LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		Severity			Precision	
		EWMA		Shewhart	EWMA	
Chart Level	Limit Type	LAMBDA	K	K	LAMBDA	K
Stand	Action	--	--	2.0 (3.0)[A]	--	--
Lab	Action	0.2	0.00	--	0.2	2.65
Industry	Warning	0.2	2.24	--	0.2	2.00
	Action	0.2	2.88	--	0.2	2.65

[A] 3.0 K-value applies in special cases; see alarm actions below

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. The laboratory always has the option of removing any stand from the system.

- Exceed EWMA laboratory chart limit for severity
  - Calculate test laboratory Severity Adjustment (SA) for each parameter that exceeds the limit. Use the current laboratory EWMA (Z_i) as follows:

    PVIS: $SA = (-Z_i) \times (0.2919)$
    WPD: $SA = (-Z_i) \times (0.60)$
    ACLW: $SA = (-Z_i) \times (0.1903)$

  - Confirm calculation with the TMC.
- Exceed Shewhart stand chart limit for severity
  - If the test exceeds the Shewhart limit in the same direction (mild or severe) as an existing EWMA severity alarm, use the special case K-value and recheck the test for a Shewhart severity alarm. If the alarm no longer exists, no additional testing is required; however, the calibration period is reduced to 75 days or 18 test starts in the laboratory. If the test is still in alarm, conduct an additional calibration test on the same test stand. The additional calibration test must be started within 10 days or the stand is automatically removed from the system. For ACLW, tests failing outside the lower (mild) shewhart limit will not require an additional calibration test or a reduction in the calibration period.
  - If the test exceeds the Shewhart limit in the opposite direction (mild or severe) of an existing EWMA severity alarm or no EWMA severity alarm exists, conduct an additional calibration test on the same test stand. The additional calibration test must be started within 10 days or the stand is automatically removed from the system.

30. L-60-1 LTMS Requirements

The following are the specific L-60-1 calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Viscosity Increase, Pentane Insolubles, Average Carbon/Varnish, and Average Sludge. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM L-60-1 Surveillance Panel. The means and standard deviations for the current reference oils for each critical and noncritical parameter are presented below.

VISCOSITY INCREASE
Unit of Measure: VISI
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	81.451	7.659
131-4	75.944	7.659
148-1	36.966	7.659
151-2	37.070	2.717
155-1	27.750	3.242

PENTANE INSOLUBLES
Unit of Measure: PEN
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	2.293	0.413
131-4	2.560	0.413
148-1	0.387	0.413
151-2	2.064	0.380
155-1	1.490	0.529

AVERAGE CARBON/VARNISH
Unit of Measure: ACV
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	1.111	0.511
131-4	1.053	0.511
148-1	8.306	0.511
151-2	8.801	0.517
155-1	8.875	0.678

AVERAGE SLUDGE
Unit of Measure: ASL
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	9.411	0.106
131-4	9.483	0.106
148-1	9.532	0.106
151-2	9.382	0.106
155-1	9.435	0.103

TOLUENE INSOLUBLES
Unit of Measure: TOL
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	0.554	0.249
131-4	0.923	0.249
148-1	0.257	0.249
151-2	1.329	0.394
155-1	1.135	0.639

B. Acceptance Criteria

1. New Test Stand

- 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), 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.

L-60-1 Reference Oil Targets													
		Effective Dates		Viscosity Increase		Pentane Insolubles		Toluene Insolubles		Average Carbon/Varnish		Average Sludge	
Oil	n	From[1]	To[2]	$\bar{X}$	s^3	$\bar{X}$	s^3	$\bar{X}$	s^3	$\bar{X}$	s^3	$\bar{X}$	s^3
131-3	30	6-3-94	***	81.451	7.659	2.293	0.413	0.554	0.249	1.111	0.511	9.411	0.106
131-4	--	11-2-95	***	75.944	7.659	2.560	0.413	0.923	0.249	1.053	0.511	9.483	0.106
133	9	8-23-00	***	93.691	7.659	2.801	0.413	1.405	0.249	6.548	0.511	9.381	0.106
143	30	6-3-94	***	31.500	7.659	1.271	0.413	0.914	0.249	9.002	0.511	9.503	0.106
148	30	6-3-94	***	36.966	7.659	0.387	0.413	0.257	0.249	8.306	0.511	9.532	0.106
148-1	--	3-11-02	***	36.966	7.659	0.387	0.413	0.257	0.249	8.306	0.511	9.532	0.106
151-2	9	8-23-00	***	37.070	2.717	2.064	0.380	1.329	0.394	8.801	0.517	9.382	0.106
155-1	17	6-7-14	2-10-16	27.176	3.127	1.388	0.372	1.035	0.451	8.971	0.436	9.441	0.106
155-1	20	2-11-16	***	27.750	3.242	1.490	0.529	1.135	0.639	8.875	0.678	9.435	0.103

1. Effective for all tests completed on or after this date.
2. *** = currently in effect.
3. Standard deviations are pooled s values for all oils except 151-2 and 155-1.

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)]
	August 4, 2015	***	All test using VUXOA or VUXOB Hardware	Multiply Average Top Ring Weight Loss by 0.912
				Multiply Average Cylinder Liner Wear by 0.953
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.895)]
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.954)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.942)]
	February 25, 2016	***	All test using VUYPx	Multiply Average Top Ring Weight Loss by 0.912
				Multiply Average Cylinder Liner Wear by 0.970
				If $OC_{100\text{-}300} > 65.0$ $\Delta Lead(250\text{-}300)_{Final}$ = exp[(ln(ΔLead(250-300) + (65.0 - $OC_{100\text{-}300}$) x 0.04021)] If $OC_{100\text{-}300} \leq 65.0$ $\Delta Lead(250\text{-}300)_{Final}$ = ΔLead(250-300)
				If $OC_{100\text{-}300} > 65.0$ $\Delta Lead_{Final}$ = exp[(ln(ΔLead) + (65.0 - $OC_{100\text{-}300}$) x 0.03088] If $OC_{100\text{-}300} \leq 65.0$ $\Delta Lead_{Final}$ = ΔLead
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.940)]
T-13	None		All Tests	None
RFWT	None		All Tests	None
EOAT	None		All Tests	None
T-12A	None		All Tests	None

APPENDIX B (continued)
HISTORY OF INDUSTRY CORRECTION FACTORS

Test Area	Effective From	Effective To	Condition			Description
L-33-1			None			None
L37	20010612	***	V1L686/P4L626A Non-reference	Lubrited Ring	Canadian	Ridging add 0.9922
	20040825	***	V1L686/P4L626A Non-reference	Lubrited Pinion & Ring	Canadian	Ridging add 0.6065
	***	***	L247/T758A Non-reference	Lubrited Pinion	Canadian	Ridging add 0.5878, Pitting/Spalling add 0.7340
	***	20130514	V1L528/P4T883A Non-reference	Nonlubrited Pinion	Standard	Ridging add 0.3365, Rippling add 0.3365
					Canadian	Rippling add 0.7885
				Lubrited Pinion	Standard	Ridging add 0.3365
					Canadian	Ridging add 0.5878, Rippling add 0.5878
				Lubrited Ring	Canadian	Ridging add 0.3365
	20130515	***	V1L528/P4T883A Non-reference	Nonlubrited Pinion	Standard	Ridging add 0.3365, Rippling add 0.3365
					Canadian	Rippling add 0.7566
				Lubrited Pinion	Standard	Ridging add 0.3365
					Canadian	Ridging add 0.5878, Rippling add 0.5878
				Lubrited Ring	Canadian	Ridging add 0.3365
L-42	20140529	***	All reference oil tests using oil 117			Add 6% to pinion scoring result and add 4% to ring scoring result
L-60-1	20151001	***	All tests			Add 0.6 merits to ACV
HTCT			None			None
OSCT			None			None

APPENDIX E

APPLYING SEVERITY ADJUSTMENTS

In order to adjust non-reference oil test results for laboratory or stand severity, an exponentially weighted, moving average technique (EWMA) is applied to standardized calibration test results. See Section 1.A.3 of this document for an explanation.

When the EWMA laboratory or stand (for stand based test areas) chart action limit for severity is exceeded, a severity adjustment is calculated and applied to all subsequent non-reference oil tests. The following table lists the laboratory (or stand) EWMA severity alarm limit for all tests in the current LTMS. Alarm limits are calculated by the formula listed in Section 1.A.3.

Test Type	Alarm Level	Parameter(s)	Alarm Limit
IIIF	Laboratory	All	±0.653
IIIG	Laboratory	All	±0.000 (Continuous)
IIIGA	Laboratory	All	±0.550
IIIGB	Laboratory	All	±0.550
IVA	Laboratory	All	±0.600
VG	Laboratory	All	±0.653
VID	Stand	All	±0.000 (Continuous)
VIII	Laboratory	TBWL	±0.600
1M-PC	Laboratory	All	±0.653
1K	Laboratory	WTD,TGF,TLHC	±0
1N	Laboratory	WTD,TGF,TLHC	±0.653
1P	Laboratory	All	±0.653
1R	Laboratory	All	±0.653
C13	None	None	None
COAT	Stand	All	±0.000 (Continuous)
ISB	None	None	None
ISM	None	None	None
T-8/T-8E	Laboratory	All	±0.653
T-10A	Laboratory	All	±0.600
T-11	Laboratory	All	±0.653
T-12	Laboratory	All	±0.653
T-13	Laboratory	All	±0.000 (Continuous)
RFWT	Laboratory	All	±0.600
EOAT	Stand	All	±0.000 (Continuous)
L-33-1	Laboratory	All	±0.823
L-37	Stand	All	±0.653
L-42	None	None	None
L-60-1	Stand	All	±0.653
HTCT	None	None	None
OSCT	None	None	None