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9. Aged Oil LSPI LTMS Requirements

The following are the specific Aged Oil LSPI calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical performance criteria is Average Number of Preignitions (AVPIE). The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence IX Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

Average Number of Preignitions (AVPIE)
Unit of Measure: Square Root (AVPIE+0.5)

Reference Oil	Mean	Standard Deviation
API01	1.6280	0.4070
API02	3.4085	0.4717

B. Acceptance Criteria

1. New Aging Test Stands

- A minimum of two (2) operationally valid calibration tests, with no Shewhart alarms (preferably one on each oil) and no Level 2 Z_i or Ei Level 3 alarms after the second operationally valid test must be conducted in a new Aging stand on any approved reference oils

- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

2. Existing Aging Test Stand

- The Aging stand must have previously been accepted into the system by meeting the LTMS requirements

- Existing test stands that have run an acceptable reference in the past 360 days may calibrate with 1 test.

- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

3. Reference Oil Assignment

Once Aging test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration according to the reference oil mix:

- Scheduled calibration tests should be conducted on reference oils API01 and API02 or subsequent approved reblends in equal proportion with random assignment.

4. Control Charts

In Section 1, the construction of the control charts that contribute to the Lubricant Test Monitoring System is outlined. For the Aged Oil LSPI, Z_0=Mean Y_i of all operationally valid tests in the initial stand calibration sequence. The constants used for the construction of the control charts for the Sequence IX, and the response necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Stand Prediction Error		Shewhart
		Severity		Severity		Severity
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit	Limit
	Level 1	0.2		Level 1	±1.351	±2.000
	Level 2		±1.300	Level 2	±1.734	
				Level 3	±2.066	
Industry	Level 1	0.2	±0.775	--	-	N/A
	Level 2		±0.859	-	-	

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 Aging Stand chart of Prediction Error (e_i)

Level 3:

– Immediately conduct one additional reference test in the stand that triggered the alarm. Do not update the control charts until the follow up reference test is completed and Excessive Influence (refer to Section 1.A.5) has been performed.

Level 2:

– The Level 2 limit applies in situations that have been pre-determined by the surveillance panel to have a potential impact on test results. These situations may include the introduction of new critical parts, fuel batches, reference oil reblends, or other test components. When these conditions have been met and a Level 2 alarm is triggered, immediately conduct one additional reference test in the stand that triggered the alarm. Evaluate the subsequent test(s) using Level 3 limit.

Level 1:

– The Level 1 limit applies in situations where a previously calibrated stand has not been calibrated for two reference periods and is attempting to calibrate again. Immediately conduct one additional reference test in the stand that triggered the alarm. Evaluate the subsequent test(s) using Level 3 limit.

- Exceed Stand EWMA of Standardized Test Result

(Z_i) Level 2:

– Conduct one additional reference test in the stand that triggered the alarm. The stand that triggered the alarm is not qualified for non- reference tests until the Level 2 alarm is cleared.

– In instances where surveillance panel has deemed that industry-wide circumstances are impacting the Level 2 alarm, the TMC may be asked to

review stand calibration status in accordance with the surveillance panel's findings.

Exceed Stand Shewhart Alarm limit

– Conduct one additional reference test in the stand that triggered the alarm. The stand that triggered the alarm is not qualified for non- reference tests until the shewhart alarm is cleared.

The following industry issues are handled by the TMC and do not require individual laboratory action.

- Exceed Industry EWMA of Standardized Test Result (Z_i)

Level 2:

– The TMC informs the surveillance panel that the limit has been exceeded. The surveillance panel then investigates and pursues resolution of the alarm.

Level 1:

– The TMC investigates whether severity adjustments are adequately addressing the trend, investigates the possible causes, and communicates as appropriate with industry.

5. Removal of Test Stands from the System

The laboratory must notify the TMC and the ACC Monitoring Agency when removing a stand from the system. No reference oil data shall be removed from the control charts from test stands that have been used for registered candidate oil testing. Reintroduction of a stand into the system requires completion of new stand acceptance requirements.

- For an existing test stand in an existing lab run one test.

- Following the necessary tests, check the status of the control charts and follow the prescribed actions

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 reference oil mix:

   - 100% of the scheduled calibration tests should be conducted on reference oil 823 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. For the T-13, Z_0=Mean Y_i of first two operationally valid tests in the laboratory. The constants used for the construction of the control charts for the T-13, 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		Laboratory Prediction Error	
		Severity		Severity	
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit
Lab	Level 1	0.3	0.000	Level 1	±1.351
	Level 2		±1.800	Level 2	±1.734
	--	--	--	Level 3	±2.066
Industry	Level 1	0.2	±0.775	--	--
	Level 2		±0.859	--	--

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.

32. L-37 LTMS Requirements

The following are the specific L-37 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 Surveillance Panel. The means and standard deviations for the current reference oils for each critical parameter are presented below.

RIDGING
Unit of Measure: Merits

Hardware	Pinion Batch	Reference Oil	Mean	Standard Dev.	Acceptance Band
MNP-COATED	L247/T758A	128-1	7.40	0.516	6 – 8
		151-3	8.80	0.422	8 – 10
		155	9.00	0.000	9 – 9
	V1L686/P4L626A	128-1	6.35	0.813	5 – 8
		151-3	6.43	1.207	4 – 9
		152	5.25	0.500	4 – 6
		153	5.00	0.000	5 – 5
		155	7.00	0.000	7 – 7
	V1L528/P4T883A	134	7.214	0.802	6 – 8
		152-1	6.500	1.769	4 – 9
		152-2	6.500	1.769	4 – 9
		155	8.286	0.825	7 – 9
UNCOATED	V1L417/P4L792	151-3	9.47	0.507	9 – 10
		152	9.17	0.408	8 – 10
		152-1	9.47	0.640	8 – 10
		153	9.00	0.816	8 – 10
		153-1	8.80	0.616	8 – 10
		155	9.50	0.527	9 – 10
	V1L500/P4T813	152-1	8.85	0.689	8 – 10
		155	9.07	0.594	8 – 10
	V1L528/P4T883A	134	6.182	1.328	4 – 8
		152-1	7.583	1.832	5 – 10
		152-2	7.583	1.832	5 – 10
		155	8.714	0.611	8 – 9

RIPPLING
Unit of Measure: Merits

Hardware	Pinion Batch	Reference Oil	Mean	Standard Dev.	Acceptance Band
MNP-COATED	L247/T758A	128-1	7.60	1.075	6 - 10
		151-3	8.60	0.516	8 - 10
		155	8.00	0.000	8 - 8
	V1L686/P4L626A	128-1	7.20	1.473	5 - 10
		151-3	8.71	0.463	8 - 10
		152	8.25	0.500	7 - 9
		153	8.00	0.000	8 - 8
		155	9.00	0.000	9 - 9
	V1L528/P4T883A	134	7.429	1.284	6 - 9
		152-1	8.792	0.833	8 - 10
		152-2	8.792	0.833	8 - 10
		155	8.786	0.699	8 - 10
UNCOATED	V1L417/P4L792	151-3	9.33	0.606	8 - 10
		152	9.17	0.408	8 - 10
		152-1	9.40	0.507	8 - 10
		153	8.25	0.500	7 - 9
		153-1	8.90	0.447	8 - 10
		155	9.60	0.516	9 - 10
	V1L500/P4T813	152-1	9.39	0.506	8 - 10
		155	9.33	0.488	8 - 10
	V1L528/P4T883A	134	8.364	0.809	7 - 9
		152-1	8.917	0.669	7 - 10
		152-2	8.917	0.669	8 - 10
		155	8.714	0.726	8 - 10

PITTING/SPALLING
Unit of Measure: Merits

Hardware	Pinion Batch	Reference Oil	Mean	Standard Dev.	Acceptance Band
MNP-COATED	L247/T758A	128-1	9.02	0.892	7 - 10
		151-3	9.49	0.586	8 - 10
		155	9.30	0.000	9.3 - 9.3
	V1L686/P4L626A	128-1	9.77	0.421	9 - 10
		151-3	9.68	0.632	9 - 10
		152	9.53	0.359	9 - 10
		153	9.30	0.424	9 - 10
		155	9.90	0.000	9.9 - 9.9
	V1L528/P4T883A	134	9.364	1.302	7 - 10
		152-1	8.533	1.720	6 - 10
		152-2	8.533	1.720	6 - 10
		155	9.893	0.027	9.8 – 9.9
UNCOATED	V1L417/P4L792	151-3	9.71	1.080	8 - 10
		152	9.90	0.000	9.9 - 9.9
		152-1	9.44	1.782	6 - 10
		153	9.88	0.050	9.8 - 10
		153-1	9.89	0.049	9.8 - 10
		155	9.90	0.040	9.8 - 10
	V1L500/P4T813	152-1	9.89	0.028	9.8 - 9.9
		155	9.84	0.124	9.6 - 10
	V1L528/P4T883A	134	4.364	3.491	0 - 10
		152-1	8.883	1.872	6 - 10
		152-2	8.883	1.872	6 - 10
		155	9.514	1.038	8 - 10

WEAR
Unit of Measure: Merits

Hardware	Pinion Batch	Reference Oil	Mean	Standard Dev.	Acceptance Band
MNP-COATED	L247/T758A	128-1	5.80	0.422	5 - 7
		151-3	6.00	0.000	6 - 6
		155	6.00	0.000	6 - 6
	V1L686/P4L626A	128-1	6.40	0.598	5 - 7
		151-3	6.57	0.598	5 - 8
		152	6.25	0.500	5 - 7
		153	5.50	0.707	4 - 7
		155	7.00	0.000	7 - 7
	V1L528/P4T883A	134	6.357	0.497	6 - 7
		152-1	6.208	0.833	5 - 7
		152-2	6.208	0.833	5 - 7
		155	6.929	0.267	6 - 7
UNCOATED	V1L417/P4L792	151-3	8.00	0.587	7 - 9
		152	8.00	0.632	7 - 9
		152-1	8.00	0.378	7 - 9
		153	7.50	0.577	6 - 9
		153-1	7.55	0.605	6 - 9
		155	8.00	0.289	7 - 9
	V1L500/P4T813	152-1	7.46	0.519	7 - 8
		155	7.47	0.516	7 - 8
	V1L528/P4T883A	134	5.545	0.820	5 - 7
		152-1	6.500	0.522	6 - 7
		152-2	6.500	0.522	6 - 7
		155	6.714	0.469	6 - 7

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 for continuing calibration according to the following reference oil mix:

Test Hardware	Pinion/Ring Batch	Reference Oil	Assignment Frequency
MNP-Coated	C1L308/P4L309R	128-1	100%
		128-2	
	C1L426/P4L404A	128-1	100%
		128-2	
	V1L303/P4L514A	128-1	100%
		128-2	
	V1L686/P4L626A	128-1	25%
		128-2	
		155	25%
		152	25%
		153	25%
	L247/T758A	128-1	33.3%
		128-2	33.3%
		155	33.3%
	V1L528/P4T883A	134	20%
		152-1 or -2	40%
		155	40%
Uncoated	C1L308/P4L318R	128-1	100%
		128-2	
	C1L426/P4L415A	128-1	100%
		128-2	
	V1L303/P4L514A	128-1	100%
		128-2	
	V1L686/P4L626A	128-1	50%
		128-2	
		155	50%
		155	
	V1L176/P4L741A	128-1	50%
		128-2	
		155	50%
	V1L351/P4T771	155	50%
		152	25%
		153	25%
	V1L417/P4L792	155	50%
		152	25%
		153	25%
	V1L500/P4T813	152-1	25%
		153-1	25%
		155	50%
	V1L528/P4T883A	134	20%
		152-1 or -2	40%
		155	40%

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, 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: $SA = (-Z_i) \times (1.430)$
    Rippling: $SA = (-Z_i) \times (0.476)$
    Pitting/Spalling: $SA = (-Z_i) \times (0.579)$
    Wear: $SA = (-Z_i) \times (0.519)$

Confirm calculations with the TMC.

  - SA calculations are for information purposes only.

- Result outside acceptance band
  - 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 potential problem.

33. 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.
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	134/134-1	4.1	0.9
		152-2	9.0	0.8
		155-1	9.5	0.5
Gleason 04-2014	MNP-COATED	134/134-1	6.1	2.4
		152-2	9.7	0.5
		155-1	9.3	1.0

RIPPLING
Unit of Measure: Merits

Pinion Batch	Hardware	Reference Oil	Mean	Standard Dev.
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	134/134-1	7.4	1.4
		152-2	8.3	1.2
		155-1	8.6	1.1
Gleason 04-2014	MNP-COATED	134/134-1	7.4	1.6
		152-2	9.3	0.5
		155-1	8.7	0.7

PITTING/SPALLING
Unit of Measure: Merits

Pinion Batch	Hardware	Reference Oil	Mean	Standard Dev.
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	134/134-1	7.9	2.0
		152-2	9.9	0.1
		155-1	9.9	0.0
Gleason 04-2014	MNP-COATED	134/134-1	9.9	0.1
		152-2	9.7	0.6
		155-1	9.9	0.0

WEAR
Unit of Measure: Merits

Pinion Batch	Hardware	Reference Oil	Mean	Standard Dev.
Gleason 04-2014, 06-2018, 2019/20	UNCOATED	134/134-1	5.3	0.9
		152-2	7.6	0.7
		155-1	7.5	0.7
Gleason 04-2014	MNP-COATED	134/134-1	6.8	0.9
		152-2	8.2	0.7
		155-1	7.9	0.8

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.

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 = $(-Z_i)$ x (0.666)
Rippling:	SA = $(-Z_i)$ x (0.557)
Pitting/Spalling:	SA = $(-Z_i)$ x (0.847)
Wear:	SA = $(-Z_i)$ x (0.713)

  MNP-coated Test Hardware:

Ridging:	SA = $(-Z_i)$ x (n/a)
Rippling:	SA = $(-Z_i)$ x (n/a)
Pitting/Spalling:	SA = $(-Z_i)$ x (n/a)
Wear:	SA = $(-Z_i)$ x (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.

Aged Oil LSPI Oil Targets					
		Effective Dates		Average Number of Pre-Ignitions Sqrt (AVPIE+0.5)	
Oil	n	From[1]	To[2]	$\overline{X}$	s
API01	12	20220215	***	1.628	0.4070
API02	12	20220215	***	3.4085	0.4717

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

L-37 Reference Oil Targets																	
						Ridging			Rippling			Spitting			Wear		
	Pinion Batch	Oil	n	From	To	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands
UNCOATED	C1L308	127	17	19000101	***	6.41	2.033	3 - 10	6.06	1.784	3 - 9	9.54	0.450	9 - 10	6.82	2.038	3 - 10
		128	30	19000101	***	7.93	0.980	6 - 10	5.90	2.426	2 - 10	9.71	0.306	9.2 - 10	6.37	0.718	5 - 8
		128-1	8	19000101	***	8.38	0.744	7 - 10	5.75	1.982	2 - 9	9.43	0.883	8 - 10	6.50	0.535	6 - 7
		128-2	1	19000101	***	8.00	0.000	8 - 8	6.00	0.000	6 - 6	8.00	0.000	8 - 8	6.00	0.000	6 - 6
		129	19	19000101	***	9.26	0.933	8 - 10	9.89	0.315	9 - 10	9.89	0.091	9.7 - 10	8.11	0.875	7 - 10
	C1L426	127	10	19000101	***	7.25	1.752	4 - 10	8.30	1.767	5 - 10	9.40	1.039	8 - 10	6.50	0.972	5 - 8
		128	10	19000101	***	7.90	0.738	7 - 9	8.20	0.789	7 - 10	9.21	0.998	7 - 10	5.80	0.422	5 - 7
		128-1	11	19000101	***	8.36	0.674	7 - 10	8.00	1.095	6 - 10	9.54	0.785	8 - 10	5.73	0.467	5 - 7
		128-2	2	19000101	***	8.00	0.000	8 - 8	7.50	0.707	6 - 9	9.90	0.000	9.9 - 9.9	6.00	0.000	6 - 6
		129	8	19000101	***	9.50	0.535	9 - 10	9.75	0.463	9 - 10	9.96	0.052	9.9 - 10	7.00	1.195	5 - 9
	V1L176	127	2	19000101	***	7.00	2.828	2 - 10	8.00	0.000	8 - 8	6.45	4.879	0 - 10	6.00	1.414	3 - 9
		128-1	12	19000101	***	8.25	0.754	7 - 10	7.17	2.038	4 - 10	9.72	0.208	9.3 - 10	6.08	0.289	6 - 7
		128-2	1	19000101	***	7.00	0.000	7 - 7	9.00	0.000	9 - 9	9.90	0.000	9.9 - 9.9	6.00	0.000	6 - 6
		151-3	14	19000101	***	9.14	0.363	8 - 10	8.86	0.363	8 - 10	9.56	1.314	7 - 10	6.64	0.633	6 - 8
	V1L303	127	3	19000101	***	6.67	1.155	5 - 9	6.67	2.082	3 - 10	9.80	0.173	9.5 - 10	6.00	0.000	6 - 6
		128-1	13	19000101	***	8.08	0.494	7 - 9	6.92	1.656	4 - 10	8.07	2.451	4 - 10	5.85	0.376	5 - 7
		129	4	19000101	***	9.50	0.577	8 - 10	9.00	0.816	8 - 10	9.93	0.050	9.8 - 10	6.75	0.957	5 - 8
	V1L351	151-3	5	19000101	***	9.20	1.304	7 - 10	9.20	0.447	8 - 10	9.92	0.045	9.8 - 10	7.00	1.000	5 - 9
		152	5	19000101	***	9.40	0.548	8 - 10	8.80	0.447	8 - 10	9.88	0.045	9.8 - 10	7.20	0.837	6 - 9
		153	9	19000101	***	7.22	0.972	5 - 9	7.22	0.972	5 - 9	9.62	0.618	9 - 10	6.44	0.726	5 - 8
		155	3	19000101	***	9.33	0.577	8 - 10	8.67	0.577	8 - 10	9.90	0.000	9.9 - 9.9	7.00	1.000	5 - 9
	V1L417	151-3	30	19000101	***	9.47	0.507	9 - 10	9.33	0.606	8 - 10	9.71	1.080	8 - 10	8.00	0.587	7 - 9
		152	6	19000101	***	9.17	0.408	8 - 10	9.17	0.408	8 - 10	9.90	0.000	9.9 - 9.9	8.00	0.632	7 - 9
		152-1	15	19000101	***	9.47	0.640	8 - 10	9.40	0.507	8 - 10	9.44	1.782	6 - 10	8.00	0.378	7 - 9
		153	4	19000101	***	9.00	0.816	8 - 10	8.25	0.500	7 - 9	9.88	0.050	9.8 - 10	7.50	0.577	6 - 9
		153-1	20	19000101	***	8.80	0.616	8 - 10	8.90	0.447	8 - 10	9.89	0.049	9.8 - 10	7.55	0.605	6 - 9
		155	10	19000101	***	9.50	0.527	9 - 10	9.60	0.516	9 - 10	9.90	0.040[1]	9.8 - 10	8.00	0.289[1]	7 - 9

L-37 Reference Oil Targets																	
						Ridging			Rippling			Spitting			Wear		
	Pinion Batch	Oil	n	From	To	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands	$\overline{X}$	s	Bands
UNCOATED	V1L500	152-1	13	19000101	***	8.85	0.689	8 - 10	9.39	0.506	8 - 10	9.89	0.028	9.8 - 9.9	7.46	0.519	7 - 8
		155	15	19000101	***	9.07	0.594	8 - 10	9.33	0.488	8 - 10	9.84	0.124	9.6 - 10	7.47	0.516	7 - 8
	V1L686	127	9	19000101	***	7.00	2.000	3 - 10	7.56	1.236	5 - 10	9.71	0.643	9 - 10	6.67	0.500	6 - 8
		128-1	8	19000101	***	7.50	0.926	6 - 9	5.63	1.188	3 - 8	9.93	0.046	9.8 - 10	6.88	0.641	6 - 8
		129	2	19000101	***	9.50	0.707	8 - 10	10.00	0.000	10 - 10	10.00	0.000	10 - 10	8.00	1.414	5 - 10
		151-2	11	19000101	***	9.09	0.701	8 - 10	8.73	0.647	8 - 10	9.92	0.040	9.8 - 10	7.55	0.688	6 - 9
		151-3	1	19000101	***	9.00	0.000	9 - 9	8.00	0.000	8 - 8	9.90	0.000	9.9 - 9.9	7.00	0.000	7 - 7
	V1L528	134	5	19000101	20180606	6.40	1.673	3 - 9	8.40	0.894	6 - 10	3.80	1.483	1 - 7	5.60	0.894	4 - 8
			11	20180607	***	6.128	1.328	4 - 8	8.364	0.809	7 - 9	4.364	3.491	0 - 10	5.545	0.820	5 - 7
		152-1	8	19000101	20180606	8.75	0.707	7 - 10	8.63	0.916	7 - 10	9.45	1.003	7 - 10	7.00	0.500	6 - 8
			12	20180607	***	7.583	1.832	5 - 10	8.917	0.669	8 - 10	8.883	1.872	6 - 10	6.5	0.522	6 - 7
		152-2	8	19000101	20180606	8.75	0.707	7 - 10	8.63	0.916	7 - 10	9.45	1.003	7 - 10	7.00	0.500	6 - 8
			12	20180607	***	7.583	1.832	5 - 10	8.917	0.669	8 - 10	8.883	1.872	6 - 10	6.5	0.522	6 - 7
		155	9	19000101	20180606	8.56	0.882	7 - 10	8.44	1.014	6 - 10	8.70	1.578	5 - 10	6.78	0.441	6 - 8
			14	20180607	***	8.714	0.611	8 - 9	8.714	0.726	8 – 10	9.514	1.038	8 - 10	6.714	0.469	6 - 7

L-37-1 Reference Oil Targets													
						Ridging		Rippling		Spitting		Wear	
Hardware	Pinion Batch	Oil	n	From[1]	To	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
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

L-37-1 Reference Oil Targets													
						Ridging		Rippling		Spitting		Wear	
Hardware	Pinion Batch	Oil	n	From[1]	To	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
UNCOATED	Gleason 04-2014, 06-2018, 2019/20	134/ 134-1	24	20200521	***	4.1	0.9	7.4	1.4	7.9	2.0	5.3	0.9
		152-2	28	20200521	***	9.0	0.8	8.3	1.2	9.9	0.1	7.6	0.7
		155-1	21	20200521	***	9.5	0.5	8.6	1.1	9.9	0.0	7.5	0.7
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	9	20191001	***	9.3	1.0	8.7	0.7	9.9	0.0	7.9	0.8

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