Unapproved Minutes of the October 22, 2014
Sequence V Surveillance Panel
Meeting in San Antonio, TX

The meeting was called to order by Chairman Andy Ritchie at 1:00 PM CST.

Mike McMillan agreed to take the minutes of the meeting.

A list of the attendees is included as Attachment 1.

A copy of the agenda is included as Attachment 2.

Chairman Ritchie asked if there were any corrections to the minutes from the September 9, 2014 VG Panel Conference call. There being none, Jason Bowden moved and Ed Altman seconded a motion to approve the minutes. The motion was approved unanimously.

Rich Grundza went through the action items from the November 20, 2013 meeting. All have been completed or are in progress.

There was no Test Sponsor report provided.

Rich Grundza asked if there were any questions on the TMC Semi-Annual report available on the TMC website. There were no questions. The TMC report can be accessed via the following link:

ftp://ftp.astmtmc.cmu.edu/docs/gas/B01SemiAnnualReports/semiannualreports/B01%20SemiAnnualReport%20-%20October%202014.pdf

Mark Overaker provided a verbal Fuel Supplier report. There are approximately 180K gallons remaining of the current SVGM2 fuel batch. Assuming a usage rate of ~20,000 gal/month, the current fuel batch should be exhausted by about March or April next year. (Note: This is also assuming 40K gallons are also set aside for precision matrix work in February or March of 2015, as decided during the September 9, 2014 VG call.) The stands needing fuel will be 6 VG stands (2 at Intertek + 4 at SwRI) + however many VH stands are set up. Jason Bowden pointed out that all critical components should carry on for at least 1 reference period

after the VH matrix is completed, and based on these projections there will not be enough of the current fuel batch to do this. In addition, it was pointed out that if we try to run the VH matrix on the current fuel batch, the first runs on the new VH test will be to approve a new fuel batch. This suggests that a better approach is to run the VH precision matrix on a new fuel batch. Ron Romano replied that he doesn't like postponing conducting the VH precision matrix that long. Ron offered that maybe we should conserve all of the remaining fuel batch for VH development and conducting the VH matrix, and make the VG test unavailable until after a new fuel batch is approved. Doing this, however, would mean the new VH test might have to be used to approve the new fuel batch, and might not be able to meet the one referencing period minimum critical component requirement.

An extensive period of discussion ensued. It was offered that if we had another tank, we could approve a new fuel batch for VG testing (probably with a correction factor) before the current fuel batch runs out. With 17 total stands using an estimated 27K gal/month, it would take ~ 6.5 months to deplete current batch (including the 40K gallons set aside for the VH matrix). This should be long enough to approve a new fuel batch. After much discussion, it was concluded that the following scenario seems at this point to be the best course to pursue:

Dedicate current SVGM2 fuel batch for VG testing and remaining VH test development. Drain the current Haltermann SVGM2 storage tank by securing tankage (Haltermann tank, lab tanks or a combination) for storage of the current SVGM2 fuel batch. Perform required maintenance on the current Haltermann SVGM2 storage tank. Build a new SVGM2 fuel batch and conduct the fuel prove-out matrix for the new SVGM2 fuel batch using VG tests. Once the new SVGM2 fuel batch is approved, use the new SVGM2 fuel batch to conduct the VH precision matrix and any VH candidate testing beyond that. VG testing will continue to be conducted on the current SVGM2 fuel batch until it is depleted, at which time the labs will then switch VG testing to the new SVGM2 fuel batch.

Chairman Ritchie indicated that he would like to reconvene the monthly VG SP calls starting in November and asked the Panel to consider the possible approach highlighted above before the next VG conference call in November. Mark Overaker also indicated Haltermann would investigate options to secure a second storage tank, or additional storage capabilities

(ISO containers, etc.), to be able to handle an overlap of the current SVGM2 fuel batch and a new SVGM2 fuel batch.

Chairman Ritchie also asked Haltermann to project their capabilities and report back as to what is realistic to address the SVGM2 fuel situation at the next VG call in November.

The next agenda item, Planning for Next Batch of Sequence V fuel, had already been covered in the discussion above.

Under Operational and Hardware Items, Dan Worcester made the following motion:
Motion - Recommend to the Surveillance Panel the Horiba Air Fuel Ratio meter be included as a recommended system for the VG test. Modify Section X2.1.22 Lambda Measurement Devices to add:

Horiba MEXA 700 or 110
Horiba Instruments, Inc.
17671 Armstrong
Irvine Industrial Complex
Irvine, CA 92623

Telephone: (714) 250-4811

The motion was seconded by Al Lopez and was approved unanimously. The effective date is October 22, 2014.

A review of the Scope and Objectives was deferred until the next meeting/call.

Under Old Business, Rich Grundza indicated he would like to do away with the pressure measuring cart to eliminate the outdated incline manometer, and replace it with a pressure gage. Rich proposed the following motion which was seconded by Dan Worcester:
Motion – Revise the text for legend item 6 of Figure 7 of the VG test procedure to allow use of a differential pressure sensor or an inclined manometer, which will match the text in section 9.3.4.2 of the VG test procedure.
The motion passed with all affirmative except for one waive.

In other Old Business, Chairman Ritchie reported that he had received a request from Thom Smith, Chairman of the PCEOCP, to attempt to establish limits in the VH test which are equivalent to the limits for the VG test in GF-5. Following some discussion, it was agreed by all Panel members that the question was premature at this point. The Panel will consider this question again when the new test is in place.

For the agenda item, ASTM Test Template review, based on discussions within the Sequence VI and Sequence III SPs the past two days, it was agreed by the Panel that trying to complete the template for the VH test at this time was premature. The template will be considered again when the VH test development is close to completion.

Sequence VH Test Development Update

Following a break in the meeting, Chairman Ritchie asked Ron Romano to give an update on VH test development. Ron went through the latest data which has been obtained. (See Attachment 3) As indicated in Slide 3 of Ron's presentation, Oil 940 is giving an average AES of 6.89, while Oil 1009 is showing an average AES of 8.08. Both averages are reasonably close to the targets for the two oils, but differences between IAR and SwRI for the two oils still exist. IAR is close to the targets on both oils, as well as on Oil 1006, and is showing discrimination. SwRI is running somewhat milder, and stand calibration differences have been found that could be causing the severity differences. Changes have been made at the labs, and additional testing will be conducted.

Using different rating locations has been investigated and found to increase sludge severity on Oil 940, but it also increases severity on Oil 1009 which decreases discrimination between the two oils. The same conditions in the 3 stages as in the VG test are being used, but several changes in stand hardware have been made: An external coolant pump is being used, as are marine manifolds, a new wiring harness combining the dynamometer and engine harnesses, a new oil separator (Morossso), a new programmable PCM (which should be available in December), a new calibration (-20 end of injection timing, A/F ratio, stage 2-3 and 3-1 ramps). A procedure update is also in progress.

To improve the lack of discrimination, they are still investigating new rating sites, e.g., cam tower, rocker arm cover. The plan going forward is to run

the tests on newly delivered hardware. Verification testing of the new PCM should be complete by December.

Chain Wear Test Development Update: (See Attachment 3)

Testing to date has resulted in 3 groupings of oils – A bad reference oil, two CJ-4 oils, and the bad reference oil but drained and refilled with new oil every 24 hrs. Good repeatability and reproducibility is evident in each grouping. There is also good discrimination among the 3 groups. All tests were conducted with an 8-hr break in, using EEE fuel, and with inspections and wear (stretch) measurements every 24 hr. Test length is 216 hr. Tests at IAR on a new batch of bad reference oil blended with different base oil showed a decrease in chain wear. The test development group is investigating whether this is caused by a severity shift in the test or because of a formulation change.

At this point, a lengthy discussion of chain wear measurement techniques ensued between Ford, Lubrizol, Afton, SwRI and Intertek. George Szappanos of Lubrizol provided details and photos of Lubrizol's measurement rig.

Ford rebuilds their test engine between runs. They replace rings and install clean parts. Ford has seen some screen plugging in some tests. Afton has not seen any ring sticking or screen plugging. Ron has also seen differences with different motor mounts. He wants to specify them in the test procedure (see slide 8), as well as the oil pan (shorter than stock) and pick-up tube, the intercooler (Type 5), the measurement technique/apparatus, and the PCV cooler.

LSPI Test Development Update: (See Attachment 3)

Recent testing has been focused on investigating lower intake air temperatures in an attempt to reduce the occurrences of pressure transducer failures. Some initial data showed lower peak pressures at the lower intake air temperature, but repeat testing could not duplicate these reductions in peak pressure, and transducer failures occurred. The range of these transducers is from 0-350 bar. The test development group is now attempting to procure higher pressure transducers in hopes that they will be able to endure the high pressure spikes which occur during LSPI events.

One high pressure transducer with a range of 0 -550 bar has been installed in an engine, and additional high pressure transducers are on order.

There was no New Business brought forth.

The meeting was adjourned at 6:10 PM CST.

ASTM Sequence V Surveillance Panel date: 10/22/14

Name/Address	Phone/Fax/Email		Signature
Ed Altman Afton Chemical Corporation 500 Spring Street Richmond, VA 23219 USA	804-788-5279 804-788-6358 ed.altman@aftonchemical.com	Voting Member	Present
Art Andrews ExxonMobil Products Research 600 Billingsport Rd. Paulsboro, NJ 08066 USA	856-224-3013 arthur.t.andrews@exxonmobil.com	Non-Voting Member	Present
Zack Bishop Test Engineering, Inc. 12718 Cimarron Path San Antonio, TX 78249-3423 USA	210-877-0223 210-690-1959 zbishop@tei-net.com	Non-Voting Member	Present
Doyle Boese Infineum 1900 E. Linden Avenue Linden, NJ 07036 USA	908-474-3176 908-474-3637 doyle.boese@infineum.com	Non-Voting Member	Present
Adam Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 adbowden@ohtech.com	Non-Voting Member	Present
Jason Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 jhbowden@ohtech.com	Voting Member	Present
Dwight H. Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 dhbowden@ohtech.com	Non-Voting Member	Present

ASTM Sequence V Surveillance Panel date: 10/22/14

Name/Address	Phone/Fax/Email		Signature
Matt Bowden OH Technologies, Inc. 9300 Progress Parkway P.O. Box 5039 Mentor, OH 44061-5039 USA	440-354-7007 440-354-7080 mjbowden@ohtech.com	Non-Voting Member	Present
Jerome A. Brys Lubrizol Corp. 29400 Lakeland Blvd. Wickliffe, Ohio 44092 USA	440 347-2631 jerome.brys@lubrizol.com	Non-Voting Member	Present
Bill Buscher III ~~Southwest Research Institute~~ ~~6220 Culebra Road~~ ~~P.O. Box 28510~~ ~~San Antonio, TX 78228~~ USA INTERTEK	~~210-522-6802~~ ~~210-684-7523~~ ~~william.buscher@swri.org~~ 210 - 647-9489 210 - 240-8990 william.buscher@intertek.com	Non-Voting Member	Present WAJS
Bob Campbell Afton Chemical Corporation 500 Spring Street Richmond, VA 23219 USA	804-788-5340 804-788-6358 bob.campbell@aftonchemical.com	Non-Voting Member	Present
Timothy L. Caudill Ashland Oil Inc. 22nd & Front Streets Ashland, KY 41101 USA Represented by AMOL SAVANT (Proxy for Tim Caudill)	606-329-1960 x5708 606-329-2044 tlcaudill@ashland.com	Voting Member	Present
Jeff Clark Sequence III Secretary ASTM Test Monitoring Center 6555 Penn Avenue Pittsburgh, PA 15206 USA	412-365-1032 412-365-1047 jac@atc-erc.org	Non-Voting Member	Present
Sid Clark Southwest Research 50481 Peggy Lane Chesterfiled, MI 48047 USA	586-873-1255 Sidney.L.Clark@swri.org	Non-Voting Member	Present
Todd Dvorak Afton Chemical Corporation P.O. Box 2158 Richmond, VA 23218-2158 USA	804-788- 6367 804-788- 6388 todd.dvorak@aftonchemical.com	Non-Voting Member	Present

ASTM Sequence V Surveillance Panel date: 10/22/14

Name/Address	Phone/Fax/Email		Signature
Gordon R. Farnsworth Infineum RR # 5 Box 211 Montrose, PA 18801 USA	570-934-2776 570-934-0141 gordon.farnsworth@infineum.com	Non-Voting Member	Present
Richard Grundza ASTM Test Monitoring Center 6555 Penn Avenue Pittsburgh, PA 15206 USA	412-365-1031 412-365-1047 reg@astmtmc.cmu.edu	Voting Member	Present
Jeffrey Hsu Shell 3333 Hwy 6 South Mail Drop L107C Houston, TX 77082 USA	281-544-8619 281-544-8150 j.hsu@shell.com	Voting Member	Present
Tracey King Haltermann Solutions MI USA	947-517-4107 tking@Jhaltermann.com	Voting Member	Present
Dan Lanctot ~~Clayton Knight~~ Test Engineering, Inc. 12718 Cimarron Path San Antonio, TX 78249-3423 USA	210-690-1958 210-690-1959 ~~cknight@tei-net.com~~ dlanctot@tei-net.com	Voting Member	Present
Teri Kowalski Toyota Motor North America, Inc. 1555 Woodridge Ann Arbor, MI 48105	734-995-4032 734-995-9049 teri.kowalski@tema.toyota.com	Voting Member	Present
Al Lopez Intertek Automotive Research 5404 Bandera Road San Antonio, TX 78238 USA	210-647-9465 210-523-4607 ~~charlie.leverett~~@intertek.com al.lopez@intertek.com	Voting Member	Present
Josephine G. Martinez Chevron Oronite Company LLC 100 Chevron Way Richmond, CA 94802 USA	510-242-5563 510-242-3173 jogm@chevrontexaco.com	Non Voting Member	Present

ASTM Sequence V Surveillance Panel date: 10/22/14

Name/Address	Phone/Fax/Email		Signature
Bruce Matthews GM Powertrain Mail Code 483-730-472 823 Jocyln Avenue Pontiac, MI 48340 USA	248-830-9197 248-857-4441 bruce.matthews@gm.com **Test Sponsor Representative**	Voting Member	Present Robert Stockdale for Bruce
Mike McMillan	mmcmillan123@comcast.net	Non-Voting Member	Present
Christopher Mileti The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, OH 44092 USA	440-347-2352 440-347-4096 greg.seman@lubrizol.com	Voting Member	Present
Timothy Miranda BP Castrol Lubricants USA 1500 Valley Road Wayne, NJ 07470 USA	973-305-3334 973-686-4039 Timothy.Miranda@bp.com	Voting Member	Present
Christian Porter Afton Chemical Corp. 500 Spring Street Richmond, VA 23219 USA	804-788-5837 804-788-6358 christian.porter@aftonchemical.com	Non-Voting Member	Present
Allison Rajakumar The Lubrizol Corporation Drop 152A 29400 Lakeland Blvd. Wickliffe, OH 44092 USA	440-347-4679 440-347-2014 Allison.Rajakumar@Lubrizol.com	Non-Voting Member	Present
Andrew Ritchie Infineum 1900 East Linden Avenue P.O. Box 735 Linden, NJ 07036 USA	908-474-2097 908-474-3637 Andrew.Ritchie@Infineum.com **Surveillance Panel Chairman**	Sequence V Chair	Present
Ron Romano Ford Motor Company Diagnostic Service Center II Room 410. 1800 Fairlane Drive Allen Park, MI 48101 USA	313-845-4068 313-32-38042 rromano@ford.com	Voting Member	Present

ASTM Sequence V Surveillance Panel date: 10/22/14

Name/Address	Phone/Fax/Email		Signature
Amol Savant Ashland Oil Inc. 22nd & Front Streets Ashland, KY 41101 USA	asavant@ashland.com	Non-Voting Member	Present A Savant (Repeated from Proxy for Tim Caudill)
Philip R. Scinto The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, OH 44092 USA	440-347-2161 440-347-9031 prs@lubrizol.com	Non-Voting Member	Present
Kaustav. Sinha Chevron 4800 Fournace Pl Bellaire, TX 77401 USA	713-432-6642 713-432-3330 ksinha@chevronl.com	Voting Member	Present KS.
Mark Sutherland Test Engineering, Inc. 12718 Cimarron Path San Antonio, TX 78249-3423 USA	msutherland@tei-net.com	Non-Voting Member	Present
George Szappanos The Lubrizol Corporation 29400 Lakeland Boulevard Wickliffe, OH 44092 USA	440-347-2352 440-347-4096 greg.seman@lubrizol.com	Voting Member	Present
DAN WOODSTA		4	
Mark Mosher ExxonMobil			
Ricardo Affinito Oronite		Non-V.	
Pat Lang			P. L.
Ben Weber - I'll e-mail you.			BW
George Szappanos J. Michael Conrad # - Lubrizol			
Jim Linden	LINDENJIM@JLINDENCONSULTING.COM		

over

JOFRAN PASTOR	INFINEUM	313 348 3120	
Mike Warholic	INFINEUM	908 - 474 - 2069	
Jason Soto	IAR	210 - 383 - 9355	
Michael Lochte	SwRI	210 - 522 - 5430	MLOCHTE@SWRI.ORG please add to mailing list
Fred Gerhart	SwRI	210-522-3842	
Felt Mounce	SwRI	210-522-5911	
MARK OVERAKER	HALTERMANN	832-376-2202	

Attachment 2

Sequence V Surveillance Panel

October 22nd , 2014
1:00 – 5.30 CST
Call-in Number : 888-272-5498
Access Code: 1938246

Agenda

1) Attendance

2) Approval of minutes from September 9th 2014 call

3) Action Item Review

4) Test Sponsor report

5) TMC reports – Questions on semi-annual report

6) Fuel supplier report

7) Planning for next batch of Sequence V fuel

8) Operational and hardware Items

9) Review scope and objectives

10) Old business

15 minute BREAK

11) ASTM Test Template review

12) Sequence VH Update

13) Chain wear test update

14) LSPI test update

15) New business

16) Adjourn

Attachment 3

Ford Engine Test Development Update

Sequence VH

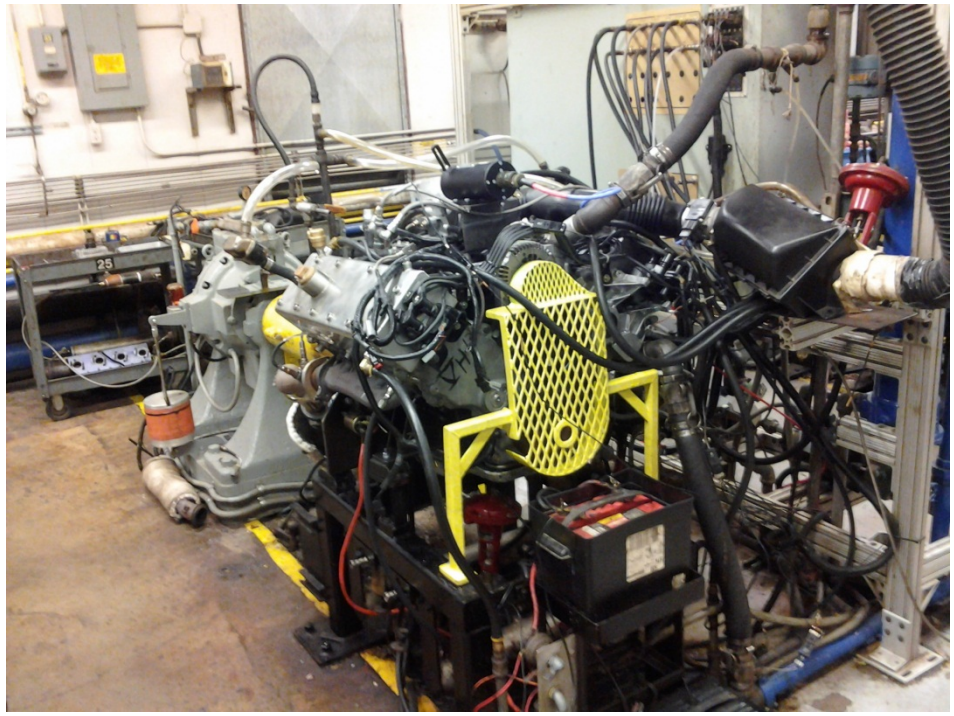
Chainwear

Low Speed Pre-ignition

Ron Romano
Ford Motor Company
October 22, 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, targeting 216 hours.

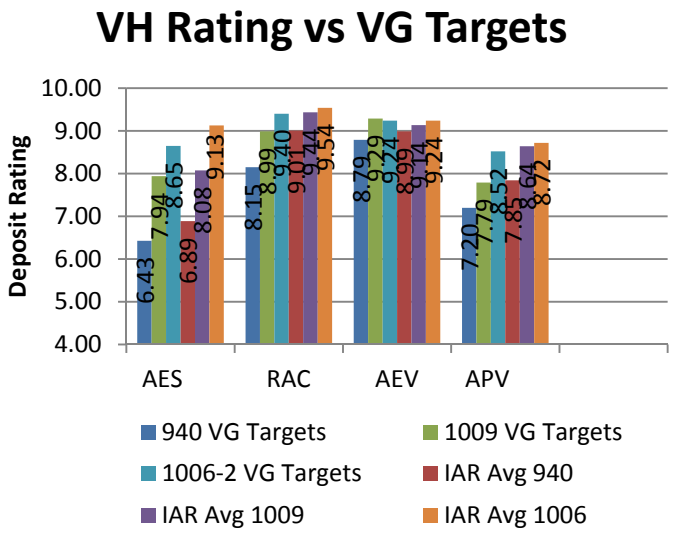


Sequence VH (4.6L 2V)

VH Sludge and Varnish Ratings								FUEL
	Test hours	**AES**	**RAC**	**AEV**	**APV**	**OSC**		DILUTION
940 VG Targets		**6.43**	**8.15**	**8.79**	**7.20**	**50.93**		
940 VG Fuel Mean		**6.29**	**8.72**	**8.42**	**6.82**	**91.40**		
IAR VH98-0-7	216	6.83	9.54	9.07	7.97	59		14.52
IAR VH98-0-9	216	6.95	8.48	8.91	7.72	85.00		14.98
SWRI 7-VH-10*	216	7.71	8.79	8.37	6.53	25		16.90
SWRI 12-VH-4	216	7.41	8.93	7.91	6.72	12		14.43
IAR Average 940		**6.89**	**9.01**	**8.99**	**7.85**	**72.00**		
1006-2 VG Targets		**8.65**	**9.40**	**9.24**	**8.52**	**1.46**		
1006-2 VG Fuel Mean		**8.43**	**9.36**	**9.16**	**8.64**	**5.40**		
IAR VH98-0-9	216	9.13	9.54	9.24	8.72	1.00		13.43
1009 VG Targets		**7.94**	**8.99**	**9.29**	**7.79**	**8.00**		
1009 VG Fuel Mean		**7.11**	**9.25**	**8.88**	**7.87**	**48.17**		
IAR VH98-0-8	216	8.64	9.53	9.11	8.59	2		11.30
IAR VH98-0-10	216	7.51	9.34	9.16	8.69	49		13.86
IAR Average 1009		**8.08**	**9.44**	**9.14**	**8.64**	**25.50**		

All tests -20 dgres EOI

* Before RPECS fix



- Seeing separation between the oils at IAR.
- Seeing a severity difference between the two labs
- IAR appears to be close to VG targets for 1009, 1006 and 940.
- Discovered stand and calibration differences between labs that could be causing labs severity differences
- Changes have been made at labs .

Sequence VH Test Conditions

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

Deviation for VG procedure

1) External coolant pump, thermostat orifice and marine manifolds replace w/new OHT water cooled manifold.
2) New Wire harness combining the dyno and engine harness
3) New oil separtor (Morosso)

2) New PCM (Should be available in 2months)
3) New calibration, -20 end of injection timing, A/F ratio stage 2-3 and 3-1 ramps
4) Procedure update in progress

Proposed changes to improve lack of discrimination

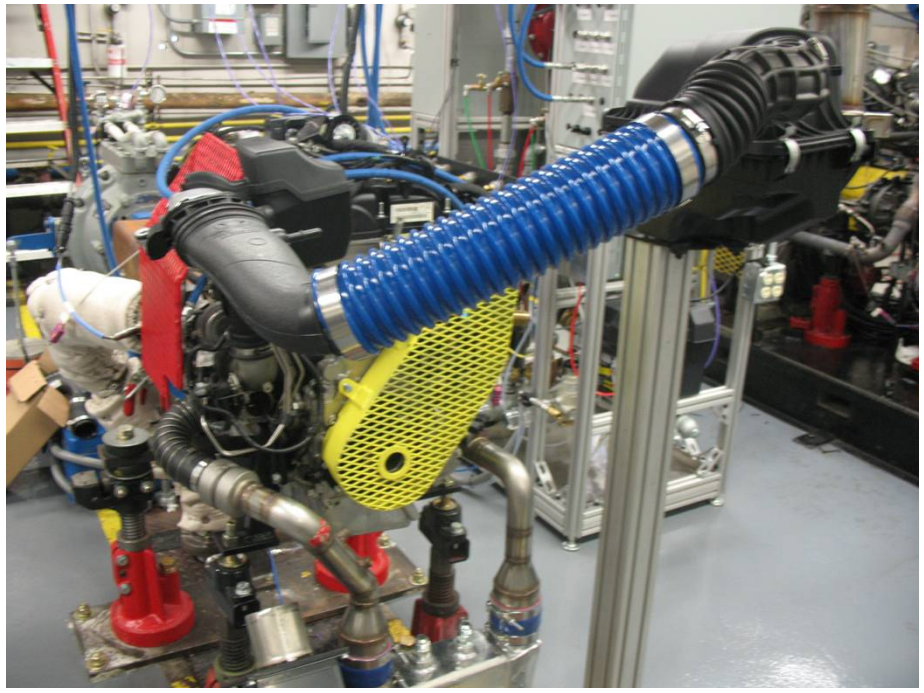
1) Still investigating new rating sight, cam tower, rocker arm cover.

VH parts delivered

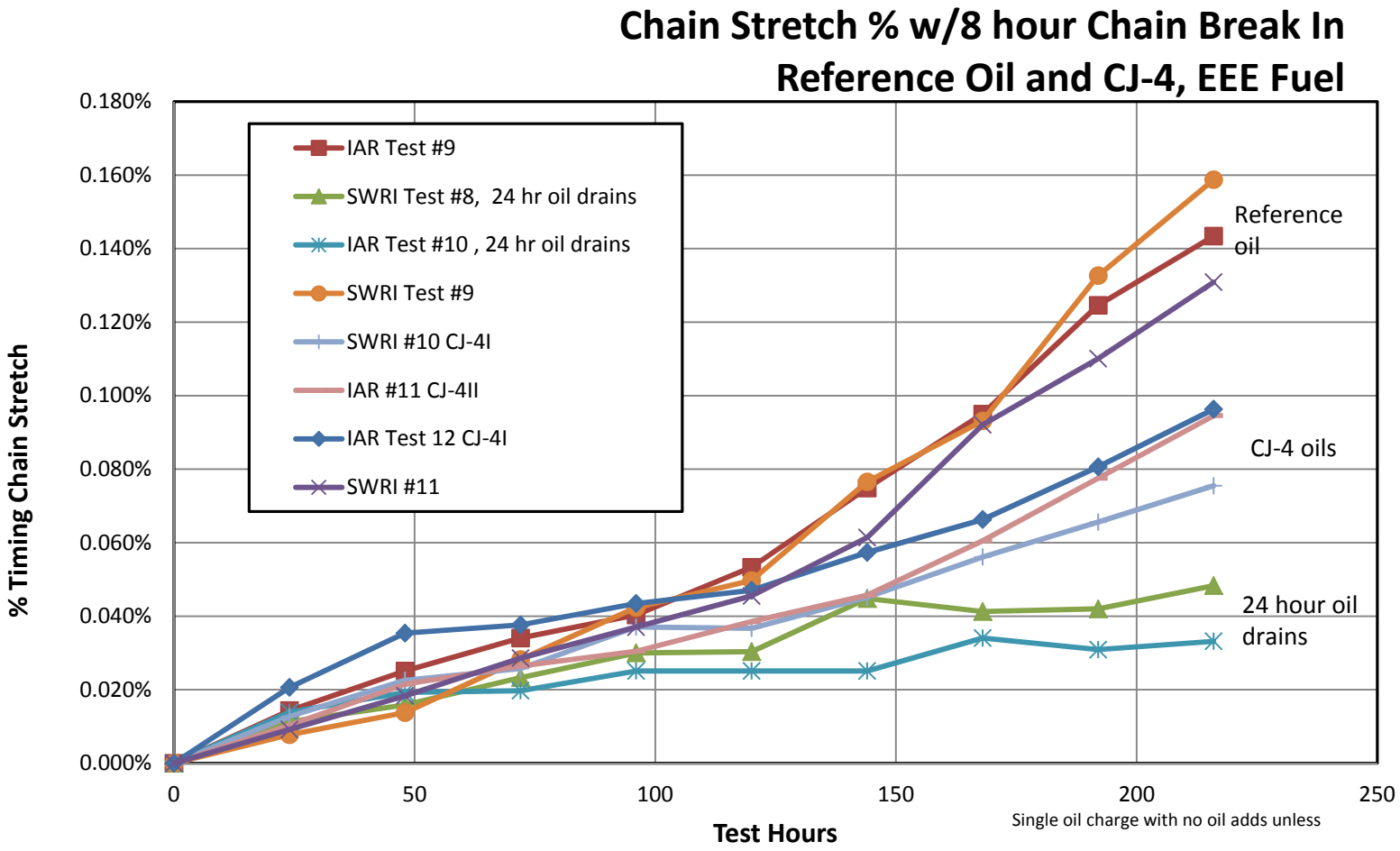
1) Run next tests on newly delivered hardware
2) Verification testing of new PCM should be complete by December

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)

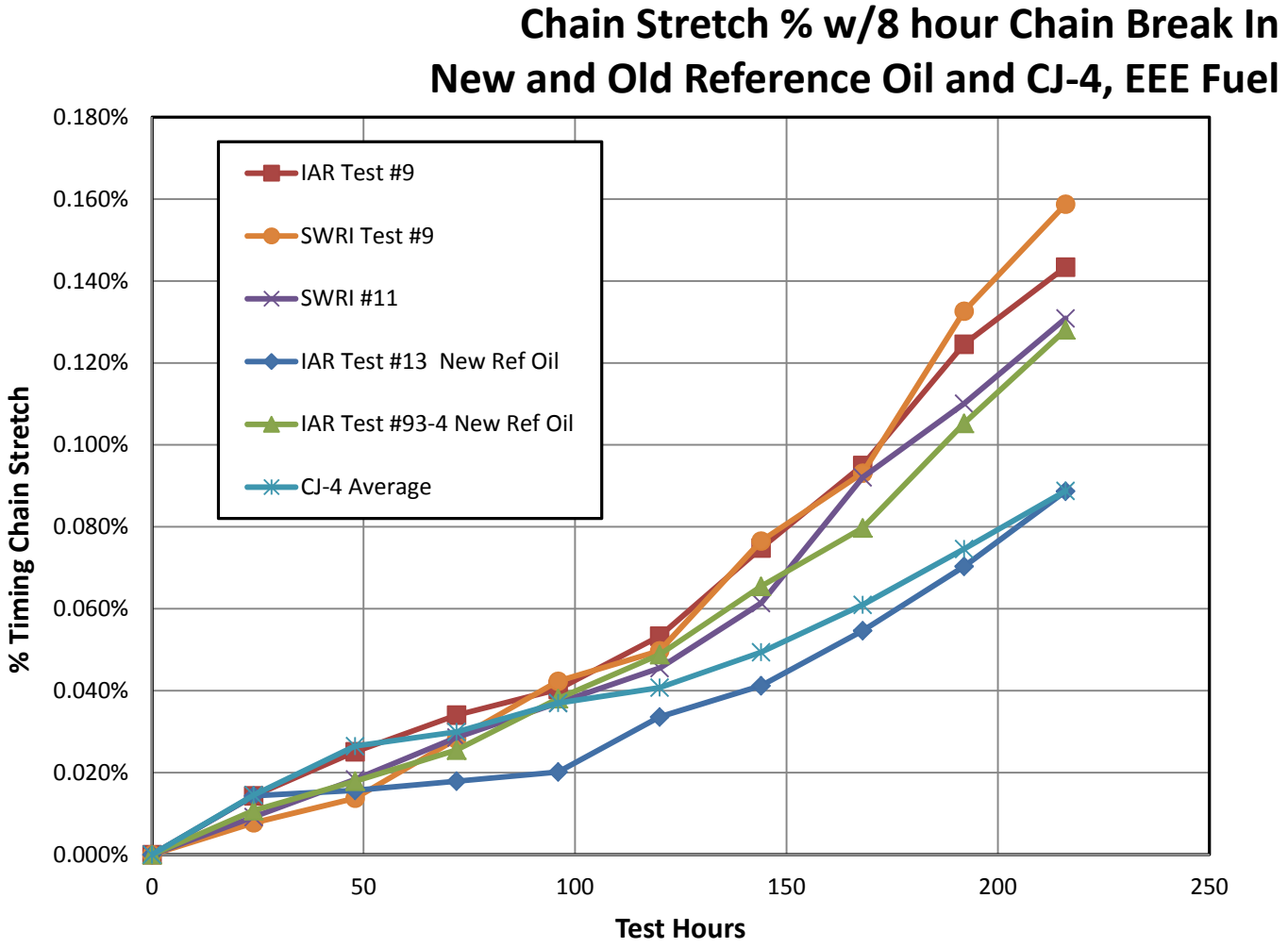


Shows discrimination between single oil charge tests and tests run with oil changed every 24 hours.

CJ-4 formulations showed and improvement over reference oil

Tests on reference oil and CJ-4 oils shows good repeatability and reproducibility

Chain Wear (2.0LGTDI)



Tests conducted on new batch oil reference oil blended with a different base oil showed a decrease in chain wear. Investigating if this is a severity shift in the test or decrease due to the formulation change.

Chain Wear Procedure

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
Intake manigold air, °C		
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 (being updated).

Chain Wear Procedure

- Rebuild between test.
  - Replace rings and clean parts
  - Screen plugging
- Motor Mounts
- Oil Pan and pick up tube
- Intercooler (Type 5)
- Measurement Technique/apparatus
- PCV cooler

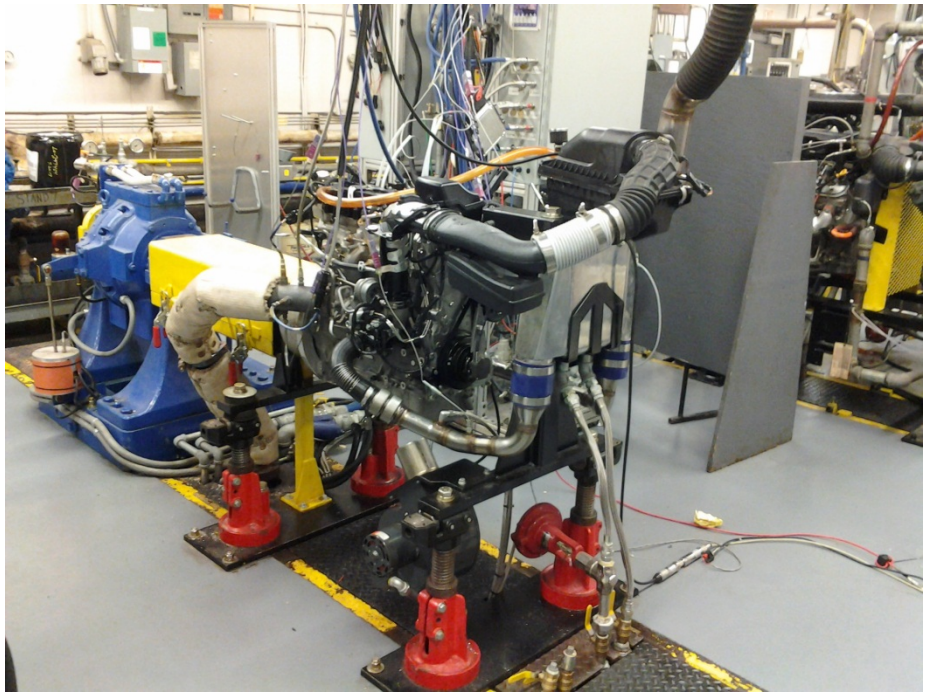
Low Speed Pre-Ignition Test Overview

- 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, < 1750 rpm
  - High Load, >80% max BMEP
  - Test duration, 4 hours



Summary/Next steps

- Investigating lower are intake temperatures
  - Initial data shows lower peak pressures.
  - Repeating testing showed now real reduction in peak pressure. Still destroyed transducer.
- Investigating higher pressure transducer.
- Installing one higher pressure transducer into an engine to evaluate. More transducers on order.