

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 for Stage 1 | Set Point for Stage 2 |
|---|--------------------------|---------------------------|
| Time, h | 30 | 170 standard ^A |
| Controlled Quantities, units | | |
| 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 |
| Ranged Quantities^C, units | | |
| 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 ^A |
| SAE Viscosity | Number of Tests Since Last Calibration ^C |

| 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 ^B | |
| 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 ^B | |
|---|----------------|
| 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 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 nd 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: | | |

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

| Top Ring | | | | | | | |
|---|---|------------------------|-------------------------|---|---|---|---|
| | | Cylinder | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1" Before 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 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
2nd Ring Measurements

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

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

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

DD13 Engine Scuffing Test

Form 29
Oil Ring Measurements

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

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

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

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 [^] , ppm | 7 - 15 | | | D 5453 |
| Gravity [^] , °API | 34 - 37 | | | D 4052 |

[^] Measurements are stand samples.