

# DD13 Engine Scuffing Test

## Version

## Conducted For

|  |   |
|--|---|
|  | V = Valid; The Reference Oil/Non-Reference Oil was evaluated in accordance with the test procedure.   |
|  | I = Invalid; The Reference Oil/Non-Reference Oil was not evaluated in accordance with the test procedure.   |
|  | N = Results Cannot be Interpreted As Representative of Oil Performance (Non-Reference Oil) and shall not be used in determining an average test result using multiple test criteria |

|  |                             |
|--|-----------------------------|
|  | NR = Non-Reference Oil Test |
|  | RO = Reference Oil Test     |

| Test Number        |            |                   |                |
|--------------------|------------|-------------------|----------------|
| Stand:             | Stand Run: | Engine:           | Engine Kit ID: |
| End of Test Date:  |            | End of Test 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 the appropriate amendments through the information letter system.  
The remarks included in the report describe the anomalies associated with this test.

Submitted By:

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

\_\_\_\_\_  
Signature

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

\_\_\_\_\_  
Title

## DD13 Engine Scuffing Test

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## DD13 Engine Scuffing Test

### Form 3 Summary of Test Method

This test method evaluates the liner scuffing and ring distress performance of engine oils in turbocharged and intercooled four-cycle diesel engines equipped with EGR, uncoated top rings, and running on ultra-low sulfur diesel fuel. Results are obtained from used oil analysis, operational data, and component measurements before and after test.

The test engine is a four stroke Detroit Diesel DD13 12.8 L, six-cylinder diesel engine with EGR. The engine is disassembled prior to each test, the parts solvent-cleaned and measured, and rebuilt using all new pistons, uncoated rings, cylinder liners, and connecting rod bearings.

#### Schedule of Conditions for the Test Procedure

|   | Set Point<br>for Stage 1 | Set Point for<br>Stage 2  |
|---|--------------------------|---------------------------|
| Time, h   | 30                       | 170 standard <sup>A</sup> |
| <b>Controlled Quantities, units</b>             |                          |                           |
| Engine Speed, r/min                             | 1800                     | 1800                      |
| Fuel Flow Rate, kg/h                            | 32                       | 71                        |
| Air Temperature in Engine Intake, °C            | 35                       | 35                        |
| Coolant Temperature at Jacket Outlet, °C        | 105                      | 105                       |
| Oil Temperature in Gallery, °C                  | 118                      | 118                       |
| Fuel Temperature at Engine Inlet, °C            | 38                       | 38                        |
| Air Temperature in Intake Manifold, °C          | 75                       | 87                        |
| Coolant Pressure at Jacket Inlet, kPa (gauge)   | 250                      | 250                       |
| Exhaust Pressure in Tailpipe, kPa (absolute)    | 105.5                    | 125.5                     |
| Air Pressure in Intake Manifold, kPa (absolute) | 202.5                    | 327.5                     |
| Air Pressure in Engine Intake, kPa (absolute)   | 96.4                     | 94.8                      |
| <b>Ranged Quantities<sup>C</sup>, units</b>     |                          |                           |
| Coolant Flow Rate, L/min                        | 340 to 360               | 340 to 360                |

# DD13 Engine Scuffing Test

## Form 4 Test Result Summary

|                         |           |              |
|-------------------------|-----------|--------------|
| Laboratory:             | EOT Date: | EOT Time:    |
| Test Number:            |           | Test Length: |
| Oil Code:               |           |              |
| Formulation Stand Code: |           |              |

|               |   |
|---------------|---|
| Lab Oil Code  | TMC Oil Code <sup>A</sup>                           |
| SAE Viscosity | Number of Tests Since Last Calibration <sup>C</sup> |

| Start Dates and Time                 |                       |
|--------------------------------------|-----------------------|
| Oil Charge Date                      | Oil Charge Time       |
| Engine Start Date                    | Engine Start Time     |
| Test Clock Start Date                | Test Clock Start Time |
| Test Length                          |                       |
| Total Test Hours on Engine Block     |                       |
| Total Number of Test on Engine Block |                       |

|                                  | Hours to Scuff |
|----------------------------------|----------------|
| Original Result                  |                |
| Transformed Result               |                |
| Correction Factor                |                |
| Corrected Transformed Result     |                |
| Severity Adjustment <sup>B</sup> |                |
| Final Transformed Result         |                |
| Final Original Unit Result       |                |

| Additional Result           |   |   |   |   |   |   |
|-----------------------------|---|---|---|---|---|---|
| Delta Iron @ Hours to Scuff |   |   |   |   |   |   |
| Cylinder                    | 1 | 2 | 3 | 4 | 5 | 6 |
| Average % Liner Scuff       |   |   |   |   |   |   |
| Top Ring Weight Loss        |   |   |   |   |   |   |

| Last Stand Reference Results <sup>B</sup> |                |
|---|----------------|
| Test Number:                              |                |
| Oil Code:                                 |                |
| Test Length:                              | TMC Oil Code:  |
| EOT Date:                                 | EOT Time:      |
| Stand Calibration Expiration Date:        |                |
|   | Hours to Scuff |
| Final Original Unit Result                |                |

A - Reference Tests Only

B - Non-Reference Tests Only

C- Operationally Valid Tests Only, including current test

DD13 Engine Scuffing Test

**Form 5**  
**Operational Summary**  
**Controlled Parameters**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Controlled Parameters          | Parameter | Units | QI Threshold | EOT QI<br>A | Target  |         | Stage 1 |         |      |      | Stage 2 |         |     |     | No of Samples | BQD |
|--------------------------------|-----------|-------|--------------|-------------|---------|---------|---------|---------|------|------|---------|---------|-----|-----|---------------|-----|
|                                |           |       |              |             | Stage 1 | Stage 2 | Avg     | Std Dev | Max  | Min  | Avg     | Std Dev | Max | Min |               |     |
|                                |           |       |              |             | Speed   | r/min   | 0.000   |         | 1800 | 1800 |         |         |     |     |               |     |
| Fuel Flow                      | kg/h      | 0.000 |              | 32          | 71      |         |         |         |      |      |         |         |     |     |               |     |
| Intake Manifold Temperature    | °C        | 0.000 |              | 75          | 87      |         |         |         |      |      |         |         |     |     |               |     |
| Coolant Jacket Out Temperature | °C        | 0.000 |              | 105         | 105     |         |         |         |      |      |         |         |     |     |               |     |
| Fuel In Temperature            | °C        | 0.000 |              | 38          | 38      |         |         |         |      |      |         |         |     |     |               |     |
| Oil Gallery Temperature        | °C        | 0.000 |              | 118         | 118     |         |         |         |      |      |         |         |     |     |               |     |
| Intake Air Temperature         | °C        | 0.000 |              | 35          | 35      |         |         |         |      |      |         |         |     |     |               |     |
| Intake Air Restriction         | kPaA      | 0.000 |              | 96.4        | 94.8    |         |         |         |      |      |         |         |     |     |               |     |
| Intake Manifold Pressure       | kPaA      | 0.000 |              | 202.5       | 327.5   |         |         |         |      |      |         |         |     |     |               |     |
| Exhaust Pressure               | kPaA      | 0.000 |              | 105.5       | 125.5   |         |         |         |      |      |         |         |     |     |               |     |
| Coolant Jacket In Pressure     | kPa       | 0.000 |              | 250         | 250     |         |         |         |      |      |         |         |     |     |               |     |
| Coolant Flow                   | L/min     |       |              | 340-360     | 340-360 |         |         |         |      |      |         |         |     |     |               |     |

A - QI values above the threshold are acceptable by then surveillance panel. QI values below the threshold may not be considered acceptable based on engineer review.

| Counts Above Control Limit     |            |              |                          |            |              |
|--------------------------------|------------|--------------|--------------------------|------------|--------------|
|                                | Transition | Steady State |                          | Transition | Steady State |
| Oil Gallery Temperature        |            |              | Intake Air Temperature   |            |              |
| Intake Manifold Temperature    |            |              | Intake Manifold Pressure |            |              |
| Coolant Jacket Out Temperature |            |              | Torque                   |            |              |



# DD13 Engine Scuffing Test

## Form 7 Cylinder Scuffing Summary

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder        | 1 | 2 | 3 | 4 | 5 | 6 |
|-----------------|---|---|---|---|---|---|
| Position 1 (%)  |   |   |   |   |   |   |
| Position 2 (%)  |   |   |   |   |   |   |
| Position 3 (%)  |   |   |   |   |   |   |
| Position 4 (%)  |   |   |   |   |   |   |
| Position 5 (%)  |   |   |   |   |   |   |
| Position 6 (%)  |   |   |   |   |   |   |
| Position 7 (%)  |   |   |   |   |   |   |
| Position 8 (%)  |   |   |   |   |   |   |
| Position 9 (%)  |   |   |   |   |   |   |
| Position 10 (%) |   |   |   |   |   |   |
| Average (%)     |   |   |   |   |   |   |

| As Measured   |  |
|---------------|--|
| Average       |  |
| Std Deviation |  |
| Minimum       |  |
| Maximum       |  |

| Additional Liner Deposit and Condition Ratings |  |
|--|--|
| Cylinder                                       |  |
| 1  |  |
| 2  |  |
| 3  |  |
| 4  |  |
| 5  |  |
| 6  |  |

# DD13 Engine Scuffing Test

## Form 8 Top Ring Scuffing Summary

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder          | 1 | 2 | 3 | 4 | 5 | 6 |
|-------------------|---|---|---|---|---|---|
| Position 1 (%)    |   |   |   |   |   |   |
| Position 2 (%)    |   |   |   |   |   |   |
| Position 3 (%)    |   |   |   |   |   |   |
| Position 4 (%)    |   |   |   |   |   |   |
| Position 5 (%)    |   |   |   |   |   |   |
| Position 6 (%)    |   |   |   |   |   |   |
| Position 7 (%)    |   |   |   |   |   |   |
| Position 8 (%)    |   |   |   |   |   |   |
| Position 9 (%)    |   |   |   |   |   |   |
| Position 10 (%)   |   |   |   |   |   |   |
| Average (%)       |   |   |   |   |   |   |
| Ring Gap Location |   |   |   |   |   |   |

| As Measured   |  |
|---------------|--|
| Average       |  |
| Std Deviation |  |
| Minimum       |  |
| Maximum       |  |

| Additional Top Ring Deposit and Condition Ratings |  |
|---|--|
| Cylinder  |  |
| 1   |  |
| 2   |  |
| 3   |  |
| 4   |  |
| 5   |  |
| 6   |  |



# DD13 Engine Scuffing Test

## Form 9 2nd Ring Scuffing Summary

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder          | 1 | 2 | 3 | 4 | 5 | 6 |
|-------------------|---|---|---|---|---|---|
| Position 1 (%)    |   |   |   |   |   |   |
| Position 2 (%)    |   |   |   |   |   |   |
| Position 3 (%)    |   |   |   |   |   |   |
| Position 4 (%)    |   |   |   |   |   |   |
| Position 5 (%)    |   |   |   |   |   |   |
| Position 6 (%)    |   |   |   |   |   |   |
| Position 7 (%)    |   |   |   |   |   |   |
| Position 8 (%)    |   |   |   |   |   |   |
| Position 9 (%)    |   |   |   |   |   |   |
| Position 10 (%)   |   |   |   |   |   |   |
| Average (%)       |   |   |   |   |   |   |
| Ring Gap Location |   |   |   |   |   |   |

| As Measured   |  |
|---------------|--|
| Average       |  |
| Std Deviation |  |
| Minimum       |  |
| Maximum       |  |

| Additional 2 <sup>nd</sup> Ring Deposit and Condition Ratings |  |
|---|--|
| Cylinder  |  |
| 1   |  |
| 2   |  |
| 3   |  |
| 4   |  |
| 5   |  |
| 6   |  |

# DD13 Engine Scuffing Test

## Form 10 Oil Ring Scuffing Summary

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder          | 1 | 2 | 3 | 4 | 5 | 6 |
|-------------------|---|---|---|---|---|---|
| Position 1 (%)    |   |   |   |   |   |   |
| Position 2 (%)    |   |   |   |   |   |   |
| Position 3 (%)    |   |   |   |   |   |   |
| Position 4 (%)    |   |   |   |   |   |   |
| Position 5 (%)    |   |   |   |   |   |   |
| Position 6 (%)    |   |   |   |   |   |   |
| Position 7 (%)    |   |   |   |   |   |   |
| Position 8 (%)    |   |   |   |   |   |   |
| Position 9 (%)    |   |   |   |   |   |   |
| Position 10 (%)   |   |   |   |   |   |   |
| Average (%)       |   |   |   |   |   |   |
| Ring Gap Location |   |   |   |   |   |   |

| As Measured   |  |
|---------------|--|
| Average       |  |
| Std Deviation |  |
| Minimum       |  |
| Maximum       |  |

| Additional Oil Ring Deposit and Condition Ratings |  |
|---|--|
| Cylinder  |  |
| 1   |  |
| 2   |  |
| 3   |  |
| 4   |  |
| 5   |  |
| 6   |  |

DD13 Engine Scuffing Test

**Form 11  
Piston Top Groove Rating**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder |         | 1 | 2 | 3 | 4 | 5 | 6 |
|----------|---------|---|---|---|---|---|---|
| HC       | Area    |   |   |   |   |   |   |
|          | Demerit |   |   |   |   |   |   |
| MC       | Area    |   |   |   |   |   |   |
|          | Demerit |   |   |   |   |   |   |
| LC       | Area    |   |   |   |   |   |   |
|          | Demerit |   |   |   |   |   |   |
| Total    | Area    |   |   |   |   |   |   |
|          | Demerit |   |   |   |   |   |   |

|       |  |  |  |  |  |  |
|-------|--|--|--|--|--|--|
| TGF % |  |  |  |  |  |  |
|-------|--|--|--|--|--|--|

| Additional Piston Top Groove Deposit and Condition Ratings |  |
|--|--|
| Cylinder   |  |
| 1  |  |
| 2  |  |
| 3  |  |
| 4  |  |
| 5  |  |
| 6  |  |

DD13 Engine Scuffing Test

**Form 12**  
**Ring Weight Measurements**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder | Top Ring Weight, mg               |        |                 |
|----------|-----------------------------------|--------|-----------------|
|          | SOT, g                            | EOT, g | Weight Loss, mg |
| 1        |                                   |        |                 |
| 2        |                                   |        |                 |
| 3        |                                   |        |                 |
| 4        |                                   |        |                 |
| 5        |                                   |        |                 |
| 6        |                                   |        |                 |
|          | Top Ring Weight Average, mg       |        |                 |
|          | Top Ring Weight Std Deviation, mg |        |                 |
|          | Top Ring Weight Minimum, mg       |        |                 |
|          | Top Ring Weight Maximum, mg       |        |                 |

| Cylinder | 2nd Ring Weight, mg               |        |                 |
|----------|-----------------------------------|--------|-----------------|
|          | SOT, g                            | EOT, g | Weight Loss, mg |
| 1        |                                   |        |                 |
| 2        |                                   |        |                 |
| 3        |                                   |        |                 |
| 4        |                                   |        |                 |
| 5        |                                   |        |                 |
| 6        |                                   |        |                 |
|          | 2nd Ring Weight Average, mg       |        |                 |
|          | 2nd Ring Weight Std Deviation, mg |        |                 |
|          | 2nd Ring Weight Minimum, mg       |        |                 |
|          | 2nd Ring Weight Maximum, mg       |        |                 |

| Cylinder | Oil Ring Weight, mg               |        |                 |
|----------|-----------------------------------|--------|-----------------|
|          | SOT, g                            | EOT, g | Weight Loss, mg |
| 1        |                                   |        |                 |
| 2        |                                   |        |                 |
| 3        |                                   |        |                 |
| 4        |                                   |        |                 |
| 5        |                                   |        |                 |
| 6        |                                   |        |                 |
|          | Oil Ring Weight Average, mg       |        |                 |
|          | Oil Ring Weight Std Deviation, mg |        |                 |
|          | Oil Ring Weight Minimum, mg       |        |                 |
|          | Oil Ring Weight Maximum, mg       |        |                 |

# DD13 Engine Scuffing Test

## Form 13 Ring Gap Measurements

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder | Top Ring Gap, mm               |     |                   |
|----------|--------------------------------|-----|-------------------|
|          | SOT                            | EOT | Delta (EOT - SOT) |
| 1        |                                |     |                   |
| 2        |                                |     |                   |
| 3        |                                |     |                   |
| 4        |                                |     |                   |
| 5        |                                |     |                   |
| 6        |                                |     |                   |
|          | Top Ring Gap Average, mm       |     |                   |
|          | Top Ring Gap Std Deviation, mm |     |                   |
|          | Top Ring Gap Minimum, mm       |     |                   |
|          | Top Ring Gap Maximum, mm       |     |                   |

| Cylinder | 2nd Ring Gap, mm               |     |                   |
|----------|--------------------------------|-----|-------------------|
|          | SOT                            | EOT | Delta (EOT - SOT) |
| 1        |                                |     |                   |
| 2        |                                |     |                   |
| 3        |                                |     |                   |
| 4        |                                |     |                   |
| 5        |                                |     |                   |
| 6        |                                |     |                   |
|          | 2nd Ring Gap Average, mm       |     |                   |
|          | 2nd Ring Gap Std Deviation, mm |     |                   |
|          | 2nd Ring Gap Minimum, mm       |     |                   |
|          | 2nd Ring Gap Maximum, mm       |     |                   |

| Cylinder | Oil Ring Gap, mm               |     |                   |
|----------|--------------------------------|-----|-------------------|
|          | SOT                            | EOT | Delta (EOT - SOT) |
| 1        |                                |     |                   |
| 2        |                                |     |                   |
| 3        |                                |     |                   |
| 4        |                                |     |                   |
| 5        |                                |     |                   |
| 6        |                                |     |                   |
|          | Oil Ring Gap Average, mm       |     |                   |
|          | Oil Ring Gap Std Deviation, mm |     |                   |
|          | Oil Ring Gap Minimum, mm       |     |                   |
|          | Oil Ring Gap Maximum, mm       |     |                   |











DD13 Engine Scuffing Test

**Form 16**  
**Crankcase Pressure Plot**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |



DD13 Engine Scuffing Test

**Form 17**  
**Blow-By Flow Plot**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |



DD13 Engine Scuffing Test

**Form 18**

**Intake Manifold Pressure Transition Plot**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |



DD13 Engine Scuffing Test

**Form 19**

**Intake Manifold Temperature Transition Plot**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |



DD13 Engine Scuffing Test

**Form 20**

**Oil Gallery Temperature Transition Plot**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |



DD13 Engine Scuffing Test

**Form 21**

**Coolant Jacket Temperature Transition Plot**

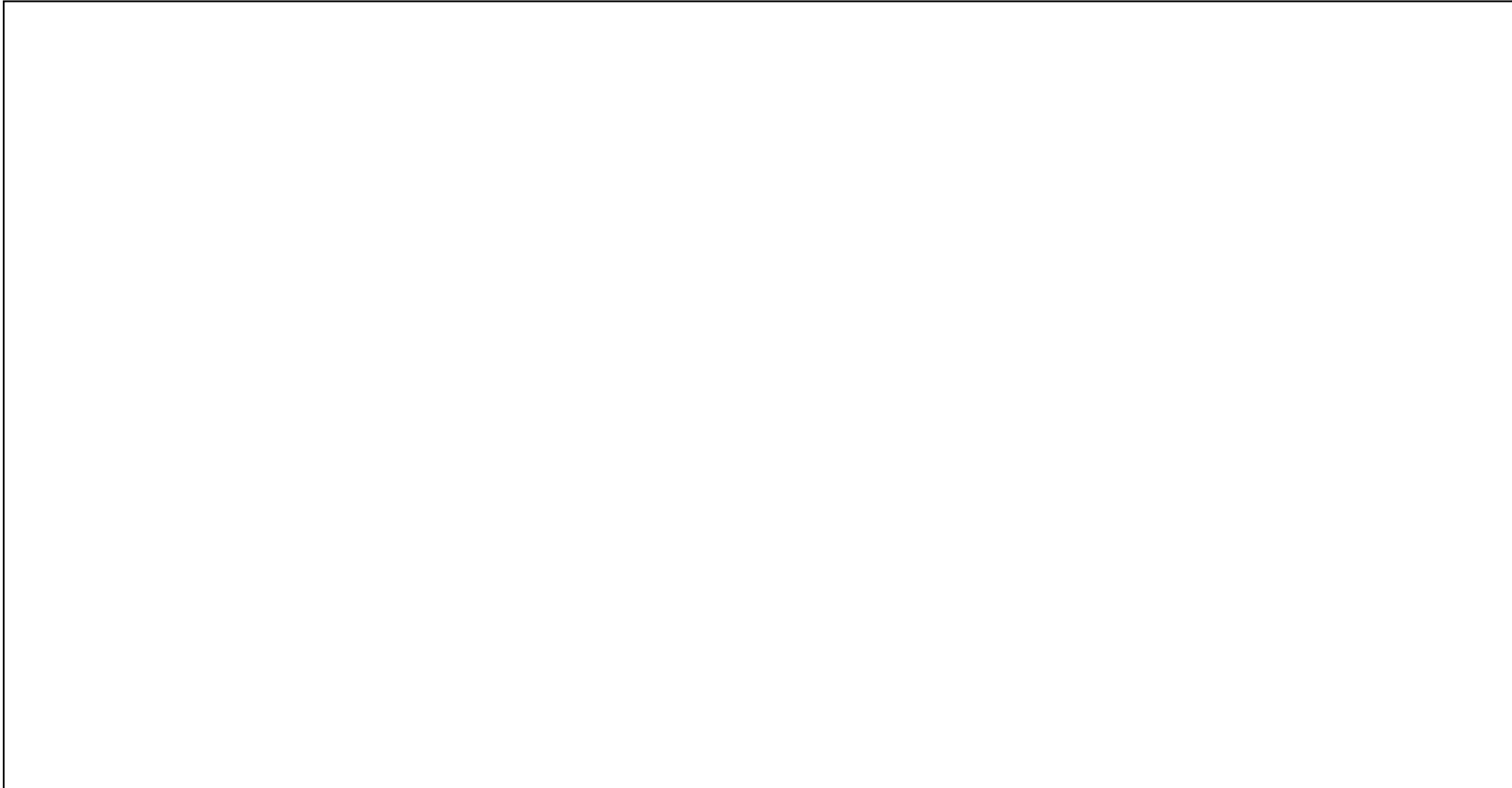
|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |



DD13 Engine Scuffing Test

**Form 22**  
**Torque Transition Plot**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |





## DD13 Engine Scuffing Test

### Form 23 Hardware

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Part                            | Part Number | Serial Number |
|---------------------------------|-------------|---------------|
| Uncoated Top Ring               |             |               |
| 2nd Ring                        |             |               |
| Oil Ring                        |             |               |
| Wrist Pin                       |             |               |
| Wrist Pin Retainer              |             |               |
| Connecting Rod                  |             |               |
| Connecting Rod Bearings - Upper |             |               |
| Connecting Rod Bearings - Lower |             |               |
| Main Bearing - Upper            |             |               |
| Main Bearing - Lower            |             |               |
| Carbon Scraper Ring             |             |               |
| Piston Cooling Nozzle           |             |               |
| Intake Rocker Arm               |             |               |
| Exhaust Rocker Arm - A          |             |               |
| Exhaust Rocker Arm - B          |             |               |
| Exhaust Rocker Arm - C          |             |               |
| Intake Camshaft                 |             |               |
| Exhaust Camshaft                |             |               |
| Oil Pump                        |             |               |
| Number of Runs on Oil Pump      |             |               |
| Engine Kit ID                   |             |               |

DD13 Engine Scuffing Test

**Form 24**  
**Supplemental Hardware Information**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Position | Upper Main Serial No. | Upper Main Date Code | Lower Main Serial No. | Lower Main Date Code |
|----------|-----------------------|----------------------|-----------------------|----------------------|
| 1        |                       |                      |                       |                      |
| 2        |                       |                      |                       |                      |
| 3        |                       |                      |                       |                      |
| 4        |                       |                      |                       |                      |
| 5        |                       |                      |                       |                      |
| 6        |                       |                      |                       |                      |
| 7        |                       |                      |                       |                      |

| Cylinder | Connecting Rod Serial No. | Upper Connecting Rod Bearing Serial No. | Upper Connecting Rod Bearing Date Code | Lower Connecting Rod Bearing Serial No. | Lower Connecting Rod Bearing Date Code |
|----------|---------------------------|---|--|---|--|
| 1        |                           |   |  |   |  |
| 2        |                           |   |  |   |  |
| 3        |                           |   |  |   |  |
| 4        |                           |   |  |   |  |
| 5        |                           |   |  |   |  |
| 6        |                           |   |  |   |  |

DD13 Engine Scuffing Test

**Form 25**  
**Supplemental Hardware - Continued**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Cylinder | Liner Serial No. | Liner Part No. | Liner Manufacture Date | Liner Semi-Finish Part No. | Liner Source | Liner Semi Finish Date |
|----------|------------------|----------------|------------------------|----------------------------|--------------|------------------------|
| 1        |                  |                |                        |                            |              |                        |
| 2        |                  |                |                        |                            |              |                        |
| 3        |                  |                |                        |                            |              |                        |
| 4        |                  |                |                        |                            |              |                        |
| 5        |                  |                |                        |                            |              |                        |
| 6        |                  |                |                        |                            |              |                        |

| Cylinder | Piston Serial No. | Piston Part No. | Piston Date Code | Piston Batch ID |
|----------|-------------------|-----------------|------------------|-----------------|
| 1        |                   |                 |                  |                 |
| 2        |                   |                 |                  |                 |
| 3        |                   |                 |                  |                 |
| 4        |                   |                 |                  |                 |
| 5        |                   |                 |                  |                 |
| 6        |                   |                 |                  |                 |

| Cylinder | Top Ring Batch ID |
|----------|-------------------|
| 1        |                   |
| 2        |                   |
| 3        |                   |
| 4        |                   |
| 5        |                   |
| 6        |                   |

DD13 Engine Scuffing Test

**Form 26**  
**Top Ring Measurements**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| <b>Top Ring</b> |               |                           |                        |
|-----------------|---------------|---------------------------|------------------------|
| Cylinder        | Serial Number | Ring Tension @ 132 mm (N) | Ring Gap @ 132 mm (mm) |
| 1               |               |                           |                        |
| 2               |               |                           |                        |
| 3               |               |                           |                        |
| 4               |               |                           |                        |
| 5               |               |                           |                        |
| 6               |               |                           |                        |

| <b>Top Ring</b>                         |   |                        |                         |   |   |   |   |  |
|---|---|------------------------|-------------------------|---|---|---|---|--|
|   |   | Cylinder               |                         |   |   |   |   |  |
|   |   | 1                      | 2                       | 3 | 4 | 5 | 6 |  |
| <b>1" Before Gap</b>                    | <b>Ring Face</b>                            | <b>Rpk (µm)</b>        |                         |   |   |   |   |  |
|   |   | <b>Rvk (µm)</b>        |                         |   |   |   |   |  |
|   |   | <b>Rz (µm)</b>         |                         |   |   |   |   |  |
|   |   | <b>Ra (µm)</b>         |                         |   |   |   |   |  |
|   |   | <b>Rk (µm)</b>         |                         |   |   |   |   |  |
|   |   | <b>Rmr1 (%)</b>        |                         |   |   |   |   |  |
|   |   | <b>Rmr2 (%)</b>        |                         |   |   |   |   |  |
|   |   | <b>Vo ((µm*µm)/µm)</b> |                         |   |   |   |   |  |
|   |   | <b>Width (mm)</b>      |                         |   |   |   |   |  |
|   |   | <b>Peak Height</b>     | <b>Peak Height (µm)</b> |   |   |   |   |  |
|   | <b>Location (mm)</b>                        |                        |                         |   |   |   |   |  |
|   | <b>To 0.2 mm Diff (µm)</b>                  |                        |                         |   |   |   |   |  |
|   | <b>To 2.75 mm Diff (µm)</b>                 |                        |                         |   |   |   |   |  |
|   | <b>Back of Ring width (Top-Bottom) (mm)</b> |                        |                         |   |   |   |   |  |
| <b>Ring Thickness (Front-Rear) (mm)</b> |   |                        |                         |   |   |   |   |  |

DD13 Engine Scuffing Test

**Form 27**  
**Top Ring Measurements –Continued**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

|                                      |             | Top Ring             |   |   |   |   |   |
|--------------------------------------|-------------|----------------------|---|---|---|---|---|
|                                      |             | Cylinder             |   |   |   |   |   |
|                                      |             | 1                    | 2 | 3 | 4 | 5 | 6 |
| 180° From Gap                        | Ring Face   | Rpk (µm)             |   |   |   |   |   |
|                                      |             | Rvk (µm)             |   |   |   |   |   |
|                                      |             | Rz (µm)              |   |   |   |   |   |
|                                      |             | Ra (µm)              |   |   |   |   |   |
|                                      |             | Rk (µm)              |   |   |   |   |   |
|                                      |             | Rmr1 (%)             |   |   |   |   |   |
|                                      |             | Rmr2 (%)             |   |   |   |   |   |
|                                      |             | Vo ((µm*µm)/µm)      |   |   |   |   |   |
|                                      |             | Width (mm)           |   |   |   |   |   |
|                                      | Peak Height | Peak Height (µm)     |   |   |   |   |   |
|                                      |             | Location (mm)        |   |   |   |   |   |
|                                      |             | To 0.2 mm Diff (µm)  |   |   |   |   |   |
|                                      |             | To 2.75 mm Diff (µm) |   |   |   |   |   |
| Back of Ring width (Top-Bottom) (mm) |             |                      |   |   |   |   |   |
| Ring Thickness (Front-Rear) (mm)     |             |                      |   |   |   |   |   |

|                                      |             | Top Ring             |   |   |   |   |   |
|--------------------------------------|-------------|----------------------|---|---|---|---|---|
|                                      |             | Cylinder             |   |   |   |   |   |
|                                      |             | 1                    | 2 | 3 | 4 | 5 | 6 |
| 1" After Gap                         | Ring Face   | Rpk (µm)             |   |   |   |   |   |
|                                      |             | Rvk (µm)             |   |   |   |   |   |
|                                      |             | Rz (µm)              |   |   |   |   |   |
|                                      |             | Ra (µm)              |   |   |   |   |   |
|                                      |             | Rk (µm)              |   |   |   |   |   |
|                                      |             | Rmr1 (%)             |   |   |   |   |   |
|                                      |             | Rmr2 (%)             |   |   |   |   |   |
|                                      |             | Vo ((µm*µm)/µm)      |   |   |   |   |   |
|                                      |             | Width (mm)           |   |   |   |   |   |
|                                      | Peak Height | Peak Height (µm)     |   |   |   |   |   |
|                                      |             | Location (mm)        |   |   |   |   |   |
|                                      |             | To 0.2 mm Diff (µm)  |   |   |   |   |   |
|                                      |             | To 2.75 mm Diff (µm) |   |   |   |   |   |
| Back of Ring width (Top-Bottom) (mm) |             |                      |   |   |   |   |   |
| Ring Thickness (Front-Rear) (mm)     |             |                      |   |   |   |   |   |

DD13 Engine Scuffing Test

**Form 28**  
**2<sup>nd</sup> Ring Measurements**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| <b>2<sup>nd</sup> Ring</b> |               |                           |                        |
|----------------------------|---------------|---------------------------|------------------------|
| Cylinder                   | Serial Number | Ring Tension @ 132 mm (N) | Ring Gap @ 132 mm (mm) |
| 1                          |               |                           |                        |
| 2                          |               |                           |                        |
| 3                          |               |                           |                        |
| 4                          |               |                           |                        |
| 5                          |               |                           |                        |
| 6                          |               |                           |                        |

| <b>2<sup>nd</sup> Ring</b> |                                |          |   |   |   |   |   |
|----------------------------|--------------------------------|----------|---|---|---|---|---|
|                            |                                | Cylinder |   |   |   |   |   |
|                            |                                | 1        | 2 | 3 | 4 | 5 | 6 |
| <b>1" Before Gap</b>       | <b>Face Width (mm)</b>         |          |   |   |   |   |   |
|                            | <b>Witness Line Width (mm)</b> |          |   |   |   |   |   |
|                            | <b>Base Angle (°)</b>          |          |   |   |   |   |   |
| <b>180° From Gap</b>       | <b>Face Width (mm)</b>         |          |   |   |   |   |   |
|                            | <b>Witness Line Width (mm)</b> |          |   |   |   |   |   |
|                            | <b>Base Angle (°)</b>          |          |   |   |   |   |   |
| <b>1" After Gap</b>        | <b>Face Width (mm)</b>         |          |   |   |   |   |   |
|                            | <b>Witness Line Width (mm)</b> |          |   |   |   |   |   |
|                            | <b>Base Angle (°)</b>          |          |   |   |   |   |   |

DD13 Engine Scuffing Test

**Form 29**  
**Oil Ring Measurements**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| <b>Oil Ring</b> |               |                           |                        |
|-----------------|---------------|---------------------------|------------------------|
| Cylinder        | Serial Number | Ring Tension @ 132 mm (N) | Ring Gap @ 132 mm (mm) |
| 1               |               |                           |                        |
| 2               |               |                           |                        |
| 3               |               |                           |                        |
| 4               |               |                           |                        |
| 5               |               |                           |                        |
| 6               |               |                           |                        |

| <b>Oil Ring</b>      |                                      |          |   |   |   |   |   |
|----------------------|--------------------------------------|----------|---|---|---|---|---|
|                      |                                      | Cylinder |   |   |   |   |   |
|                      |                                      | 1        | 2 | 3 | 4 | 5 | 6 |
| <b>1" Before Gap</b> | <b>Gap Between Rails (mm)</b>        |          |   |   |   |   |   |
|                      | <b>Ring Width (mm)</b>               |          |   |   |   |   |   |
|                      | <b>Top Rail Width (mm)</b>           |          |   |   |   |   |   |
|                      | <b>Bottom Rail Width (mm)</b>        |          |   |   |   |   |   |
|                      | <b>Rail Height Differential (µm)</b> |          |   |   |   |   |   |
| <b>180° From Gap</b> | <b>Gap Between Rails (mm)</b>        |          |   |   |   |   |   |
|                      | <b>Ring Width (mm)</b>               |          |   |   |   |   |   |
|                      | <b>Top Rail Width (mm)</b>           |          |   |   |   |   |   |
|                      | <b>Bottom Rail Width (mm)</b>        |          |   |   |   |   |   |
|                      | <b>Rail Height Differential (µm)</b> |          |   |   |   |   |   |
| <b>1" After Gap</b>  | <b>Gap Between Rails (mm)</b>        |          |   |   |   |   |   |
|                      | <b>Ring Width (mm)</b>               |          |   |   |   |   |   |
|                      | <b>Top Rail Width (mm)</b>           |          |   |   |   |   |   |
|                      | <b>Bottom Rail Width (mm)</b>        |          |   |   |   |   |   |
|                      | <b>Rail Height Differential (µm)</b> |          |   |   |   |   |   |

DD13 Engine Scuffing Test

**Form 30**  
**Liner and Piston Cooling Jet Measurements**

|                         |              |           |
|-------------------------|--------------|-----------|
| Laboratory:             | EOT Date:    | EOT Time: |
| Test Number:            | Test Length: |           |
| Oil Code:               |              |           |
| Formulation Stand Code: |              |           |

| Liner    |               |
|----------|---------------|
| Cylinder | Serial Number |
| 1        |               |
| 2        |               |
| 3        |               |
| 4        |               |
| 5        |               |
| 6        |               |

|   |                 | Liner    |   |   |   |   |   |
|---|-----------------|----------|---|---|---|---|---|
|   |                 | Cylinder |   |   |   |   |   |
|   |                 | 1        | 2 | 3 | 4 | 5 | 6 |
| Average of Surface Traces at 0°, 90°, 180° and 270° | Ra (µm)         |          |   |   |   |   |   |
|   | Rk (µm)         |          |   |   |   |   |   |
|   | Rmr1 (%)        |          |   |   |   |   |   |
|   | Rmr2 (%)        |          |   |   |   |   |   |
|   | Rpk (µm)        |          |   |   |   |   |   |
|   | Rvk (µm)        |          |   |   |   |   |   |
|   | Vo ((µm*µm)/µm) |          |   |   |   |   |   |
| Crosshatch Angle (°)                                |                 |          |   |   |   |   |   |

| P-Tube   |               |
|----------|---------------|
| Cylinder | Serial Number |
| 1        |               |
| 2        |               |
| 3        |               |
| 4        |               |
| 5        |               |
| 6        |               |

|                    |  | P-Tube   |   |   |   |   |   |
|--------------------|--|----------|---|---|---|---|---|
|                    |  | Cylinder |   |   |   |   |   |
|                    |  | 1        | 2 | 3 | 4 | 5 | 6 |
| Hole Diameter (mm) |  |          |   |   |   |   |   |







DD13 Engine Scuffing Test

**Form 33**  
**Test Fuel Analysis (Last Batch)**

|                         |                |           |
|-------------------------|----------------|-----------|
| Laboratory:             | EOT Date:      | EOT Time: |
| Test Number:            | Test Length:   |           |
| Oil Code:               |                |           |
| Formulation Stand Code: |                |           |
| Fuel Supplier:          | Fuel Batch ID: |           |

| Measurement                     | Specs.  | Analysis |     | Test Method |
|---------------------------------|---------|----------|-----|-------------|
|                                 |         | New      | EOT |             |
| Total Sulfur <sup>^</sup> , ppm | 7 - 15  |          |     | D 5453      |
| Gravity <sup>^</sup> , °API     | 34 - 37 |          |     | D 4052      |

<sup>^</sup> Measurements are stand samples.