Committee D-2 ON PETROLEUM PRODUCTS AND LUBRICANTS

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June 20, 2000

Reply to: Mark Cooper
Chevron Chemical Co.
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San Antonio, TX 78228
P 210 731-5606
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email mawc@chevron.com

Unconfirmed Minutes of the ASTM Mack T10 Task Force

Held in Cleveland, Ohio On April 18, 2000

1. Call to Order

1.1 An agenda is shown as Attachment 1.

1.2 An attendance list is shown as Attachment 2.

2. Minutes from the December 2, 1999 Meeting

2.1 The minutes from the December 2, 1999 meeting were not available for review before this meeting.

3. Membership Changes

3.1 Brian Lawrence indicated that he would be moving back to England in June and that the June meeting in Seattle will be the last meeting that he presides over as chairman. Brian noted that Mark Stevens will probably represent Infineum with support from Pat Fetterman.

4. CPD Report

4.1 Perkin Elmer purchased an engine that TEI is using for the development of modified EGR components to reduce breakage problems. TEI is working with Mack and other interested parties on these modifications.

4.2 TEI is still working on the supply of other EGR engine parts such as camshafts. TEI did not have any estimate of when turbochargers or rebuild kids would be available. Ken Goshorn is still working on the supply of EGR components.

4.3 Greg Shank indicated that Mack is working with the supplier to provide EGR cylinder kits. The supplier would prefer to work with an accurate initial estimate. After some discussion Bob Campbell made the following motion (seconded by Dino Righi):

Motion: Acquire 1296 cylinder rebuild kids (sufficient quantity for 216 engine rebuilds)

Motion Passed: Unanimously

4.4 Gary Tietze showed a slide that indicated the quantities of connecting rod bearings and main bearings on hand. The panel discussed which bearings should be used during the matrix. The panel wanted to ensure that bearings from the same batches used in the matrix would be available after the matrix. Mark Cooper made the following motion (seconded by Gary Tietze):

Motion: Use Batch 4 connecting rod bearings and Batch 3 main bearings for matrix testing

Motion Passed: Unanimously

5. Operations and Hardware Issues

5.1 Jim Wells indicated that SwRI is making modifications to the oil cooler that will allow labs to run separate water paths through the engine and the oil cooler. SwRI is making 10 adapters that should be complete by early May. Labs should call SwRI to arrange for shipping. TEI indicated that they will work with SwRI to distribute the modified components. Jim Collum made the following motion (seconded by Jeff Clark):

Motion: Use the new oil cooler modification on any test that begins after May 15

Motion Passed: Unanimously

5.2 Jim Collum asked if any labs were having other difficulties that they wanted to have addressed. The bracket / supports for EGR hardware and the water pump belt were mentioned.

6. Test Sponsor Update

6.1 Greg Shank presented the T10 Test Discrimination Data shown in Attachment 3.

6.2 Bob Campbell asked to Greg if he had any soot numbers. Greg indicated that some of the data is in the 5% range and some of the data is in the 7% range. Greg indicated that labs had not indicated any problems hitting the soot window of 4.5-5.5%.

7. Oil Temperature

7.1 Greg Shank presented the results of some heat rejection studies that had recently been completed by Mack in their engine lab. These studies show that heat rejection is 30 to 40% higher on EGR engines when compared to conventional engines. Mack's chassis people indicated that they cannot provide that much additional cooling.

7.2 Mark Stevens showed various plots of iron, TAN, TBN and lead from T10 tests run at 225 and 235 F oil temperature on the same oil. Mark also showed data from two tests run on Oil 1005, one test run at 225 and the other run at 235 F oil temperature. Oil consumption rate became excessive during the last 25 hours on the 235 F run. This data is shown in Attachment 4.

7.3 Brian Lawrence asked if the group was comfortable that the T10 test demonstrates discrimination using the data shown by Greg Shank end the data shown by Mark Stevens. Bob Campbell stated that data needs to be provided from an oil that does not show a sharp increase in oil consumption and lead between 250 and 300 hours.

7.4 Don Marn noted that the EMA has selected oil technologies for the matrix. Greg Shank indicated that the EMA would possibly revisit matrix oil selection (specifics of the formulations not necessarily technology changes) if we adopt 235 F oil temperature.

7.5 Greg Shank stated that Oil 1005 is not appropriate for comparisons at 235 F, but Greg recognized that a baseline is needed. There was considerable discussion about the loss of a baseline and the changes required (example oil additions) associated with the 235 F oil temperature and the end on magnitude of the change.

7.6 The Unknown Motion Maker made the following motion (seconded by Jim Collum):

Motion: Use 113 C oil temperature for each lab except SwRI. SwRI will use 235.4 F oil temperature.

Motion Passed: Unanimously

8. Oxidation Measurement

8.1 Mark Stevens expressed interest in changing the oxidation measurement from the peak measurement to an area measurement. Mark indicated that he will provide details on the integration technique to the group.

9. Oil Consumption

9.1 The current oil addition rate does not provide sufficient quantity of oil to prevent the oil weigh bucket from going dry late in the test with some oils. The panel discussed various options to address the oil consumption problem including using different oil addition rates during Stage 1 and Stage 2. After considerable discussion the panel decided to shift the oil addition to the latter portion of the test. Jim Collum made the following motion which (seconded by Jay Dinklage):

Motion: Add no oil during the first 100 hours of the test, and add 5 pounds of oil every 50 hours beginning at 100 hours.

Motion Passed: Unanimously

9.2 The task force discussed how to obtain and oil sample if the oil weigh bucket goes dry. If there is insufficient oil in the oil weigh bucket to obtain a sample at 300 hours, the 300 hour sample will be removed from the sump within 30 minutes of EOT.

9.3 The task force also discussed the status of a test if the oil weigh bucket goes dry before EOT. The task force decided that a test will be considered non-interpretable if there is insufficient oil in the oil weigh bucket to remove an oil sample at 250 hours or earlier.

10. Chemical Analysis Subgroup Report

10.1 No report was given because there was little activity in the subgroup. Information pertaining to area integration to determine oxidation level will be provided to the subgroup.

11. Lab Visitation

11.1 Jeff Clark noted that the checklist is still in complete, but would be available soon.

11.2 Jim Collum indicated the goal is to complete the lab visitation by early June if possible. Jim also indicated that an attempt is being made to coordinate the lab visitations with the M11 EGR test.

11.3 Jeff Clark stated that the TMC will not grant calibration status for any lab if test stands are not available for review by the lab visitation group.

12. Timeline

12.1 Jim Collum presented an updated timeline that is shown as Attachment 5.

13. Scope and Objectives

13.1 A copy of the Scope and Objectives is shown as Attachment 6.

13.2 Greg Shank suggested adding the template checklist to the Scope and Objectives.

13.3 Greg Shank also indicated that he would like to move lead from the secondary to the primary test parameters.

14. Next Meeting

14.1 the next meeting will be scheduled after completion of some T10 tests at 235 F oil temperature but before the Seattle ASTM meetings.

15. Adjournment

Attachment 1

Mack T-10 Task Force Meeting

Date: Tuesday, April 18, 2000
Time: 8:30 AM - Noon
Location: Four Points Hotel, Cleveland East
Wickliffe, Ohio

Agenda

1. Membership	Mark Cooper
2. Previous Minutes	Mark Cooper
3. Test sponsor's update – Discrimination matrix status – Determination of oil gallery temp. – Oxidation – Forced oil make-up/oil consumption	Greg Shank
4. O&H Sub-Group Report – Operational & procedural experience	Jim Collum
5. Chemical Analysis Sub-Group Report	Joe Franklin
6. Lab visitation issues arising	Jeff Clark
7. CPD issues arising	Gary Tietze
8. Timeline Update	Jim Collum (for Brent Shoffner)
9. TF Scope & Objectives - Review	Brian Lawrence
10. Next Meeting/Adjournment	

NB: Will presenters kindly remember to bring a copy of their material on a 3.5" floppy disk, for inclusion in the minutes (MS Word preferred, Powerpoint or Excel acceptable). Thank you.

Secretary:	Chairman:
Mark Cooper/Oronite	Brian Lawrence/Infineum
210-731-5606	210-732-8123

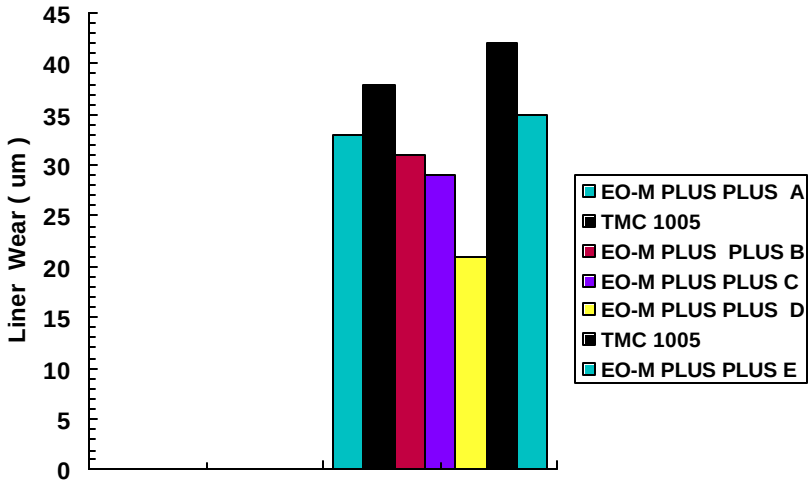
Attachment 2

Attendance Roster

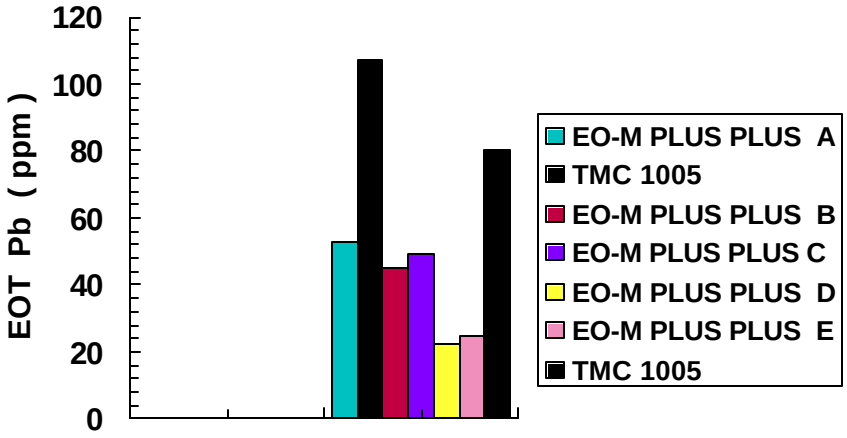
Name	Company
Brian Lawrence	Infineum
Mark Cooper	Oronite
Bob Campbell	Ethyl
Jeff Clark	TMC
Jim Collum	Perkin Elmer
Jay Dinklage	Equilon
Bill Larch	Lubrizol
Don Marn	Lubrizol
Dino Righi	Lubrizol
Greg Shank	Mack
Mark Stevens	Infineum
Gary Tietze	TEI
Jim Wells	SwRI

Attachment 3

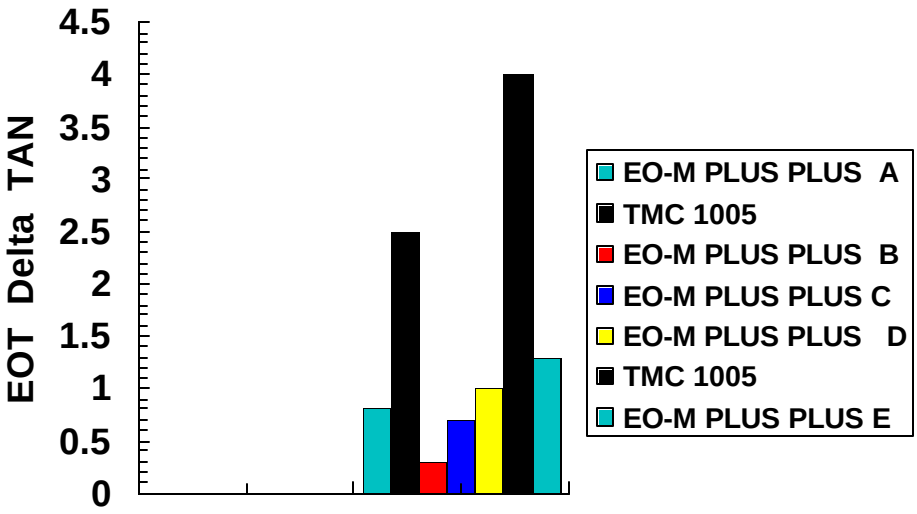
T 10 EGR Test Discrimination



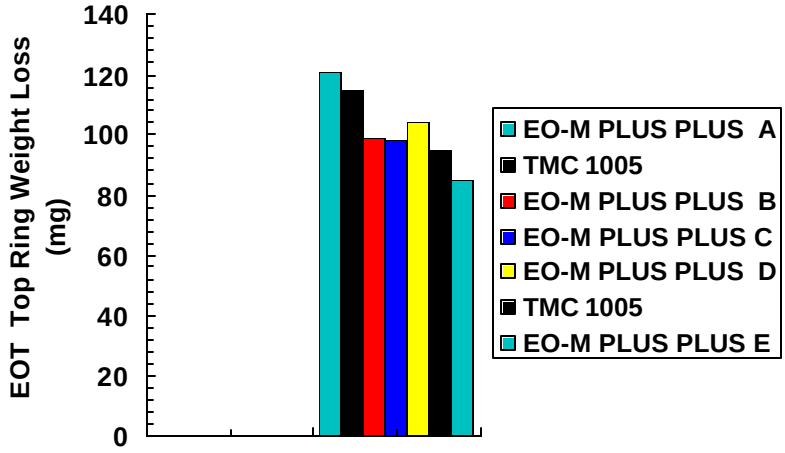
T 10 EGR Test Discrimination



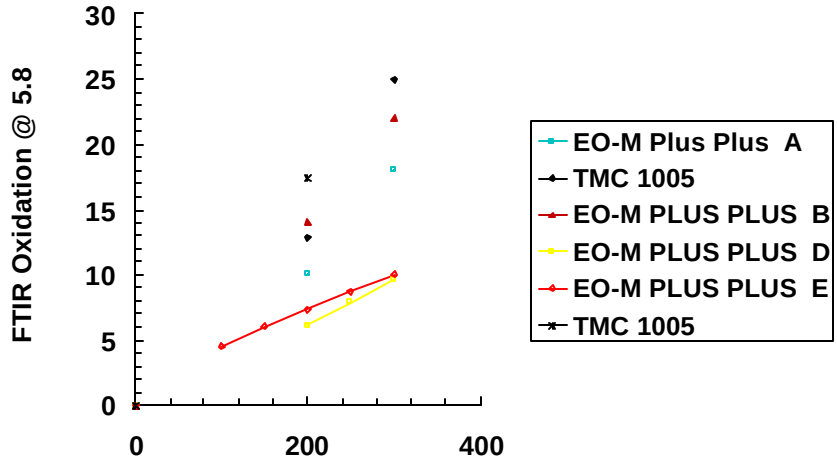
T 10 EGR Test Discrimination



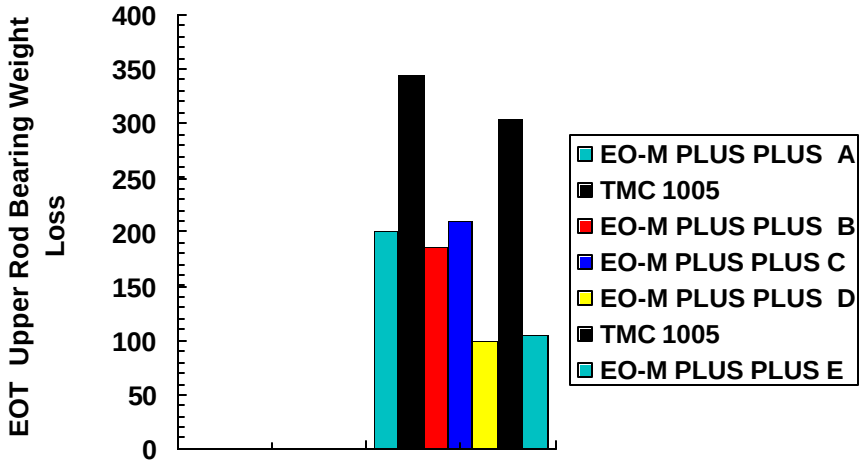
T 10 EGR Test Discrimination



T 10 EGR Test Discrimination



T 10 EGR Test Discrimination



Attachment 4

PC-9 Oxidation Test

EGR Option

PC-9 is an EGR Category

- New Oils Must Protect EGR Engines
- Engines with EGR will place Oil in Different Gas Environment

⇒EGR Engines have Different Oxidation Responses

  - ♦ DSC
  - ♦ Mack T-10

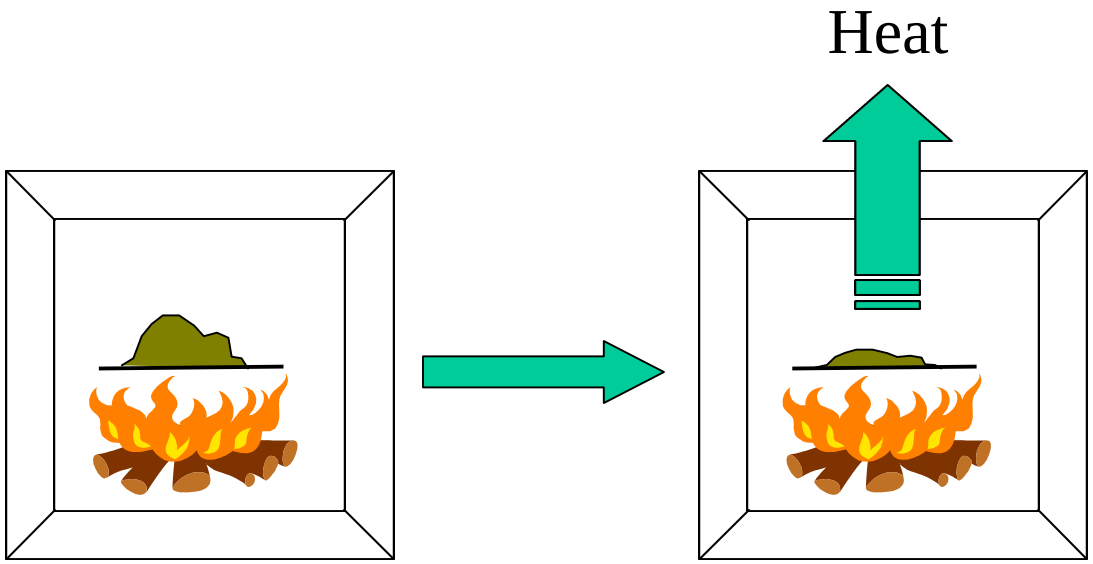
- Measurement of “true” oxidation is critical and possible

Lubricant Oxidation Responses

EGR Effects

Method

- Use Differential Scanning Calorimetry (DSC)



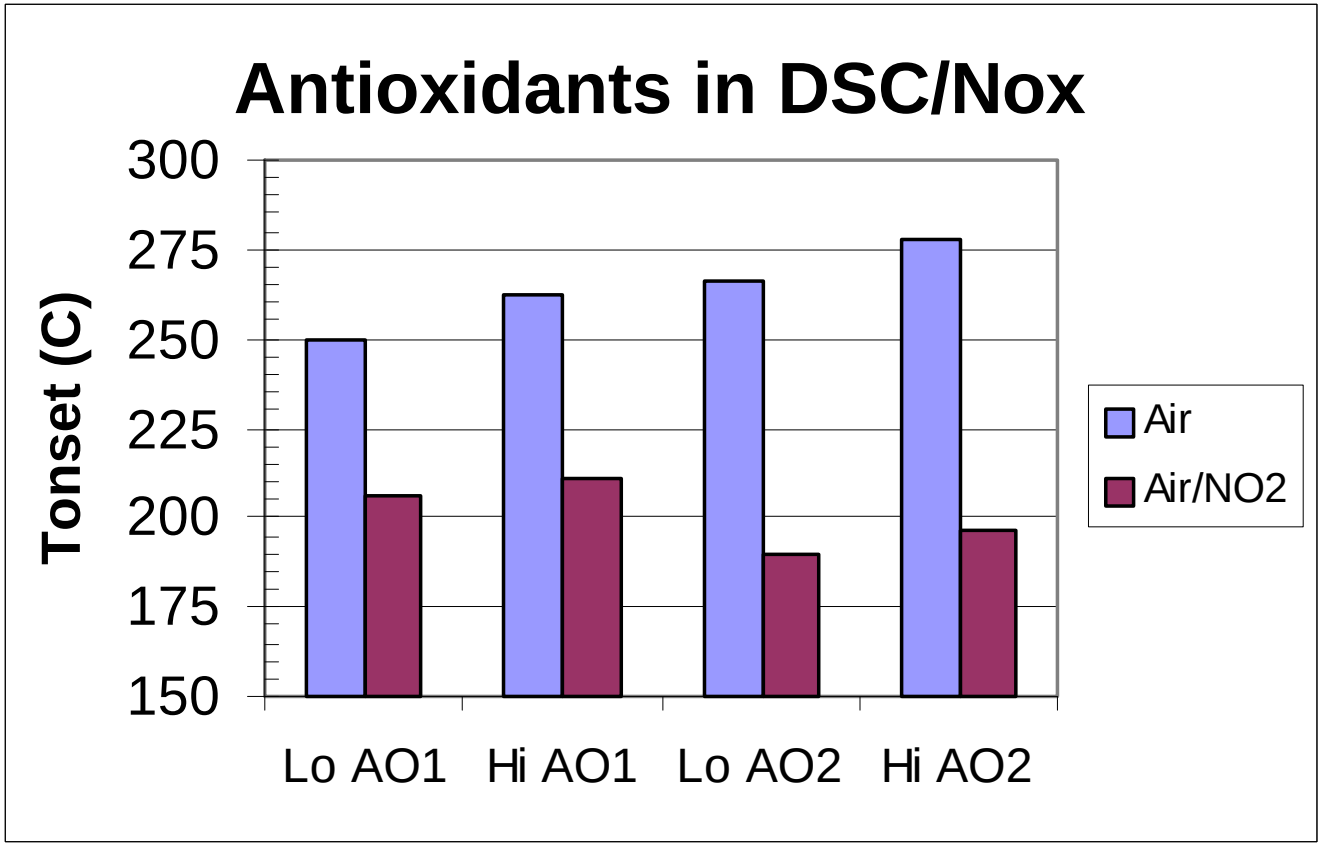
•Air
•Air/NO2

- Gradually heat oil sample
- As critical temperature is reached, oil oxidizes and releases heat.
- Measure temperature at which oil oxidizes.

Experimental Design 1

- Four Oils (typical NA HD technology)
  - Two types of antioxidants
  - High/Low concentrations

Results

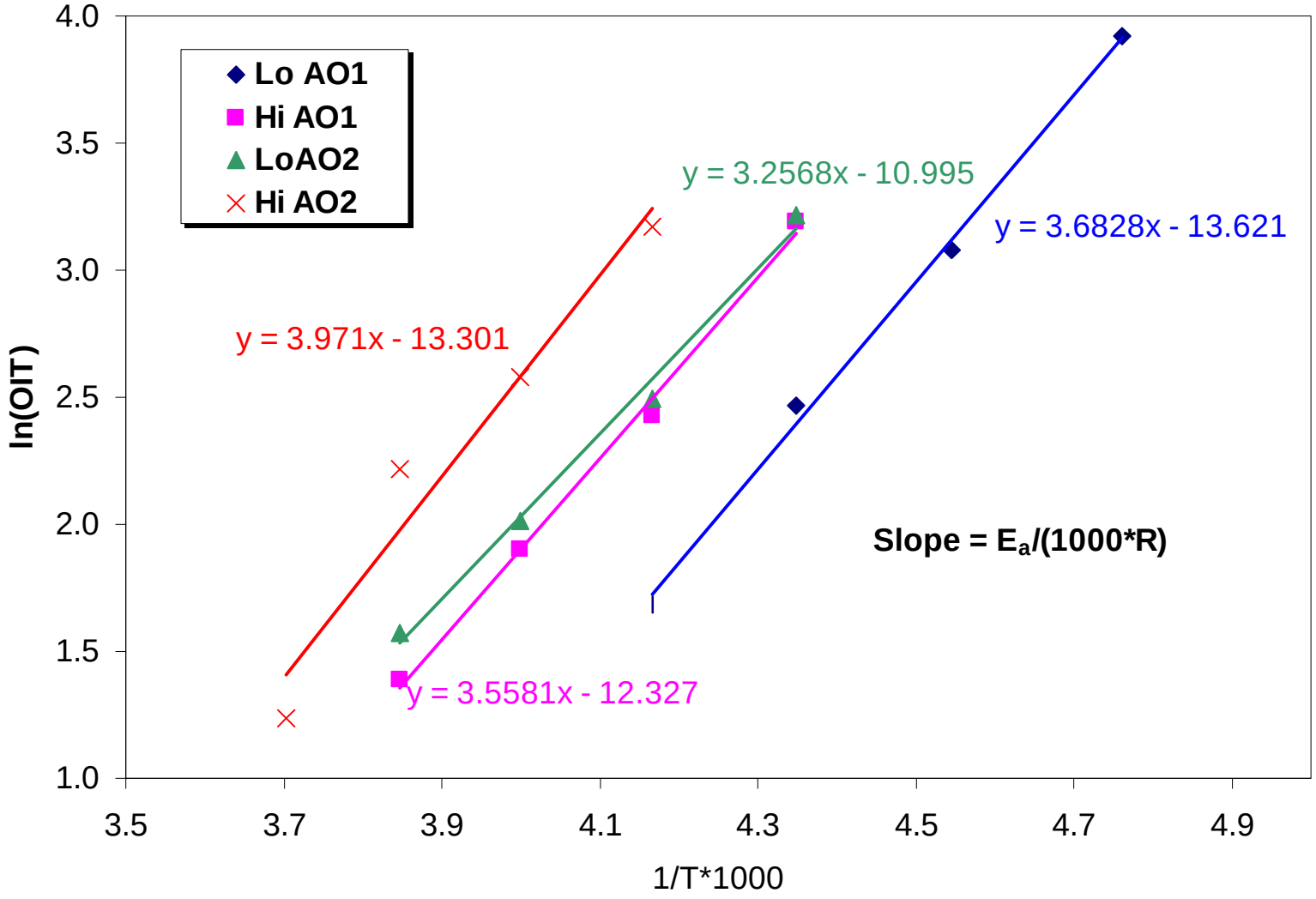


- AO2 is better in air; AO1 is better in NO_2

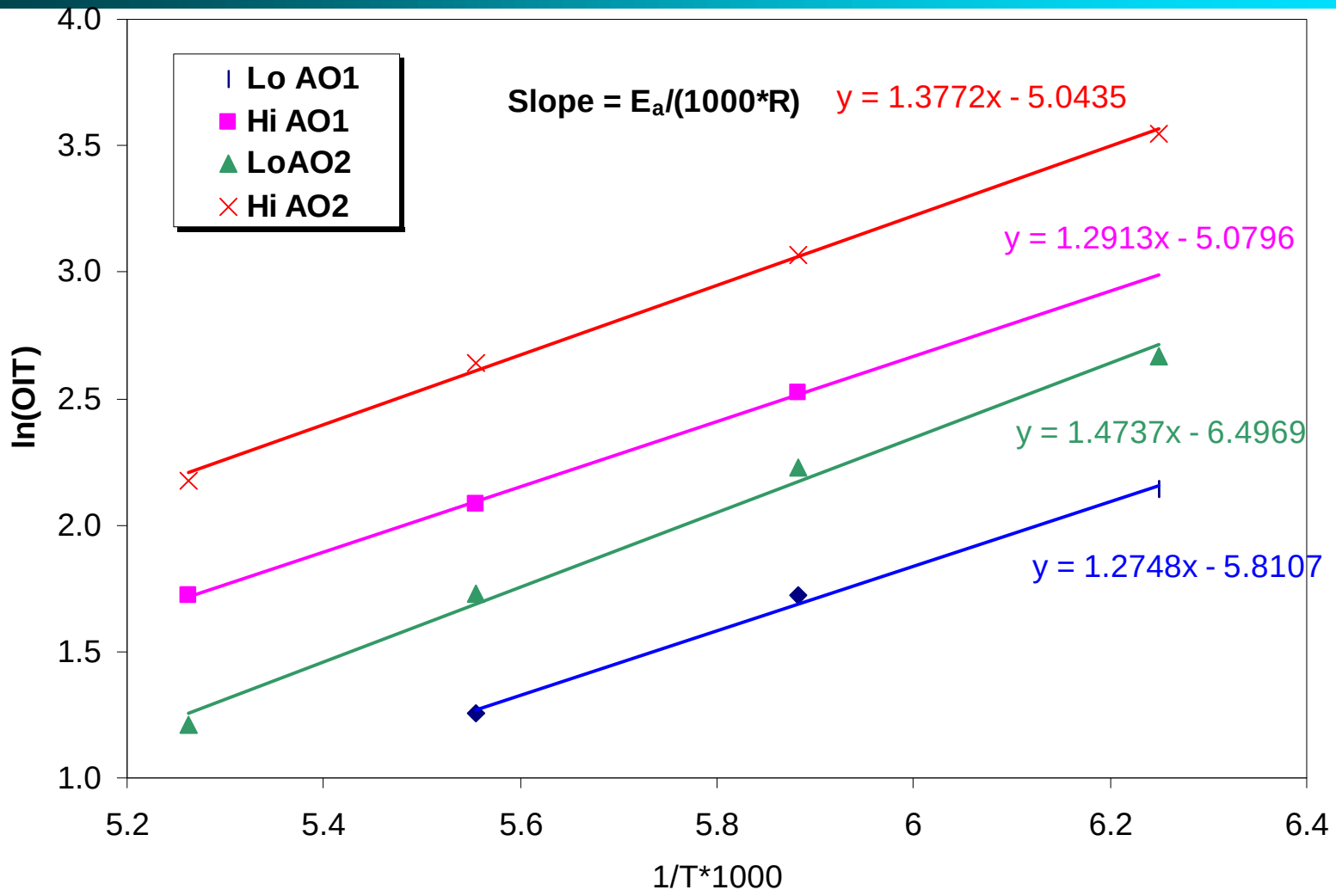
Experimental Design 2

- Four Oils (typical NA HD technology)
  - Two types of antioxidants
  - High/Low concentrations

Oxidation in Air



Oxidation in 1000 ppm NO_2



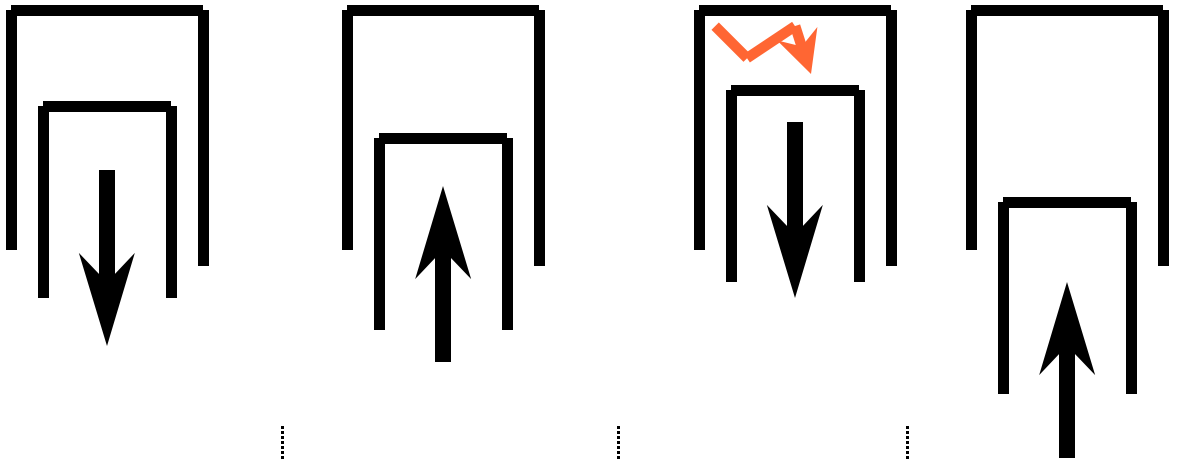
Activation Energy Summary

(kcal/mole)	Air	1000 ppm NO_2
Low AO1	7.3	2.5
High AO1	7.1	2.6
Low AO2	6.5	2.9
High AO2	7.9	2.7

NO_X Catalyzes Oxidation

EGR means Longer NO_X Exposure

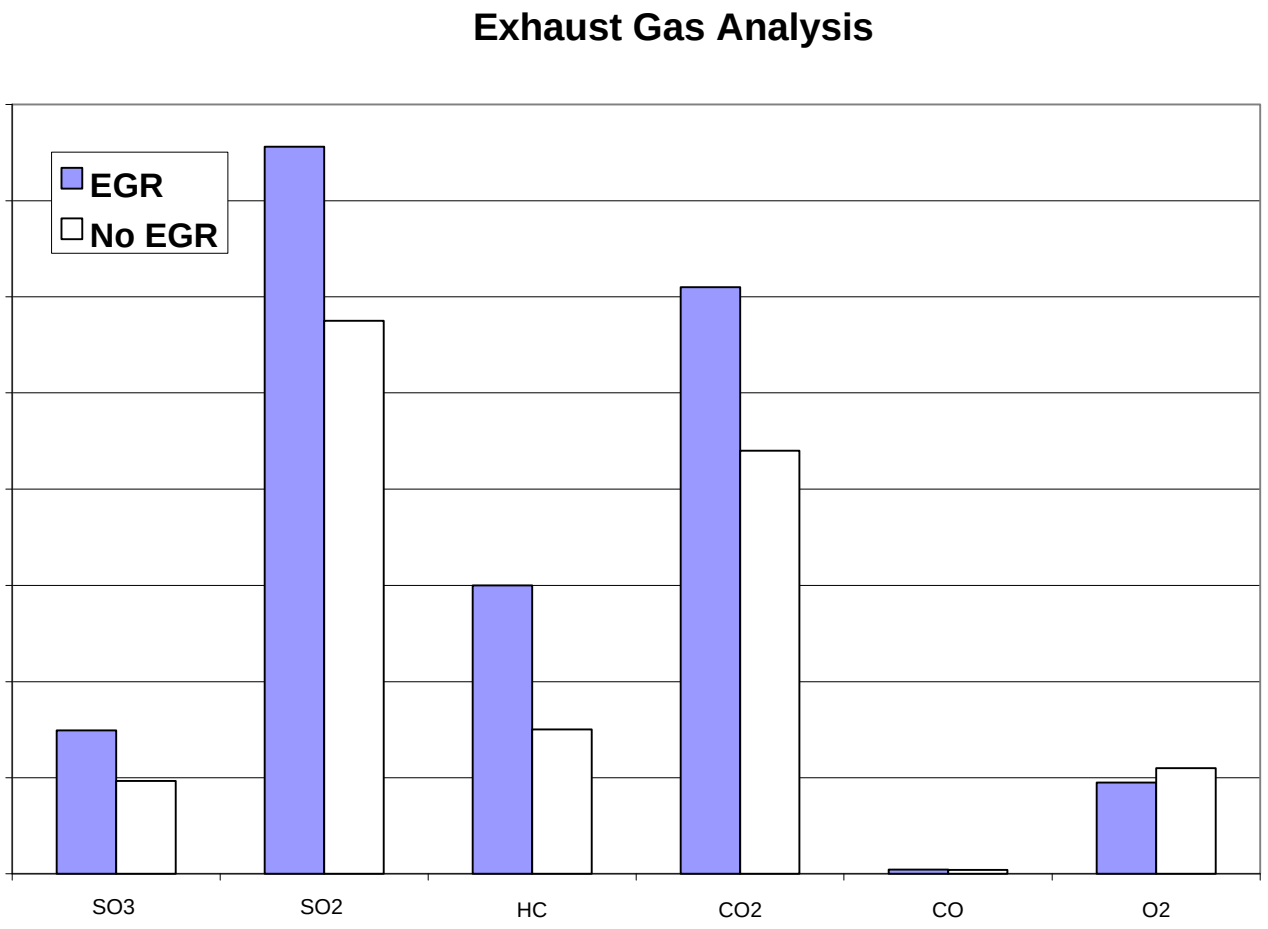
Exposure to NOx during the 4 strokes, without / with EGR, of the lubricant film on the liner and piston (rings, grooves, lands):



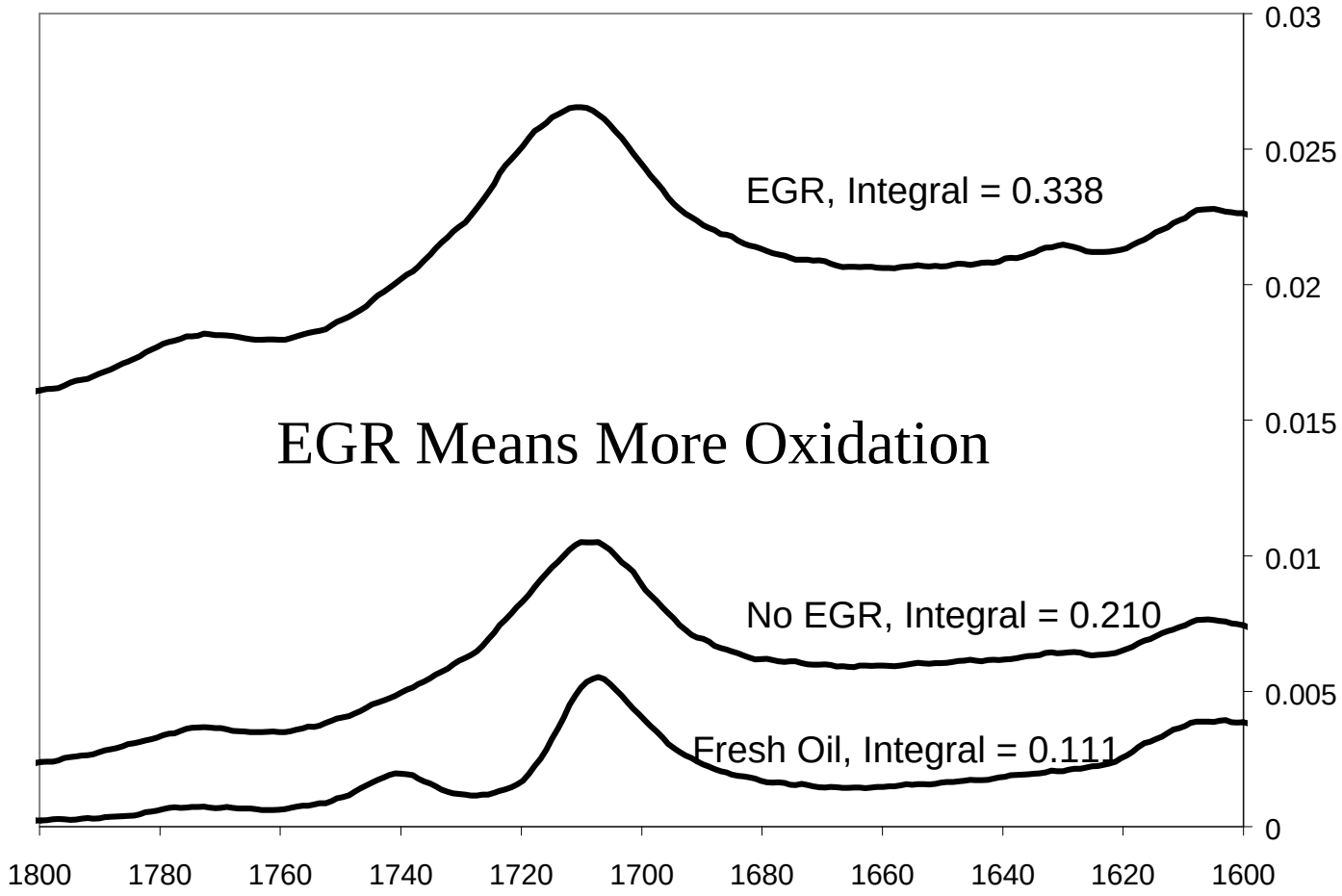
NOx, ppm	intake	**compression**	combustion	exhaust
without EGR	0	**0**	400	400
with EGR	40	**40**	200	200

With EGR, the lubricant film is exposed to NOx during all 4 strokes, esp. ***during the high temperature and pressure compression stroke***

Other differences



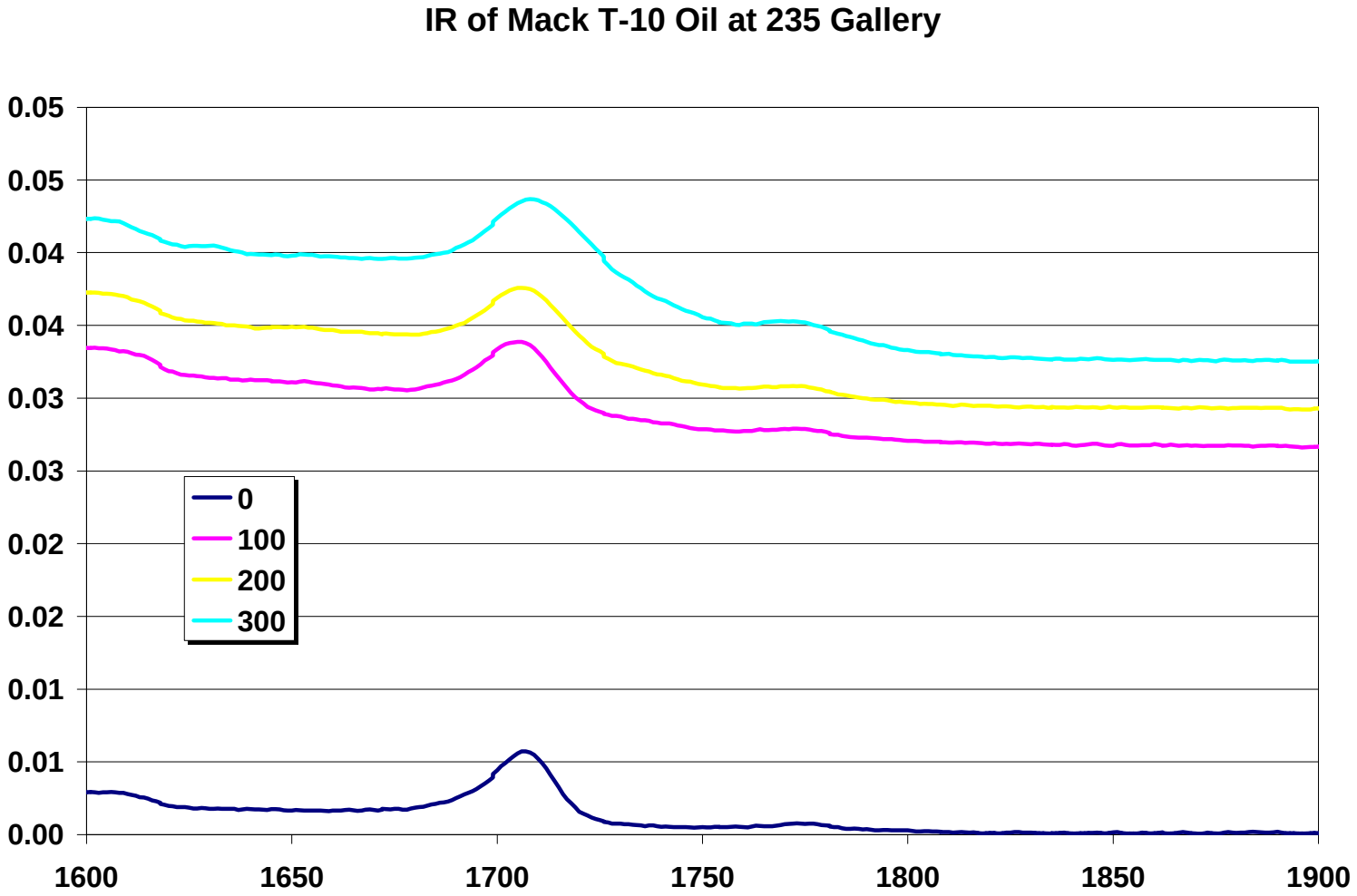
What Does That Mean?



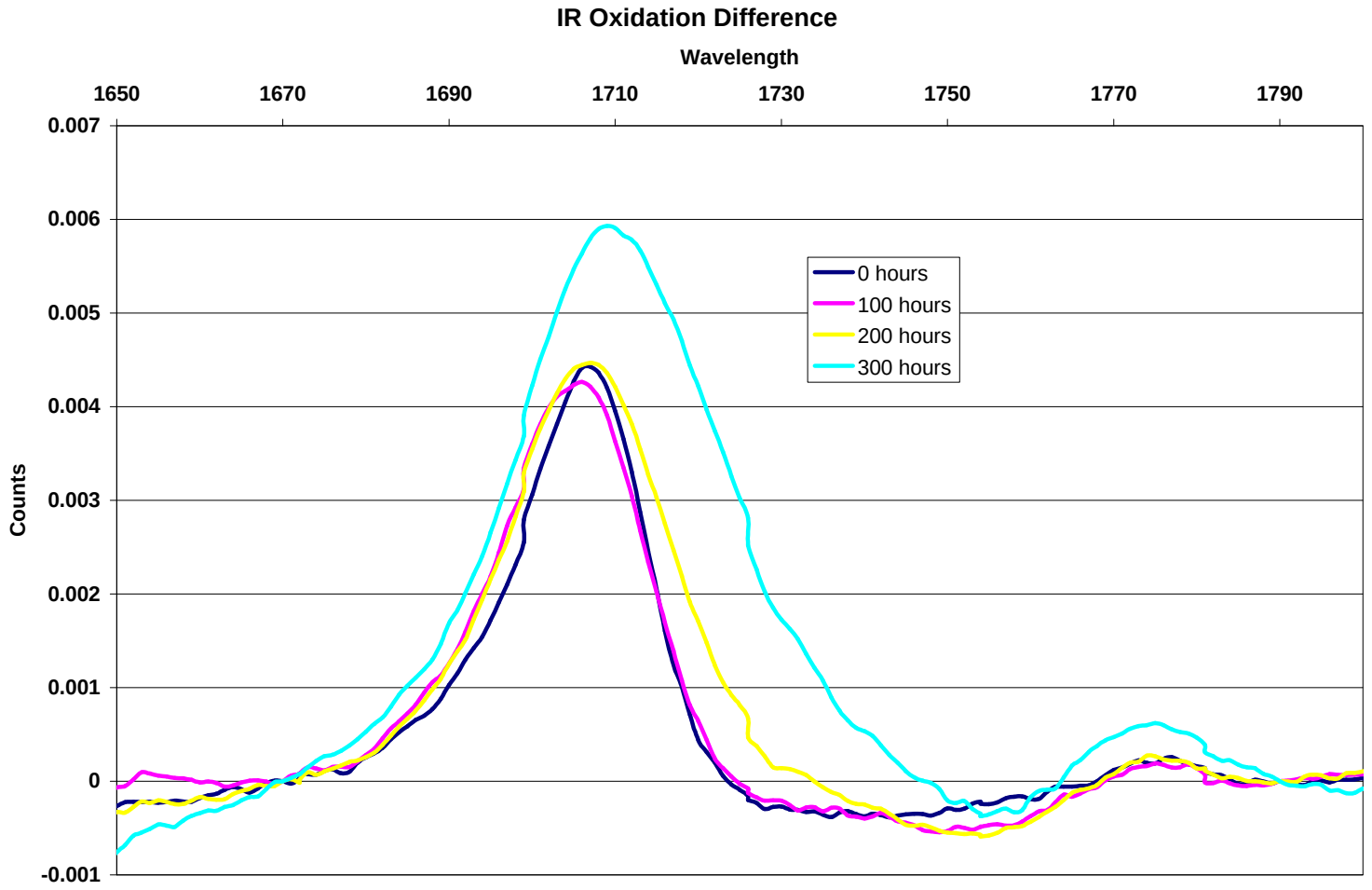
How to Measure Oxidation

Integrated IR Trace indicates the actual amount of oxidized oil products

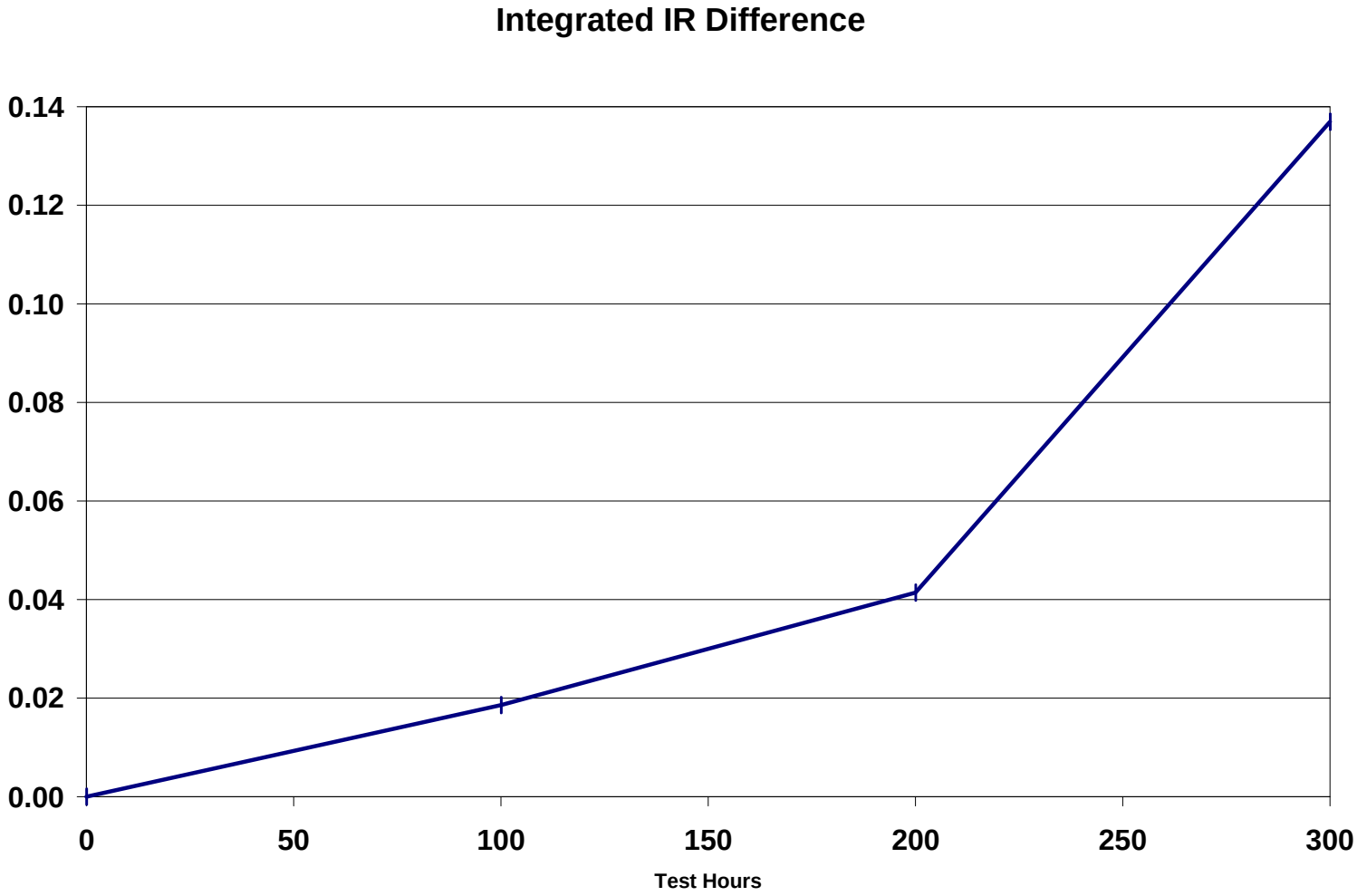
Integrated IR Method



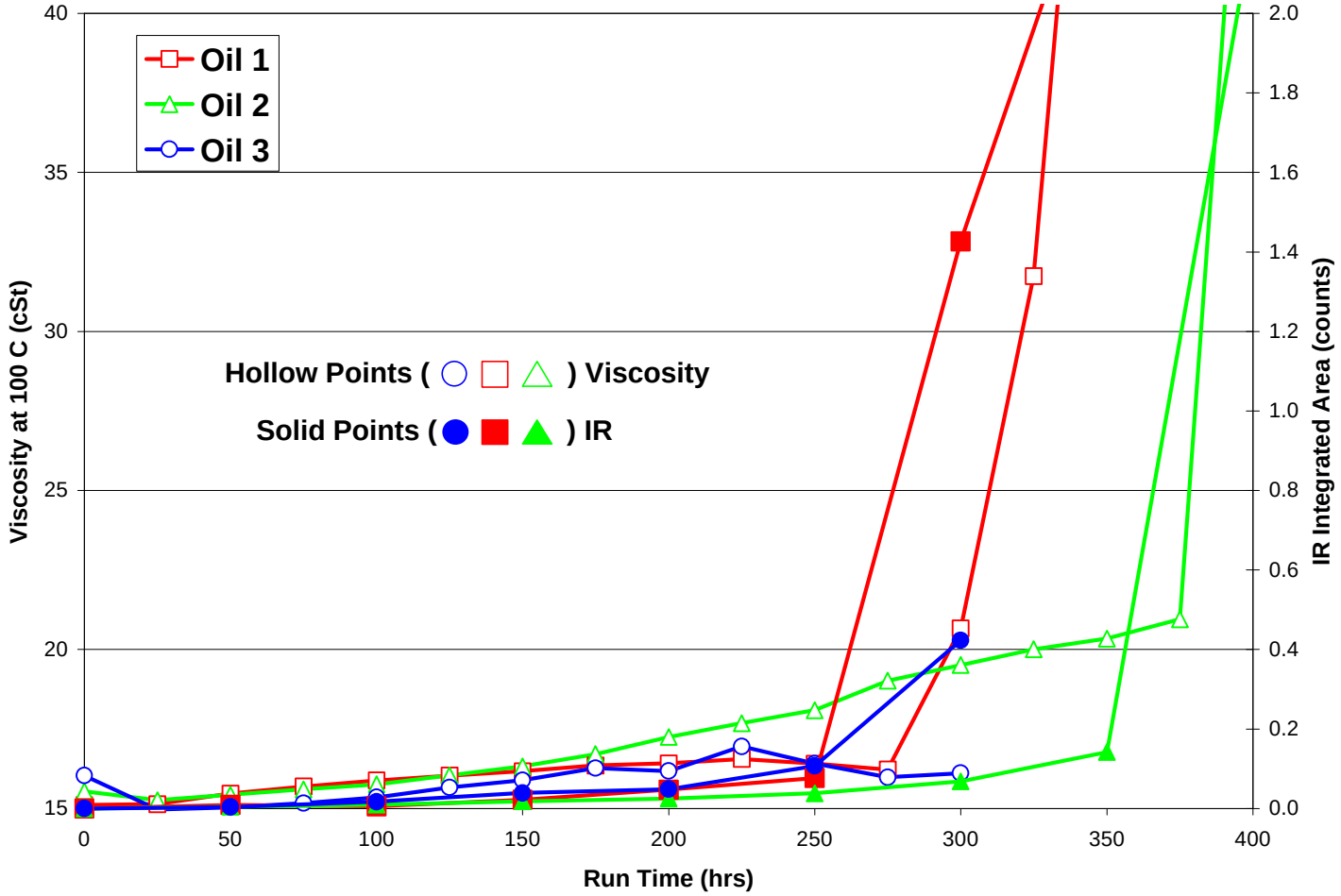
Baseline Correction



Integration

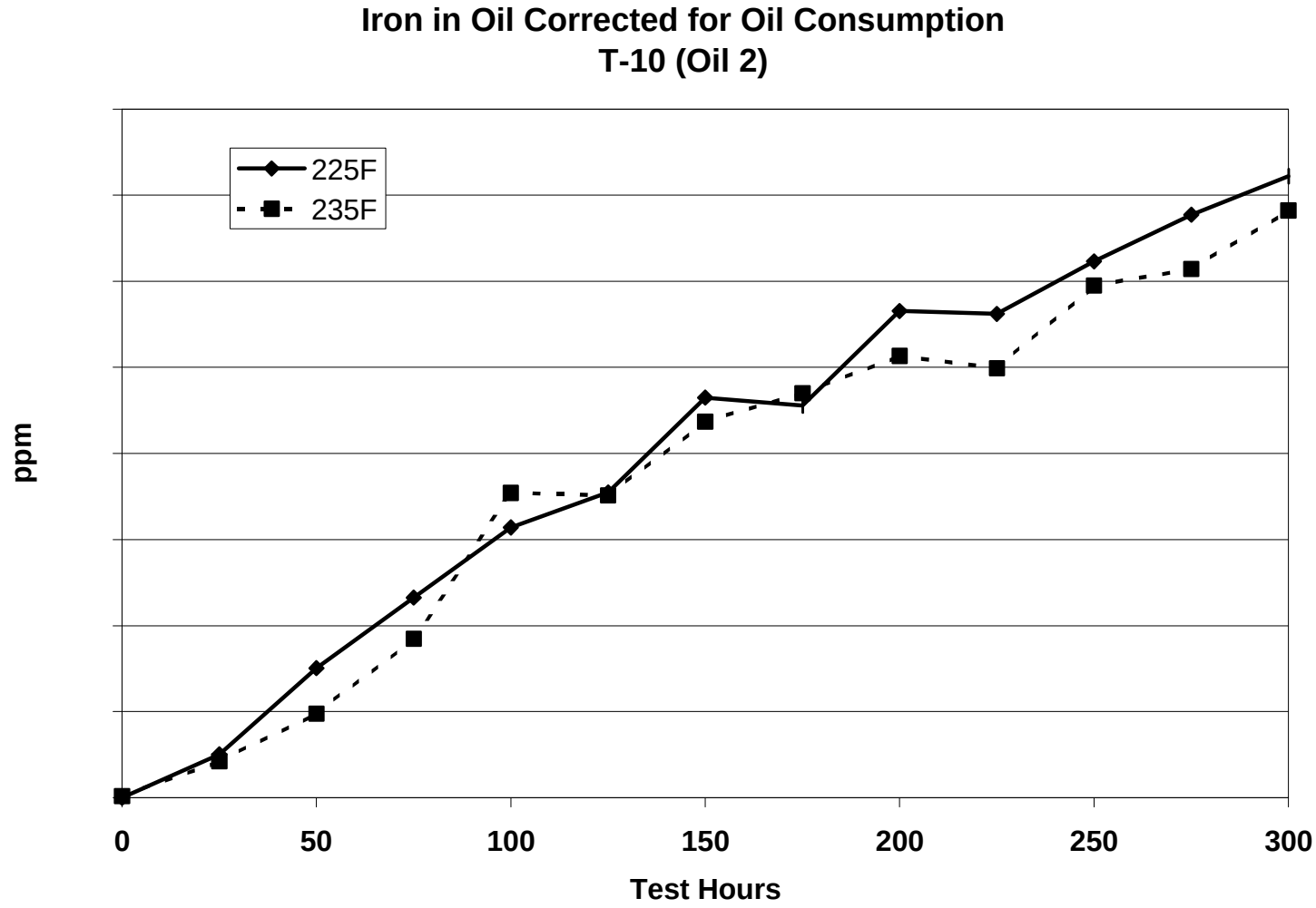


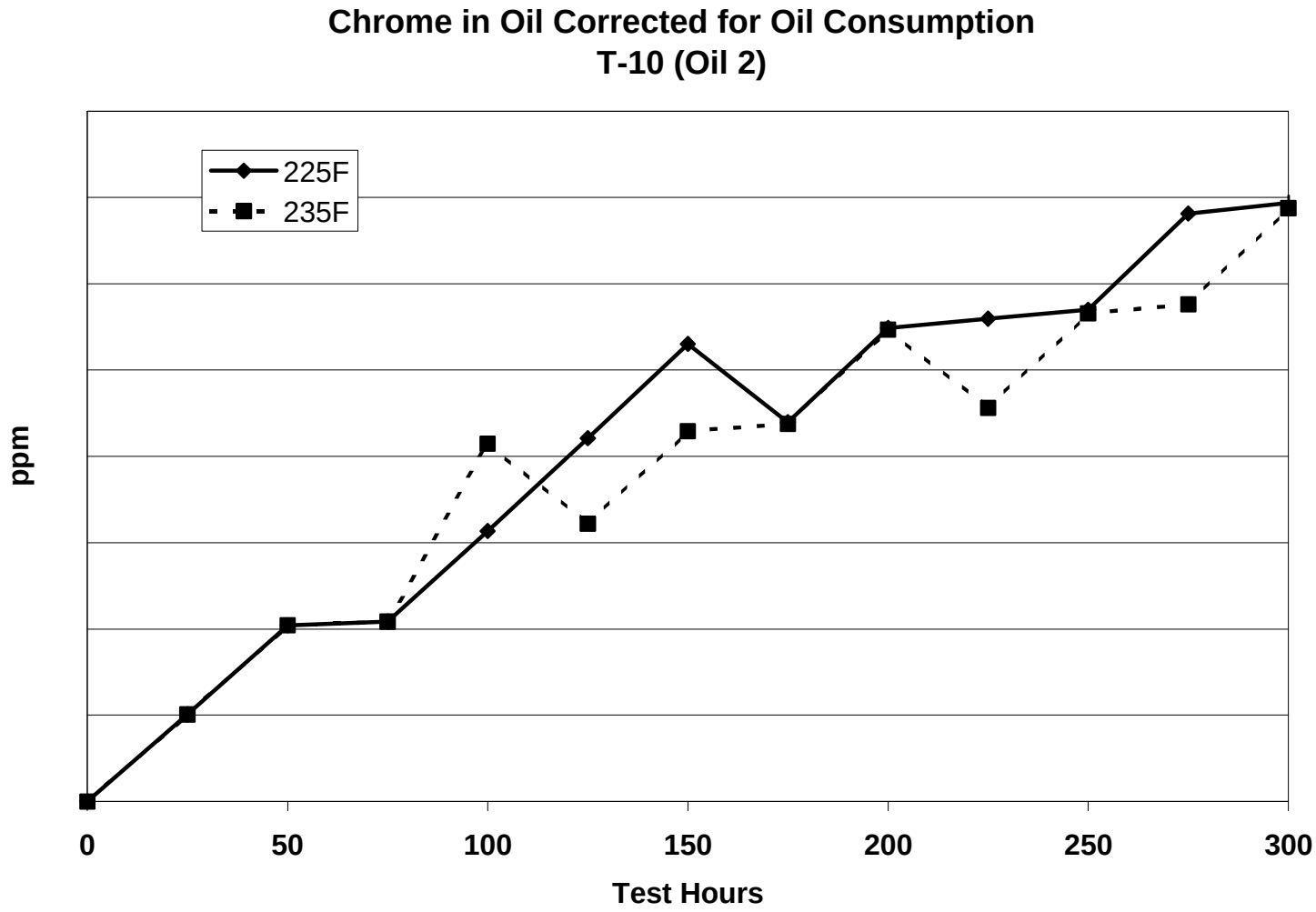
JDQ Integrated IR vs. Viscosity

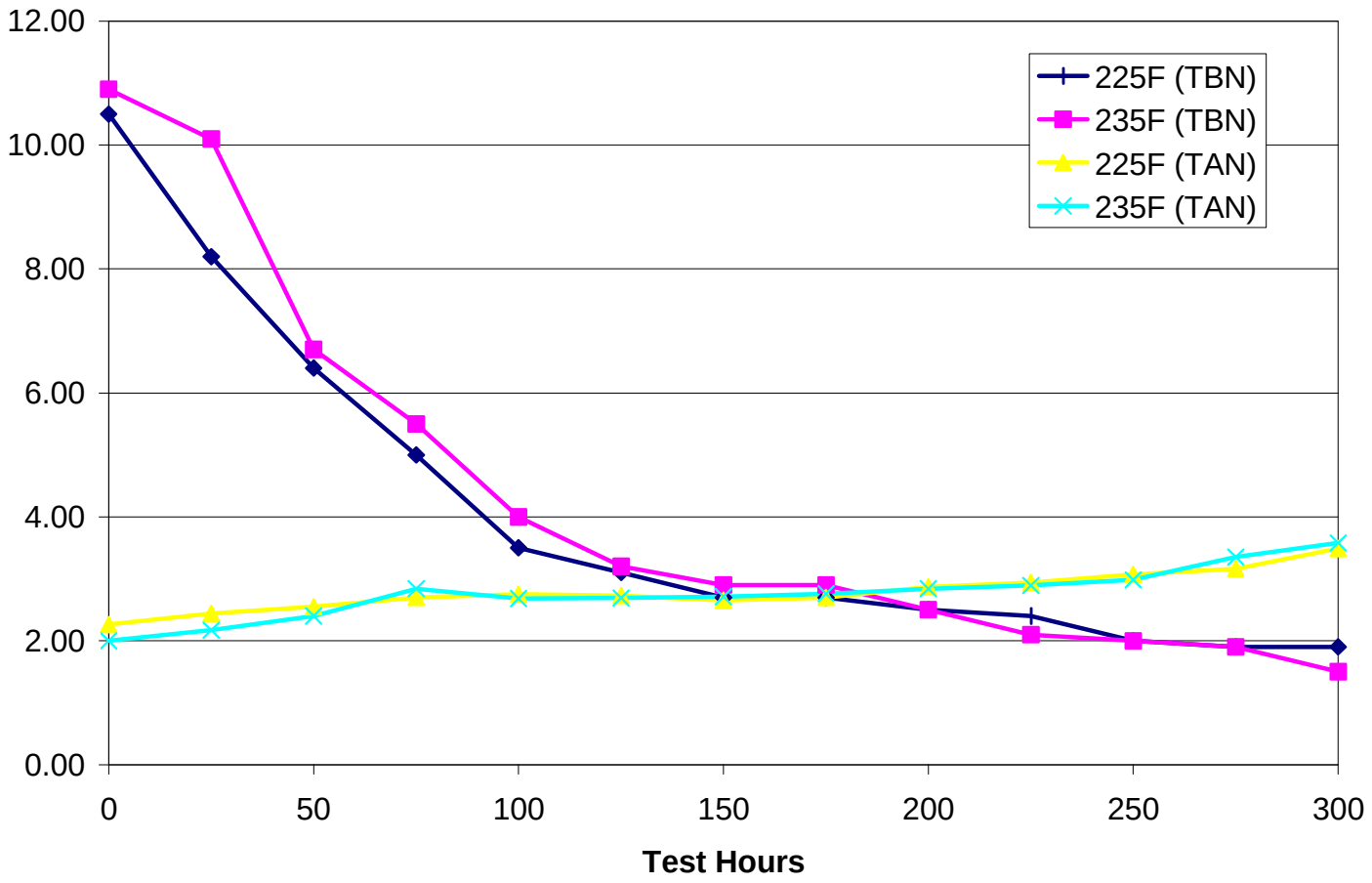


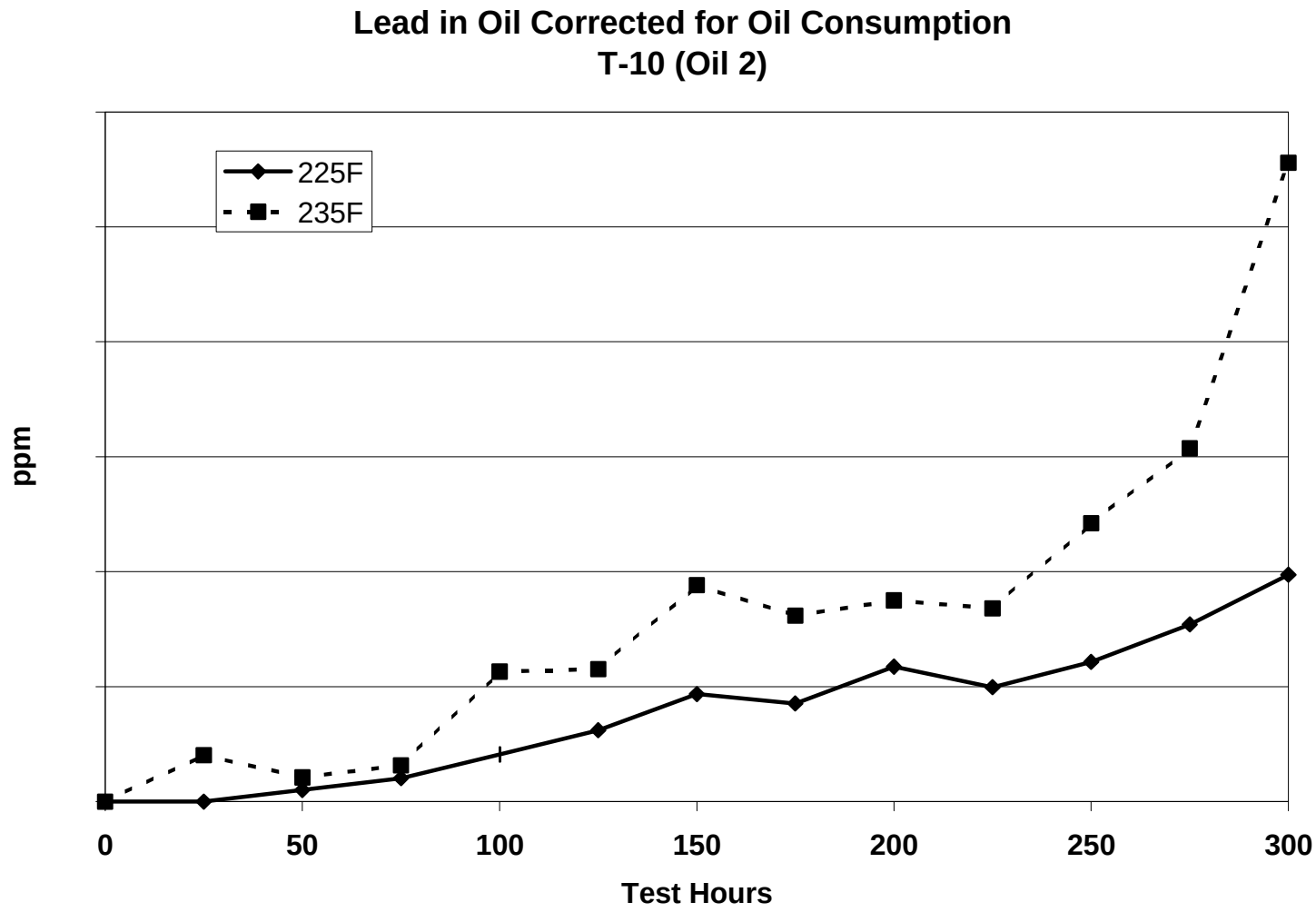
The Oxidation Test

Suggested Mack T-10
at 235°F Oil Gallery


Iron in Oil Corrected for Oil Consumption
T-10 (Oil 2)
225F
235F
ppm
0
50
100
150
200
250
300
Test Hours


Chrome in Oil Corrected for Oil Consumption
T-10 (Oil 2)
225F
235F
ppm
0
50
100
150
200
250
300
Test Hours

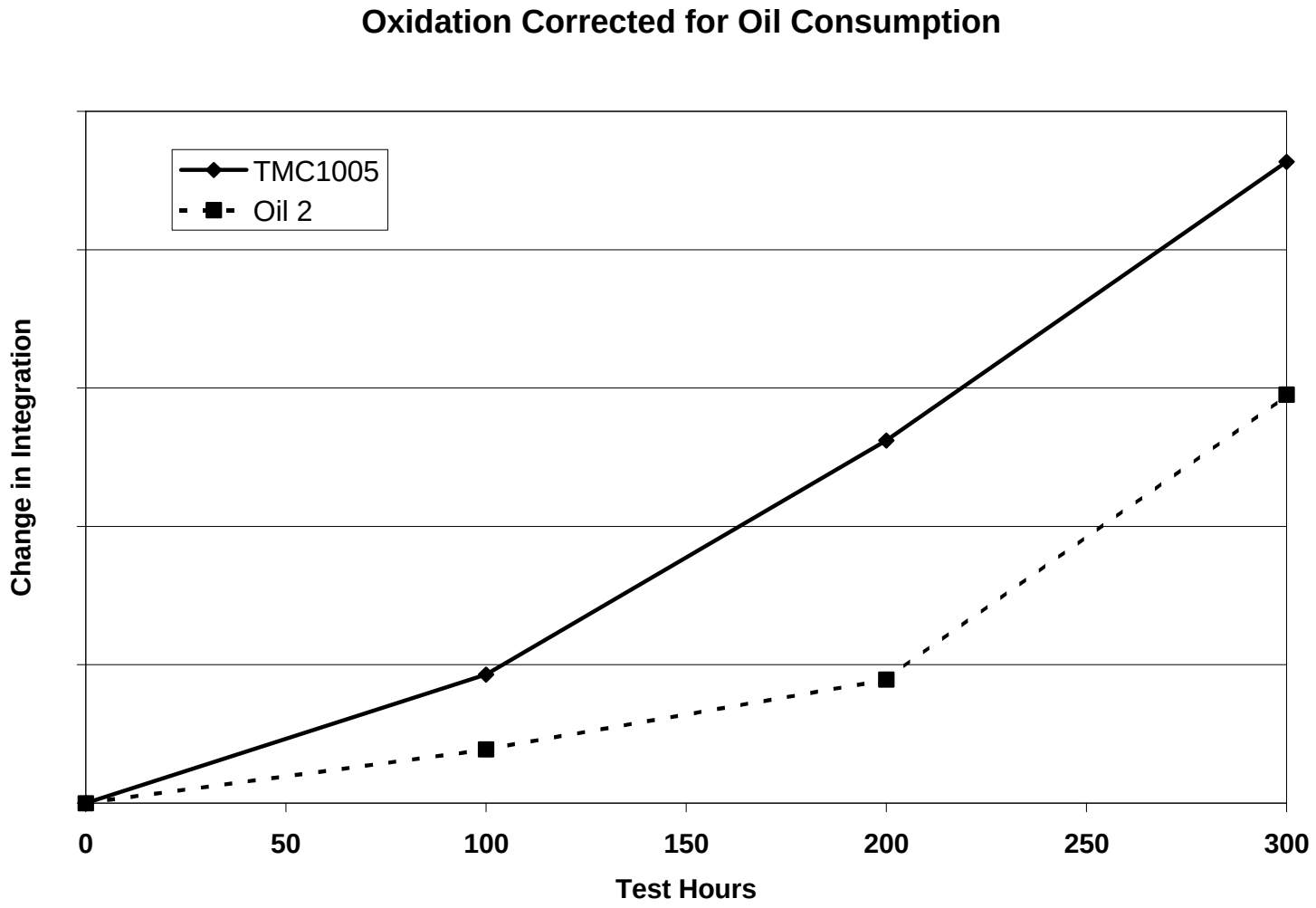

TAN & TBN
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
50
100
150
200
250
300
Test Hours
225F (TBN)
235F (TBN)
225F (TAN)
235F (TAN)


Lead in Oil Corrected for Oil Consumption
T-10 (Oil 2)
225F
235F
ppm
0
50
100
150
200
250
300
Test Hours

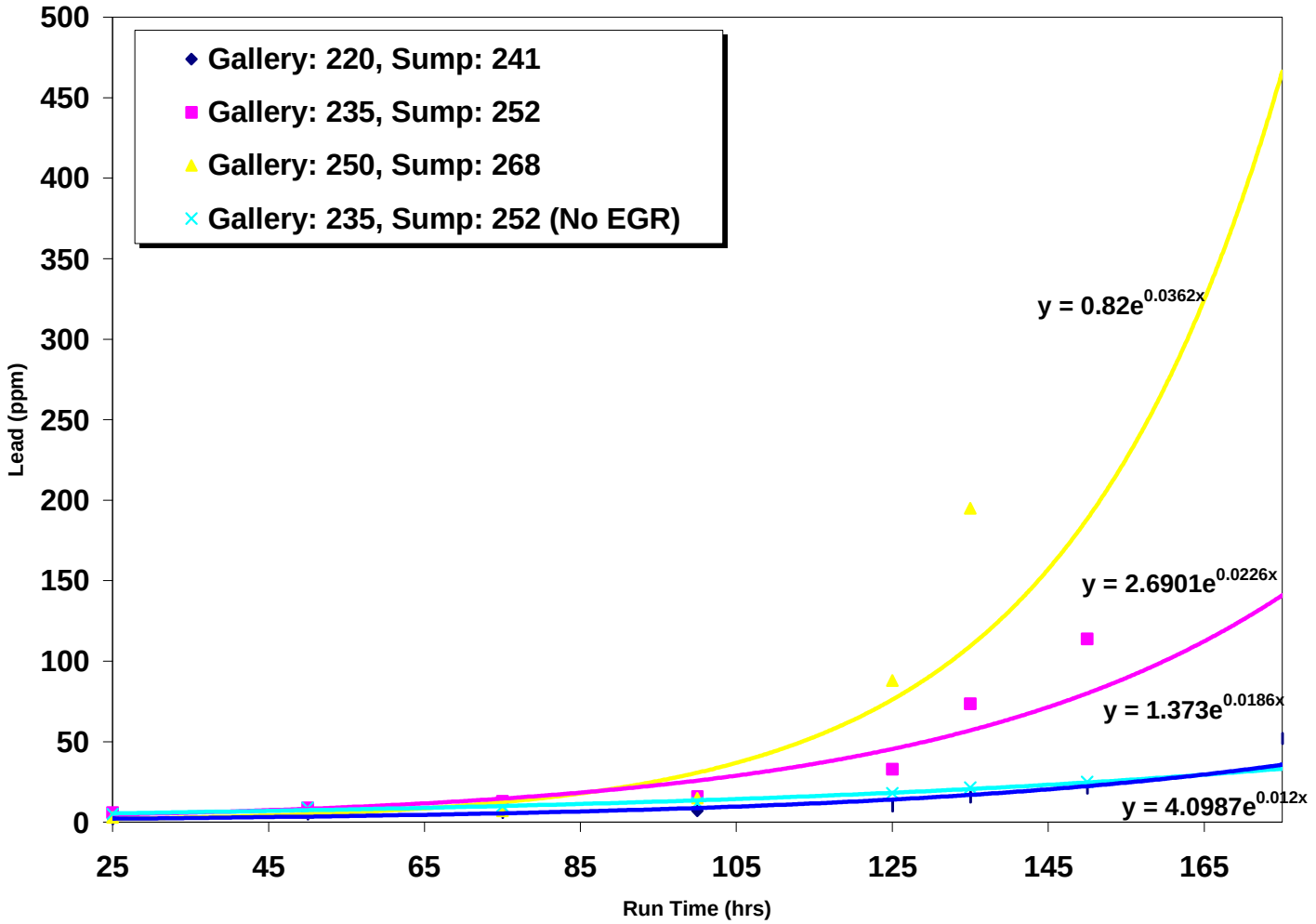
Summary Comparison

Gallery Temp (F)	Liner Wear (Microns)	Corrected Liner Wear (Microns)	Top Ring Wt Loss (mg)	Upper Bearing Wt Loss (mg)	EOT Lead (ppm)
225	36.4	23.4	91.48	160.98	18
235	22.6	22.6	98.07	295.82	52

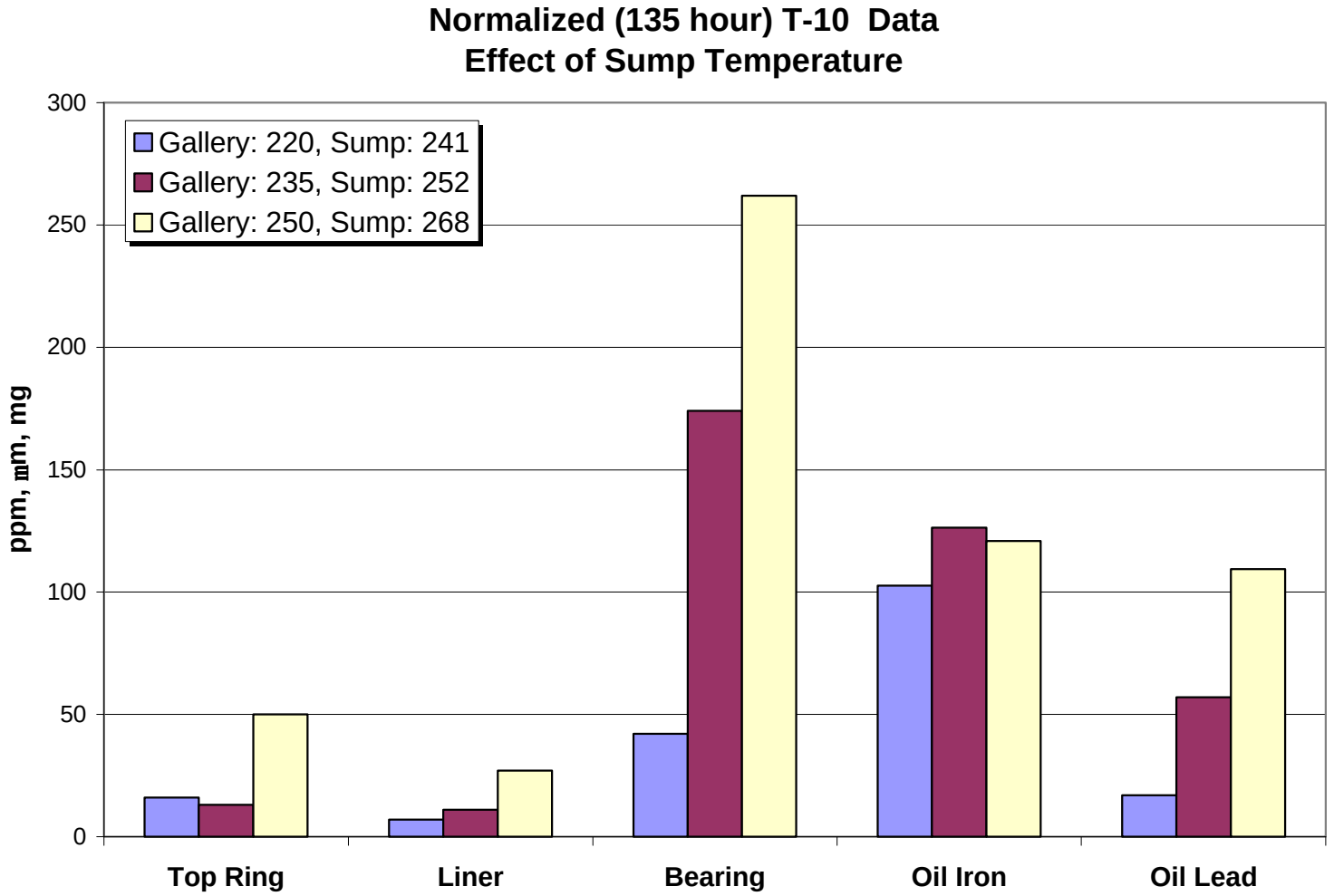
Oil Formulation & Oxidation (T-10)



Oxidation is Critical in T-10



Oxidation is Critical in T-10



Conclusions

- Different types of antioxidants react differently to air versus air/NO2
- Oxidation response of oil depends on composition of air in combustion chamber
- What about SO_2 and SO_3?
- Atmosphere and **Residence Time** is different in EGR Engine
- ***EGR engines provide a more severe oxidizing environment***
- ***Oxidation test should have EGR to better protect EGR engines in the field***

Conclusions

- Integrated IR method gets to the root of the problem and identifies the onset of oil oxidation
- Integrated IR Corrects for variations in soot loading by shifting the baseline
- Integrated IR always “takes off” before Lead or viscosity
- Integrated IR is not confounded with other parameters such as TAN/TBN or soot/volatility
- The method is simple and can quickly be initiated
- Integrated IR is the only true measure of oxidation available

Recommendation

- Mack T-10 at 235°F gallery (252 sump) is a severe oxidizing environment *with EGR*
- Integrated IR is the most accurate measure of oxidation in diesel engines

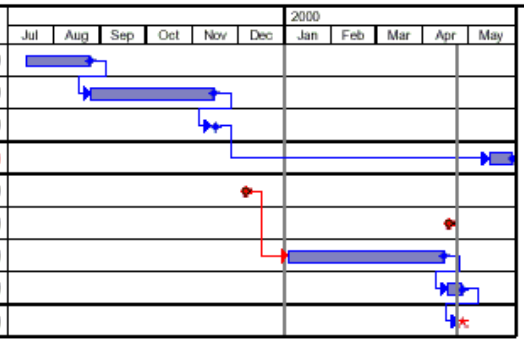
⇒***Mack T-10 with Integrated IR measurements provides the best oxidation protection for PC-9***

Attachment 5

Time Line for the T-10 Test

Brent Shoffner - 4/26/00

ID	Task Name	Start	Finish
1	Final Kits/Parts Available (1 per lab)	07/14/99	08/24/99
2	Install engines and run shakedown	08/25/99	11/15/99
3	Procedure Available	11/16/99	11/16/99
4	Lab Visits for Precision Matrix	05/15/00	05/30/00
5	Procedure Adequate	12/06/99	12/06/99
6	Oil Gallery Temp 225F to 235F	04/18/00	04/18/00
7	Run Preliminary Tests & Report Data*, **	01/03/00	04/14/00
8	Data Analysis	04/17/00	04/26/00
9	HDEOCP Approves Proof of Concept*	04/27/00	04/27/00



* Contingent on HDEOCP Meeting Date
** Will include TMC 1005-1

Attachment 6

Mack T-10 Task Force

Scope & Objectives

Revision Date - November 16, 1999

Scope:

This Task Force is responsible for development of the Mack T-10 engine test. It is accountable to the ASTM Heavy Duty Engine Oil Classification Panel and subsequently to ASTM Sub-Committee B0.02.

The Task Force will strive to achieve its objectives via close co-operation and interaction with the test sponsor, participating test laboratories and other ASTM functions (including Task Force Sub-Groups, the Test Monitoring Center and designated Critical Parts Distributor).

Objectives:	**Completed**
1. Evaluate preliminary test configuration and operational conditions and develop accordingly.	12/6/99
2. Expedite "fit-for-purpose" test/test procedure consistent with PC-9 timeline.	
3. Identify and evaluate key performance criteria.	
4. Demonstrate discrimination with respect to key performance criteria.	
5. Optimize test procedure for maximum test precision and reliability.	
6. Monitor PC-9 Precision/BOI matrix execution.	
7. Monitor/assist statistical evaluation of matrix data.	
8. Recommend HDEOCP endorsement of T-10 test, key performance criteria and associate limits.	
9. Complete ASTM ballots for test approval/PC-9 inclusion.	
10. Complete ASTM ballots of Mack T-10 Research report.	

Specific Activities:

Develop primary test parameters:

1. Average Ring Weight Loss.
2. Average Cylinder Liner Wear.

Evaluate and compare range of secondary test parameters including:

1. Lead content of EOT lubricant.
2. Lubricant TBN depletion.
3. Lubricant TAN accumulation.
4. TBN/TAN interaction.
5. Oxidation/Nitration assessment via IR or alternative analytical method.
6. Bearing weight loss.
7. Piston deposits.