Date RR# Approved (To be assigned by ASTM)

Committee D02 on Petroleum Products
Subcommittee D02.B0 on Automotive Lubricants

Research Report RR: D02-XXXX

Interlaboratory Study to Establish Precision Statements for ASTM D-XXXX Standard Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VID Spark Ignition Engine

Technical Contact:
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1. Introduction:

An Interlaboratory Study was conducted to establish a precision statement for Sequence VID, RR: D2-XXXX, Standard Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VID Spark Ignition Engine.

2. Test Method:

The Test Method used for this ILS is DXXXX-09. To obtain a copy of DXXXX-09 go to ASTM's website, www.astm.org, or contact ASTM Customer Service by phone at 610-832-9585 (8:30 a.m. - 4:30 p.m. Eastern U.S. Standard Time, Monday through Friday) or by email at service@astm.org.

3. Participating Laboratories:

The following laboratories participated in this Interlaboratory study:

1. Intertek Automotive Research 5404 Bandera Road San Antonio, TX 78238 Charlie Leverett Senior Engineering Technologist 210-684-2310	2. Afton Chemical Corp. 500 Spring Street Richmond, VA 23218-2158 David L. Glaenzer Manager-Engine Oil Testing 804-788-5214
3. The Lubrizol Corp. 29400 Lakeland Blvd. Wickliffe, OH 44092 George Szappanos Senior Test Engineer 440-347-2352	4. SwRI 6220 Culebra Road San Antonio, TX 78238-5166 Guy Stubbs Principal Engineer 210-522-5039
5. ExxonMobil Research & Engineering Product Operations 600 Billingsport Road Paulsboro, NJ 08066-0480 Mark Mosher 856-224-2132	

4. Description of Samples

There were five samples of varying targeted results used for this study. Each sample was randomized and distributed by ASTM Test Monitoring Center (TMC). Below is a list of the samples with the corresponding supplier:

1. Reference Oil A
   Provided by ASTM, TMC

2. Reference Oil D
   Provided by ASTM, TMC

3. Reference Oil X
   Provided by ASTM, TMC

4. Reference Oil *B
   Provided by ASTM, TMC

5. Reference Oil *C
   Provided by ASTM, TMC

- *Please note oil B and C were only run by Labs A and G, these are not used for the Precision statement*

4.1 Sequence VID Precision Oil Information

Sequence VID Precision Matrix Oil Information

Oil Code	Technology	SAE Viscosity Grade	KV @ 100°C	CCS at -30°C, cP	HTHS at 100°C, cP	HTHS at 150°C, cP	NOACK	Bosch S-I-G 30 Pass, cSt
A	1	5W-20	8.68	6121	6.10	2.70	13.60	7.7
B	1	0W-30	10.63	3124	6.71	3.07	12.30	8.65
C	3	5W-30	10.58	6170	6.56	3.23	12.20	8.51
D	2	10W-30	10.74	11473	7.04	3.17	11.40	8.91
X	3	0W-20	8.85	4360	5.51	2.74	13.40	7.4

5. Interlaboratory Study Instructions

Laboratory participants were emailed the test program instructions. For a copy of the instructions, please see Annex A.

6. Description of Equipment/Apparatus[1]:

For information on the equipment/apparatus used by each laboratory, please see Annex B, for the VID Draft Procedure.

7. Data Report Forms:

Each laboratory was provided with a data report form for the collection of data. A summary the data collected is provided in Annex C, the full data set is available on the ASTM TMC website at the following link:

ftp://ftp.astmtmc.cmu.edu/refdata/gas/vid/data/

Please note: The laboratories have been randomly coded and cannot be identified herein.

8. Statistical Data Summary:

A summary of the statistics calculated from the data returned by the participating laboratories is provided in Annex D.

9. Precision and Bias Statement:

TABLE 8 Sequence VID Reference Oil Precision Statistics [A]

Variable	Intermediate Precision		Reproducibility	
	$s_{i.p.}$ [B]	i.p.	S_R [B]	R
Fuel Economy Improvement, %				
at 16 h	0.14	0.392	0.22	0.616
at 100 h	0.16	0.448	0.23	0.644

[A] These statistics are based on results obtained on Test Monitoring Reference Oils GF5A, GF5X, GF5B, GF5C and 1008.
[B] s = standard deviation.

[1] The equipment listed was used to develop a precision statement for D-XXXX-09. This listing is not an endorsement or certification by ASTM International.

Annex A
Interlaboratory Study Instructions & Acknowledgement Documents

Charlie Leverett Intertek
From: Charlie Leverett Intertek
Sent: Monday, March 02, 2009 3:20 PM
To: Charlie Leverett Intertek; 'guy.stubbs@swri.org'; 'dave.glaenzer@aftonchemical.com'; 'Mark Mosher'; Szappanos, George
Cc: 'Rich Grundza'
Subject: Sequence VID Phase II Participants

Follow Up Flag: Follow up
Due By: Monday, March 09, 2009 9:00 AM
Flag Status: Flagged

Sequence VID Phase II Participants,

According to the ASTM Template for the VID Research Report I am required to email the program instructions to all participants. The program instructions are as follows:

1.) Laboratories must be pre-approved to participate in Phase II by the Sequence VI Surveillance Panel, as-of issuance of this email the following are approved:

Afton
ExxonMobil
Intertek -AR
Lubrizol
Southwest Research Institute

2.) Laboratories will obtain the oil assignments from TMC, to obtain these assignments labs shall first submit the Break-in Traces as noted in Section 11.3.5 of the VID Procedure Draft 6.0 (posted on TMC Web Site).

3.) All tests shall follow the requirements as noted in the VID Procedure Draft 6.0 (posted on TMC Web Site).

4.) Laboratories are to inform TMC and the Surveillance Panel Chairman of any terminated or invalid tests ASAP.

5.) Laboratories will report the final results to TMC using the current version of the VID Data Dictionary (posted on TMC Web Site).

Each Laboratory shall acknowledge receipt of these requirements to the Surveillance Panel Chairman and the TMC prior to any oil assignments being issued by replying to this email stating you have read and agree to these program instructions.

If you are not the primary contact for this program please let me know who should receive this notice.

Charlie Leverett
ASTM Sequence VI Surveillance Panel Chairman
Intertek Automotive Research
Phone: 210-647-9422
Email: charlie.leverett@intertek.com

Annex B
Description of Equipment/Apparatus

A copy of the VID Procedure Draft 6.0 can be found at the following link:

ftp://ftp.astmtmc.cmu.edu/docs/gas/sequencevi/procedure_and_ils/VID/VIDDraft6.0.pdf

Annex C
Data Summary

VID Precision Matrix Tests

Lab	Stand	EOT Date	Eng. #	Eng. Run #	Stand Run #	Eng. Hrs @ EOT	Indus Cod
G	1	20090119	13A	2	39	486	GF5
G	1	20090302	13A	8	45	1428	GF5
G	2	20090302	8A	9	9	1599	GF5
G	1	20090324	13A	11	48	1901	GF5
A	1	20090325	10B	11	38	1716	GF5
D	1	20090326	13B	5	36	952	GF5
G	2	20090331	8A	13	13	2237	GF5
D	2	20090402	10A	13	15	2309	GF5
B	1	20090405	3A	9	9	1406	GF5
A	2	20090408	6B	20	39	3029	GF5
F	1	20090410	11A	20	20	2971	GF5
G	2	20090126	8A	4	4	810	GF5
G	2	20090309	8A	10	10	1766	GF5
A	1	20090310	10B	9	36	1407	GF5
G	2	20090223	8A	8	8	1441	GF5
G	1	20090223	13A	7	44	1271	GF5
A	1	20090224	10B	7	34	1100	GF5
A	2	20090224	6B	14	33	2102	GF5
A	2	20090119	6B	9	28	1315	GF5
G	1	20090309	13A	9	46	1585	GF5
B	1	20090312	3A	7	7	1058	GF5
G	2	20090317	8A	11	11	1923	GF5
G	1	20090317	13A	10	47	1744	GF5
A	1	20090318	10B	10	37	1563	GF5
A	2	20090318	6B	17	36	2567	GF5
D	2	20090318	10A	11	13	1969	GF5
D	1	20090319	13B	4	35	793.2	GF5
A	2	20090325	6B	18	37	2722	GF5
F	1	20090326	11A	17	17	2614	GF5

VID Precision Matrix Tests

Lab	Stand	EOT Date	Eng. #	Eng. Run #	Stand Run #	Eng. Hrs @ EOT	Indus Cod
A	1	20090118	10B	2	29	330	GF5
A	1	20090303	10B	8	35	1254	GF5
A	2	20090303	6B	15	34	2256	GF5
G	2	20090324	8A	12	12	2080	GF5
D	2	20090326	10A	12	14	2150	GF5
G	1	20090331	13A	12	49	2058	GF5
A	1	20090401	10B	12	39	1869	GF5
A	2	20090401	6B	19	38	2875	GF5
F	1	20090401	11A	18	18	2770	GF5
D	1	20090402	13B	6	37	1110	GF5
B	1	20090412	3A	10	10	1570	GF5
			**** FEI I & FEI II include engine hr adjustment***				

Annex D
Statistical Data Summary

Sequence VID Precision Matrix Analysis

Statistical Group
April 22, 2009

Summary - 1

- The Sequence VID precision is estimated to be 0.18% for FEI1 and 0.19% for FEI2 without accounting for engine hours or 0.14% and 0.16% for FEI1 and FEI2, respectively, with engine hour correction.
  - FEI1 and FEI2 meet ACC Code of Practice Appendix K Template
- No data transformation is needed for FEI1 or FEI2.
- Engine aging effect is significant for FEI1 and FEI2 and is currently best estimated by the natural logarithmic transformation.
- Engine difference within lab is not significant for FEI1 and FEI2 after engine aging correction.
- Engine build difference within lab is not significant for FEI1 and FEI2 after engine aging correction.
- Lab A significantly higher than labs B, D and G while lab F is not significantly different from the other labs.
- Shell data was considered but did not add anything to the matrix analysis because of confounding with engine.

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Summary - 2

- Overall Model:
  - Lab, Engine(Lab), Oil (A, B, C, D, X)
  - Lab, Engine(Lab), Oil (A, B, C, D, X), LnEngHr
- Viscosity Grade differences are significant for FEI1 and FEI2.
  - FEI1: 0w20, 5w20 > 5w30, 10w30
  - FEI2: 0w20 > 5w30, 10w30
- HTHS@150C significantly correlates with FEI1 and FEI2 but CCS@-30C weakly correlates with FEI1 and FEI2.
  - HTHS@100C is highly correlated with HTHS@150C
- There is some relationship between FEI results and some measures of oil pressure but there is not additional information from knowing this oil pressure when engine hours are known.
- Draft LTMS to be presented by TMC
  - Option 1: No correction for engine hours
  - Option 2: Correct all reference and candidate results with engine hours (similar to soot correction)

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Reference Oil Targets

Fuel Economy Improvement at 16 hours
Unit of Measure: % FEI1

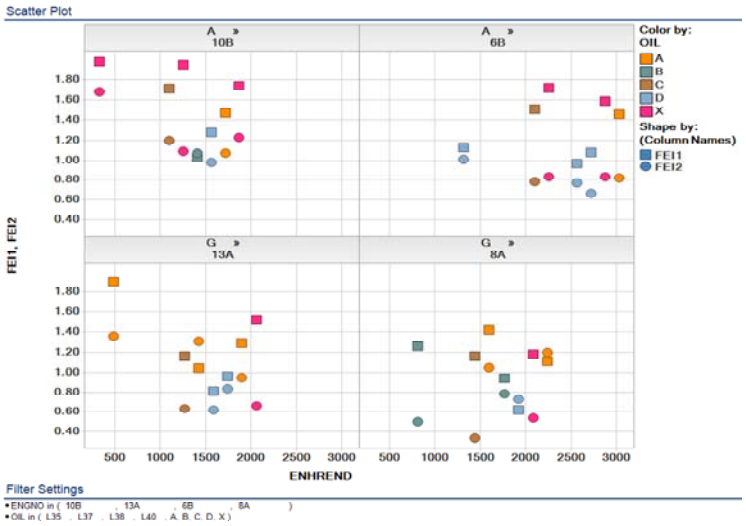
Reference Oil	Mean	Standard Deviation
A	1.32	0.18/0.14
D	0.87	0.18/0.14
X	1.49	0.18/0.14

Fuel Economy Improvement at 100 hours
Unit of Measure: % FEI2

Reference Oil	Mean	Standard Deviation
A	1.04	0.19/0.16
D	0.71	0.19/0.16
X	0.80	0.19/0.16

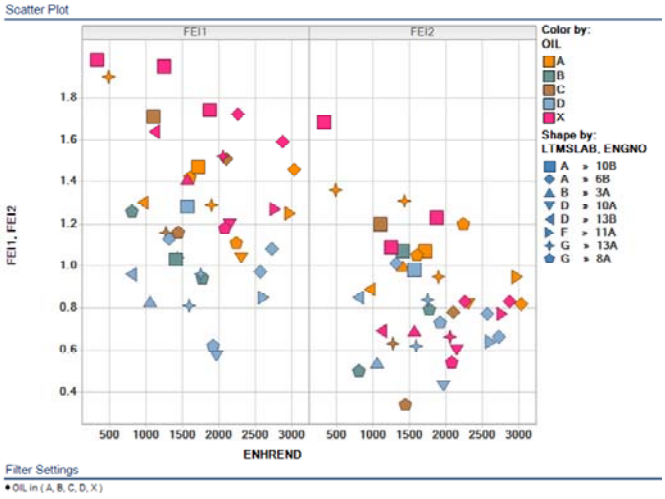
4

FEI by Engine Hours by Engine



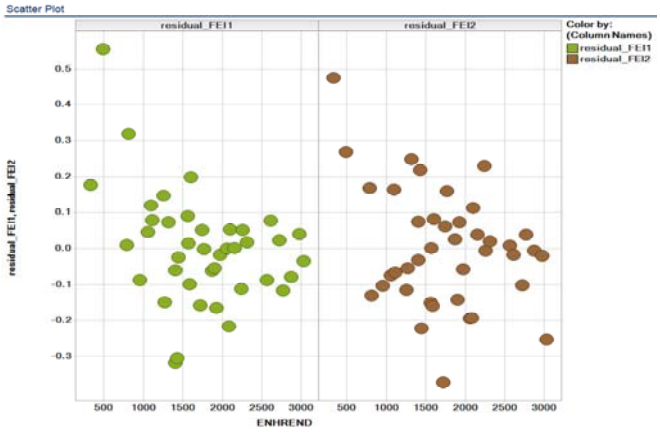
5

FEI by Engine Hours



6

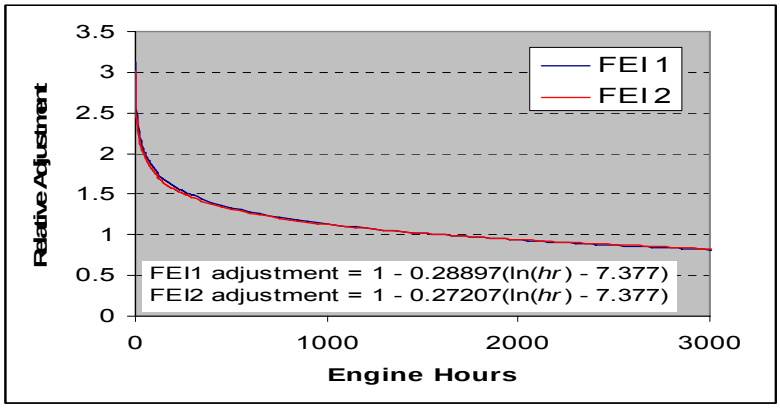
FEI Residuals by Engine Hours



Strong indication of engine hour effect on FEI after correcting for Oil, Lab and Engine within Lab.

7

Ln Engine Hour Correction



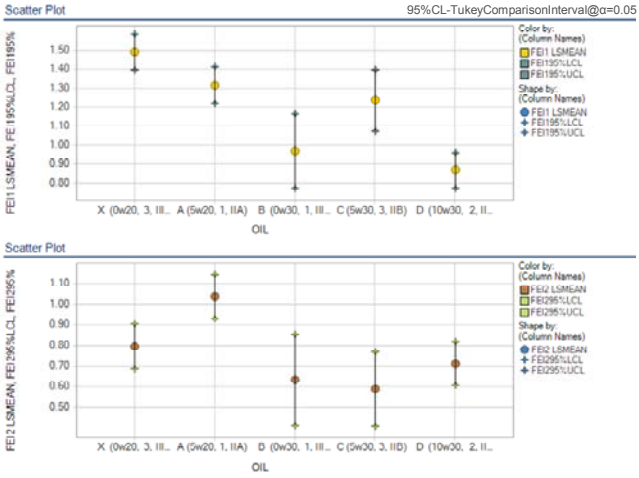
How to apply correction:

FEI1corrected = FEI1original + 0.28897[ln(hour) – 7.377]

FEI2corrected = FEI2original + 0.27207[ln(hour) – 7.377]

8

FEI LSMean by Oil



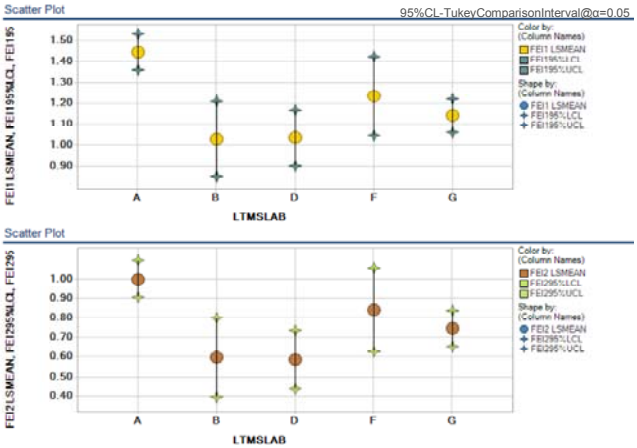
OIL	FEI1 LSMEAN	FEI2 LSMEAN
A	1.32	1.04
B	0.97	0.63
C	1.24	0.59
D	0.87	0.71
X	1.49	0.80
OIL Difference	**P-value**	**P-value**
A-B	0.0172	0.0133
A-C	0.8792	0.0008
A-D	<.0001	0.0007
A-X	0.0706	0.0173
B-C	0.1651	0.9963
B-D	0.8579	0.9612
B-X	0.0002	0.6228
C-D	0.0018	0.7044
C-X	0.0468	0.2286
D-X	<.0001	0.7457

FEI1: A, X > B, D
X > C > D
FEI2: A > B, C, D, X

Based on repeated oils data.

9

FEI LSMean by Lab

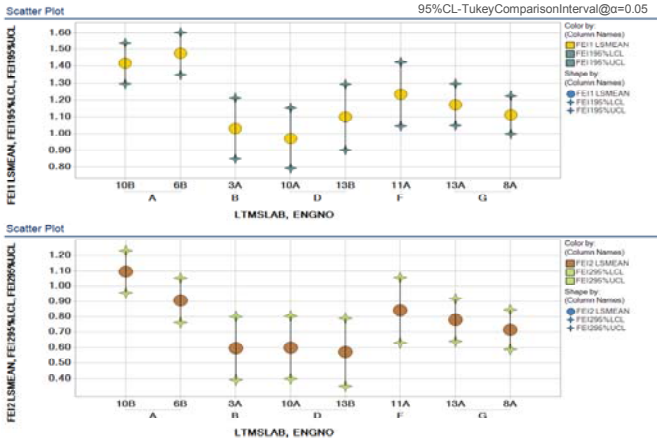


Lab A is significantly higher than labs B, D and G while lab F is not significantly different than the other labs.

Based on repeated oils data.

10

FEI LSMean by Engine within Lab

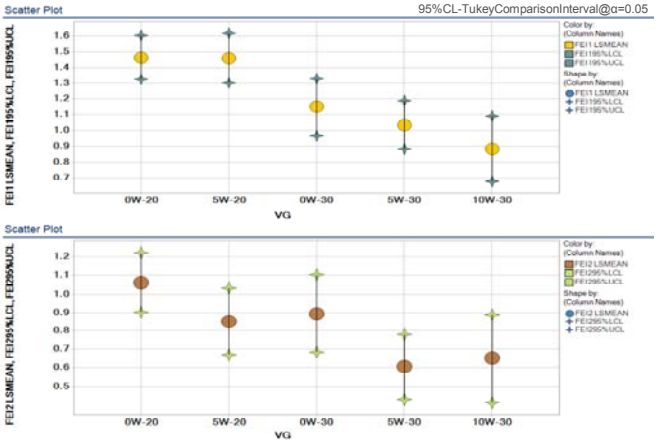


Engine differences within lab are not significant after engine aging correction.

11

Based on repeated oils data.

FEI LSMean by Viscosity Grade



FEI1:

0W20, 5w20 > 5w30, 10w30

FEI2:

0W20 > 5w30, 10w30

Viscosity Grade differences are significant for FEI1 and FEI2.

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Based on all matrix data.

Chem Information for Matrix Oils

Oil Code	A	B	C	D	X
Technology	1	1	3	2	3
SAE Viscosity Grade	5W-20	0W-30	5W-30	10W-30	0W-20
Base Oil	IIA	IIIA	IIB	IIB	IIIB
KV @ 100°C	8.68	10.63	10.58	10.74	8.85
KV @ 40°C *	--	--	--	70.03	--
VI *	--	--	--	142	--
CCS at -25°C, cP *	--	--	--	5767	--
CCS at -30°C, cP	6121	3124	6170	11473	4360
CCS at -35°C, cP *	--	5999	--	--	5790
HTHS at 100°C, cP	6.10	6.71	6.56	7.04	5.51
HTHS at 150°C, cP	2.70	3.07	3.23	3.17	2.74
NOACK	13.60	12.30	12.20	11.40	13.40
Volatility (D 6417) *	--	--	--	4	--
Pumping, cP (D 4684) *	--	--	--	17436 @ -30°C	--
Gelation Index *	--	--	--	4.3	--
Pour Point, cSt *	--	--	--	-39	--
Bosch S-I-G 30 Pass, cSt	7.7	8.65	8.51	8.91	7.4
HTHS at 100°C after 30 Cycles, cP *	--	--	--	7.09	--

HTHS at 150°C after 30 Cycles, cP *	--	--	--	2.78	--
VM Type	Non-Disp	Non-Disp	Non-Disp	Non-Disp	Non-Disp
VM Content (Relative to X, Y, or Z)	2.25X	4.25X	3.50Z	1.03Y	3.04Z
Base Oil Blend KV @ 100°C	4.85	4.68	4.97	5.55	4.59
Base Oil Blend KV at 40°C *	--	--	--	32.01	--
Base Oil Blend VI	117	132	114	111	126