23. T-13 LTMS Requirements

The following are the specific T-13 calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical performance criteria are IR Oxidation Peak Height at 360 hours and percent increase in 40° kinematic viscosity from 300 to 360 hours. The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM T-13 Test Development Task Force. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

IR Oxidation Peak Height
Unit of Measure: absorbance / cm

Reference Oil	Mean	Standard Deviation
823	127.4	11.1

Percent Increase in Viscosity at 40°C from 300 to 360 hour
Unit of Measure: SQRT(%)

Reference Oil	Mean	Standard Deviation
823	8.610	0.929

B. Acceptance Criteria

1. New Test 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, and test stands in an existing test lab that have not run an acceptable reference in the past two years, may calibrate with one test provided e_i Level 1 limits are not exceeded. Otherwise a second test is required for calibration.

COAST SIDE PINION SCORING
Unit of Measure: % Scoring
Gear Batch P8L604

Reference Oil	Mean	Standard Deviation
115	25.3	4.58
116	22.9	4.81
116-1	22.9	4.81

COAST SIDE PINION SCORING
Unit of Measure: % Scoring
Gear Batch P4L806

Reference Oil	Mean	Standard Deviation
116	25.1	5.49
116-1	25.1	5.49

COAST SIDE PINION SCORING
Unit of Measure: % Scoring
Gear Batch P8L119

Reference Oil	Mean	Standard Deviation
116	23.0	5.49
116-1	23.0	5.49

COAST SIDE PINION SCORING
Unit of Measure: % Scoring
Gear Batch P8T025A

Reference Oil	Mean	Standard Deviation
116-1	23.0	5.49
117	23.0	5.49

COAST SIDE PINION SCORING
Unit of Measure: % Scoring
Gear Batch P8AD078X

Reference Oil	Mean	Standard Deviation
116-1	23.0	5.49
117	23.0	5.49

B. Acceptance Criteria

1. New Test Stand

- A minimum of four (4) operationally valid calibration tests, with no stand Shewhart severity alarms, must be conducted. Three (3) tests must be conducted on reference oil 114, 115, 116, 117 or subsequent approved reblends. All three tests must be completed on the same reference oil. The remaining one (1) calibration test must be conducted on discrimination reference oil 112, 113 or subsequent approved reblends. The end of test coast side pinion scoring value of the discrimination oil must be a minimum of twice the average value of the preceding three (3) acceptable reference oil tests. If a second discrimination oil test is needed, the test, if acceptable, will count as one (1) of the 15 non-reference oil tests. In the event that neither discrimination oil test meets the above requirement, a complete new calibration sequence must be performed. The results from tests conducted on discrimination oils are not charted.

- 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 previously accepted into the system by meeting LTMS calibration requirements.

- A test stand must complete three (3) operationally valid calibration tests, with no stand Shewhart severity alarms, on reference oil 114, 115, 116, or subsequent approved reblends. All three tests must be completed on the same reference oil. Every six months or fourth calibration sequence, an additional test must be conducted on discrimination reference oil 112, 113 or subsequent approved reblends. The end of test coast side pinion scoring value of the discrimination oil must be a minimum of twice the average value of the preceding three (3) acceptable reference oil tests. If a second discrimination oil test is needed, the test, if acceptable, will count as one (1) of the 15 non-reference oil tests. In the event that neither discrimination oil test meets the above requirement, a complete new calibration sequence must be performed. The results from tests conducted on discrimination oils are not charted.

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:

Gear Batch	Oil Assignments
P8L123	Assign either three 116, three 115, or three 114 oils (or subsequent reblend). Every 6 months or fourth calibration sequence, also assign one discrimination oil 112.
P8L119	Assign three 116 oils (or subsequent reblend). Every 6 months or fourth calibration sequence, also assign one discrimination oil 112 or 113.
P8L205	Assign either three 116, three 115, or three 114 oils (or subsequent reblend). Every 6 months or fourth calibration sequence, also assign one discrimination oil 112.
P8L737	Assign either three 115 or three 114 oils (or subsequent reblend). Every 6 months or fourth calibration sequence, also assign one discrimination oil 112.
P8L327	Assign either three 116 or three 115 oils (or subsequent reblend). Every 6 months or fourth calibration sequence, also assign one discrimination oil 112.
P8L604	Assign either three 116 or three 115 oils (or subsequent reblend). Every 6 months or fourth calibration sequence, also assign one discrimination oil 112.
P4L806	Assign three 116 oils (or subsequent reblend). Every 6 months or fourth calibration sequence, also assign one discrimination oil 112, 113 or subsequent reblends.
P8T025A	Assign three 116 or 117 oils (or subsequent reblend) or see the test procedure for alternate single test calibration requirements. Every 6 months or fourth calibration sequence, also assign one discrimination oil 112, 113 or subsequent reblends.
P8AD078X	Assign three 116 or 117 oils (or subsequent reblend) or see the test procedure for alternate single test calibration requirements. Every 6 months or fourth calibration sequence, also assign one discrimination oil 112, 113 or subsequent reblends.

Note: See Sections 1 & 2 above for more details on oil assignments.

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-42, 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	--	--	--	--	--	--
	Action	--	--	-	--	--	1.80
Lab	Action	--	--	--	--	--	--
Industry	Warning	0.2	0.2	2.19	2.45	--	--
	Action	0.2	0.2	2.88	3.08	--	--

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

- Exceed Shewhart test stand chart limit for severity
  - 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
  - TMC to notify surveillance panel chairman. Meeting of TMC and the surveillance panel required to determine course of action.
- Exceed EWMA industry chart warning limit
  - TMC to notify surveillance panel chairman. Coordination of TMC and the surveillance panel chairman is required to discuss potential problem.

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	27.176	3.127

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	1.388	0.372

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	8.971	0.436

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	9.441	0.106

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	1.035	0.451

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.

- 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:

- 100% of the scheduled calibration tests should be conducted on reference oils 148, 151-2, and 155-1 or subsequent approved reblends.

- Oil 131-3 or 131-4 should be assigned as needed for investigation of test stand problems.

4. Control Charts

In Section 1 of the LTMS, 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-60-1, 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	0.2	--	2.235	--	--	--
	Action	0.2	0.2	2.81	1.96	2.10	1.80
Lab	Action	0.2	0.2	2.81	3.03	--	1.80
Industry	Warning	0.15	0.15	2.235	2.49	--	--
	Action	0.15	0.15	2.81	3.03	--	--

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 test stand chart action limit for precision (critical parameters only)

  – 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 (critical parameters only)

  – Immediately begin two calibration tests on the test stand.

- Exceed Shewhart test stand chart limit for precision (critical parameters only)
  - Conduct an additional calibration test.
- Exceed EWMA laboratory chart limit for precision or severity (all parameters)
  - Notify the TMC for guidance.
- Exceed EWMA test stand chart action limit for severity (all parameters)
  - Calculate test stand Severity Adjustment (SA) for each parameter that exceeds action limit, using the current test stand EWMA (Z_i) as follows:

Viscosity Increase:	$SA = (-Z_i) \times (7.659)$
Pentane Insolubles:	$SA = (-Z_i) \times (0.413)$
Toluene Insolubles:	$SA = (-Z_i) \times (0.249)$
Average Carbon/Varnish:	$SA = (-Z_i) \times (0.511)$
Average Sludge:	$SA = (-Z_i) \times (0.106)$

  - Confirm calculations with the TMC.
- Exceed Shewhart test stand chart limit for severity (all parameters)
  - 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 the TMC and the surveillance panel 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 required to discuss potential problem.

T-13 Reference Oil Targets							
Oil	n	Effective Dates		IR Oxidation Peak Height absorbance / cm		% Increase in Viscosity at 40°C from 300 to 360 hour[2]	
		From	To[1]	$\overline{X}$	s	$\overline{X}$	s
PC11A	6	10-01-2014	11-24-2015	142.7	12.4	9.303	1.212
PC11A	6	11-25-2015	***	127.4	11.1	8.610	0.929
PC11B	3	10-01-2014	***	59.7	12.4	4.690	1.212
PC11C	4	10-01-2014	***	121.1	12.4	8.146	1.212
PC11D	7	10-01-2014	***	133.5	12.4	8.676	1.212
PC11E	7	10-01-2014	***	59.2	12.4	4.606	1.212
PC11F	4	10-01-2014	***	123.6	12.4	9.044	1.212
823(PC11A)	-	05-01-2015	11-24-2015	142.7	12.4	9.303	1.212
823(PC11A)	-	11-25-2015	***	127.4	11.1	8.610	0.929

1 *** = currently in effect
2 SQRT Transformation adopted 20151019

L-42 Reference Oil Targets						
			Effective Dates		Coast Side Pinion Scoring	
Oil	Gear Batch	N	From[1]	To[2]	$\bar{X}$	s
114	P8L123	30	3-24-95	***	23.2	8.06
	P8L205	30	7-11-96	***	23.4	5.27
	P8L737	30	3-21-95	***	20.2	6.97
114-1	P8L123[3]	--	7-2-97	***	23.2	8.06
	P8L205[3]	--	7-2-97	***	23.4	5.27
	P8L737[3]	--	7-2-97	***	20.2	6.97
	P8L327	30	6-1-99	***	25.3	4.58
115	P8L123[4]	--	2-24-03	***	23.2	8.06
	P8L205[4]	--	9-22-03	***	23.4	5.27
	P8L737[4]	--	9-22-03	***	20.2	6.97
	P8L327[4]	--	8-8-01	***	25.3	4.58
	P8L604[5]	--	11-25-02	***	25.3	4.58
116	P8L123[6]	--	9-25-05	***	22.9	4.81
	P8L205[6]	--	9-25-05	***	22.9	4.81
	P8L327[6]	--	9-25-05	***	22.9	4.81
	P8L604	9	9-25-05	***	22.9	4.81
	P4L806	32	3-20-07	***	25.1	5.49
	P8L119	10	3-22-09	***	23.0	5.49[8]
116-1	P8L123[7]	--	3-1-09	***	22.9	4.81
	P8L205[7]	--	3-1-09	***	22.9	4.81
	P8L327[7]	--	3-1-09	***	22.9	4.81
	P8L604[7]	--	3-1-09	***	22.9	4.81
	P4L806[7]	--	3-1-09	***	25.1	5.49
	P8L119	10	3-22-09	***	23.0	5.49[8]
	P8T025A	10	4-17-12	***	23.0[9]	5.49[9]
	P8AD078X	10	3-7-15	***	23.0[9]	5.49[9]
117	P8T025A	10	5-29-14	***	23.0[10]	5.49[10]
	P8AD078X	10	3-7-15	***	23.0[9,10]	5.49[9,10]

1 Effective for all tests completed on or after this date
2 *** = currently in effect
3 Targets based on oil 114
4 Targets based on oil 114-1
5 Targets based on gear batch P8L327
6 Targets based on gear batch P8L604
7 Targets based on oil 116
8 Standard deviation based on gear batch P4L806

9 Carried over from previous hardware batch

10 Target based on 116/116-1. A +6% correction factor is used with this oil to maintain parity with 116/116-1

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	***	27.176	3.127	1.388	0.372	1.035	0.451	8.971	0.436	9.441	0.106

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.

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

Test	Parameter	s	Effective Dates	
			From	To
RFWT	Ave. Wear	0.08	19930527	19941016
	Ave. Wear	0.05	19941017	19950625
	Ave. Wear	0.04	19950626	***
EOAT	Average Aeration	0.25	19990101	***
T-12A	MRV Viscosity	331	20100216	***

Test	Parameter	s	Effective Dates	
			From	To
L-33-1	Rust	0.350	20020611	***
L-37 Nonlubrited	Pinion Ridging	0.666	19000101	***
	Pinion Rippling	0.557	19000101	***
	Pinion Spitting	0.847	19000101	***
	Pinion Wear	0.713	19000101	***
L-37 Lubrited	Pinion Ridging	1.430	19000101	***
	Pinion Rippling	0.476	19000101	***
	Pinion Spitting	0.579	19000101	***
	Pinion Wear	0.519	19000101	***
L-42	% Scoring	None	--	--
L-60-1	Vis. Inc.	7.659	19000101	***
	Pentane	0.413	19000101	***
	Carbon/Varnish	0.249	19000101	***
	Sludge	0.511	19000101	***
	Toluene	0.106	19000101	***
HTCT	Cycles	None	--	--
OSCT	Elongation	None	--	--
	Shore Hardness	None	--	--
	Volume Change	None	--	--