

## 7. Sequence VG LTMS Requirements

The following are the specific Sequence VG calibration test requirements.

### A. Reference Oils and Parameters

The critical parameters are Average Engine Sludge, Average Rocker Cover Sludge, Average Engine Varnish, Average Piston Varnish, and Oil Screen Clogging. Number of Hot Stuck Rings is a discrete parameter and is monitored for occurrence only. The reference oils required for stand calibration are the reference oils accepted by the ASTM Sequence VG Surveillance Panel. The means and standard deviations for the current reference oils for each critical parameter are presented below.

#### AVERAGE ENGINE SLUDGE

Unit of Measure: Merits

| Reference Oil | Mean | Standard Deviation |
|---------------|------|--------------------|
| 940           | 6.43 | 0.51               |
| 1006          | 8.43 | 0.60               |
| 1006-2        | 8.65 | 0.41               |
| 1007          | 8.93 | 0.30               |
| 1009          | 7.94 | 0.52               |

#### AVERAGE ROCKER COVER SLUDGE

Unit of Measure: Merits

| Reference Oil | Mean | Standard Deviation |
|---------------|------|--------------------|
| 940           | 8.15 | 0.44               |
| 1006          | 9.35 | 0.20               |
| 1006-2        | 9.40 | 0.15               |
| 1007          | 8.99 | 0.41               |
| 1009          | 9.29 | 0.18               |

#### AVERAGE ENGINE VARNISH

Unit of Measure: Merits

| Reference Oil | Mean | Standard Deviation |
|---------------|------|--------------------|
| 940           | 8.79 | 0.25               |
| 1006          | 9.27 | 0.10               |
| 1006-2        | 9.24 | 0.12               |
| 1007          | 9.24 | 0.11               |
| 1009          | 8.99 | 0.22               |

### AVERAGE PISTON VARNISH

Unit of Measure: Merits

| Reference Oil | Mean | Standard Deviation |
|---------------|------|--------------------|
| 940           | 7.20 | 0.63               |
| 1006          | 8.49 | 0.18               |
| 1006-2        | 8.52 | 0.22               |
| 1007          | 8.57 | 0.23               |
| 1009          | 7.79 | 0.43               |

### OIL SCREEN CLOGGING

Unit of Measure: LN(OSCRNSLG + 1)

| Reference Oil | Mean  | Standard Deviation |
|---------------|-------|--------------------|
| 940           | 3.951 | 0.840              |
| 1006          | 1.384 | 0.850              |
| 1006-2        | 0.896 | 0.579              |
| 1007          | 0.968 | 0.614              |
| 1009          | 2.200 | 1.038              |

### NUMBER OF HOT STUCK RINGS

Unit of Measure: Count

| Reference Oil | Maximum Allowable |
|---------------|-------------------|
| 940           | 0                 |
| 1006          | 0                 |
| 1006-2        | 0                 |
| 1007          | 0                 |
| 1009          | 0                 |

#### B. Acceptance Criteria

##### 1. New Test Stand

##### a. Less than six (6) Operationally Valid Calibration Results in Laboratory

- A minimum of two (2) operationally valid calibration tests, with no stand Shewhart severity alarms and no stand Shewhart precision alarms must be conducted on any approved reference oils except 940.
- All operationally valid calibration results must be charted to determine if the test stand is currently “in control” as defined by the control chart from the Lubricant Test Monitoring System.

b. Six (6) or more Operationally Valid Calibration Results in Laboratory\*

- The first operationally valid test run on any approved reference oil must have no stand Shewhart severity alarm and no stand Shewhart precision alarm using the “Reduced K” values. If the first operationally valid calibration test does not meet this acceptance criteria, then the New Test Stand criteria listed above in 1.a must be followed.

\* Only test results from calibrated stands in the laboratory count towards the tally of six (6) required operationally valid calibration tests. The sixth test must complete (date and time) before the first test completes (date and time) on a new test stand that is seeking calibration with a single test result. In addition, the first test for the stand is to begin within six (6) months of the completion of the last acceptable calibration test. Also, there must not be any outstanding precision alarms for the laboratory.

2. Existing Test Stand

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

3. Reference Oil Assignment

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

- 25% each, oils 940, 1006, 1007, and 1009 (or subsequent reblends).

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. The constants used for the construction of the control charts for Sequence VG, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters, except Number of Hot Stuck Rings, is required.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

|             |            | EWMA Chart |          |           |          | Shewhart Chart |          |
|-------------|------------|------------|----------|-----------|----------|----------------|----------|
|             |            | LAMBDA     |          | K         |          | K              |          |
| Chart Level | Limit Type | Precision  | Severity | Precision | Severity | Precision      | Severity |
| Stand       | Reduced K  | --         | --       | --        | --       | 1.48           | 1.48     |
|             | Action     | 0.30       | 0.30     | 1.80      | 2.10     | 1.80           | 1.80     |
| Lab         | Warning    | 0.30       | -        | 1.80      | -        | -              | -        |
|             | Action     | 0.30       | 0.20     | 2.24      | 1.96     | 1.80           | 1.80     |
| Industry    | Warning    | 0.15       | 0.15     | 1.80      | 2.10     | -              | -        |
|             | Action     | 0.15       | 0.15     | 2.57      | 2.81     | 1.80           | 1.80     |

The following are the steps that must be taken in the case of exceeding control chart limits. The steps are listed in order of priority, although charts should be studied simultaneously to

## 22. T-12 LTMS Requirements

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

### A. Reference Oils and Parameters

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

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

| Reference Oil | Level | Mean | Standard Deviation |
|---------------|-------|------|--------------------|
| 821           | Stand | 16.2 | 3.7                |
| 821           | Lab   | 15.1 | 2.8                |
| 821-1         | Stand | 16.2 | 3.7                |
| 821-1         | Lab   | 15.1 | 2.8                |
| 821-2         | Stand | 16.2 | 3.7                |
| 821-2         | Lab   | 15.1 | 2.8                |
| 821-3         | Stand | 16.2 | 3.7                |
| 821-3         | Lab   | 15.1 | 2.8                |

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

| Reference Oil | Mean | Standard Deviation |
|---------------|------|--------------------|
| 821           | 62.0 | 28.2               |
| 821-1         | 62.0 | 28.2               |
| 821-2         | 62.0 | 28.2               |
| 821-3         | 62.0 | 28.2               |

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

| Reference Oil | Mean   | Standard Deviation |
|---------------|--------|--------------------|
| 821           | 4.0930 | 0.0790             |
| 821-1         | 4.0930 | 0.0790             |
| 821-2         | 4.0930 | 0.0790             |
| 821-3         | 4.0930 | 0.0790             |

$\Delta$ PB AT END OF TEST  
 Unit of Measure: LN( $\Delta$ Pb ppm)  
 CRITICAL PARAMETER  
 NORMAL K VALUE

| Reference Oil | Mean   | Standard Deviation |
|---------------|--------|--------------------|
| 821           | 3.1060 | 0.2420             |
| 821-1         | 3.1060 | 0.2420             |
| 821-2         | 3.1060 | 0.2420             |
| 821-3         | 3.1060 | 0.2420             |

$\Delta$ PB 250 – 300 HOURS  
 Unit of Measure: LN( $\Delta$ Pb 250-300 ppm)  
 NONCRITICAL PARAMETER  
 NORMAL K VALUE

| Reference Oil | Mean   | Standard Deviation |
|---------------|--------|--------------------|
| 821           | 2.1250 | 0.3330             |
| 821-1         | 2.1250 | 0.3330             |
| 821-2         | 2.1250 | 0.3330             |
| 821-3         | 2.1250 | 0.3330             |

B. Acceptance Criteria

1. New Test Stand

a. First Test Stand in a Laboratory

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

b. All Subsequent New Test Stands in a Laboratory

- One operationally valid test with no stand Shewhart severity alarms (critical parameters only) 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.

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 821 or subsequent approved reblends.

4. Control Charts

In Section 1 of the LTMS, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. The constants used for the construction of the control charts for the T-12, and the response necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

|             |            |            | EWMA Chart |          |           |          | Shewhart Chart |          |
|-------------|------------|------------|------------|----------|-----------|----------|----------------|----------|
|             |            |            | LAMBDA     |          | K         |          | K              |          |
| Chart Level | Parameters | Limit Type | Precision  | Severity | Precision | Severity | Precision      | Severity |
| Stand       | Normal     | Action     | 0.3        | 0.3      | 2.10      | 2.36     | 2.10           | 1.80     |
|             | Expanded K | Action     | 0.3        | 0.3      | 2.10      | 2.36     | 2.10           | 2.40     |
| Lab         | All        | Warning    | 0.3        | --       | 2.10      | --       | --             | --       |
|             | Normal     | Action     | 0.3        | 0.2      | 2.80      | 1.96     | 2.10           | 1.80     |
|             | Expanded K | Action     | 0.3        | 0.2      | 2.80      | 1.96     | 2.10           | 2.40     |
| Industry    | All        | Warning    | 0.2        | 0.2      | 2.10      | 2.36     | --             | --       |
|             | All        | Action     | 0.2        | 0.2      | 2.80      | 3.00     | --             | --       |

The following are the steps that must be taken in the case of exceeding control chart limits. The steps are listed in order of priority, although charts should be studied simultaneously to determine the cause(s) of a problem. In the case of multiple alarms, contact the TMC for guidance.

- Exceed EWMA laboratory chart action limit for precision (critical parameters 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 during the alarm period.
- Exceed EWMA laboratory chart warning limit for precision (critical parameters 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 during the alarm period.
- Exceed EWMA test stand chart limit for precision (critical parameters 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 parameters 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 laboratory chart action limit for precision (critical parameters 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 during the alarm period.
- Exceed EWMA laboratory chart action limit for severity (all parameters)
  - Calculate laboratory Severity Adjustment (SA) for each parameter that exceeds action limit, using the current laboratory EWMA ( $Z_i$ ) as follows:
 

|                              |                               |
|------------------------------|-------------------------------|
| Cylinder Liner Wear:         | $SA = (-Z_i) \times (1.6)$    |
| Top Ring Weight Loss:        | $SA = (-Z_i) \times (24.9)$   |
| Oil Consumption:             | $SA = (-Z_i) \times (0.0610)$ |
| $\Delta Pb$ at End of Test:  | $SA = (-Z_i) \times (0.2880)$ |
| $\Delta Pb$ 250 - 300 Hours: | $SA = (-Z_i) \times (0.3630)$ |
  - Confirm calculations with the TMC.
- Exceed EWMA test stand chart limit for severity (critical parameters 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 parameters 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 (all parameters)
  - TMC to notify test developer, surveillance panel chairman, and ACC Monitoring Agency. Meeting of the TMC, test developer, and the surveillance panel required to determine course of action.
- Exceed EWMA industry chart warning limit (all parameters)
  - TMC to notify test developer, surveillance panel chairman, and ACC Monitoring Agency. Coordination of TMC, test developer, and surveillance panel chairman required to discuss potential problem.



25. T-12A

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

A. Reference Oils and Critical Parameter

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

MRV VISCOSITY  
Unit of Measure: cP

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

B. Acceptance Criteria

## 1. New Test Stand

- A minimum of one (1) operationally valid calibration test must be conducted on any approved reference oil.
- All operationally valid calibration test results must be charted to determine if the test stand is currently “in control” as defined by the control charts from the Lubricant Test Monitoring System.

## 2. Existing Test Stand

- The test stand must have been an ASTM TMC calibrated test stand prior to LTMS introduction or have previously been accepted into the system by meeting LTMS calibration requirements.
- All operationally valid calibration test results must be charted to determine if the test stand is currently “in control” as defined by the control charts from the Lubricant Test Monitoring System.

## 3. Reference Oil Assignment

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

- 100% of the scheduled calibration tests should be conducted on reference oils 821-1 or subsequent approved reblends.

| Sequence VG Reference Oil Targets |                 |                   |                 |           |                   |           |                   |           |                   |           |                   |                       |                    |                   |
|-----------------------------------|-----------------|-------------------|-----------------|-----------|-------------------|-----------|-------------------|-----------|-------------------|-----------|-------------------|-----------------------|--------------------|-------------------|
| Oil                               | n               | Effective Dates   |                 | AES       |                   | RCS       |                   | AEV       |                   | APV       |                   | OSCRNSLG <sup>7</sup> |                    | Hot Stuck Rings   |
|                                   |                 | From <sup>1</sup> | To <sup>2</sup> | $\bar{X}$ | S                 | $\bar{X}$ | s                 | $\bar{X}$ | s                 | $\bar{X}$ | s                 | $\bar{X}$             | s                  | Maximum Allowable |
| 925-3                             | 4               | 11-17-00          | 5-31-01         | 6.44      | 0.83              | 7.60      | 0.36              | 8.52      | 0.29              | 7.39      | 0.41              | 3.992                 | 1.018              | 0                 |
|                                   | 10              | 6-1-01            | 11-02-04        | 6.23      | 0.62              | 7.38      | 0.45              | 8.57      | 0.24              | 7.40      | 0.28              | 4.147                 | 0.649              | 0                 |
|                                   | 22              | 11-3-04           | 5-2-05          | 6.51      | 0.60              | 7.40      | 0.48              | 8.58      | 0.20              | 7.38      | 0.28              | 4.084                 | 0.665              | 0                 |
|                                   | 26              | 5-3-05            | 7-28-11         | 6.49      | 0.55              | 7.43      | 0.44              | 8.56      | 0.20              | 7.38      | 0.26              | 3.997                 | 0.669              | 0                 |
|                                   | 30              | 7-29-11           | ***             | 6.49      | 0.55              | 7.43      | 0.44              | 8.56      | 0.25 <sup>7</sup> | 7.38      | 0.36 <sup>7</sup> | 3.997                 | 0.669              | 0                 |
| 940 <sup>8</sup>                  | 5               | 11-14-12          | ***             | 6.43      | 0.51              | 8.15      | 0.44              | 8.79      | 0.25              | 7.20      | 0.63              | 3.951                 | 0.840              | 0                 |
| 1006                              | 18 <sup>4</sup> | 9-16-98           | 5-31-99         | 6.64      | 0.61 <sup>3</sup> | 8.23      | 0.56 <sup>3</sup> | 8.91      | 0.23 <sup>3</sup> | 7.72      | 0.32 <sup>3</sup> | 4.615                 | 1.313 <sup>3</sup> | 0                 |
|                                   | 14 <sup>6</sup> | 6-1-99            | 11-15-99        | 8.11      | 0.68 <sup>5</sup> | 9.28      | 0.32 <sup>5</sup> | 9.25      | 0.10 <sup>5</sup> | 8.48      | 0.26 <sup>5</sup> | 1.680                 | 0.645 <sup>5</sup> | 0                 |
|                                   | 10              | 11-16-99          | 5-24-00         | 8.35      | 0.72              | 9.34      | 0.26              | 9.27      | 0.12              | 8.56      | 0.20              | 1.412                 | 0.828              | 0                 |
|                                   | 20              | 5-25-00           | 11-16-00        | 8.29      | 0.60              | 9.31      | 0.21              | 9.26      | 0.11              | 8.51      | 0.20              | 1.342                 | 0.894              | 0                 |
|                                   | 29              | 11-17-00          | ***             | 8.43      | 0.60              | 9.35      | 0.20              | 9.27      | 0.10              | 8.49      | 0.18              | 1.384                 | 0.850              | 0                 |
| 1006-2                            | 10              | 1-27-03           | 1-4-04          | 8.64      | 0.31              | 9.37      | 0.14              | 9.26      | 0.10              | 8.54      | 0.12              | 1.092                 | 0.782              | 0                 |
|                                   | 20              | 1-5-04            | 11-02-04        | 8.69      | 0.42              | 9.41      | 0.16              | 9.25      | 0.11              | 8.54      | 0.13              | 0.918                 | 0.649              | 0                 |
|                                   | 30              | 11-03-04          | 7-28-11         | 8.65      | 0.41              | 9.40      | 0.15              | 9.24      | 0.11              | 8.52      | 0.14              | 0.896                 | 0.579              | 0                 |
|                                   | 30              | 7-29-11           | ***             | 8.65      | 0.41              | 9.40      | 0.15              | 9.24      | 0.12 <sup>7</sup> | 8.52      | 0.22 <sup>7</sup> | 0.896                 | 0.579              | 0                 |
| 1007                              | 18 <sup>4</sup> | 9-16-98           | 5-31-99         | 7.02      | 0.61 <sup>3</sup> | 7.72      | 0.56 <sup>3</sup> | 8.88      | 0.23 <sup>3</sup> | 7.83      | 0.32 <sup>3</sup> | 4.581                 | 1.313 <sup>3</sup> | 0                 |
|                                   | 14 <sup>6</sup> | 6-1-99            | 11-15-99        | 9.16      | 0.68 <sup>5</sup> | 9.25      | 0.32 <sup>5</sup> | 9.28      | 0.10 <sup>5</sup> | 8.64      | 0.26 <sup>5</sup> | 0.462                 | 0.645 <sup>5</sup> | 0                 |
|                                   | 10              | 11-16-99          | 11-16-00        | 8.94      | 0.28              | 9.06      | 0.30              | 9.24      | 0.09              | 8.59      | 0.13              | 0.801                 | 0.667              | 0                 |
|                                   | 29              | 11-17-00          | 7-28-11         | 8.93      | 0.30              | 8.99      | 0.41              | 9.24      | 0.09              | 8.57      | 0.16              | 0.968                 | 0.614              | 0                 |
|                                   | 30              | 7-29-11           | ***             | 8.93      | 0.30              | 8.99      | 0.41              | 9.24      | 0.11 <sup>7</sup> | 8.57      | 0.23 <sup>7</sup> | 0.968                 | 0.614              | 0                 |
| 1008                              | 18 <sup>4</sup> | 9-16-98           | 8-13-99         | 9.00      | 0.61 <sup>3</sup> | 8.94      | 0.56 <sup>3</sup> | 9.16      | 0.23 <sup>3</sup> | 8.97      | 0.32 <sup>3</sup> | 0.660                 | 1.313 <sup>3</sup> | 0                 |

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| Sequence VG Reference Oil Targets ( continued) |    |                   |                 |           |      |           |      |           |                   |           |                   |                       |       |                   |
|------------------------------------------------|----|-------------------|-----------------|-----------|------|-----------|------|-----------|-------------------|-----------|-------------------|-----------------------|-------|-------------------|
| Oil                                            | n  | Effective Dates   |                 | AES       |      | RCS       |      | AEV       |                   | APV       |                   | OSCRNSLG <sup>7</sup> |       | Hot Stuck Rings   |
|                                                |    | From <sup>1</sup> | To <sup>2</sup> | $\bar{X}$ | S    | $\bar{X}$ | s    | $\bar{X}$ | s                 | $\bar{X}$ | s                 | $\bar{X}$             | s     | Maximum Allowable |
| 1009                                           | 3  | 8-1-02            | 10-4-02         | 8.00      | 0.22 | 9.25      | 0.09 | 8.93      | 0.16              | 7.80      | 0.54              | 1.823                 | 0.739 | 0                 |
|                                                | 5  | 10-5-02           | 5-14-03         | 7.78      | 0.36 | 9.15      | 0.22 | 8.93      | 0.11              | 7.84      | 0.40              | 2.670                 | 1.303 | 0                 |
|                                                | 10 | 5-15-03           | 2-16-04         | 7.82      | 0.46 | 9.23      | 0.19 | 9.01      | 0.16              | 7.85      | 0.33              | 2.362                 | 1.337 | 0                 |
|                                                | 20 | 2-17-04           | 11-02-04        | 7.87      | 0.43 | 9.29      | 0.19 | 9.00      | 0.15              | 7.80      | 0.29              | 2.274                 | 1.044 | 0                 |
|                                                | 30 | 11-03-04          | 7-28-11         | 7.94      | 0.52 | 9.29      | 0.18 | 8.99      | 0.11              | 7.79      | 0.28              | 2.200                 | 1.038 | 0                 |
|                                                | 30 | 7-29-11           | ***             | 7.94      | 0.52 | 9.29      | 0.18 | 8.99      | 0.22 <sup>7</sup> | 7.79      | 0.43 <sup>7</sup> | 2.200                 | 1.038 | 0                 |

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

2 \*\*\* = currently in effect.

3 Pooled s from GF-3 matrix analysis.

4 GF-3matrix n-size

8 See TMC Memo 12-033

5 Pooled s from fuel matrix analysis

6 Fuel matrix n-size

7 Updated AEV and APV standard deviations using last 30 tests, including fuel approval results for oil 925-3, 1006-2, 1007 and 1009

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

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

| T-12A Reference Oil Targets |                 |                   |                 |               |     |
|-----------------------------|-----------------|-------------------|-----------------|---------------|-----|
| Oil                         | n               | Effective Dates   |                 | MRV Viscosity |     |
|                             |                 | From <sup>1</sup> | To <sup>2</sup> | $\bar{X}$     | s   |
| 821-1                       | 14 <sup>3</sup> | 2-16-10           | ***             | 11736         | 331 |
| 821-2                       | 14 <sup>3</sup> | 2-16-10           | ***             | 11736         | 331 |
| 821-3                       | 14 <sup>3</sup> | 8-21-12           | ***             | 11736         | 331 |

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

APPENDIX B  
HISTORY OF INDUSTRY CORRECTION FACTORS  
APPLICABLE TO LTMS DATA

| Test Area | Effective          | Description                                                                                                                             |
|-----------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| IIIF      | None               | None                                                                                                                                    |
| IIIG      | None               | None                                                                                                                                    |
| IIIGA     | None               | None                                                                                                                                    |
| IIIGB     | July 24, 2009      | Add 1.61 to PHOS                                                                                                                        |
| IVA       | None               | None                                                                                                                                    |
| VG        | July 1, 2005       | For Fuel Batch TF2221LS20, Add 0.19 to AEV; Add 2.175 to AES and divide by 1.192 Add 0.54 to APV; Add 0.627 to RCS and divide by 1.041  |
|           | November 10, 2007  | For Fuel Batch TF2221LS20, Add 0.12 to AEV; Add 0.42 to AES ; Add 0.39 to APV; Add 0.23 to RCS                                          |
|           | May 26, 2009       | For Fuel Batch XC2721NX10, Add 3.011 to AEV and divide by 1.356; Add 1.325 to APV and divide by 1.207                                   |
|           | October 1, 2009    | For Fuel Batch XC2721NX10, Subtract 0.24 from APV; subtract 0.12 from AEV.                                                              |
| VIB       | None               | None                                                                                                                                    |
| VID       | None               | None                                                                                                                                    |
| VIII      | None               | None                                                                                                                                    |
| 1M-PC     | None               | None                                                                                                                                    |
| 1K        | None               | None                                                                                                                                    |
| 1N        | May 1, 2004        | Add -1.135 to ln(TLHC+1)                                                                                                                |
| 1P        | None               | None                                                                                                                                    |
| 1R        | None               | None                                                                                                                                    |
| C13       | None               | None                                                                                                                                    |
| ISB       | April 21, 2011     | For Batch B Tappets with Batch E, F, and G Cams; Multiply ATWL by 0.637; Add -9.5 to ACSW                                               |
| ISB       | December 11, 2011  | For Batch C Tappets with Batch H Cams; Multiply ATWL by 0.637; Add -9.5 to ACSW                                                         |
| ISB       | November 13, 2012  | For Batch C Tappets with Batch H and J Cams; Multiply ATWL by 0.711; Add -5.6 to ACSW                                                   |
| ISM       | June 28, 2007      | Add +1.7 to Crosshead Wear At 3.9% Soot<br>Add +19.1 to Injector Adjusting Screw Wear At 3.9% Soot                                      |
| T-8       | September 17,2011  | Add +0.40 to Viscosity Increase at 3.8% Soot                                                                                            |
| T-8E      | September 17,2011  | Add +0.08 to Relative Viscosity at 4.8% Soot (50% DIN Shear Loss)<br>Add +0.09 to relative Viscosity at 4.8% Soot (100% DIN Shear Loss) |
| T-10A     | None               | None                                                                                                                                    |
| T-11      | September 14, 2005 | Add -0.39% to Soot @ 12cSt Vis. Inc., Add 1274 cP to MRV Vis.                                                                           |
|           | December 6, 2005   | Add -0.36% to Soot @ 12cSt Vis. Inc., Add 713 cP to MRV Vis.                                                                            |
|           | March 24, 2006     | Add -0.35% to Soot @ 12cSt Vis. Inc., Add 956 cP to MRV Vis.                                                                            |

APPENDIX D  
REFERENCE OIL VISCOSITY GRADES

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