

# 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

### **Form 2** **Table of Contents**

1.	Title / Validity Declaration Page	Form 1
2.	Table of Contents	Form 2
3.	Summary of Test Method	Form 3
4.	Test Results Summary	Form 4
5.	Operational Summary - Controlled Parameters	Form 5
6.	Operational Summary - Uncontrolled Parameters	Form 6
7.	Cylinder Scuffing Summary	Form 7
8.	Top Ring Scuffing Summary	Form 8
9.	2nd Ring Scuffing Summary	Form 9
10.	Oil Ring Scuffing Summary	Form 10
11.	Piston Top Groove Rating Summary	Form 11
12.	Ring Weight Measurements	Form 12
13.	Ring Gap Measurements	Form 13
14.	Used Oil Analysis Results	Form 14
15.	ICP Metals Analysis	Form 15
16.	ICP Metals Analysis - Continued	Form 15A
17.	ICP Metals Analysis – Continued	Form 15B
18.	Crankcase Pressure Plot	Form 16
19.	Blow-By Flow Plot	Form 17
20.	Intake Manifold Pressure Transition Plot	Form 18
21.	Intake Manifold Temperature Transition Plot	Form 19
22.	Oil Gallery Temperature Transition Plot	Form 20
23.	Coolant Jacket Temperature Transition Plot	Form 21
24.	Torque Transition Plot	Form 22
25.	Hardware	Form 23
26.	Supplemental Hardware	Form 24
27.	Supplemental Hardware - Continued	Form 25
28.	Top Ring Measurements	Form 26
29.	Top Ring Measurements – Continued	Form 27
30.	2 <sup>nd</sup> Ring Measurements	Form 28
31.	Oil Ring Measurements	Form 29
32.	Liner and Piston Cooling Jet Measurements	Form 30
33.	Downtime & Maintenance Summary	Form 31
34.	Test Comments	Form 32
35.	Test Fuel Analysis (Last Batch)	Form 33

## 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 <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 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
<b>HC</b>	Area						
	Demerit						
<b>MC</b>	Area						
	Demerit						
<b>LC</b>	Area						
	Demerit						
<b>Total</b>	Area						
	Demerit						

<b>TGF %</b>						
--------------	--	--	--	--	--	--

<b>Additional Piston Top Groove Deposit and Condition Ratings</b>	
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**

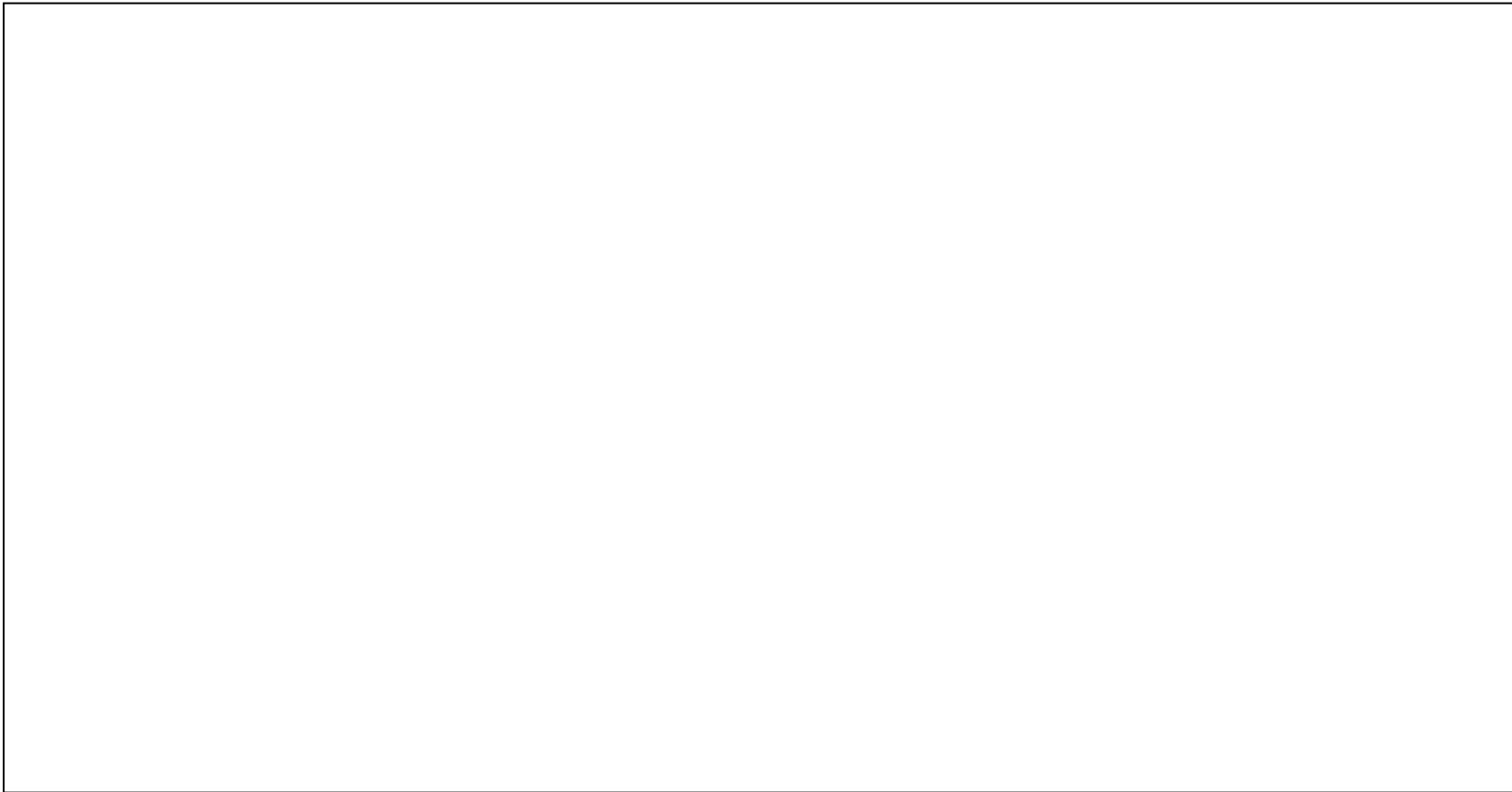
Laboratory:	EOT Date:	EOT Time:
Test Number:	Test Length:	
Oil Code:		
Formulation Stand Code:		



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.