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Committee D02 on PETROLEUM PRODUCTS AND LUBRICANTS

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February 24, 2003

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Unapproved Minutes of the February 19, 2003 Sequence IIIF Surveillance Panel Meeting held in San Antonio, Texas

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Chairman Nahumck called the meeting to order at 9:05am. A copy of the agenda (Attachment 1) was handed out and reviewed. Southwest Research Institute was thanked for sponsoring both the meeting room and lunch for the meeting attendees.

Secretary and Motion & Action Item Recorder – Ben Weber volunteered to be Motion & Action Item Recorder for this meeting. Since Frank Farber, who is now permanent secretary for this Surveillance Panel, was not in attendance Michael Kasimirsky volunteered to perform secretary duties for this meeting.

Membership changes – Dennis Florkowski replaces Frank Duffy as the DiamlerChrysler member. Hannah Murray was added as a member for Toyota. Add Robert Rumford of Dow Chemical to the Sequence IIIF Mailing List. Irwin Goldblatt was also acting as the Castrol member for this meeting, in place of John Moffa. The membership list is attached (Attachment 2).

Sequence IIIG Survey Review – Chairman Nahumck reviewed the results of the Sequence IIIG Survey that was recently circulated to the Surveillance Panel on the readiness of the Sequence IIIG test for inclusion in the GF-4 commercial oil category.

Test Developer's Report on the Status of the Sequence IIIG test – Sid Clark presented the Test Development Group's report (Attachment 3) on the status of the Sequence IIIF test. He reviewed the test conditions of the IIIG test, relative to the IIIF test, and then reviewed the results of the 46 development runs made as of February 14, 2003. He also discussed the results of early runs on NF-200 camshafts. The Test Development Group's conclusions are that they do not believe that further development work will result in lower wear variability. Bob Olree commented that this should not be taken to mean that GM will not continue to investigate wear and further refine the test in the future, but rather that wear tests had more variability and that the current performance of the IIIG test is not unexpected. Phil Scinto commented that while the statement that IIIG wear variability is similar to IIIE and VE wear variability *may* be true, the data he has reviewed does not support that conclusion at this time. Bob Olree then reviewed some Sequence IIIE data in regards to wear variability to address his comments. Mr. Clark went on to discuss the recent GM/TMC laboratory visits at Southwest Research Institute and PerkinElmer Automotive Research in preparation for beginning the IIIG Matrix.

Bob Olree then presented some information on Sequence IIIG wear in preparation for the GF-4 Category (Attachments 4 & 5). He detailed the various configurations of Sequence III tests that have been developed over the years, leading to the Sequence IIIG test. Mr. Olree then presented an overview of the effects on changing to unleaded fuel on wear performance, from the leaded fuel used in the Sequence IIIE test and before. He next covered phosphate coating of camshafts and scuffing wear in the history of the Sequence III test. Next he discussed the relationship between oxidation and wear. He noted that the Sequence IIIG is *not* a replacement for the Sequence VE test. SAE paper 861516 was discussed in that it detailed a very poor correlation between the Sequence VD test and GM V-8 taxi fleet test results. Another SAE paper, 831760, noted that the camshaft and lifter wear results in a taxi fleet test correlated with the Sequence IIID test but not the Sequence VD test. The Sequence IIIG test is not a replacement for the Sequence VE test. He has yet to find any publication that indicates a correlation between camshaft wear in the Sequence VE test and camshaft and lifter wear in pushrod engines. In conclusion, he believes that the test is ready and that it's time to begin the Sequence IIIG GF-4 Matrix. He then presented a slide containing the latest Sequence IIIG test data.

Gordon Farnsworth then presented some information oils considered as IIIG Matrix candidates (Attachment 6). This information was presented primarily for information only and there was no discussion on it amongst the panel membership.

{At this time a 15-minute break was taken.}

Clarification of CCS/MRV Requirements – Bob Olree presented some information on refinements to the CCS and MRV requirements in the Sequence IIIG test procedure (Attachment 7). There was some discussion of the new requirements amongst the panel membership. The GM representatives noted that the intent of this change is to assure that a used oil will pump at a temperature at least five degrees lower than it will allow the engine to crank. This change was to bring the Sequence IIIG test procedure in line with the requirements of the SAE J300 specification.

Motion (Charlie Leverett/Sid Clark) The Sequence IIIG test is ready to go forward into the GF-4 Matrix. The motion was finally withdrawn after several revisions and much discussion.

Discussion – The discussion of this motion then moved on to the PAPTG request (Attachment 8) that camshaft batch code capture information on the phosphate coating dip rack used, rough and final grind lots, hardening information, etc. General Motors' position is that this information would lead to parts selection and as such they are totally opposed to the idea on that basis. Several representatives of companies who are users of the test noted that they desire this information to better understand the data they've generated on the test. Both sides were unwilling to compromise on the issue. The suggestion was made to form a small working group to see if this issue could be resolved to the agreement of all parties involved. Dwight Bowden noted that this issue was discussed at the November 2002 Sequence IIIF Surveillance Panel meeting and that the OH

Technologies, Inc. position on this issue then was "no" and that nothing has changed in that regard. Mr. Bowden went on to note that he had made a proposal on this issue to ACC and he was not aware of the ACC response to this proposal. A working group consisting of: Pat Lang, Sid Clark, Monica Beyer, Jason Bowden, Michael Kasimirsky, Jim Newcombe, and Charlie Leverett (chairman) was formed to address this item and also address implementation of the parts usage guidelines spelled out in Sequence IIIE Information Letter No. 60.

{At this time the meeting was stopped for a lunch break; no vote on the motion on the floor had been taken at this time.}

Working Group Scope & Objectives – Charlie Leverett, chairman of the working group, asked that the panel take a few minutes to spell out a Scope & Objectives for this working group. The group was tasked with reviewing Information Letter No. 60, the OHT proposal to ACC, the PAPTG response, and the Batch Concept/Quality Control Task Force guidelines on this topic. The prohibition on parts selection in the Sequence IIIG was to be a result of this activity as well. Any differences in the treatment of reference oil tests and non-reference oil tests should also be spelled out. This activity is to be completed by March 30, 2003.

Discussion (cont.) – The previous motion was revised, yet again, to the version listed above. There also was additional discussion regarding the objectives of the working group identified above and the recommendations the panel expects that group to return with. Ben Weber presented some wear data from the development partners showing laboratory differences in wear severity. On some of the graphs, it was noted that the tests were run on the same camshaft batches, yet there was a difference in the final wear result of the test. Sid Clark presented some information on the new metrology requirements that will be part of the Sequence IIIG test, specifically in regard to the measurement equipment required for camshaft and lifter measurements. The discussion then moved on to the laboratory differences, if any, and what to do about them if they do exist.

Jo Martinez presented her analysis of Sequence IIIG data available to date (Attachment 9) with regards to discrimination in the Sequence IIIG test.

Motion (Charlie Leverett/Sid Clark) The Sequence IIIF Surveillance Panel recommends to the PCEOCP that the Sequence IIIG test be considered ready for GF-4 Matrix testing provided that the laboratory issues are investigated and resolved to the satisfaction of the Surveillance Panel before the matrix can start. This action will be concluded within the next six weeks while reference oils are being blended and distributed by the TMC to the test laboratories. The motion passed 14-0-2.

O&H Issues – Nothing to present or discuss. The blowby limits & forms will be addressed after the matrix is completed. Clarification of CCS/MRV requirements was completed earlier in the meeting. Reporting of MRV results in the Sequence IIIG test was discussed, resulting in the following TMC Action Item:

TMC Action Item – Put copies of MRV fields on Form 4 of the Sequence IIIG Report Form Set.

<u>Old Business</u>
Used Oil Samples – Chris May reiterated his request for used oil samples for use by Section D02.07C. Several members commented that they have sent oil samples to Mr. May.

Review of TMC Memo 03-002 – The memo was briefly reviewed. The conclusion listed in the memo, that there are no hardware-related severity shifts in the Sequence IIIF test at this time, was reiterated.

<u>New Business</u>
Crossover Limits for IIIE to IIIF – Pat Lang asked about the application of severity adjustments and such when using a 60-hour Sequence IIIF test for SJ Category approval.

Motion (Daryl Baumgartner/Gordon Farnsworth) The TMC shall issue a Memo stating that in cases where the Sequence IIIF test is used for the purposes of supporting alternate categories (SJ or SH Categories, etc.) the 60-hour viscosity result should be severity adjustments in the same manner as is done for the Sequence IIIF-HD test. The motion passed unanimously by voice vote.

Fuel Review – Robert Rumford briefly reviewed the Sequence IIIF fuel situation. He noted that due to recent crude oil prices, the price of the test fuel would probably increase. In addition, the fuel would now only be stocked in Channelview, Texas, resulting in increased shipping costs for Northern laboratories.

The meeting was adjourned at 4:08pm. The next meeting is at the call of the Chairman.

Attachment 1

AGENDA
SEQUENCE IIIF SURVEILLANCE PANEL MEETING
San Antonio, Texas
February 19, 2003

1. APPOINTMENT OF RECORDER OF ACTIONS/MOTIONS
2. AGENDA REVIEW
3. MEMBERSHIP CHANGES

SEQUENCE IIIG

1. SEQUENCE IIIG DEVELOPMENT UPDATE
   A. Review of Recent Survey Results
   B. Developer's Report of the Status of the IIIG test
   C. Letter from ACC PAPTG concerning camshaft batches
   D. Update from the Matrix Design Task Force
   E. ACC Template Update
   F. Is the test ready for a Precision Matrix?

2. CPD SUPPLIER REPORTS
   A. OHT
   B. GM MOTORSPORTS

O&H ISSUES

A. SEQUENCE IIIG
- Blowby limits and forms
- Clarification of CCS/MRV requirements

OLD BUSINESS
A. Drain Oil Request from Chris May, Section D02.07C
B. Review of ASTM Memo 03-002 – Michael Kasimirsky

NEW BUSINESS

A. Crossover limits for IIIE to IIIF

ADJOURNMENT

Attachment 2

ASTM SEQUENCE IIIF LIST

February 19, 2003 **San Antonio, Texas**

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Attachment 2

ASTM SEQUENCE IIIF LIST

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Attachment 2

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February 19, 2003 **San Antonio, Texas**

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Attachment 2

ASTM SEQUENCE IIIF LIST

February 19, 2003 **San Antonio, Texas**

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Attachment 2

ASTM SEQUENCE IIIF LIST

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John Moffa Castrol International Technology Centre Whitchurch Reading, RG8 7QR ENGLAND	00441189765263 00441189841131 John_Moffa@burmahcastrol.com	☑ IIIF SURV PANEL ☐ IIIF MAILING LIST ☑ O&H SUBPANEL ☐ O&H Mailing List	Present [signature] for JM

Attachment 2

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Attachment 2

ASTM SEQUENCE IIIF LIST

February 19, 2003 **San Antonio, Texas**

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SEQUENCE IIIF SURVEILLANCE PANEL MEETING
GUEST LIST
February 19, 2003
San Antonio, Texas

Attachment 2

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Attachment 2

SEQUENCE IIIF SURVEILLANCE PANEL MEETING
GUEST LIST
February 19, 2003
San Antonio, Texas

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Attachment 2

SEQUENCE IIIF SURVEILLANCE PANEL MEETING
GUEST LIST
February 19, 2003
San Antonio, Texas

NAME/ADDRESS	PHONE/FAX/EMAIL	SIGNATURE

Attachment 3

Sequence IIIG Development

and the

Road to GF-4

Sid Clark

GM Powertrain Materials Engineering

Presented to the Sequence IIIF / IIIG Surveillance Panel February 19, 2003

Attachment 3

ILSAC GF-4 Goals

The Automotive Manufacturer View

Technological Goals:*

- **Provide Improved performance in areas of**
  - Oxidation stability
  - Deposit control
  - Low-temperature rust/corrosion
  - Used oil pumpability
  - Emissions system compatibility
  - Fuel efficiency
- **Work with additive industry to evaluate new anti-wear technologies**
  - Low - Phosphorus, Sulfur, & Ash technologies
- **Work with auto, oil, and additive industries to determine the level of anti-wear required to protect new and older engines**

**Presented by Mike McMillan to The Society of Tribologists and Lubrication Engineers Detroit Section October 23, 2000*

Attachment 3

ILSAC GF-4 Goals

The Automotive Manufacturer View

Where we were and where we are trying to go:

ILSAC	Years	Test Changes	Relative Oil Durability
GF-1	1993-1996	Same as API SG (1989-1992) except test registration required	+10%
GF-2	1997-2001	Fuel economy test switched to Ford engine, phosphorus & volatility limits reduced	No Change
GF-3	2002-2004	All new engine tests, volatility limit reduced to European limit, phosphorus held at same (0.10% mass) maximum limit	+25%
GF-4	2004-2XXX	Seq. III test severity increased, fuel economy requirements increased, phosphorus limit reduced*	+50%

* Pending confirmation testing to show no degradation in anti-wear performance

Attachment 3

Sequence IIIG Development Goals

- **Provide Improved performance in areas of**
  - Oxidation stability
  - Deposit control
  - Used oil pumpability
- **Provide backward compatibility**
  - Design a test that delivers all the above using flat follower, pushrod valvetrain geometry

The Sequence IIIG Test

- Essentially the same as a IIIF with exception:
  - Increased:
    - Horsepower
    - Intake air temperature
    - Test length
    - Run blocks (20hr. Vs 10hr. Levels with same oil additions)
  - Reduced:
    - Oil temperature
    - Coolant temperature
  - Changed:
    - Piston Ring gapping strategy (0.025” top / 0.042” bottom)
    - Camshaft (we now use a manganese phosphate coated camshaft)
    - Higher load valve springs (205 Vs 180lb.)
    - Spark plugs (NGK TR6)
    - Oil filter (Wix)

IIIG vs IIIF Test Conditions

- Test length 100h vs 80h
- 20h levels vs 10h
  - (5500ml initial with 472 ml additions)
- Coolant temp 115°C vs 122 °C
- Oil temp 150 °C vs 155 °C
- Inlet air temp 35 °C vs 27 °C
- 250 Nm vs 200Nm @ 3600 RPM
- Rings .025 Top .042 2nd vs .042 / .038
- Manganese phosphate coated camshaft vs non-coated camshaft

Attachment 3

Attachment 3

IIIG Development Runs
(as of 2/14/03)

- 46 Total tests
  - 15 MB non phosphated camshaft runs
  - 3 MK non phosphated camshaft runs
  - 14 Original MK 160 phosphated camshaft runs
  - 2 NF190 phosphate dip development runs
  - 12 NF200 final phosphate process runs

Attachment 3

IIIG Update

- It appears from candidate test results that a few tests run using early NF-200 cams generated milder test results than more recent materials.
- The lower and higher wear test results on 433-1 shown at the November SP meeting may also be representative of these differences.
- However, Oil 538 was run using all of the above materials and appears to give similar low wear results on all tests.

Statement made at ILSAC / Oil meeting December 2002

Attachment 3

IIIG Update

- It appears from candidate test results that a few tests run using early NF-200 cams generated milder test results than more recent materials.
- The lower and higher wear test results on 433-1 shown at the November SP meeting may also be representative of these differences.
- However, Oil 538 was run using all of the above materials and appears to give similar low wear results on all tests.

Additional test data now indicates wear variability may not be as closely related to phosphate coating weights as supposed in December 2002.

Attachment 3

IIIG Development Update Cont.

- Several companies have commented that they have seen a 2 to 1 wear ratio in replicate testing.
- Earlier testing with MK phosphated camshafts showed the same 2 to 1 ratio.

Lab/Run#	Viscosity	Test Oil	% Vis. Inc.	Avg. Wear	WPD	PSV	Oil Cons.
SR/14	5W-20	GF-3 TMC Ref. 538	118	12.8	3.5	9.16	4.2
PE/12	5W-20	GF-3 TMC Ref. 538	117	14.2	3.7	8.93	3.86
PE/09	5W-20	Early Proto-type GF-4	102	57.2	2.53	7.74	3.78
SR/13	5W-20	Early Proto-type GF-4	88	38.5	2.79	7.94	3.95
SR/18	5W-30	TMC Ref. 433-1	150	62	2.37	7.19	3.51
PE/13	5W-30	TMC Ref. 433-1	228	35.9	2.76	8.52	4.36

- Similar variability in wear existed in both Sequence IIIE and VE tests.

Attachment 3

So, Where Are We?

- Phosphating camshafts has greatly reduced lobe-to-lobe wear variability.
- Average wear variability in the IIIG is similar to other engine wear tests (IIIE & VE)
- No reason to expect lower variability with further development work.

Attachment 3

Recapping our Development Objectives

- Increase severity over IIIF
  - By about a factor of two times in oxidation
  - By about a factor of two times in piston deposits
  - Increased high temperature wear discrimination

The Development Group believes these objectives have been met.

Attachment 3

Summary

- General consensus among those companies who have used the test is that it is not quite as severe as two times the IIIF test on oxidation and more severe than two times on piston deposits.
- The wear responds to ZDDP level and overall formulation chemistry.
- Because the phosphated camshaft has greatly reduced start-up scuffing, the sensitivity of the IIIG to ZDDP level and types seems to be different from that in the IIIE and IIIF tests.

Attachment 3

Conclusion

- The Sequence IIIG test is ready for precision matrix testing.
- In preparation for matrix testing, the IIIG Development Team in conjunction with the Test Monitoring Center conducted a joint laboratory visit in San Antonio the week of January 27, 2003

Attachment 3

Joint PerkinElmer - SwRI

GM TMC Laboratory Visit

- Areas reviewed included:
  - Parts preparation and cleaning
  - Honer setup, calibration, maintenance and operations
  - Engine short block assembly
  - Camshaft and lifter measurements and installation procedures
  - Cylinder head calibration, setup and operation
  - Engine block final assembly and test stand installation
  - Test operations:
    - Initial installation, fuel rail priming, oil charging and priming
    - Initial start and oil leveling
    - Break-in ramping and on test control
      - Speed and load control
      - AFR control loops (closed loop and actual analysis)
      - Temperature and flow control
      - Blowby and crankcase ventilation
      - QI calculation

Attachment 4

Unraveling Sequence IIIG Wear
on the
Road to GF-4

Bob Olree

GM Powertrain Materials Engineering

Presented to the Sequence IIIF / IIIG Surveillance Panel and the Passenger Car Engine Oil Classification Panel February 19, 2003

Test Development Chronicle

Understanding Camshaft and Lifter Wear

Brief History of the Sequence III Wear Test Materials :

- The Sequence III test started with ACI lifters and phosphated hardenable gray iron camshafts, a combination identified in the mid 1950's as being scuff and wear resistant.
- From there it kept steadily moving until it reached its most scuffing and wear sensitive configuration - the Sequence IIIE.
- The Sequence IIIF switched back to ACI lifters
- The Sequence IIIG incorporates both ACI lifters and a phosphated camshaft

Attachment 4

Test Development Chronicle

Understanding Camshaft and Lifter Wear

Brief History of the Sequence III Wear Test Materials :

- The Sequence III test started with ACI lifters and phosphated hardenable gray iron camshafts, a combination identified in the mid 1950's as being scuff and wear resistant.
- From there it kept steadily moving until it reached its most scuffing and wear sensitive configuration - the Sequence IIIE.
- The Sequence IIIF switched back to ACI lifters
- The Sequence IIIG incorporates both ACI lifters and a phosphated camshaft

We have come full circle on camshaft and lifter materials. It is not reasonable to expect an unleaded test using ACI lifters and a phosphated camshaft to correlate perfectly with a leaded fuel test using low carbide D500 lifters and a non-phosphated camshaft. The fact that oil 403 gave failing wear results in the Sequence IIIE test does not mean it must also do the same in the Sequence IIIG test.

Attachment 4

Test Development Chronicle

Understanding Camshaft and Lifter Wear

1. The switch to unleaded fuel and its effect on wear

   – Field data on 350 CID Chevy V-8's run on reference oil 403 showed normal wear at 100,000 miles with 3,000 and 12,000 mile drain intervals when fueled *with unleaded fuel*.

   – In the same field test, wear was 2 times higher with 3,000 mile and 3½ times higher with 12,000 mile drain intervals at 60,000 – 70,000 test miles when fueled *with leaded fuel*.

   – Sequence IIID Development test run on reference oil 472 using unleaded fuel was suspended after 100 hours without a break in viscosity or wear.

Attachment 4

Test Development Chronicle

Understanding Camshaft and Lifter Wear

1. **The switch to unleaded fuel and its effect on wear**
   - Sequence IIID Development test run on reference oil 472 using unleaded fuel was suspended after 100 hours without a break in viscosity or wear.
   - Reference oil 472 contained 0.07% Aryl Phosphorus and was the failing wear and oxidation oil in the IIID leaded fuel test.
   - This exercise was repeated during IIIE Development. The borderline reference oil 403 gave extremely low wear and the goal of switching the test to unleaded fuel was again abandoned.
   - This exercise was repeated yet again at the beginning of IIIF Development. Double length IIIE tests run on oil 403 with unleaded fuel resulted in very low wear. This result prompted the use of 52100 low carbide steel as the wear lifter in IIIF Development.

Attachment 4

Test Development Chronicle

Understanding Camshaft and Lifter Wear

1. The switch to unleaded fuel and its effect on wear

- Sequence IIID Development test run on reference oil 472 using unleaded fuel was suspended after 100 hours without a break in viscosity or wear.
- Reference oil 472 contained 0.07% Aryl Phosphorus and was the failing wear and oxidation oil in the IIID leaded fuel test.
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- This exercise was repeated yet again at the beginning of IIIF Development. Double length IIIE tests run on oil 403 with unleaded fuel resulted in very low wear. This result prompted the use of 52100 low carbide steel as the wear lifter in IIIF Development.

In Summary, *Unleaded Fuel changed everything!*

Attachment 4

Test Development Chronicle

Understanding Camshaft and Lifter Wear

2. Phosphated Camshafts and Scuffing

– The D500 lifters used in the IIIC/D tests were modified by grinding 0.005 inch off the foot to enhance scuffing.

– The IIIE test incorporated:
  - Special heat treatment of the D500 material to further reduce carbides.
  - Elimination of the phosphating from the camshaft.
  - Resulted in:
    – The failing IIID oil, reference oil 472, not being able to complete the 4 hour break-in portion of the IIIE without exhibiting high wear.
    – The borderline failing oil from the IIID test, reference oil 403, was relabeled as the failing IIIE oil.

Test Development Chronicle

Understanding Camshaft and Lifter Wear

Attachment 4

2. Phosphated Camshafts and Scuffing

– The combination of ACI (Alloy Cast Iron) lifters and a phosphated camshaft has not been used in the Sequence III test since the IIA & IIIA test. The primary pass - fail criterion in that test was a visual inspection for scuffing.

– In one test reported by Lubrizol, elimination of all ZDP in the Sequence IIA & IIIA test resulted in 2 scuffed positions and low wear on the other positions.

Test Development Chronicle

Understanding Camshaft and Lifter Wear

3. The Relationship Between Oxidation and Wear

(The chicken or the egg?)

– Reference oil wear in the Sequence IIID test was inversely proportional to the "hours to viscosity breakpoint" which was used to rank the oils. Reference oil 472 broke at ~ 24 hours, 403 at ~ 40 hours, 402 and 476 at ~ 56 hours, and oil 400 at 64 hours.

– In SAE paper 861516, Smolenski and Kabel observed, "Low used oil oxidation induction times (as measured by differential scanning calorimetry) were related to high camshaft and lifter wear." This was based on taxi fleet testing using production D500 lifters and unleaded fuel.

Attachment 4

Test Development Chronicle

Understanding Camshaft and Lifter Wear

3. The Relationship Between Oxidation and Wear

(The chicken or the egg?)

– Reference oil wear in the Sequence IIID test was inversely proportional to the "hours to viscosity breakpoint" which was used to rank the oils. Reference oil 47? broke at ~ 2? hours, 403 at ~ 40 hours, 402 and 476 at ~ 56 hours, and oil 400 at 64 hours.

– In SAE paper 861516, Smolenski and Kel?er observed, "Low used oil oxidation induction times (as measured by differential scanning calorimetry) were related to high camshaft and lifter wear. This was based on taxi fleet testing using production D500 filters and unleaded fuel.

Question:

Do the Group II+ base stock and high ashless anti-oxidant formulations we are running today protect the ZDP from being depleted as an anti-wear component?

Attachment 4

Test Development Chronicle

Backward Compatibility

4. **The Sequence IIIG test is not a replacement for the Sequence VE**

– The SAE paper (861516) mentioned earlier pointed out that there was a very poor correlation between the Sequence V-D test and GM V-8 taxi fleet test results.

– Oils formulated with primary ZDPs could pass the Sequence V-D test.

– Smolenski and Kabel in SAE paper 831760 identified C_4-C_5 primary and C_3-C_6 secondary ZDP types as giving the best wear protection in 100,000 mile taxi tests. Camshaft and lifter wear in taxi testing correlated with the Sequence IIID test but not with the Sequence V-D test.

Attachment 4

Test Development Chronicle

Backward Compatibility

4. The Sequence IIIG test is not a replacement for the Sequence VE

   – Reference oils 403 and 927 were failing Sequence VE oils that generated low wear in pushrod engines running in the field using unleaded fuels.

   – There are many publications on the unique valve train design and materials used in the Sequence VE test.

   – We have yet to find any publication that indicates a correlation between camshaft wear in the Sequence VE test and camshaft and lifter wear in pushrod engines.

Attachment 4

Test Development Chronicle

Backward Compatibility

4. The Sequence IIIG test is not a replacement for the Sequence VE

– Reference oils 403 and 927 were failing Sequence VE oils that generated low wear in pushrod engines running in the field using unleaded fuels.

– There are many publications on the unique valve train design and materials used in the Sequence VE test.

– We have yet to find any publication that indicates a correlation between camshaft wear in the Sequence VE test and camshaft and lifter wear in pushrod engines.

Summary:
We see no reason to expect primary ZDP oils - which had problems passing the Sequence VE test - to fail in a Sequence IIIG test.

Attachment 4

Attachment 4

Test Development Chronicle

Thoughts on Backward Compatibility

5. Increased wear observed in the Sequence IIIG compared to the Sequence IIIF (both with non-phosphated camshafts) is thought to be attributed to the higher load and crankcase NOx levels. This observation is similar to one made by Bill Nahumck in SAE paper 872123 on the development of the Sequence VE test.

6. High camshaft and lifter wear and a significant jump in ICP Pb seem to be associated. This is consistent with the fact that ZDPs were first used to protect bearings from de-leading.

7. When high wear is observed in the Sequence IIIG test it appears to occur near the end of test as evidenced in SR/18 run on 433-1 where ICP showed significant increases in Fe and Pb toward the end of test.

Summary

- **Results obtained in leaded fuel tests can not necessarily be read across to unleaded fuel tests.**
- **Scuffing was a key test parameter in all Sequence III tests up thru the IIIE. It is not in the Sequence IIIG test.**
- **Short chain primary ZDP oils gave excellent wear performance in pushrod engine field tests.**
- **There never has been a strong correlation between the Sequence III and V tests. It is not reasonable to expect the Sequence IIIG test to correlate with the Sequence VE test.**
- **In leaded fueled Sequence III tests, wear mechanisms were influenced by Tetra Ethyl Lead Scavengers in the crankcase blowby gasses and special low carbide lifters.**
- **In the unleaded fueled Sequence IIIG test, wear mechanisms are influenced by higher loads, high crankcase blowby Nox values, reduced additive replenishment through reduced oil additions, and longer test length.**

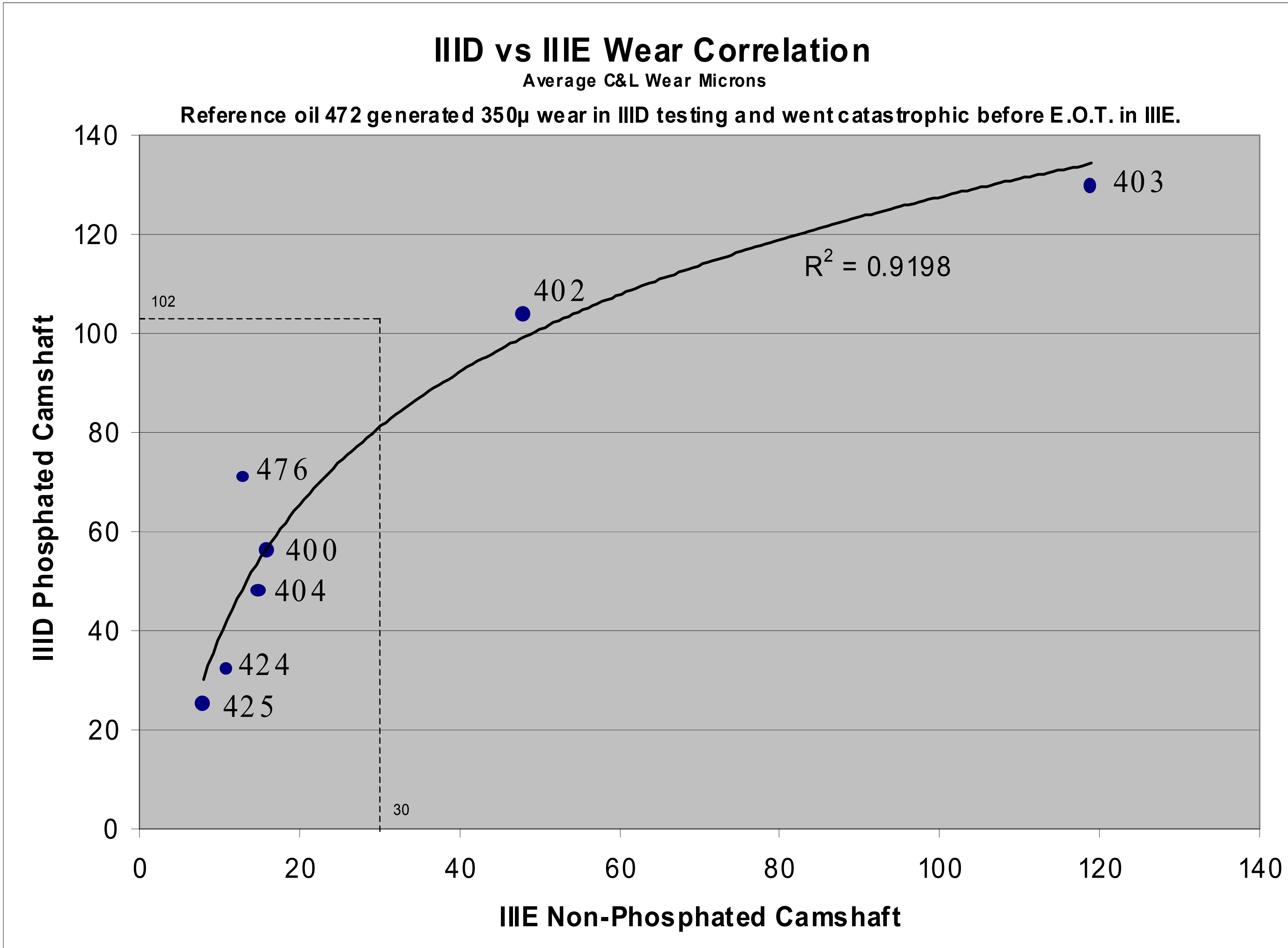
Attachment 4

Attachment 4

Conclusion

- The Sequence IIIG test uses production type valvetrain components and is more representative of real world operations than any pushrod flat follower type engine wear test ever developed within ASTM.
- The precision matrix will provide the needed data to determine the test viability for GF-4 certification and backward compatibility.
- It's time to run the matrix!

Attachment 5



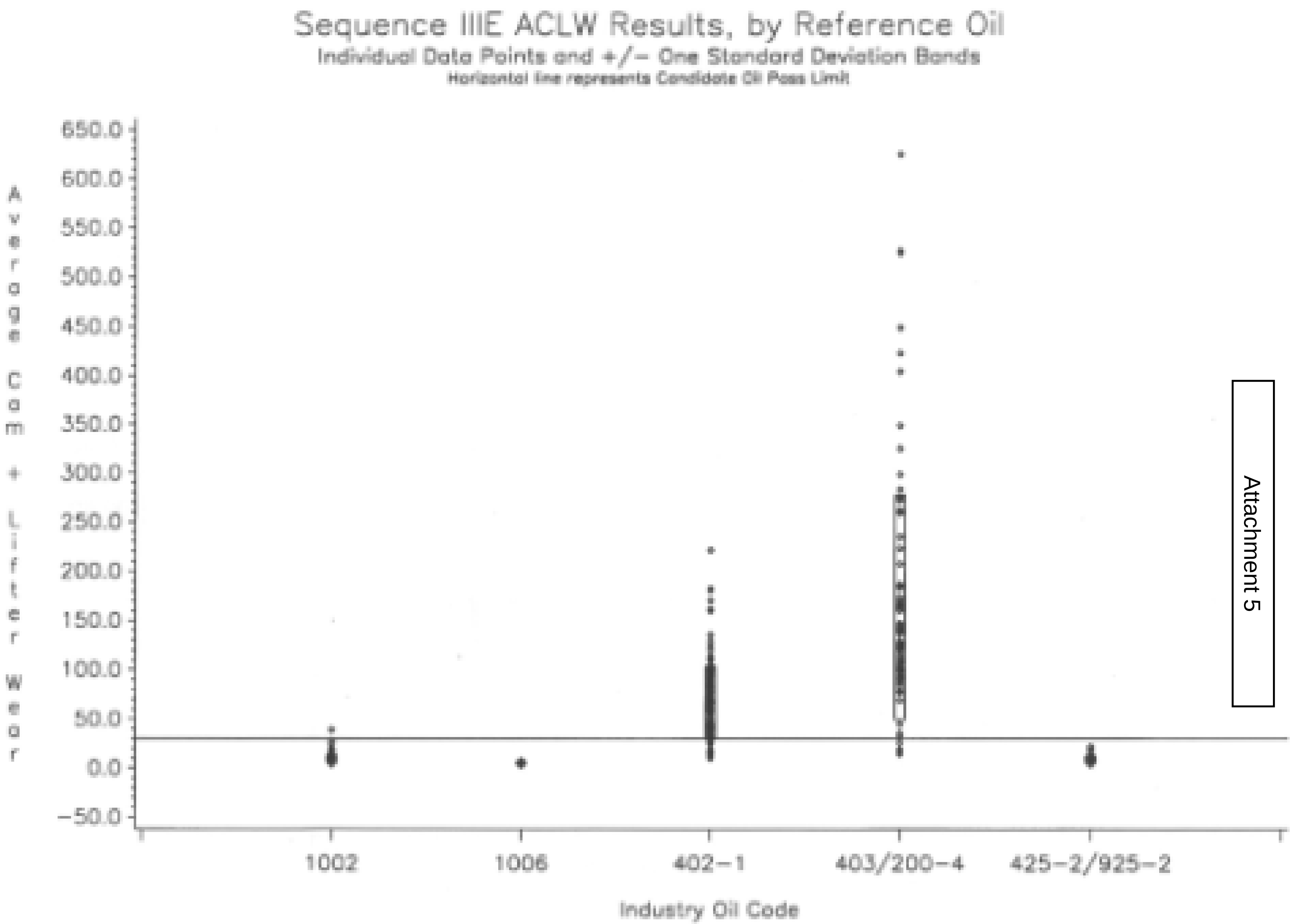
Attachment 5

2/17/03

Sequence IIIG Tests with Phosphated Camshafts

Lab/Run#	Viscosity	Test Oil	% Vis. Inc.	Avg. Wear	WPD	PSV	Oil Cons.	MRV @ -30
All runs are NF 200 Phosphated Camshafts								
OHT/PE	5W-30	TMC Ref. 433-1	191	37.7	2.94	8.46	4.09	>400000
SR/19	5W-30	TMC Ref. 433-1	TVTM	98.9	3.13	8.51	4.31	N/A
PE/20	5W-30	TMC Ref. 433-1	153	37.8	3.14	8.64	4.13	>400000
OHT/SR	5W-20	GF-3 TMC Ref. 538	91.6	17.9	2.90	8.73	3.80	18100
SR/20	5W-20	GF-3 TMC Ref. 538	92.7	19.3	2.89	8.25	3.12	17500
PE/16	5W-20	GF-3 TMC Ref. 538	118.9	16.8	3.30	9.04	4.61	22800
PE/17	5W-20	GF-3 TMC Ref. 538	101.2	15.8	2.64	8.10	3.29	20300
PE/18	5W-30	0.03 Phos.	114	36.7	3.24	8.48	3.66	57400
SR/21	5W-20	Candidate Ref Oil A	106	44.6	3.74	8.46	3.50	28100
PE/19	5W-30	Candidate Ref Oil B	91	21.0	4.21	8.70	3.67	26300
SR/22	5W-30	Candidate Ref Oil B	155	42.2	4.06	8.66	?	108600
SR/23	5W-20	Candidate Ref Oil C	159	43.2	2.97	7.88	3.73	70700

Attachment 5



Attachment 6

Matrix Oil Selection Work Group Report
To
Passenger Car Engine Oil Classification Panel

February 20, 2003

<u>Work Group Members</u>

•George Barth
•Gordon Farnsworth
•Frank Fernandez
•Pat Lang
•Charlie Leverett
•Robert Olree
•Ben Weber
•Lew Williams

Oils Considered for IIIG Matrix Candidates

- **ASTM 538:** *5W-20 ASTM Sequence VIB reference oil*
  - 0.095% Phos. Oil with data from six IIIG tests
- **Oil B:** *5W-30 GF-4 proto-type oil*
  - 0.075% Phos. oil with data from two IIIG tests
- **Oil C:** *5W-20 GF-4 proto-type oil*
  - 0.075% Phos. oil with data from two IIIG tests

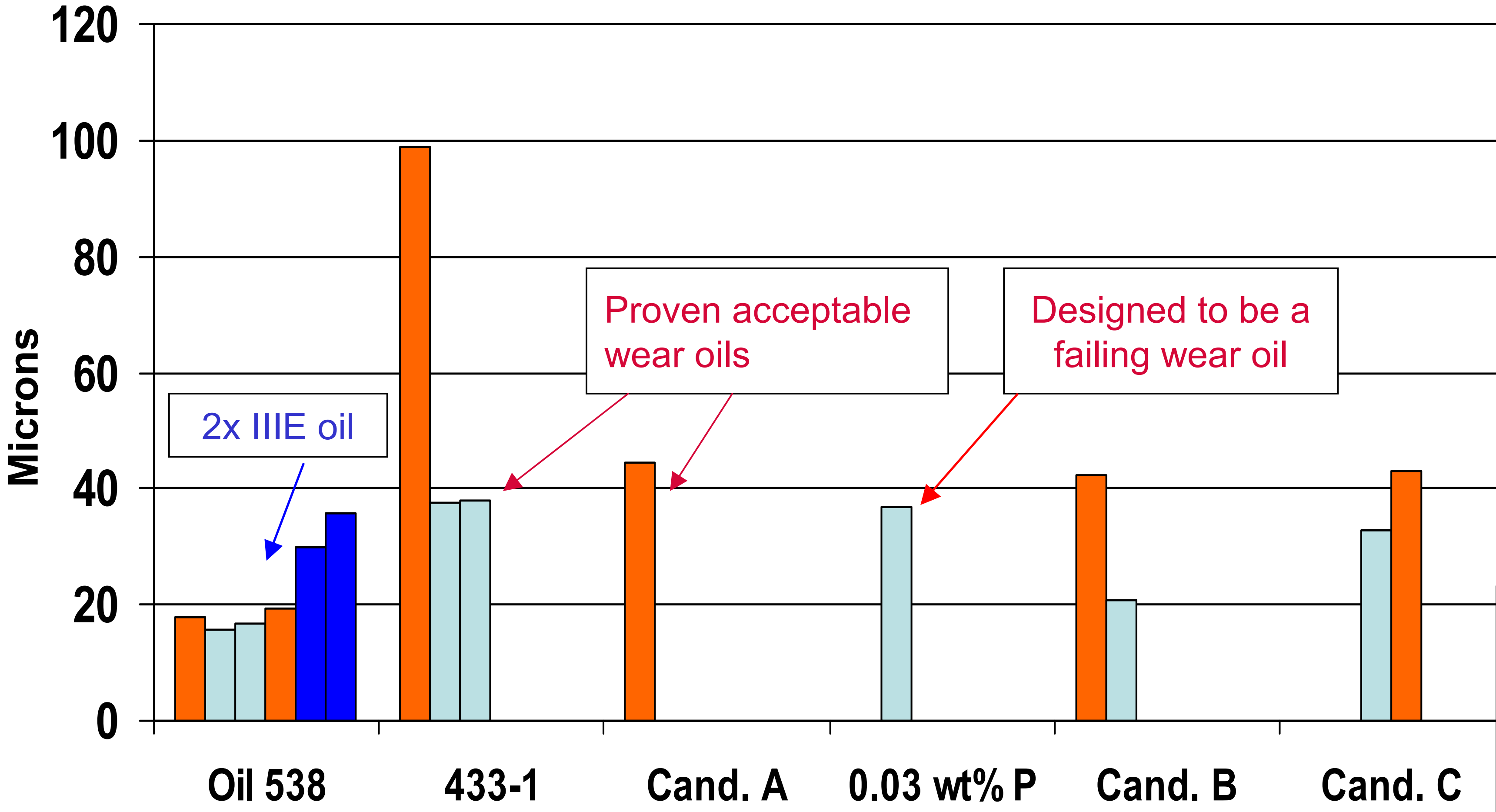
- **ASTM Oil 433:** *5W30 ASTM Sequence IIIF reference oil*
  - 0.095% Phos. oil with data from three IIIG tests
- **Oil A:** *5W-20 GF-4 proto-type oil*
  - 0.095% Phos. oil with data from one IIIG test
- **Low Phos. Oil:** *5W-30 oil expected to give high wear*
  - 0.03% Phos. Oil with one data IIIG test

All IIIG data mentioned above was with latest camshaft hardware 'NF200'

Attachment 6

Attachment 6

Sequence IIIG Wear

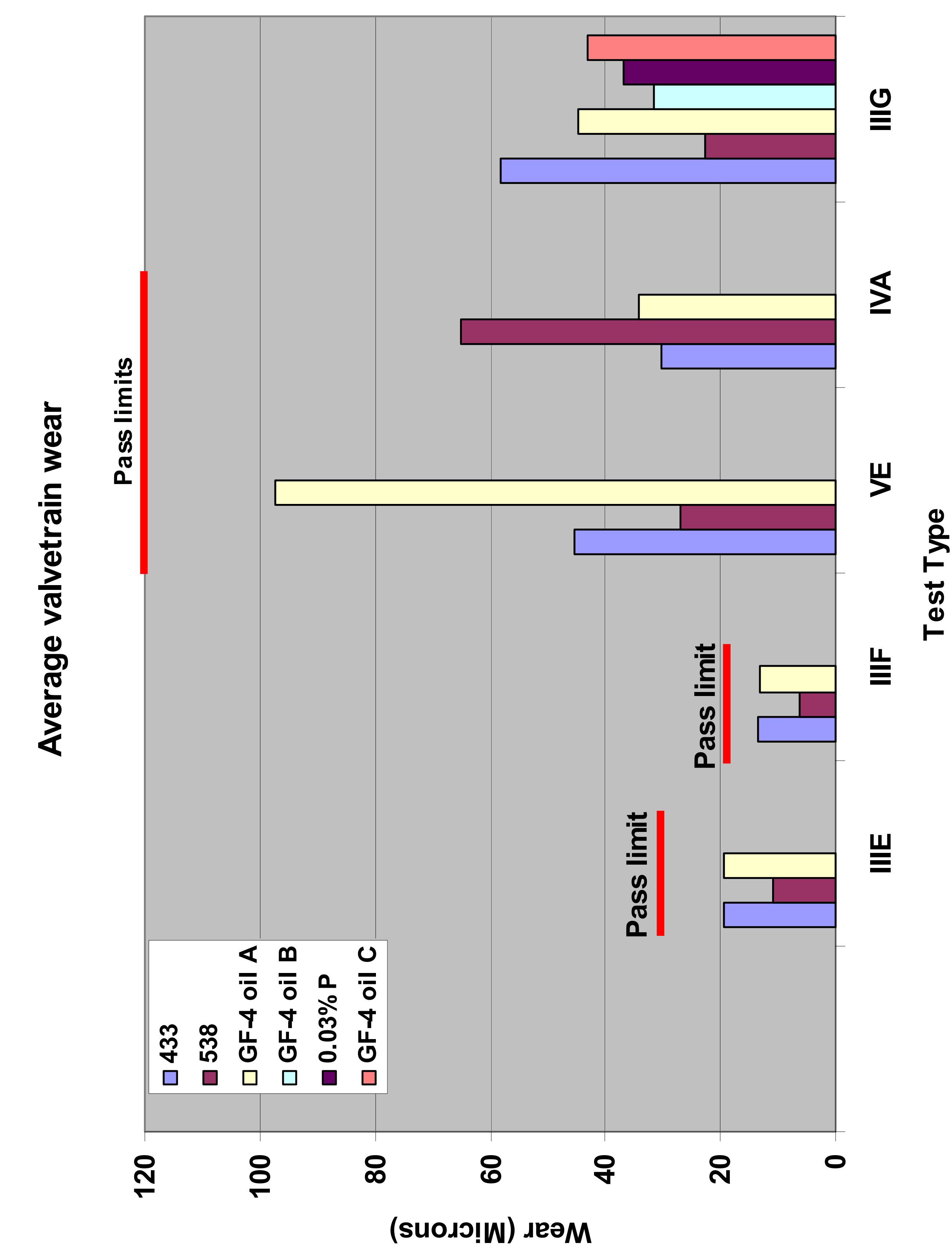


Orange – SwRI

Green – PE

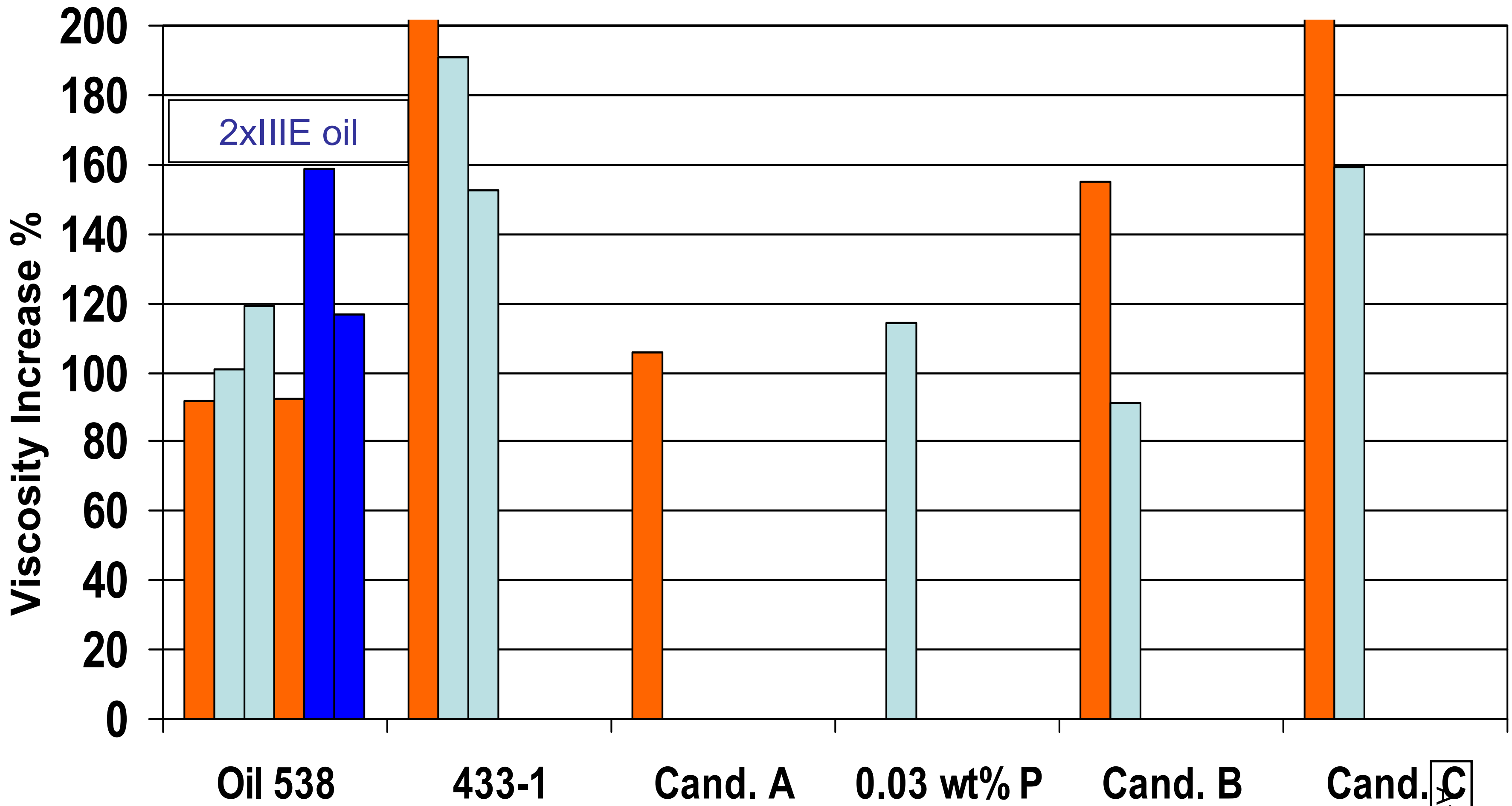
Blue - LZ

Attachment 6



Attachment 6

Sequence IIIG Viscosity Increase



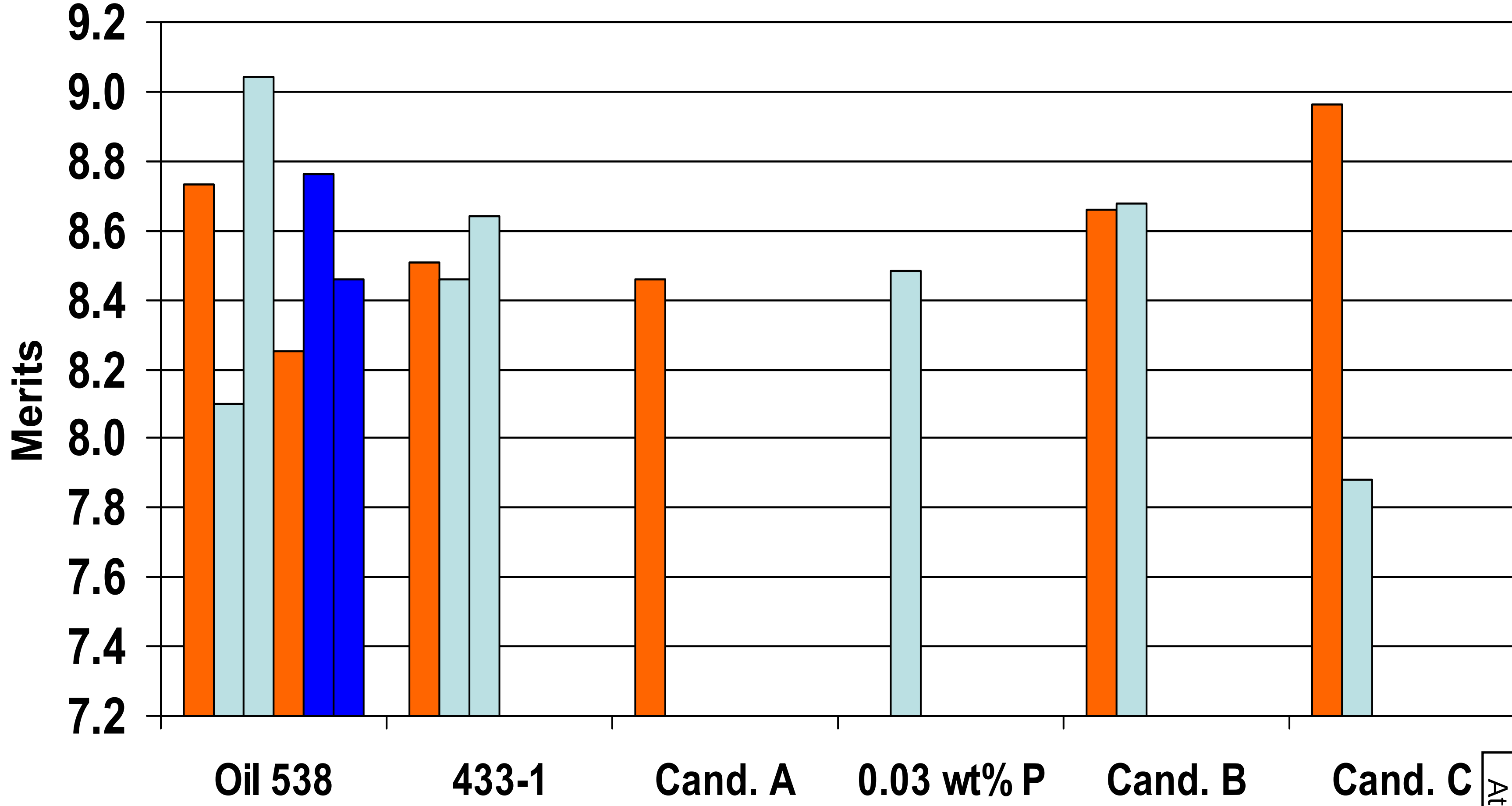
Orange – SwRI

Green – PE

Blue - LZ

Attachment 6

Sequence IIIG PSV



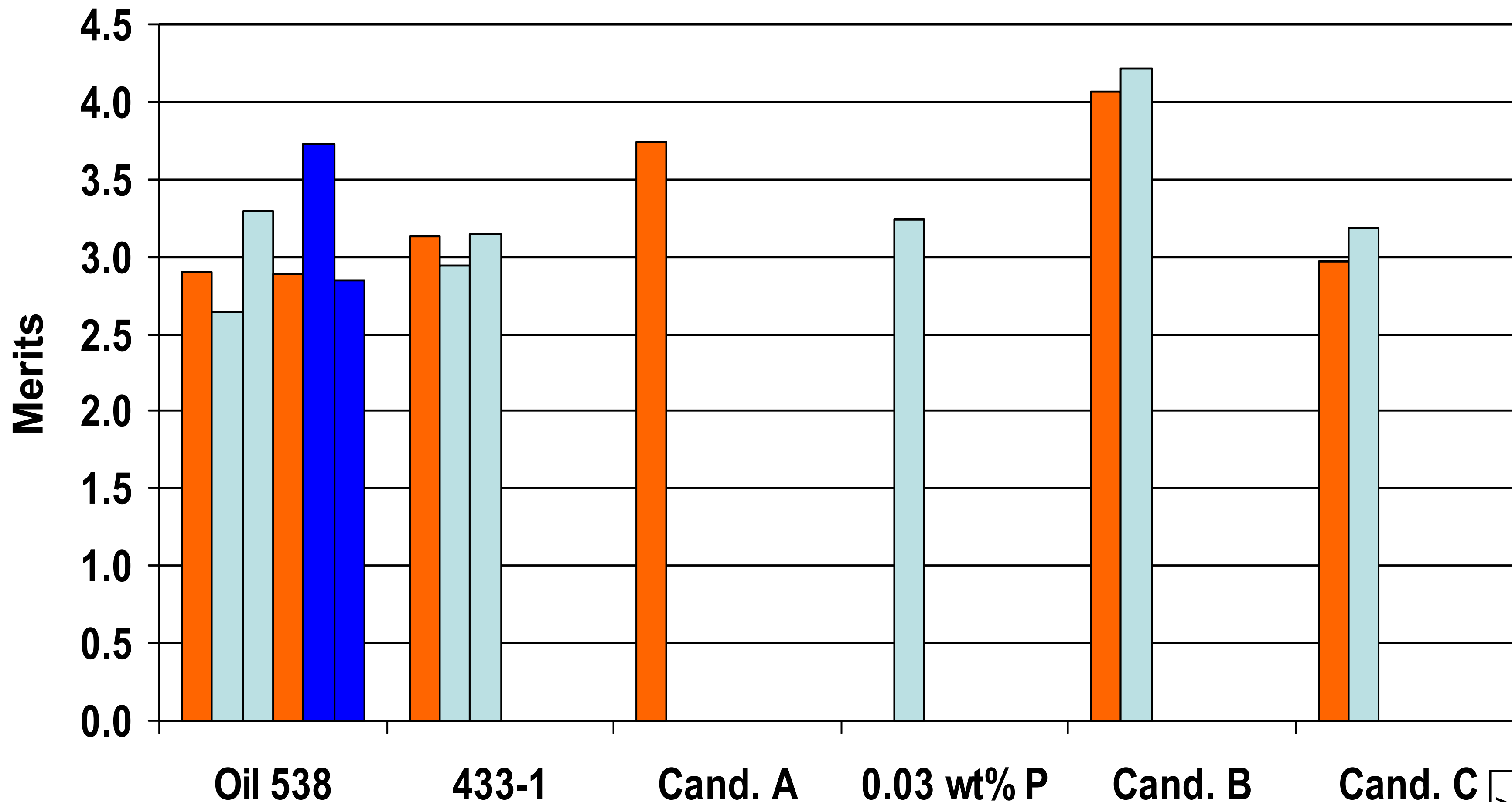
Orange – SwRI

Green – PE

Blue - LZ

Attachment 6

Sequence IIIG WPD

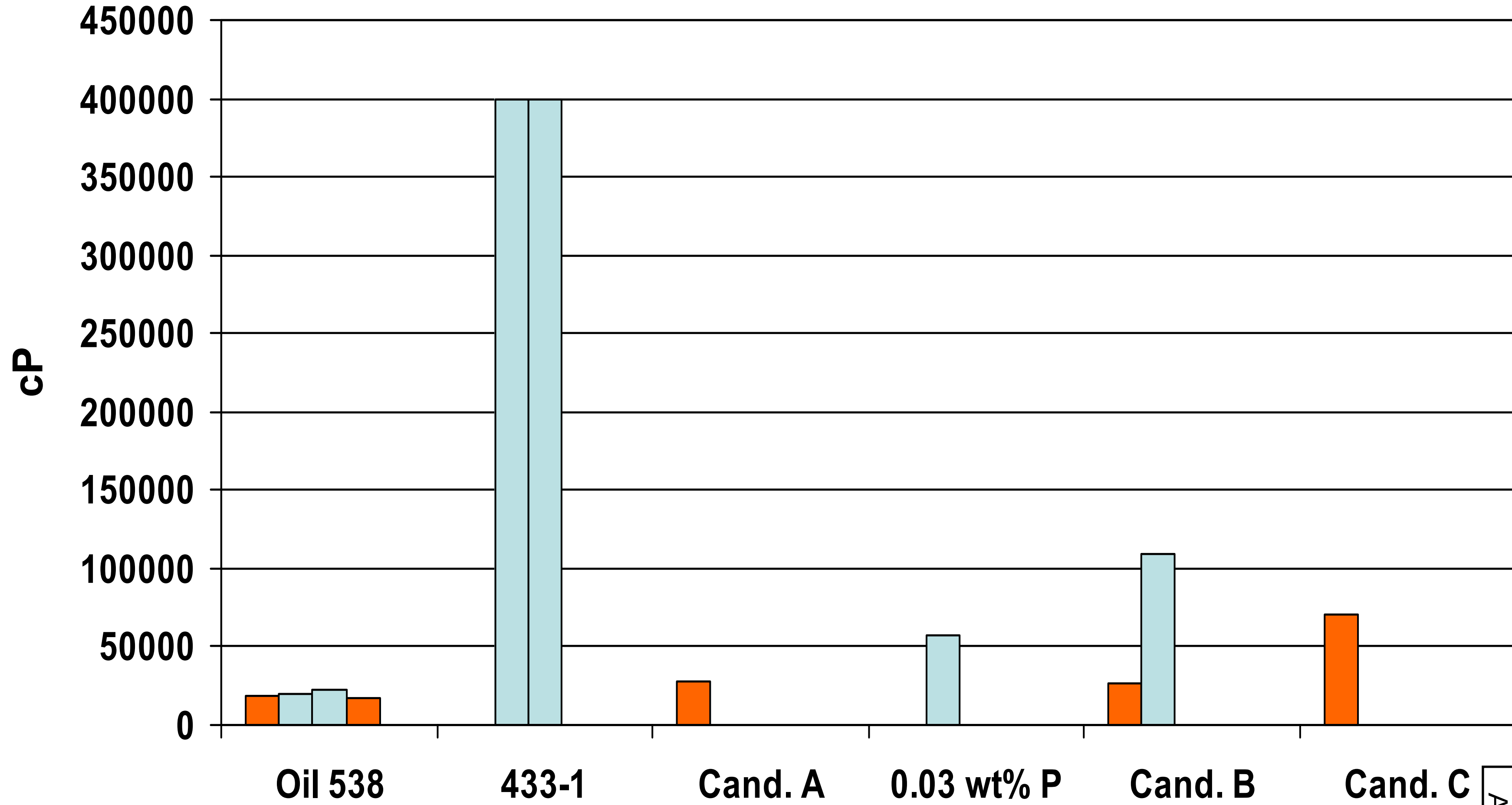


Orange – SwRI

Green – PE

Blue - LZ

Sequence IIIG MRV



Orange – SwRI

Green – PE

Blue - LZ

Attachment 6

Attachment 6

Sequence IIIG Matrix Oils Performance in Other Tests

Matrix Oil	TMC 538	Oil B	Oil C
SAE Grade	5W-20	5W-30	5W-20
% Phosphorous	0.095	0.075	0.075
Sequence IIIE	BL fail ORLD		
Sequence 2x IIIE	MTAC pass		
Sequence IIIF	MTAC pass	Pass (modeling data)	
Sequence 2XIIIF	Pass		Pass
Sequence IVA	Pass	Pass (modeling data)	Pass
Sequence VE	Pass		
Sequence VG	Pass	Pass (modeling data)	Pass
Sequence VIB	1.89/1.55*	1.5/1.1 (modeling data)	Pass (GF-3)
Sequence VIII	Pass	Pass (modeling data)	Pass
BRT	Pass	Pass (modeling data)	Pass
TEOST 33	<20		Pass (GF-3)
TEOST MHT-4	<25	29 (modeling data)	Pass (GF-3)
Field Tests	Commercial		Ford & DC

* Current LTMS targets

Attachment 6

Sequence IIIG Recommended Matrix Oils IIIG Performance Data Available

	ASTM 538	Oil B	Oil C
SAE Grade	5W-20	5W-30	5W-20
# of Tests	5	2	2
Viscosity Increase %	113	123	194
PSV merits	8.58	8.67	8.42
WPD merits	3.09	4.14	3.08
ACLW micrometers	19.9	31.5	38

Attachment 6

Other Sequence IIIG Matrix Oils Considered IIIG Performance Data Available

	ASTM 433	Oil A	0.03% P Oil
SAE Grade	5W-30	5W-20	5W-30
# of Tests	3	1	1
Viscosity Increase %	172	106	114
PSV merits	8.54	8.46	8.48
WPD merits	3.07	3.74	3.24
ACLW micrometers	58.1	44.6	36.7

Oil Supply

- **A minimum supply of 500 gallons of each oil is desired before starting the matrix**

- **Oil 538 is in current ASTM TMC inventory in large supply**
  - **1000 gallons should be assigned for IIIG use**

- **The suppliers of oils B & C have been requested to supply 500 gallons of oil to the ASTM TMC by the end of February**
  - **Oil B should meet this request**
  - **Oil C should meet this request**

Changes to IIIG procedure CCS and MRV testing

13.6 End-of-Test Used Oil Sample Testing -Conduct a Cold-Cranking Simulator test (Test Method D5293) and a Mini Rotary Viscometer test (Test Method D4684) on the end-of-test (EOT) used oil sample with the exceptions that follow.

13.6.1 For non reference oils run a Cold-Cranking Simulator (CCS) test (Test Method D5293) on the end-of-test (100 hour) analysis sample at the temperature specified for the test oils given viscosity grade in [1]Table 1 of SAE J300 Revised DEC1999. Report results on Form 6, Used Oil Analysis Results, in the standardized report form set (See A6).

13.6.2 Run the Mini Rotary Viscometer test (Test Method D4684), MRV-TP1 at grade using the SAE J300 specifications, if a passing CCS result is obtained at grade. If the CCS fails run the MRV at the same temperature as the CCS (one grade higher based on the J300). Report the end-of-test Mini Rotary Viscometer test results as MRV Temperature in °C as follows. If a Yield Stress is obtained at the designated temperature report the Yield Stress in Pa and note the Apparent Viscosity as not measured (NM). If a Yield Stress is not obtained at the designated temperature, report the Yield Stress as not measured (NM) and record the Apparent Viscosity in cP. Report the results on Form 6, Used Oil Analysis Results, in the standardized report form set (See A6).

13.6.3 If the % Viscosity Increase for the kinematic viscosity at EOT is higher than (*IIIG limit specified*) TBD %, the CCS and MRV tests are not required. A notation is required in the Other Comments & Outlier section of Form 13 (See A6) indicating that the CCS and MRV were not run and enter not measured (NM) in the standardized report form set (See A6).

13.6.4 If the test oil is a straight-grade oil, the Cold- Cranking Simulator and Mini -Rotary Viscometer tests are not required. A notation is required in the Other Comments & Outlier section of Form 13 (See A6) indicating that the CCS and MRV were not run and enter not measured (NM) in the standardized report form set (See A6).

The following section will be deleted.

~~13.6.5 If the end-of-test used oil sample fails the Cold Cranking Simulator test at -10°C, the, Mini Rotary Viscometer (MRV) test is 'not required. A notation is required in the Other Comments & Outlier section of Form 13 (See A6) indicating that the MRV was not run because the EOT drain did .not meet the -10°C CCS requirements. Enter not measured (NM) in the standardized report form set (See A6) for the MRV measurement.~~

[1] *SAE J300, Engine Oil Viscosity Classification, December 1999. {Footnote will be given an appropriate number when this section is incorporated into the Sequence IIIG Test Method.}*

Attachment 8

February 14, 2003

To: William Nahumck, Sequence III Surveillance Panel Chair

Re: Sequence III G Cam Batch Coding Proposal

As requested at the November 2002 Sequence III Surveillance Panel meeting, this letter formalizes the American Chemistry Council (ACC) Product Approval Protocol Task Group (PAPTG) members' consensus request that the III G cams be batch coded so as to provide information on phosphating runs. We believe this is a valuable adjunct to the much appreciated efforts by the test sponsor, supplier and Surveillance Panel to ensure a well controlled phosphating process, which we trust will result in a test more useful to the entire industry.

PAPTG's request is intended to facilitate hardware trace-ability at the most appropriate batch scale. We expect that the cost of including phosphate run information in the batch code should be minimal. Given the demonstrated importance of the process, PAPTG believes it is reasonable to expect that changes across phosphate runs *could* produce a significant step change in test performance. In the event that such a change ever does occur, the ability to identify a phosphate run could prove invaluable, affording benefits such as: faster diagnosis and data-based management of the problem, facilitation of root cause analysis, and improved maintenance of test precision. Rapid recognition that a change has occurred can also afford significant test cost savings. Cam batch codes should also define uniquely the other major production steps within the pour code: rough grind runs, hardening runs, and final grind runs.

As requested, the Sequence III D process was investigated. Cam batch codes were not documented at all for III D candidate or reference tests. However, the production workflow of the III D cam production was quite similar to the III G system with "Pour," "Grind," and "Phosphate" runs. III D phosphate runs were scheduled in three successive "baskets" of about 40 cams each, which represented a single day's production, or about 120 cams. PAPTG proposes adoption of this scheduling approach of three successive "baskets" on a single day for III G cams. This produces three phosphate lots of cams, which should be most nearly identical, affording anticipated benefits in test precision and, in conjunction with "basket" scale batch codes, enhanced analytical acuity.

As a point of information, every III D phosphate run was also monitored on site by representatives from industry (test labs). Today's system likely obtains similar or better oversight via the parts distributor.

In summary, PAPTG urges that III G cam batch codes capture phosphating dip rack information, that phosphating racks be scheduled in the longest sequential runs possible, and that codes also capture rough grind, hardening, and final grind lots, in addition to the pour lots currently coded.

Thank you for considering PAPTG's viewpoint in your deliberations, and for the collective efforts of all Panel participants toward creating a Sequence III G test which best fulfills its mission. Please share this request with your Panel members, test sponsors, and hardware suppliers. We look forward to your actions addressing our request.

Regards,

W.D. Anderson
W.D. (Doug) Anderson
PAPTG Manager

Rick Klein
Rick Klein
PAPTG Chair

Attachment 9

Sequence IIIG Discrimination Data Analysis

Jo Martinez
Chevron Oronite
February 11, 2003

Attachment 9

Discrimination

- At least one of the oils used in matrix testing must be ***statistically significantly different*** from at least one of the remaining oils.

- This difference must be in the correct direction.

- ***Significant difference*** may be declared with a ***p-value of 0.10 or less*** using the appropriate multiple comparison technique for the least square means of the oils.

Attachment 9

Sequence IIIG Data

Lab	TestOil	VisInc	ACLW	WPD	PSV
PE	Ref Oil 538	118.9	16.8	3.3	9.04
SR	Ref Oil 538	91.6	17.9	2.9	8.73
PE	Ref Oil 538	101.2	15.8	2.64	8.1
SR	Ref Oil 538	92.7	19.3	2.89	8.25
WK	Ref Oil 538	158.7	29.9	3.73	8.76
SR	Ref Oil 433-1	TVTM	98.9	3.13	8.51
PE	Ref Oil 433-1	191	37.7	2.94	8.46
PE	Ref Oil 433-1	152.6	37.8	3.14	8.64
PE	0.03Phos	114	36.7	3.24	8.48
SR	CandA	106	44.6	3.74	8.46
PE	CandB	91.3	20.8	4.21	8.68
SR	CandB	154.8	42.2	4.06	8.66
SR	CandC	159	43.2	2.97	7.88

Statistical Analysis

- Two linear models were fitted.

1. With Test Oil effect
2. With Test Oil effect and Laboratory effect

- Tukey-Kramer's multiple comparison technique was used to compare the least square means of oils.

Attachment 9

WPD

P-values for Model: WPD = Test Oil ; Sigma=RMSE=0.33

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	3.07	3.09	3.24	3.74	4.14	2.97
Oil 433-1	3.07		1.00	1.00	0.54	**0.07**	1.00
Oil 538	3.09	1.00		1.00	0.53	**0.05**	1.00
0.03 wt% P	3.24	1.00	1.00		0.88	0.34	0.99
Cand. A	3.74	0.54	0.53	0.88		0.91	0.60
Cand. B	4.14	**0.07**	**0.05**	0.34	0.91		0.15
Cand. C	2.97	1.00	1.00	0.99	0.60	0.15	

- **Candidate Oil B is statistically significantly higher than Oil 433-1 and Oil 538. If direction is acceptable then discrimination is evident.**

P-values for Model: WPD = Test Oil + Lab ; Sigma=RMSE=0.23

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	3.33	3.20	3.49	4.03	4.40	3.26
Oil 433-1	3.33		0.97	0.99	0.28	**0.02**	1.00
Oil 538	3.20	0.97		0.87	0.15	**0.01**	1.00
0.03 wt% P	3.49	0.99	0.87		0.67	0.14	0.98
Cand. A	4.03	0.28	0.15	0.67		0.78	0.30
Cand. B	4.40	**0.02**	**0.01**	0.14	0.78		**0.07**
Cand. C	3.26	1.00	1.00	0.98	0.30	**0.07**	

- **Candidate Oil B is statistically significantly higher than Candidate Oil C. If direction is acceptable then discrimination is evident.**

PSV

P-values for Model: PSV = Test Oil ; Sigma=RMSE=0.30

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	8.54	8.58	8.48	8.46	8.67	7.88
Oil 433-1	8.54		1.00	1.00	1.00	1.00	0.47
Oil 538	8.58	1.00		1.00	1.00	1.00	0.37
0.03 wt% P	8.48	1.00	1.00		1.00	0.99	0.72
Cand. A	8.46	1.00	1.00	1.00		0.99	0.74
Cand. B	8.67	1.00	1.00	0.99	0.99		0.36
Cand. C	7.88	0.47	0.37	0.72	0.74	0.36	

- **No oil is statistically significantly different from other oils thus lacking discrimination.**

P-values for Model: PSV = Test Oil + Lab ; Sigma=RMSE=0.34

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	8.60	8.61	8.53	8.56	8.75	7.98
Oil 433-1	8.60		1.00	1.00	1.00	1.00	0.69
Oil 538	8.61	1.00		1.00	1.00	1.00	0.64
0.03 wt% P	8.53	1.00	1.00		1.00	0.99	0.89
Cand. A	8.56	1.00	1.00	1.00		1.00	0.82
Cand. B	8.75	1.00	1.00	0.99	1.00		0.55
Cand. C	7.98	0.69	0.64	0.89	0.82	0.55	

- **No oil is statistically significantly different from other oils thus lacking discrimination.**

Attachment 9

Attachment 9

ACLW

P-values for Model: ACLW = Test Oil ; Sigma=RMSE=20.2

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	58.1	19.9	36.7	44.6	31.5	43.2
Oil 433-1	58.1		0.22	0.93	0.99	0.70	0.98
Oil 538	19.9	0.22		0.97	0.86	0.98	0.89
0.03 wt% P	36.7	0.93	0.97		1.00	1.00	1.00
Cand. A	44.6	0.99	0.86	1.00		0.99	1.00
Cand. B	31.5	0.70	0.98	1.00	0.99		1.00
Cand. C	43.2	0.98	0.89	1.00	1.00	1.00	

- **No oil is statistically significantly different from other oils thus lacking discrimination.**

P-values for Model: ACLW = Test Oil + Lab ; Sigma=RMSE=16.7

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	66.4	21.6	53.3	36.3	35.6	34.9
Oil 433-1	66.4		**0.10**	0.98	0.70	0.45	0.67
Oil 538	21.6	**0.10**		0.62	0.96	0.91	0.98
0.03 wt% P	53.3	0.98	0.62		0.98	0.95	0.97
Cand. A	36.3	0.70	0.96	0.98		1.00	1.00
Cand. B	35.6	0.45	0.91	0.95	1.00		1.00
Cand. C	34.9	0.67	0.98	0.97	1.00	1.00	

- **Oil 433-1 is statistically significantly higher than Oil 538. If direction is acceptable then discrimination is evident.**

Transformed Viscosity Increase

P-values for Model: TVisInc = Test Oil ; Sigma=RMSE=0.026

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	0.051	0.096	0.094	0.097	0.093	0.079
Oil 433-1	0.051		0.28	0.72	0.65	0.54	0.92
Oil 538	0.096	0.28		1.00	1.00	1.00	0.99
0.03 wt% P	0.094	0.72	1.00		1.00	1.00	1.00
Cand. A	0.097	0.65	1.00	1.00		1.00	1.00
Cand. B	0.093	0.54	1.00	1.00	1.00		1.00
Cand. C	0.079	0.92	0.99	1.00	1.00	1.00	

- **No oil is statistically significantly different from other oils thus lacking discrimination.**

P-values for Model: TVisInc = Test Oil + Lab ; Sigma=RMSE=0.024

Test Oil		Oil 433-1	Oil 538	0.03 wt% P	Cand. A	Cand. B	Cand. C
	LSMean	0.040	0.093	0.074	0.103	0.086	0.085
Oil 433-1	0.040		0.20	0.83	0.42	0.43	0.69
Oil 538	0.093	0.20		0.98	1.00	1.00	1.00
0.03 wt% P	0.074	0.83	0.98		0.97	1.00	1.00
Cand. A	0.103	0.42	1.00	0.97		0.99	0.99
Cand. B	0.086	0.43	1.00	1.00	0.99		1.00
Cand. C	0.085	0.69	1.00	1.00	0.99	1.00	

- **No oil is statistically significantly different from other oils thus lacking discrimination.**

Attachment 9

Attachment 9

Lab to Lab Variability

WPD

Lab		PE	SR	WK
	LSMean	3.37	3.33	4.15
PE	3.37		0.96	**0.07**
SR	3.33	0.96		**0.06**
WK	4.15	**0.07**	**0.06**	

- **WK is statistically significantly higher compared to PE and SR.**

PSV

Lab		PE	SR	WK
	LSMean	8.46	8.40	8.66
PE	8.46		0.97	0.87
SR	8.40	0.97		0.80
WK	8.66	0.87	0.80	

- **No statistically significant difference between laboratories.**

ACLW

Lab		PE	SR	WK
	LSMean	24.8	49.6	49.7
PE	24.8		0.17	0.47
SR	49.6	0.17		1.00
WK	49.7	0.47	1.00	

- **No statistically significant difference between laboratories.**

TVisInc

Lab		PE	SR	WK
	LSMean	0.100	0.074	0.067
PE	0.100		0.36	0.52
SR	0.074	0.36		0.96
WK	0.067	0.52	0.96	

- **No statistically significant difference between laboratories.**