3. Sequence IIIG LTMS Requirements

The following are the specific Sequence IIIG calibration test requirements.

A. Reference Oils and Critical Parameters

The parameters are Percent Viscosity Increase (PVIS), Weighted Piston Deposits (WPD), and Average Camshaft plus Lifter Wear (ACLW). The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Sequence III Surveillance Panel. The means and standard deviations for the current reference oils for each parameter are presented below.

PERCENT VISCOSITY INCREASE
Unit of Measure: LN(PVIS)

Reference Oil	Mean	Standard Deviation
434	4.7269	0.3859
435	5.1838	0.3096
435-2	5.1838	0.3096
438	4.5706	0.1768

WEIGHTED PISTON DEPOSITS
Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
434	4.80	0.96
435	3.59	0.58
435-2	3.59	0.58
438	3.20	0.33

AVERAGE CAMSHAFT plus LIFTER WEAR
Unit of Measure: LN(ACLW)

Reference Oil	Mean	Standard Deviation
434	3.4657	0.1993
435	3.4985	0.2342
435-2	3.4985	0.2342
438	2.8814	0.2082

4. Sequence IIIGA LTMS Requirements

The following are the specific Sequence IIIGA calibration test requirements.

A. Reference Oils and Parameters

The critical parameter is MRV Apparent Viscosity. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Sequence III Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameter are presented below.

MRV VISCOSITY
Unit of Measure: LN(MRV)

Reference Oil	Mean	Standard Deviation
434	10.7881	0.45550
435[A]	- -	- -
435-2[A]	- -	- -
438	9.8277	0.16646

[A] For oil 435 and 435-2, use Sequence IIIG PVIS Yi value as MRV Yi value

B. Acceptance Criteria

1. New Test Stand

   - Stand must be calibrated according to Sequence IIIG requirements. A Sequence IIIGA test must be conducted as part of each Sequence IIIG test.
   - A minimum of one (1) operationally valid calibration test must be conducted on any approved reference oil.
   - 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

   - Stand must be calibrated according to Sequence IIIG requirements. A Sequence IIIGA test must be conducted as part of each Sequence IIIG test.
   - 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.

5. Sequence IIIGB LTMS Requirements

The following are the specific Sequence IIIGB calibration test requirements.

A. Reference Oils and Parameters

The critical parameter is Phosphorus Retention. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Sequence III Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameter are presented below.

PHOSPHORUS RETENTION
Unit of Measure: Percent

Reference Oil	Mean	Standard Deviation
434	76.00	2.02
434-1	76.00	2.02
435	82.40	2.28
435-2	82.40	2.28
438	78.20	2.56

B. Acceptance Criteria

1. New Test Stand

- Stand must be calibrated according to Sequence IIIG requirements. A Sequence IIIGB test must be conducted as part of each Sequence IIIG test.
- A minimum of one (1) operationally valid calibration test must be conducted on any approved reference oil.
- 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

- Stand must be calibrated according to Sequence IIIG requirements. A Sequence IIIGB test must be conducted as part of each Sequence IIIG test.
- 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.

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 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 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:

- 25% each, oils 940, 1006, 1007, and 1009 (or subsequent 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 VG, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters, except Number of Hot Stuck Rings, 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	1.48
	Action	0.30	0.30	1.80	2.10	1.80	1.80
Lab	Warning	0.30	-	1.80	-	-	-
	Action	0.30	0.20	2.24	1.96	2.00	2.00
Industry	Warning	0.15	0.15	1.80	2.10	-	-
	Action	0.15	0.15	2.57	2.81	2.00	2.00

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

22. T-12 LTMS Requirements

The following are the specific T-12 calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Cylinder Liner Wear, Top Ring Weight Loss, Oil Consumption, and ΔPb at End of Test. The noncritical parameter is ΔPb 250–300 hours. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Mack Test Surveillance Panel. The means and standard deviations for the current reference oils for each critical and noncritical parameter are presented below.

CYLINDER LINER WEAR
Unit of Measure: Micrometres
CRITICAL PARAMETER
NORMAL K VALUE

Reference Oil	Level	Mean	Standard Deviation
821-2	Stand	16.2	3.7
821-2	Lab	15.1	2.8
821-3	Stand	16.2	3.7
821-3	Lab	15.1	2.8
821-4	Stand	16.2	3.7
821-4	Lab	15.1	2.8

TOP RING WEIGHT LOSS
Unit of Measure: Milligrams
CRITICAL PARAMETER
EXPANDED K VALUE

Reference Oil	Mean	Standard Deviation
821-2	62.0	28.2
821-3	62.0	28.2
821-4	62.0	28.2

OIL CONSUMPTION
Unit of Measure: LN(OC grams/hour)
CRITICAL PARAMETER
EXPANDED K VALUE

Reference Oil	Mean	Standard Deviation
821-2	4.0930	0.0790
821-3	4.0930	0.0790
821-4	4.0930	0.0790

ΔPB AT END OF TEST
Unit of Measure: LN(ΔPb ppm)
CRITICAL PARAMETER
NORMAL K VALUE

Reference Oil	Mean	Standard Deviation
821-2	3.1060	0.2420
821-3	3.1060	0.2420
821-4	3.1060	0.2420

ΔPB 250 – 300 HOURS
Unit of Measure: LN(ΔPb 250-300 ppm)
NONCRITICAL PARAMETER
NORMAL K VALUE

Reference Oil	Mean	Standard Deviation
821-2	2.1250	0.3330
821-3	2.1250	0.3330
821-4	2.1250	0.3330

B. Acceptance Criteria

1. New Test Stand

a. First Test Stand in a Laboratory

- A minimum of two (2) operationally valid calibration tests with no stand Shewhart severity alarms (critical parameters only), must be conducted on any approved reference oil.

25. T-12A

The following are the specific T-12A calibration requirements.

A. Reference Oils and Critical Parameter

The critical parameter is MRV Viscosity. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Mack Test Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameter are presented below.

MRV VISCOSITY
Unit of Measure: cP

Reference Oil	Mean	Standard Deviation
821-3	11736	331
821-4	11736	331

B. Acceptance Criteria

1. New Test Stand

- A minimum of one (1) operationally valid calibration test must be conducted on any approved reference oil.

- 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 821-1 or subsequent approved reblends.

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

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

	subsequent reblends.
P8T025A	Assign three 116 or 117 oils (or subsequent reblend). 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.

7

Sequence IIIG Reference Oil Targets									
		Effective Dates		PVIS[3]		WPD		ACLW[4]	
Oil	n	From[1]	To[2]	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
434	12	5-1-03	1-31-04	4.7623	0.4402	4.90	1.12	3.5306	0.1644
	20	2-1-04	5-31-04	4.7040	0.3877	4.73	1.01	3.4872	0.2061
	23	6-1-04	***	4.7269	0.3859	4.80	0.96	3.4657	0.1993
435	12	5-1-03	1-31-04	5.3726	0.2715	3.44	0.45	3.5851	0.2186
	19	2-1-04	5-31-04	5.2903	0.2852	3.53	0.47	3.5596	0.1960
	26	6-1-04	9-30-04	5.2333	0.2924	3.59	0.51	3.5044	0.2256
	31	10-1-04	***	5.1838	0.3096	3.59	0.58	3.4985	0.2342
435-2	-	2-1-11	***	5.1838	0.3096	3.59	0.58	3.4985	0.2342
438	13	5-1-03	1-31-04	4.5867	0.2106	3.20	0.42	2.8697	0.1649
	22	2-1-04	5-31-04	4.5707	0.1953	3.22	0.36	2.8902	0.1946
	25	6-1-04	8-31-04	4.5761	0.1877	3.20	0.35	2.8799	0.1864
	30	9-1-04	***	4.5706	0.1768	3.20	0.33	2.8814	0.2082

1 Effective for all tests completed on or after this date
2 *** = Currently in effect
3 Transformation is ln(PVIS)
4 Transformation is ln(ACLW)

Sequence IIIGA Reference Oil Targets					
		Effective Dates		MRV Viscosity[3]	
Oil	n	From[1]	To[2]	$\overline{X}$	s
434	16	11-3-03	1-31-04	10.7440	0.38793
	20	2-1-04	5-31-04	10.7378	0.40442
	23	6-1-04	***	10.7881	0.45550
435[4]	- -	11-3-03	***	- -	- -
435-2[4]	- -	2-1-11	***	- -	- -
438	16	11-3-03	1-31-04	9.8632	0.19411
	22	2-1-04	5-31-04	9.8351	0.17518
	25	6-1-04	8-31-04	9.8405	0.16998
	30	9-1-04	***	9.8277	0.16646

1 Effective for all tests completed on or after this date

2 *** = Currently in effect

3 Transformation is ln(MRV)

4 For oil 435, use Sequence IIIG PVIS Yi value as MRV Yi value

Sequence IIIGB Reference Oil Targets					
		Effective Dates		Phosphorus Retention	
Oil	n	From[1]	To[2]	$\overline{X}$	s
434	54	11-12-08	***	76.00	2.02
434-1[3]	--	11-12-08	***	76.00	2.02
435	51	11-12-08	***	82.40	2.28
435-2	--	2-1-11	***	82.40	2.28
438	53	11-12-08	***	78.20	2.56

1 Effective for all tests completed on or after this date
2 *** = Currently in effect
3 Targets based on oil 434

T-12 Reference Oil Targets														
			Effective Dates		Cylinder Liner Wear		Top Ring Weight Loss		Oil Consumption		ΔPB @ End of Test		ΔPB 250-300 Hours	
Oil	Level	n	From	To[1]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
820-2	Stand	4	2-19-05	3-20-05	23.2	4.5	102.0	15.0	4.2770	0.0950	3.0269	0.2034	2.1647	0.1074
820-2	Lab	4	2-19-05	3-20-05	23.2	4.5	102.0	15.0	4.2770	0.0950	3.0269	0.2034	2.1647	0.1074
820-2	Stand	8	6-13-05	12-31-05	18.2	3.5	54.6	24.9	4.2040	0.0610	2.9250	0.2880	2.0020	0.3630
820-2	Lab	8	6-13-05	12-31-05	19.2	1.6	54.6	24.9	4.2040	0.0610	2.9250	0.2880	2.0020	0.3630
831 (PC10B)	Stand	5	6-13-05	12-31-05	12.8	3.2	54.5	24.9	4.1240	0.0610	3.3770	0.2880	2.2450	0.3630
831 (PC10B)	Lab	5	6-13-05	12-31-05	12.5	1.6	54.5	24.9	4.1240	0.0610	3.3770	0.2880	2.2450	0.3630
821 (PC10E)	Stand	6	6-13-05	3-12-08	15.1	3.4	66.4	24.9	4.0830	0.0610	3.2590	0.2880	2.2510	0.3630
821 (PC10E)	Stand	25	3-13-08	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821 (PC10E)	Lab	6	6-13-05	3-12-08	14.6	1.6	66.4	24.9	4.0830	0.0610	3.2590	0.2880	2.2510	0.3630
821 (PC10E)	Lab	25	3-13-08	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-1[2]	Stand	--	3-13-08	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-1[2]	Lab	--	3-13-08	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-2[3]	Stand	--	9-27-11	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-2[3]	Lab	--	9-27-11	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-3[3]	Stand	--	8-21-12	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-3[3]	Lab	--	8-21-12	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-4[3]	Stand	--	4-29-14	***	16.2	3.7	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330
821-4[3]	Lab	--	4-29-14	***	15.1	2.8	62.0	28.2	4.0930	0.0790	3.1060	0.2420	2.1250	0.3330

1 *** = currently in effect
2 Targets based on oil 821
3 Targets based on 25 tests on 821

T-12A Reference Oil Targets					
		Effective Dates		MRV Viscosity	
Oil	n	From[1]	To[2]	$\overline{X}$	s
821-1	14[3]	2-16-10	***	11736	331
821-2	14[3]	2-16-10	***	11736	331
821-3	14[3]	8-21-12	***	11736	331
821-4	14[3]	4-29-14	***	11736	331

1 Effective for all tests completed on or after this date.
2 *** = currently in effect.
3 n-size is based on 14 T-12 tests using 821 and 821-1 run for T-12A development

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]
117	P8T025A	10	5-30-12	***	23.0[10]	5.49[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

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			None			None
HTCT			None			None
OSCT			None			None

APPENDIX D
REFERENCE OIL VISCOSITY GRADES

Oil	SAE Viscosity Grade[1]
112	90
113	90
114	90
115	80W-90
116	80W-90
117	80W-90
121	90
123	90
127	80W-90
128	80W-90
129	90
131	90
133	85W-140
134	80W-90
143	80W-90
148	80W-90
150	80W-90
151	80W-90
152	75W-90
153	75W-90
154	90
155	90
160	80W-90
161	75W-90
162	80W-90
168	80W-90
169	75W-90
433	5W-30
434	5W-30
435	5W-20
438 (538)	5W-20
539	10W-30
540 (GF5A)	5W-20
541 (GF5D)	10W-30
542 (GF5X)	0W-20
704	10W-30
809	15W-40
810	15W-40
811	15W-40
820 (PC-9A)	15W-40
821 (PC10E)	15W-40
822	15W-40
830 (PC-9E)	15W-40
831 (PC10B)	15W-40
873	40
925	5W-30
940	5W-30
1004	15W-40
1005	15W-40