

6. Sequence IVA LTMS Requirements

A. Reference Oils and Parameters

The critical parameter is Average Camshaft Wear. The reference oils required for stand calibration are the reference oils accepted by the ASTM Sequence IVA Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameter are presented below.

AVERAGE CAMSHAFT WEAR
Unit of Measure: micrometers

Reference Oil	Mean	Standard Deviation
1006-2	100.18	18.65
1007	84.76	15.40
1009	18.76	7.05

B. Acceptance Criteria

1. New Test Stand

a. Less than six (6) Operationally Valid Calibration Results in Laboratory

- A minimum of two (2) operationally valid calibration tests, with no stand Shewhart severity alarms (all parameters) and no stand Shewhart precision alarms (critical parameters only) on any approved reference oils.
- All operationally valid calibration results must be charted to determine if the test stand is currently “in control” as defined by the control chart from the Lubricant Test Monitoring System.

b. Six (6) or more Operationally Valid Calibration Results in Laboratory*

- The first operationally valid test run on any approved reference oil must have no stand Shewhart severity alarm and no stand Shewhart precision alarm using the “Reduced K” values. If the first operationally valid calibration test does not meet these acceptance criteria, then the New Test Stand criteria listed above in 1.a must be followed.

- * Only test results from calibrated stands in the laboratory count towards the tally of six (6) required operationally valid calibration tests. The sixth test must complete (date and time) before the first test completes (date and time) on a new test stand that is seeking calibration with a single test result. In addition, the first test for the stand is to begin within six (6) months of the completion of the last acceptable calibration test. Also, there must not be any outstanding precision alarms for the laboratory.

- Exceed EWMA laboratory chart warning limit for precision
 - Immediately begin two (2) calibration tests on calibrated test stands different from the test stand which exceeded the warning limit. (Calibration tests currently running on “existing” test stands may be used.) If a laboratory has two (2) test stands, conduct one (1) calibration test in each of those two (2) stands. If a laboratory has only one (1) test stand, conduct two (2) additional calibration tests in that test stand. Notify the TMC for potential laboratory visit. Candidate testing may continue on other calibrated test stands.
- Exceed EWMA test stand chart limit for precision
 - Remove test stand from the system. Notify the TMC. Correct test stand precision problem. Follow requirements for entry of a new test stand into the system.
- Exceed Shewhart test stand chart limit for precision
 - Conduct an additional calibration test.
- Exceed Shewhart laboratory chart limit for precision
 - Notify TMC for guidance.
- Exceed EWMA laboratory chart limit for severity
 - Calculate laboratory Severity Adjustment (SA) for each parameter that exceeds action limit, using the current laboratory EWMA (Z_i) as follows:

$$\text{ACW } (\mu\text{m}) \qquad \text{SA} = (-Z_i) * (15.72)$$
 - Confirm calculations with TMC.
- Exceed EWMA test stand chart limit for severity
 - Notify the TMC. If the direction of the test stand is deemed different from that of the laboratory, conduct an additional calibration test in the identified test stand. If this limit is still exceeded after the additional calibration test, then remove the test stand from the system, notify the TMC, correct test stand severity problem, and follow requirements for entry of a new test stand into the system.
- Exceed Shewhart test stand chart limit for severity
 - Conduct an additional calibration test.

31. Oil Seal Compatibility Test LTMS Requirements

The following are the specific Oil Seal Compatibility Test calibration test requirements.

A. Reference Oils and Critical Parameters

The critical parameters are Elongation, Shore Hardness, and Volume Change. The reference oils required for test stand and test laboratory calibration are the reference oils accepted by the ASTM Oil Seal Compatibility Test Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameters are presented below.

ELONGATION

Unit of Measure: Percent

Reference Oil	Elastomer	Mean	Standard Deviation
160-1	Polyacrylate	23.04	14.289
160-1	Fluoroelastomer	-47.65	5.506
161-1	Polyacrylate	68.88	17.850
161-1	Fluoroelastomer	-34.57	6.989
161-1	Nitrile	10.43	10.691
162	Nitrile	-65.35	7.330
168	Nitrile	-74.52	6.965
169	Polyacrylate	49.2	21.82
169	Fluoroelastomer	-39.5	6.99
169	Nitrile	-16.2	10.69

SHORE HARDNESS

Unit of Measure: Points

Reference Oil	Elastomer	Mean	Standard Deviation
160-1	Polyacrylate	-1.8	1.16
160-1	Fluoroelastomer	1.6	1.36
161-1	Polyacrylate	-24.9	2.83
161-1	Fluoroelastomer	1.6	1.30
161-1	Nitrile	-16.1	2.18
162	Nitrile	2.0	2.03
168	Nitrile	3.0	1.89
169	Polyacrylate	-16.0	2.83
169	Fluoroelastomer	0.1	1.30
169	Nitrile	-8.6	2.18

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

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 or 161 (or subsequent reblends) for every calibration sequence.
FL	Assign reference oils 160 or 161 (or subsequent reblends) for every calibration sequence.
NI	Assign reference oils 161, 162, or 168 (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 test stand chart 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.

Sequence IVA Reference Oil Targets					
Oil	n	Effective Dates		Average Camshaft Wear	
		From ¹	To ²	\bar{X}	s
1006	24 ⁴	8-19-98	9-30-99	115.80	9.47 ³
	5 ⁵	10-1-99	1-25-00	117.14 ⁵	12.23 ⁵
	10	1-26-00	5-23-01	121.38	9.86
	77	5-24-01	***	121.76	12.50
1006-2	6	2-11-02	7-18-02	88.74	12.50 ⁶
	11	7-19-02	1-20-04	90.72	11.16
	22	1-21-04	2-01-12	91.15	8.93
	4	2-2-12	***	100.18	18.65
1007	24 ⁴	8-19-98	9-30-99	95.58	9.47 ³
	11	5-24-01	12-31-02	92.12	16.76
	21	1-1-03	7-27-04	86.94	16.22
	31	7-28-04	***	84.76	15.40
1008	24 ⁴	8-19-98	9-30-99	40.16	9.47 ³
1009	5	12-18-02	4-30-04	21.03	6.23
	11	5-1-04	11-13-07	19.08	5.60
	29	11-14-07	***	18.76	7.05

- 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 Individual oil 1006 statistics from prove-out matrix
- 6 Standard deviation based on oil 1006

Oil Seal Compatibility Test Reference Oil Targets										
Oil	n	Elastomer	Effective Dates		Elongation		Shore Hardness		Volume Change	
			From ¹	To ²	\bar{X}	s	\bar{X}	s	\bar{X}	s
160 ³	--	Polyacrylate	11-18-94	***	23.04	14.289	-1.8	1.16	0.343	0.4473
	--	Fluoroelastomer	11-18-94	***	-47.65	5.506	1.6	1.36	2.053	0.4075
160-1	144	Polyacrylate	11-18-94	***	23.04	14.289	-1.8	1.16	0.343	0.4473
	141	Fluoroelastomer	11-18-94	***	-47.65	5.506	1.6	1.36	2.053	0.4075
161 ⁴	--	Polyacrylate	11-18-94	***	68.88	17.850	-24.9	2.83	19.624	1.4348
	--	Fluoroelastomer	11-18-94	***	-34.57	6.989	1.6	1.30	6.199	0.7080
	--	Nitrile	11-18-94	***	10.43	10.691	-16.1	2.18	18.444	1.7057
161-1	144	Polyacrylate	11-18-94	***	68.88	17.850	-24.9	2.83	19.624	1.4348
	141	Fluoroelastomer	11-18-94	***	-34.57	6.989	1.6	1.30	6.199	0.7080
	119	Nitrile	11-18-94	***	10.43	10.691	-16.1	2.18	18.444	1.7057
162	119	Nitrile	11-18-94	***	-65.35	7.330	2.0	2.03	2.460	1.5821
168	13	Nitrile	7-7-06	2-28-09	-74.22	2.422	3.0	1.49	1.424	0.1295
	38	Nitrile	3-1-09	3-10-09	-74.52	1.599	3.0	0.79	1.326	0.1388
	38	Nitrile	3-11-09	***	-74.52	6.965 ⁵	3.0	1.89 ⁵	1.326	1.4730 ⁵
169	19	Polyacrylate	3-7-12	***	49.2	21.82	-16.0	2.83 ⁶	13.1	1.430 ⁶
	18	Fluoroelastomer	3-7-12	***	-39.5	6.99 ⁶	0.1	1.30 ⁶	4.4	0.71 ⁶
	22	Nitrile	3-7-12	***	-16.2	10.69 ⁶	-8.6	2.18 ⁶	11.8	1.710 ⁶

- 1 Effective for all tests completed on or after this date.
- 2 *** = currently in effect.
- 3 Targets based on oil 160-1.
- 4 Targets based on oil 161-1.
- 5 Standard deviation based on oil 162 (n=138).
- 6 Standard deviation based on oil 161-1.

APPENDIX B
HISTORY OF INDUSTRY CORRECTION FACTORS
APPLICABLE TO LTMS DATA

Test Area	Effective	Description
IIIF	None	None
IIIG	None	None
IIIGA	None	None
IIIGB	July 24, 2009	Add 1.61 to PHOS
IVA	None	None
VG	July 1, 2005	For 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	For 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	For 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	For Fuel Batch XC2721NX10, Subtract 0.24 from APV; subtract 0.12 from AEV.
VIB	None	None
VID	None	None
VIII	None	None
1M-PC	None	None
1K	None	None
1N	May 1, 2004	Add -1.135 to ln(TLHC+1)
1P	None	None
1R	None	None
C13	None	None
ISB	April 21, 2011	For Batch B Tappets with Batch E, F, and G Cams; Multiply ATWL by 0.637; Add -9.5 to ACSW
ISB	December 11, 2011	For Batch C Tappets with Batch H Cams; Multiply ATWL by 0.637; Add -9.5 to ACSW
ISM	June 28, 2007	Add +1.7 to Crosshead Wear At 3.9% Soot Add +19.1 to Injector Adjusting Screw Wear At 3.9% Soot
T-8	September 17,2011	Add +0.40 to Viscosity Increase at 3.8% Soot
T-8E	September 17,2011	Add +0.08 to Relative Viscosity at 4.8% Soot (50% DIN Shear Loss) Add +0.09 to relative Viscosity at 4.8% Soot (100% DIN Shear Loss)
T-10A	None	None
T-11	September 14, 2005	Add -0.39% to Soot @ 12cSt Vis. Inc., Add 1274 cP to MRV Vis.
	December 6, 2005	Add -0.36% to Soot @ 12cSt Vis. Inc., Add 713 cP to MRV Vis.
	March 24, 2006	Add -0.35% to Soot @ 12cSt Vis. Inc., Add 956 cP to MRV Vis.

APPENDIX C
HISTORY OF SEVERITY ADJUSTMENT (SA)
STANDARD DEVIATIONS

Test	Parameter	s	Effective Dates	
			From	To
Sequence IIIF	VIS80	0.0129546	20000610	***
	APV	0.220	20000610	***
	WPD	0.658	20000610	***
	VIS60	0.17334	20011115	***
Sequence IIIG	PVIS	0.2919	20030501	***
	WPD	0.60	20030501	***
	ACLW	0.1936	20030501	20040120
		0.1903	20040121	***
Sequence IIIGA	MRV Viscosity	0.30763	20031103	20040526
Sequence IIIGB	Phos. Retention	2.33	20081112	***
Sequence IVA	ACW	9.47	19980819	20010524
		12.50	20010525	20050630
		12.52	20050701	20120208
		15.72	20120209	***

HISTORY OF SEVERITY ADJUSTMENT (SA)
STANDARD DEVIATIONS

Test	Parameter	s	Effective Dates	
			From	To
Sequence VG	AES	0.61	19980916	19990531
		0.68	19990601	19991115
		0.55	19991116	20000524
		0.51	20000525	20001116
		0.47	20001117	20041231
		0.45	20050101	***
	RCS	0.56	19980916	19990531
		0.32	19990601	19991115
		0.28	19991116	20000524
		0.24	20000525	20001116
		0.33	20001117	20041231
		0.25	20050101	***
	AEV	0.23	19980916	19990531
		0.10	19990601	19991115
		0.11	19991116	20000524
		0.10	20000525	20001116
		0.09	20001117	20041231
		0.10	20050101	20110728
		0.16	20110729	***
	APV	0.32	19980916	19990531
		0.26	19990601	19991115
		0.17	19991116	20000524
		0.18	20000525	20001116
		0.17	20001117	20041231
		0.20	20050101	20110728
		0.31	20110729	***
	OSCRNSLG	27.34	19980916	19990531
		18.10	19990601	19991115
		3.40	19991116	20000524
		0.828 ¹	20000525	20001116
		0.742 ¹	20001117	20041231
		0.793 ¹	20050101	***

1 Transformation $\ln(\text{OSCRNSLG} + 1)$ adopted 20000525.

HISTORY OF SEVERITY ADJUSTMENT (SA)
STANDARD DEVIATIONS (Continued)

Test	Parameter	s	Effective Dates	
			From	To
Sequence VIB	FEI1	0.18	19980825	***
	FEI2	0.17	19980825	***
Sequence VID	FEI1	0.14	20090422	20091202
	FEI2	0.16	20090422	20091202
	FEI1	0.12	20091203	***
	FEI2	0.14	20091203	***
Sequence VIII	TBWL	3.40	19980829	19991116
		5.28	19991117	20020205
		4.80	20020206	***
	10hr. Stripped Vis.	None	--	--
1M-PC	WTD	50.5	19930914	***
	TGF	16.1	19930914	***
1K	WDK	35.6	19900506	***
	TGF	15.7	19900506	***
	TLHC	1.1	19900506	***
	OC	None	--	--
1N	WDN	27.1	19930314	***
	TGF	14.6	19930314	***
	TLHC	0.9	19930314	***
	OC	None	--	--
1P	TGC	7.740	19970219	***
	TLC	13.150	19970219	***
	AOC	0.3238	19970219	***
	WDP	57.60	19970219	***
	EOTOC	0.5177	19970219	***
1R	WDR	29.0	20010701	***
	TGC	9.70	20010701	***
	TLC	7.84	20010701	***
	IOC	1.32	20010701	***
	EOTOC	1.35	20010701	***
C13	TGC	None	--	--
	TLC	None	--	--
	OCA	None	--	--
	R2TC	None	--	--
ISB	Camshaft Wear	None	--	--
	Tappet Wt. Loss	None	--	--
ISM	X-Head Wear	None	--	--
	OFDP	None	--	--
	Average Sludge	None	--	--
	Adj. Screw Wear	None	--	--