

## 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

### 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.

## 2. Existing Test Stand

The test stand must have previously been 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:

- 100% of the scheduled calibration tests should be conducted on reference oils 1006 and 1007, or subsequent approved reblends.

## 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 Sequence IVA, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters is required.

### LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart				Shewhart Chart	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Reduced K	--	--	--	--	1.11	1.48
	Action	0.3	0.3	1.46	1.80	1.46	1.80
Lab	Warning	0.2	--	1.46	--	--	--
	Action	0.2	0.3	2.33	1.80	1.46	1.80
Industry	Warning	0.2	0.2	1.46	1.80	--	--
	Action	0.2	0.2	2.33	2.58	--	--

The following are the steps that must be taken in the case of exceeding control chart limits. The steps are listed in order of priority, although charts should be studied simultaneously to determine the cause(s) of a problem. In the case of multiple alarms, contact the TMC for guidance.

- Exceed the EWMA laboratory chart action limit for precision
  - Cease all candidate starts in the laboratory. Develop plan to correct laboratory precision problem. Coordinate efforts with the TMC.

## 26. L-33-1 LTMS Requirements

The following are the specific L-33-1 calibration test requirements.

### A. Reference Oils and Critical Parameter

The critical parameter is Final Rust. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM L-33-1 Surveillance Panel. The mean and standard deviations for the current reference oils for the critical parameter are presented below.

FINAL RUST  
Unit of Measure: Merits  
Gear Versions V99.1 & V01.1

Reference Oil	Mean	Standard Deviation
123	8.560	0.230
123-2	8.740	0.260
151-3	9.640	0.250
155	9.580	0.250
155-1	9.580	0.250

### B. Acceptance Criteria

#### 1. New Test Stand

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

#### 2. Existing Test Stand

- The test stand must have been an ASTM TMC calibrated test stand prior to LTMS introduction or have previously been accepted into the system by meeting LTMS calibration requirements.
- All operationally valid calibration test results must be charted to determine if the test stand is currently “in control” as defined by the control charts from the Lubricant Test Monitoring System.

### 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:

- 50% of the scheduled calibration tests should be conducted on reference oil 123 or subsequent approved reblends.
- 50% of the scheduled calibration tests should be conducted on reference oil 151-3 or 155 or subsequent approved reblends.

### 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 L-33-1, 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	Warning	0.30	0.30	1.65	--	--	--
	Action	0.30	0.30	2.33	1.96	1.46	1.80
Lab	Action	--	0.20	--	1.80	--	--
Industry	Warning	0.20	0.20	1.46	1.80	--	--
	Action	0.20	0.20	2.33	2.58	--	--

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

- Exceed EWMA test stand chart action 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 EWMA test stand chart warning limit for precision
  - Immediately begin two calibration tests on the test stand.
- Exceed Shewhart test stand chart limit for precision
  - Conduct an additional calibration test.

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, 161 or 169 (or subsequent reblends) for every calibration sequence.
FL	Assign reference oils 160, 161 or 169 (or subsequent reblends) for every calibration sequence.
NI	Assign reference oils 161, 162, or 168 (or subsequent reblends) for every calibration sequence.

Sequence IVA Reference Oil Targets					
Oil	n	Effective Dates		Average Camshaft Wear	
		From <sup>1</sup>	To <sup>2</sup>	$\bar{X}$	s
1006	24 <sup>4</sup>	8-19-98	9-30-99	115.80	9.47 <sup>3</sup>
	5 <sup>5</sup>	10-1-99	1-25-00	117.14 <sup>5</sup>	12.23 <sup>5</sup>
	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 <sup>6</sup>
	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 <sup>4</sup>	8-19-98	9-30-99	95.58	9.47 <sup>3</sup>
	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 <sup>4</sup>	8-19-98	9-30-99	40.16	9.47 <sup>3</sup>
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	6-1-11	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

L-33-1 Reference Oil Targets						
Oil	Gear Version	n	Effective Dates		Rust	
			From <sup>1</sup>	To	$\bar{X}$	s
121	V94.1	12 <sup>2</sup>	6-5-96	4-19-00	9.370 <sup>2</sup>	0.280 <sup>2</sup>
	V95.1	12 <sup>2</sup>	6-5-96	4-19-00	9.370 <sup>2</sup>	0.280 <sup>2</sup>
121-1	V94.1	--	1-19-98	4-29-99	9.370 <sup>3</sup>	0.280 <sup>3</sup>
	V94.1	45 <sup>2</sup>	4-30-99	11-17-00	9.390 <sup>2</sup>	0.218 <sup>2</sup>
	V95.1	--	1-19-98	4-29-99	9.370 <sup>3</sup>	0.280 <sup>3</sup>
	V95.1	45 <sup>2</sup>	4-30-99	11-17-00	9.390 <sup>2</sup>	0.218 <sup>2</sup>
121-2	V99.1	8	4-20-00	11-17-00	9.830	0.260 <sup>4</sup>
	V94.1	--	12-14-99	11-17-00	9.390 <sup>5</sup>	0.218 <sup>5</sup>
	V95.1	--	12-14-99	11-17-00	9.390 <sup>5</sup>	0.218 <sup>5</sup>
	V99.1	--	4-20-00	11-17-00	9.830 <sup>6</sup>	0.260 <sup>4</sup>
123	V94.1	54 <sup>2</sup>	5-5-95	4-19-00	9.000 <sup>2</sup>	0.330 <sup>2</sup>
	V95.1	54 <sup>2</sup>	5-5-95	4-19-00	9.000 <sup>2</sup>	0.330 <sup>2</sup>
	V99.1	12	6-11-02	8-24-04	8.430	0.390
	V01.1	--	11-25-02	8-24-04	8.430 <sup>10</sup>	0.390 <sup>10</sup>
123-1	V99.1 & V01.1	30	8-25-04	***	8.560	0.230
	V94.1	13 <sup>7</sup>	4-20-00	11-17-00	8.240 <sup>7</sup>	0.330 <sup>8</sup>
	V95.1	--	12-14-99	4-19-00	9.000 <sup>9</sup>	0.330 <sup>9</sup>
	V95.1	13 <sup>7</sup>	4-20-00	11-17-00	8.240 <sup>7</sup>	0.330 <sup>8</sup>
123-2	V99.1	13 <sup>7</sup>	4-20-00	11-17-00	8.240 <sup>7</sup>	0.330 <sup>8</sup>
	V99.1	--	11-25-02	8-24-04	8.430 <sup>10</sup>	0.390 <sup>10</sup>
	V99.1 & V01.1	--	8-25-04	6-1-06	8.560 <sup>9</sup>	0.230 <sup>9</sup>
151-3	V99.1 & V01.1	15	6-2-06	***	8.740	0.260
	V99.1	13	6-11-02	8-24-04	9.690	0.350
	V01.1	--	11-25-02	8-24-04	9.690 <sup>11</sup>	0.350 <sup>11</sup>
155	V99.1 & V01.1	30	8-25-04	2-8-06	9.640	0.250
	V99.1 & V01.1	--	6-2-06	---	9.580	0.250 <sup>12</sup>
155-1	V99.1 & V01.1	--	4-4-12	---	9.580	0.250 <sup>12</sup>

1 Effective for all tests completed on or after this date.

2 Based on V94.1 & V95.1 data.

3 Based on oil 121 data.

4 Based on lab pooled s of V94.1 & V95.1 data (all blends of oil 121).

5 Based on oil 121-1 data.

6 Based on V99.1 data on oil 121-1.

7 Based on V99.1 and V95.1 data.

8 Based on lab pooled s of V94.1 & V95.1 data (all blends of oil 123).

9 Based on oil 123 data.

10 Based on V99.1 data on oil 123.

11 Based on V99.1 data on oil 151-3.

12 Based on V99.1 & V01.1 data on oil 151-3.