History of Industry Correction Factors
Appendix B

Test Area	Effective		Condition	Description
	From	To		
1M-PC	None		All Tests	None
1K	None		All Tests	None
1N	May 1, 2004	September 27, 2005	All Tests	Add -1.135 to ln(TLHC+1)
	September 28, 2005	March 31,2015	All Tests	Add -0.451 to ln(TLHC+1)
	April 1,2015	***	All Tests on 1Y3998 Liners	Add 0.419954 to ln(TGF+1)
1P	None		All Tests	None
1R	None		All Tests	None
C13	None		All Tests	None
COAT	20190510	***	All Tests	Multiply AAVE4050 by 0.9606
ISB	April 21, 2011	October 18, 2017	All tests using batch B tappets with batch E, F, and G cams	Multiply ATWL by 0.637; Add -9.5 to ACSW
	December 11, 2011	November 12, 2012	All tests using batch C tappets with batch H cams	Multiply ATWL by 0.637; Add -9.5 to ACSW
	November 13, 2012	October 18, 2017	All tests using batch C tappets with batch H and J cams	Multiply ATWL by 0.711; Add -5.6 to ACSW
	None	October 18, 2017	All test using batch D tappets and batch K cams	Multiply ATWL by 1; Add -11.3 to ACSW
	October 19, 2017	September 3,2020	All tests using batch K cams with batch D tappets and batch E crossheads	Multiply ATWL by 0.7851; Add -18.5 to ACSW
	September 4, 2020	***	All tests using batch K cams with batch D tappets	Multiply ATWL by 0.7851; Multiply ACSW by 0.94
	September 4, 2020	***	All tests using batch L cams with batch E tappets	Multiply ATWL by 0.7851; Multiply ACSW by 0.77

L-37-1 Reference Oil Targets													
						Ridging		Rippling		Spitting		Wear	
Hardware	Pinion Batch	Oil	n	From[1]	To	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
NONLUBRITED	Gleason 04-2014	134/ 134-1	6	20170503	20190630	3.8	1.2	7.8	1.2	7.7	1.9	4.8	1.2
		152-2	8	20170503	20190630	9.3	0.7	8.9	1.6	9.9	0.0	7.8	0.9
		155-1	7	20170503	20190630	9.6	0.5	9.6	0.5	9.9	0.0	7.9	0.7
	Gleason 04-2014	134/ 134-1	10	20190701	20190806	3.8	0.9	7.2	1.3	7.9	1.5	5.1	1.0
		152-2	11	20190701	20190806	9.3	0.6	8.7	1.4	9.9	0.1	7.5	0.8
		155-1	11	20190701	20190806	9.6	0.5	8.7	1.3	9.9	0.0	7.5	0.7
	Gleason 04-2014,06-2018	134/ 134-1	14	20190807	20200520	3.9	0.9	7.1	1.5	8	1.7	5.1	0.9
		152-2	15	20190807	20200520	9.3	0.6	8.7	1.3	9.9	0.1	7.5	0.8
		155-1	16	20190807	20200520	9.6	0.5	8.8	1.1	9.9	0.0	7.6	0.7

L-37-1 Reference Oil Targets													
						Ridging		Rippling		Spitting		Wear	
Hardware	Pinion Batch	Oil	n	From[1]	To	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
NONLUBRTIED	Gleason 04-2014, 06-2018, 2019/20	134/ 134-1	24	20200521	***	4.1	0.9	7.4	1.4	7.9	2.0	5.3	0.9
		152-2	28	20200521	***	9.0	0.8	8.3	1.2	9.9	0.1	7.6	0.7
		155-1	21	20200521	***	9.5	0.5	8.6	1.1	9.9	0.0	7.5	0.7
LUBRITED	Gleason 04-2014	134/ 134-1	12	20191001	***	6.1	2.4	7.4	1.6	9.9	0.1	6.8	0.9
		152-2	9	20191001	***	9.7	0.5	9.3	0.5	9.7	0.6	8.2	0.7
		155-1	9	20191001	***	9.3	1.0	8.7	0.7	9.9	0.0	7.9	0.8

1 Effective for all tests completed on or after this date.
2 *** = currently in effect.

VOLUME CHANGE
Unit of Measure: Percent

Reference Oil	Elastomer	Mean	Standard Deviation
160-1	Polyacrylate	0.343	0.4473
160-1	Fluoroelastomer	2.053	0.4075
161-1	Polyacrylate	19.624	1.4348
161-1	Fluoroelastomer	6.199	0.7080
161-1	Nitrile	18.444	1.7057
162	Nitrile	2.460	1.5821
168	Nitrile	1.326	1.4730
169	Polyacrylate	13.1	1.43
169	Fluoroelastomer	4.4	0.71
169	Nitrile	11.8	1.71
170	Nitrile	1.500	0.718
171	Polyacrylate	-0.088	1.096
171	Fluoroelastomer	2.167	1.201

B. Acceptance Criteria

1. New Test Stand

   - For each elastomer type, an operationally valid calibration test, with no Shewhart severity alarms, must be conducted on each of the two approved reference oils.

2. Existing Test Stand

   - The test stand must have been TMC calibrated prior to LTMS introduction or previously accepted into the system by meeting LTMS calibration requirements.

3. Reference Oil Assignment

   Once test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration according to the following reference oil mix:

Elastomer Type	Oil Assignments
PA	Assign reference oils 160, 161, 169 or 171 (or subsequent reblends) for every calibration sequence.
FL	Assign reference oils 160, 161, 169 or 171 (or subsequent reblends) for every calibration sequence.
NI	Assign reference oils 161, 162, 168, 169 or 170 (or subsequent reblends) for every calibration sequence.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. The constants used for the construction of the control charts for the Oil Seal Compatibility Test, and the response necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart				Shewhart Chart	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Action	--	--	--	--	--	2.20
Lab	Warning	--	--	--	--	--	--
	Action	--	--	--	--	--	--
Industry	Warning	0.15	0.15	2.24	2.49	--	--
	Action	0.15	0.15	2.88	3.03	--	--

The following are steps that must be taken in the case of exceeding control chart limits.

- Exceed Shewhart limit for severity (all parameters)
  - For each failed elastomer type, conduct an additional calibration test.

The following industry issues are handled by the TMC and do not require individual laboratory action.

- Exceed EWMA industry chart action limit (all parameters)
  - TMC to notify surveillance panel chairman. Meeting of TMC and surveillance panel chairman required to determine course of action.
- Exceed EWMA industry chart warning limit (all parameters)
  - TMC to notify surveillance panel chairman. Coordination of TMC and surveillance panel chairman required to discuss potential problem

43. D7528 ROBO Test LTMS Requirements

The following are the specific D7528 ROBO Test calibration requirements.

A. Reference Oils and Critical Parameters

1. The critical pass/fail parameter is MRV Apparent Viscosity of the aged oil in transformed units. The reference oils, performance targets and acceptance criteria required for the test stand calibration with the TMC are listed in Table 1 and have been approved by the ASTM D02.B0.07 ROBO Surveillance Panel.

Table 1
MRV VISCOSITY
Unit of Measure: LN(MRV)

D7528 (ROBO) Aged Oil MRV Acceptance Bands, mPa·s and ln(mPa·s)

Oil	n	Natural Log Transformed Mean (ln)	Mean in Original Units	s.d. (ln)	95% band in mPa·s Min[1]	95% band in mPa·s Max[1]	95% Bands Min (ln)	95% Bands Max (ln)
434-1	13	10.6599	42,612	0.1672	30,706	59,136	10.3322	10.9876
434-2	36	[2]10.9284	[2]55,737	0.1551	[2]41,126	[2]76,008	[2]10.6244	[2]11.2386
434-3	22	[2]10.8172	[2]49,871	0.1389	[2]37,987	[2]65,473	[2]10.5450	[2]11.0894
435	15	11.4895	97,685	0.2932	[3]60,000	173,546	[3]11.0021	12.0642
435-1	22	11.0416	62,420	0.20295	[4]44570	92910	[4]10.7048	11.4394
436	17	[2]10.3437	[2]31,061	0.1605	22,677	42,544	10.0291	10.6583
438	14	10.2676	28,785	0.2037	19,308	42,912	9.8683	10.6669
438-2	19	[2]10.5404	[2]37813	0.2596	[2]22,734	[2]62,894	[2]10.0316	[2]11.0492

[1] 95% bands in mPa·s are listed for information purposes only, the transformed values will be used to judge acceptance in all cases.
[2] A bias adjustment has been applied to the mean of reference oils 434-2, 434-3, 436 and 438-2 to account for biases observed in the TMC reference data during the periods that each oil target dataset was generated. The 95% confidence range reflects the inclusion of the bias adjustments.
[3] The minimum value for Reference oil 435 is fixed at 60,000 (11.0021 in transformed units) and not a true 95% minimum as calculated from the statistics.
[4]The minimum value for reference oil 435-1 is based on -1.66 standard deviations from the target mean (to match the range previously approved for oil 435 min), so is not actually a 95% confidence range. A 95% confidence range would use 1.96 standard deviations from target mean.

2. EOT MRV (MRVEOT) viscosity values >400,000 mPa·s shall be reported as >400000.

3. EOT volatiles (VOLEOT) for the reference oils, in a properly run test, should never reach or exceed 60%. Tests with EOT volatility >= 60% will be declared operationally invalid.

4. Tests with EOT yield stress (MRVYSEOT) measured or reported at anything other than <35 will be declared operationally invalid. An exception is allowed for reference oil 434-3 only, where any yield stress measured at >35 Pa does not invalidate the test.

B. Acceptance Criteria

1. New Laboratory/New Test Stand(s)

D7528 ROBO Test Reference Oil Targets					
		Effective Dates		LN(EOT MRV)	
Oil	N	From[1]	To[2]	$\overline{X}$	s
434-1	13	20080801	***	10.6599	0.1672
434-2	5	20170713	20180727	10.941	0.1672
	36	20180728	***	10.9284	0.1551
434-3	13	20191101	***	10.8411	0.1342
435	15	20080801	20110928	11.4895	0.2932
435-1	22	20100408	***	11.0416	0.20295
436	17	20210429	***	10.3437	0.1605
438	14	20080801	***	10.2676	0.2037
438-2	10	20190221	20191031	10.4421	0.2322
	19	20191101	***	10.5404	0.2596

1 Effective for all tests completed on or after this date.
2 *** = currently in effect.

7. VH LTMS Requirements

The following are the specific VH calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical performance criteria are Average Engine Sludge (AES), Rocker Cover Sludge (RAC), Average Engine Varnish (AEV50), and Average Piston Varnish (APV50). Number of Hot Stuck Rings is a discrete parameter and is monitored for occurrence only. The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence V Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

AVERAGE ENGUNE SLUDGE (AES)
Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
931	8.00	0.60
940	6.47	0.49
1009	7.21	0.44
1011	8.43	0.57

ROCKER COVER SLUDGE (RAC)
Unit of Measure: ln(10-RAC)

Reference Oil	Mean	Standard Deviation
931	0.2283	0.5715
940	0.9155	0.2260
1009	0.0515	0.3139
1011	-0.5294	0.1924

AVERAGE ENGINE VARNISH (AEV50)
Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
931	8.97	0.30
940	8.77	0.28
1009	8.81	0.40
1011	9.26	0.21

AVERAGE PISTON VARNISH (APV50)
Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
931	8.35	0.60
940	7.35	0.64
1009	7.89	0.74
1011	8.67	0.48

NUMBER OF HOT STUCK RINGS
Unit of Measure: Count

Reference Oil	Maximum Allowable
931	0
940	0
1009	0
1011	0

Any test failing on hot stuck rings is not chartable and must be re-run.

B. Acceptance Criteria

1. New Test Lab – a minimum of three valid calibration tests are required to establish a new lab.

   a. The first two stands in a laboratory

   - A minimum of two (2) operationally valid calibration tests and/or matrix tests, with no Level 3 e_i alarms must be conducted in a new laboratory on any approved reference oils.

   - Note that industry matrix runs may be included, as well as reference runs, at the discretion of the surveillance panel.

   - Following the necessary tests, check the status of the control charts and follow the prescribed actions

   b. Third and subsequent stands in a laboratory

   - New test stands in an existing lab may calibrate with one test provided e_i Level 1 limits are not exceeded. Otherwise a second test is required for calibration.

   - For an existing test stand in an existing lab run one test.

   - Following the necessary tests, check the status of the control charts and follow the prescribed actions

Sequence VH Reference Oil Targets												
Oil	n	Effective Dates		AES		RAC		AEV50		APV50		Hot Stuck Rings
		From[1]	To[2]	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s	Maximum Allowable
931	6	20210316	***	8.00	0.60	0.2283	0.5715	8.97	0.30	8.35	0.60	0
940	7	20170128	***	6.47	0.49	0.9155	0.2260	8.77	0.28	7.35	0.64	0
1009	8	20170128	***	7.21	0.44	0.0515	0.3139	8.81	0.40	7.89	0.74	0
1011	7	20170128	***	8.43	0.57	-0.5294	0.1924	9.26	0.21	8.67	0.48	0

History of Industry Correction Factors
Appendix B

Test Area	Effective		Condition	Correction
	From	To		
IIIF	June 13, 2010	***	Reference Tests	Adjust the Hours to 275 % Viscosity Increase by adding 10 hours.
			Non-reference Tests	Refer to Section 12.7.9.6 of Test Method D6984
IIIG	None		All Tests	None
IIIGA	None		All Tests	None
IIIGB	July 24, 2009	***	All Tests	Add 1.61 to PHOS
IIIH	July 1, 2015	***	All Tests	None
IIIHA	July 1, 2015	***	All Tests	None
IIIHB	July 1, 2015	***	All Tests	None
IVA	None		All Tests	None
IVB	None		All Tests	None
VG	July 1, 2005	November 9, 2007	All tests using fuel batch TF2221LS20	Add 0.19 to AEV
				Add 2.175 to AES and divide by 1.192
				Add 0.54 to APV
				Add 0.627 to RCS and divide by 1.041
	November 10, 2007	***	All tests using fuel batch TF2221LS20	Add 0.12 to AEV
				Add 0.42 to AES
				Add 0.39 to APV
				Add 0.23 to RCS
	May 26, 2009	September 30, 2009	All tests using fuel batch XC2721NX10	Add 3.011 to AEV and divide by 1.356
				Add 1.325 to APV and divide by 1.207
	October 1, 2009	***	All tests using fuel batch XC2721NX10	Subtract 0.24 from APV
				Subtract 0.12 from AEV
	September 25, 2013	***	All tests using fuel batch AK2821NX10-1	Adjust AES by equation: $AES + e^{[(AES-5.00)(AES-9.70)]/351}$
				Adjust RAC by equation: $(RAC - 4.71)/0.49$
				Subtract 0.757 from transformed OSCR
				Add 0.18 to AEV.
	All tests using fuel batch DJ0121NX10			None
VH	All reference tests using fuel Batches GI0321NX10 and GI0321NX10-1			Subtract 0.32 from AES result

History of Industry Correction Factors
Appendix B

Test Area	Effective From	Effective To	Condition	Correction
VH	March 16, 2021	Batches GI0321NX10 and GI0321NX10-1	Non reference tests	Subtract 0.32 from AES results for all non-reference oil tests completing on or after 3/16/21
IX	None		All Tests	None
X	None		All Tests	None
Test Area	Effective From	Effective To	Condition	Correction
VIE	March 14, 2018 to ****		All Tests as noted adjacent	Add +0.21 to FEI1 and +0.22 to FEI2 Apply to Reference Tests completing on or after 3/14/18 Apply to Non reference tests on stand/engines referenced with correction factor applied. Apply correction factors to three previous reference tests completing before 3/14/18 in a given stand for purposes of Zi calculation.
VIF	None		All Test	None
VIII	None		All Tests	None

REFERENCE OIL VISCOSITY GRADES

Oil	SAE Viscosity Grade	Date Received[1]
822-2	15W-40	20130722
823 (PC11A)	10W30	20150521
830 (PC-9E)	15W-40	20001109
830-1	15W-40	20020107
830-2	15W-40	20020401
830-3	15W-40	20161221
831 (PC10B)	15W-40	20050330
831-1	15W-40	20070710
831-2	15W-40	20111128
831-3	15W-40	20150317
831-4	15W-40	20170217
832 (PC11G)	15W-40	20150521
832-1	15W-40	20180524
833 (PC11K)	15W-40	20150325
833-1	15W-40	20170619
864 (X)	5W-30	20160520
864-1	5W-30	20160705
866 (C)	10W-30	20160609
873	40	19930728
873-1	40	19940214
873-2	40	20020313
925	5W-30	19870123
925-1	5W-30	19880216
925-2	5W-30	19900614
925-3	5W-30	19930608
931	0W-20	20200303
940	5W-30	20120425
940-1	5W-30	20180605
1004-2	15W-40	19941216
1004-3	15W-40	19960508
1005	15W-40	19960229
1005-1	15W-40	19980121
1005-2	15W-40	20030926
1005-3	15W-40	20090928
1005-4	15W-40	20120731
1005-5	15W-40	20150116
1006	5W-30	19961014
1006-1	5W-30	20000907
1006-2	5W-30	20001026
1007	5W-30	19980424
1008	5W-30	19980601
1008-1	5W-30	20020318
1009	5W-30	20020307
1009-1	5W-30	20170530
1010	5W-20	20100824

12. Sequence VIII LTMS Requirements

The following are the specific Sequence VIII calibration test requirements. For purposes of the Sequence VIII, a test stand is defined as an engine/stand combination.

A. Reference Oils and Parameters

The critical parameter is Total Bearing Weight Loss (TBWL). The reference oils required for test stand and laboratory calibration are reference oils accepted by the ASTM Sequence VIII Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameter are presented below.

TOTAL BEARING WEIGHT LOSS
Unit of Measure: mg
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
704-1	8.3	2.32
1006	15.9	4.85
1006-2	17.5	4.23

10-HOUR STRIPPED VISCOSITY
Unit of Measure: centistokes
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
704-1	10.27	0.11
1006	9.00	0.17
1006-2	9.37	0.07

B. Acceptance Criteria

In addition to the calibration test requirements described below for new and existing test stands:

- A new bearing batch requires a minimum of two (2) operationally valid calibration tests with no stand Shewhart alarms per laboratory.

Sequence VIII Reference Oil Targets							
		Effective Dates		TBWL		10 Hr. Stripped Viscosity	
Oil	n	From[1]	To[2]	$\overline{X}$	s	$\overline{X}$	s
704-1	10[4]	8-29-98	11-16-99	7.9	3.40[3]	10.27	0.12[3]
	11	11-17-99	4-15-01	8.0	3.40	10.25	0.15
	23	4-16-01	12-16-01	8.3	2.44	10.29	0.11
	35	12-17-01	***	8.3	2.32	10.27	0.11
1006	10[4]	8-29-98	11-16-99	19.6	3.40[3]	9.09	0.12[3]
	10	11-17-99	4-15-01	17.1	5.28	9.00	0.22
	23	4-16-01	12-16-01	15.6	4.66	8.98	0.19
	32	12-17-01	***	15.9	4.85	9.00	0.17
1006-2	7	10-25-02	8-31-03	13.0	4.26	9.23	0.07
	12	9-1-03	5-14-04	12.4	2.59	9.24	0.06
	20	5-15-04	9-18-06	12.6	2.81	9.24	0.07
	--	9-19-06	3-11-07	15.9[5]	4.85[5]	9.24	0.07
	11	3-12-07	***	17.5	4.23	9.37	0.07
1009	5	1-7-03	1-23-05	12.8	2.00	9.51	0.10
	11	1-24-05	5-21-21	13.8	2.14	9.51	0.10

1 Effective for all tests completed on or after this date.
2 *** = currently in effect.
3 Pooled s from GF-3 matrix analysis.
4 GF-3 matrix n-size.
5 Targets based on oil 1006.