

Unapproved Minutes of the May 6, 2014  
Sequence VG Surveillance Panel  
Conference Call

The meeting was called to order by Chairman Andy Ritchie at 2:00 PM EST.

Mike McMillan agreed to take the minutes of the meeting.

A list of the attendees on the call is included as Attachment 1.

Chairman Ritchie listed the agenda items he would like to cover in this call:

- 1) Approval of the minutes from the April 1, 2014 Sequence VG Panel conference call
- 2) Discussion of schedule for future meetings of Sequence V Panel
- 3) Report on calibration testing results with new fuel batch
- 4) Update from Haltermann on possibility of developing larger fuel batch for next reblend
- 5) Report from Dan Worcester on roller follower pin wear requirements in industry specifications
- 6) Old Business
- 7) New Business
- 8) Next meeting/call

Chairman Ritchie asked if there were any corrections to the minutes from the April 1, 2014 VG Panel Conference call. There being none, Dave Glaenzer moved and Jason Bowden seconded a motion to approve the minutes. The motion was approved unanimously.

Chairman Ritchie indicated that he wishes to continue to convene Sequence VG/VH SP conference calls on the first Tuesday of each month for the foreseeable future to cover both current Sequence VG-related issues, as well as issues related to the development of the new Sequence VH test. This means the next three VG SP calls will be convened at 2:00 PM EDT on June 3, July 1, and August 5.

Because no one from Haltermann has been present on either of the last two calls to address item #4 above, Chairman Ritchie suggested that we assume this item is dead unless we hear differently from Haltermann. Other Panel members agreed. As for item #5, Dan Worcester indicated he needed additional time to complete this, so it will be deferred until the next call.

Chairman Ritchie suggested that we divide the items to be discussed during the call today into two categories: Sequence VG housekeeping items and Sequence VH-related items. Beginning with the VG items, Jason Bowden announced that there are only two wiring harnesses for the VG/VH engine available. One is being held for future VH development purposes, while the other is being reserved in case it is needed by a VG laboratory. Also, the flywheel for the VG engine is no longer available from the current supplier. OHT is working with Ford to source the flywheel from a different supplier. Al Lopez asked about flashing additional PCMs. Ron Romano said Ford is working on that. The question of the need for additional reference oils for the VG was raised. After some discussion it was agreed that since it is so late in the GF-5 category, it probably makes more sense to focus our efforts on consideration of reference oils for the next category.

Attention then turned to the April 23 VH ad hoc Sequence VH meeting. Ron Romano reported that it was generally a good meeting, with all participants given a chance to view the VH stands at SwRI and Intertek. It was agreed that Ed Altman will chair the ad hoc group going forward. There was a lot of discussion about using the Bosch ETAS control unit, as the Ford ECC IV ECU controller used in the VG test is no longer in production or available. The ETAS unit is apparently expensive, and there are numerous issues with using it, including the need for modifying the calibration software and dyno wiring harness. Dave Glaenzer commented that Afton's position was that, while it was expensive, it was not worth losing a test by not using it. Others agreed, and Ron acknowledged his pleasure with the Panel's position on this.

The question was raised as to whether there had been any further data generated on whether the 2.0 standard deviation limit for the acceptance band for VG parameters should be retained, or whether we should revert back to the traditional 1.8 standard deviation limit. Rich Grundza reported that there haven't been any instances where the 1.8 value has been exceeded, so in his opinion there is no reason not to go back to the 1.8 value. Ron Romano made a motion that we revert back to 1.8 standard deviations for

the Shewhart limits in the LTMS. Rich Grundza seconded the motion, which if passed would become effective June 2. The motion passed with 13 affirmatives, 0 waives, and 0 negatives.

Turning to Sequence VH development items, Ron Romano provided an update on Sequence VH test development. (See Attachment 2 for additional detail on this as well as the Chain Wear and LSPI test developments.) Recent testing has focused on looking at different rating sites, like cam towers. They are also trying to fine tune coolant flow in the external coolant pump, thermostat orifice and marine manifolds.

Ron questioned whether we need additional VH reference oils for GF-6. Feeling was we want to keep Oil 940 as a failing oil, but maybe not Oil 1009 or maybe even Oil 1006-2. The Precision and BOI/VGRA matrices should highlight additional oils which could be candidates for future reference oils.

With regard to development of a new chain wear test, testing with a CJ-4 oil showed no improvement over GF-5 oils. Ford is also working with Lubrizol, who have some ideas on improving discrimination. Oils are being exchanged between Ford, Lubrizol, SwRI and Intertek. Jason Bowden put together a test procedure which has been distributed to all of the labs. Ford is happy with the test, but is still looking for a good reference oil. They are also working on an improved honing procedure for the cylinders, as it is intended that the engine will be used for multiple tests.

For the LSPI test development, the two cylinder heads manufactured two months ago have held together. Good discrimination is being shown at Intertek. However, some differences in the results obtained by the two labs continue to exist; this is being investigated further. Ford has been looking for a test sequence that doesn't produce such high peak pressures, but as yet hasn't found one. May have to live with such high peak pressures and get AVL to produce more transducers to replace ones which fail under such high peak pressures.

**Old Business:** Al Lopez brought up the fact that his lab is consuming the new batch of fuel at a faster rate than anticipated. Some of the other labs agreed. Chairman Ritchie indicated that he had noticed this occurring as well, and took as an action item that he will follow up on this with Haltermann and report back to the Panel.

**New Business:** None

**Next Meeting:** The next VG Panel conference call will be held Tuesday, June 3, 2014 at 2:00 PM EDT.

**Attachment 1**

**Sequence VG Attendance for 5/6/14 Call**

**Infineum:** Andrew Ritchie, Mike McMillan, Doyle Boese, Gordon Farnsworth

**Ashland** Tim Caudell

**BP Castrol** Timothy Miranda

**Ford:** Ron Romano

**GM:** Robert Stockwell, Bruce Matthews

**SwRI :** Dan Worcester, Janet Buckingham

**Intertek:** Al Lopez

**Afton:** Dave Glaenzer

**TMC:** Rich Grundza

**Lubrizol:** Jerry Brys, Chris Mileti

**Oronite:** Jo Martinez, Ricardo Efiniteo

**OHT:** Jason Bowden

**TEI:** Clayton Knight

# Ford Engine Test Development Update

Sequence VH

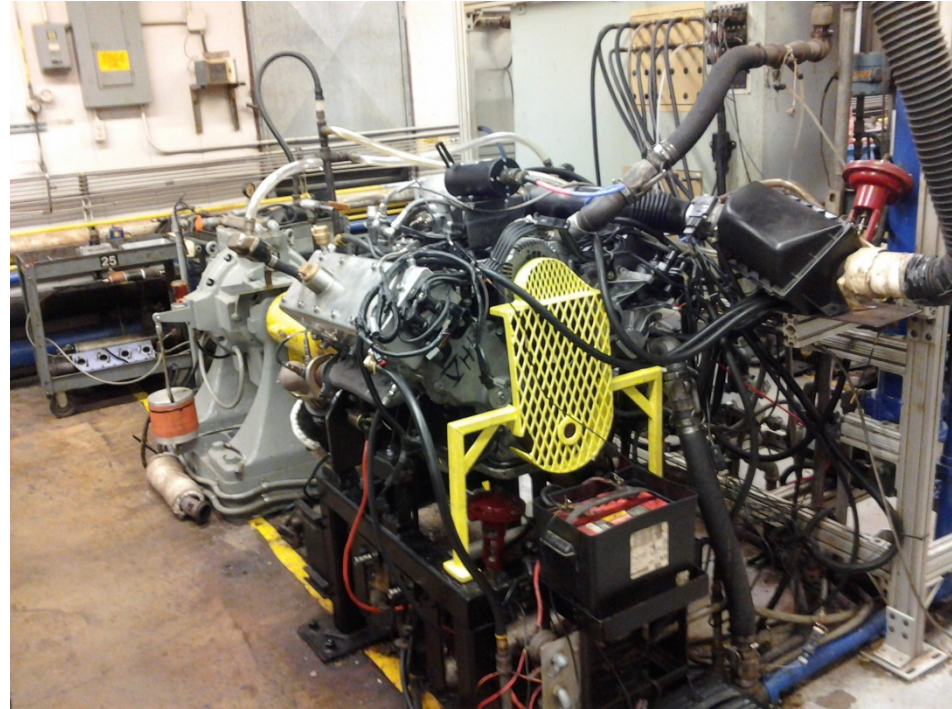
Chainwear

Low Speed Pre-ignition

Ron Romano  
Ford Motor Company  
May 8, 2014

# Sequence VH Sludge Test Overview

- 2013 4.6L 2V V8 engine  
178 Kw@4900  
389 N-m@4100
- Same 3 stage conditions  
as the Sequence VG.
- VG fuel
- Test duration 216 hours.



# Sequence VH (4.6L 2V)

VH Sludge and Varnish Ratings							FUEL
	Test hours	AES	RAC	AEV	APV	OSC	DILUTION
<b>940 VG Targets</b>		<b>6.43</b>	<b>8.15</b>	<b>8.79</b>	<b>7.20</b>	<b>50.93</b>	
<b>940 VG Fuel Mean</b>		<b>6.29</b>	<b>8.72</b>	<b>8.42</b>	<b>6.82</b>	<b>91.40</b>	
SWRI 7-VH-6	216 Hours	6.76	8.92	8.43	6.13	85.00	20.44
SWRI 7-VH-7	216 Hours	7.22	8.78	7.84	6.35	95	23.90
SWRI 7-VH-9	216 Hours	7.63	9.18	8.8	6.84	7	24.20
IAR 97-0-2	216 Hours	6.83	8.64	9.04	7.77	98	20.10
IAR 97-0-2 new rating sight	216 Hours	6.15	8.64	9.04	7.77	98	20.10
<b>Average</b>		<b>6.99</b>	<b>8.85</b>	<b>8.14</b>	<b>6.24</b>	<b>90.00</b>	
<b>Doesn't include new sight rating</b>							
<b>1006-2 VG Targets</b>		<b>8.65</b>	<b>9.40</b>	<b>9.24</b>	<b>8.52</b>	<b>1.46</b>	
<b>1006-2 VG Fuel Mean</b>		<b>8.43</b>	<b>9.36</b>	<b>9.16</b>	<b>8.64</b>	<b>5.40</b>	
SWRI 6-VH-2	216 Hours	8.40	9.44	8.89	7.99	2.00	15.14
<b>1009 VG Targets</b>		<b>7.94</b>	<b>8.99</b>	<b>9.29</b>	<b>7.79</b>	<b>8.00</b>	
<b>1009 VG Fuel Mean</b>		<b>7.11</b>	<b>9.25</b>	<b>8.88</b>	<b>7.87</b>	<b>48.17</b>	
IAR VH98-0-3	216 Hours	7.02	9.56	8.77	8.43	20.00	20.50
IAR VH98-0-4	216 Hours	6.92	9.50	8.97	8.19	65.00	17.51
SWRI 7-VH-4	216 Hours	7.61	9.37	8.85	7.37	38.40	22.98
SWRI 7-VH-5	216 Hours	7.72	9.36	8.62	8.21	18.00	21.53
IAR VH98-0-5	216 Hours	6.73	9.60	8.95	8.02	87.00	21.70
SWRI 7-VH-8	216 Hours	7.48	8.73	7.88	6.71	75.00	24.20
IAR VH97-0-1	216 Hours	7.10	9.57	8.97	7.80	57.00	18.40
<b>Average</b>		<b>7.23</b>	<b>9.38</b>	<b>8.72</b>	<b>7.82</b>	<b>51.49</b>	

VG Fuel Mean = average from latest fuel batch matrix

# Sequence VH Test Conditions

Condition	Stage I	Stage II	Stage III
Duration, min	120	75	45
Engine speed, r/min	1200 $\pm$ 5	2900 $\pm$ 5	700 $\pm$ 15
Engine power, kW	record	record	1.30 6 0.2
Manifold abs press, kPa (abs)	69 $\pm$ 0.2	66 $\pm$ 0.2	record
Engine oil in, °C	68 $\pm$ 0.5	100 $\pm$ 0.5	45 $\pm$ 1
Engine coolant out, °C	57 $\pm$ 0.5	85 $\pm$ 0.5	45 $\pm$ 1
Engine coolant flow, L/min	48 $\pm$ 2	record	record
Engine coolant pressure, kPa (gage)	70 $\pm$ 10	70 $\pm$ 10	70 $\pm$ 10
RAC coolant in, °C	29 $\pm$ 0.5	85 $\pm$ 0.5	29 $\pm$ 1
Rocker cover flow, L/min	15 $\pm$ 1	15 $\pm$ 1	15 $\pm$ 1
Intake, air, °C	30 $\pm$ 0.5	30 $\pm$ 0.5	30 $\pm$ 0.5
Intake air press, kPa (gage)	0.05 $\pm$ 0.02	0.05 $\pm$ 0.02	0.05 $\pm$ 0.02
Lambda, typical values	1.0	1.0	0.75
Blowby flow rate, avg, L/min	record	60-70	—
Intake air humidity, g/kg	11.4 $\pm$ 0.8	11.4 $\pm$ 0.8	11.4 $\pm$ 0.8
Exhaust back pressure, kPa abs	104 $\pm$ 2	107 $\pm$ 2	record
Fuel flow, kg/min	record	record	record
3000 gram oil charge			

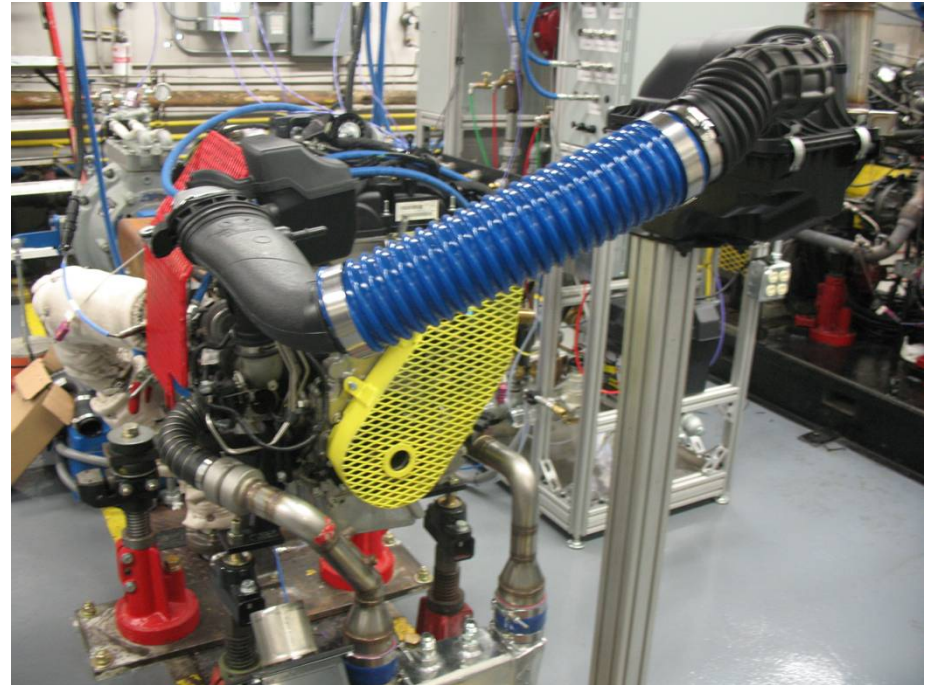
## Additional testing:

- 1 ) Testing was conducted with no oil adds . Starting with a 4000 gram oil charge turned the test mild. 9+ AES after 192 hours on oil 1009
- 2) Forced oil adds of 200 grams of new oil every 24 hours starting at 72 hours and 3000 initial oil charge made the test mild so this was abandoned.
- 3) Presently testing with 2013 piston rings
- 4) Presently test with external coolant pump, thermostat orifice and marine manifolds. Production coolant pump can't achieve 48 L/min.
- 5) Investigating new rating sights. Improving coolant and oil flow.



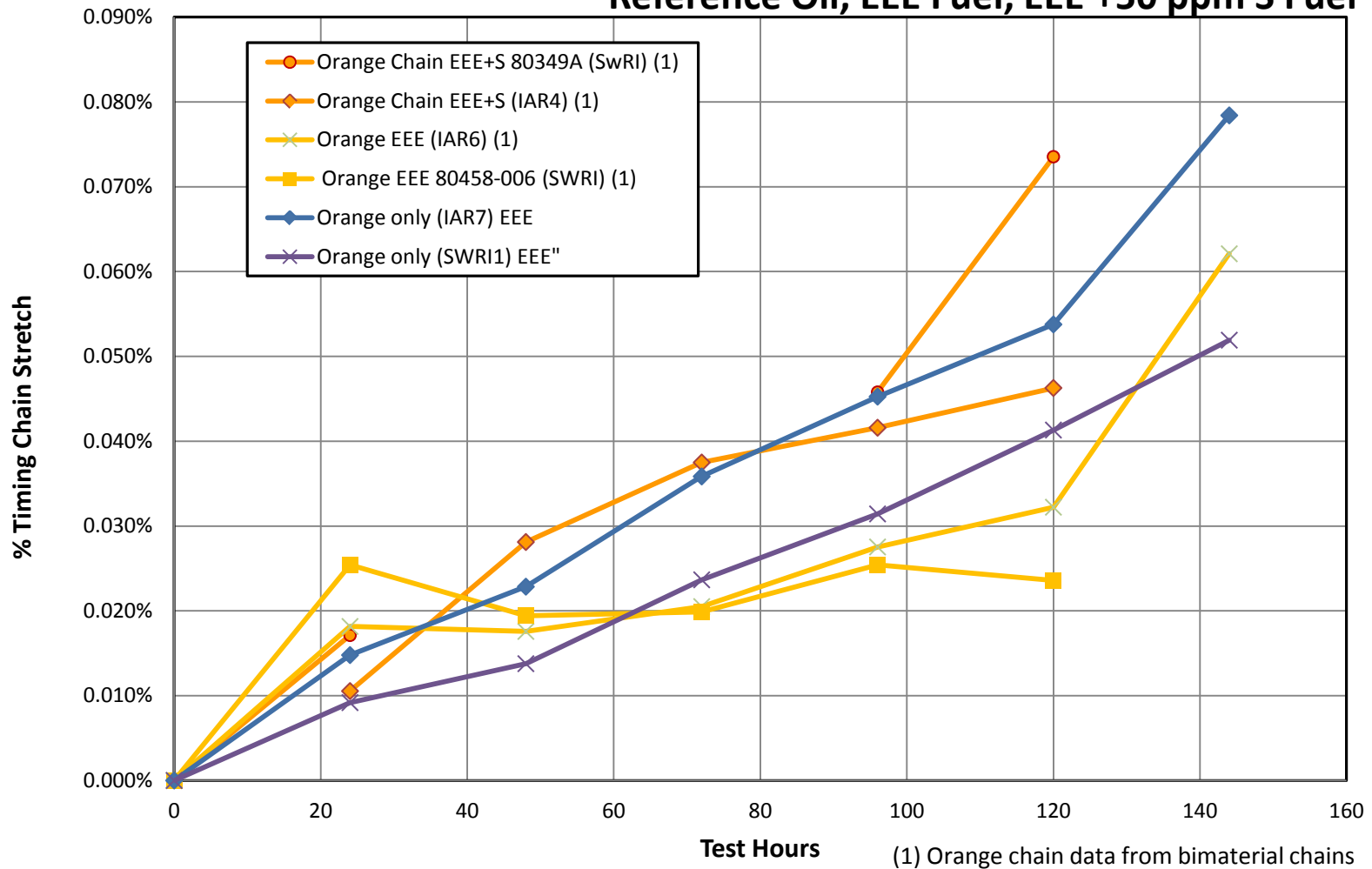
# Timing Chain Wear Test Overview

- Test engine: 2012 Ford 2.0L, EcoBoost, 4-cylinder  
178Kw@5500  
366N-m@3000
- Soot induced chain wear
- Low- moderate speed and load.
- Two stage test, low and normal running temperatures.
- Test duration 144 hours



# Chain Wear (2.0LGTDI)

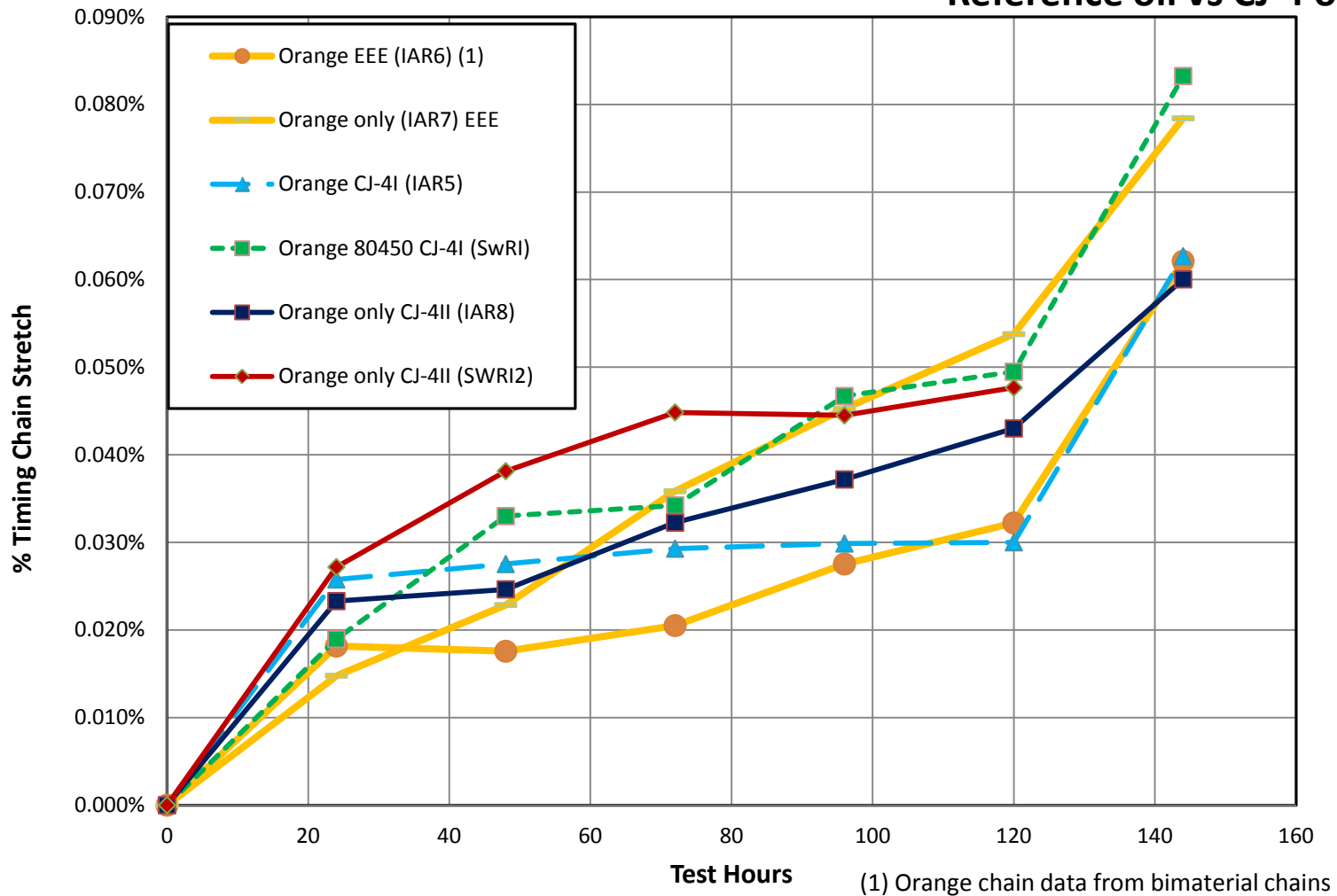
Chain Stretch % w/8 hour Chain Break In  
Reference Oil, EEE Fuel, EEE +50 ppm S Fuel



Single piece orange chains (IAR7, SWRI1) shows same wear as orange portion as orange portion of bimaterial chains.

# Chain Wear (2.0LGTDI)

Chain Stretch % w/8 hour chain break in  
Reference oil vs CJ-4 oil



CJ-4 oil showed doesn't appear to show an improvement over the reference oil.

# Chain Wear (2.0LGTDI)

Condition	Stage 1	Stage 2
Duration, min	120	60
Speed (rpm)	1550	2500
Torque (N-m)	50	128
Engine oil in, °C	50+/- 0.5	100+/- 0.5
Engine coolant out, °C	45+/- 0.5	85+/- 0.5
Engine coolant pressure, kPa (gage)	70 +/- 10	70 +/- 10
PCV cooler coolant in, °C	20+/- 0.5	85+/- 0.5
PCV cooler flow, L/min	12 +/-1	12+/-1
Intake, air, °C	30+/- 0.5	30+/- 0.5
Intake air press, kPa (gage)	0.05 +/- 0.02	0.05 +/- 0.02
Air/Fuel Ratio (lambda)	0.78	0.98
Blowby flow rate, SOT, L/min record		60-70
3600 gram initial oil charge, no oil additions		

30 minute temp ramp between stages

30 sec speed/load ramp between stages

Ramp time is not counted in the stage time

Test chain used during 8 hour engine break in

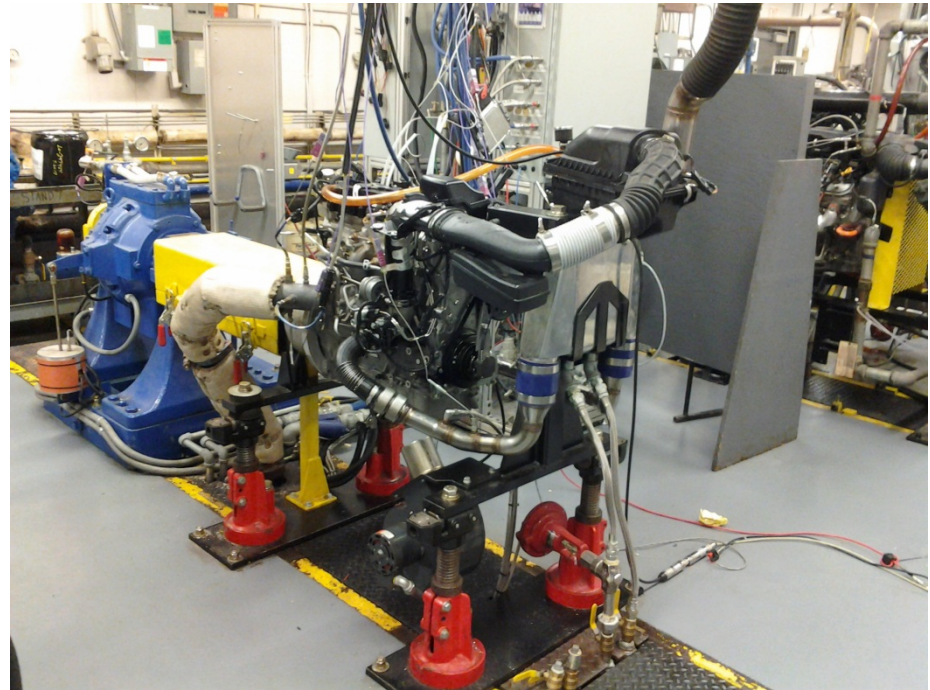
Post 8 hour break in chain length measurement used as initial length for calculating chain stretch

Test and build procedure distributed to dependent labs

Investigating vent system changes

# Low Speed Pre-Ignition Test Overview

- Test engine: 2012 Ford 2.0L, EcoBoost, 4-cylinder
  - 178Kw@5500
  - 366N-m@3000
- Combustion analysis data acquisition system: AVL IndiSmart Gigabit 612
- Running conditions
  - Low speed, < 2000 rpm
  - High Load, >70% max BMEP
  - Test duration, 4 hours



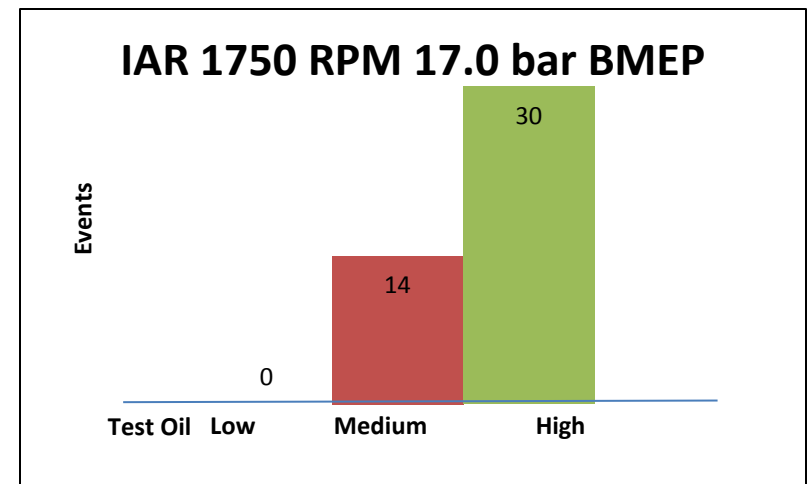
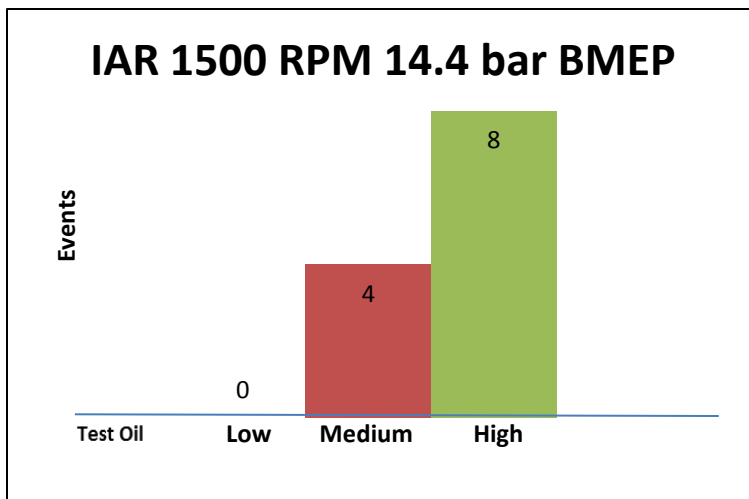
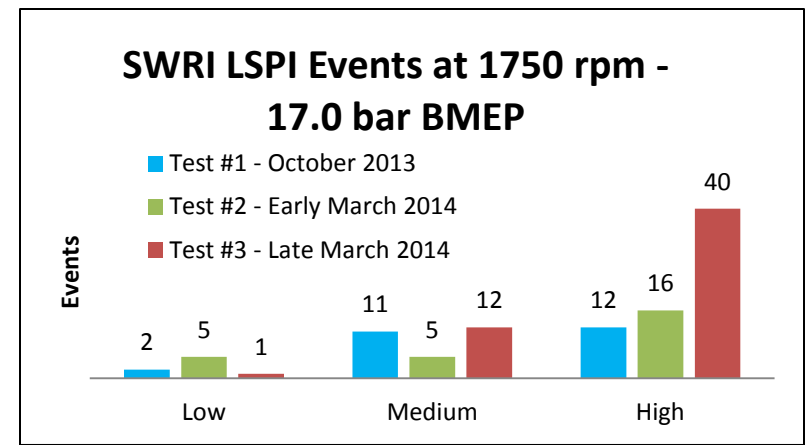
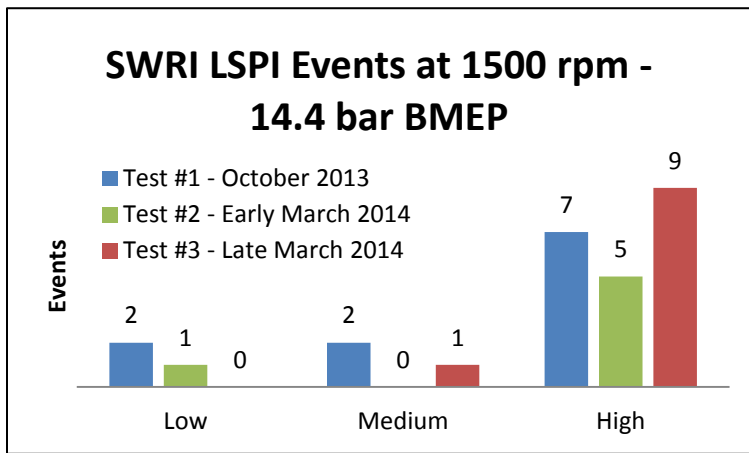
# LSPI Results

4 hour test duration

1500 RPM/80% BMEP

1750 RPM/80% BMEP

Test run on 3 oils with low, medium and high tendency to cause LSPI



# Summary/Next steps

- Run DOE to investigate effect of coolant oil, and air temperature on LSPI and fuel dilution.
- Could not find lower load that reduced peak pressure and gave adequate number of events
- Could not change running conditions to improve transducer durability.