

**Report On**  
**Sequence IVB Evaluation**

Version

Conducted For

|  |   |
|--|---|
|  | V = Valid   |
|  | I = Invalid   |
|  | N = Results cannot be interpreted as representative of oil performance (Non-reference oil) and shall not be used for multiple test acceptance |

|  |                             |
|--|-----------------------------|
|  | NR = Non-reference oil test |
|  | RO = Reference oil test     |

| Test Number        |   |                          |  |
|--------------------|---|--------------------------|--|
| Test Stand         | Number of Tests Since Last Stand Calibration Test | Total Runs on Test Stand |  |
|                    |   |                          |  |
| Lab Engine Number  |   | Total Runs on Engine     |  |
| Lab Head Number    |   | Total Runs on Cyl Head   |  |
| Intake Cam Number  |   | Test Fuel                |  |
| Exhaust Cam Number |   | Fuel Batch               |  |
| EOT Date           |   | EOT Time                 |  |
| Oil Code           |   |                          |  |
| Formulation/Stand  |   |                          |  |
| Alternate Codes    |   |                          |  |

In my opinion this test \_\_\_\_\_ been conducted in a valid manner in accordance with the Test Method, D XXXX, and appropriate amendments. The remarks included in the report describe the anomalies associated with this test.

Submitted By:

\_\_\_\_\_ Testing Laboratory

\_\_\_\_\_ Signature

\_\_\_\_\_ Typed Name

\_\_\_\_\_ Title

**Sequence IVB**  
**Form 2**  
**Table of Contents**

|     |  |         |
|-----|--|---------|
| 1.  | Title / Validity Declaration Page  | Form 1  |
| 2.  | Table of Contents  | Form 2  |
| 3.  | Summary of Test Method   | Form 3  |
| 4.  | Test Result Summary  | Form 4  |
| 5.  | Operational Summary- Phase 1   | Form 5  |
| 6.  | Operational Summary- Phase 2   | Form 6  |
| 7.  | New and Used Oil Analysis  | Form 7  |
| 8.  | Oil Analysis Trend Plots   | Form 8  |
| 9.  | Engine Build Measurements  | Form 9  |
| 10. | Bucket Lifter Wear Measurements  | Form 10 |
| 11. | Camshaft Lobe Wear Measurements  | Form 11 |
| 12. | Hardware Information   | Form 12 |
| 13. | Downtime Report Form   | Form 13 |
| 14. | Outlier Report Form  | Form 14 |
| 15. | American Chemistry Council Code of Practice Test Laboratory<br>Conformance Statement | Form 15 |

**Sequence IVB  
Form 3  
Summary of Test Method**

The Sequence IVB engine valve train wear test is a fired engine dynamometer lubricant test which evaluates the ability of a test lubricant to reduce valve train wear. The test method is a low temperature cyclic test, with a total running duration of 200 hours.

The Sequence IVB uses a Toyota 2NR-FE water cooled, 4 cycle, in-line cylinder, 1.5 liter engine as the test apparatus. The engine incorporates a dual overhead cam, four valves per cylinder (2 intake; 2 exhaust), and direct acting mechanical bucket lifter valve train design. The critical test parts (camshafts, direct acting mechanical bucket lifters) are replaced each test. A 95 minute run-in schedule, followed by a 100 hour aging schedule, for Silicon (Si) pacification, is conducted whenever the long block or cylinder head are replaced with new components.

The Sequence IVB valve train wear test is a flush and run type of lubricant test with one 6 minute engine oil system flush and three 38 minute engine oil system flushes conducted prior to the actual test start. The test sequence is repeated for 24,000 test cycles. Each cycle consists of four stages as outlined in the table below:

| Parameter                               | Units   | Ramp to Stage 1 | Stage 1 | Ramp to Stage 2 | Stage 2 |
|---|---------|-----------------|---------|-----------------|---------|
| Duration                                | sec     | 8               | 7       | 8               | 7       |
| Engine Speed                            | r/min   | 4300 to 800     | 800     | 800 to 4300     | 4300    |
| Engine Torque                           | N·m     | 25              | 25      | 25              | 25      |
| Oil Gallery Temperature                 | °C      | 55 to 53        | 53      | 53 to 55        | 55      |
| Coolant In Temperature                  | °C      | 49              | 49      | 49              | 49      |
| Intake Air Temperature                  | °C      | 32              | 32      | 32              | 32      |
| Intake Air Pressure                     | kPa     | 0.07            | 0.07    | 0.07            | 0.07    |
| Intake Air Humidity                     | g/kg    | 11.5            | 11.5    | 11.5            | 11.5    |
| Exhaust Back Pressure                   | kPa-abs | 104.5 to 103.5  | 103.5   | 103.5 to 104.5  | 104.5   |
| Differential Coolant Temperature        | °C      | 5 to 2          | 2       | 2 to 5          | 5       |
| Rocker Cover Coolant Outlet Temperature | °C      | 20              | 20      | 20              | 20      |

**Sequence IVB  
Form 4  
Test Result Summary**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |

|                 |  |               |  |
|-----------------|--|---------------|--|
| Date Started    |  | Engine No.    |  |
| Time Started    |  | Fuel Batch    |  |
| Date Completed  |  | SAE Viscosity |  |
| Time Completed  |  | Reference Oil |  |
| Hours on Engine |  | Hours on Head |  |
| Test Length     |  |               |  |

| PARAMETER   | RESULT |
|---|--------|
| Intake Camshaft Average Heel to Toe Wear, $\mu\text{m}$     |        |
| Intake Camshaft Summation Heel to Toe Wear, $\mu\text{m}$   |        |
| Exhaust Camshaft Average Heel to Toe Wear, $\mu\text{m}$    |        |
| Exhaust Camshaft Summation Heel to Toe Wear, $\mu\text{m}$  |        |
| Intake Bucket Lifters Average z diff, $\mu\text{m}$         |        |
| Intake Bucket Lifters Summation z diff, $\mu\text{m}$       |        |
| Intake Bucket Lifters Average Area Loss, $\mu\text{m}^2$    |        |
| Intake Bucket Lifters Summation Area Loss, $\mu\text{m}^2$  |        |
| Intake Bucket Lifters Average Mass Loss, mg                 |        |
| Intake Bucket Lifters Summation Mass Loss, mg               |        |
| Exhaust Bucket Lifters Average z diff, $\mu\text{m}$        |        |
| Exhaust Bucket Lifters Summation z diff, $\mu\text{m}$      |        |
| Exhaust Bucket Lifters Average Area Loss, $\mu\text{m}^2$   |        |
| Exhaust Bucket Lifters Summation Area Loss, $\mu\text{m}^2$ |        |
| Exhaust Bucket Lifters Average Mass Loss, mg                |        |
| Exhaust Bucket Lifters Summation Mass Loss, mg              |        |
| Oil Consumption, g  |        |
| Fuel Consumption, l   |        |
| Fuel Dilution @ EOT, %                                      |        |
| 40°C Viscosity @ EOT, cSt                                   |        |
| Total Acid Number @ EOT, g KOH/g                            |        |
| Total Base Number @ EOT, g KOH/g                            |        |
| Oxidation by FTIR 5.8 Peak Area @EOT, ABS/cm <sup>2</sup>   |        |
| Nitration by FTIR 6.1 Peak Area @EOT, ABS/cm <sup>2</sup>   |        |
| Used Oil Iron @EOT, mg/Kg                                   |        |

**Sequence IVB  
Form 5  
Operational Summary – Phase 1**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |

| Parameter                            | Units   | Target      | Minimum | Maximum | Average | Std. Dev. | CV, % |
|--------------------------------------|---------|-------------|---------|---------|---------|-----------|-------|
| Engine Speed                         | r/min   | 800 ± 25    |         |         |         |           |       |
| Engine Torque                        | N-m     | 25 ± 2      |         |         |         |           |       |
| Engine Power                         | kW      |             |         |         |         |           |       |
| Brake Mean Effective Power           | bar     |             |         |         |         |           |       |
| Air Fuel Ratio                       | afr     | 14.5 ± .2   |         |         |         |           |       |
| Fuel Flow Rate                       | kg/h    |             |         |         |         |           |       |
| Coolant Temperature Into Engine      | °C      | 49 ± 3      |         |         |         |           |       |
| Coolant Temperature Out of Engine    | °C      |             |         |         |         |           |       |
| Coolant Delta                        | °C      | 2 ± 1       |         |         |         |           |       |
| Engine Oil Sump                      | °C      |             |         |         |         |           |       |
| Engine Oil Gallery                   | °C      | 53 ± 3      |         |         |         |           |       |
| Intake Air Temperature               | °C      | 32 ± 3      |         |         |         |           |       |
| Exhaust Gas Temperature              | °C      |             |         |         |         |           |       |
| Fuel Rail Temperature                | °C      | 24 ± 3      |         |         |         |           |       |
| Test Cell Air Temperature            | °C      |             |         |         |         |           |       |
| Rocker Cover Coolant In Temperature  | °C      |             |         |         |         |           |       |
| Rocker Cover Coolant Out Temperature | °C      | 20 ± 2      |         |         |         |           |       |
| Oil Gallery Pressure                 | kPa G   |             |         |         |         |           |       |
| Exhaust Pressure                     | kPa Abs | 103.5 ± 1   |         |         |         |           |       |
| Intake Air Pressure                  | kPa G   | 0.07 ± 0.02 |         |         |         |           |       |
| Fuel Rail Pressure                   | kPa G   | 335 ± 5     |         |         |         |           |       |
| Crankcase Gas Pressure               | kPa G   |             |         |         |         |           |       |
| Barometric Pressure                  | kPa Abs |             |         |         |         |           |       |
| Intake Manifold Pressure             | kPa Abs |             |         |         |         |           |       |
| Intake Air Humidity                  | g/kg    | 11.5 ± 0.5  |         |         |         |           |       |
| Blowby Flow Rate                     | sl/min  |             |         |         |         |           |       |

**Sequence IVB  
Form 6  
Operational Summary – Phase 2**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |

| Parameter                            | Units   | Target      | Minimum | Maximum | Average | Std. Dev. | CV, % |
|--------------------------------------|---------|-------------|---------|---------|---------|-----------|-------|
| Engine Speed                         | r/min   | 4300 ± 25   |         |         |         |           |       |
| Engine Torque                        | N-m     | 25 ± 2      |         |         |         |           |       |
| Engine Power                         | kW      |             |         |         |         |           |       |
| Brake Mean Effective Power           | bar     |             |         |         |         |           |       |
| Air Fuel Ratio                       | afr     | 14.5 ± .2   |         |         |         |           |       |
| Fuel Flow Rate                       | kg/h    |             |         |         |         |           |       |
| Coolant Temperature Into Engine      | °C      | 49 ± 3      |         |         |         |           |       |
| Coolant Temperature Out of Engine    | °C      |             |         |         |         |           |       |
| Coolant Delta                        | °C      | 5 ± 1       |         |         |         |           |       |
| Engine Oil Sump                      | °C      |             |         |         |         |           |       |
| Engine Oil Gallery                   | °C      | 55 ± 3      |         |         |         |           |       |
| Intake Air Temperature               | °C      | 32 ± 3      |         |         |         |           |       |
| Exhaust Gas Temperature              | °C      |             |         |         |         |           |       |
| Fuel Rail Temperature                | °C      | 24 ± 3      |         |         |         |           |       |
| Test Cell Air Temperature            | °C      |             |         |         |         |           |       |
| Rocker Cover Coolant In Temperature  | °C      |             |         |         |         |           |       |
| Rocker Cover Coolant Out Temperature | °C      | 20 ± 2      |         |         |         |           |       |
| Oil Gallery Pressure                 | kPa G   |             |         |         |         |           |       |
| Exhaust Pressure                     | kPa Abs | 104.5 ± 1   |         |         |         |           |       |
| Intake Air Pressure                  | kPa G   | 0.07 ± 0.02 |         |         |         |           |       |
| Fuel Rail Pressure                   | kPa G   | 335 ± 5     |         |         |         |           |       |
| Crankcase Gas Pressure               | kPa G   |             |         |         |         |           |       |
| Barometric Pressure                  | kPa Abs |             |         |         |         |           |       |
| Intake Manifold Pressure             | kPa Abs |             |         |         |         |           |       |
| Intake Air Humidity                  | g/kg    | 11.5 ± 0.5  |         |         |         |           |       |
| Blowby Flow Rate                     | sl/min  |             |         |         |         |           |       |



**Sequence IVB  
Form 8**

**Oil Analyses Trend Plots**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |



**Sequence IVB  
Form 9  
Engine Build Measurements**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |

| Bucket Lifter Size and Identification |          |      |    |           |      |    |
|---------------------------------------|----------|------|----|-----------|------|----|
| Cylinder                              | Intake   |      |    | Exhaust   |      |    |
|                                       | Location | Size | ID | Location  | Size | ID |
| 1                                     | Intake 1 |      |    | Exhaust 1 |      |    |
|                                       | Intake 2 |      |    | Exhaust 2 |      |    |
| 2                                     | Intake 3 |      |    | Exhaust 3 |      |    |
|                                       | Intake 4 |      |    | Exhaust 4 |      |    |
| 3                                     | Intake 5 |      |    | Exhaust 5 |      |    |
|                                       | Intake 6 |      |    | Exhaust 6 |      |    |
| 4                                     | Intake 7 |      |    | Exhaust 7 |      |    |
|                                       | Intake 8 |      |    | Exhaust 8 |      |    |

| Camshaft Journal Measurements |                        |                  |                        |                  |
|-------------------------------|------------------------|------------------|------------------------|------------------|
| Journal Number                | Intake                 |                  | Exhaust                |                  |
|                               | Oil Feed Hole Dia., mm | Journal Dia., mm | Oil Feed Hole Dia., mm | Journal Dia., mm |
| Main Feed                     |                        |                  |                        |                  |
| 1                             |                        |                  |                        |                  |
| 2                             |                        |                  |                        |                  |
| 3                             |                        |                  |                        |                  |
| 4                             |                        |                  |                        |                  |
| Run Out, mm                   |                        |                  | Run Out, mm            |                  |

| Camshaft Lobe Measurements |                 |                   |                   |                 |                   |                   |
|----------------------------|-----------------|-------------------|-------------------|-----------------|-------------------|-------------------|
| Lobe                       | Intake          |                   |                   | Exhaust         |                   |                   |
|                            | Heel to Toe, mm | Wt, $\mu\text{m}$ | Ra, $\mu\text{m}$ | Heel to Toe, mm | Wt, $\mu\text{m}$ | Ra, $\mu\text{m}$ |
| 1                          |                 |                   |                   |                 |                   |                   |
| 2                          |                 |                   |                   |                 |                   |                   |
| 3                          |                 |                   |                   |                 |                   |                   |
| 4                          |                 |                   |                   |                 |                   |                   |
| 5                          |                 |                   |                   |                 |                   |                   |
| 6                          |                 |                   |                   |                 |                   |                   |
| 7                          |                 |                   |                   |                 |                   |                   |
| 8                          |                 |                   |                   |                 |                   |                   |



**Sequence IVB  
Form 11  
Camshaft Lobe Wear Measurements**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |

| <b>Camshaft Lobe Measurements</b> |                                     |                                   |                     |                                     |                                   |                     |
|-----------------------------------|-------------------------------------|-----------------------------------|---------------------|-------------------------------------|-----------------------------------|---------------------|
| Lobe                              | Intake Camshaft                     |                                   |                     | Exhaust Camshaft                    |                                   |                     |
|                                   | Start of Test<br>Heel to Toe,<br>mm | End of Test<br>Heel to Toe,<br>mm | Wear, $\mu\text{m}$ | Start of Test<br>Heel to Toe,<br>mm | End of Test<br>Heel to Toe,<br>mm | Wear, $\mu\text{m}$ |
| 1                                 |                                     |                                   |                     |                                     |                                   |                     |
| 2                                 |                                     |                                   |                     |                                     |                                   |                     |
| 3                                 |                                     |                                   |                     |                                     |                                   |                     |
| 4                                 |                                     |                                   |                     |                                     |                                   |                     |
| 5                                 |                                     |                                   |                     |                                     |                                   |                     |
| 6                                 |                                     |                                   |                     |                                     |                                   |                     |
| 7                                 |                                     |                                   |                     |                                     |                                   |                     |
| 8                                 |                                     |                                   |                     |                                     |                                   |                     |
|                                   |                                     | Sum of Wear                       |                     |                                     | Sum of Wear                       |                     |
|                                   |                                     | Average                           |                     |                                     | Average                           |                     |
|                                   |                                     | Minimum                           |                     |                                     | Minimum                           |                     |
|                                   |                                     | Maximum                           |                     |                                     | Maximum                           |                     |
|                                   |                                     | Std. Dev.                         |                     |                                     | Std. Dev.                         |                     |

**Sequence IVB  
Form 12  
Miscellaneous Information**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |

| <b>Hardware Information</b> |   |        |         |
|-----------------------------|---|--------|---------|
|                             |   | Intake | Exhaust |
| Camshaft                    |   |        |         |
| Bucket Lifter Position      | 1 |        |         |
|                             | 2 |        |         |
|                             | 3 |        |         |
|                             | 4 |        |         |
|                             | 5 |        |         |
|                             | 6 |        |         |
|                             | 7 |        |         |
|                             | 8 |        |         |

|                                 |  |
|---------------------------------|--|
| Engine                          |  |
| Cylinder Head                   |  |
| Oil Filter                      |  |
| Spark Plug                      |  |
| Number of Runs on Cylinder Head |  |
| Number of Runs on Engine        |  |

| <b>Compression and Cylinder Leak Down</b> |                  |           |          |                          |           |
|---|------------------|-----------|----------|--------------------------|-----------|
| Cylinder                                  | Compression, kpa |           |          | Cylinder Leak Down,<br>% |           |
|   | Pre-test         | Post test | Delta, % | Pre-test                 | Post test |
| 1   |                  |           |          |                          |           |
| 2   |                  |           |          |                          |           |
| 3   |                  |           |          |                          |           |
| 4   |                  |           |          |                          |           |

**Sequence IVB  
Form 13  
Downtime Summary**

|                        |  |          |  |
|------------------------|--|----------|--|
| Lab                    |  | Oil Code |  |
| Stand                  |  | Test No. |  |
| Laboratory Oil Code    |  |          |  |
| Formulation Stand Code |  |          |  |

| Number of Downtime Occurrences |      |          |                               |
|--------------------------------|------|----------|-------------------------------|
| Test Hours                     | Date | Downtime | Reasons                       |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          |                               |
|                                |      |          | <b>Total Downtime (hours)</b> |



**Sequence IVB  
Form 15  
American Chemistry Council Code of Practice  
Test Laboratory Conformance Statement**

|                          |  |            |  |           |  |
|--------------------------|--|------------|--|-----------|--|
| Test Laboratory          |  |            |  |           |  |
| Test Sponsor             |  |            |  |           |  |
| Formulation / Stand Code |  |            |  |           |  |
| Test Number              |  |            |  |           |  |
| Start Date               |  | Start Time |  | Time Zone |  |

Declarations

No. 1 All requirements of the ACC Code of Practice for which the test laboratory is responsible were met in the conduct of this test. Yes \_\_\_\_\_ No \_\_\_\_\_ \*

No. 2 The laboratory ran this test for the full duration following all procedural requirements; and all operational validity requirements of the latest version of the applicable test procedure (ASTM or other), including all updates issued by the organization responsible for the test, were met. Yes \_\_\_\_\_ No \_\_\_\_\_ \*

If the response to this Declaration is “No”, does the test engineer consider the deviations from operational validity requirements that occurred to be beyond the control of the laboratory? Yes \_\_\_\_\_ \* No \_\_\_\_\_

No 3. A deviation occurred for one of the test parameters identified by the organization responsible for the test as being a special case. Yes \_\_\_\_\_ \* No \_\_\_\_\_ (This currently applies only to specific deviations identified in the ASTM Information Letter System)

|  |   |
|--|---|
|  | Operational review of this test indicates that the results should be included in the Multiple Test Acceptance Criteria calculations.      |
|  | *Operational review of this test indicates that the results should not be included in the Multiple Test Acceptance Criteria calculations. |

Note: Supporting comments are required for all responses identified with an asterisk.

|          |
|----------|
| Comments |
|          |
|          |
|          |
|          |

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Typed Name

\_\_\_\_\_  
Title