

**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**  
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**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 50 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  | Stage 2 → 1 | Stage 1     | Stage 1 → 2 | Stage 2     |
|---------------------------------------|--------|-------------|-------------|-------------|-------------|
| Duration                              | Sec.   | 8           | 7           | 8           | 7           |
| Engine Speed                          | r/min  | 4300 to 800 | 800 ± 25    | 800 to 4300 | 4300 ± 25   |
| Engine Torque                         | N-m    | 25 ± 1.5    | 25 ± 1.5    | 25 ± 1.5    | 25 ± 1.5    |
| Coolant Out Temperature               | °C     |             | 51.5 ± 0.75 |             | 52.5 ± 0.75 |
| Coolant Flow (Engine)                 | L/min  | 80 ± 0.4    | 80 ± 0.4    | 80 ± 0.4    | 80 ± 0.4    |
| Coolant Flow (RAC)                    | L/min  | 120 ± 0.75  | 120 ± 0.75  | 120 ± 0.75  | 120 ± 0.75  |
| Oil Gallery Temperature               | °C     | 54 ± 4      | 54 ± 4      | 54 ± 4      | 54 ± 4      |
| RAC Coolant Out Temperature           | °C     | 20 ± 0.75   | 20 ± 0.75   | 20 ± 0.75   | 20 ± 0.75   |
| Fuel Rail Temperature                 | °C     | 24 ± 0.5    | 24 ± 0.5    | 24 ± 0.5    | 24 ± 0.5    |
| Load Cell Temperature                 | °C     | 45 ± 4      | 45 ± 4      | 45 ± 4      | 45 ± 4      |
| Intake Air Temperature                | °C     | 32 ± 0.75   | 32 ± 0.75   | 32 ± 0.75   | 32 ± 0.75   |
| Blowby Gas Temperature                | °C     | 29 ± 0.5    | 29 ± 0.5    | 29 ± 0.5    | 29 ± 0.5    |
| Intake Air Pressure                   | kPa(g) | 0.25 ± 0.25 | 0.25 ± 0.25 | 0.25 ± 0.25 | 0.25 ± 0.25 |
| Intake Air Humidity                   | g/kg   | 11.5 ± 0.5  | 11.5 ± 0.5  | 11.5 ± 0.5  | 11.5 ± 0.5  |
| Exhaust Pressure                      | kPa(a) |             |             |             | 104.5 ± 3   |
| Engine Coolant Pressure               | kPa    | 70 ± 10     | 70 ± 10     | 70 ± 10     | 70 ± 10     |
| Fuel Rail Pressure                    | kPa    | 335 ± 10    | 335 ± 10    | 335 ± 10    | 335 ± 10    |
| Air-to-Fuel Ratio<br>(Not Controlled) | :1     | Record      | 14.5 ± 0.5  | Record      | 14.5 ± 0.5  |

**Sequence IVB  
Form 4  
Test Results 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     |  |               |  |

| <b>Critical Parameters</b>        |                                                                        |                                           |                                                       |
|-----------------------------------|------------------------------------------------------------------------|-------------------------------------------|-------------------------------------------------------|
|                                   | Intake Lifter<br>Average Volume<br>Loss by Keyence,<br>mm <sup>3</sup> | Intake Lifter<br>Average Mass Loss,<br>mg | Intake Camshaft<br>Average Heel<br>to Toe Wear,<br>µm |
| Original Unit Result              |                                                                        |                                           |                                                       |
| Transformed Result                |                                                                        |                                           |                                                       |
| Industry Correction Factor        |                                                                        |                                           |                                                       |
| Corrected Transformed Result      |                                                                        |                                           |                                                       |
| Severity Adjustment               |                                                                        |                                           |                                                       |
| Final Transformed Result          |                                                                        |                                           |                                                       |
| <b>Final Original Unit Result</b> |                                                                        |                                           |                                                       |

| <b>Additional Information</b>                                  |  |
|----------------------------------------------------------------|--|
| Exhaust Lifter Average Volume Loss by Keyence, mm <sup>3</sup> |  |
| Exhaust Lifter Average Mass Loss, mg                           |  |
| Exhaust Camshaft Average Heel to Toe Wear, µm                  |  |
| Camshaft Lobe Failure (Y or N)                                 |  |
| 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                                      |  |
| Used Oil Water at EOT, mg/Kg                                   |  |

**Sequence IVB  
Form 5  
Operational Summary**

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

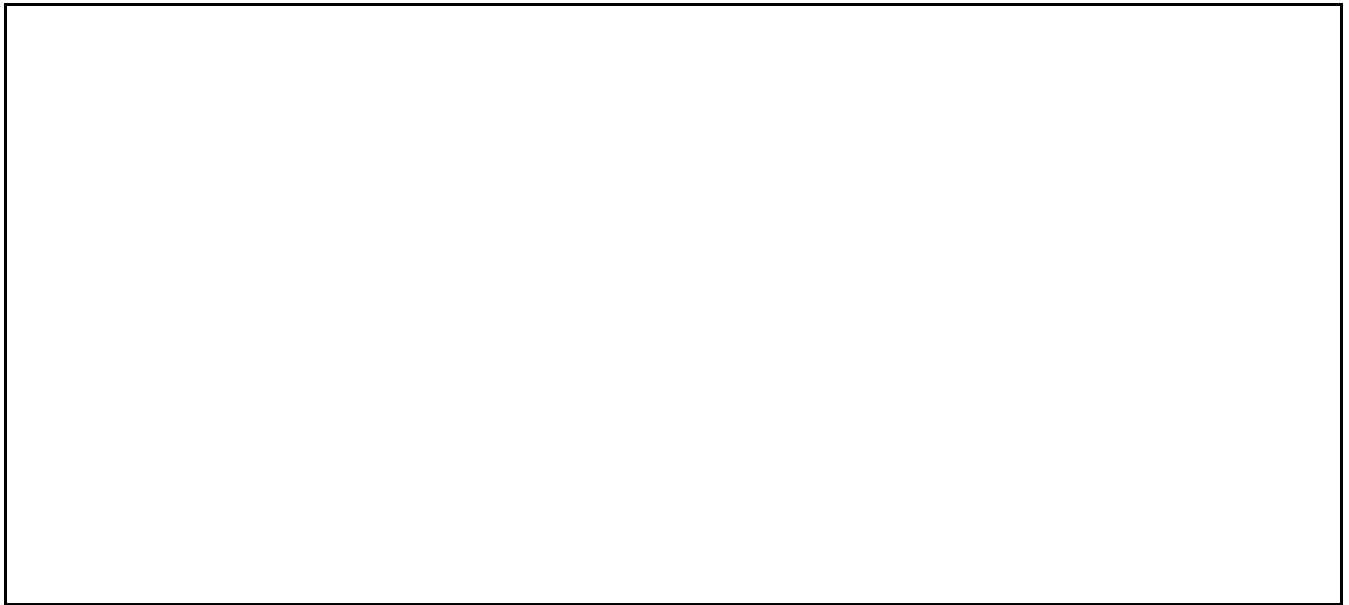
| Controlled Parameters     | Parameter                | Units | QI Threshold | EOT QI | Target  |         | Average |         | Samples | BQD |
|---------------------------|--------------------------|-------|--------------|--------|---------|---------|---------|---------|---------|-----|
|                           |                          |       |              |        | Stage 1 | Stage 2 | Stage 1 | Stage 2 |         |     |
|                           |                          |       |              |        | Speed   | r/min   | 0.000   |         |         |     |
| Torque                    | n·m                      | 0.000 |              | 25     | 25      |         |         |         |         |     |
| Engine Oil Gallery        | °C                       | 0.000 |              | 54     | 54      |         |         |         |         |     |
| Engine Coolant Out        | °C                       | 0.000 |              | 52     | 52      |         |         |         |         |     |
| Engine Coolant Flow       | L/min                    | 0.000 |              | 80     | 80      |         |         |         |         |     |
| Engine Coolant Pressure   | kPa                      | 0.000 |              | 70     | 70      |         |         |         |         |     |
| RAC Coolant Out           | °C                       | 0.000 |              | 20     | 20      |         |         |         |         |     |
| Load Cell                 | °C                       | 0.000 |              | 45     | 45      |         |         |         |         |     |
| RAC Flow                  | L/min                    | 0.000 |              | 120    | 120     |         |         |         |         |     |
| Intake Air                | °C                       | 0.000 |              | 32     | 32      |         |         |         |         |     |
| Intake Air Pressure       | kPa                      | 0.000 |              | 0.25   | 0.25    |         |         |         |         |     |
| Intake Air Humidity       | g/kg                     | 0.000 |              | 11.5   | 11.5    |         |         |         |         |     |
| Fuel Rail Temperature     | °C                       | 0.000 |              | 24     | 24      |         |         |         |         |     |
| Blowby Gas                | °C                       | 0.000 |              | 29     | 29      |         |         |         |         |     |
| Fuel Rail Pressure        | kPa                      | 0.000 |              | 335    | 335     |         |         |         |         |     |
| Exhaust Backpressure      | kPaA                     | 0.000 |              |        | 104.5   |         |         |         |         |     |
| Non-controlled Parameters | Parameter                | Units |              |        |         |         |         |         |         |     |
|                           | Fuel Flow                | kg/h  |              |        | Record  | Record  |         |         |         |     |
|                           | Blowby                   | L/min |              |        | Record  | Record  |         |         |         |     |
|                           | Power                    | kW    |              |        | Record  | Record  |         |         |         |     |
|                           | Air Fuel Ratio           | AFR   |              |        | Record  | Record  |         |         |         |     |
|                           | Engine Coolant In        | °C    |              |        | Record  | Record  |         |         |         |     |
|                           | Engine Coolant Delta     | °C    |              |        | Record  | Record  |         |         |         |     |
|                           | RAC Coolant In           | °C    |              |        | Record  | Record  |         |         |         |     |
|                           | Oil Sump Temp            | °C    |              |        | Record  | Record  |         |         |         |     |
|                           | Exhaust Gas              | °C    |              |        | Record  | Record  |         |         |         |     |
|                           | Cell Ambient             | °C    |              |        | Record  | Record  |         |         |         |     |
|                           | Oil Gallery              | kPa   |              |        | Record  | Record  |         |         |         |     |
|                           | Crankcase Pressure       | kPa   |              |        | Record  | Record  |         |         |         |     |
|                           | Intake Manifold Pressure | kPaA  |              |        | Record  | Record  |         |         |         |     |



**Sequence IVB  
Form 7  
Oil Analysis Trend Plots**

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

**Fuel Dilution and Kinematic Viscosity @ 40°C Plot**



**TAN, TBN, and Fe Plot**







**Sequence IVB  
Form 9  
Camshaft and Lifter Wear Measurements**

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

| <b>Lifter Measurements</b> |                                           |                    |                                           |                    |
|----------------------------|-------------------------------------------|--------------------|-------------------------------------------|--------------------|
| Lifter                     | Intake                                    |                    | Exhaust                                   |                    |
|                            | Keyence<br>Volume Loss<br>mm <sup>3</sup> | Mass<br>Loss<br>mg | Keyence<br>Volume Loss<br>mm <sup>3</sup> | Mass<br>Loss<br>mg |
| 1                          |                                           |                    |                                           |                    |
| 2                          |                                           |                    |                                           |                    |
| 3                          |                                           |                    |                                           |                    |
| 4                          |                                           |                    |                                           |                    |
| 5                          |                                           |                    |                                           |                    |
| 6                          |                                           |                    |                                           |                    |
| 7                          |                                           |                    |                                           |                    |
| 8                          |                                           |                    |                                           |                    |
| <b>Average</b>             |                                           |                    |                                           |                    |
| <b>Minimum</b>             |                                           |                    |                                           |                    |
| <b>Maximum</b>             |                                           |                    |                                           |                    |
| <b>Std. Dev.</b>           |                                           |                    |                                           |                    |

| <b>Camshaft Lobe Measurements</b> |                  |     |            |                        |                  |     |             |                        |
|-----------------------------------|------------------|-----|------------|------------------------|------------------|-----|-------------|------------------------|
| Lobe                              | Intake Camshaft  |     |            |                        | Exhaust Camshaft |     |             |                        |
|                                   | Heel to Toe, mm  |     | Wear<br>μm | Lobe<br>Fail<br>Y or N | Heel to Toe, mm  |     | Wear,<br>μm | Lobe<br>Fail<br>Y or N |
|                                   | SOT              | EOT |            |                        | SOT              | EOT |             |                        |
| 1                                 |                  |     |            |                        |                  |     |             |                        |
| 2                                 |                  |     |            |                        |                  |     |             |                        |
| 3                                 |                  |     |            |                        |                  |     |             |                        |
| 4                                 |                  |     |            |                        |                  |     |             |                        |
| 5                                 |                  |     |            |                        |                  |     |             |                        |
| 6                                 |                  |     |            |                        |                  |     |             |                        |
| 7                                 |                  |     |            |                        |                  |     |             |                        |
| 8                                 |                  |     |            |                        |                  |     |             |                        |
|                                   | <b>Average</b>   |     |            |                        | <b>Average</b>   |     |             |                        |
|                                   | <b>Minimum</b>   |     |            |                        | <b>Minimum</b>   |     |             |                        |
|                                   | <b>Maximum</b>   |     |            |                        | <b>Maximum</b>   |     |             |                        |
|                                   | <b>Std. Dev.</b> |     |            |                        | <b>Std. Dev.</b> |     |             |                        |

**Sequence IVB  
Form 10  
Valve Clearance, Compression and Leakdown Measurements**

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

| <b>Valve Clearance Measurements</b> |   |   |   |   |   |   |   |   |
|-------------------------------------|---|---|---|---|---|---|---|---|
| <b>Intake</b>                       |   |   |   |   |   |   |   |   |
| Position                            | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Clearance, SOT                      |   |   |   |   |   |   |   |   |
| Clearance, EOT                      |   |   |   |   |   |   |   |   |
| Change                              |   |   |   |   |   |   |   |   |
| <b>Exhaust</b>                      |   |   |   |   |   |   |   |   |
| Clearance, SOT                      |   |   |   |   |   |   |   |   |
| Clearance, EOT                      |   |   |   |   |   |   |   |   |
| Change                              |   |   |   |   |   |   |   |   |

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

**Sequence IVB  
Form 11  
Hardware 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        |  |

| Serial Numbers   |  |
|------------------|--|
| Engine           |  |
| Cylinder Head    |  |
| Intake Camshaft  |  |
| Exhaust Camshaft |  |

Sequence IVB  
Form 12  
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 14  
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