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36. Oil Seal Compatibility Test LTMS Requirements

The following are the specific Oil Seal Compatibility Test calibration test requirements.

A. Reference Oils and Critical Parameters

The critical parameters are Elongation, Shore Hardness, and Volume Change. The reference oils required for test stand and test laboratory calibration are the reference oils accepted by the ASTM Oil Seal Compatibility Test Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameters are presented below.

ELONGATION

Unit of Measure: Percent

| Reference Oil | Elastomer | Mean | Standard Deviation |
|---------------|-----------------|---------|--------------------|
| 160-1 | Polyacrylate | 23.04 | 14.289 |
| 160-1 | Fluoroelastomer | -47.65 | 5.506 |
| 161-1 | Polyacrylate | 68.88 | 17.850 |
| 161-1 | Fluoroelastomer | -34.57 | 6.989 |
| 161-1 | Nitrile | 10.43 | 10.691 |
| 162 | Nitrile | -65.35 | 7.330 |
| 168 | Nitrile | -74.52 | 6.965 |
| 169 | Polyacrylate | 49.2 | 21.82 |
| 169 | Fluoroelastomer | -39.5 | 6.99 |
| 169 | Nitrile | -16.2 | 10.69 |
| 170 | Nitrile | -70.68 | 3.007 |
| 171 | Polyacrylate | 25.090 | 11.415 |
| 171 | Fluoroelastomer | -47.949 | 5.947 |

SHORE HARDNESS

Unit of Measure: Points

| Reference Oil | Elastomer | Mean | Standard Deviation |
|---------------|-----------------|-------|--------------------|
| 160-1 | Polyacrylate | -1.8 | 1.16 |
| 160-1 | Fluoroelastomer | 1.6 | 1.36 |
| 161-1 | Polyacrylate | -24.9 | 2.83 |
| 161-1 | Fluoroelastomer | 1.6 | 1.30 |
| 161-1 | Nitrile | -16.1 | 2.18 |
| 162 | Nitrile | 2.0 | 2.03 |
| 168 | Nitrile | 3.0 | 1.89 |
| 169 | Polyacrylate | -16.0 | 2.83 |
| 169 | Fluoroelastomer | 0.1 | 1.30 |
| 169 | Nitrile | -8.6 | 2.18 |
| 170 | Nitrile | 2.325 | 0.341 |
| 171 | Polyacrylate | 0.223 | 1.858 |
| 171 | Fluoroelastomer | 0.987 | 1.664 |

VOLUME CHANGE
Unit of Measure: Percent

| Reference Oil | Elastomer | Mean | Standard Deviation |
|---------------|-----------------|--------|--------------------|
| 160-1 | Polyacrylate | 0.343 | 0.4473 |
| 160-1 | Fluoroelastomer | 2.053 | 0.4075 |
| 161-1 | Polyacrylate | 19.624 | 1.4348 |
| 161-1 | Fluoroelastomer | 6.199 | 0.7080 |
| 161-1 | Nitrile | 18.444 | 1.7057 |
| 162 | Nitrile | 2.460 | 1.5821 |
| 168 | Nitrile | 1.326 | 1.4730 |
| 169 | Polyacrylate | 13.1 | 1.43 |
| 169 | Fluoroelastomer | 4.4 | 0.71 |
| 169 | Nitrile | 11.8 | 1.71 |
| 170 | Nitrile | 1.500 | 0.718 |
| 171 | Polyacrylate | -0.088 | 1.096 |
| 171 | Fluoroelastomer | 2.167 | 1.201 |

B. Acceptance Criteria

1. New Test Stand

- For each elastomer type, an operationally valid calibration test, with no Shewhart severity alarms, must be conducted on each of the two approved reference oils.

2. Existing Test Stand

- The test stand must have been TMC calibrated prior to LTMS introduction or previously 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:

| Elastomer Type | Oil Assignments |
|----------------|---|
| PA | Assign reference oils 160, 161, 169 or 171 (or subsequent reblends) for every calibration sequence. |
| FL | Assign reference oils 160, 161, 169 or 171 (or subsequent reblends) for every calibration sequence. |
| NI | Assign reference oils 161, 162, 168 or 170 (or subsequent reblends) for every calibration sequence. |

| Oil Seal Compatibility Test Reference Oil Targets | | | | | | | | | | |
|---|-----|-----------------|-------------------|-----------------|------------|--------------------|----------------|-------------------|---------------|---------------------|
| Oil | n | Elastomer | Effective Dates | | Elongation | | Shore Hardness | | Volume Change | |
| | | | From ¹ | To ² | \bar{X} | s | \bar{X} | s | \bar{X} | s |
| 160 ³ | -- | Polyacrylate | 11-18-94 | *** | 23.04 | 14.289 | -1.8 | 1.16 | 0.343 | 0.4473 |
| | -- | Fluoroelastomer | 11-18-94 | *** | -47.65 | 5.506 | 1.6 | 1.36 | 2.053 | 0.4075 |
| 160-1 | 144 | Polyacrylate | 11-18-94 | *** | 23.04 | 14.289 | -1.8 | 1.16 | 0.343 | 0.4473 |
| | 141 | Fluoroelastomer | 11-18-94 | *** | -47.65 | 5.506 | 1.6 | 1.36 | 2.053 | 0.4075 |
| 161 ⁴ | -- | Polyacrylate | 11-18-94 | *** | 68.88 | 17.850 | -24.9 | 2.83 | 19.624 | 1.4348 |
| | -- | Fluoroelastomer | 11-18-94 | *** | -34.57 | 6.989 | 1.6 | 1.30 | 6.199 | 0.7080 |
| | -- | Nitrile | 11-18-94 | *** | 10.43 | 10.691 | -16.1 | 2.18 | 18.444 | 1.7057 |
| 161-1 | 144 | Polyacrylate | 11-18-94 | *** | 68.88 | 17.850 | -24.9 | 2.83 | 19.624 | 1.4348 |
| | 141 | Fluoroelastomer | 11-18-94 | *** | -34.57 | 6.989 | 1.6 | 1.30 | 6.199 | 0.7080 |
| | 119 | Nitrile | 11-18-94 | *** | 10.43 | 10.691 | -16.1 | 2.18 | 18.444 | 1.7057 |
| 162 | 119 | Nitrile | 11-18-94 | *** | -65.35 | 7.330 | 2.0 | 2.03 | 2.460 | 1.5821 |
| 168 | 13 | Nitrile | 7-7-06 | 2-28-09 | -74.22 | 2.422 | 3.0 | 1.49 | 1.424 | 0.1295 |
| | 38 | Nitrile | 3-1-09 | 3-10-09 | -74.52 | 1.599 | 3.0 | 0.79 | 1.326 | 0.1388 |
| | 38 | Nitrile | 3-11-09 | *** | -74.52 | 6.965 ⁵ | 3.0 | 1.89 ⁵ | 1.326 | 1.4730 ⁵ |
| 169 | 19 | Polyacrylate | 3-7-12 | *** | 49.2 | 21.82 | -16.0 | 2.83 ⁶ | 13.1 | 1.430 ⁶ |
| | 18 | Fluoroelastomer | 3-7-12 | *** | -39.5 | 6.99 ⁶ | 0.1 | 1.30 ⁶ | 4.4 | 0.71 ⁶ |
| | 22 | Nitrile | 3-7-12 | *** | -16.2 | 10.69 ⁶ | -8.6 | 2.18 ⁶ | 11.8 | 1.710 ⁶ |
| 170 | 12 | Nitrile | 1-24-16 | 8-20-18 | -72.75 | 3.416 | 1.500 | 0.674 | 2.275 | 0.449 |
| | 32 | Nitrile | 8-21-18 | *** | -70.68 | 3.007 | 2.325 | 0.341 | 1.500 | 0.718 |
| 171 | 3 | Polyacrylate | 8-21-18 | 5-26-20 | 24.167 | 20.929 | 0.333 | 0.577 | -0.233 | 0.306 |
| 171 | 3 | Fluoroelastomer | 8-21-18 | 5-26-20 | -42.6 | 4.2 | -0.667 | 0.577 | 1.467 | 0.306 |
| 171 | 40 | Polyacrylate | 5-27-20 | *** | 25.090 | 11.415 | 0.223 | 1.858 | -0.088 | 1.096 |
| 171 | 39 | Fluoroelastomer | 5-27-20 | *** | -47.949 | 5.947 | 0.987 | 1.664 | 2.167 | 1.201 |

- 1 Effective for all tests completed on or after this date.
- 2 *** = currently in effect.
- 3 Targets based on oil 160-1.
- 4 Targets based on oil 161-1.
- 5 Standard deviation based on oil 162 (n=138).
- 6 Standard deviation based on oil 161-1.

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, 119 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, 119 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, 119 or subsequent reblends. |
| P8AD132 | 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, 119 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.

32. 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 | NONLUBRITED | 134/134-1 | 4.1 | 0.9 |
| | | 152-2 | 9.0 | 0.8 |
| | | 155-1 | 9.5 | 0.5 |
| Gleason 04-2014 | LUBRITED | 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 | NONLUBRITED | 134/134-1 | 7.4 | 1.4 |
| | | 152-2 | 8.3 | 1.2 |
| | | 155-1 | 8.6 | 1.1 |
| Gleason 04-2014 | LUBRITED | 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 | NONLUBRITED | 134/134-1 | 7.9 | 2.0 |
| | | 152-2 | 9.9 | 0.1 |
| | | 155-1 | 9.9 | 0.0 |
| Gleason 04-2014 | LUBRITED | 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 | NONLUBRITED | 134/134-1 | 5.3 | 0.9 |
| | | 152-2 | 7.6 | 0.7 |
| | | 155-1 | 7.5 | 0.7 |
| Gleason 04-2014 | LUBRITED | 134/134-1 | 6.8 | 0.9 |
| | | 152-2 | 8.2 | 0.7 |
| | | 155-1 | 7.9 | 0.8 |

SCORING
Non-lubrited & Lubrited 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

| L-37-1 Reference Oil Targets | | | | | | | | | | | | | |
|------------------------------|--------------------------------------|---------------|----|-------------------|-----|-----------|-----|-----------|-----|-----------|-----|-----------|-----|
| Hardware | Pinion Batch | Oil | n | From ¹ | To | Ridging | | Rippling | | Spitting | | Wear | |
| | | | | | | \bar{X} | s | \bar{X} | s | \bar{X} | s | \bar{X} | s |
| NONLUBRITED | 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 |
| LUBRTIED | 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.

43. D874 Sulfated Ash LTMS Requirements

The following are the specific D874 Sulfated Ash calibration requirements.

A. Reference Oils and Critical Parameters

1. The critical pass/fail parameter is Mass % Sulfated Ash. The reference oils, performance targets and acceptance criteria required for the test stand calibration with the TMC are listed in Table 1 and have been approved by the ASTM D02.B0.07 Sulfated Ash Surveillance Panel.

Table 1
D874 (Sulfated Ash) Reference Oil Targets and Acceptance Bands Effective 20001002

| Test | Oil Code | Parameter | n | Mean | sR | Acceptance Bands* | |
|----------------------------|----------|---------------------|----|------|------|-------------------|-------|
| | | | | | | 95% | |
| | | | | | | Lower | Upper |
| Sulfated Ash by D874 | 90 | Mass % Sulfated Ash | 27 | 1.07 | 0.08 | 0.91 | 1.23 |
| | 91 | Mass % Sulfated Ash | 27 | 0.82 | 0.05 | 0.72 | 0.92 |
| | 820-2 | Mass % Sulfated Ash | 27 | 1.57 | 0.08 | 1.40 | 1.73 |

*95% Acceptance Bands = Mean +/- (1.960 x sR)

B. Test Stand Defined

1. This test method does not have a specific instrument or test stand to be calibrated, but rather is a wet-chemistry process. The TMC D874 calibration program is to periodically confirm the expected results of the D874 test process at each participating lab using oils of known performance in the test (reference oils). Therefore, the 'test stand' is defined as the participating lab ID for this test.

C. Acceptance Criteria

1. New Laboratories

- a. A minimum of two (2) operationally valid calibration tests which fall within the acceptance bands for the oils assigned are required to calibrate a lab for the first time. These must be simultaneous or consecutive runs, though exceptions can be made at the sole discretion of the TMC for operational fails for reasons that would be considered to have had no bearing on the operational performance of the test stand for subsequent tests.
- b. Passing two back-to-back consecutive TMC calibrations places the lab's D874 process in TMC calibrated status. Both tests must pass on operational and statistical criteria.

- c. TMC calibrated status of a lab's D874 process is valid for no more than 90 days from date completed of a valid TMC calibration. To renew the calibration at the end of the calibration period, see Item 2 for Existing Laboratory.

2. Existing Laboratory

- a. An existing TMC calibrated lab, or one where the TMC calibrated status had expired within the past 90 days, can renew its TMC calibrated status by demonstrating a successful calibration on another single TMC blind calibration audit. The test must pass on both operational and statistical criteria.
- b. TMC calibrated status of an existing lab process is valid for no more than 90 days from date completed of a valid TMC calibration (that is, the day of the final ash weighing). Labs that exceed these time/run specifications are considered to be out of calibration for TMC monitoring purposes.
- c. A lab that has been out of TMC calibration for more than 90 days from the prior TMC calibration expiration date will require New Laboratory calibration as listed in C.1.a through C.1.c. of this document.
- d. A lab must pass the TMC calibration within two operationally valid test runs. If a lab cannot produce a calibration test that falls into the acceptance bands for the assigned oil within two operationally valid runs, renewing calibration on that stand will require the two-test calibration as listed in C.1.a through C.1.c.

3. Tracking and Reporting Lab ID's

- a. Tracking a lab's calibration status will be effected by tracking the lab's two letter lab ID, Date Completed and the calibration test sulfated ash results.

4. Reference Oil Assignment:

- a. Of the two tests required to bring a new lab into TMC calibrated status, the tests shall be conducted on reference oils listed in Table 1, or reblends or replacement oils as approved by the surveillance panel. Once a lab has attained TMC calibrated status (existing test lab), 100% of the scheduled calibration tests shall be conducted on an assigned blind reference oil sample from the currently accepted set of reference oils. There shall be no preference for any one reference oil in blind calibration runs, and each shall be assigned for approximately 1/3 of the passing runs at each lab.

5. Mandatory QC Check Sample

- a. All TMC-monitored instruments must utilize TMC reference oil 90 to comply with the Quality Control sections of D874 test method. The frequency is to be one QC oil run with each batch of routine test samples and the QC test result must be in the approved acceptance range for TMC reference oil 90. A non-

conforming result places the results of the batch of samples run concurrently in question and all must be rerun.

- b. One-liter aliquots of TMC oil 90, for use as a D874 daily QC check fluid, are available for purchase from the TMC.

6. Calibration Test Evaluation:

- a. The calibration status of the lab will be based on a review of operational parameters for compliance with the test method, followed by a statistical evaluation of the critical parameter test result against the acceptance ranges in Section A, Table 1 (commonly referred to as a Shewhart severity evaluation). Unless otherwise noted, the acceptance bands in Section A are based on a 95% confidence treatment of round robin test results with data exclusions as approved by the surveillance panel.

7. Introduction of New or Re-Blended Reference Oils

Introduction of new or replacement reference oils will be conducted at the discretion of the surveillance panel. Participating laboratories may be asked to donate tests on the new oil(s) to establish baseline performance in the D874 Sulfated Ash test. The number of tests requested will be sufficient to rigorously evaluate the oil's performance. Preliminary statistical performance targets and acceptance criteria will be established by the surveillance panel, and those values will be re-assessed as the TMC collects additional calibration data.

| D874 Test Reference Oil Targets | | | | | |
|---------------------------------|----|-------------------|-----------------|----------------------|------|
| Oil | n | Effective Dates | | Sulfated Ash, mass % | |
| | | From ¹ | To ² | \bar{X} | s |
| 90 | 27 | 20070206 | *** | 1.07 | 0.08 |
| 91 | 27 | 20070726 | *** | 0.82 | 0.50 |
| 830-2 | 27 | 20070726 | *** | 1.57 | 0.80 |

1 Effective for all tests completed on or after this date.

2 *** = currently in effect.

18. C13 LTMS Requirements

The following are the specific C13 calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Top Groove Carbon, Top Land Carbon, Oil Consumption Delta, and Second Ring Top Carbon. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM C13 Surveillance Panel. The mean and standard deviation for the current reference oils for test parameters are presented below.

TOP GROOVE CARBON
Unit of Measure: Demerits
Normal K Value

| Reference Oil | Mean | Standard Deviation |
|---------------|-------|--------------------|
| 831-3 | 46.02 | 5.90 |
| 831-4 | 46.02 | 5.90 |

TOP LAND CARBON
Unit of Measure: Demerits
Normal K Value

| Reference Oil | Mean | Standard Deviation |
|---------------|-------|--------------------|
| 831-3 | 21.87 | 7.89 |
| 831-4 | 21.87 | 7.89 |

OIL CONSUMPTION DELTA
Unit of Measure: SQRT (g/h)
Normal K Value

| Reference Oil | Mean | Standard Deviation |
|---------------|--------|--------------------|
| 831-3 | 5.5089 | 0.7141 |
| 831-4 | 5.5089 | 0.7141 |

SECOND RING TOP CARBON
Unit of Measure: LN (Demerits)
Expanded K Value

| Reference Oil | Mean | Standard Deviation |
|---------------|--------|--------------------|
| 831-3 | 2.8828 | 0.2900 |
| 831-4 | 2.8828 | 0.2900 |

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, must be conducted on any approved reference oil.

b. All Subsequent New Test Stands in a Laboratory

- One operationally valid test with no stand Shewhart severity alarms must be conducted on any approved reference oil.

2. Existing Test Stand

- The test stand must have been previously accepted into the system by meeting LTMS calibration requirements.
- One operationally valid test with no stand Shewhart severity alarms must be conducted on any approved reference oil.

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 oil 831 (or subsequent approved reblends).

4. Control Charts

In Section 1, the construction of the four control charts that constitute the Lubricant Test Monitoring System is outlined. The constants used for the construction of the control charts for the C13, and the response necessary in the case of control chart limit alarms, are depicted below.

| C13 Reference Oil Targets | | | | | | | | | | | |
|---------------------------|----|-----------------|-----------------|-------------------|-------|-----------------|------|----------------------------|--------|--|--------|
| Oil | n | Effective Dates | | Top Groove Carbon | | Top Land Carbon | | Oil Consumption Δ^2 | | 2 nd Ring Top Carbon ³ | |
| | | From | To ¹ | \bar{X} | s | \bar{X} | s | \bar{X} | s | \bar{X} | s |
| PC10A | 3 | 5-28-05 | 2-20-06 | 45.55 | 6.44 | 23.18 | 5.57 | 6.2676 | 0.8226 | 2.3301 | 0.3430 |
| PC10C | 2 | 5-28-05 | 2-20-06 | 54.57 | 2.92 | 26.98 | 0.21 | 5.7229 | 1.8966 | 3.2447 | 0.3966 |
| PC10D | 3 | 5-28-05 | 2-20-06 | 39.18 | 5.85 | 23.58 | 2.33 | 3.8405 | 1.8509 | 2.4426 | 0.3400 |
| PC10E | 7 | 5-28-05 | 2-20-06 | 45.52 | 8.02 | 23.52 | 7.02 | 4.8593 | 1.4265 | 2.8197 | 0.4024 |
| PC10F | 3 | 5-28-05 | 2-20-06 | 54.08 | 11.09 | 36.32 | 2.82 | 6.5929 | 0.9750 | 3.8424 | 0.2573 |
| PC10G | 3 | 5-28-05 | 2-20-06 | 35.85 | 2.83 | 29.05 | 0.84 | 3.8066 | 0.8456 | 2.7134 | 0.1936 |
| 831 (PC10B) | 8 | 5-28-05 | 3-12-08 | 45.18 | 7.42 | 24.99 | 7.59 | 5.7336 | 0.7280 | 2.8945 | 0.2055 |
| | 14 | 3-13-08 | *** | 46.02 | 5.90 | 21.87 | 7.89 | 5.5089 | 0.7141 | 2.8828 | 0.2900 |
| 831-1 ⁴ | -- | 05-10-08 | *** | 46.02 | 5.90 | 21.87 | 7.89 | 5.5089 | 0.7141 | 2.8828 | 0.2900 |
| 831-2 ⁴ | -- | 08-06-13 | *** | 46.02 | 5.90 | 21.87 | 7.89 | 5.5089 | 0.7141 | 2.8828 | 0.2900 |
| 831-3 ⁴ | -- | 06-16-15 | *** | 46.02 | 5.90 | 21.87 | 7.89 | 5.5089 | 0.7141 | 2.8828 | 0.2900 |
| 831-4 ⁴ | -- | 05-19-20 | *** | 46.02 | 5.90 | 21.87 | 7.89 | 5.5089 | 0.7141 | 2.8828 | 0.2900 |

- 1 *** = Currently in effect
- 2 Transformation for Oil Consumption Delta is sqrt(OC Δ)
- 3 Transformation for 2nd Ring Top Carbon is ln(R2TC)
- 4 Targets based on oil 831

30. L-33-1 LTMS Requirements

The following are the specific L-33-1 calibration test requirements.

A. Reference Oils and Critical Parameter

The critical parameter is Final Rust. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM L-33-1 Surveillance Panel. The mean and standard deviations for the current reference oils for the critical parameter are presented below.

FINAL RUST
Unit of Measure: Merits
Gear Versions V99.1 & V01.1

| Reference Oil | Mean | Standard Deviation |
|---------------|-------|--------------------|
| 123 | 8.560 | 0.230 |
| 123-2 | 8.740 | 0.260 |
| 151-3 | 9.640 | 0.250 |
| 155 | 9.580 | 0.250 |
| 155-1 | 9.580 | 0.250 |

FINAL RUST
Unit of Measure: Merits
Gear Version AAM K2XX

| Reference Oil | Mean | Standard Deviation |
|---------------|------|--------------------|
| 123-2 | 8.37 | 0.39 |
| 155-1 | 9.47 | 0.13 |

B. Acceptance Criteria

1. New Test Stand

- A minimum of two (2) operationally valid calibration tests, with no stand Shewhart severity alarms, 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

| L-33-1 Reference Oil Targets | | | | | | |
|------------------------------|---------------|-----------------|-------------------|----------|---------------------|---------------------|
| Oil | Gear Version | n | Effective Dates | | Rust | |
| | | | From ¹ | To | \bar{X} | s |
| 121 | V94.1 | 12 ² | 6-5-96 | 4-19-00 | 9.370 ² | 0.280 ² |
| | V95.1 | 12 ² | 6-5-96 | 4-19-00 | 9.370 ² | 0.280 ² |
| 121-1 | V94.1 | -- | 1-19-98 | 4-29-99 | 9.370 ³ | 0.280 ³ |
| | V94.1 | 45 ² | 4-30-99 | 11-17-00 | 9.390 ² | 0.218 ² |
| | V95.1 | -- | 1-19-98 | 4-29-99 | 9.370 ³ | 0.280 ³ |
| | V95.1 | 45 ² | 4-30-99 | 11-17-00 | 9.390 ² | 0.218 ² |
| | V99.1 | 8 | 4-20-00 | 11-17-00 | 9.830 | 0.260 ⁴ |
| | V94.1 | -- | 12-14-99 | 11-17-00 | 9.390 ⁵ | 0.218 ⁵ |
| 121-2 | V95.1 | -- | 12-14-99 | 11-17-00 | 9.390 ⁵ | 0.218 ⁵ |
| | V99.1 | -- | 4-20-00 | 11-17-00 | 9.830 ⁶ | 0.260 ⁴ |
| 123 | V94.1 | 54 ² | 5-5-95 | 4-19-00 | 9.000 ² | 0.330 ² |
| | V95.1 | 54 ² | 5-5-95 | 4-19-00 | 9.000 ² | 0.330 ² |
| | V99.1 | 12 | 6-11-02 | 8-24-04 | 8.430 | 0.390 |
| | V01.1 | -- | 11-25-02 | 8-24-04 | 8.430 ¹⁰ | 0.390 ¹⁰ |
| | V99.1 & V01.1 | 30 | 8-25-04 | *** | 8.560 | 0.230 |
| | V94.1 | 13 ⁷ | 4-20-00 | 11-17-00 | 8.240 ⁷ | 0.330 ⁸ |
| 123-1 | V95.1 | -- | 12-14-99 | 4-19-00 | 9.000 ⁹ | 0.330 ⁹ |
| | V95.1 | 13 ⁷ | 4-20-00 | 11-17-00 | 8.240 ⁷ | 0.330 ⁸ |
| | V99.1 | 13 ⁷ | 4-20-00 | 11-17-00 | 8.240 ⁷ | 0.330 ⁸ |
| | V99.1 | -- | 11-25-02 | 8-24-04 | 8.430 ¹⁰ | 0.390 ¹⁰ |
| 123-2 | V99.1 & V01.1 | -- | 8-25-04 | 6-1-06 | 8.560 ⁹ | 0.230 ⁹ |
| | V99.1 & V01.1 | 15 | 6-2-06 | *** | 8.740 | 0.260 |
| | AAM K2XX | 10 | 6-24-16 | 06-28-17 | 8.05 | 0.43 |
| | AAM K2XX | 19 | 6-29-17 | 11-07-17 | 8.09 | 0.41 |
| | AAM K2XX | 22 | 11-08-17 | 0-01-20 | 8.12 | 0.38 |
| | AAM K2XX | 19 | 01-02-20 | *** | 8.37 | 0.39 |
| 151-3 | V99.1 | 13 | 6-11-02 | 8-24-04 | 9.690 | 0.350 |
| | V01.1 | -- | 11-25-02 | 8-24-04 | 9.690 ¹¹ | 0.350 ¹¹ |
| | V99.1 & V01.1 | 30 | 8-25-04 | *** | 9.640 | 0.250 |
| | V99.1 & V01.1 | -- | 6-2-06 | --- | 9.580 | 0.250 ¹² |
| 155-1 | V99.1 & V01.1 | -- | 4-4-12 | --- | 9.580 | 0.250 ¹² |
| | AAM K2XX | 9 | 6-24-16 | 06-28-17 | 9.26 | 0.12 |
| | AAM K2XX | 20 | 6-29-17 | 11-07-17 | 9.24 | 0.19 |
| | AAM K2XX | 23 | 11-08-17 | 01-01-20 | 9.25 | 0.22 |
| | AAM K2XX | 20 | 01-02-20 | *** | 9.47 | 0.13 |

- 1 Effective for all tests completed on or after this date. 7 Based on V99.1 and V95.1 data.
2 Based on V94.1 & V95.1 data. 8 Based on lab pooled s of V94.1 & V95.1 data (all blends of oil 123).
3 Based on oil 121 data. 9 Based on oil 123 data.
4 Based on lab pooled s of V94.1 & V95.1 data (all blends of oil 121). 10 Based on V99.1 data on oil 123.
5 Based on oil 121-1 data. 11 Based on V99.1 data on oil 151-3.
6 Based on V99.1 data on oil 121-1. 12 Based on V99.1 & V01.1 data on oil 151-3.

History of Industry Correction Factors
Appendix B

| Test Area | Effective | | Condition | | | Description |
|--------------------|-----------|---|---------------------------------------|---------------------------------|------------------|---|
| | From | To | | | | |
| L-33-1 | 20200102 | *** | AAM K2XX | | | Add +1 to rated areas 2 and 3. Do not exceed 10. |
| 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 |
| | 20130515 | *** | V1L528/P4T883A Non-reference | Lubrited Pinion | Canadian | Ridging add 0.5878, Rippling add 0.5878 |
| | | | | | Lubrited Ring | Canadian |
| | | | | 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-37-1 | None | *** | All Tests | | | None |
| 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 |

| Test Area | Effective | | Condition | | | Description |
|-----------|-----------|----|-----------|--|--|-------------|
| | From | To | | | | |
| D874 | None | | All Tests | | | None |
| D5800 | None | | All Tests | | | None |

31. 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 |
|---------------|----------------|---------------|-------|---------------|-----------------|
| LUBRICATED | 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 |
| NONLUBRICATED | 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 | |
|----------------|----------------|---------------|-------|---------------|-----------------|--------|
| LUBRITED | 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 | |
| | V1L528/P4T883A | 155 | 9.00 | 0.000 | 9 - 9 | |
| | | 134 | 7.429 | 1.284 | 6 - 9 | |
| | | 152-1 | 8.792 | 0.833 | 8 - 10 | |
| | | 152-2 | 8.792 | 0.833 | 8 - 10 | |
| | NONLUBRITED | V1L417/P4L792 | 155 | 8.786 | 0.699 | 8 - 10 |
| 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 | |
| V1L500/P4T813 | | 155 | 9.60 | 0.516 | 9 - 10 | |
| | | 152-1 | 9.39 | 0.506 | 8 - 10 | |
| V1L528/P4T883A | | 155 | 9.33 | 0.488 | 8 - 10 | |
| | | 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 |
|-------------|----------------|---------------|-------|---------------|-----------------|
| LUBRITED | 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 |
| NONLUBRITED | 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 |
|-------------|----------------|---------------|-------|---------------|-----------------|
| LUBRITED | 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 |
| NONLUBRITED | 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 |

SCORING
Non-lubrited & Lubrited 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.

| L-37 Reference Oil Targets | | | | | | | | | | | | | | | | | |
|----------------------------|--------------|-------|----------|----------|----------|-----------|-------|--------|-----------|--------|--------|-----------|-----------|-----------|-----------|-------|-------|
| | Pinion Batch | Oil | n | From | To | Ridging | | | Rippling | | | Spitting | | | Wear | | |
| | | | | | | \bar{X} | s | Bands | \bar{X} | s | Bands | \bar{X} | s | Bands | \bar{X} | s | Bands |
| LUBRICATED | C1L308 | 128 | 15 | 19000101 | *** | 6.53 | 1.407 | 4 - 9 | 7.63 | 1.420 | 5 - 10 | 8.83 | 1.754 | 6 - 10 | 5.60 | 1.298 | 3 - 8 |
| | | 128-1 | 7 | 19000101 | *** | 7.00 | 0.000 | 7 - 7 | 8.00 | 0.577 | 7 - 9 | 8.84 | 1.723 | 6 - 10 | 5.57 | 0.535 | 5 - 7 |
| | | 129 | 5 | 19000101 | *** | 9.00 | 0.000 | 9 - 9 | 8.40 | 0.894 | 7 - 10 | 9.56 | 0.089 | 9.4 - 9.7 | 6.80 | 1.483 | 4 - 9 |
| | C1L426 | 128 | 7 | 19000101 | *** | 7.57 | 0.976 | 6 - 9 | 8.29 | 1.380 | 6 - 10 | 6.83 | 2.357 | 3 - 10 | 5.71 | 0.488 | 5 - 7 |
| | | 128-1 | 7 | 19000101 | *** | 7.71 | 1.113 | 6 - 10 | 7.86 | 0.690 | 7 - 9 | 7.57 | 3.187 | 2 - 10 | 6.00 | 0.577 | 5 - 7 |
| | | 129 | 2 | 19000101 | *** | 9.00 | 0.000 | 9 - 9 | 9.50 | 0.707 | 8 - 10 | 9.60 | 0.141 | 9.3 - 9.9 | 7.50 | 0.707 | 6 - 9 |
| | L247 | 128-1 | 10 | 19000101 | *** | 7.40 | 0.516 | 6 - 8 | 7.60 | 1.075 | 6 - 10 | 9.02 | 0.892 | 7 - 10 | 5.80 | 0.422 | 5 - 7 |
| | | 151-3 | 10 | 19000101 | *** | 8.80 | 0.422 | 8 - 10 | 8.60 | 0.516 | 8 - 10 | 9.49 | 0.586 | 8 - 10 | 6.00 | 0.000 | 6 - 6 |
| | | 155 | 1 | 19000101 | *** | 9.00 | 0.000 | 9 - 9 | 8.00 | 0.000 | 8 - 8 | 9.30 | 0.000 | 9.3 - 9.3 | 6.00 | 0.000 | 6 - 6 |
| | V1L303 | 128 | 1 | 19000101 | *** | 7.00 | 0.000 | 7 - 7 | 7.00 | 0.000 | 7 - 7 | 8.00 | 0.000 | 8 - 8 | 6.00 | 0.000 | 6 - 6 |
| | | 128-1 | 30 | 19000101 | *** | 7.30 | 1.264 | 5 - 10 | 6.97 | 1.497 | 4 - 10 | 5.26 | 3.144 | 0 - 10 | 5.67 | 0.959 | 4 - 7 |
| | | 129 | 9 | 19000101 | *** | 8.11 | 0.601 | 7 - 9 | 8.56 | 0.527 | 8 - 10 | 9.61 | 0.366 | 9 - 10 | 6.56 | 0.527 | 6 - 8 |
| | V1L686 | 128-1 | 20 | 19000101 | *** | 6.35 | 0.813 | 5 - 8 | 7.20 | 1.473 | 5 - 10 | 9.77 | 0.421 | 9 - 10 | 6.40 | 0.598 | 5 - 7 |
| | | 151-3 | 21 | 19000101 | *** | 6.43 | 1.207 | 4 - 9 | 8.71 | 0.463 | 8 - 10 | 9.68 | 0.632 | 9 - 10 | 6.57 | 0.598 | 5 - 8 |
| | | 152 | 4 | 19000101 | *** | 5.25 | 0.500 | 4 - 6 | 8.25 | 0.500 | 7 - 9 | 9.53 | 0.359 | 9 - 10 | 6.25 | 0.500 | 5 - 7 |
| | | 153 | 2 | 19000101 | *** | 5.00 | 0.000 | 5 - 5 | 8.00 | 0.000 | 8 - 8 | 9.30 | 0.424 | 9 - 10 | 5.50 | 0.707 | 4 - 7 |
| | | 155 | 1 | 19000101 | *** | 7.00 | 0.000 | 7 - 7 | 9.00 | 0.000 | 9 - 9 | 9.90 | 0.000 | 9.9 - 9.9 | 7.00 | 0.000 | 7 - 7 |
| | V1L528 | 134 | 4 | 19000101 | 20180606 | 7.00 | 1.155 | 4 - 10 | 7.00 | 1.414 | 4 - 10 | 8.83 | 0.974 | 7 - 10 | 6.00 | 0.242 | 5 - 7 |
| | | | 14 | 20180607 | *** | 7.214 | 0.802 | 6 - 8 | 7.429 | 1.284 | 6 - 9 | 9.364 | 1.302 | 7 - 10 | 6.357 | 0.497 | 6 - 7 |
| | | 152-1 | 6 | 19000101 | 20180606 | 8.00 | 0.632 | 7 - 10 | 8.83 | 0.753 | 7 - 10 | 9.88 | 0.041 | 9.3 - 10 | 7.00 | 0.242 | 6 - 8 |
| | | | 24 | 20180607 | *** | 6.5 | 1.769 | 4 - 9 | 8.792 | 0.833 | 8 - 10 | 8.533 | 1.72 | 6 - 10 | 6.208 | 0.833 | 5 - 7 |
| | | 152-2 | 6 | 19000101 | 20180606 | 8.00 | 0.632 | 7 - 10 | 8.83 | 0.753 | 7 - 10 | 9.88 | 0.041 | 9.3 - 10 | 7.00 | 0.242 | 6 - 8 |
| | | | 24 | 20180607 | *** | 6.5 | 1.769 | 4 - 9 | 8.792 | 0.833 | 8 - 10 | 8.533 | 1.72 | 6 - 10 | 6.208 | 0.833 | 5 - 7 |
| | | 155 | 8 | 19000101 | 20180606 | 8.29 | 0.488 | 7 - 10 | 8.86 | 0.690 | 7 - 10 | 9.90 | 0.436 | 9 - 10 | 6.86 | 0.378 | 6 - 8 |
| | | 14 | 20180607 | *** | 8.286 | 0.825 | 7 - 9 | 8.786 | 0.699 | 8 - 10 | 9.893 | 0.027 | 9.8 - 9.9 | 6.929 | 0.267 | 6 - 7 | |

| L-37 Reference Oil Targets | | | | | | | | | | | | | | | | | |
|----------------------------|--------------|----------|-----|----------|----------|-----------|-------|--------|-----------|-------|---------|-----------|-------|-----------|-----------|-------|--------|
| | Pinion Batch | Oil | n | From | To | Ridging | | | Rippling | | | Spitting | | | Wear | | |
| | | | | | | \bar{X} | s | Bands | \bar{X} | s | Bands | \bar{X} | s | Bands | \bar{X} | s | Bands |
| NONLUBRICATED | 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 | | |

MRV VISCOSITY
Unit of Measure: cP
NONCRITICAL PARAMETER

| Reference Oil | Mean | Standard Deviation |
|---------------|-------|--------------------|
| 820-3 | 14981 | 916 |
| 822-1 | 13948 | 584 |
| 822-2 | 13948 | 1156 |

B. Acceptance Criteria

1. New Test Stand

a. Less than four (4) Operationally Valid Calibration Results in Laboratory

- A minimum of two (2) operationally valid calibration tests with no stand Shewhart severity alarms, 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.

b. Four (4) or more Operationally Valid Calibration Results in Laboratory*

- The first operationally valid calibration test run on any approved reference oil must have no stand Shewhart severity alarms 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 toward the tally of four (4) required operationally valid calibration tests. The fourth 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.

c. Stand for which a lapse in calibration is not greater than two years.

- The first operationally valid calibration test run on any approved reference oil must have no stand Shewhart severity 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.

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.

- Exceed EWMA test stand chart limit for precision (critical parameter only)
 - Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports for the stand in question during the alarm period.
- Exceed Shewhart test stand chart limit for precision (critical parameter only)
 - Immediately provide written notice of the alarm and its meaning to all Test Purchasers and the TMC. This notice shall be appended to all test reports for the stand in question during the alarm period.
- Exceed EWMA laboratory chart action limit for severity (all parameters)
 - Calculate laboratory Severity Adjustment (SA) using the current laboratory EWMA (Z_i) as follows:

| | |
|--------------------------------------|-----------------------------|
| Soot at 4.0 cSt Viscosity Increase: | $SA = (-Z_i) \times (0.20)$ |
| Soot at 12.0 cSt Viscosity Increase: | $SA = (-Z_i) \times (0.50)$ |
| Soot at 15.0 cSt Viscosity Increase: | $SA = (-Z_i) \times (0.61)$ |
| MRV Viscosity: | $SA = (-Z_i) \times (1117)$ |
 - Confirm calculation with the TMC.
- Exceed EWMA test stand chart limit for severity (critical parameter only)
 - Notify the TMC. If the direction of the test stand severity is deemed different from that of the test laboratory, conduct an additional calibration test in the identified test stand. If this limit is still exceeded after the additional calibration test, then remove test stand from the system, notify the TMC, correct test stand severity problem, and follow requirements for entry of a new test stand into the system.
- Exceed Shewhart test stand chart limit for severity (critical parameter 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 test developer, surveillance panel chairman, and ACC Monitoring Agency. Meeting of TMC, test developer, and surveillance panel required to determine course of action.

| T-11 Reference Oil Targets | | | | | | | | | | | |
|----------------------------|-----------------|-----------------|-----------------|-------------------------|------|--------------------------|-------------------|---------------------------|------|--------------------|-------------------|
| Oil | n | Effective Dates | | Soot @ 4.0 cSt Vis. Inc | | Soot @ 12.0 cSt Vis. Inc | | Soot @ 15.0 cSt Vis. Inc. | | MRV Viscosity | |
| | | From | To ¹ | \bar{X} | S | \bar{X} | s | \bar{X} | s | \bar{X} | s |
| 820-2 | 32 | 3-8-03 | *** | -- | -- | 5.78 | 0.21 | -- | -- | 14969 | 1097 |
| 820-2 | 16 | 5-28-05 | 5-31-10 | 3.81 | 0.23 | 5.78 ² | 0.21 ² | 6.36 | 0.26 | 14969 ² | 1097 ² |
| | -- ³ | 6-1-10 | *** | 3.95 | 0.30 | 5.92 | 0.22 | 6.51 | 0.20 | 14981 | 916 |
| 820-3 | 11 | 9-7-07 | *** | 3.95 | 0.30 | 5.92 | 0.22 | 6.51 | 0.20 | 14981 | 916 |
| 822-1 | 4 | 2-1-2013 | 7-2-2013 | 3.99 | 0.21 | 5.65 | 0.54 | 6.35 | 0.66 | 14408 | 314 |
| | 8 | 7-3-2013 | *** | 4.09 | 0.20 | 5.81 | 0.50 | 6.48 | 0.61 | 13948 | 584 |
| 822-2 | 8 | 1-1-2014 | 7-29-2020 | 4.09 | 0.20 | 5.81 | 0.50 | 6.48 | 0.61 | 13948 | 584 |
| | 57 | 7-30-2020 | *** | 4.09 | 0.20 | 5.81 | 0.50 | 6.48 | 0.61 | 13948 | 1156 |

1 *** = currently in effect

2 Value based on earlier data set (n=32)

3 Targets based on oil 820-3

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

| Test | Parameter | s | Effective Dates | |
|------|------------------------------------|------|-----------------|----------|
| | | | From | To |
| ISB | Camshaft Wear | 8.7 | 20171129 | *** |
| | Tappet Wt. Loss | 14.8 | 20171129 | *** |
| 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 | *** |

APPENDIX D
REFERENCE OIL VISCOSITY GRADES

| Oil | SAE Viscosity Grade | Date Received ¹ |
|-------|---------------------|----------------------------|
| 52 | 15W-40 | 19950830 |
| 55 | 10W-30 | 19950918 |
| 58 | 5W-30 | 19981001 |
| 62 | 10W-40 | 19960304 |
| 66 | 15W-40 | 20020418 |
| 75 | 5W-30 | 20101007 |
| 90 | 15W-40 | 20050922 |
| 91 | 5W-20 | 20060814 |
| 112 | 90 | 19940221 |
| 112-1 | 90 | 19940621 |
| 112-2 | 90 | 19951127 |
| 113 | 90 | 20021113 |
| 114 | 90 | 19940222 |
| 114-1 | 90 | 19970617 |
| 115 | 80W-90 | 19971103 |
| 116 | 80W-90 | 20050415 |
| 116 | 80W-90 | 20050418 |
| 117 | 80W-90 | 20130819 |
| 121 | 90 | 19960329 |
| 121-1 | 90 | 19970303 |
| 121-2 | 90 | 19990930 |
| 123 | 90 | 19950116 |
| 123-1 | 90 | 19991029 |
| 123-2 | 90 | 20010723 |
| 127 | 80W-90 | 19930819 |
| 128 | 80W-90 | 19930820 |
| 128-1 | 80W-90 | 19960209 |
| 128-2 | 80W-90 | 20010725 |
| 129 | 90 | 19930823 |
| 131 | 85W-140 | 19850924 |
| 131-1 | 85W-140 | 19860318 |
| 131-2 | 85W-140 | 19880126 |
| 131-3 | 85W-140 | 19911025 |
| 131-4 | 85W-140 | 19950315 |
| 133 | 85W-140 | 19981013 |
| 134 | 80W-90 | 20070926 |

REFERENCE OIL VISCOSITY GRADES

| Oil | SAE Viscosity Grade | Date Received ¹ |
|--------|---------------------|----------------------------|
| 134-1 | 80W-90 | 20151106 |
| 143 | 80W-90 | 19891009 |
| 148 | 80W-90 | 19930713 |
| 148-1 | 80W-90 | 20010927 |
| 150 | 80W-90 | 19930603 |
| 150-1 | 80W-90 | 19940430 |
| 150-2 | 80W-90 | 19950510 |
| 151 | 80W-90 | 19930520 |
| 151-1 | 80W-90 | 19940503 |
| 151-2 | 80W-90 | 19950727 |
| 151-3 | 80W-90 | 19990929 |
| 152 | 75W-90 | 20040223 |
| 152-1 | 75W-90 | 20040927 |
| 152-2 | 75W-90 | 20090915 |
| 152-2A | 75W-90 | 2009915 |
| 152-2B | 75W-90 | 20090821 |
| 152-3 | 75W-90 | 20110627 |
| 153 | 75W-90 | 20040213 |
| 153-1 | 75W-90 | 20040913 |
| 154 | 90 | 20050905 |
| 155 | 90 | 20050510 |
| 155-1 | 90 | 20101123 |
| 155-2 | 90 | 20200708 |
| 160 | 80W-90 | 19920925 |
| 160-1 | 80W-90 | 19960328 |
| 161 | 75W-90 | 19930104 |
| 161-1 | 75W-90 | 19951003 |
| 162 | 80W-90 | 19921015 |
| 168 | 80W-90 | 20050721 |
| 169 | 75W-90 | 20100602 |
| 170 | 80W-90 | 20150819 |
| 171 | 80W-90 | 20170331 |
| 221 | 0W-16 | 20151202 |
| 222 | 10W-30 | 20151215 |
| 224 | 5W-30 | 20180524 |
| 270 | 5W-30 | 20150708 |
| 271 | 5W-30 | 20151009 |
| 433 | 5W-30 | 20000713 |
| 433-1 | 5W-30 | 20000928 |

REFERENCE OIL VISCOSITY GRADES

| Oil | SAE Viscosity Grade | Date Received ¹ |
|---------------|---------------------|----------------------------|
| 433-2 | 5W-30 | 20130306 |
| 434 | 5W-30 | 20030303 |
| 434-1 | 5W-30 | 20080512 |
| 434-2 | 5W-30 | 20140228 |
| 434-3 | 5W-30 | 20170718 |
| 435 | 5W-20 | 20030313 |
| 435-1 | 5W-20 | 20080904 |
| 435-2 | 5W-20 | 20100902 |
| 436 | 5W-20 | 20141105 |
| 438 | 5W-20 | 20030302 |
| 438-1 (538-1) | 5W-20 | 20070212 |
| 438-2 | 5W-20 | 20170922 |
| 538 | 5W-20 | 20010622 |
| 538-1 | 5W-20 | 20070212 |
| 539 | 10W-30 | 20020308 |
| 540 (GF5A) | 5W-20 | 20090106 |
| 541 (GF5D) | 10W-30 | 20081211 |
| 541-1 | 10W-30 | 20110405 |
| 542 (GF5X) | 0W-20 | 20081215 |
| 542-1 | 0W-20 | 20130109 |
| 542-2 | 0W-20 | 20141007 |
| 542-3 | 0W-20 | 20151006 |
| 542-4 | 0W-20 | 20181212 |
| 543 | 0W-16 | 20150925 |
| 544 | 5W-30 | 20151007 |
| 704 | 10W-30 | 19910131 |
| 704-1 | 10W-30 | 19920114 |
| 809-1 | 15W-40 | 19910402 |
| 810-1 | 15W-40 | 19890920 |
| 810-2 | 15W-40 | 19921214 |
| 811-1 | 15W-40 | 19900419 |
| 811-2 | 15W-40 | 19950921 |
| 820 (PC-9A) | 15W-40 | 20001016 |
| 820-1 | 15W-40 | 20011005 |
| 820-2 | 15W-40 | 20011130 |
| 820-3 | 15W-40 | 20060828 |
| 821 (PC10E) | 15W-40 | 20050307 |
| 821-1 | 15W-40 | 20071105 |
| 821-2 | 15W-40 | 20090327 |
| 821-3 | 15W-40 | 20120807 |
| 821-4 | 15W-40 | 20131220 |
| 822 | 15W-40 | 20120828 |
| 822-1 | 15W-40 | 20130125 |

REFERENCE OIL VISCOSITY GRADES

| Oil | SAE Viscosity Grade | Date Received ¹ |
|-------------|---------------------|----------------------------|
| 822-2 | 15W-40 | 20130722 |
| 823 (PC11A) | 10W30 | 20150521 |
| 830 (PC-9E) | 15W-40 | 20001109 |
| 830-1 | 15W-40 | 20020107 |
| 830-2 | 15W-40 | 20020401 |
| 830-3 | 15W-40 | 20161221 |
| 831 (PC10B) | 15W-40 | 20050330 |
| 831-1 | 15W-40 | 20070710 |
| 831-2 | 15W-40 | 20111128 |
| 831-3 | 15W-40 | 20150317 |
| 831-4 | 15W-40 | 20170217 |
| 832 (PC11G) | 15W-40 | 20150521 |
| 832-1 | 15W-40 | 20180524 |
| 833 (PC11K) | 15W-40 | 20150325 |
| 833-1 | 15W-40 | 20170619 |
| 864 (X) | 5W-30 | 20160520 |
| 864-1 | 5W-30 | 20160705 |
| 866 (C) | 10W-30 | 20160609 |
| 873 | 40 | 19930728 |
| 873-1 | 40 | 19940214 |
| 873-2 | 40 | 20020313 |
| 925 | 5W-30 | 19870123 |
| 925-1 | 5W-30 | 19880216 |
| 925-2 | 5W-30 | 19900614 |
| 925-3 | 5W-30 | 19930608 |
| 940 | 5W-30 | 20120425 |
| 940-1 | 5W-30 | 20180605 |
| 1004-2 | 15W-40 | 19941216 |
| 1004-3 | 15W-40 | 19960508 |
| 1005 | 15W-40 | 19960229 |
| 1005-1 | 15W-40 | 19980121 |
| 1005-2 | 15W-40 | 20030926 |
| 1005-3 | 15W-40 | 20090928 |
| 1005-4 | 15W-40 | 20120731 |
| 1005-5 | 15W-40 | 20150116 |
| 1006 | 5W-30 | 19961014 |
| 1006-1 | 5W-30 | 20000907 |
| 1006-2 | 5W-30 | 20001026 |
| 1007 | 5W-30 | 19980424 |
| 1008 | 5W-30 | 19980601 |
| 1008-1 | 5W-30 | 20020318 |
| 1009 | 5W-30 | 20020307 |
| 1009-1 | 5W-30 | 20170530 |
| 1010 | 5W-20 | 20100824 |
| 1010-1 | 5W-20 | 20141016 |

REFERENCE OIL VISCOSITY GRADES

| Oil | SAE Viscosity Grade | Date Received ¹ |
|---------|---------------------|----------------------------|
| 1011 | 0W-16 | 20150413 |
| 1011-1 | 0W-16 | 20190924 |
| 1012 | 5W-20 | 20170126 |
| FOAMB18 | 5W-20 | 20180111 |
| GIA17 | 10W-30 | 20171220 |
| VOLC12 | 5W-30 | 20130214 |
| VOLD12 | 0W-20 | 20130218 |
| VOLE12 | 5W-20 | 20130218 |

¹ Date received into TMC warehouse.