35. L-37-1 LTMS Requirements

The following are the specific L-37-1 calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Pinion Ridging, Pinion Rippling, Pinion Pitting/Spalling, Pinion Wear, and Pinion Scoring. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM L-37/L-37-1 Surveillance Panel. The means and standard deviations for the current reference oils for each critical parameter are presented below.

RIDGING
Unit of Measure: Merits

Pinion Batch	Hardware	Reference Oil	Mean	Standard Dev.	Acceptance Bands
All Gleason	UNCOATED	134/134-1	-	-	3 - 6
		152-2	-	-	8 - 10
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	155-1/155-2	9.5	0.5	-
Gleason 04-2014	MNP-COATED	134/134-1	6.1	2.4	-
		152-2	9.7	0.5	-
		155-1/155-2	9.3	1.0	-
Gleason 04-2021		134/134-1	-	-	4 - 6
		152-2	-	-	8 – 10
		155-1/155-2	-	-	8 – 10

RIPPLING
Unit of Measure: Merits

Pinion Batch	Hardware	Reference Oil	Mean	Standard Dev.	Acceptance Bands
All Gleason	UNCOATED	134/134-1	-	-	5 - 10
		152-2	-	-	7 - 10
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	155-1/155-2	8.6	1.1	-
Gleason 04-2014	MNP-COATED	134/134-1	7.4	1.6	-
		152-2	9.3	0.5	-
		155-1/155-2	8.7	0.7	-
Gleason 04-2021		134/134-1	-	-	5 - 8
		152-2	-	-	7 – 9
		155-1/155-2	-	-	7 – 9

PITTING/SPALLING
Unit of Measure: Merits

Pinion Batch	Hardware	Reference Oil	Mean	Standard Dev.	Acceptance Bands
All Gleason	UNCOATED	134/134-1	-	-	5 - 10
		152-2	-	-	10 - 10
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	155-1/155-2	9.9	0.0	-
Gleason 04-2014	MNP-COATED	134/134-1	9.9	0.1	-
		152-2	9.7	0.6	-
		155-1/155-2	9.9	0.0	-
Gleason 04-2021		134/134-1	-	-	9.8 - 9.9
		152-2	-	-	9.9 – 10.0
		155-1/155-2	-	-	9.8 – 10.0

WEAR
Unit of Measure: Merits

Pinion Batch	Hardware	Reference Oil	Mean	Standard Dev.	Acceptance Bands
All Gleason	UNCOATED	134/134-1	-	-	5 - 7
		152-2	-	-	6 - 9
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	155-1/155-2	7.5	0.7	-
Gleason 04-2014	MNP-COATED	134/134-1	6.8	0.9	-
		152-2	8.2	0.7	-
		155-1/155-2	7.9	0.8	-
Gleason 04-2021		134/134-1	-	-	6 - 7
		152-2	-	-	7 – 8
		155-1/155-2	-	-	7 – 8

SCORING
Uncoated & MNP-coated Test Hardware
Unit of Measure: Merits

At the present time, no targets are available for Scoring. As a result, Pinion Scoring cannot be charted. However, the TMC will monitor the reporting of scoring values for results that are different from 10.00 and report occurrences to the surveillance panel. Any reference oil test exhibiting Pinion Scoring less than 10.00 is unacceptable for calibration.

B. Acceptance Criteria

1. New Stand

- A minimum of three (3) operationally valid calibration tests must be conducted with results falling within the acceptance bands. Two of the three tests are to be conducted on either uncoated or MNP-coated hardware (laboratory choice). The remaining test is to be conducted on the other type of hardware.

- Reference oil assignment is dependent on hardware and gear batch selection by the laboratory. See Section 3 below for approved gear batches and oil assignments.

- 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. Note that uncoated and MNP-coated hardware test results are charted separately.

2. Existing Test Stand

- The test stand must have previously been accepted into the system by meeting LTMS calibration requirements.

- All operationally valid calibration test results on approved hardware and reference oils, as outlined in Section 3 below, 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. Note that uncoated and MNP-coated hardware test results are charted separately.

- Alternate MNP-coated and uncoated hardware with each reference oil calibration sequence.

3. Reference Oil Assignment
Once test stands have been accepted into the system, the TMC will assign reference oils evenly distributed among oils 134, 152-2, and 155-1 or their approved reblends. Reference oils 155-1 and 155-2 will be phased out beginning with the 2024 coated and uncoated hardware batches.

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-37-1, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all critical 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	Warning	0.2	--	2.24	--	--	1.80
	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	0.2	0.2	2.24	2.49	--	--
	Action	0.2	0.2	2.88	3.03	--	--

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 severity

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

  Uncoated Test Hardware:
  Ridging: $SA = (-Z_i) \times (0.666)$
  Rippling: $SA = (-Z_i) \times (0.557)$
  Pitting/Spalling: $SA = (-Z_i) \times (0.847)$
  Wear: $SA = (-Z_i) \times (0.713)$

  MNP-coated Test Hardware:
  Ridging: $SA = (-Z_i) \times (n/a)$
  Rippling: $SA = (-Z_i) \times (n/a)$
  Pitting/Spalling: $SA = (-Z_i) \times (n/a)$
  Wear: $SA = (-Z_i) \times (n/a)$

Confirm calculations with the TMC.

  – SA calculations are for information purposes only and are not to be used to adjust reported test results.

- Exceed Shewhart test stand chart action limit for severity

  – Conduct an additional calibration test.

- Exceed GL-5 minimum pass limits for all critical parameters, both MNP-coated and uncoated test hardware, reference oil 134 (and reblends) only
  – 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 the 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 surveillance panel required to discuss the potential problem.

L-37-1 Reference Oil Targets

Hardware	Pinion Batch	Oil	n	From[1]	To[2]	Ridging			Rippling			Spitting			Wear		
						$\bar{X}$	s	Bands	$\bar{X}$	s	Bands	$\bar{X}$	s	Bands	$\bar{X}$	s	Bands
UNCOATED	Gleason 04-2014	134/134-1	6	20170503	20190630	3.8	1.2	-	7.8	1.2	-	7.7	1.9	-	4.8	1.2	-
		152-2	8	20170503	20190630	9.3	0.7	-	8.9	1.6	-	9.9	0.0	-	7.8	0.9	-
		155-1	7	20170503	20190630	9.6	0.5	-	9.6	0.5	-	9.9	0.0	-	7.9	0.7	-
	Gleason 04-2014	134/134-1	10	20190701	20190806	3.8	0.9	-	7.2	1.3	-	7.9	1.5	-	5.1	1.0	-
		152-2	11	20190701	20190806	9.3	0.6	-	8.7	1.4	-	9.9	0.1	-	7.5	0.8	-
		155-1	11	20190701	20190806	9.6	0.5	-	8.7	1.3	-	9.9	0.0	-	7.5	0.7	-
	Gleason 04-2014,06-2018	134/134-1	14	20190807	20200520	3.9	0.9	-	7.1	1.5	-	8	1.7	-	5.1	0.9	-
		152-2	15	20190807	20200520	9.3	0.6	-	8.7	1.3	-	9.9	0.1	-	7.5	0.8	-
		155-1	16	20190807	20200520	9.6	0.5	-	8.8	1.1	-	9.9	0.0	-	7.6	0.7	-
	Gleason 04-2014, 06-2018, 2019/20	134/134-1	24	20200521	20250812	4.1	0.9	-	7.4	1.4	-	7.9	2.0	-	5.3	0.9	-
		152-2	28	20200521	20250812	9.0	0.8	-	8.3	1.2	-	9.9	0.1	-	7.6	0.7	-
		155-1/155-2	21	20200521	***	9.5	0.5	-	8.6	1.1	-	9.9	0.0	-	7.5	0.7	-
	Gleason 04-2014, 06-2018, 2019/20, 07-2024	134-1	38	20250813	***	-	-	3 - 6	-	-	5 - 10	-	-	5 - 10	-	-	5 - 7
		152-2	44	20250813	***	-	-	8 - 10	-	-	7 - 10	-	-	10 - 10	-	-	6 - 9

L-37-1 Reference Oil Targets																	
Hardware	Pinion Batch	Oil	n	From[1]	To[2]	Ridging			Rippling			Spitting			Wear		
						$\overline{X}$	s	Bands	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands
MNP-COATED	Gleason 04-2014	134/134-1	12	20191001	***	6.1	2.4	-	7.4	1.6	-	9.9	0.1	-	6.8	0.9	-
		152-2	9	20191001	***	9.7	0.5	-	9.3	0.5	-	9.7	0.6	-	8.2	0.7	-
		155-1/155-2	9	20191001	***	9.3	1.0	-	8.7	0.7	-	9.9	0.0	-	7.9	0.8	-
	Gleason 04-2021	134/134-1	6	20230510	***	-	-	4 - 6	-	-	5 - 8	-	-	9.8-9.9	-	-	6 - 7
		152-2	5	20230510	***	-	-	8 – 10	-	-	7 – 9	-	-	9.9-10.0	-	-	7 – 8
		155-1/155-2	7	20230510	***	-	-	8 – 10	-	-	7 – 9	-	-	9.8-10.0	-	-	7 – 8

1 Effective for all tests completed on or after this date.
2 *** = currently in effect.

History of Industry Correction Factors
Appendix B

Test Area	Effective		Condition	Description
	From	To		
1M-PC	None		All Tests	None
1K	None		All Tests	None
1N	May 1, 2004	September 27, 2005	All Tests	Add -1.135 to ln(TLHC+1)
	September 28, 2005	March 31,2015	All Tests	Add -0.451 to ln(TLHC+1)
	April 1,2015	***	All Tests on 1Y3998 Liners	Add 0.419954 to ln(TGF+1)
1P	None		All Tests	None
1R	None		All Tests	None
C13	None		All Tests	None
COAT	20190510	***	Batch A Oil Filters	Multiply AAVE4050 by 0.9606
	20221118	***	Batch B Oil Filters	Multiply AAVE4050 by 0.9310
ISB	April 21, 2011	October 18, 2017	All tests using batch B tappets with batch E, F, and G cams	Multiply ATWL by 0.637; Add -9.5 to ACSW
	December 11, 2011	November 12, 2012	All tests using batch C tappets with batch H cams	Multiply ATWL by 0.637; Add -9.5 to ACSW
	November 13, 2012	October 18, 2017	All tests using batch C tappets with batch H and J cams	Multiply ATWL by 0.711; Add -5.6 to ACSW
	None	October 18, 2017	All test using batch D tappets and batch K cams	Multiply ATWL by 1; Add -11.3 to ACSW
	October 19, 2017	September 3,2020	All tests using batch K cams with batch D tappets and batch E crossheads	Multiply ATWL by 0.7851; Add -18.5 to ACSW
	September 4, 2020	***	All tests using batch K cams with batch D tappets	Multiply ATWL by 0.7851; Multiply ACSW by 0.94
	September 4, 2020	***	All tests using batch L cams with batch E tappets	Multiply ATWL by 0.7851; Multiply ACSW by 0.77
	September 4, 2020	June 30, 2024	All tests using batch M cams with batch F tappets and batch F crossheads (and subsequent batches)	Multiply ATWL by 0.92; Multiply ACSW by 0.77
	July 1, 2025	***	All tests using batch F tappets (and subsequent batches)	Add -0.741 to SQRT(ATWL) Add -0.4552 to LN(ACSW)
	***	August 5, 2025	All tests using batch G tappets, N (and subsequent batch) camshafts	Add 1.3147 to SQRT(ATWL) Add -0.4552 to LN(ACSW)
	August 6, 2025	***	All tests using batch G tappets, N (and subsequent batch) camshafts	Add 1.1153 to SQRT(ATWL) Add -0.4552 to LN(ACSW)

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

Test	Parameter	s	Effective Dates	
			From	To
C13 Aeration	AAVE4050	0.285	20141101	20180201
		0.2774	20180202	***
ISB	Camshaft Wear	8.7	20171129	20200903
		8.5	20200904	20210630
		0.2302	20210701	***
	Tappet Wt. Loss	14.8	20171129	20210630
		9.7057	20210701	***
ISM	X-Head Wear	None	--	--
	OFDP	None	--	--
	Average Sludge	None	--	--
	Adj. Screw Wear	None	--	--
T-8	Vis. Inc. @ 3.8%	1.19	19940401	19960930
		0.93	19961001	19990131
		0.90	19990201	20070524
		0.00	20070525	20110916
		0.56	20110917	***
T-8E	Rel. Vis. @ 4.8% 50% DIN Shear	0.26	19970127	20070524
		0.00	20070525	20110916
		0.08	20110917	***
	Rel. Vis. @ 4.8% 100% DIN Shear	0.27	20020306	20070524
		0.00	20070525	20110916
		0.09	20110917	***
T-11	Soot@4.0 cSt Vis	0.23	20050528	20130702
	Soot@12.0 cSt Vis	0.21	20030308	20130702
	Soot@15.0 cSt Vis	0.26	20050528	20130702
	MRV Viscosity	1097	20030308	20130702
	Soot@4.0 cSt Vis	0.20	20130703	***
	Soot@12.0 cSt Vis	0.50	20130703	***
	Soot@15.0 cSt Vis	0.61	20130703	***
	MRV Viscosity	584	20130703	20200729
	MRV Viscosity	1117	20200730	***