

**HEAVY-DUTY ENGINE OIL CLASSIFICATION PANEL**  
OF  
ASTM D02.B0.02  
June 28, 2022  
Seattle, WA

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**ACTION ITEMS**

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**MINUTES**

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- 1.0 Call to order
  - 1.1 The Heavy-Duty Engine Oil Classification Panel (HDEOCP) was called to order by Chairman Shawn Whitacre at 1:30 P.M. on Tuesday, June 28, 2022, in the Columbia C Room of the Hyatt Regency Seattle, Seattle, WA.
  - 1.2 There were 13 members present and 61 guests present. The attendance list is included as **Attachment 2**.
- 2.0 Agenda
  - 2.1 The agenda circulated prior (included as Attachment 1) was not changed.
- 3.0 Minutes
  - 3.1 The December 7, 2021, minutes were approved as written.
- 4.0 Membership
  - 4.1 There were no membership changes.
- 5.0 Maintenance Report - Sean Moyer. **Attachment 3**
  - 5.1 Test activity is steady.
  - 5.2 A plan is in place to implement new filters for the COAT test.
  - 5.3 Reference oil 832-1 oil was removed due to severity issues.
  - 5.4 No updates on Mack tests.
  - 5.5 No updates on Cummins tests.
  - 5.6 No new updates on RFWT and EOAT test.
- 6.0 CLOG update - Brent Calcut. **Attachment 4**
  - 6.1 Trying to find replacement tests for the T-11 and T-12 Mack tests
  - 6.2 CLOG collected and analyzed existing data.
  - 6.3 SwRI is developing a bench test that could be proposed to correspond to Mack T-12 ring/liner wear. The test is early in development.

- 6.4 No task force has been created to replace the Mack T-12, CLOG still leading the investigation.
  - 6.5 The group looked at other tests and data that have lead (Pb). The Seq VIII, HTCBT and the Volvo T13.
  - 6.6 A shorter T13 test is an option to replace the Mack T-12 lead parameters.
  - 6.7 CLOG looked at the Cummins ISM as an option for the Mack T-8E and T-11 Viscosity increase, however the ISM does not show same vis increase.
  - 6.8 CLOG started initiatives to find other areas of evaluation, Lubrizol and SwRI to give update at NCDT.
  - 6.9 CLOG spent time looking at other tests that could be used for Used Oil MRV replacement for both the Mack T11A and Mack T12A tests, CLOG has not received any data from companies for evaluation.
  - 6.10 For the Caterpillar C13 vs 1N update the majority of tests that passed the CAT C13 also pass the CAT 1N. The 1N test could be viewed as redundant.
  - 6.11 Next CLOG meeting is on July 14<sup>th</sup>.
- 7.0 EOAT and COAT Equivalency - Hind Abi-Akar. **Attachment 5**
- 7.1 The low aeration reference oil is on hold due to a severity shift. The oil supplier is re-blending oil.
  - 7.2 Reference oil 833-1 oil is stable and will continue to be used.
  - 7.3 A new filter batch will be introduced. Batch A will be used for equivalency to batch B
  - 7.4 The CAT SP will conduct an equivalency matrix using Reference oil 1005-6 on Batch A Filters.
  - 7.5 Q: what mechanism has been explored for funding?
    - 7.5.1 A: the Panel has formally asked API.
  - 7.6 Q: Is it too soon to talk about timing.
    - 7.6.1 A: One of the labs is still not ready to start testing on new filters.
  - 7.7 Q: What is the timing for lab A to run EOAT for comparison.
    - 7.7.1 A: Waiting for MoA to be in place
  - 7.8 Q: Is there a risk of limited number of EOAT tests?
    - 7.8.1 A: There is no risk due to historical data available.
- 8.0 Ford 6.7L VTW Test Update - Mike Deegan. **Attachment 6**
- 8.1 Provided whisker charts to show test results. **Attachment 7**
  - 8.2 Will transition to MY 2023 engine due to hardware support until 2040. There are no changes to the critical hardware components.
  - 8.3 The MY23 Engine will have a variable displacement oil pump and steel pistons
  - 8.4 Mike Deegan feels like there is low risk to the test due to the use of the same critical hardware.
  - 8.5 An oil supplier for a border line oil has been identified. The oil will need to run a prove out test.
  - 8.6 Both labs in San Antonio have the new engines and are waiting on dyno hardware.
  - 8.7 Mike needs NCDT to define the precision matrix and BOI/VGRA matrix.
  - 8.8 Two other labs need to be considered for the precision matrix.
  - 8.9 The use of the bookends of D975 fuel is proposed for the Fuel Matrix
  - 8.10 Each engine can run up to 7 times with turbo swaps ever other test.
- 9.0 Old business- EOEC - Shawn Whitacre
- 9.1 Per actions captured at the December 2021 meeting, the entirety of the Stats group were given opportunity to review the revised limit proposals. The data and proposals were also shared during a meeting with the EMA Lubricants Committee. An email ballot proposal was

issued to accept revised variable limits using SL 107. The ballot received 16 affirmative votes, 3 Abstentions (BASF, Total, Volvo), and 1 Negative (GM)

- 9.2 GM's negative expressed a preference for fixed limits.
- 9.3 Next steps, the TMC will issue an information letter without implementation.
- 9.4 Further adjudication may take in next meeting
- 9.5 Fixed limits were never in place.
- 9.6 New fluid is now in use.

#### 10.0 Next meetings

- 10.1 December 7<sup>th</sup>, in Orlando, FL

11.0 The meeting was adjourned at 2:22 pm.

**AGENDA**  
**D02.B0.02.1**  
**Heavy-Duty Engine Oil Classification Panel**  
**Tuesday, June 28, 2022 1:30pm PDT**  
**Hyatt Regency Seattle**  
**Seattle, Washington USA**

- 1) Call to Order/Anti-trust statement**
- 2) Minutes** – Approval of Minutes from December 7, 2021 Meeting in Anaheim, CA USA
- 3) Membership**
  - a) Review current panel membership
- 4) Existing tests/categories**
  - a) Review of status of carry-over engine tests that support API CK-4, FA-4 and legacy categories (Sean Moyer, TMC)
  - b) CLOG Update (Brent Calcut, Afton)
  - c) EOAT/COAT Update (Hind Abi-Akar, Caterpillar)
  - d) Ford 6.7L VTW Test Update (Mike Deegan, Ford)
- 5) Old Business**
  - a) EOEC Fixed limits ballot review and next steps (Shawn Whitacre, Chevron)
- 6) New Business**
- 7) HDEOCP Adjournment**

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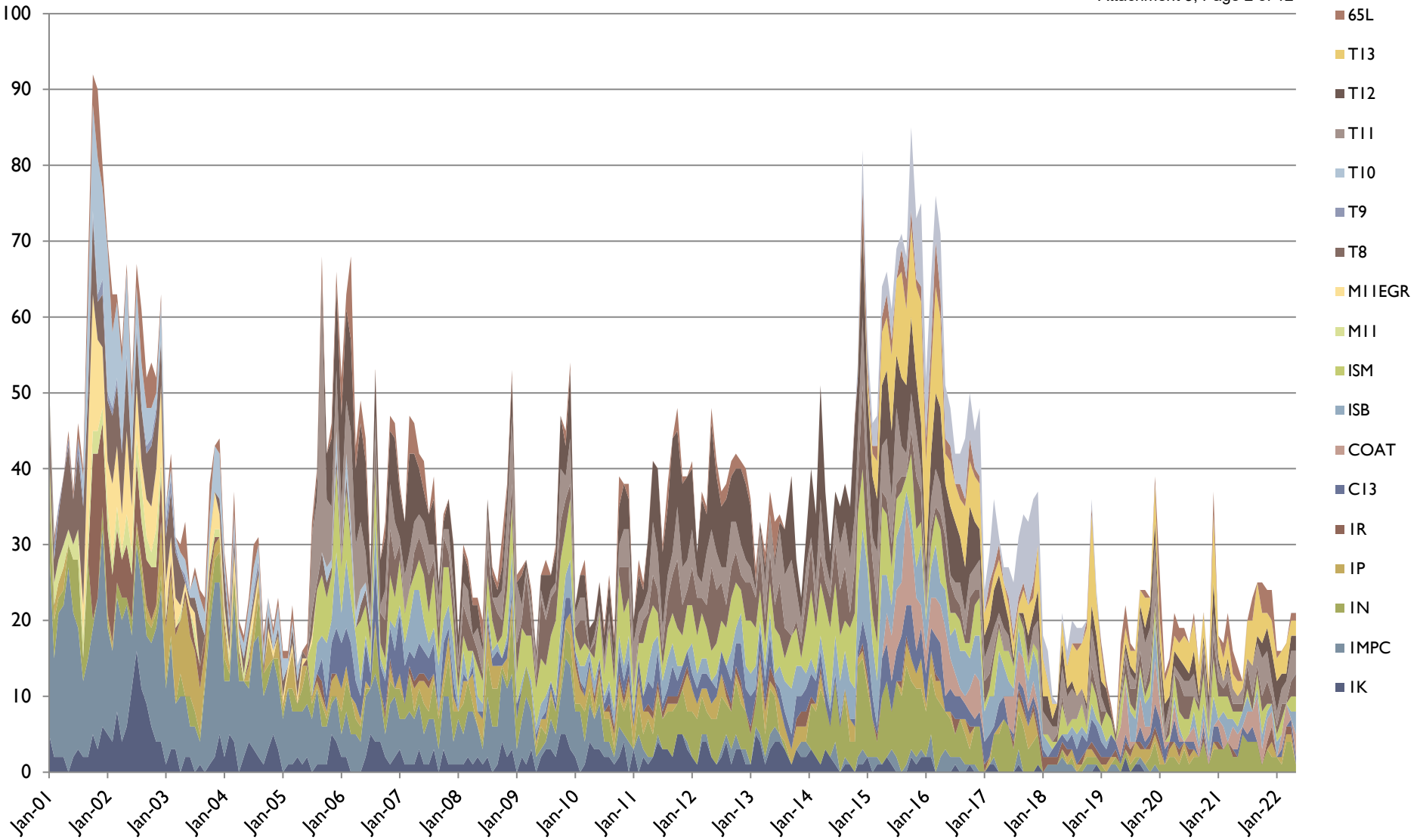


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# D02.B0.02 Maintenance Report

June 2022

# ALL TEST CANDIDATE ACTIVITY



# Calibrated Labs and Stands\*

Test	Labs	Stands
IK	1	1
IN	3	3
IM-PC	0	0
IP	2	2
IR	1	1
CI3	3	3
ISB	4	5
ISM	3	4
EOAT	1	1
RFWT	1	1
T-8/E	1	1
T-11	2	4
T-12/T-12A	3/3	4/5
T-13	4	7
COAT	2	2
DDI3	2	2

\*As of 03/31/2022

# Availability of API CH-4 through CJ-4 Tests

Test	Hardware Issues	Availability Through 2025	Notes
IK/IN	Auxiliary components	Likely	Ongoing resolution of issues with stand auxiliary systems and miscellaneous components.
IP/IR	No current issues	Likely	None
CI3	No current issues	Likely	Engine block, injectors, turbos only available through reman.
COAT	Oil filter batch change	Likely	Panel working to coordinate reference tests to introduce new oil filter batch. Reference oil 832-I also removed from testing. Work to restore severity and reintroduce oil is underway



# Additional Caterpillar Test Issues

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- **IMPC**

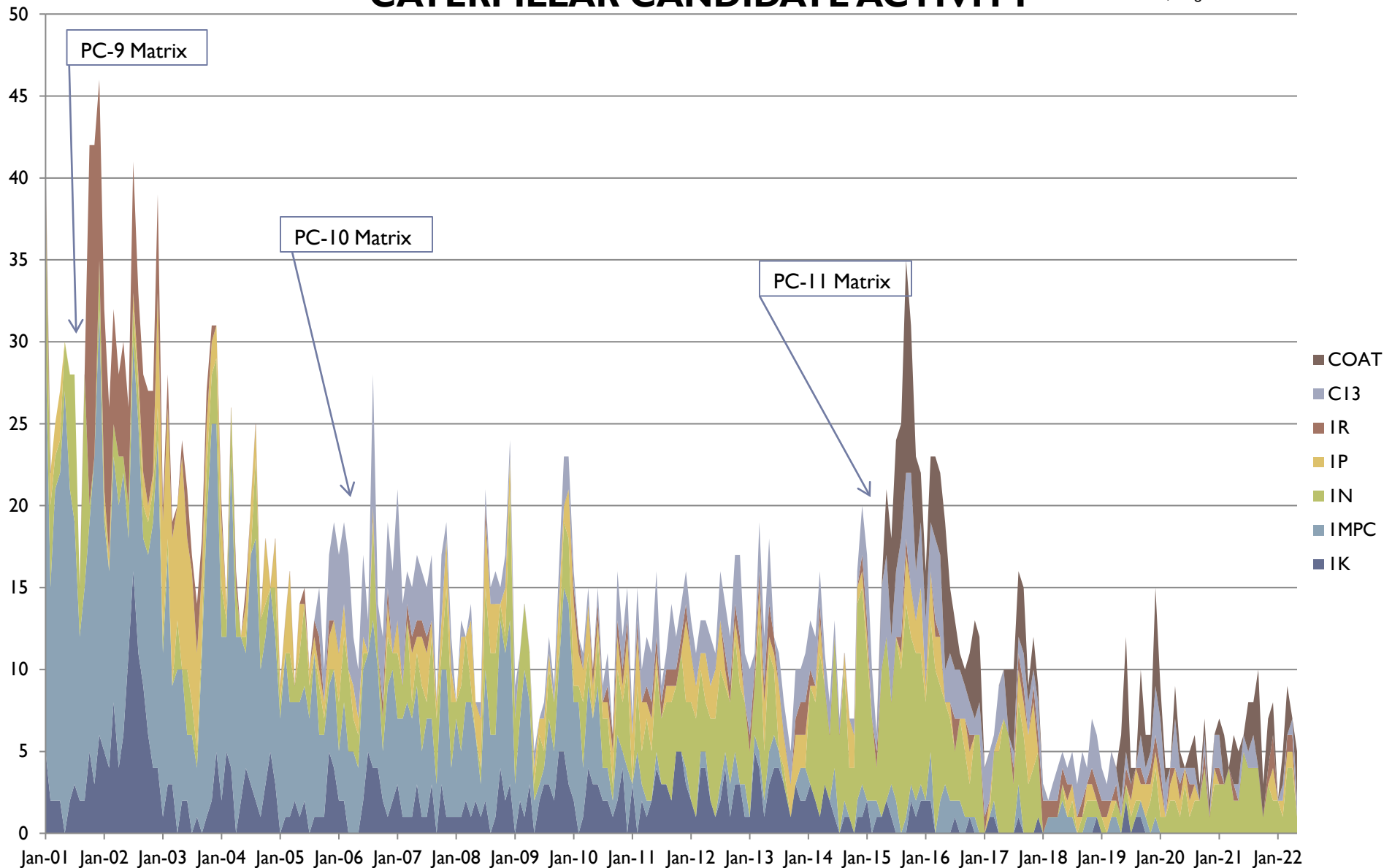
- Reference oil supply depleted.

- **COAT**

- EOAT to COAT correlation testing to resume once hardware and reference oil issues have been resolved.



# CATERPILLAR CANDIDATE ACTIVITY

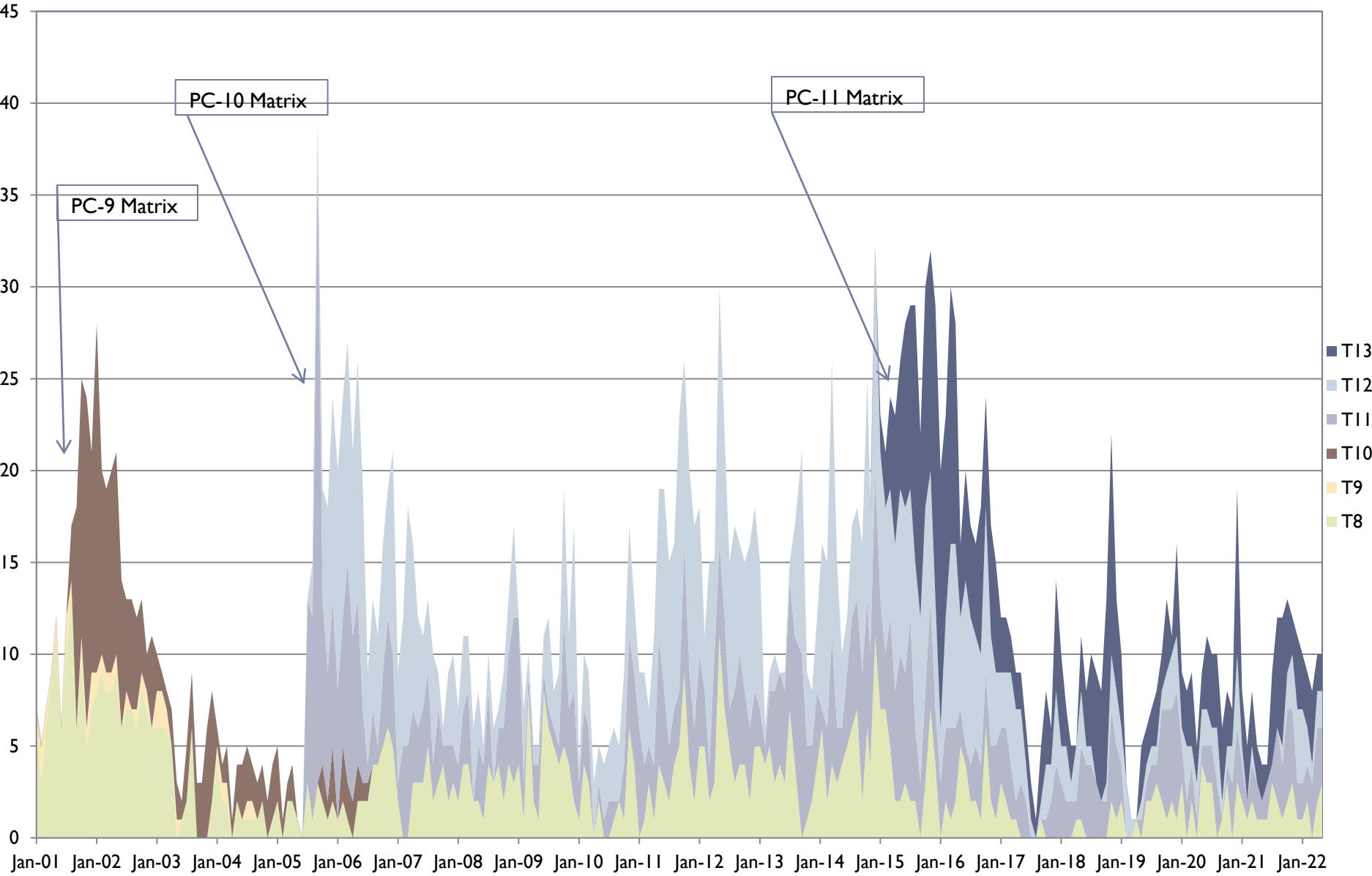


# Availability of API CH-4 through CJ-4 Tests

Test	Hardware Issues	Availability Through 2025	Notes
T-8	No current issues	Likely	Engine block supply limited. Final liner batch ordered to take test to 2026
T-11	Liners, Pistons, Rings	Likely	Initial coordinated references on new FINAL liner batch showed higher than historic norm oil consumption. Testing found combination of batched hardware with acceptable oil consumption.
T-12	Liners, Pistons, Rings	Likely	Initial coordinated references on new FINAL liner batch showed highest ever Stage I oil consumption. Testing found combination of batched hardware with acceptable oil consumption.
T-13	Cylinder head	Likely	Cylinder head no longer in production and panel investigating whether superseding part is acceptable for test. Multiple other “out of production” parts identified.



# MACK CANDIDATE ACTIVITY

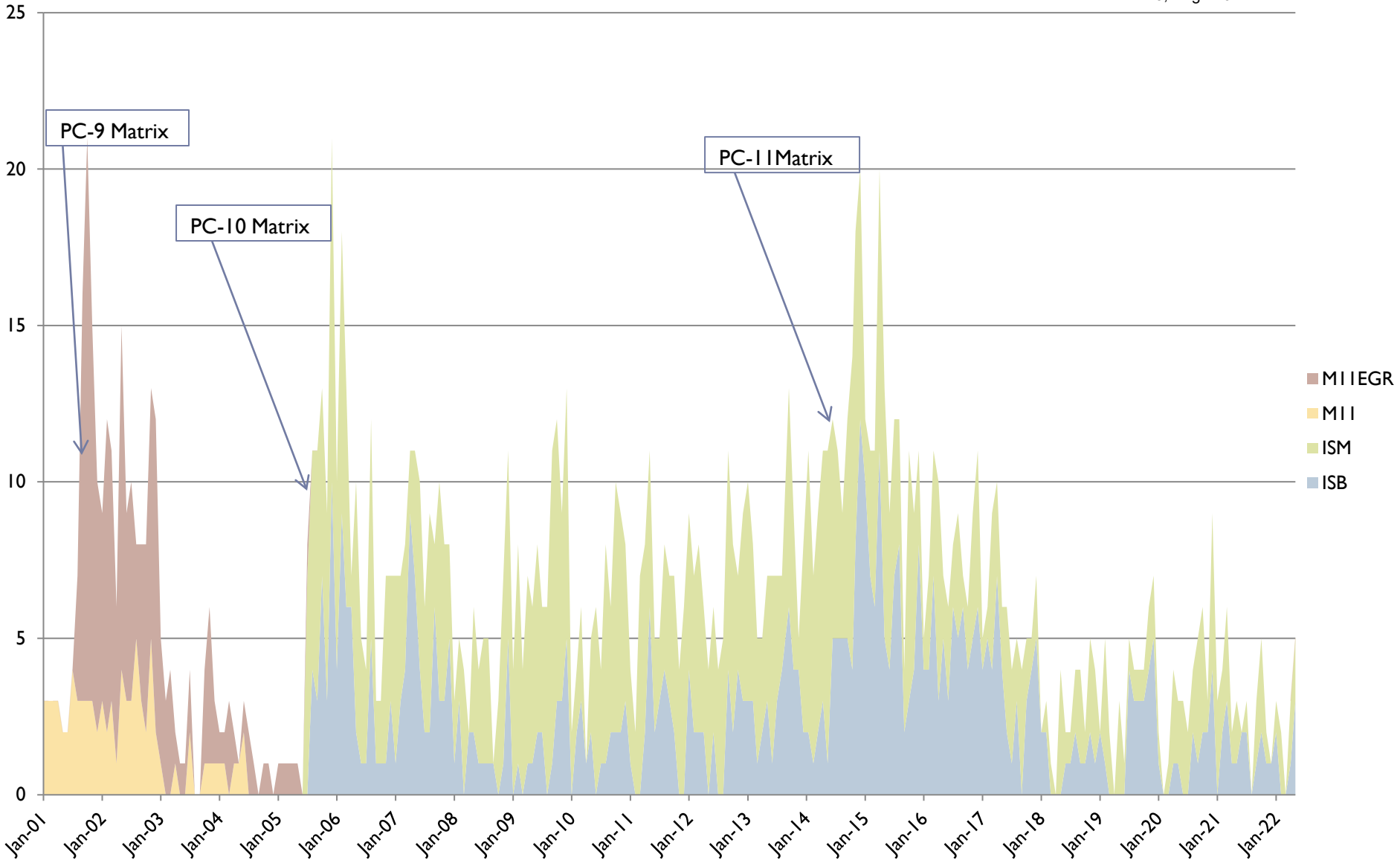


# Availability of API CH-4 through CJ-4 Tests for PC-11

Test	Hardware Issues	Availability Through 2025	Notes
<b>ISM</b>	<b>None</b>	<b>Likely</b>	<b>None.</b>
<b>ISB</b>	<b>None</b>	<b>Likely</b>	<b>None.</b>



# CUMMINS CANDIDATE ACTIVITY



# Availability of API CH-4 through CJ-4 Tests for PC-11

Test	Hardware Issues	Availability Through 2025	Notes
RFWT	None	Likely	<p>Long term supply of test parts at CPD.</p> <p>6.5 L engine no longer in production at AM General, but available through supply network.</p> <p>Injection pump still available.</p>
EOAT	Using last engine block	No	<p>Oil Temperature runs higher w/ current EOAT engine. Working on EOAT / COAT correlation.</p>



# B2 Action Items

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- **No Action Items**
- **Comments**





# CLOG Update at ASTM

June 28, 2022





# CLOG HDEO Topics

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- Mack T-12 wear
- Mack T-12 lead
- Mack T-8E/11 viscosity increase
- Mack T-11A/T-12A Sooted Oil MRV
- Cat C-13 vs. 1N



# What we need to do

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- ACC collected and analyzed existing data comparing relevant tests
- CLOG reviewed ACC dataset and requested some additional support
  - If ACC data are adequate,
    - Develop equivalency recommendation for API LSG
  - If ACC data are inadequate or still unclear,
    - Narrow down to best possible replacement test
    - Develop plan to generate additional data
    - Develop equivalency recommendation to API LSG
  - If no replacement tests seem viable, recommend new test development
- We will need plans to generate additional supporting data



# Mack T-12 Equivalency

- Mack T-12 is required in all current API 'C' categories

Target Test & Parameter(s) for Tie-Back		Categories at Stake if Tie-Back Not Established				
Test	Parameters	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4
T-9	Average Liner Wear, normalized to 1.75 % soot, $\mu\text{m}$ max	☑	-	-	-	-
	Average Top Ring Mass Loss, mg max	☑	-	-	-	-
	EOT Used Oil Lead Content less New Oil Lead Content, mg/kg, max	☑	-	-	-	-
T-10	Liner wear, $\mu\text{m}$ , max	FBO	-	-	-	-
	Ring wear, mg, max	FBO	-	-	-	-
	Lead content at EOT, mg/kg, max	FBO	-	-	-	-
	Merit rating, min	-	☑	☑	-	-
T-12	Liner wear, $\mu\text{m}$ , max	FBO	-	-	-	☑
	Top Ring Mass Loss, mg, max	FBO	-	-	-	☑
	Lead content at EOT, mg/kg, max	FBO	-	-	-	-
	Merit rating, min	-	FBO	FBO	☑	-

1000 merits, min.  
Different rating systems

CK-4 backwards  
compatibility also  
expected in PC-12A

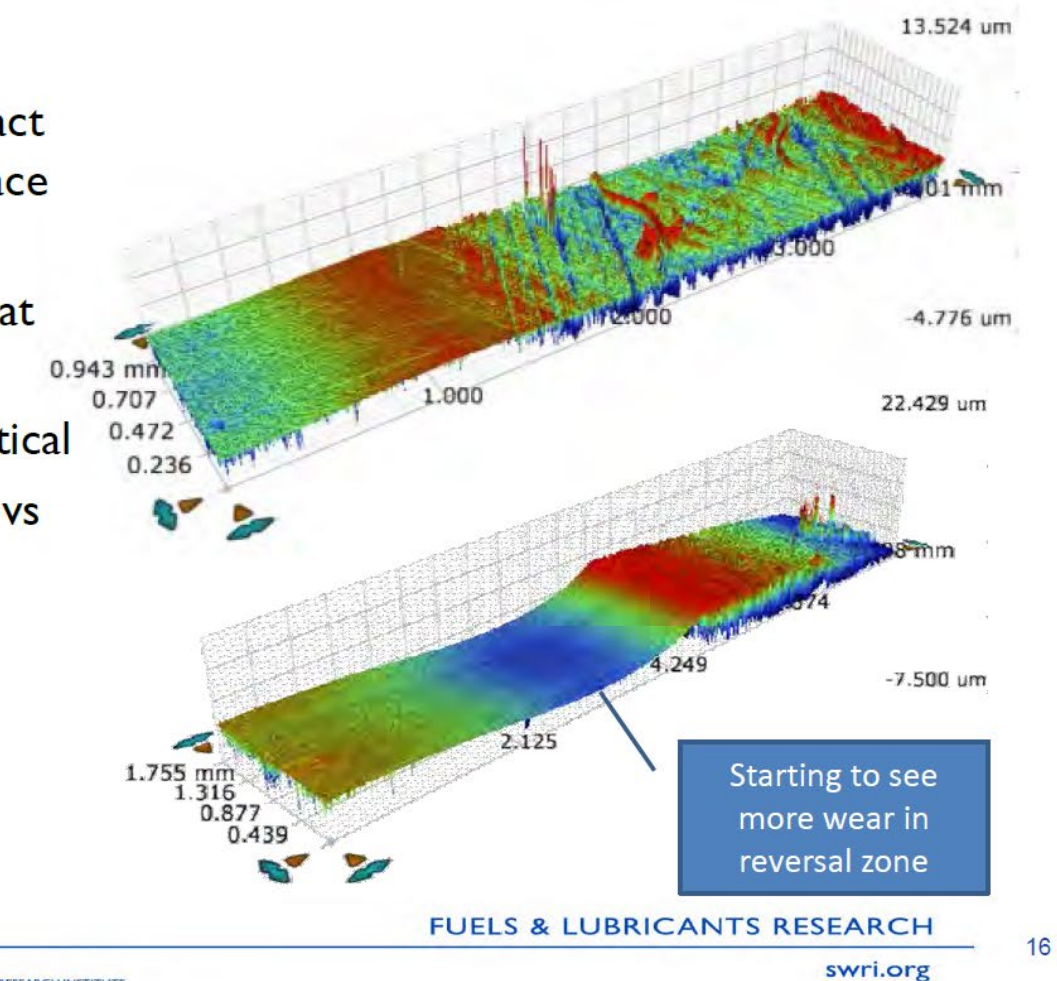


# Mack T-12 Ring/Liner Wear Status

- ACC data review concluded no existing wear tests produce enough ring or liner wear to replace the T-12
- SwRI shared preliminary work to evaluate a bench wear test using used oil
  - CLOG is interested to see this work continue
- Afton suggested a combination of:
  - TBN minimum
  - HTHS or BOV minimum
  - Existing wear tests
- Have we thoroughly reviewed or eliminated all engine test options?
  - Further discussion at the next meeting

## Bench/Rig Challenges

- Easy to go beyond the critical contact pressure and polish the whole surface evenly
- Ideally would see some crosshatch at mid-stroke
- Setup and ring alignment can be critical
- Delicate balance between duration vs scale, lubricant entrainment, temperature and load



## Suggestions for Replacing T-12

- ▲ For PC-12,
  - ▲ Volvo T-13 remains as the oxidation test
  - ▲ Liner wear mechanism is not relevant in modern engines
  - ▲ Current valvetrain wear tests and proposed DD13 Scuffing provide adequate wear protection without T-12 ring and liner wear
- ▲ For previous categories,
  - ▲ CLOG is investigating alternative oxidation tests
  - ▲ For T-12 ring and liner wear:
    - Ensure right levels of detergent through TBN minimum
    - Add sheared HTHS or BOV minimum for film thickness
    - Existing valvetrain wear tests provide adequate AW chemistry



# Mack T-12 Lead Status

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- Conclusions from ACC dataset:
  - Seq. VIII, HTCBT and Volvo T-13 lead parameters were eliminated
  - Volvo T-13 oxidation results are inconclusive; we need more data
- A shortened Volvo T-13 oxidation test could be developed to replace the Mack T-12 lead parameters
  - Review T-12 reference oil data during T-13 development
  - Test development would be required
- CLOG requested ACC to compare Mack T-12 lead data with Seq. IIIF, IIIG and IIH oxidation tests
  - Data collection is underway (nearly complete)



# Mack T-8E/T-11 Equivalency

- Mack T-8E or Mack T-11 is required in all current API 'C' categories

Target Test & Parameter(s) for Tie-Back		Categories at Stake if Tie-Back Not Established				
Test	Parameters	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4
Ext. T-8E	Relative Viscosity at 4.8 % Soot by TGA, max	☑	☑	-	-	-
	Viscosity increase at 3.8 % Soot by TGA, mm <sup>2</sup> /s, max	☑	-	-	-	-
T-11	TGA % Soot at 4.0 mm <sup>2</sup> /s increase, at 100 °C, min	-	-	☑	☑	☑
	TGA % Soot at 12.0 mm <sup>2</sup> /s increase, at 100 °C, min	-	-	☑	☑	☑
	TGA % Soot at 15.0 mm <sup>2</sup> /s increase, at 100 °C, min	-	-	☑	☑	☑
T-11A	Sooted Oil MRV TP-1, D6896 Viscosity at 180h	-	-	☑	☑	☑
	Yield Stress of 180h used oil sample	-	-	☑	☑	☑
T-12A	Sooted Oil MRV TP-1, D4684 Viscosity at 100h	-	☑	-	-	-
	Yield Stress of 100h used oil sample	-	☑	-	-	-



# Mack T-8E/11 Viscosity Increase Status

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- ACC data comparison results:
  - Cummins ISB and ISM do not generate enough viscosity increase to replace the Mack T-11
- ACC subsequently requested T-8E data to compare with ISB and ISM
  - Data collection is nearly complete
- CLOG recommended API form a test development task force group
  - Potential options:
    - Ford 6.7L VTW test in current procedure
    - Ford 6.7L modified test procedure
    - Lubrizol is scoping a modified Cummins ISM procedure



# Mack T-11A/T-12A MRV

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- Request to all stakeholders to collect Sooted Oil MRV data from:
  - Mack T-12A
  - Mack T-11A
  - Cummins ISM at 125hr
  - Cummins ISB at 300hr
  - Ford 6.7L at 175hr

*Please work with laboratories to measure MRV on retain samples*

*Submit data to Dennis Bachelder at API **by June 17th***



# Cat C-13 vs. 1N

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- ACC concludes, “CAT C13 for redundancy in place of the CAT 1N seems promising”

- CLOG statement to NCDT:

“Data collected since the introduction of API CK-4 shows that oils passing the Cat C13 also pass the Cat 1N.”



# Summary

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- Mining existing data has identified some redundancy
  - RFWT
  - Cat 1N
- Data collection efforts have expanded
  - Mack T-8E
  - Seq. IIIF, IIIG, IIH
- New activity in scoping potential new test methods
  - Used oil bench wear test
  - Modified ISM viscosity increase
- Next CLOG meeting is scheduled for July 14 at 11:00 ET



# EOAT / COAT Equivalency Testing

June 28, 2022

HDEOCP

# Current Status of COAT Test

## 1. Lab status:

3 Labs / 1 Stand per Lab

- a. Lab A has an active calibrated stand
- b. Lab B stand is out of calibration (completed reference period). Will reference soon.
- c. Lab G has installed a new stand at their lab and has calibrated this stand

## 2. Reference Oils

- a. Reference oil 832-1 (low-aeration reference) is on hold as performance has shifted severe. Supplier has remixed 2 drums of material to determine if this could re-establish prior performance of the oil. Testing of remixed material to commence shortly.
- b. Reference oil 833-1 (high-aeration reference) is stable and allowing labs to continue calibrations.

## 3. Hardware

A new filter batch will be introduced.

- a. There are 34 Batch A filters remaining (current filters). 10 Batch A filters have been set aside for usage in the comparison matrix between the COAT and EOAT.
- b. CAT Surveillance Panel is finalizing strategy for testing and acceptance of a new filter batch (Batch B) for candidate testing.
  - Email ballot sent out to CAT Surveillance Panel with submission date of July 1.

# Status of COAT / EOAT Equivalency

- Caterpillar Surveillance Panel would like to conduct the following equivalency matrix using TMC 1005-6 (Reference oil for EOAT) on Batch A filters.
  - 2 test on TMC 1005-6 in EOAT
  - 6 test on TMC 1005-6 in COAT
    - 2 tests at each lab (Lab A, Lab B, Lab G)
    - 1 test has been completed at Lab A using the Batch A filters (shared during Dec meeting)

EOAT (Lab A)	COAT (Lab A)	COAT (Lab B)	COAT (Lab G)
TMC 1005-6 (API funded)	TMC 1005-6	TMC 1005-6 (API funded)	TMC 1005-6 (API funded)
TMC 1005-6	TMC 1005-6	TMC 1005-6	TMC 1005-6

- Caterpillar Surveillance Panel has obtained offer to fund 1 EOAT, 2 COAT tests from API.
  - Contingent on the tests being run one at a time and operational data reviewed by the Surveillance Panel upon completion of each test before the next test is started.
  - Funding for other 4 test needs to still be obtained

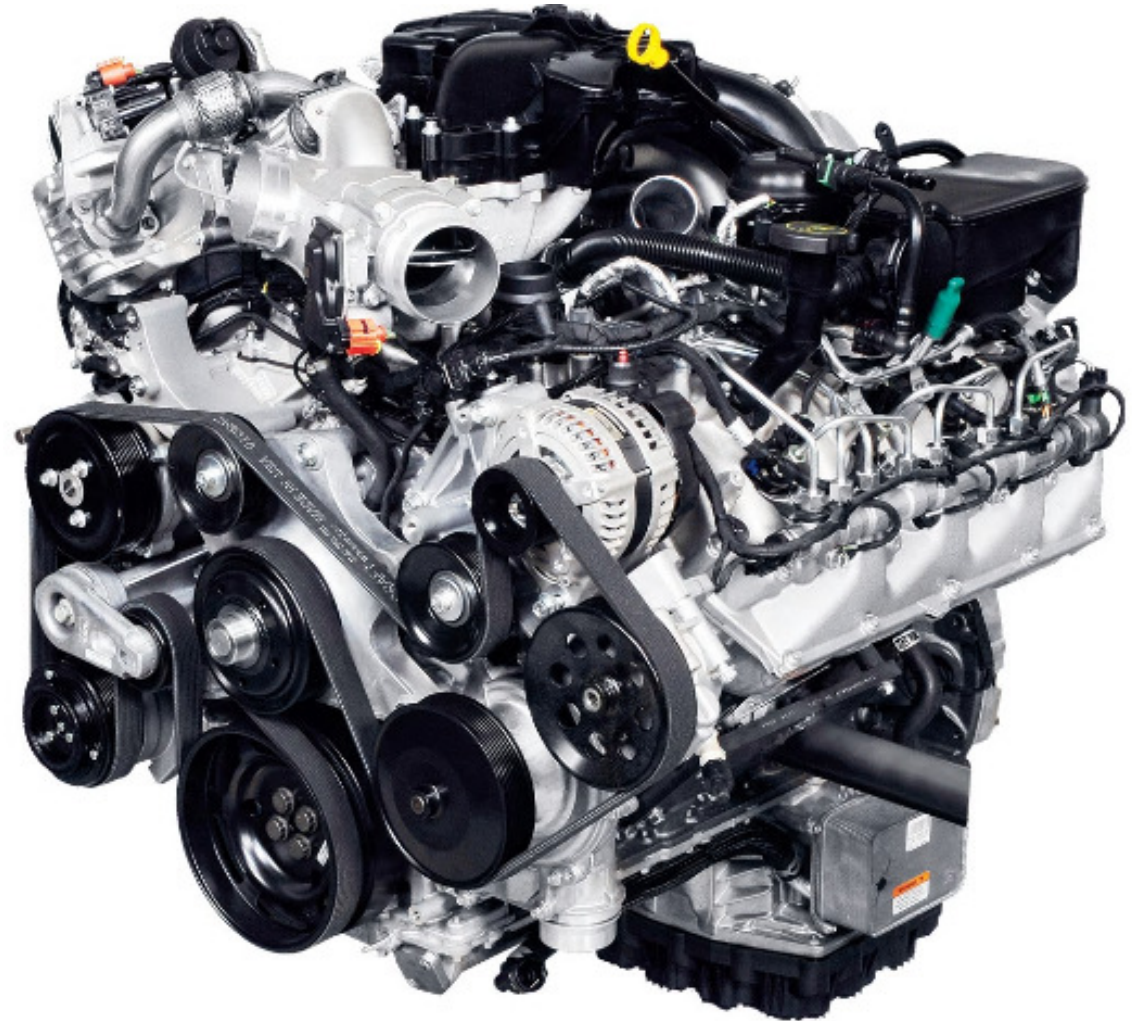


# Ford 6.7L Diesel Engine Valve Train Wear (VTW) Test Update June 2022 ASTM

**Update by:** Mike Deegan  
FCSD SEO Lubricant TS

**Additional VTW Industry Team Members:**

Nick Ariemma, John Loop (Lubrizol), Andrew Smith (Intertek), Robert Warden, Jose Starling, Travis Kostan (SwRI)



## 6.7L VTW Test Update

### Request from NCDT:

- a. Provide whisker charts. See separate file.
- b. Update ACC COP Supplement K. See separate file.
- c. Provide confidence in Long Term Engine and Component supply-CY2040.
- d. Preliminary PM Matrix Information.
- e. Request other required information.

## 6.7L VTW Test Update

Provide confidence in Long Term Engine and Component supply-CY2040.

a. MY23 required and planned on implementing.

i. MY2019 will be needed for a year.

ii. MY23 to be scoped-3<sup>rd</sup> Qtr 2022.

i. Latest Hardware designed Engines and Heads enroute to Labs.

a. Identifying component differences and impact to test.

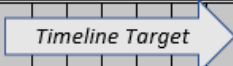
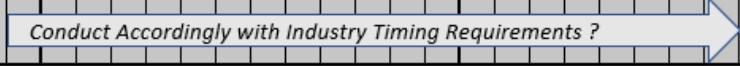
1. No changes to Critical Valvetrain components.
2. Valve seat and guide updates in Head Assys.
3. Short Block updates to steel pistons from aluminum.
4. Variable Displacement Oil Pump.

ii. Dyno kits in-process.

iii. Scoping plan reviewed with VTW Team.

a. Test LWO/HWO. Validate Borderline Oil.

# 6.7L VTW Test Update

FORD VTW TEST DEVELOPMENT	2022												2023												2024											
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12					
MY23 ENGINE CHANGEOVER TIMELINE	Timeline Target 																																			
Provide two complete MY23 Engines to San Antonio Test Labs with spare cylinder heads																																				
San Antonio Engineering Groups to Review MY 2019 / 2023 Variations with Mike Deegan																																				
Provide Dyno Kit and ECM's								In-process @ Ford																												
Review Scoping Test Requirements																																				
Run Borderline Reference Oil on MY 2019 Platform																																				
Change Over to MY 2023 Engines																																				
Conduct Scoping Runs on MY 2023 Engines Borderline and High Wear Reference Oils																																				
Secure MY 2023 Engines for Precision Matrix																																				
Review Precision Matrix Requirements with Statisticians/NCDT																																				
Schedule and Run Precision Matrix								Conduct Accordingly with Industry Timing Requirements ? 																												
Timeline for providing MY23 engines for PC12 category.																																				

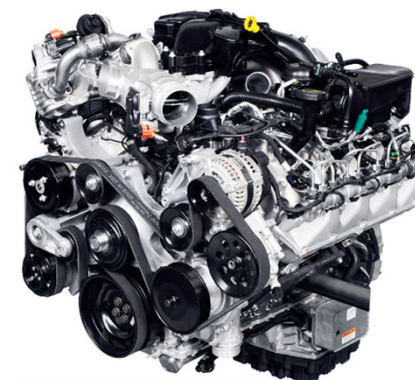
## 6.7L VTW Test Update

### Possible changes from original PM Matrix proposal:

- Additional Test Oil to be provided. Prove out of Borderline Oil required.
- MY23 Engine required. Additional Tests required to verify discrimination.
- Additional Labs. Lubrizol and/or Afton based on availability of MY23's.
- Additional Stands at each lab: 2 & 2 & 1 & 1.
- Use the bookends of D975 fuel only.
- Use short block up to 7-times.
- Use turbo's 2x.
- Inclusion of BOI/VGRA.
- Evaluate for T-11 MRV, etc.



## 6.7L VTW Test Update



### Other information request:

- Any additional information that Ford needs to provide for ASTM?

## 6.7L VTW Test Update

### **Previous Information**

## 6.7L VTW Test Update

### From D.4:

For a proposed C Category Supplement to move forward, DEOAP should consider the following items:

- a. Tests must be developed and be ASTM-approved or have made significant progress toward ASTM approval.
  - i. Ready to proceed with Precision Matrix Testing.
- b. Oils are being marketed that meet the proposed Supplement.
  - i. Approx. (200) oils on market already.
- c. Multiple technologies have been shown to meet the proposed Supplement.
  - i. Different Base Oils and Ad Pacs.
- d. There is no previous Supplement for this category (one Supplement per Category).

## 6.7L VTW Test Update

### From D.4:

The DEOAP will work to reach consensus positions on the following questions:

- a. What is the proposed change and why is it required?
  - i. Add the Ford VTW Test.
  - ii. Excessive Valve Train Wear in Ford Durability test.
- b. What field performance issues support the need for a Supplement?
  - i. Warranty avoidance from (4) OEMs.
- c. Does data presented support the request?
  - i. See following information.
- d. When is it needed in the marketplace?
  - i. ASAP
- e. What are the potential impacts on engines and aftertreatment devices?
  - a. Improved engine (e.g.: valvetrain) durability and no impact to aftertreatment.

## 6.7L VTW Test Update

### From D.4:

The DEOAP will work to reach consensus positions on the following questions:

- f. What are the potential impacts on consumers?
  - i. Improved durability of engines.
- g. What are the potential impacts on the environment?
  - i. No expected change to the environment
- h. Can the tests requested for the Supplement be used for the next full, new C Category?
  - i. Ford believes that it can be used for the next Category. EMA is considering.
- i. Are the requested performance tests available, or will they be available within the requested time frame, that properly evaluate the requested performance needs?
  - i. Yes, Test is available at (2) labs.
- j. Do the perceived benefits outweigh the projected costs?
  - i. Yes, warranty costs would be substantial if Ford spec oil is not used.

## 6.7L VTW Test Update

The OEM sponsoring each individual test shall fulfill the following requirements:

- a. Justify the need for the test and performance limits.
- b. Provide test hardware.
- c. Provide a test procedure.
- d. Provide discrimination and precision data.
- e. Provide suggested initial BOI and VGRA guidelines.
- f. Provide suggested pass/fail limits.

## 6.7L VTW Test Update

- This file has been updated from the DEOAP presentation to better explain Ford's request. Intent is to provide an improved test and oil type timeline based on DEOAP questions.
- General Test information:
  - Ford 1200 hour Durability Testing found the initial wear issues with ~800ppm phos oils.
  - After implementation of Ford Specification, a 600 hour durability test was implemented at external test labs.
  - Due to length of test and interest in protecting Ford engines, a 200 hour test has been developed with industry partners for ASTM implementation.
- Due to confidentiality, the additive package chemistries tested with Low Phos (~800ppm) or High Phos (1000 – 1200ppm) are not available.
- This request is also meant to ensure that an API licensed category can be implemented for addition to Owner Guides and on Motorcraft Heavy Duty Diesel engine oil labels as current CK-4 licensed oils may not protect Ford Engines.
- Current next category is not planned until 2027, Ford requests this supplement in the interim.

## 6.7L VTW Test Update

### Initial Ford 1200hr Dyno Durability Testing Background:

- 6.7L's Valvetrain, running prototype oils showed higher wear than CJ-4 oils on Ford 1200hr Durability Engine Test.
  - **Ford Durability Test Information: (Ad Pac information not available)**
    - 1<sup>st</sup> test-FA-4, 5W-30, Low Phos-Valvetrain Failure
    - 2<sup>nd</sup> test-FA-4, 5W-30, Low Phos-Valvetrain Failure
    - 3<sup>rd</sup> test-CJ-4, 10W-30, High Phos-Valvetrain Pass
    - **4<sup>th</sup> test-FA-4 additive system with 3.5HTHS, 10W-30, Low Phos-Valvetrain Failure**
    - **Subsequent testing was done with CK-4, 10W-30, High Phos-Valvetrain Pass.**
- Ford specification, WSS-M2C171-F1, with Phosphorus requirement between 1000 and 1200ppm implemented at same time as CK-4 licensing.



## 6.7L VTW Test Update

### **Supplement Request Test Background (cont.):**

- **Incremental 600hour Ford** Durability Testing at External Labs with prototype or licensed CK-4 oils with 800ppm Phosphorus results had excessive wear.
  - Approx. 6 tests were run at different external labs.
    - Some passed, but not all.
  - Ad Pac information can not be provided.

## 6.7L VTW Test Update

### **200 hour Test Development Background:**

- Ford/Lubrizol/Intertek/SwRI developed an ASTM Test Method over the past 5 years.
  - Using soot in the oil as wear mechanism.
  - Engine Test Hours targeted to 200 hours or less show visual correlation to wear in the Ford Durability Tests.
  - Average Rocker Arm Mass has shown discrimination in the testing between High Wear Oil (HWO) and Low Wear Oil (LWO).

## 6.7L VTW Test Development-Durability Test to VTW Test Visual Comparison

Durability Tests in 6.7L with Low Phos 5W-30 PC-11B2

Test showed excessive wear on pushrod ends and plunger tip



**Example Wear from a 200 hour High Wear Oil (Low Phos) test at the Rocker Arm to Pushrod Interface**



## 6.7L VTW Test Development: Average Rocker Arm Mass Loss

HWO – “PC11B” (shown in blue)  
3.0 HTHS-150  
800 ppm phosphorus

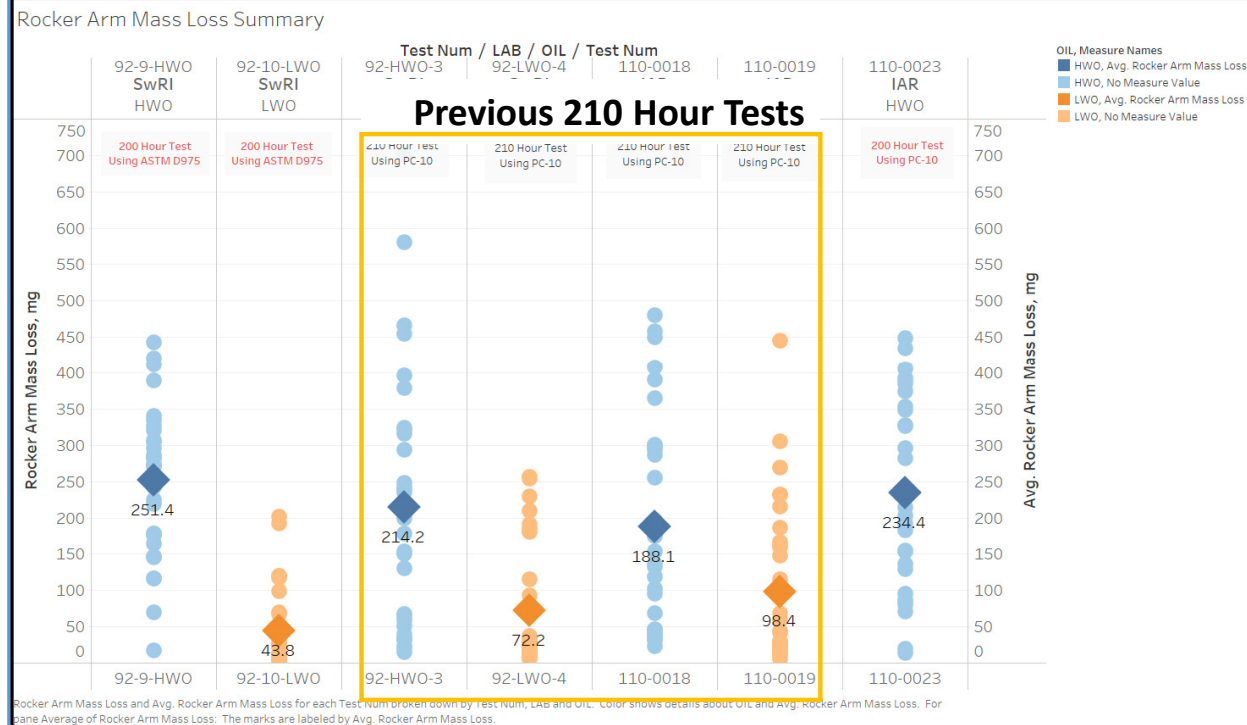
LWO – CJ-4 Factory Fill (shown in orange)  
3.5 HTHS-150  
1100 ppm phosphorus

Average Rocker Arm Mass  
discrimination based on:

- LWO/HWO run on latest test setup & procedure at SwRI and Intertek.
- Both labs within Soot Window Limits. Max of 6%.
- Both Labs within Operational Limits.

Statistician reviewed for Discrimination  
and Precision Matrix (PM)  
Recommendations.

- Discrimination acceptable.
- A transformation may be used to Improve Discrimination.
- PM needs up to (20) tests for evaluation of different fuels.



# 6.7L VTW 200hr Test Development Status

- Resolved Soot Window & QI Tolerances.
  - Revisit after Precision Matrix.
- Determined a Statistical Model for Rocker Arm Average Mass Loss Pass/Fail Criteria.
- Developed a Precision Matrix Proposal.
  - Task Force Implemented.
  - Different Fuels are a part of the proposed matrix.
  - Funding request to industry.
- Draft ASTM Test procedure with report forms and data dictionary have been completed.
- Potential replacement of other Valve Train Wear Tests.
  - Working with EMA.
  - Some Licensed CK-4 with existing Valve train wear tests do not appear to provide the same level of wear protection as CJ-4 provided on 6.7L engines.
- Several current WSS-M2C171-F1 approved oils have been tested and passed per proposed 115mg max Rocker Arm Mass Loss target.
  - Oils are between 1000 and 1200ppm phos.
  - 800ppm test in progress. Results pending.
- Appendix after slide 17 provides additional detail regarding the Ford VTW Test.

## 6.7L VTW Test Update

### **Additional Supplement Request Background:**

- Current Ford specification, WSS-M2C171-F1, approvals exceed 200.
  - These Aftermarket oils are also CK-4 licensed.
  - Ford does not use the API Donut on its Heavy Duty Motorcraft Diesel Product.
  - A CK-4+ supplement would increase the use of API Trademark by Ford.
  - Ford has no current warranty issues.
  - There is unknown use of CK-4 oils with lower phosphorus being used in Ford Trucks.
    - Approx. Industry use of High/Low Phosphorus based CK-4 oils 80/20.

## 6.7L VTW Proposed Precision Matrix (PM) Test

Item	Planned Completion MMM-YY	Responsible
<b>Finalize Draft Test Procedure</b>	Feb-21	Ford/Labs/API
Data Dictionary	Feb-21	Ford/Labs/API
Report Forms	Feb-21	Ford/Labs/API
<b>PM Agreement</b>		
Critical Parts	Mar-21	Ford/Labs/TEI
Funding for (20) Tests	Mar-21	Task Force
<b>PM Test Start</b>	Apr-21	Labs/TEI
Review of First Row- Evaluate Fuels	May-21	All
Finalize Results	Jul-21	Statisticians
Evaluation	Aug-21	All
PM Completion	Sep-21	All
<b>Finalize Test Procedure</b>	Oct-21	All
Data Dictionary	Oct-21	All
Report Forms	Oct-21	All
<b>Test accepted by API</b>	Dec-21	

### Proposed PM Test Plan-12/7/2021 with D975 (B1 & B2 Bookends)

Stand A-1	Stand A-2	Stand G-1	Stand G-2
LWO, Fuel B2	HWO, PC-10	HWO, Fuel B1	LWO, PC-10
HWO, PC-10	HWO, Fuel B1	LWO, PC-10	LWO, Fuel B2
HWO, Fuel B2	LWO, PC-10	LWO, Fuel B1	HWO, PC-10
LWO, PC-10	LWO, Fuel B1	HWO, PC-10	HWO, Fuel B2
LWO, Fuel B2	HWO, PC-10	HWO, Fuel B1	LWO, PC-10

## 6.7L VTW Test Update

The OEM sponsoring each individual test shall fulfill the following requirements:

- a. Justify the need for the test and performance limits.
  - i. Based on Ford Internal Dyno Testing. Other OEM information.
- b. Provide test hardware.
  - i. Hardware provided to Labs. Availability confirmed to 2027. Expectation is to provide for next Category.
- c. Provide a test procedure.
  - i. Draft ASTM Procedure provided.
- d. Provide discrimination and precision data.
  - i. Demonstrated in multiple tests. Request to run a Precision Matrix to improve.
- e. Provide suggested initial BOI and VGRA guidelines meeting CK-4.
  - i. BOI requirements similar to Table E-29 but may have little impact.
  - ii. VGRA requirements: From SAE 10W-30 to 5W-40, 10W-40, 15W-40.
- f. Provide suggested pass/fail limits.
  - i. Based on provided data as of January 2021:
    - a) Pass: 115mg or less average rocker arm weight loss.
  - ii. Intent is to change Ford Spec to performance based only and remove Phosphorus minimum.



## 6.7L VTW Test Update

(3) anonymous OEMs wear issues resolved with higher Phos:

- OEM 1: Top Ring and Groove-See PDF
- OEM 2: Valvetrain-Wear
- OEM 3: Valvetrain-Wear

## 6.7L VTW Test Next Steps

- Request a supplement to CK-4 for Ford VTW Test.
  - DEOAP consideration



## 6.7 VTW Test Development

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**QUESTIONS?**

Appendix:

Additional 200hour test  
information follows.



# 6.7L VTW Test Development: Overview

## MY2019 Ford Powerstroke 6.7L V8 Diesel Engine with EGR & CCV Removed

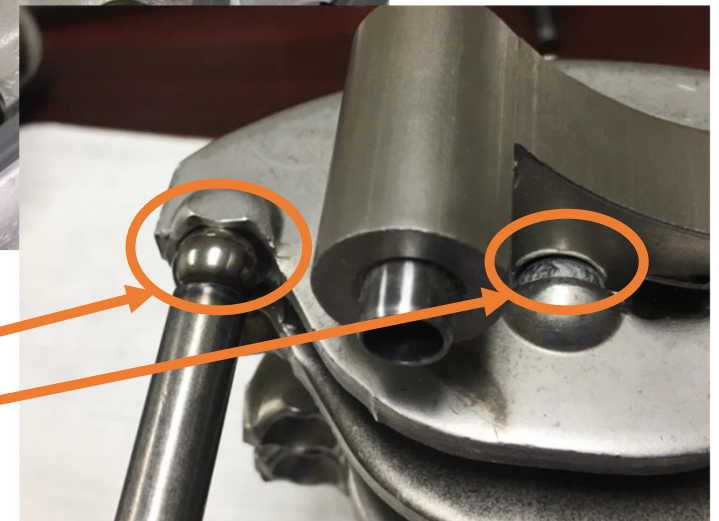
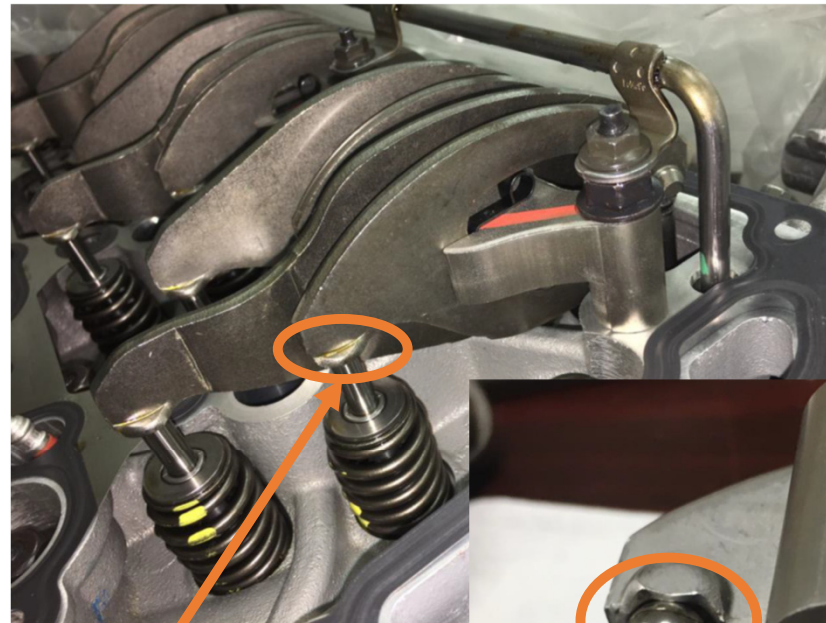
- **Test Phases**
  - Flush
  - Engine Break-In (New Engines only)
  - Flush 2 & 3
  - 200 hour test to initiate wear.
    - 1000Nm at 2800rpm.
- **Using soot as the mechanism to generate wear at Max Horsepower.**
  - Controlled by adjusting Coolant Temp Signal to PCM which in turn changes Fuel Injection Timing
  - Targets for soot loading with a maximum of 6% by End of Test (EOT).
- **14.5 kg oil charges**
  - Approximately 30 gallons of oil needed.
  - High Wear Oil (HWO)
  - Low Wear Oil (LWO)
- **Approximately 16200L (4300gal) of Diesel Fuel**
  - Evaluating PC10 & D975 Fuels to determine test sensitivity.



## 6.7 VTW Test Development: Overview

### Focused on Average Rocker Arm Wear:

- No discrimination between oils seen on other components during prove-out testing
- Will continue to monitor other components throughout precision matrix testing



### Wear locations:

- Rocker to Valve
- Rocker to Pushrod
- Rocker to Fulcrum Balls

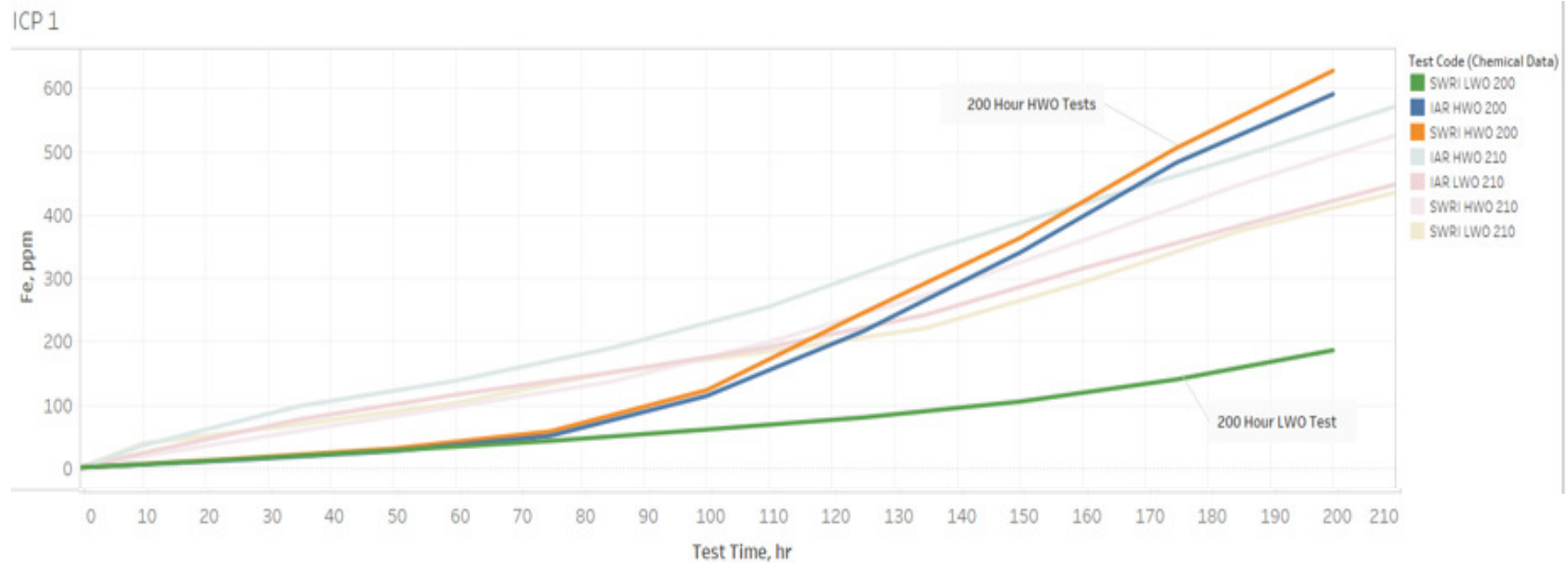
## Test Development Data: Soot Content vs Test Time

- Soot content shown for the completed tests at each lab.
- Current soot window requirements shown at 0, 100, 200 hours with soot at 0%, 3%, 6% +/-0.5%.
- Ability to manage soot content via coolant temp shown.
- 25 test hour monitoring of soot necessary.



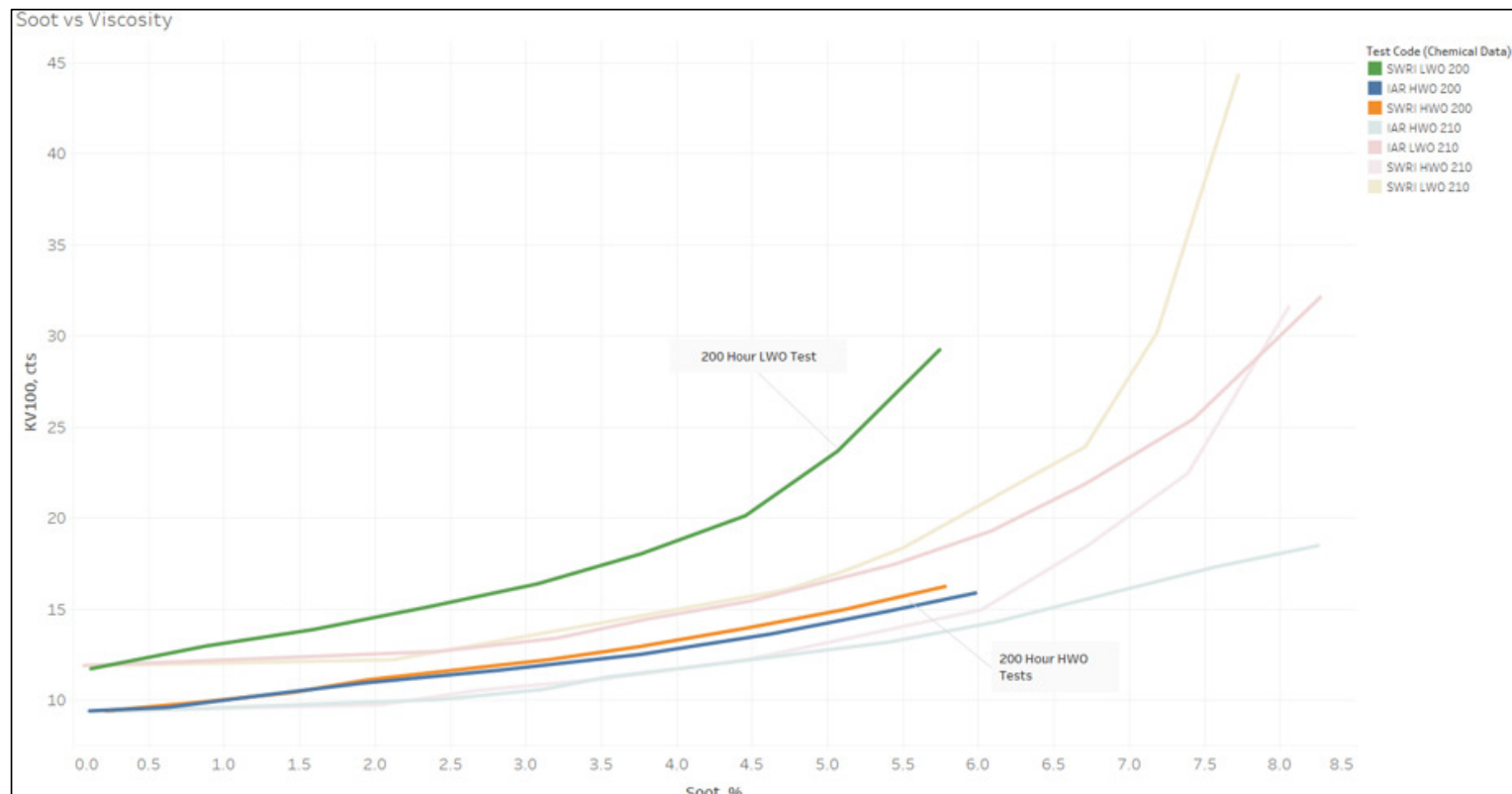
## Test Development Data: Fe vs. Test Hours

- HWO EOT Fe > LWO EOT Fe
- Labs consistent with HWO & LWO Fe content.
- May be useful for predicting failure before end of test.
- Current Test shows approx. 2% Soot impacts Valvetrain Wear at ~75hrs on HWO.

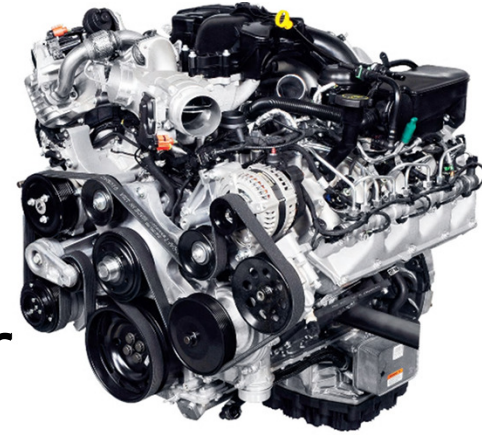


## Test Development Data: Soot Content vs Viscosity

- Results with regard to Oil Viscosity to % TGA Soot.
- Labs consistent with soot vs Viscosity including HWO & LWO up to ~6% soot.







# Ford 6.7 VTW Test 200 Hour Version Only – Results Comparison

Team:

M. Deegan, J. Starling, A. Smith, R. Warden, T. Kostan, N. Ariemma, J. Loop, S. Clark, D. Grosch, S. Moyer



Diamonds show Mass Loss AVERAGE

