12. 1K LTMS Requirements

The following are the specific 1K calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Weighted Demerits and Top Groove Fill. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Single Cylinder Diesel Surveillance Panel. The means and standard deviations for the current reference oils for each critical and noncritical parameter are presented below.

WEIGHTED DEMERITS
Unit of Measure: Demerits
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	219.2	41.9
809-1	216.4	35.6
811-1	327.7	55.9

TOP GROOVE FILL
Unit of Measure: Percent
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	12.3	6.3
809-1	17.5	15.7
811-1	27.3	16.6

TOP LAND HEAVY CARBON
Unit of Measure: LN(TLHC+1)
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	0.398	0.9
809-1	0.605	1.1
811-1	0.868	1.0

AVERAGE OIL CONSUMPTION
Unit of Measure: g/kW-h
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809	0.272	0.117
809-1	0.268	0.145
811-1	0.267	0.097

B. Acceptance Criteria

1. New Test Stand

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

- Two (2) operationally valid calibration tests, with no stand Shewhart severity alarms and no stand Shewhart precision alarms for critical parameters, must be conducted on any approved reference oils. The second run must be started not more than 14 days after the completion of the first.

- All critical parameters for 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.

b. Six (6)* or more Operationally Valid Calibration Results in Laboratory and no current laboratory level EWMA or Shewhart precision alarms

- The first operationally valid calibration test run on any approved reference oil must have no stand Shewhart severity alarms and no stand Shewhart precision alarms for critical parameters using the "Reduced K" values. If the first operationally valid calibration test does not meet this 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. The most recent of those tests must have completed not more than twelve (12) months before the end of the test being considered for "Reduced K".

Examples of stands required to meet New Test Stand acceptance criteria include:

a. an entirely new stand installation that has never before been calibrated.
b. a previously calibrated stand that has undergone significant hardware, software, or control system changes.
c. a previously calibrated stand whose last calibration expired more than one calibration period ago.

2. Existing Test Stand

   - One (1) operationally valid calibration test, with no stand Shewhart severity alarms and no stand Shewhart precision alarms for critical parameters, must be conducted on any approved reference oil.

   - All critical parameters for 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.

   Examples of stands required to meet Existing Test Stand acceptance criteria include:

   a. a previously calibrated stand whose last calibration expired not more than one calibration period ago.
   b. a stand currently calibrated as a 1N stand in a lab with at least one other currently calibrated 1K stand.

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 809 and 811, 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 1K, 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	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Reduced K	--	--	--	--	1.48	1.43
	Action	0.3	0.3	1.80	2.10	1.80	1.75
Lab	Warning	0.2	--	1.80	--	--	--
	Action	0.2	0.2	2.58	1.96	1.80	1.75
Industry	Warning	0.15	0.15	1.74	2.05	--	--
	Action	0.15	0.15	2.58	2.81	--	--

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 EWMA laboratory chart action limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports during the alarm period.

- Exceed EWMA laboratory chart warning limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports during the alarm period.

- Exceed EWMA test stand chart limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports for the stand in question during the alarm period.

- Exceed Shewhart test stand chart limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports for the stand in question during the alarm period.

- Exceed Shewhart laboratory chart action limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports during the alarm period.

- Exceed EWMA laboratory chart action limit for severity (all parameters noted below)

  – Calculate laboratory Severity Adjustment (SA) for each parameter that exceeds action limit, using the current laboratory EWMA (Z_i) as follows:

Weighted Demerits:	$SA = (-Z_i) \times (35.6)$*
Top Groove Fill:	$SA = (-Z_i) \times (15.7)$*
Top Land Heavy Carbon:	$SA = (-Z_i) \times (1.1)$*

    * s based on reference oil 809-1

  – Confirm calculations with the TMC.

- Exceed EWMA test stand chart limit for severity (critical parameters only)

  – Notify the TMC. If the direction of the test stand severity is deemed different from that of the test laboratory, conduct an additional calibration test in the identified test stand. If this limit is still exceeded after the additional calibration test, then remove 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 (all parameters except Average Oil Consumption)

  – Conduct an additional calibration test.

- Exceed 0.5 g/kWh Average Oil Consumption

  – 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 test developer, surveillance panel chairman, and ACC Monitoring Agency. Meeting of TMC, test developer, and surveillance panel required to determine course of action.

- Exceed EWMA industry chart warning limit (all parameters)

  – TMC to notify test developer, surveillance panel chairman, and ACC Monitoring Agency. Coordination of TMC, test developer, and surveillance panel chairman required to discuss potential problem.

13. 1N LTMS Requirements

The following are the specific 1N calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Weighted Demerits and Top Groove Fill. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Single Cylinder Diesel Surveillance Panel. The means and standard deviations for the current reference oils for each critical and noncritical parameter are presented below.

WEIGHTED DEMERITS
Unit of Measure: Demerits
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809-1	205.0	34.6
811-1	273.2	35.5
811-2	281.5	37.4
1004-2	204.0	25.7
1004-3	190.7	24.7

TOP GROOVE FILL
Unit of Measure: Percent
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809-1	35.3	20.5
811-1	26.2	19.8
811-2	24.7	21.6
1004-2	30.4	16.8
1004-3	23.9	14.6

TOP LAND HEAVY CARBON
Unit of Measure: LN(TLHC+1)
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809-1	1.1970	1.2130
811-1	0.454	0.6590
811-2	0.366	0.6000
1004-2	0.4900	0.8040
1004-3	0.1806	0.3977

AVERAGE OIL CONSUMPTION

Unit of Measure: g/kW-h
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
809-1	0.308	0.175
811-1	0.218	0.053
811-2	0.223	0.052
1004-2	0.206	0.075
1004-3	0.148	0.038

B. Acceptance Criteria

1. New Test Stand

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

- Two (2) operationally valid calibration tests, with no stand Shewhart severity alarms and no stand Shewhart precision alarms for critical parameters, must be conducted on any approved reference oils. The second run must be started not more than 14 days after the completion of the first.

- All critical parameters for 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.

b. Six (6)* or more Operationally Valid Calibration Results in Laboratory and no current laboratory level EWMA or Shewhart precision alarms

- The first operationally valid calibration test run on any approved reference oil must have no stand Shewhart severity alarm and no stand Shewhart precision alarms for critical parameters using the "Reduced K" values. If the first operationally valid calibration test does not meet this 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. The most recent of those tests must have completed not more than twelve (12) months before the end of the test being considered for "Reduced K".

Examples of stands required to meet New Test Stand acceptance criteria include:

a. an entirely new stand installation that has never before been calibrated.
d. a previously calibrated stand that has undergone significant hardware, software, or control system changes.
e. a previously calibrated stand whose last calibration expired more than one calibration period ago.

2. Existing Test Stand

   - One (1) operationally valid calibration test, with no stand Shewhart severity alarms and no stand Shewhart precision alarms for critical parameters, must be conducted on any approved reference oil.

   - All critical parameters for 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.

   Examples of stands required to meet Existing Test Stand acceptance criteria include:

   a. a previously calibrated stand whose last calibration expired not more than one calibration period ago.
   b. a stand currently calibrated as a 1K stand in a lab with at least one other currently calibrated 1N stand

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:

   - Calibration tests should be conducted on reference oils 809-1, and 811-1, 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 1N, 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	--	--	--	--	1.48	1.43
	Action	0.3	0.3	1.80	2.10	1.80	1.75
Lab	Warning	0.2	--	1.80	--	--	--
	Action	0.2	0.2	2.58	1.96	1.80	1.75
Industry	Warning	0.15	0.15	1.74	2.05	--	--
	Action	0.15	0.15	2.58	2.81	--	--

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 EWMA laboratory chart action limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports during the alarm period.

- Exceed EWMA laboratory chart warning limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports during the alarm period.

- Exceed EWMA test stand chart limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports for the stand in question during the alarm period.

- Exceed Shewhart test stand chart limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports for the stand in question during the alarm period.

- Exceed Shewhart laboratory chart action limit for precision (critical parameters only)

  – Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports during the alarm period.

- Exceed EWMA laboratory chart action limit for severity (all parameters noted below)

  – Calculate laboratory Severity Adjustment (SA) for each parameter that exceeds action limit, using the current laboratory EWMA (Z_i) as follows:

Weighted Demerits:	$SA = (-Z_i) \times (27.1)$*
Top Groove Fill:	$SA = (-Z_i) \times (14.6)$*
Top Land Heavy Carbon:	$SA = (-Z_i) \times (0.9)$*

    * s based on reference oil 1004-1

  – Confirm calculations with the TMC.

- Exceed EWMA test stand chart limit for severity (critical parameters only)

  – Notify the TMC. If the direction of the test stand severity is deemed different from that of the test laboratory, conduct an additional calibration test in the identified test stand. If this limit is still exceeded after the additional calibration test, then remove 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 (all parameters except Average Oil Consumption)

  – Conduct an additional calibration test.

- Exceed 0.5 g/kWh Average Oil Consumption

  – 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 test developer, surveillance panel chairman, and ACC Monitoring Agency. Meeting of TMC, test developer, and surveillance panel required to determine course of action.

- Exceed EWMA industry chart warning limit (all parameters)

  – TMC to notify test developer, surveillance panel chairman, and ACC Monitoring Agency. Coordination of TMC, test developer, and surveillance panel chairman required to discuss potential problem.

APPENDIX B (continued)
HISTORY OF INDUSTRY CORRECTION FACTORS

Test Area	Effective		Condition	Description
	From	To		
T-11	September 14, 2005	***	All Tests	Add -0.39% to Soot @ 12cSt Vis. Inc., Add 1274 cP to MRV Vis
	December 6, 2005	***	All Tests	Add -0.36% to Soot @ 12cSt Vis. Inc., Add 713 cP to MRV Vis.
	March 24, 2006	***	All Tests	Add -0.35% to Soot @ 12cSt Vis. Inc., Add 956 cP to MRV Vis.
T-12	***	***	All tests using batch R piston ring & cylinder liner hardware	Multiply Average Cylinder Liner Wear by 0.58
	***	May 18, 2011	All Tests SWTN Hardware	Multiply Average Top Ring Weight Loss by 0.95
				Multiply Average Cylinder Liner Wear by 0.86
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.95)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 1.03)]
	May 19, 2011	June 4, 2012	All tests using SWTN Hardware	Multiply Average Top Ring Weight Loss by 0.92
				Multiply Average Cylinder Liner Wear by 0.83
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.92)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.93)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.95)]
				Multiply Average Top Ring Weight Loss by 0.92
	June 5, 2012	***	All tests using SWTN Hardware	Multiply Average Top Ring Weight Loss by 0.705
				Multiply Average Cylinder Liner Wear by 0.946
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.923)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.956)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.961)]
	***	***	All tests using UUXO Hardware	Multiply Average Top Ring Weight Loss by 0.849
				Multiply Average Cylinder Liner Wear by 0.566
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.797)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.700)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.916)]
	***	August 26, 2014	All tests using VUXO Hardware	Multiply Average Top Ring Weight Loss by 0.849
				Multiply Average Cylinder Liner Wear by 0.566
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.797)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.700)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.916)]

Test Area	Effective		Condition	Description
	From	To		
T-12	August 26, 2014	***	All tests using VUXO Hardware	Multiply Average Top Ring Weight Loss by 0.719
				Multiply Average Cylinder Liner Wear by 0.818
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.813)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.710)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.913)]
RFWT	None		All Tests	None
EOAT	None		All Tests	None