HEAVY-DUTY ENGINE OIL CLASSIFICATION PANEL

OF

ASTM D02.B0.02

December 7, 2004

The Marriott Waterside Hotel – Tampa, FL

ACTION ITEMS

1. T-10 / T-9 data.	**All**
2. Input to BOI/VGRA Task Force on BOI for ISB and T-12.	**EMA**
3. Form task force to evaluate potential VTW test redundancies.	**HDEOCP**
4. Input on piston deposit test(s) for inclusion in PC-10.	**EMA**

MINUTES

1.0 Call to Order

1.1 Chairman Jim McGeehan called a meeting of the Heavy Duty Engine Oil Classification Panel (HDEOCP) to order at 1:29 p.m. on December 7, 2004 in Grand Salon I/J of the Marriott Waterside Hotel of Tampa, Florida. There were 17 members present or represented and approximately 56 guests present. The attendance list is shown as Attachment 2.

2.0 Agenda

2.1 The published agenda (see Attachment 1) was reviewed and Fred Girshick was added early with a report on shear stability.

3.0 Previous Meeting Minutes

3.1 Bill Runkle moved that the minutes of the previous meeting be approved as distributed and posted on the TMC web site. Lew Williams seconded the motion, which passed by unanimous voice vote.

4.0 Membership

4.1 There were no changes to the membership (see Attachment 3).

5.0 Shear Stability, 90 Cycle

5.1 Fred Girshick, chairman of the Sub-committee 7 Task Group on Ninety Cycle Shear Stability, reported that the test method has been approved and published, with method number D7109 assigned. The method currently has a preliminary precision statement, but that will be revised to a full precision statement and balloted early next year, after the round robin now in progress is completed. See Attachment 4.

6.0 PC-10 Matrix Design, Funding and Test Oils

6.1 Steve Kennedy reported on the PC-10 matrix funding and design (see Attachment 5) and noted the Memorandum of Agreement (MOA) will state the ISB and T-12 matrices can not start until the base oil interchange (BOI) guidelines are defined and agreed upon.

6.2 Barry Deane indicated the BOI/VGRA Task Force plans to meet toward the end of January to formulate a recommendation to the API Lubricants Committee. They request EMA input as soon as possible and plan to ballot their recommendation to the API LC before the MOA is issued.

6.3 The possibility was raised that matrix oils blended with the Group III base stock could blend to a 10W-40 grade rather than a 15W-40 grade. No concerns or objections were raised by the panel.

7.0 PC-10 Timeline

7.1 Bill Runkle presented the revised PC-10 timeline, see Attachment 6.

8.0 ISM Exit Ballot

8.1 Jim McGeehan reviewed the exit ballot results on including the ISM in PC-10 (see Attachment 7). There were 3 negatives and several affirmative comments expressing hope that tests now underway will help alleviate concerns.

8.2 Steve Kennedy's negative centered on concern that there are probable redundancies with 3 valve train wear tests (ISM, ISB, RFWT) and he wants to see a task force formed to evaluate the need for 3 tests.

8.3 Charlie Passut's negative is concerned that no soot correction exists and no outlier criteria have been defined.

8.4 Mike Lynskey's negative is concerned there is inadequate OFDP separation in the test.

8.5 An ISM presentation by Dave Stehouwer, not made at the meeting, is included for reference (see Attachment 8).

9.0 PC-10 New Test Development Status

9.1 Mack T-12

9.11 Greg Shank reported on the status of the T-12 test development (see Attachment 9). The T-12 Task Force recommends use of dyed PC-10 fuel and including oil 820-2 as a matrix test oil. He also mentioned concern with condensation possibly making it to the intake manifold. Greg made and Steve Kennedy seconded a motion that reference oil 820-2 be included as one of the PC-10 T-12 matrix oils. The motion passed with 15 votes for, 0 against, 0 abstain.

9.2 Caterpillar C13

9.21 Abdul Cassim reported on the C13 test development status (see Attachment 10). He indicated the task force is looking at a new low reference oil.

9.3 Cummins ISB

9.31 Dave Stehouwer presented the ISB report (see Attachment 11). Dave made and Greg Shank seconded a motion that reference oil 830-2 be included as a PC-10 ISB matrix test oil. The motion passed with 16 for, 0 against, 0 abstain.

10.0 Piston Deposit Tests

10.1 Tom Cousineau presented C13 and 1P piston temperature data from testing sponsored by the ACC (see Attachment 12).

10.2 Greg Shank reviewed the EMA position (see Attachment 13) and indicated they had not yet reached consensus because of the wide spread in piston temperatures. It was noted their 1N temperature data was obtained in 1994.
10.3 Abdul Cassim reviewed piston temperature data (see Attachment 10) and indicated CAT is willing to support inclusion of the 1K or 1N in PC-10, but not at the expense of losing the 1P. No 1K/1N vs. 1P data will be coming from Infineum or Lubrizol.
10.4 Pat Fetterman presented 1K piston temperature data they had obtained by a different technique (see Attachment 14). It also indicates hotter temperatures in the ring belt than the steel pistons.
10.5 EMA have agreed to reach a position by the next HDEOCP meeting, at which time, hopefully, the piston deposit tests to be included in PC-10 can be agreed upon.

11.0 Next Meeting

11.1 The next meeting is scheduled for January 13, 2005 in San Antonio.
11.2 Following meetings are tentatively set for February 10 and March 2, 2005, probably in Chicago.

12.0 PC-10 Review

12.1 Jim McGeehan presented a review and update of PC-10 progress, see Attachment 15.

13.0 PC-10 Fuel

13.1 Jim Wells reviewed the tax penalty (20 cents per gallon) if PC-10 tests use clear or "on-highway" fuel. Mack indicated their fuel system supplier sees no problem with using dyed "off-road" fuel. Detroit Diesel, Cummins and International also indicated they see no problems with dyed fuel.
13.2 Barry Deane recommended that if dyeing was agreed to, it should be done at the minimum acceptable level. The PC-10 fuel supplier, ChevronPhillips, indicated they could supply fuel with dye in the range of regulated minimum to regulated minimum plus 2%. Pat Fetterman made and Charlie Passut seconded a motion that starting in 2005, PC-10 ULSD fuel be dyed to qualify for "off-road" tax status at the minimum to minimum plus 2% regulated dye rate. The motion passed via unanimous voice vote, with one abstention.
13.3 The above discussion raised the question in regard to PC-9 fuel, which is currently clear or un-dyed. Bill Kleiser made a motion, seconded by Lew Williams, that the HDEOCP recommend to the surveillance panels of tests using PC-9 fuel, that PC-9 fuel be dyed to qualify for "off-road" tax status at the minimum to minimum plus 2% dye rate and that it be a running change. The motion passed via unanimous voice vote, with one abstention.
13.4 For reference on dye rates, see Footnote "C" of Table 1 in D975.

14.0 T-10 for T-9

14.1 Once again, no data available yet. Greg Shank promised to have some for the next meeting.

15.0 Adjournment

15.1 The meeting was adjourned at 4:13 p.m. on December 7, 2004.

Submitted by:

Jim Wells
Secretary to the HDEOCP

ATTACHMENT 1

Final Agenda
ASTMSECTION D.02.BO.02
HEAVY-DUTY ENGINE OIL CLASSIFICATION PANELS

Tampa Marriott Waterside, Tampa FL
December 7th , 2004
1:00 pm--5:00 pm

Chairman/ Secretary: **Jim Mc Geehan/Jim Wells**
Purpose: **PC-10**

Desired outcomes : **Finalize PC-10 tests, matrix oils and funding .**

TOPIC	PROCESS	WHO	TIME
Agenda Review	• Desired Outcomes & Agenda	Group	1:00-1:05
Minutes Approval	• November 11th , 2004	Group	1:05-1:10
Membership	• Changes: Additions	Jim Mc Geehan	1:10-1:15
PC-10 Timing	• Review time line	Bill Runkle	1:15-1:30
Matrix Oils and Funding	• Precision and BOI matrix: BOI agreements prior to matrix testing • Viscosity grades with API Group I, II and III. • Timing of availability of matrix oils • Funding	Steve Kennedy	1:30-2:15
PC-10 Cummins ISM	• Results of "Exit-Criteria" ballot on Cummins ISM	Jim Mc Geehan Dave Stehouwer	2:15-3:00
PC-10 Test Development report	• Mack T-12 • Caterpillar C13 • Cummins ISB • Caterpillar Cat IP Piston Temperatures • Discussion on Cat IP and Cat IN for PC-10 tests • Timing of "Exit-Criteria" ballots on remaining tests	Greg Shanks Dave Stehouwer Abdul Cassim ACC member Group	3:00-4:30
Diesel fuel	• Dyed diesel fuel (20 cents tax/gallon) • Discussion and vote	Jim Wells	4:30-4:45
Next Meeting	• Exit-Criteria ballots review: January 13th 2005. Location San Antonio. • Final meeting Feb 23rd, location, Chicago		4:45-5:00

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1	Jim A. Mc Geehan – ChevronTexaco	Greg Shank - Mack Trucks
2	Steve Kennedy - ExxonMobil	Warren Totten - Cummins Inc.
3	Matthew Urbanak - Shell	Mesfin Belay - Detroit Diesel
4	Mike Lynskey - Castrol	Abdul Cassim - Caterpillar Inc.
5	Bill Runkle - Ashland	Heather DeBaun - International
6	Scott Harold - CIBA	Ken Chao - John Deere
7	Steven Herzog - RohMax	Robert Stockwell - GM Powertrain
8	Charles Passut - Ethyl	
9	Bill Kleiser - Oronite	
10	Lew Williams - Lubrizol	
11	Pat Fetterman - Infineum U.S.A.	
12	David Taber,- ConocoPhillips	
13		
14		

ATTACHMENT 3

7B.8, Task Group on Ninety-Cycle Shear Stability (NCSS)
Report to Heavy Duty Engine Oil Classification Panel
7 December 2004

The 90-Cycle Shear Stability Method has been approved and published as ASTM D 7109-04. This version has a preliminary precision statement.

Revision to add a full precision statement will be submitted for the first Subcommittee 7 ballot of 2005, followed by Committee ballot. The Round Robin will be complete in time. Interim analysis of the data submitted to-date is not being circulated to avoid influencing those labs yet to submit. Preliminary analysis suggests precision for the various parameters, compared to other methods, is:

Precision for Kinematic Viscosity is higher than D 445
Precision for Viscosity Loss at 30 Cycles is similar to D 6278
Precision for Viscosity Loss at 90 Cycles is similar to D 7109-04
Precision for HTHS Viscosity is higher than D 4683
Precision for Viscosity Loss at HTHS cannot be compared to previous methods

Respectfully submitted,

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PC-10 Engine Test Matrix Funding, Design, and Oils

ASTM HDEOCP Meeting
December 7, 2004
Tampa, FL

PC-10 Engine Test Matrix

Funding

- **Preliminary plan to fund the PC-10 matrix established at an October 20 meeting**
  - **ACC & API each contribute $1MM in cash**
  - **EMA to provide $350M in cash and >$650M in-kind**
- **Trade association funding ($2.35MM) plus stand calibration testing allows acceptable designs**
  - **Overall cost** — **$4.2MM to $4.5MM**
  - **Stand calibration tests** — **$1.89MM to $2.14MM**
  - **Industry funded tests** — **$2.33MM**
- **Trade associations have confirmed support for the funding plan; draft MOA to be available before the end of the year**

PC-10 Engine Test Matrix

Matrix Design

- **Preliminary designs approved Task Force:**

		Cat C13	Cummis ISB	Mack T-12
Matrix Outputs	Precision	Yes	Yes	Yes
	BOI	Yes	No	No
Number ot Tests		26	14 to 16	14 to 16
Calibration		12	6 to 8	6 to 8
Funded		14	8	8
Number of Stands		7	4	4
Number of Labs		5	2 to 4	2 to 4
Runs / Stand	First Stands	4	4	4
	Second Stands	3	3	3

- **Final matrix selection to be based on additional criteria**
  - **Readiness / willingness of individual labs and stands**
  - **Agreed distribution across labs and test costs to industry**
- **PC-10 MDTF will remain in place to see if additional input is needed**

PC-10 Engine Test Matrix

Oil Selection

- **EMA selected PC-10 prototype two technologies for use in the matrix oils**

- **Base oils complying with BOI-VGRA TF recommendation have been volunteered**

Recommended			
Base Oils & Blends	**1**	**2**	**3**
Targets			
Saturates	MIN	~99%	~99%
Sulfur	0.1 MAX	~0	~0
Viscosity Index	95 - 105	95 - 105	~125
Information			
Finished Oil Vis Grade	15W-40	15W-40	~15W-40
Base Oil Blend KV@100C	5.5 - 7	5.5 - 7	~7
Offered			
Base Oil Slates			
Saturates	84 - 88%	> 99%	~99%
Sulfur	0.11%	< 10 ppm	< 10 ppm
Viscosity Index	~95	~100	125 min

PC-10 Engine Test Matrix

Oil Selection

- **API LC endorsed the following on Dec 1:**
  - Use base stocks offered to blend 6 “15W-40” matrix oils
  - PC-10B & PC-10E (“Base Oil 2”) as featured oils for all new tests
  - Guidelines for blending Technologies with “Base Oil 3”
    - Target the same base oil viscosity (KV100 +/- 0.2 cSt) used to blend with “Base Oils 1 and 2”
    - Maintain nominal SAE 40 finished oil KV100 achieved with “Base Oils 1 and 2”

- **Matrix Oil Key**

	Base Oil 1	Base Oil 2	Base Oil 3
Technology A	PC-10A	PC-10B	PC-10C
	C13	C13, ISB, T12	C13
Technology B	PC-10D	PC-10E	PC-10F
	C13	C13, ISB, T12	C13

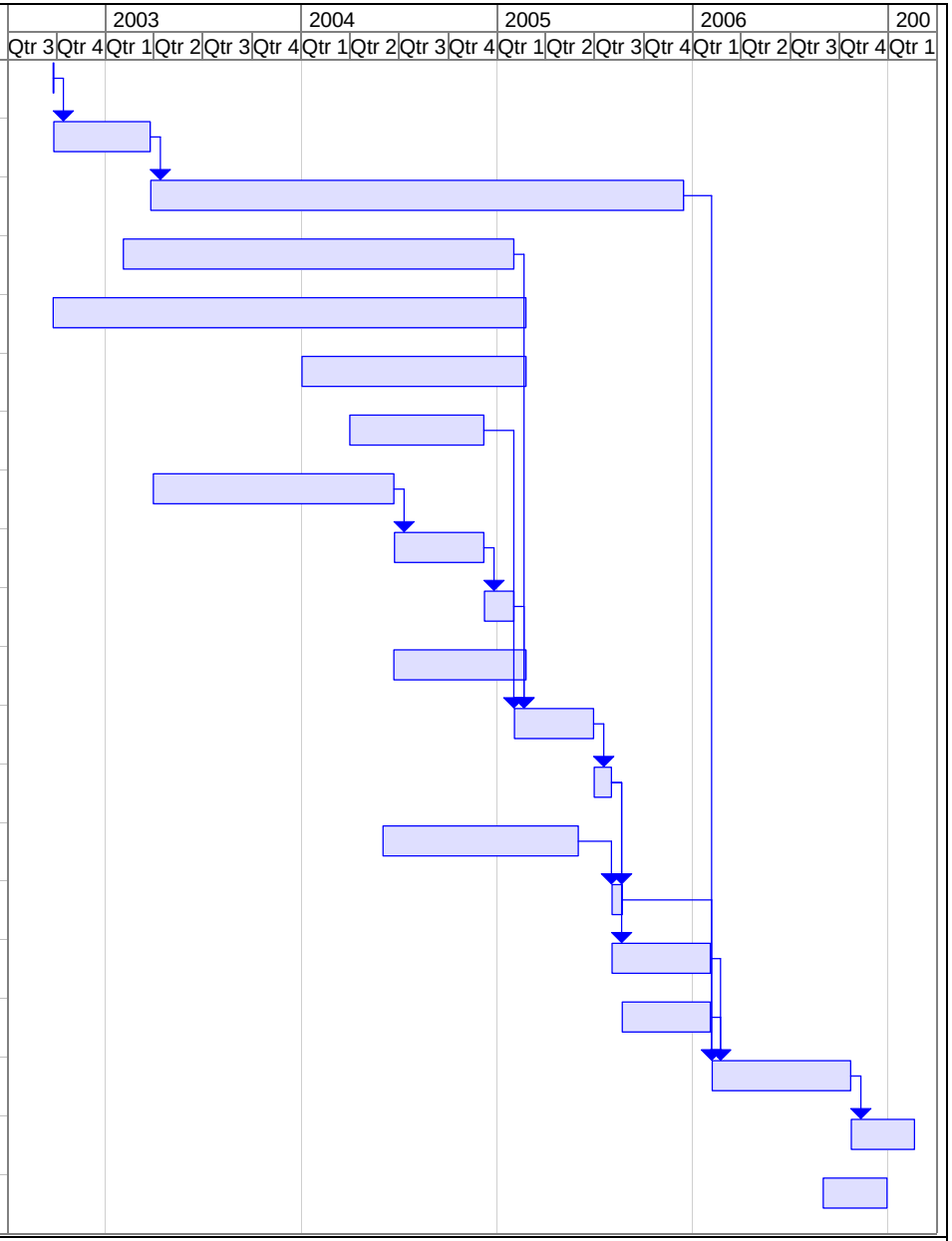
Notes: (1) Cat C13 to use PC-10B & PC-10E as the featured oils
(2) Both PC-10B and PC-10E to be available for ISB & T-12, but only one may be used

PC-10 Engine Test Matrix

Next Steps

- **Draft MOA being prepared by API**
  - **Single document to cover all 3 new tests**
  - **Each test matrix will start when declared ready**
  - **Will include stipulation that BOI for ISB & T-12 is finalized before precision testing can begin**
- **Selection of specific matrix designs**
  - **Will be impacted by the number of labs and stands to be used**
  - **Criteria for participation in precision only matrices will need to be determined**
- **Complete blending of matrix oils**

Task Name
EMA Request
NCET Activity
NCDT Activity
Funding Group
New Test Development
New Test Discrimination
Matrix Design
Chemical Limits Selection
Select Matrix Oils
Matrix Oil Prep
Accept Parameters/Tests
Matrix Testing
Analyze Matrix
Select Reference Oils
HDEOCP Acceptance
Technology Demonstration & Limits Approval
API Lubes Committee Final Approval
Minimum Product Qualification Interval
API Licensing
Engines in Field



Project: PC-10 ACC-1 12072004
Date: Mon 12/6/04

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

ATTACHMENT 6

Cummins ISM Ballot for Advancement Into PC-10 Category

James Mc Geehan
Chairman
ASTM Heavy-Duty Engine Oil Classification Panel

December 7th 2004

Ballot Returns

- 22 Returns in Total
- 3 Negatives
- 19 Affirmatives
  - Six Affirmatives Included Comments

ExxonMobil
Negative

- **We are encouraged by the progress that has been made with the ISM test, and believe that it may be viable for use in the PC-10 category. Our negative is based on a concern with the number of high-soot valve train wear tests currently proposed for PC-10. Since one of the key objectives in HD category development is to avoid redundant performance parameters, we propose a thorough evaluation of the 3 high-soot VTW tests (ISM, ISB, and RFWT) to determine if one or more of these tests could be eliminated without compromising the integrity of the category. If this activity demonstrates that each test can be justified on its own merits, and the full range of 2007 engines would not be adequately protected by using fewer than 3 VTW tests, ExxonMobil will support the use of the ISM, as well as the 2 other high-soot VTW tests, in the PC-10 category.**

Afton Chemical
Negative

- **Afton Chemical supports the Cummins ISM test and the work done by the Cummins Surveillance panel. We believe the test should be included in PC-10 and we encourage the development of correlation data to provide a replacement test for the Cummins M-11 EGR. At this time we have voted negative on the acceptability of the test for inclusion in PC-10 because:**
  1. **An outlier screening method for cross-heads, adjusting screws and top rings has not yet been developed. This method should be consistent with the current M-11 EGR test which uses the 95% confidence level. This will facilitate data analysis.**
  2. **A soot correction should be finalized to allow a better estimate of precision. The soot correction should normalize to a value that prevents extrapolation to higher soot values.**
  3. **The precision of the adjusting screw weight lost parameter needs to be improved if it is to be included in PC-10.**
  4. **The overall acceptability of the test will be enhanced with the addition of the 4 additional reference tests. These tests will also assist in defining the Sludge and Filter plugging parameters.**
- **Afton realizes that the surveillance panel is in the process of addressing these issues. When our comments have been addressed we will change our vote to affirmative for inclusion of the ISM in PC-10 .**

BP
Negative

- It is accepted that the data presented to the HDEOCP shows the ability of the ISM to differentiate oils with adequate precision on wear, however, we do not feel that there is sufficient discrimination or repeatability shown in the oil filter plugging at this time to include this parameter.

Chevron Oronite Company

Affirmative

- **Chevron Oronite approves with some reservations. The ISM taskforce state the following: *It is the opinion of the ISM Development Task Force and the Cummins Surveillance Panel that the ISM test does show the ability to differentiate oils with acceptable precision on wear and filter plugging, however items such as soot correction, outlier screening, correlation to M11 EGR, and the actual OFDP calculation still need to be finalized.***
- **A number of details must be resolved before this test will be fully acceptable.**

1. While discrimination between TMC830 and TMC1004 has been demonstrated, the scale is very compressed. We believe that the task force needs to focus efforts on minimizing any impact of operational and hardware variability.

2. The details on assessment of the OFDP need to be finalized.

3. The ISM test does not show discrimination on sludge . An alternative measurement should be considered .

4. The ISM does not discriminate on TRWL. This factor may be assessed in other tests, such as T12. Given the inability of the ISM to discriminate on this measure, we recommend focusing efforts elsewhere.

ChevronTexaco
Affirmative

- Based on the work to date we vote affirmative on advancing the ISM to PC-10 category.
- However, we are concerned that there is insufficient separation on filter delta P and lack of sludge data reported in presentation. In addition, wear data is required at 6% soot where the limits are to be set. Nevertheless, our understanding is four more tests are in progress which we hope will resolve these issues before matrix testing.

Infineum
Affirmative

- **Infineum is voting positive on the ISM status as being ready to move forward for consideration as one of the possible tests for PC-10. However, we have not yet seen sufficient data in either the ISM or the ISB to convince us that both tests will be required to protect against valve train wear. We reserve the right to accept only one of the two proposed valve train wear tests into PC-10, should later data show that both the ISM and the ISB rank oil performance in the same way. In addition, although the ISM does seem to separate oils 830-2 and 1004-3 with statistical significance on some parameters, we are concerned that the absolute levels of separation are very small and that additional testing may degrade the test statistics to the point that these oils no longer separate. Finally, we are concerned that the ISM reverses the M11-EGR ratings of oils 830-2 and ISMA – especially with respect to injector screw weight loss where ISMA looks very much like 1004. The data currently in hand do not seem to show the test can discriminate between a "good" ISMA and a "bad" 1004.**

Lubrizol
Affirmative

- Lubrizol votes affirmative on advancing the ISM for possible inclusion in the PC-10 category. Lubrizol agrees with the recommendations of the ISM Development Task Force that items such as soot correction, outlier screening, correlation to the M11 EGR, and OFDP calculations still need to be finalized. We are committed to work with the ISM Development Task Force to resolve these issues.
- Some of the wear parameters in the ISM may be highly correlated to one another. We would anticipate that redundant wear parameters within the test would be dropped.
- We recommend that consideration be given to inclusion of one of the low SAPS PC-10 matrix oils into the ISM referencing system. A goal of our referencing process is to use current technology. A low SAPS oil with less than 0.12 % wt phos would be appropriate for a test that includes wear parameters.

Citgo Petroleum Corporation

Affirmative

- **Based on the information presented, we CITGO support advancing the ISM test for inclusion in the PC-10 category.**

Jim Mc Geehan • ChevronTexaco

Shell
Affirmative

- **Shell votes affirmative to advance the ISM test for inclusion into PC-10, subject to successful completion of the "Next Steps" by mid-January in the attached ISM report.**

Jim Mc Geehan • ChevronTexaco

Affirmative

- Volvo Powertrain/Mack Division
- International Truck & Engine Co
- Cummins Inc.
- DDC
- Deere & Company
- GM

Affirmative-No Comments

- Ciba Speciality Chemicals
- ConocoPhillips
- Metro Tech Systems LTD
- PerkinElmer
- RohMax USA Inc.
- Valvoline Company.
- Safety -Kleen

Jim Mc Geehan • ChevronTexaco

Status of ISM Test Development

D M Stehouwer

To HDEOCP

December 7, 2004

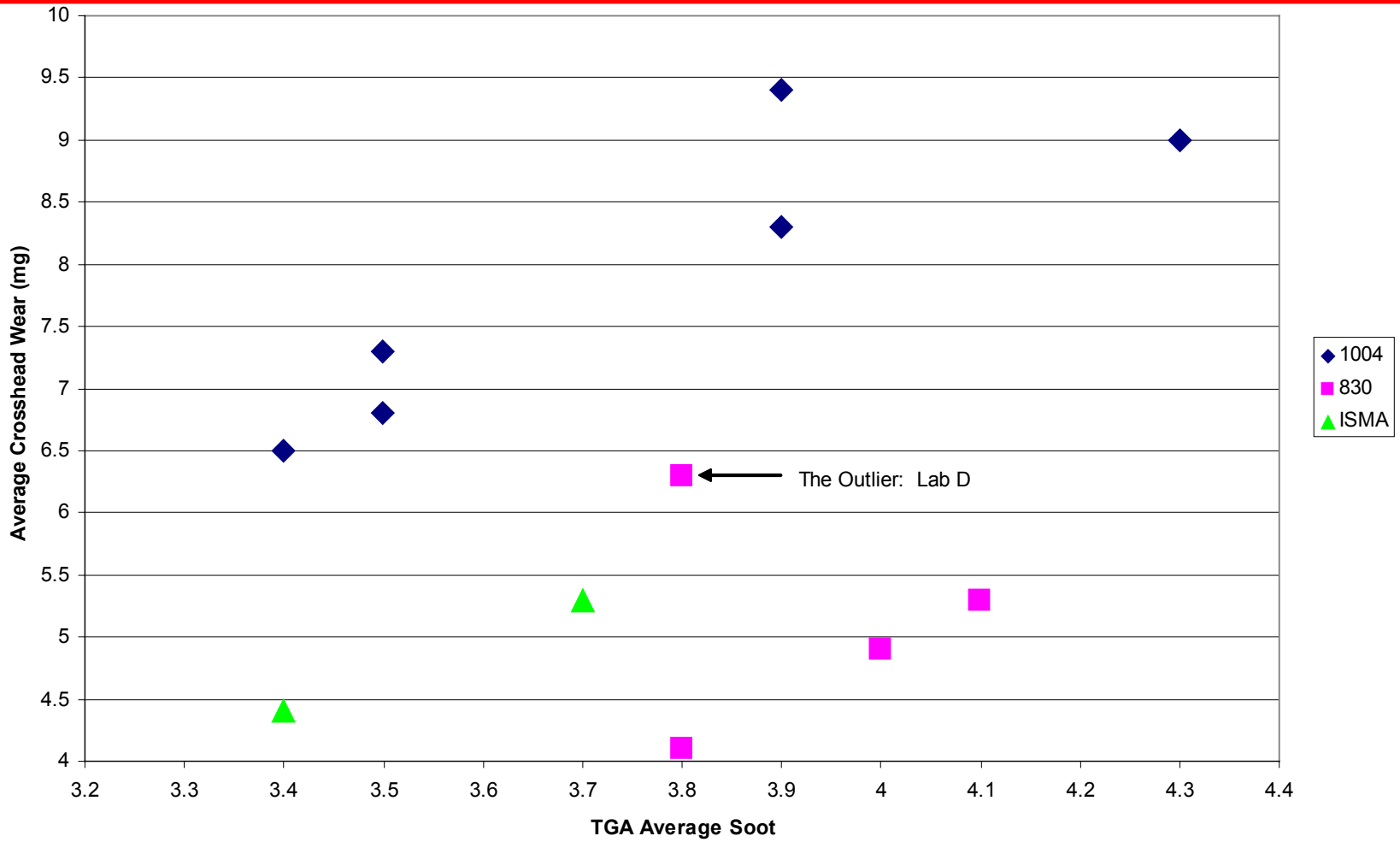
Conclusions from Surveillance Panel

- **Is ISM test ready for PC 10 carry-forward?**
  - **Statistical analysis from 12 test matrix complete**
    - **Test does discriminate between oils**
      - **Crosshead Weight Loss**
        - » **soot correction needed**
      - **Filter plugging (modified calculation)**
      - **Sludge (rater calibrations)**
    - **Precision is good**
- **Is ISM ready to set limits for M11 EGR?**
  - **Crosshead Weight Loss**
    - **soot correction needed**
  - **Filter plugging (modified calculation)**
  - **Sludge (rater calibrations)**

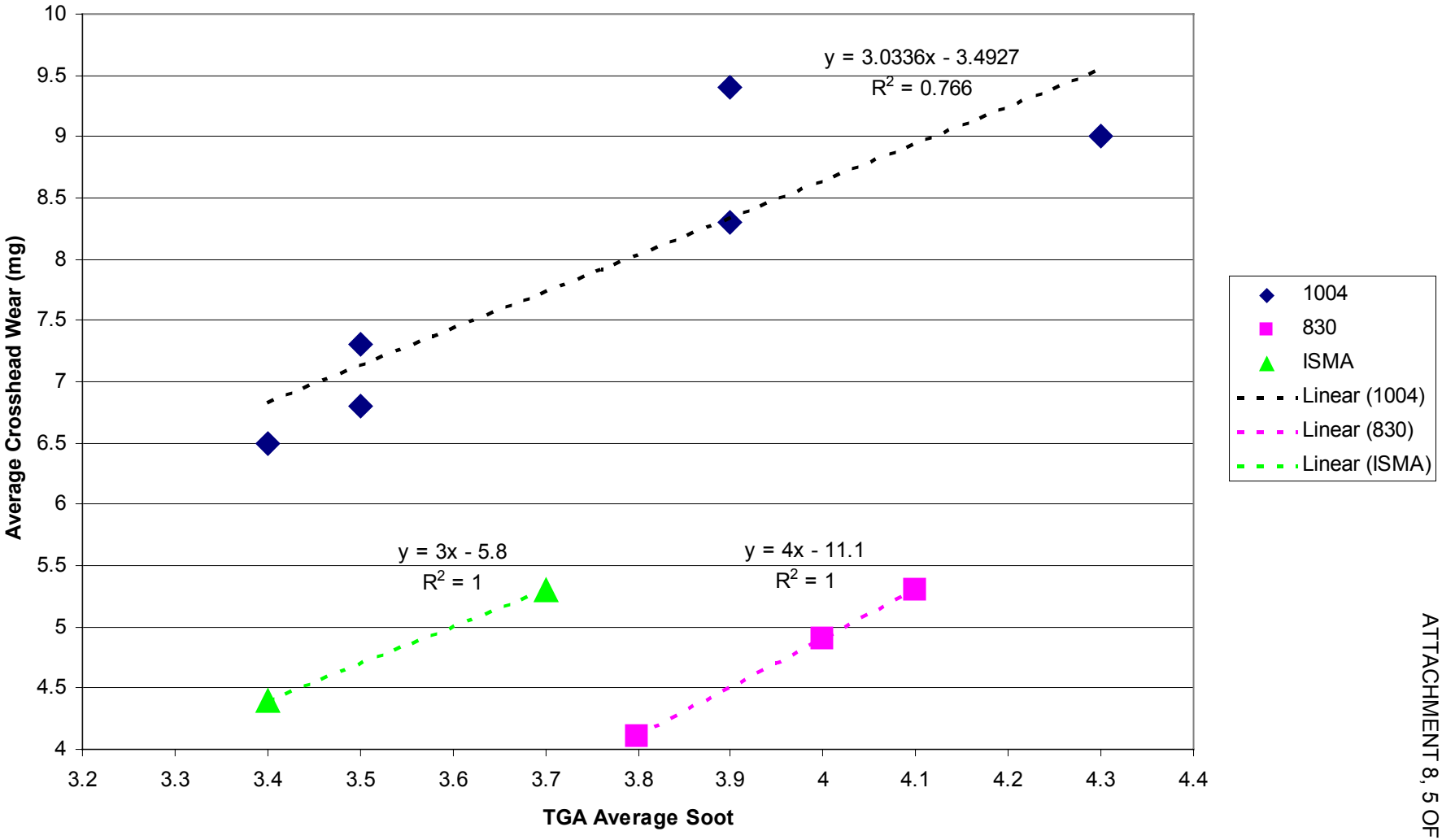
Recommendation

- **It is the opinion of the ISM Development Task Force and the Cummins Surveillance Panel that the ISM test does show the ability to differentiate oils with acceptable precision on wear and filter plugging, however items such as soot correction, outlier screening, correlation to M11 EGR, and the actual OFDP calculation still need to be finalized.**
- **Passed by unanimous vote of Cummins Surveillance Panel / ISM Task Force**

ISM Matrix Average Crosshead Wear as a Function of Soot



ISM Matrix Average Crosshead Wear as a Function of Soot
Outlier Lab Removed

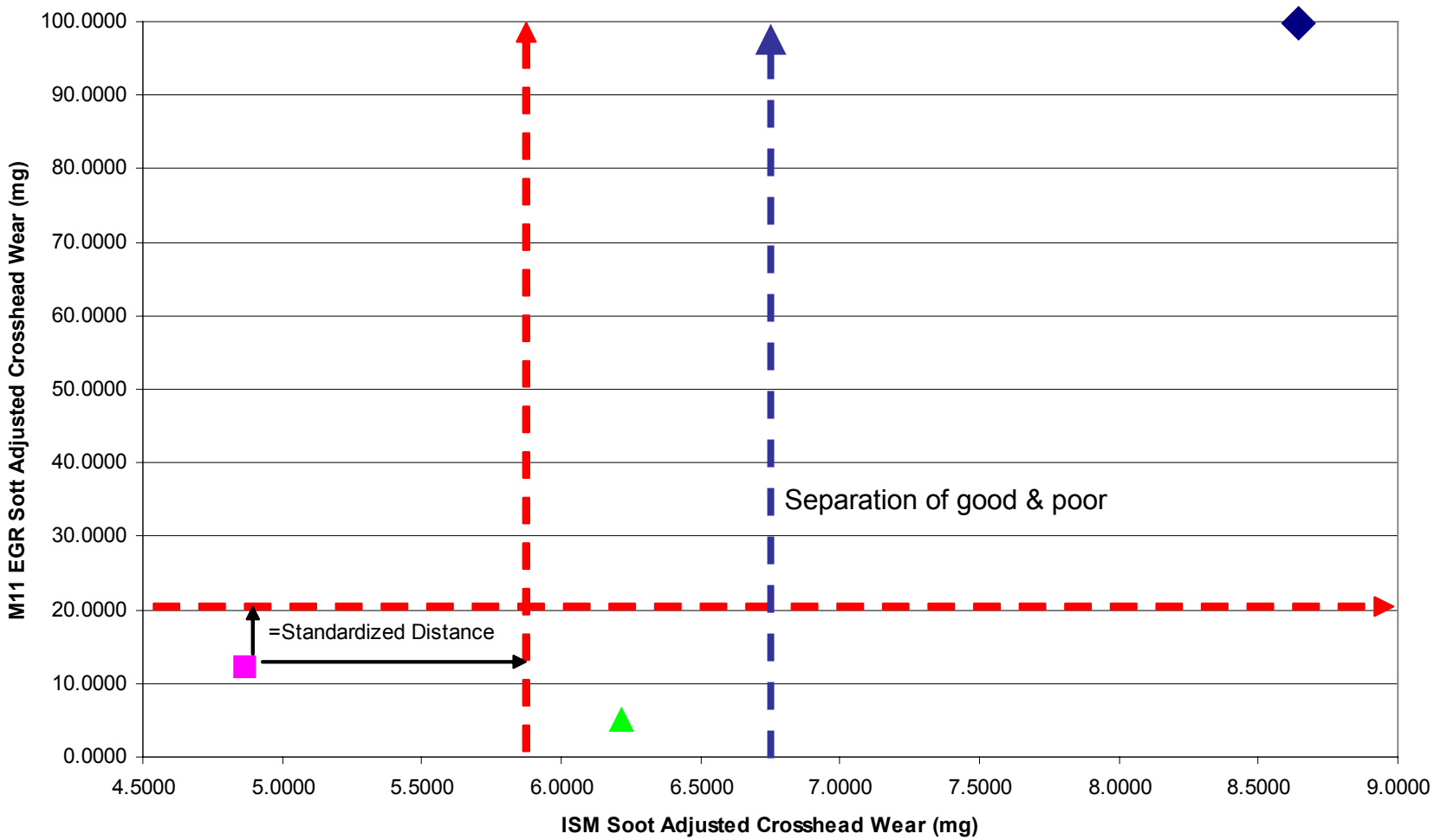


Cross Head Weight Loss

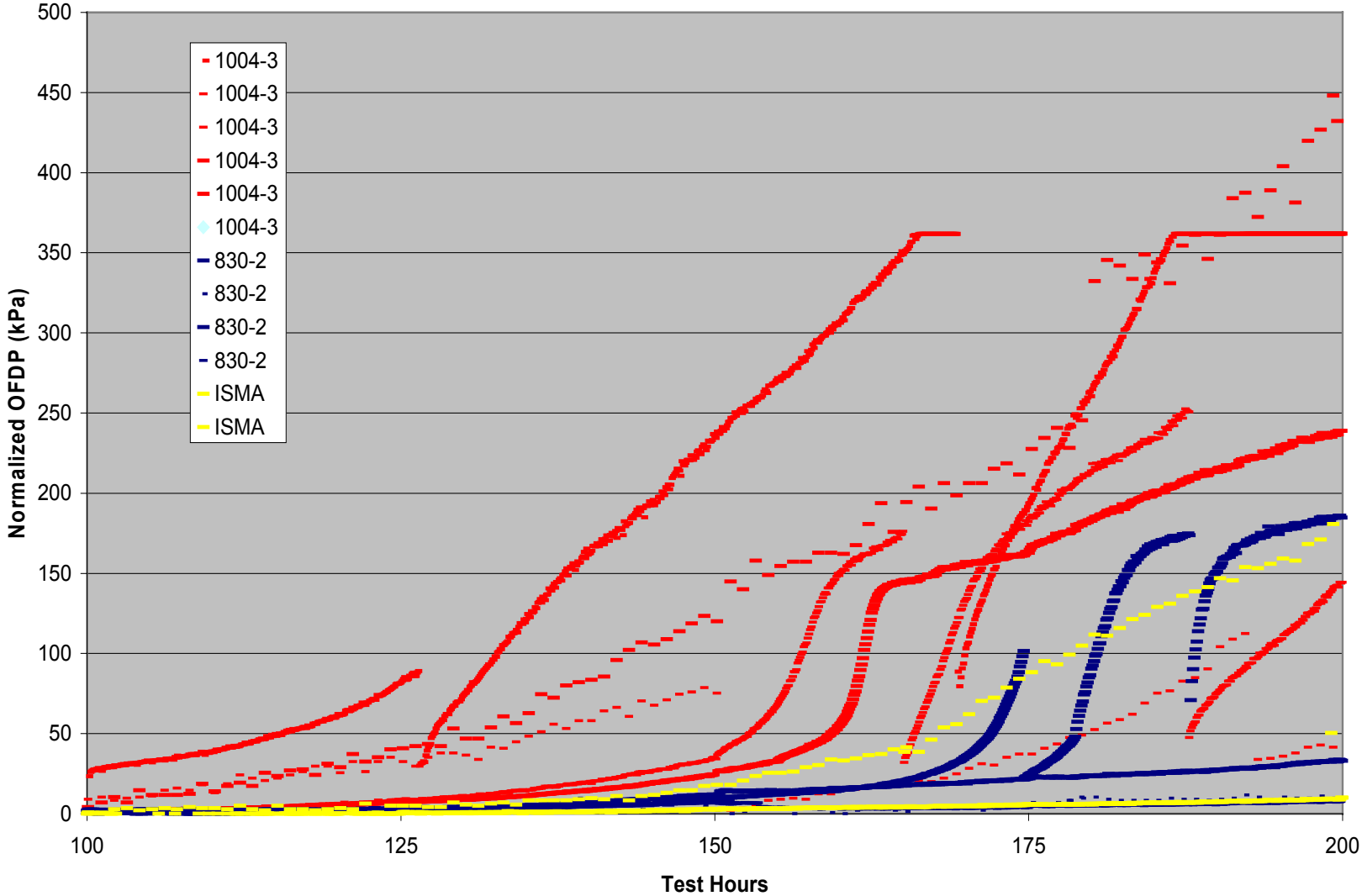
- **Model Fit: CWL=f(Lab, Oil, Average Soot)**
  - **No Lab Differences**
    - **Lab G 0.84 Mild if Fit Procedure Change Instead of Soot**
  - **All 3 Oils Statistically Significantly Different**
  - **CWL Increases 3.0332 per 1% Avg Soot**

Crosshead Weight Loss			
	Oil 1004	Oil 830	Oil ISMA
LS Mean @ 4% Soot	8.6385	4.8680	6.3605
Mean @ 4% Soot	8.6416	4.8678	6.2149
StdDev @ 4% Soot	0.5784	0.1477	0.0070
Mean @ New Soot	8.9000	4.7667	***6.8767***
StdDev @ New Soot	0.5568	0.6110	NA
M11 EGR Target	99.8000	12.2000	5.1000

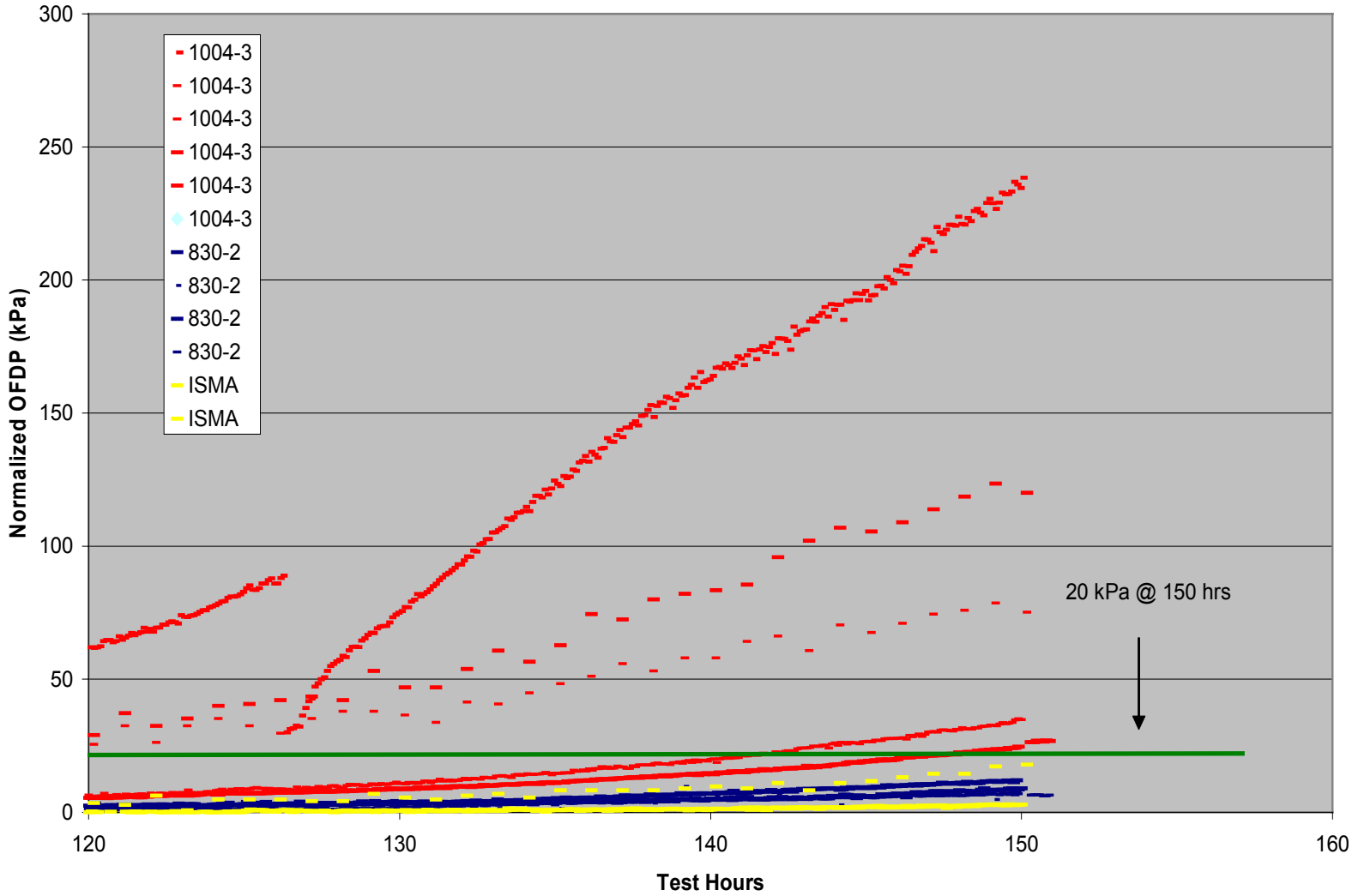
M11 EGR Crosshead Wear as a Function of ISM Crosshead Wear
Oil Averages



OFDP

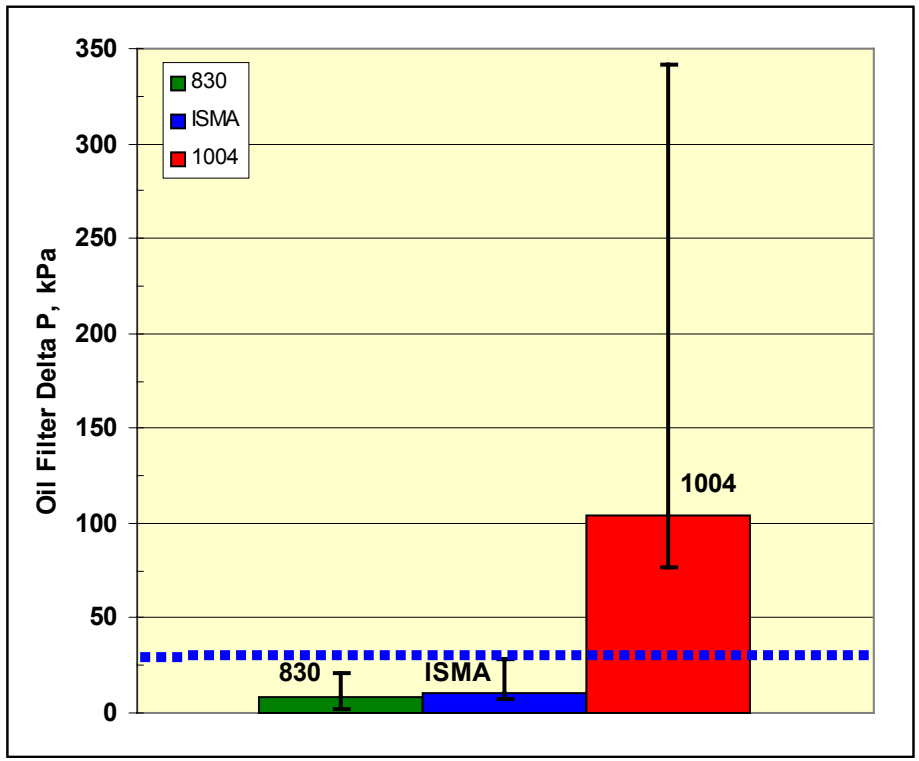

1004-3
1004-3
1004-3
1004-3
1004-3
1004-3
830-2
830-2
830-2
830-2
ISMA
ISMA
Normalized OFDP (kPa)
500
450
400
350
300
250
200
150
100
50
0
100
125
150
175
200
Test Hours

OFDP


1004-3
1004-3
1004-3
1004-3
1004-3
1004-3
830-2
830-2
830-2
830-2
ISMA
ISMA
Normalized OFDP (kPa)
300
250
200
150
100
50
0
120
130
140
150
160
Test Hours
20 kPa @ 150 hrs

ISM Oil Filter Delta P
(Uncorrected)

- Data at EOT is too scattered
- Consider using OFDP @ 150 hrs
- Uncorrected data shows clear discrimination



Surveillance Panel Actions

- By mid-January
- Run an additional 4 tests on 830-2 at the current test conditions (6.5% soot targeted)
  - In progress @ 4 labs

- Upon completion of the tests review the data and determine preliminary soot correction for crossheads and other parameters were applicable, evaluate 150-hr OFDP, and review sludge ratings.

Issues

- **ISM correlation with M11-EGR**
- **ISM Test inclusion in PC-10**
  - **Issue before HDEOCP today**

Recommendation

- **In view of the finding "of the ISM Development Task Force and the Cummins Surveillance Panel that the ISM test does show the ability to differentiate oils with acceptable precision on wear and filter plugging," the ISM test should be advanced for inclusion in the PC-10 category.**

Next Steps

- Re-do statistics
  - Agreed upon outlier rejection criteria
  - Soot corrections
  - OFDP revised calculations
    - i.e. @ 150 hrs.
  - 4 more reference runs
- Target to have data by mid-January
- Proposed CI-4 limits relate 830 values & St Dev from M11 EGR limits
- PC-10
  - CHWL, ASWL
  - OFDP
  - Sludge
  - TRWL
  - Used Oil Properties
  - Merit system ?

ISB Status

- Four Test Mini Matrix in progress
- Finish runs and analyze data for Dec ASTM meeting

Mack T12 Engine Test Update

December 7th 2004

- Mack T-12
- Based on Mack T10 & Mack T11
- With ULSD Fuel
- Length - ~ 300 Hours
- Two Phase Test
- Phase 1 100 hr (4.0 % Soot)
- Phase 2 200 hr (EOT of 6 % Soot
- Phase 2 260 F Oil Temp
- Increased EGR Flow (Heavy EGR)
(35% Phase 1 – 15-% Phase 2)
- Precision Matrix Required

•Hardware (External)

•Same as T10 Except – VGT Turbo replaces
small T10 Turbo
2 Production EGR Coolers (Breadboard) Replaces Tube Cooler- 3 ?
EGR on/off Valve

•Hardware (Internal)
T11 Power Cylinder (T10 Top Ring) & T11 Heads
New Nozzles & Spray Angle

– T12 Conversion Kits Sent to Labs

•T12 TASK FORCE – Numerous Teleconferences, Oct 20 Mtg in San Antonio – Meeting Nov 22nd @ ExxonMobil- Next Mtg Jan 12th in San Antonio

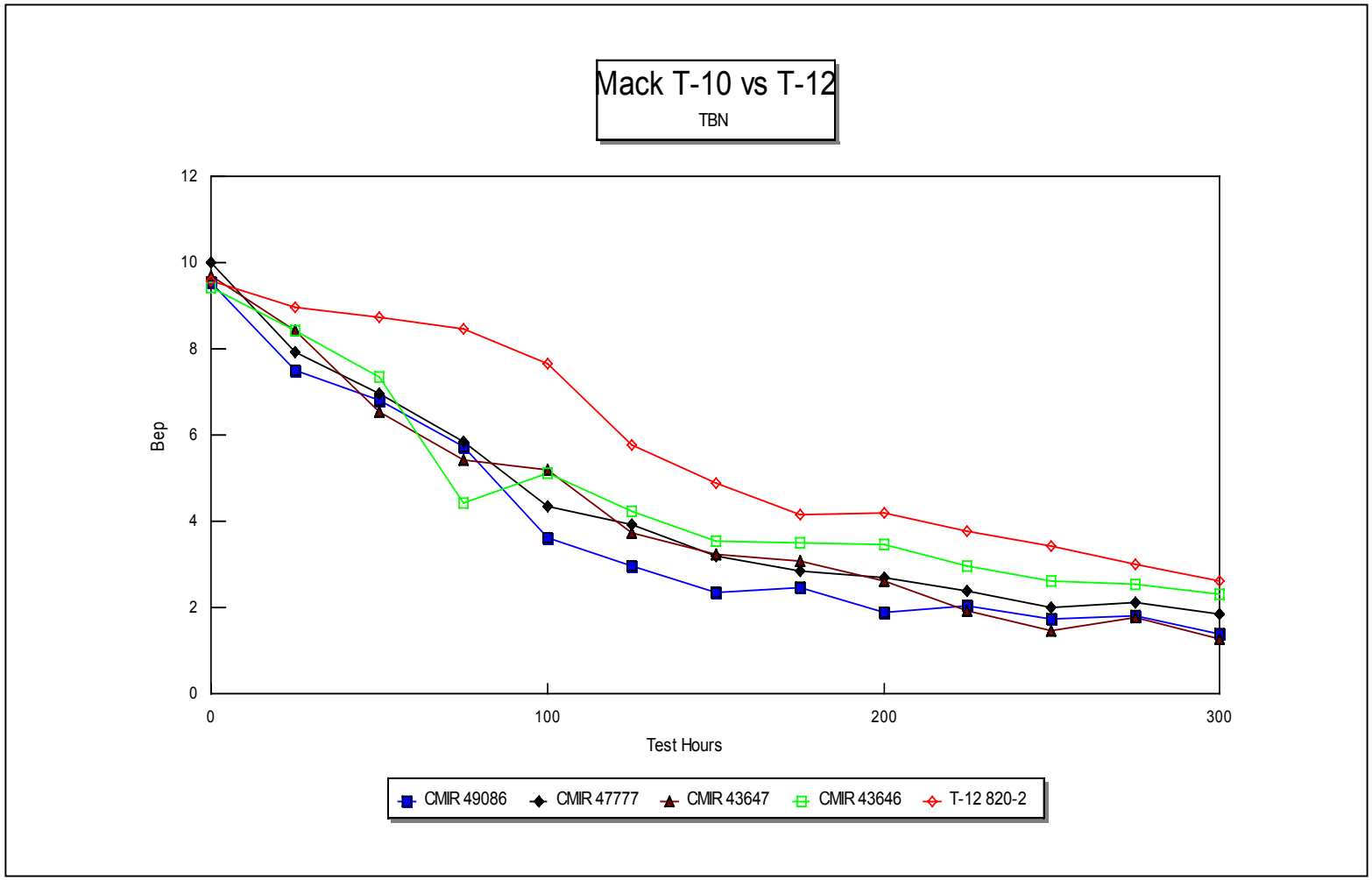
•Test Procedure Available, T12 Parts List Completed

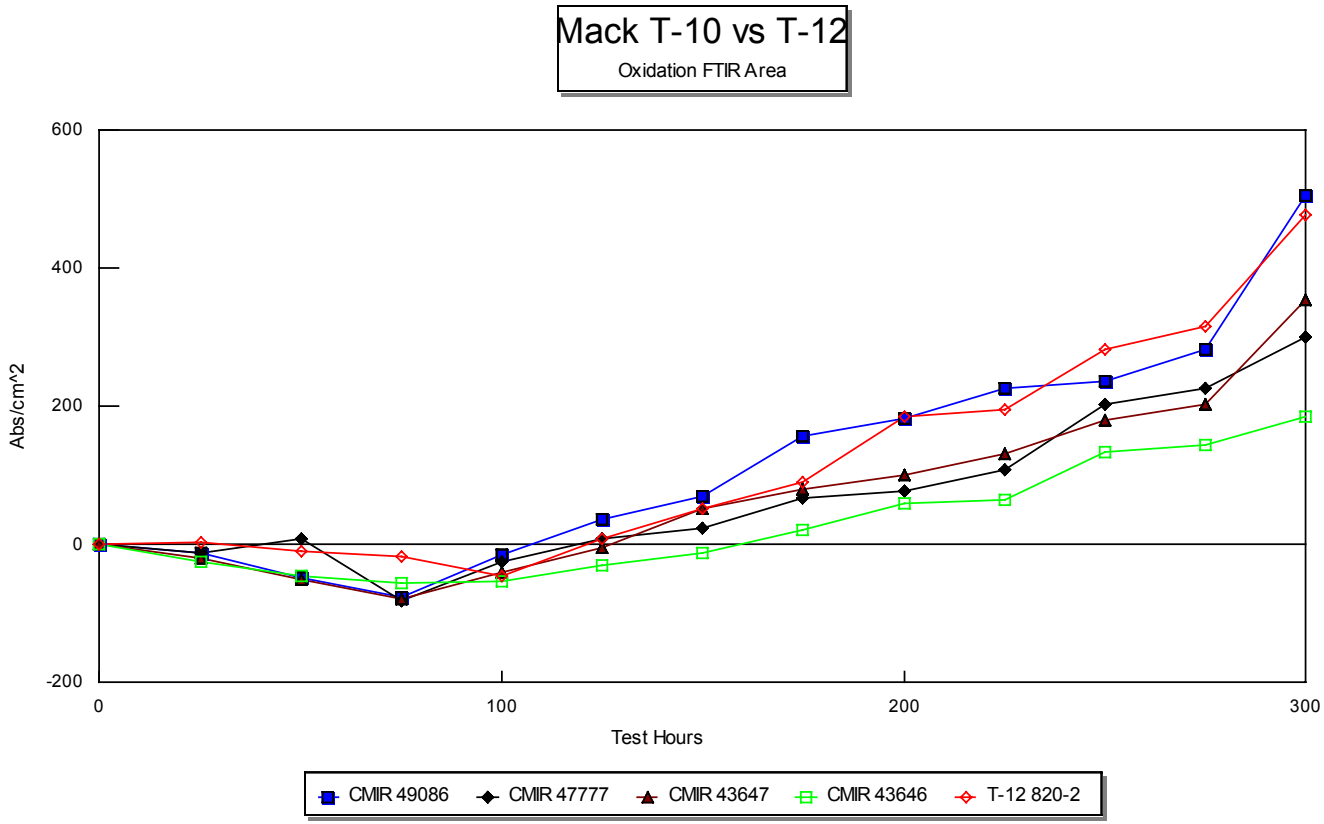
•Completed Test on 820-2 (T10 Ref Oil) , 2nd Test to Complete Mid November

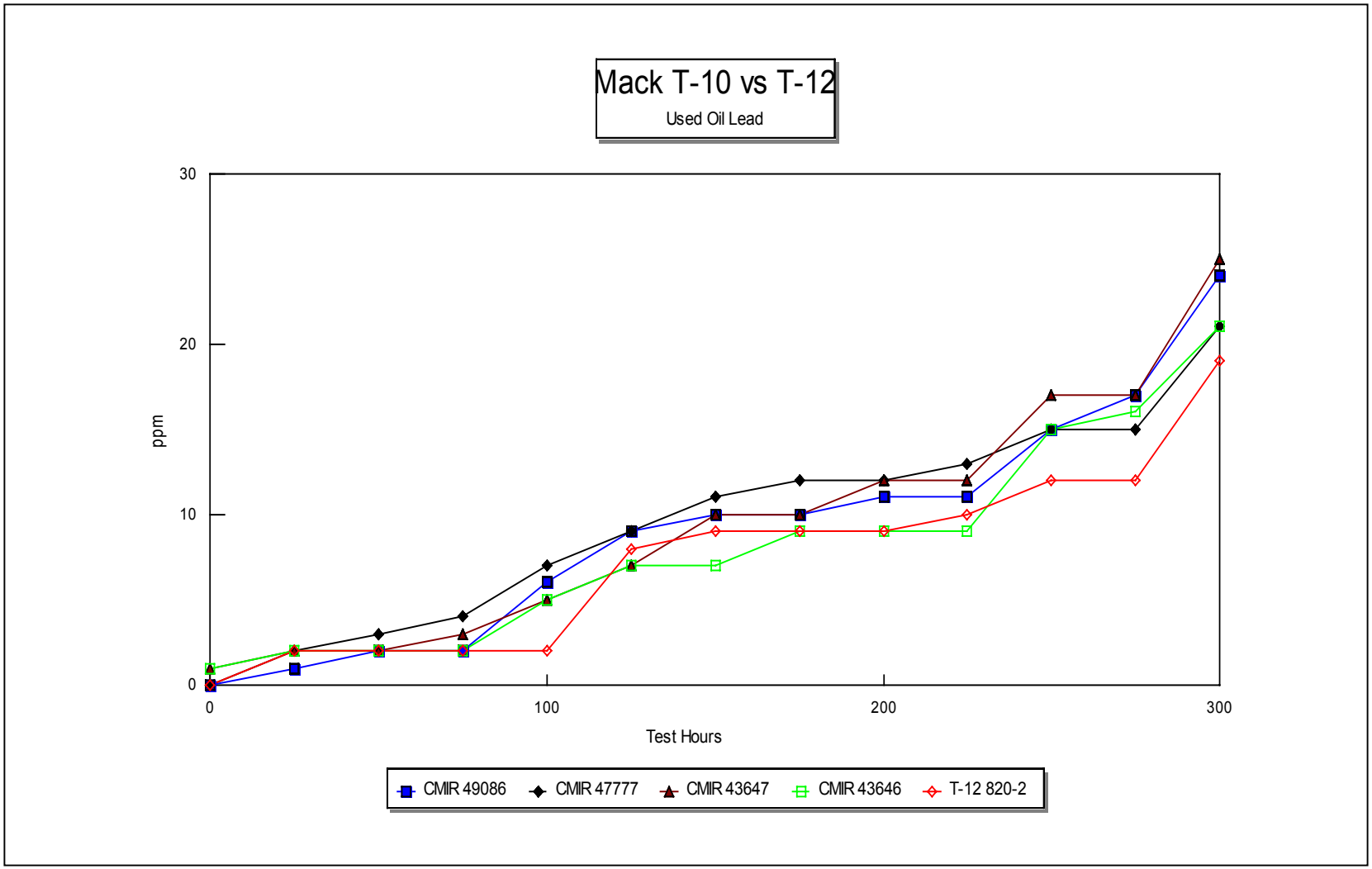
•6 Engines in 4 Labs Running week of Dec 6th

•Task Force Recommends the use of dyed PC 10 ULSD

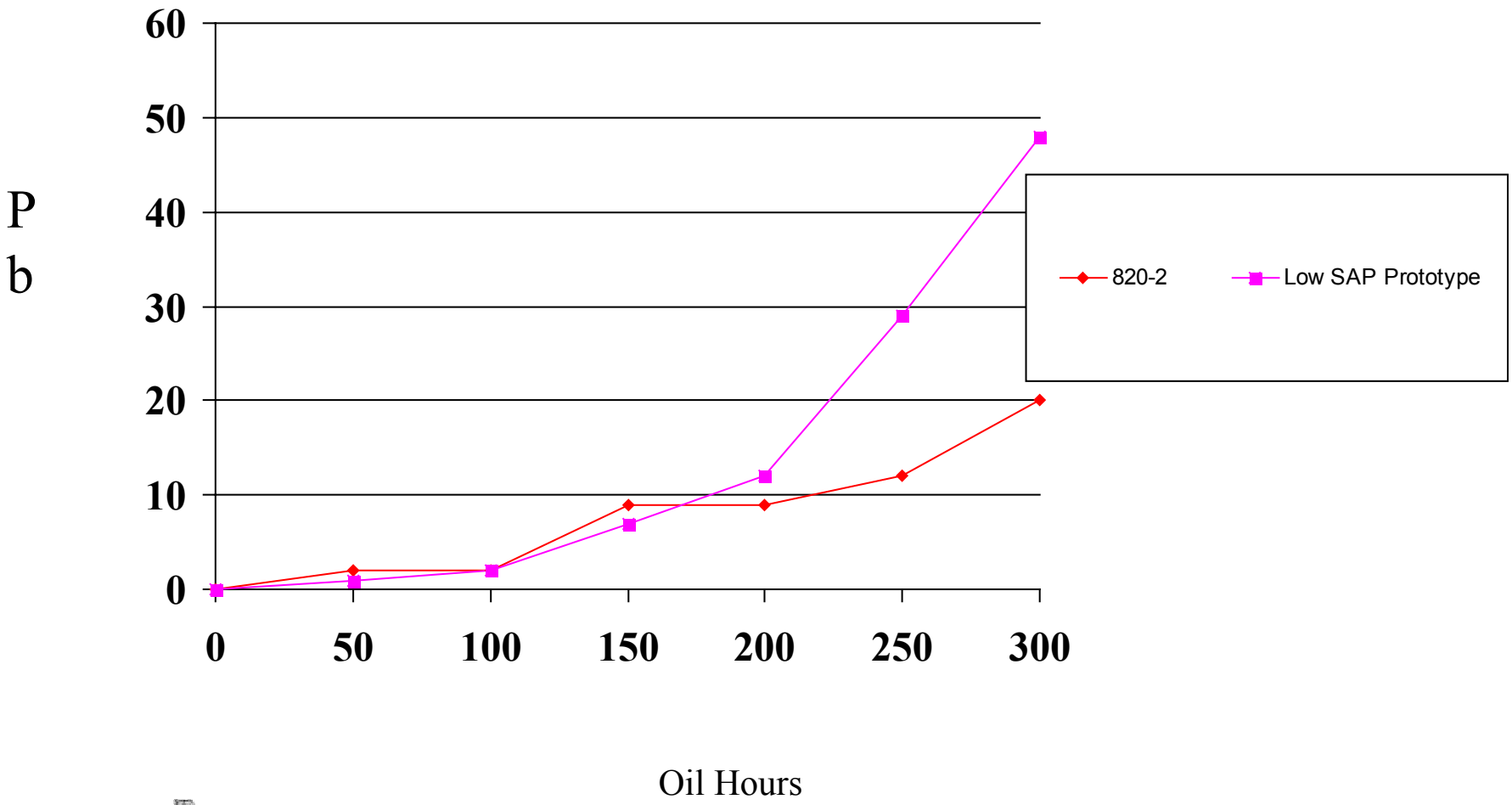
•Task Force Recommends 820-2 Should be Part of Precision Matrix



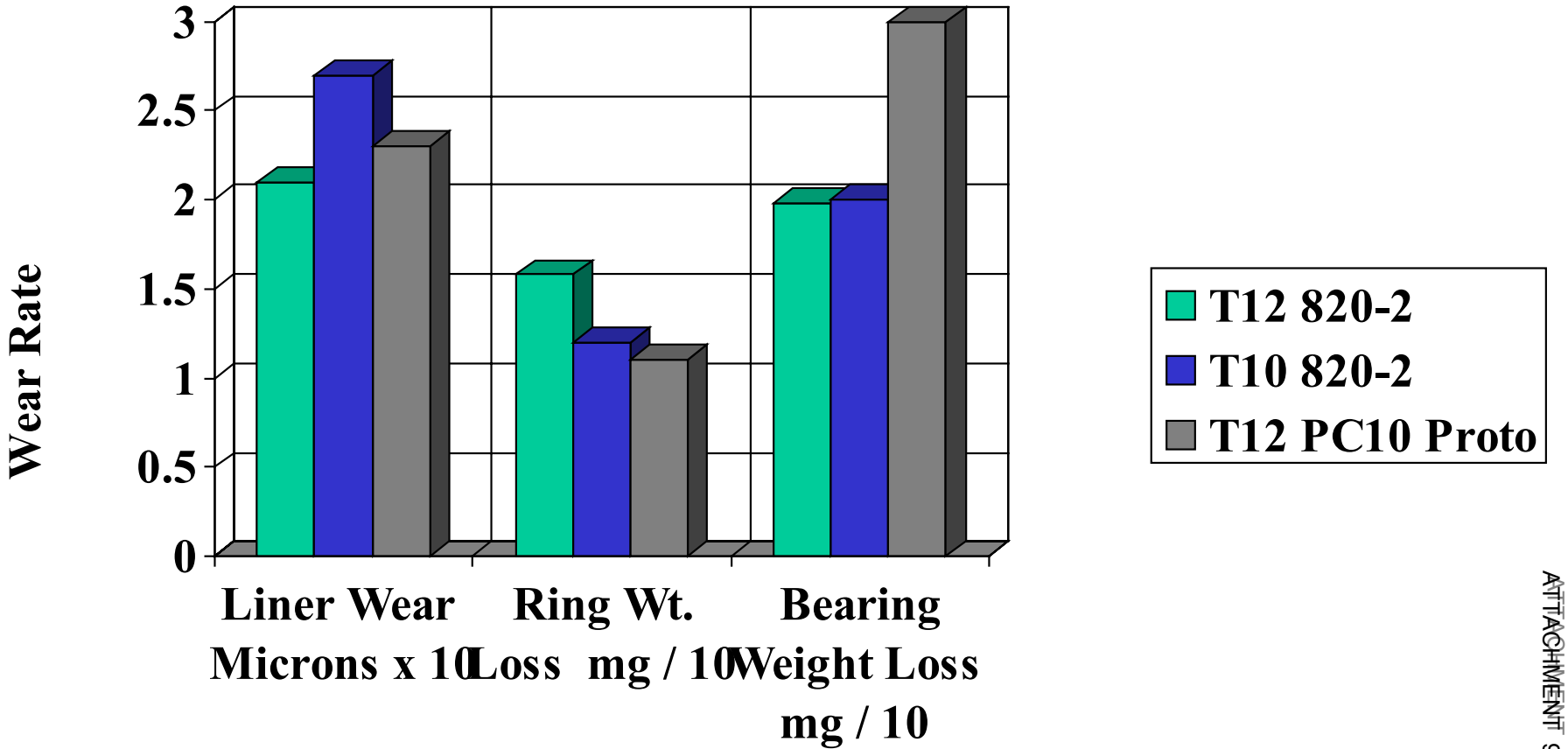

Mack T-10 vs T-12
Oxidation FTIR Area
600
400
200
0
-200
Abs/cm^2
0
100
200
300
Test Hours
CMIR 49086
CMIR 47777
CMIR 43647
CMIR 43646
T-12 820-2


Mack T-10 vs T-12
Used Oil Lead
30
20
10
0
ppm
0
100
200
300
Test Hours
CMIR 49086
CMIR 47777
CMIR 43647
CMIR 43646
T-12 820-2

T12 Pb (ppm) Discrimination



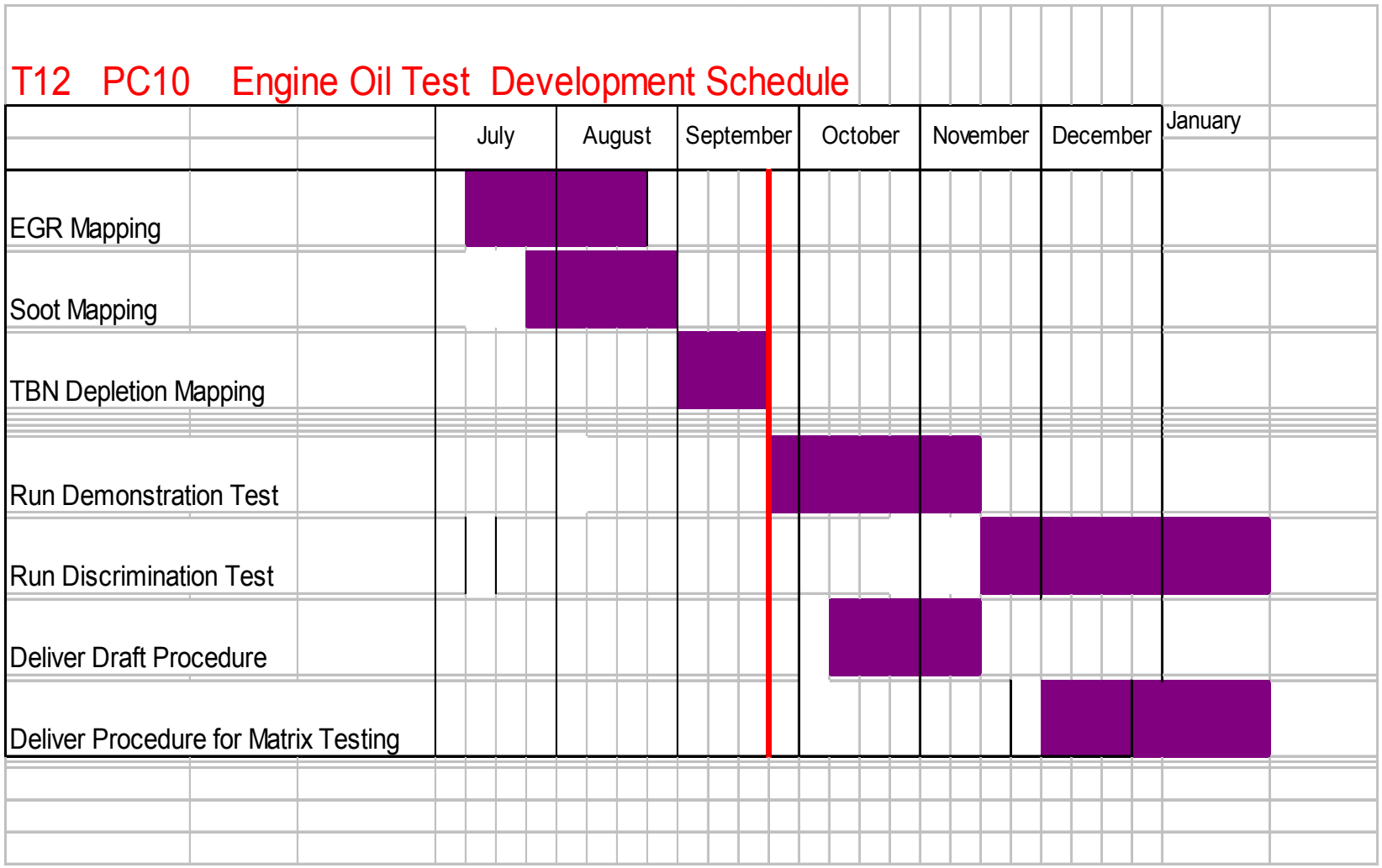
Wear / T12 vs. T10 820-2
T12-820-2 vs. PC10 Prototype



GLS 12/06/04

ATTACHMENT 9, 8 OF 9

T12 PC10 Engine Oil Test Development Schedule



Caterpillar C13 Test Criteria

500 hour – Steady State Test Cycle

Test Pass/Fail Criteria:

- No Loss of Oil Consumption Control <20% or lower? (based on average of EOT vs SOT)
- Last 150 hours stable Oil Consumption
- No stuck rings/Loss of ring side clearance




CATERPILLAR®

Caterpillar C13 Mini-matrix Test Status

- C13 Test engines installed – 13
- C13 Test engines Completed to date - 20
- Six test Mini-matrix with:
  - ULSDF, No CCV, Same Conditions,
  - Close tolerance Production Liners, Piston and Rings supplied to all labs
  - New Low Ref Oil
  - New High Ref Oil
- Complete tests by end Dec '04




Caterpillar C13 Test Update

6 more C13 tests running/planned –

- 3 Low Ref
- 3 High Ref oils

One High Ref test showed low loss of oil consumption at 300 hrs.

Two Low Ref tests showed loss oil consumption control.




Caterpillar C13 Test Update

No CCV, ULSDF Tests

Oil	Test Hours	Oil Cons Inc
Ref Oil #A	200	11.0
Ref Oil #A	350	37.4
Ref Oil #A		
Ref Oil #D	300	10.1
Ref Oil #D		
Ref Oil #D		




Cat Single vs Multi- Cylinder

- 1P and C13 needed for PC-10
- 1K/1N supportable but not at expense of 1P
- 1P covers 1K/1N due to greater severity (Afton, Oronite data confirm this)




Cat Single vs Multi- Cylinder Avg. Temperatures (°C)

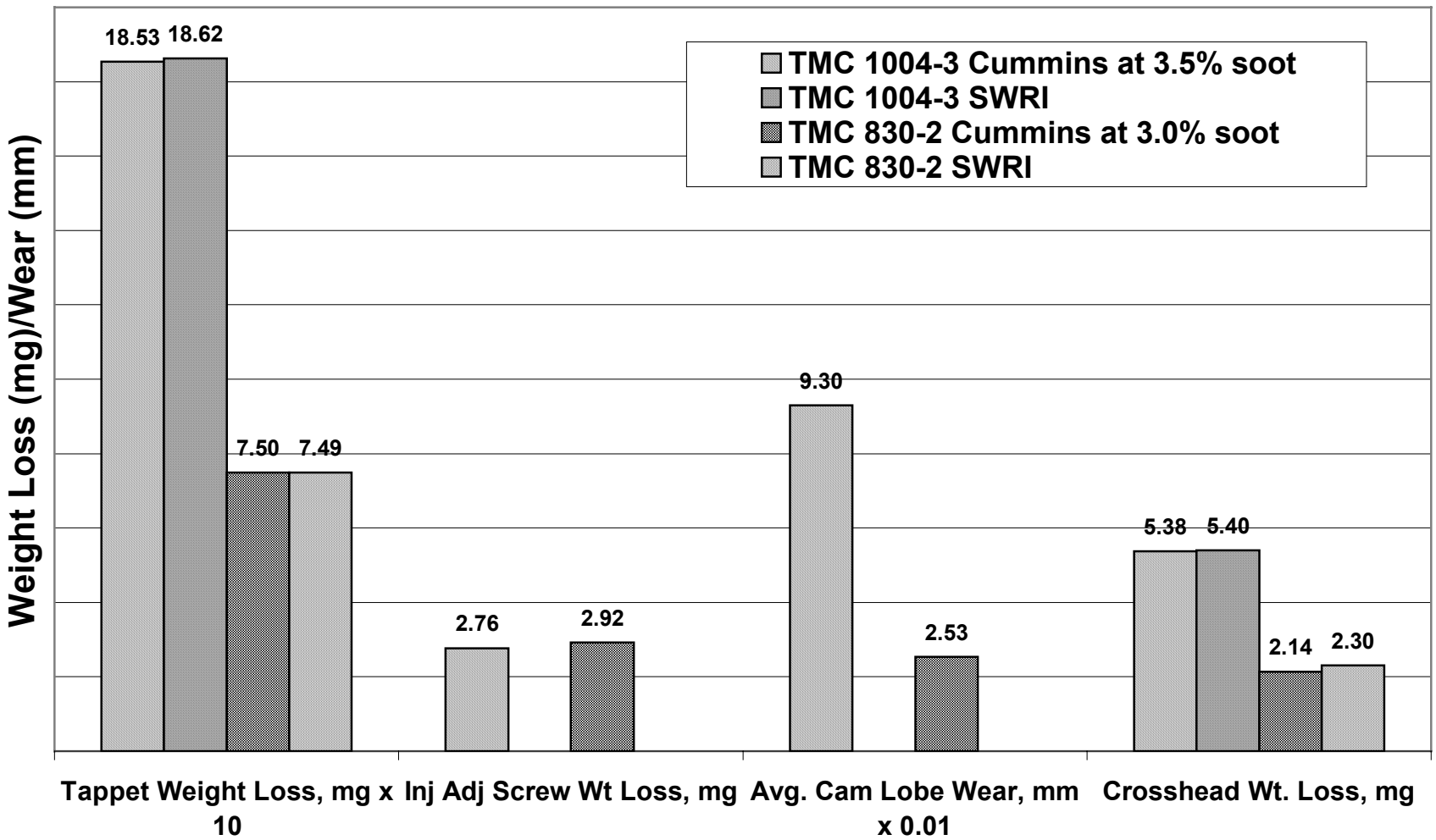
	TL	TG	2L	2G	3L	3G	Oil
1N	365	310	260	230	150	130	107
1P	283	231	171	154	142	148	130
C13	237	184	148	132	127	124	105




ISB Status

- Two Tests at SWRI complete
  - Data correlates verrry well with Cummins AEI data
  - Discrimination is very good
- Two tests at PE in progress
- Data complete by mid January

ISB Mini-Matrix



Piston Temperature Profile
CAT-1P & C13

James McCord

November 11,2004

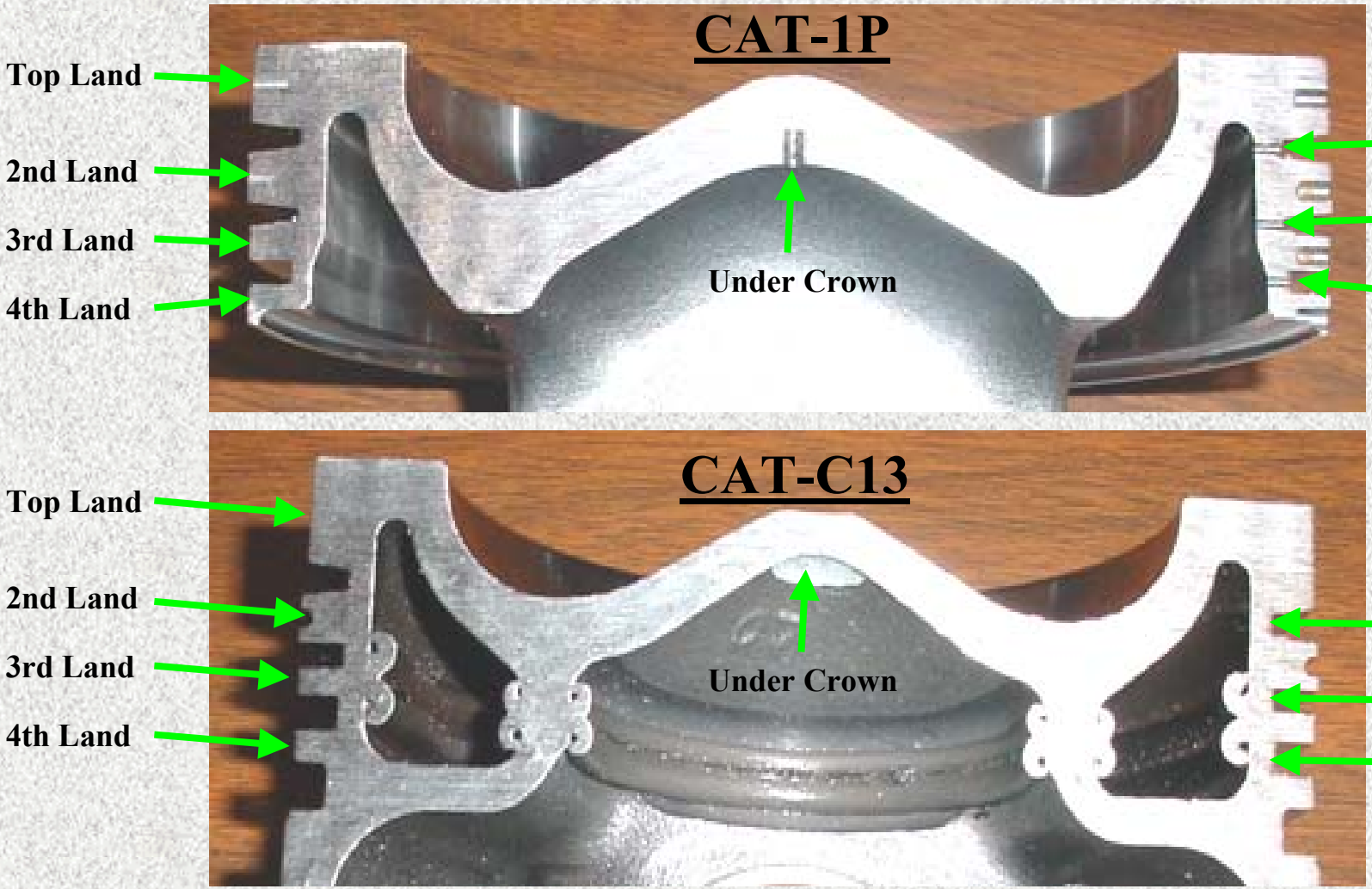
Piston Temperature Profile

- Standard operating conditions (as per current procedure)
- Both test were performed on calibrated stands
- 4 hour duration
- Six C13 pistons were equipped with 29 plugs each
- One CAT-1P piston was equipped with 29 plugs
- Four plugs were installed per land/groove location (Front, Rear, Thrust, and Anti-thrust) and one plug in the under crown.
- Depending on piston location, M3-2 or M1.6-2 plugs were utilized (see photo for plug locations)
- Optimum accuracy of method: +/- 6 C

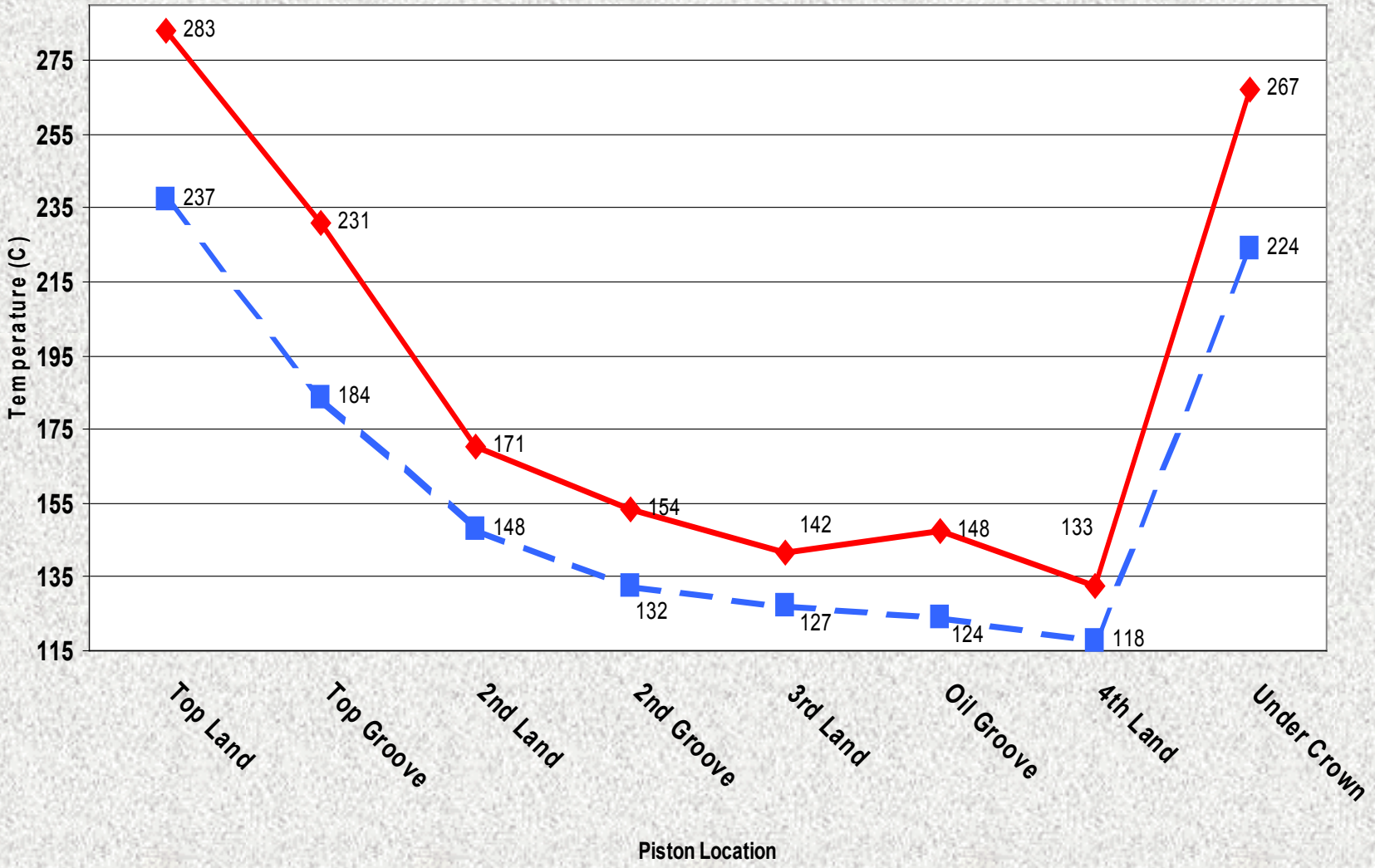
CAT-1P & C13
Operation Conditions

Operational Parameters	CAT C13	CAT 1P
Test Duration (hrs)	4	4
Engine Speed (rpm)	1800	1800
Fuel Flow (g/min)	1200	185
Coolant Out Temperature (C)	88	90
Intake Manifold Temperature (C)	40	60
Exhaust Manifold Temperature (C)	670	490
Oil Gallery Temperature (C)	105	130
Fuel Temperature (C)	40	42
Intake Manifold Pressure (kPa-g)	280	173

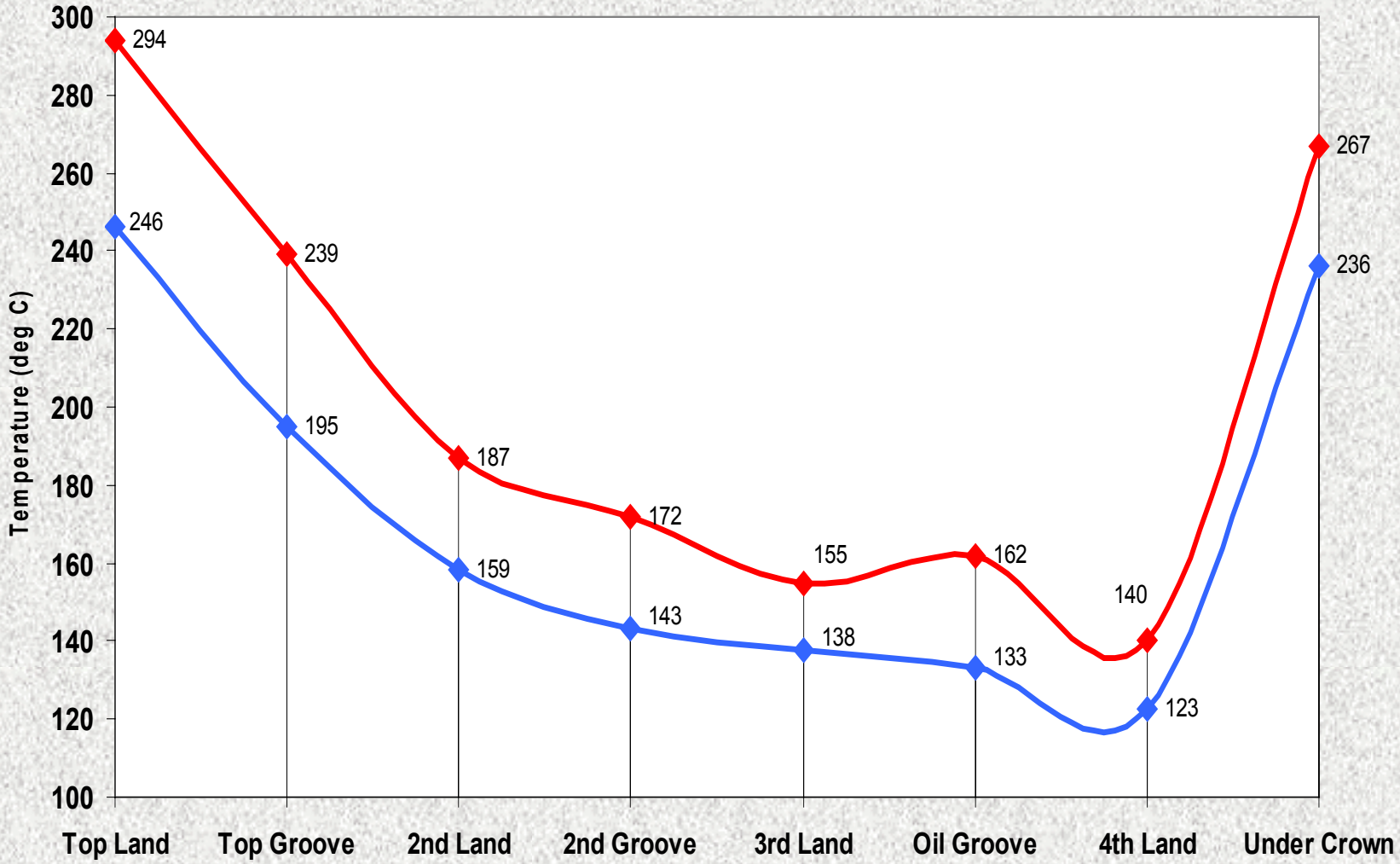
Templug Locations



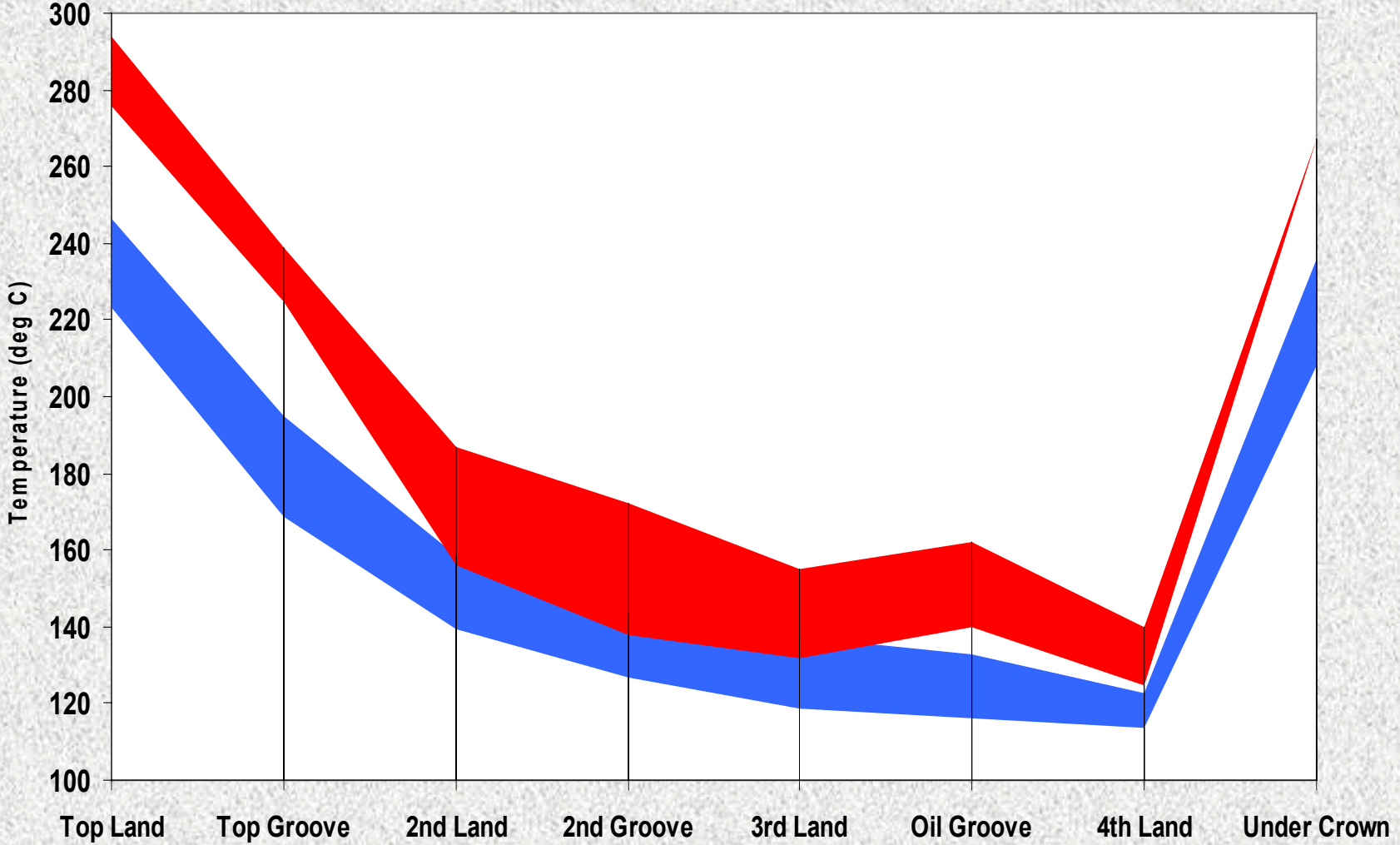
Average Temperature Profile
CAT-1P & CAT-C13



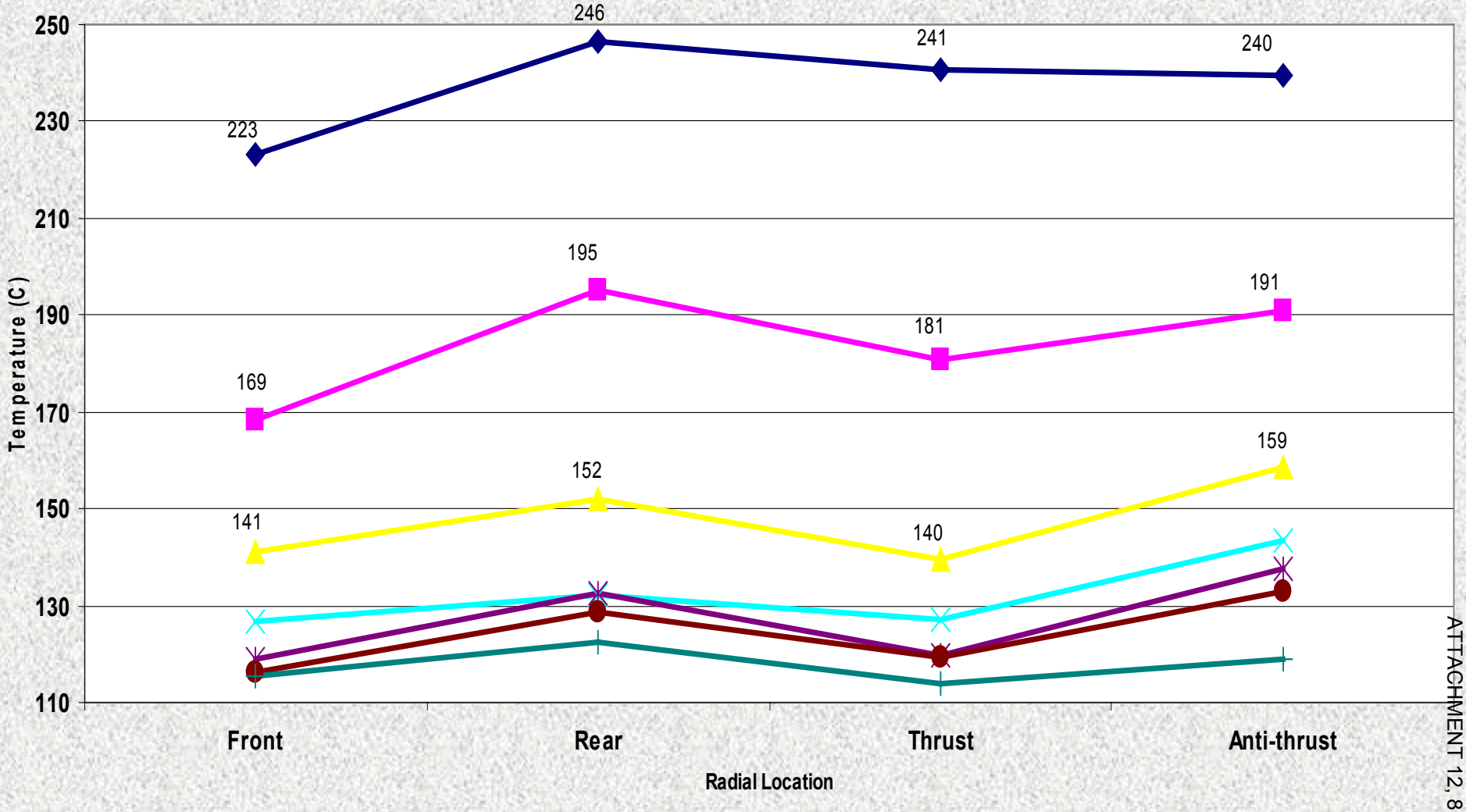
Maximum Temperature Profile
CAT-1P & CAT-C13



Min/Max Temperature Profile
CAT-1P & CAT-C13



CAT C13 Piston Temperature
(average of six pistons)



CAT-1P
Temperature Data

CAT 1P						
Piston 1		Front	Rear	Thrust	Anti-thrust	Plug Type
Top Land	Deg C	279	283	276	294	M3 #2
Top Groove	Deg C	231	225	228	239	M1.6 #2
2nd Land	Deg C	172	167	156	187	M3 #2
2nd Groove	Deg C	172	138	142	162	M1.6 #2
3rd Land	Deg C	142	132	138	155	M3 #2
3rd Groove	Deg C	140	145	143	162	M1.6 #2
4th Land	Deg C	140	125	128	138	M3 #2
Under Crown	Deg C	267				M3 #2

CAT-C13
Temperature Data

CAT C13 (6-piston avg.)						
Piston Location		Front	Rear	Thrust	Anti-thrust	*Average*
Top Land	Temp C	223	246	241	240	*237*
Top Groove		169	195	181	191	*184*
2nd Land		141	152	140	159	*148*
2nd Groove		127	132	127	143	*132*
3rd Land		119	133	120	138	*127*
3rd Groove		116	129	119	133	*124*
4th Land		115	123	114	119	*118*
Under Crown		224				*224*

Engine Piston Temperatures

	TL	TG	2L	2G	3L	3G	Oil
1N	365	310	260	230	150	130	107
1P	283	231	171	154	142	148	130
C13	237	184	148	132	127	124	105

Average Temperatures - Degrees C

Engine Manufacturers Association

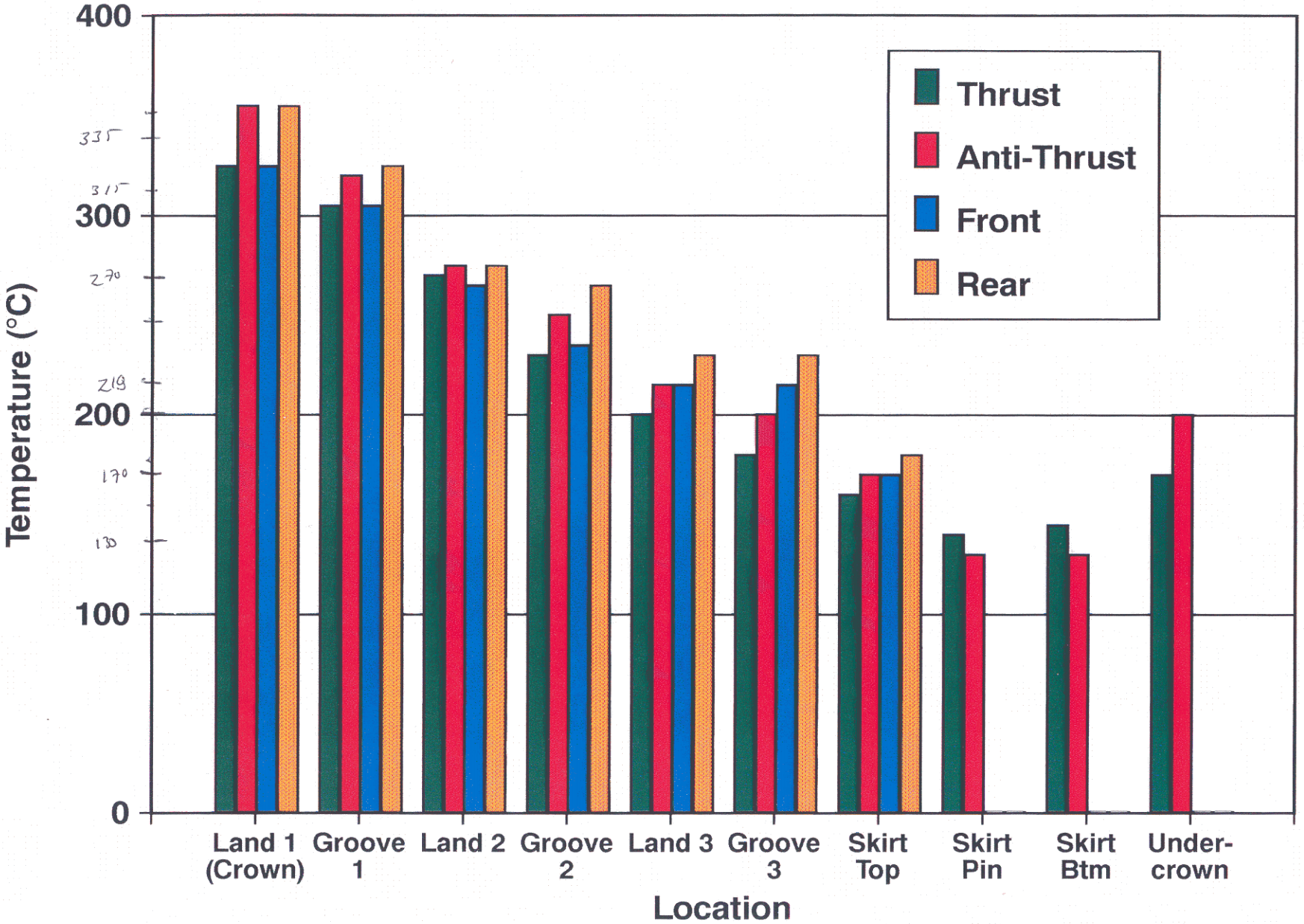
PC-10 Engine Tests

- EMA does not have consensus on the inclusion of the 1P in place of the 1N CAT tests in category
  - C13 – Multi Cylinder (colder combustion)
  - 1N – Aluminum Piston (higher temperature)
  - 1P – Legacy Product with Steel Piston
- EMA will provide aluminum piston temperatures at the January 13 meeting
- EMA requests addition industry data regarding 1N versus 1P test for January 13 meeting

Engine Manufacturers Association

CATERPILLAR 1K PISTON TEMPERATURES

MEASURED USING FUSIBLE SENTINELS



9599-07

ATTACHMENT 14

PC-10 Update

James Mc Geehan
Chairman
ASTM Heavy-Duty Engine Oil Classification Panel

November 2004

PC-10 Performance Requirement

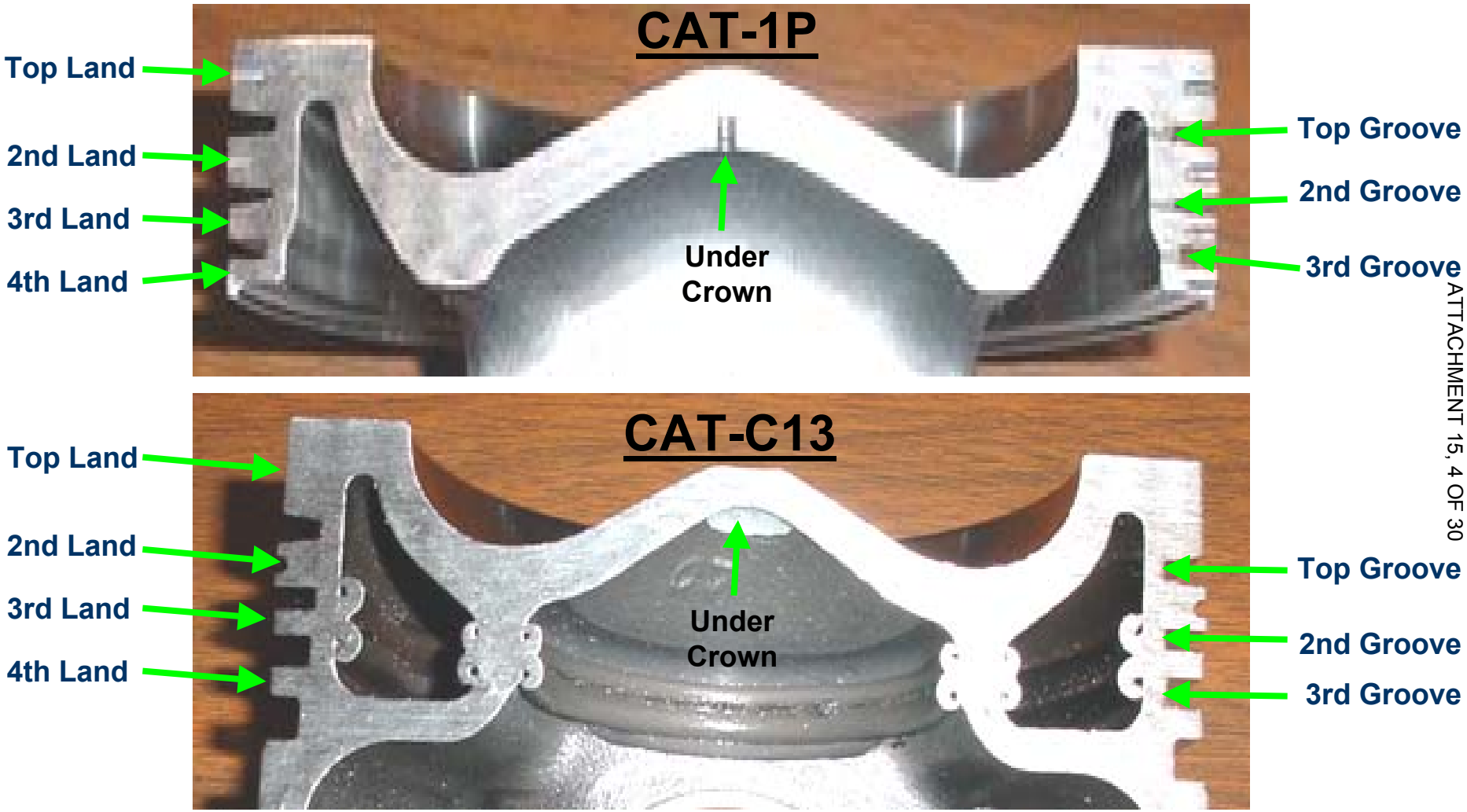
Performance Criteria	Fuel Sulfur, Wt %	Test	PC-10 2006
Aluminum Piston Deposits, Oil Consumption	0.05	Caterpillar 1N	X
Viscosity Increase Due to Soot at 6.0%	0.05	Mack T-11	X
Roller-Follower Valve Train Wear	0.05	GM 6.5-Liter PC – Diesel	X
Aeration	0.05	Navistar HEUI 7.3-Liter EOAT	X
Foam	–	Bench Test Sequence I, II, III	X
Volatility	–	Noack D 5800 or Distillation D 2887	X
Used Oil Viscometrics at Low Temperature	–	J300 Bench Tests MRV TP-1 Soot	X
Elastomer Compatibility		D-471, Ref. Oils	X
High Temperature/High Shear		Bosch Injector	X
Valve Train Wear, Filter ΔP and Sludge	.05	Cummins ISM	X
Valve Train Wear	15 ppm	Cummins ISB	X
Oil Consumption and Piston Deposit	15 ppm	Caterpillar C-13	X
Ring, Liner Bearing Wear & Oil Consumption	15 ppm	MackT-12	X
Oil Oxidation	0.10	See III G (or III F)	X
Shear Stability – 90 Cycles	–	Bosch Injector ASTM D 3945	X
Total Number of Engine and Bench Tests			*15*

Yet to Be Decided

Engine Test Decisions Yet to Be Made

- **Alternatives:**
  - **Caterpillar in Aluminum Piston (Cat IN) and Caterpillar IP Forged Steel Piston (Single-Cylinder Tests)**
  - **Gasoline Tests IIIF (API CI-4) or IIIG (ILSAC GF-4) or Neither**
  - **Mack T-12 and Caterpillar C13 for Oil Oxidation Only**

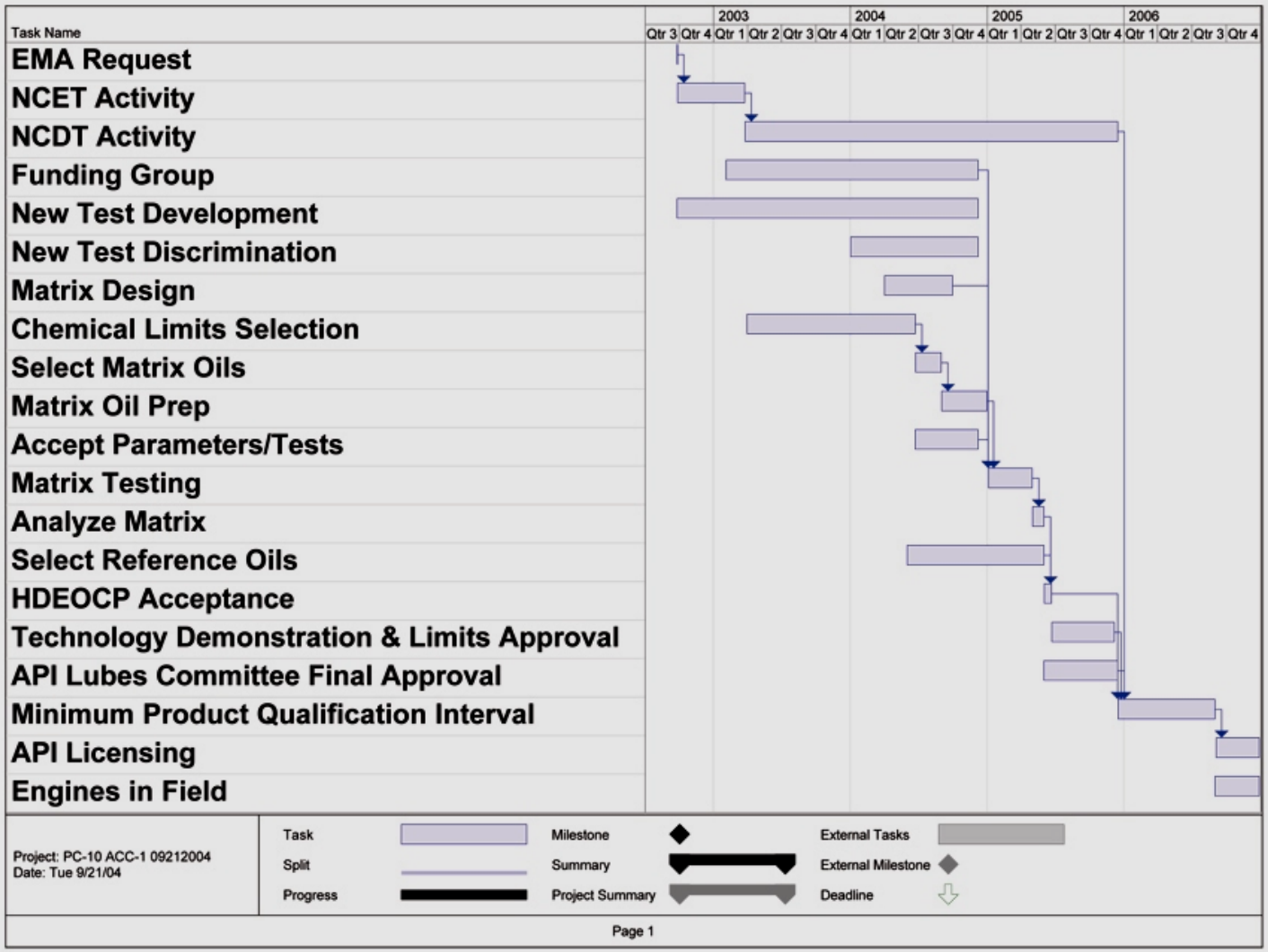
Cat IP Temperatures Higher Than Cat 13



Engine Oil Matrix for PC-10 Test

- Precision Only for Cummins ISB and Mack T-12
- Precision and Base Oil Interchange (BOI) for Cat C-13 Only
- Total Matrix Cost = $ 4.2 Million
- Base Oils Selected: API Group I, II and III

PC-10 Program Timing



Timing

- Plan Was to Select Engines for Matrix by December 7, 2004
- Due to Status of Cummins ISB, Mack T-12 and Caterpillar C13 Test Selection Moved to February 2005
- Licensing Potentially Moved to September 2006 Instead of June 2006

Mack T12

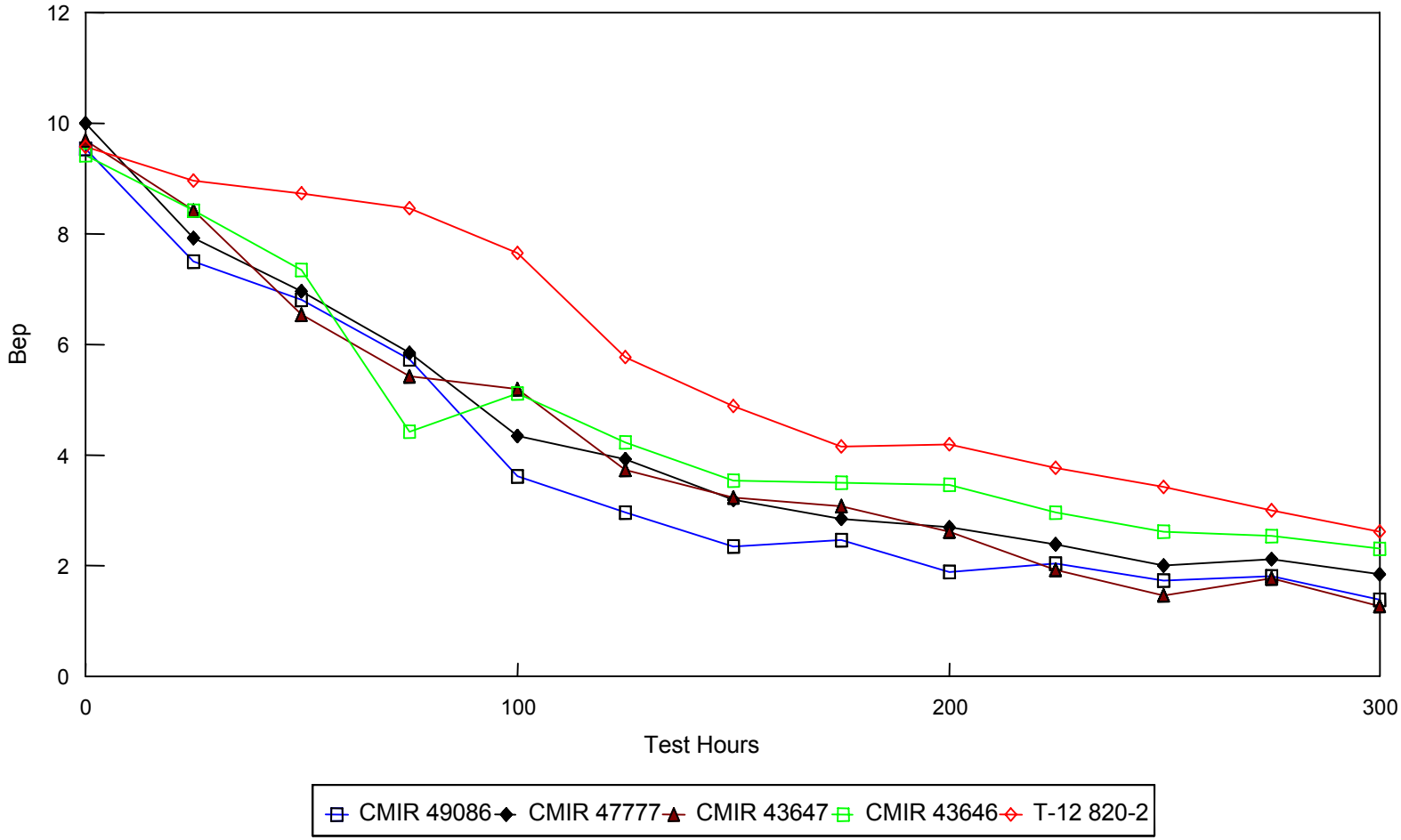
Mack T-12

- Parameters to Control
  - Ring Wear
  - Liner Wear
  - Rod Bearing Wear (Load Increase)
  - Oil Consumption
- Cyclic Based on Mack T-10 in API CI-4 With Mack T-10 Low Swirl Heads
- Test Length: 300 Hours
  - 100 Hours Rated Load and Speed
  - 200 Hours Peak Torque

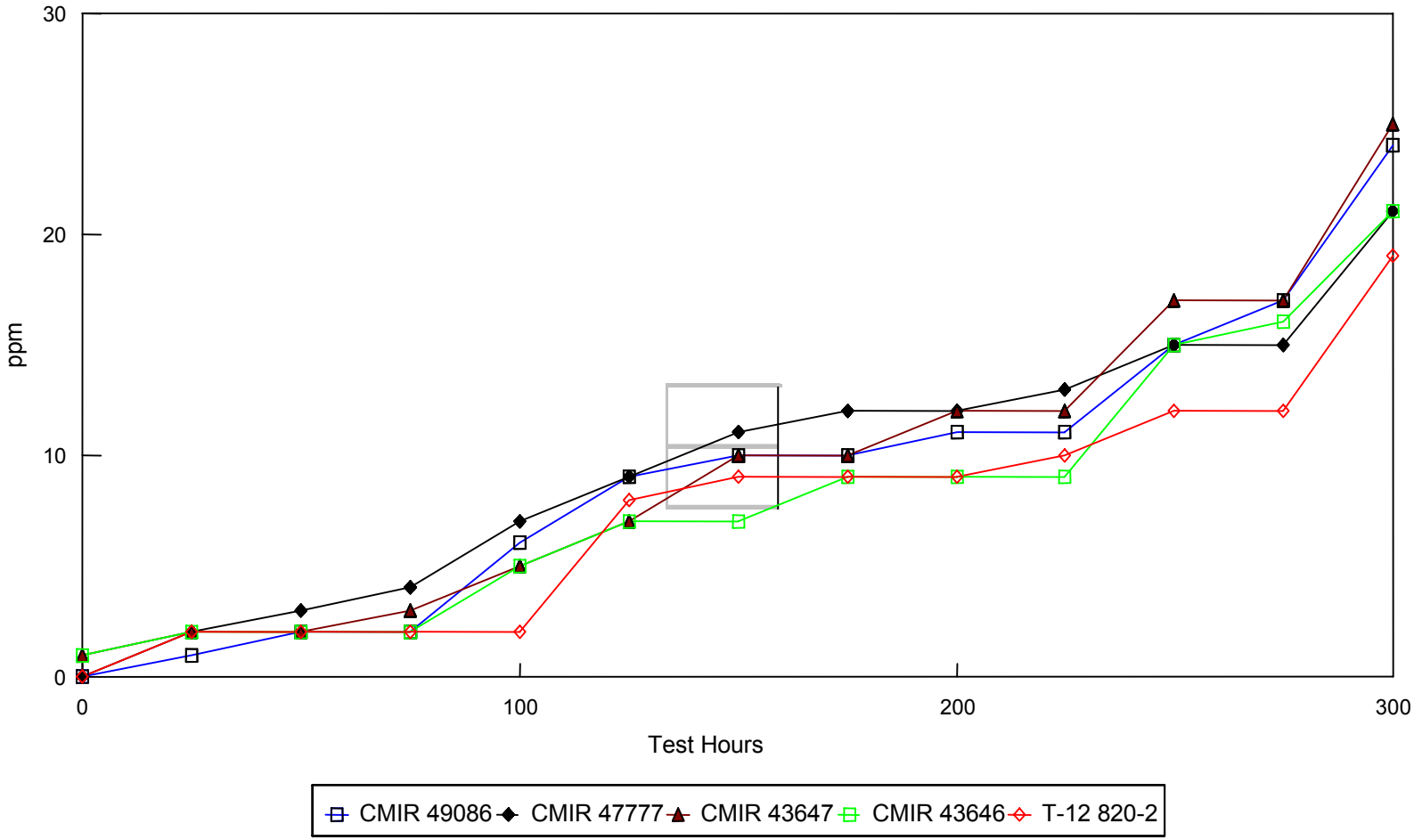
Mack T-12 Test Condition Targets

Parameter	Stage 1	Stage 2
Speed	1800	1200
Power, kW (bhp)	243 (325)	314 (420)
EGR Rate	35%	15-20%
AFR	22-23	21-22
Oil Sump Temperature , °C (°F)	99 (210)	127 (260)
Coolant Temperature, °C (°F)	66 (150)	88 (190)
Soot	4% at 100 Hours	6% at 300 Hours
Engine Hours	100	200

Mac T-10 Versus T-12
TBN – D 4739



Mac T-10 Versus T-12
Used Oil Lead



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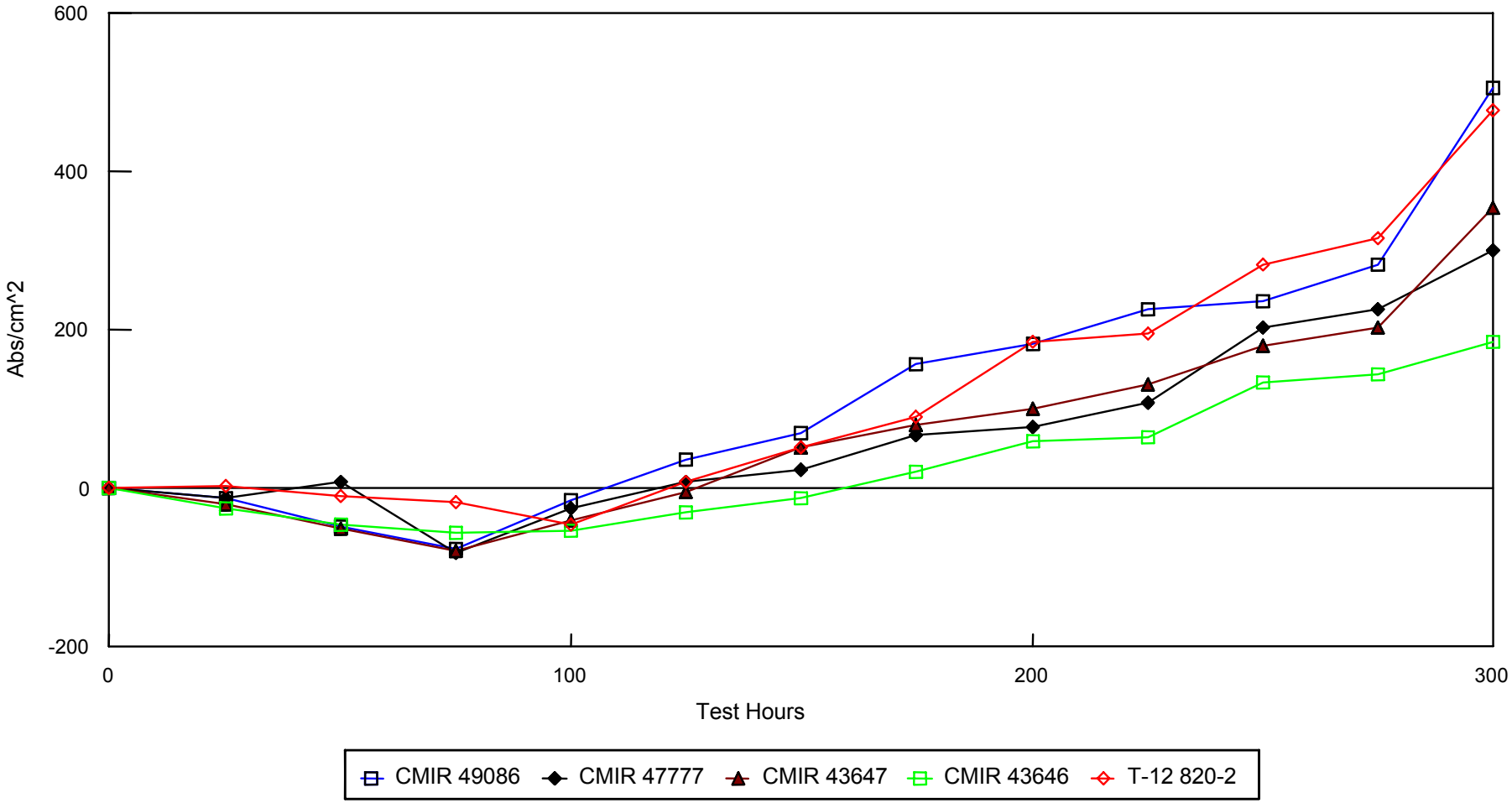
Mac T-10 Versus T-12 Oxidation FTIR Area



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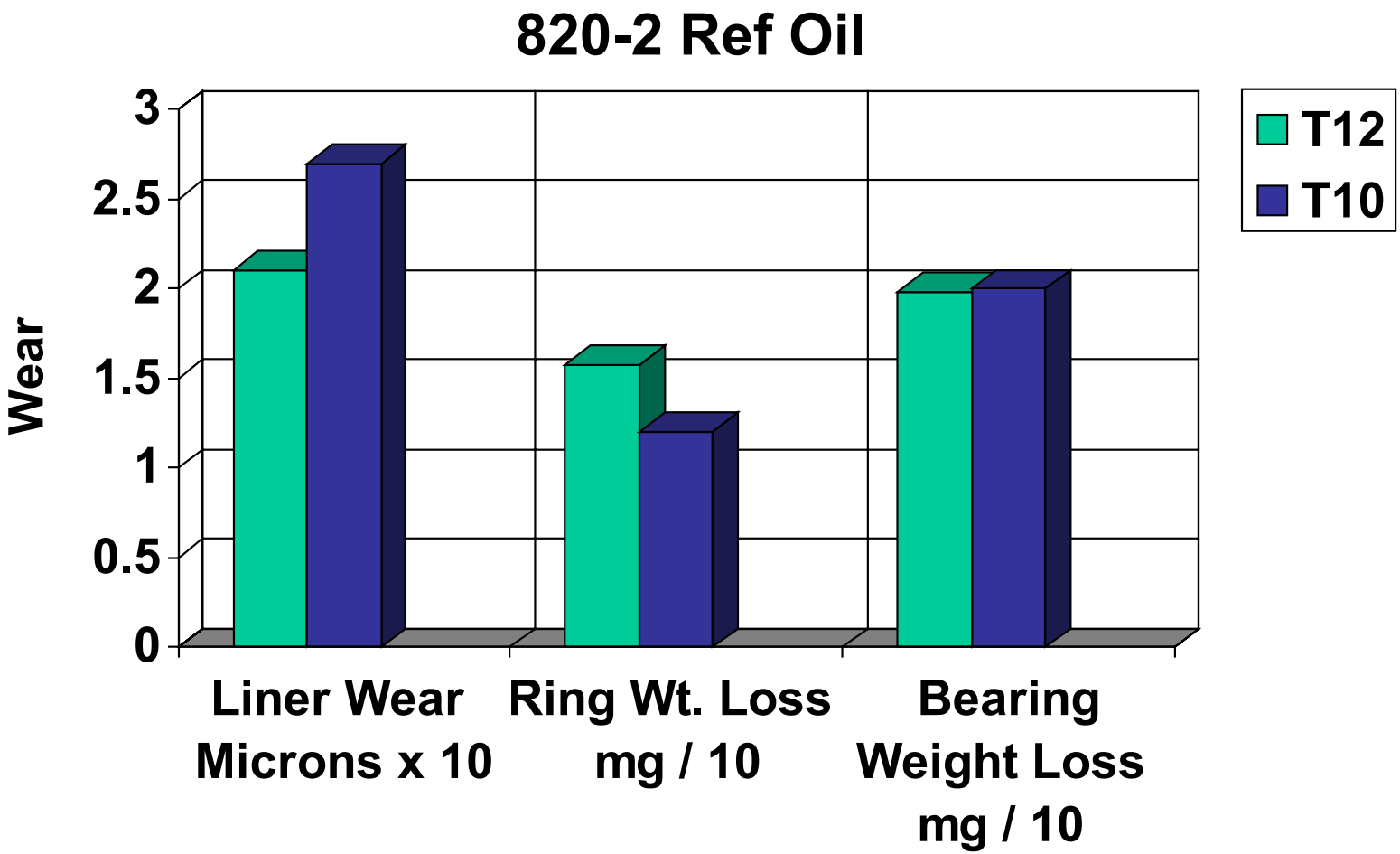
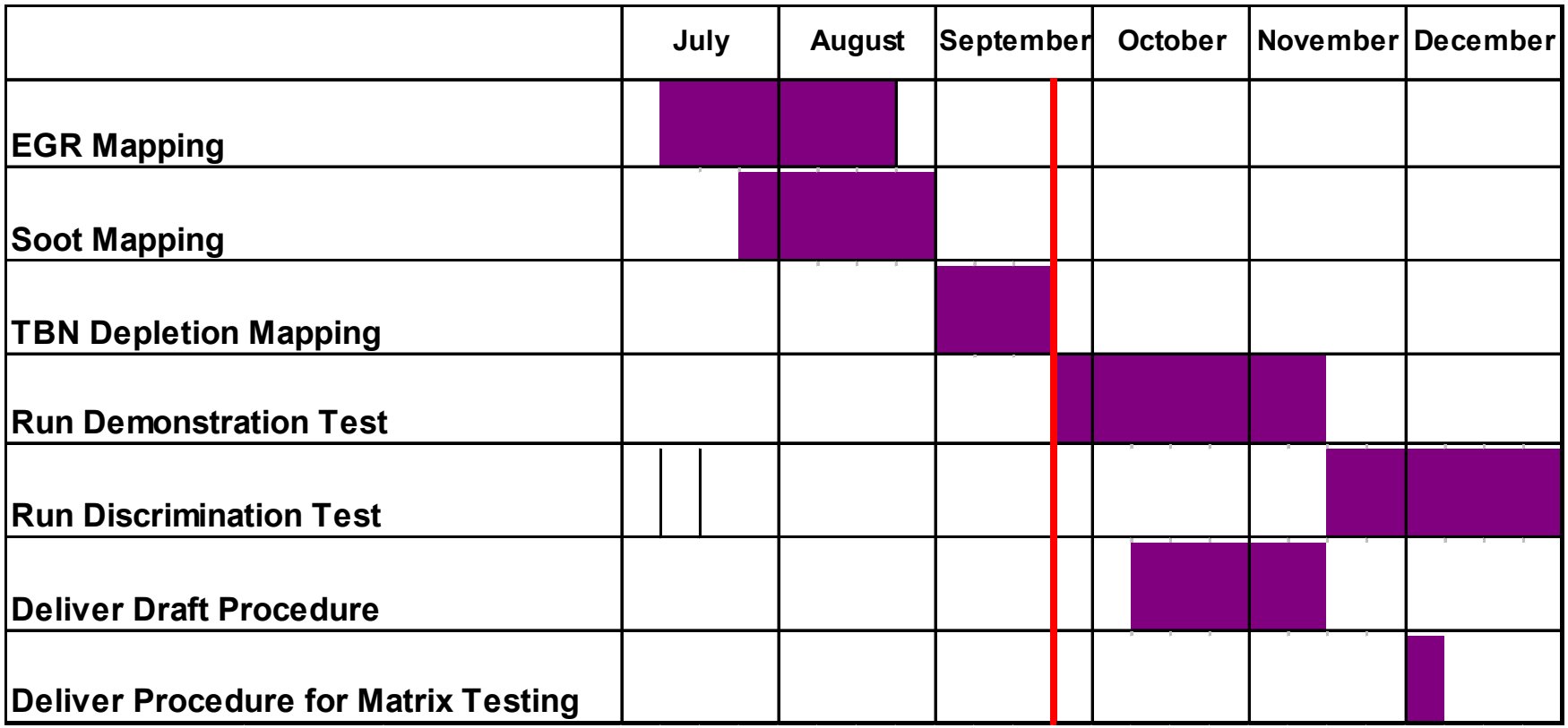
Wear T12 Versus T10



GLS Nov 11th 2004

T12 and PC10 Engine Oil Test Development Schedule



Cummins ISM (EGR)

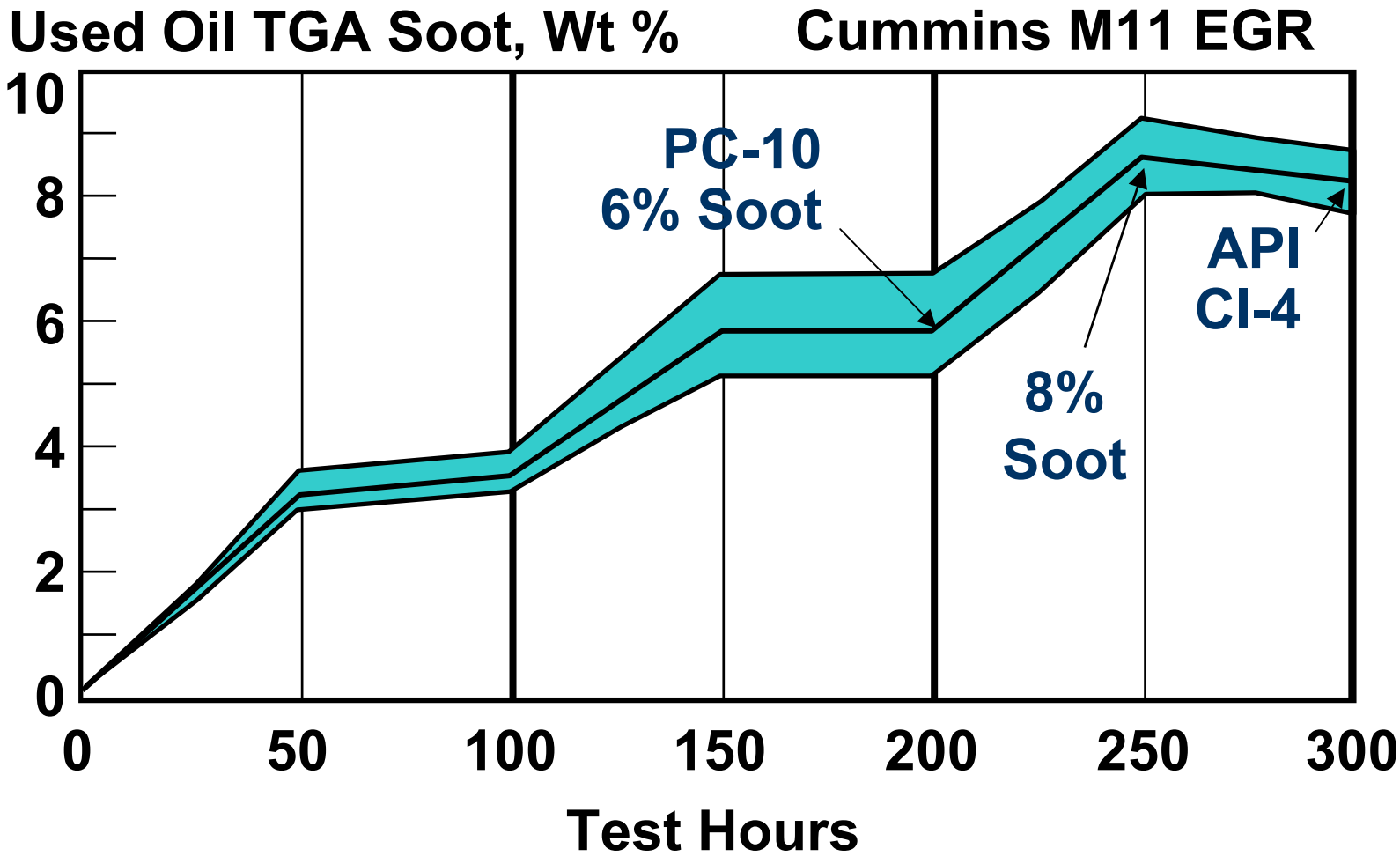
Cummins ISM (EGR)

- Replace Cummins M11 EGR
- Parameters:
  - Cross-Head Weight Loss
  - Filter Plugging
  - Sludge
- Fuel Sulfur: 500 ppm
- Test Length: 200 Hours at 6% Soot

ISM Test Conditions

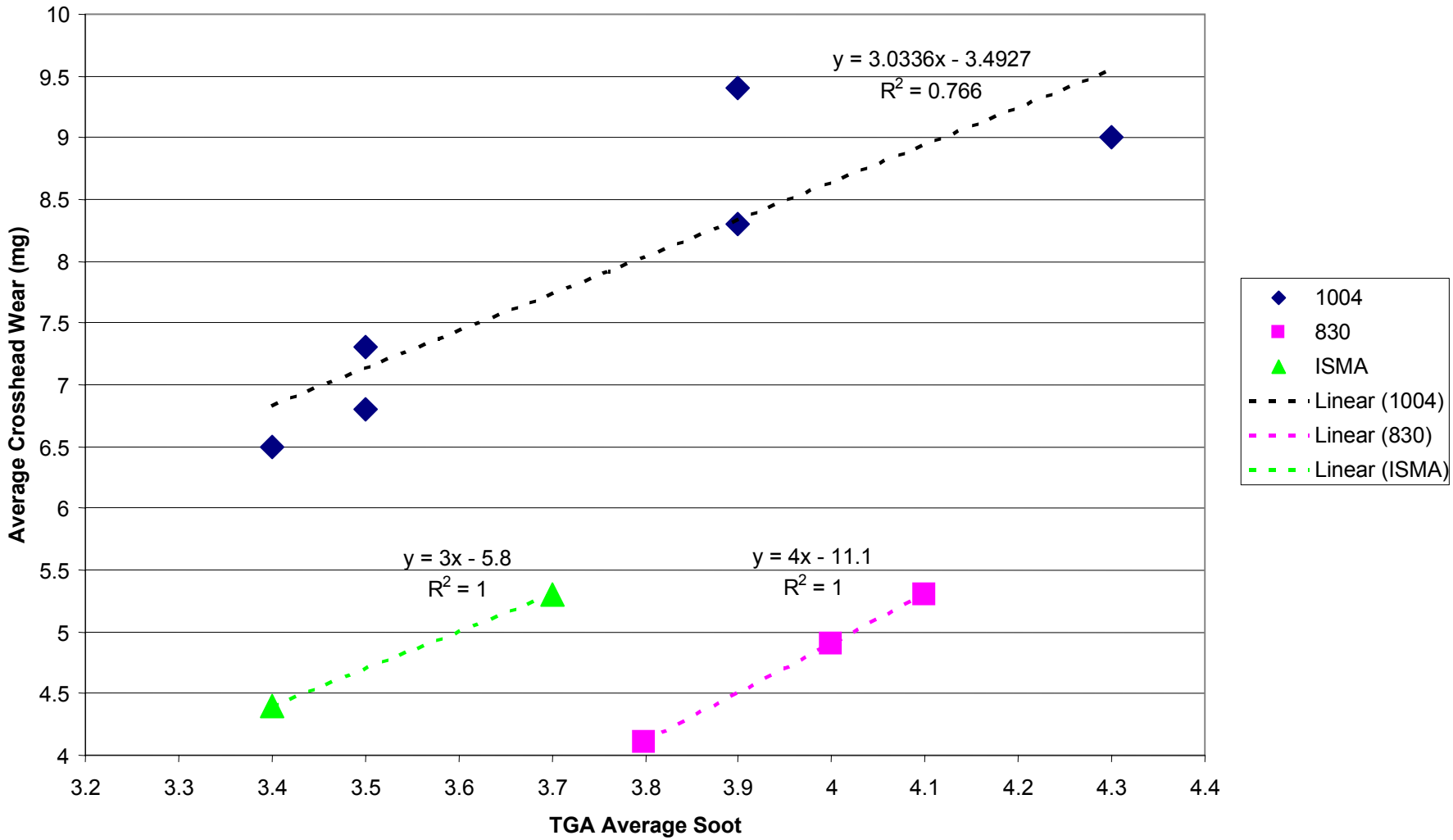
Parameter	Stage A	Stage B
Time, Hours	50	50
Speed, rpm	1800	1600
Power, kW (bhp)	236 (317)	302 (405)
Cooled EGR, %	9.5	15
Oil Gallery Temperature, °C	115	115
Fuel Flow, kg/Hour	58.0	64.4
Inlet Manifold Temperature, °C	80	65.5
Coolant Out Temperature, °C	65.5	65.5

Cummins M11-EGR and ISM-EGR Cycle



ISM Matrix Average Cross-Head Wear as a Function of Soot

Outlier Lab Removed



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Cross-Head Weight Loss

- **Model Fit: CWL=f (Lab, Oil, Average Soot)**
  - **No Lab Differences**
    - **Lab G 0.84 Mild if Fit Procedure Change Instead of Soot**
  - **All 3 Oils Statistically Significantly Different**
  - **CWL Increases 3.0332 per 1% Average Soot**

Crosshead Weight Loss	Oil 1004	Oil 830	Oil ISMA
LS Mean at 4% Soot	8.6385	4.8680	6.3605
Mean at 4% Soot	8.6416	4.8678	6.2149
StdDev at 4% Soot	0.5784	0.1477	0.0070
Mean at New Soot	8.9000	4.7667	***6.8767***
StdDev at New Soot	0.5568	0.6110	NA
M11 EGR Target	99.8000	12.2000	5.1000

Caterpillar C13

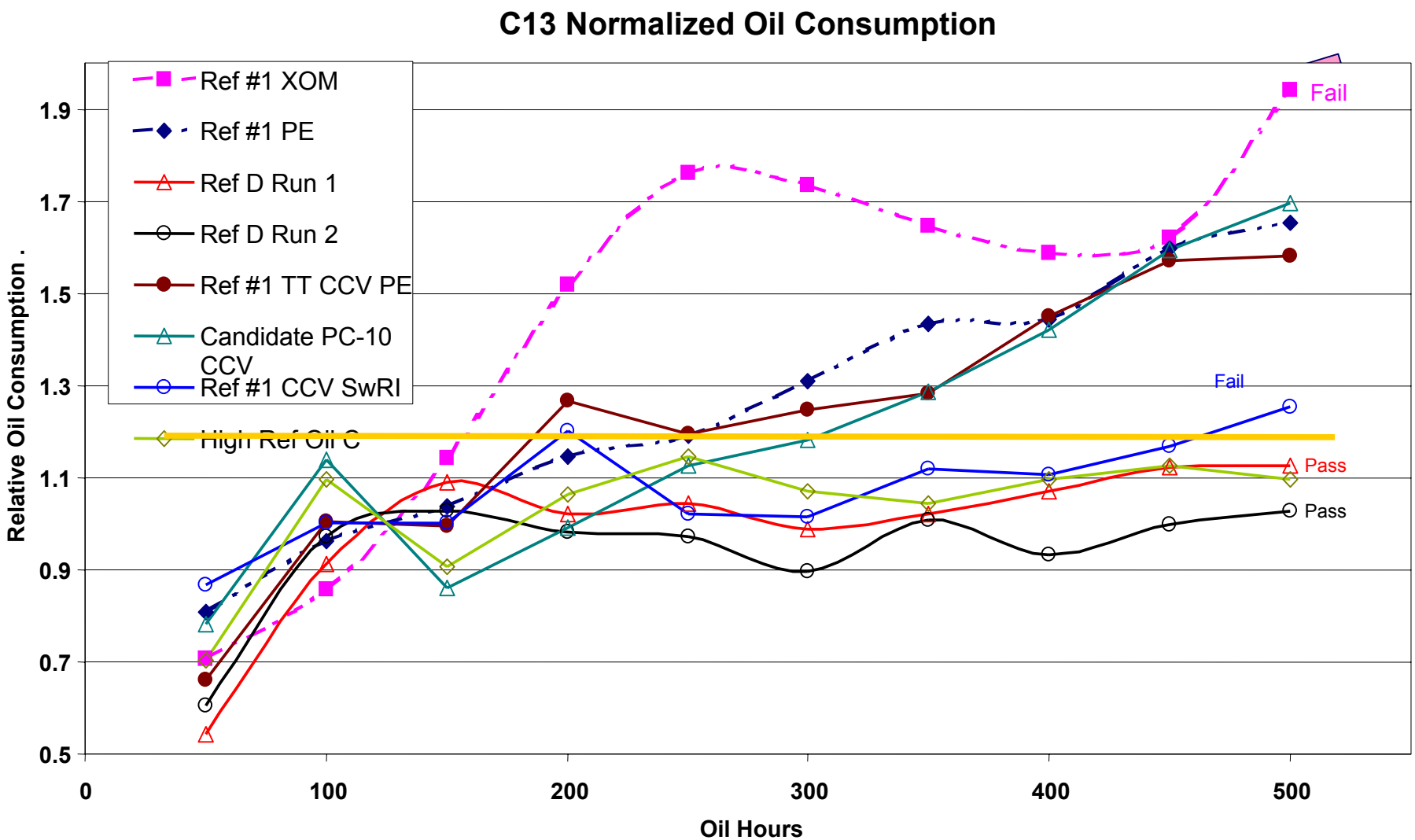
Caterpillar C13
Caterpillar ACERT Engine

- Caterpillar C13
- Parameter to Control
  - Oil Consumption
  - Piston Deposits
  - No ring sticking of second ring.

Cat C13 Operation Conditions

Operational Parameters	"Cool" Operating Condition
Power, kW (bhp)	338 (456)
Test Duration, Hours	500
Engine Speed, rpm	1800
Coolant Out Temperature, °C	88
Intake Manifold Temperature, °C	40
Exhaust Manifold Temperature, °C	641
Oil Gallery Temperature, °C	111

Caterpillar C13 Test Update



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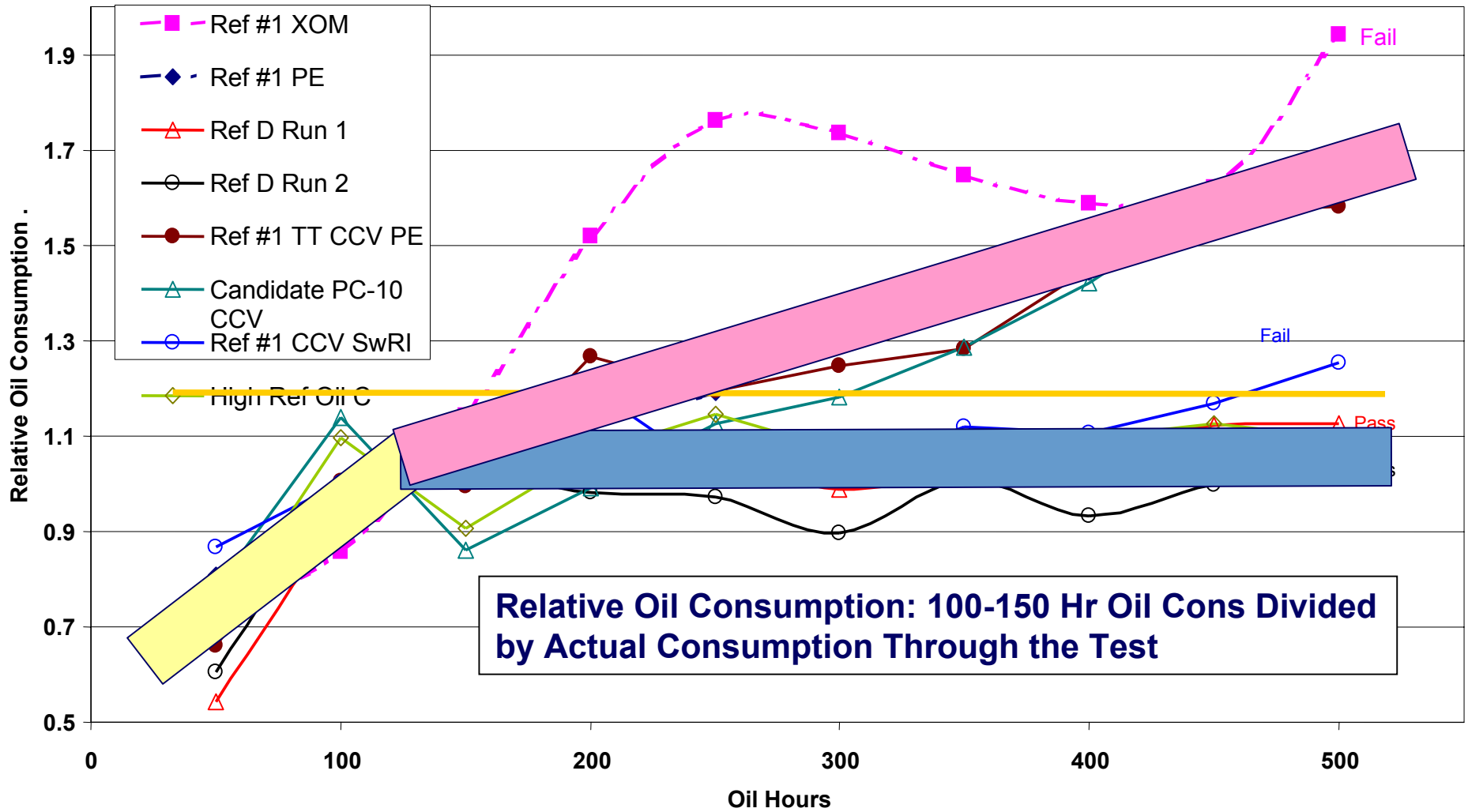
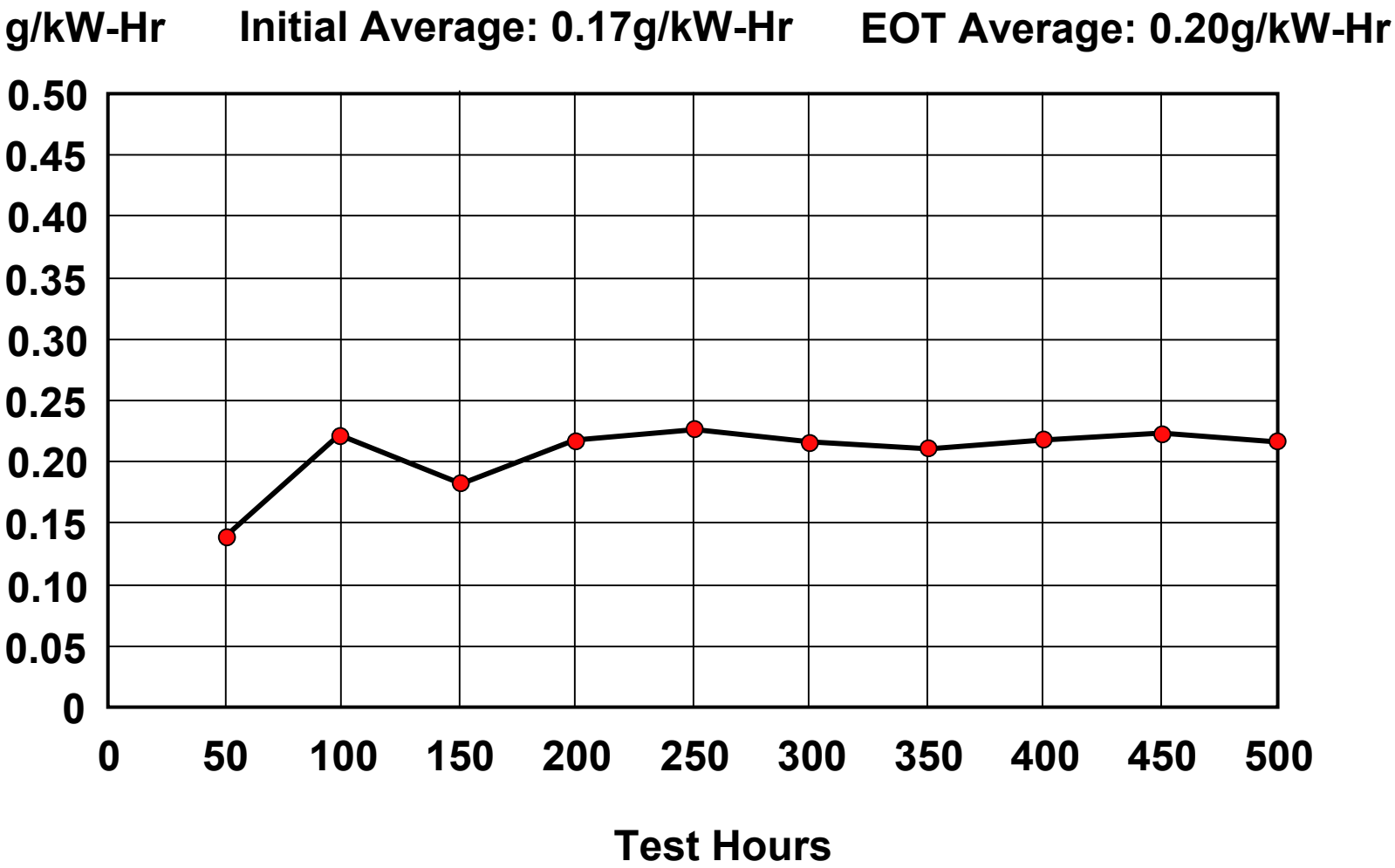
Caterpillar C13 Test Update



Cat C13 – Acceptable Oil Consumption



Caterpillar C13

- **New High and Low Reference Under Evaluation With Completion Planned by December 2004**

Cat C13 Operation Conditions

Operational Parameters	"Cool" Operating Condition	"Normal "Operating Condition	"Hot" Operation Condition
Power, kW (bhp)	338 (456)	348 (470)	352 (475)
Test Duration, Hours	500	500	500
Engine Speed, rpm	1800	1800	1800
Coolant Out Temperature, °C	88	98	105
Intake Manifold Temperature, °C	40	55	75
Exhaust Manifold Temperature, °C	641	690	735
Oil Gallery Temperature, °C	111	119	128

Note a 18% increase in oil consumption