampling rate of 1-sample every 5-seconds.

ix) Modification to VH Procedure:

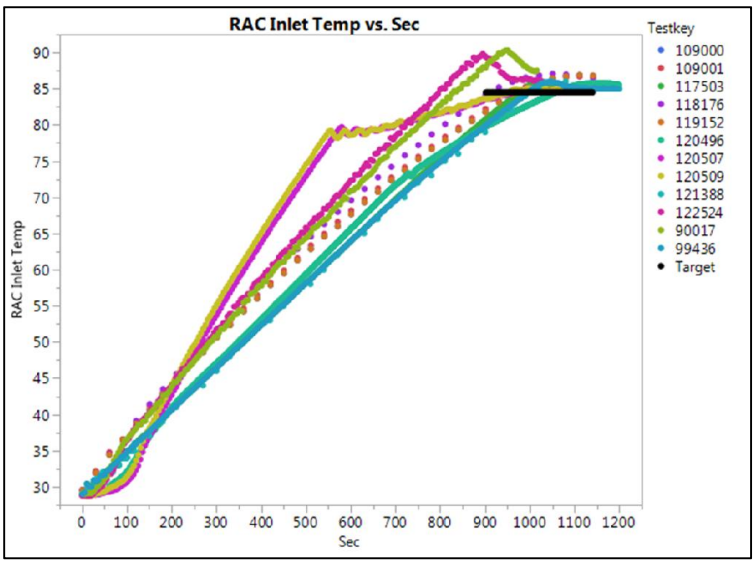
   (1) The VH procedure should be modified to require that the MAP parameter must reach its Stage 2 set-point (66.0±0.2kPa) within 150-seconds.
   (2) During this time, the MAP measurement must stay within 62-72kPa.
   (3) Some of the labs will install slave engines to confirm that they can meet these criteria before the start of the Precision Matrix.

c) Coolant Temperature at Outlet:



i) Many of the tests experienced cycling as the coolant temperature approached the set-point.
ii) Afton has already refined its PID tuning with this parameter.
iii) Not all of the tests achieve a stable temperature by the end of the time window.
iv) It may be more difficult to achieve the Stage 2 coolant temperature set-point with this new engine hardware.

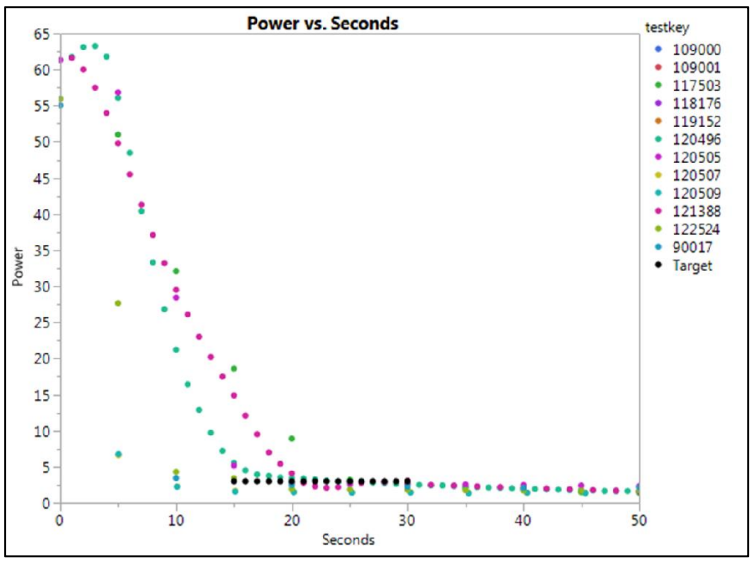
d) Rocker Arm Cover Coolant Temperature at Inlet:



i) Some of the tests significantly overshoot the temperature set-point.
ii) Most of the labs use an immersion heater to increase the temperature of their rocker arm cover coolant.
(1) Lubrizol uses a steam heat exchanger.
iii) Afton uses a two-step transition for their rocker arm cover coolant temperature.

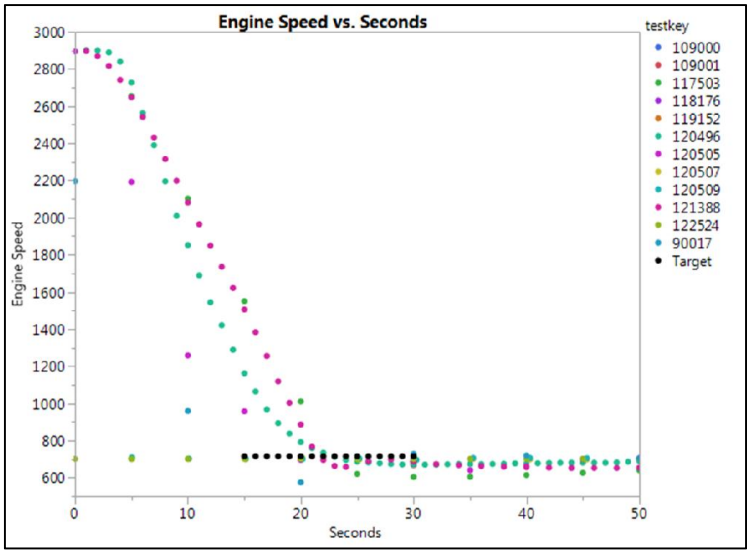
3. STAGE 2→3 TRANSITION:

a) Power:



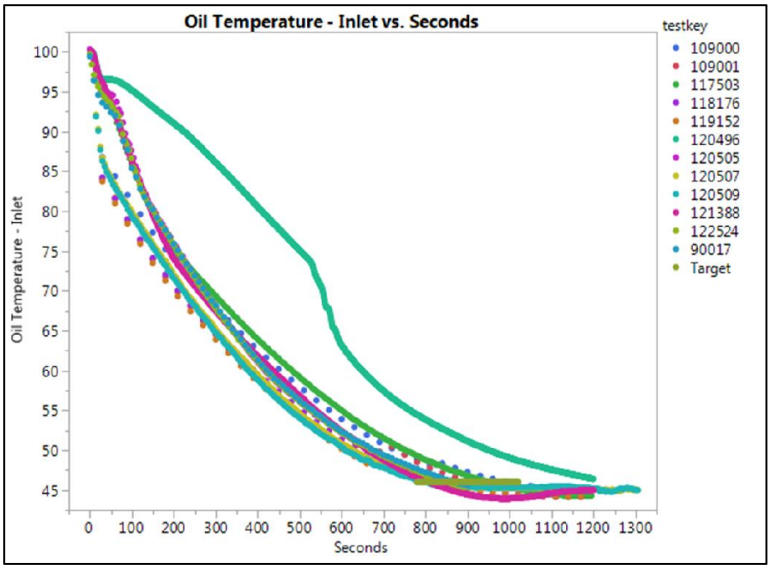
i) The allowable window of time to hit the power set-point has been adjusted to 15 to 30-seconds.
   (1) The window for the VG test was 5 to 20-seconds.
ii) All of the labs should be able to achieve the power set-point within this adjusted window.
iii) Ashland was able to meet the original window of 5 to 20-seconds.
   (1) They are now achieving the power set-point too early under the new window.
   (2) They will slow down their tuning.

b) Speed:



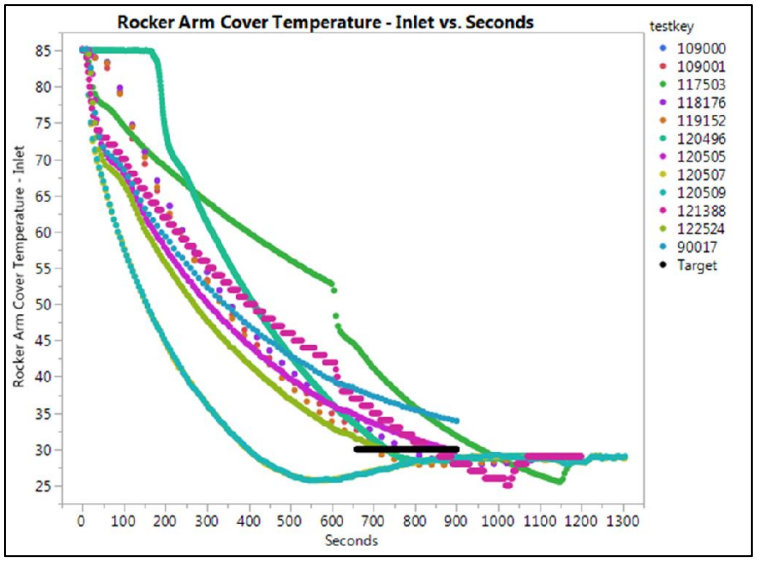
i) The allowable window of time to hit the speed set-point has been adjusted to 15 to 30-seconds.

c) Oil Temperature at Inlet:



i) Lubrizol definitely has the slowest oil temperature transition.
ii) Lubrizol generally overdamps its temperature transitions to prevent cycling around the set-point.
   (1) As a result, it will be easy to increase the speed of the PID controller to achieve the temperature set-point more quickly.

d) Rocker Arm Cover Coolant Temperature at Inlet:



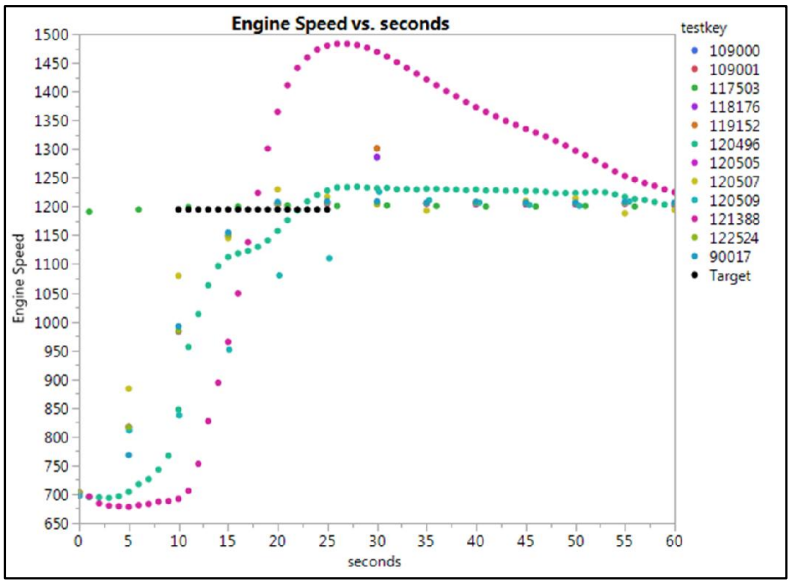
i) The transitions at some of the labs are slow, while the transitions at other labs are fast.
ii) All of these differences can likely be addressed through tuning.
iii) The allowable window of time to hit the rocker arm cover coolant temperature set-point has been adjusted to 13 ± 2 minutes.
   (1) The window for the VG test was 10 ± 2 minutes.

e) Air-to-Fuel Ratio:

i) The AFR parameter will be somewhat difficult to tightly control during this transition.

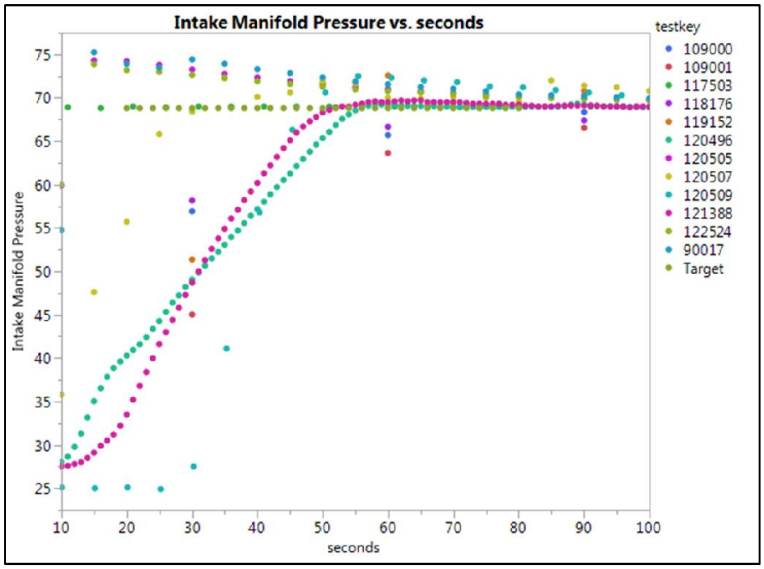
4. STAGE 3→1 TRANSITION:

a) Speed:



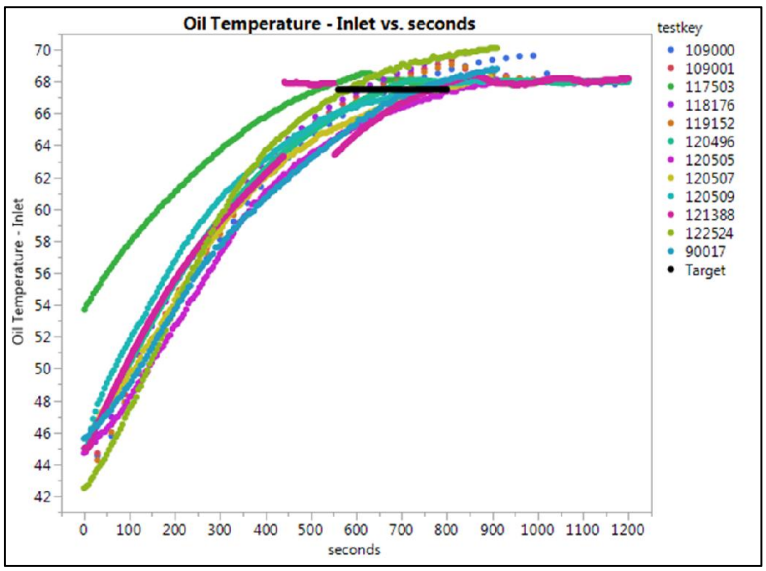
i) The allowable window of time to hit the speed parameter set-point has been modified.
   (1) The speed must now be stable around the 1200 ± 5 RPM set-point by 14-seconds.
   (2) Also, the speed cannot overshoot the set-point by more than 50RPM.
ii) One of the SWRI tests significantly overshoots the set-point.

b) Intake Manifold Absolute Pressure (MAP):



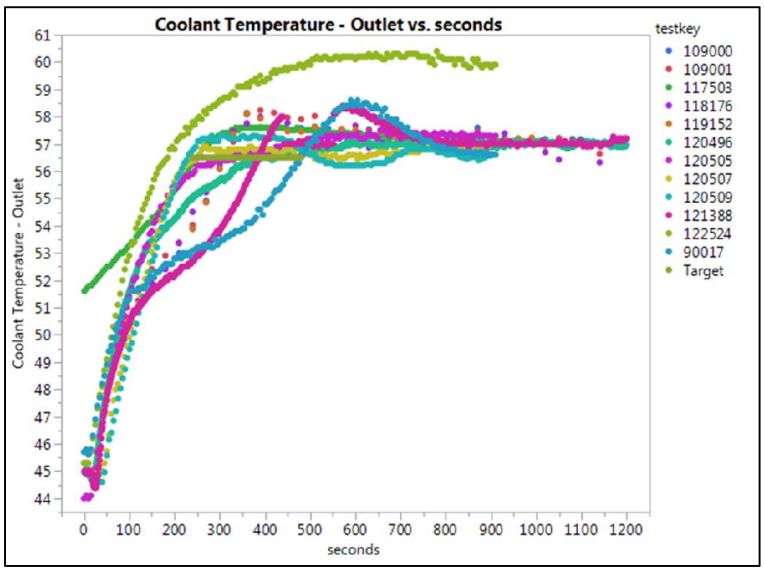
i) The Stage 1 MAP set-point is 69kPa.
ii) The MAP data from all of the tests appears to converge around 80-seconds.
iii) Some labs take too long to hit the set-point while other labs hit the set-point too quickly.
iv) The group agreed to modify the MAP transition requirements as follows:
   (1) The MAP parameter must achieve steady-state conditions at the set point (69.0±0.2kPa) by 200-seconds.
   (2) During this time, the MAP parameter is not to exceed 75kPa.

c) Oil Temperature at Inlet:



i) The set-point window has been adjusted so that it is now 560 to 800-seconds.
   (1) This adjustment was made because one test was slower than the others to reach the set-point.
ii) One SWRI test (117503) appears to start the transition from the wrong initial temperature.
   (1) SWRI will confirm that they supplied the correct data set.
   (2) They will re-submit their transition data to the TMC if needed.

d) Coolant Temperature at Outlet:



i) The group decided not to make any changes to the set-point window for this parameter.
ii) However, all of the labs are experiencing some sort of problem with their coolant temperature transition.
   (1) One of the tests exhibited a massive overshoot of the temperature set-point.

e) AFR:

i) The PCM should be in control of the AFR during the Stage 3→1 transition.
ii) The VH procedure should explicitly say that AFR control should be switched to the PCM at the start of the ramp.

f) Next Steps:

i) Each lab will be expected to revise their transition tuning by the first week of January.
ii) The group agreed to only review transitions from the following test times during future operational data reviews:
    (1) 36HRS
    (2) 84HRS
    (3) 132HRS
    (4) 180HRS

Action Items	Person responsible	Completion Date
Establish minimum data acquisition rate during the transitions of 1-sample per 5-seconds.	All Labs	
Update the VH procedure with all of the changes to the transition windows.	Ford	
SWRI to review Stage 3→1 transition data for oil temperature.	SWRI	
All labs to revise their transition tuning by the first week of January.	All Labs	

Follow-up Notes/Updates:	Initials	Date Added