

**MACK T-9  
RING/LINER WEAR TEST**

REPORT PACKET VERSION NO.  
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.

STAND:	STAND RUN NO.:	ENGINE NO.:	ENGINE HOURS:
END OF TEST DATE:		END OF TEST TIME:	
OIL CODE/CMIR <sup>A</sup> :			
FORMULATION/STAND CODE:			
ALTCODE1:	ALTCODE2:	ALTCODE3:	

In my opinion this test \_\_\_\_\_ been conducted in a valid manner in accordance with Test Method Dxxxx and the appropriate amendments through the information letter system. The remarks included in this report describe the anomalies associated with this test.

<sup>A</sup> CMIR or Non-Reference Oil Code

**SUBMITTED BY:**

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

\_\_\_\_\_ Signature

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

\_\_\_\_\_ Title

**MACK T-9  
RING/LINER WEAR TEST  
FORM 1 - NON-REFERENCE OIL TEST SUMMARY**

FORMULATION/STAND CODE				TEST LENGTH
OIL CODE NO.				
TEST LAB	TEST STAND NO.	TEST STAND RUN NO.	ENGINE BLOCK SERIAL NO.	ENGINE HOURS
DATE TEST STARTED:				
START TIME:				
DATE TEST COMPLETED:				
EOT TIME:				
STAND CALIBRATION EXPIRATION DATE:				
LABORATORY OIL CODE				
SAE VISCOSITY				

AVERAGE TGA SOOT % AT 75 h	
AVERAGE TGA SOOT % 75 – 500 h	
AVERAGE OIL CONSUMPTION (0.304 g/Kw-h max.)	
CENTRIFUGAL OIL FILTER MASS GAIN, g	
OIL FILTER DELTA P, kPa (138 max.)	
EOT TBN	

	DELTA Pb @ EOT (ppm)	ADJUSTED AVG. LINER WEAR (µm)	AVG. TOP RING WEIGHT LOSS (mg)
ORIGINAL RESULT			
TRANSFORMED RESULT A			
CORRECTION FACTOR A			
CORRECTED TRANSFORMED RESULT A			
SEVERITY ADJUSTMENT A			
FINAL TRANSFORMED RESULT A			
FINAL ORIGINAL UNIT RESULT			

<sup>A</sup> Delta Pb Value in Transformed Units

FIG 1.2 – NON-REFERENCE OIL TEST SUMMARY

**MACK T-9  
RING/LINER WEAR TEST  
FORM 1A - REFERENCE OIL TEST SUMMARY**

CMIR CODE NO.			TEST LENGTH	
TMC OIL NO.				
TEST LAB	TEST STAND NO.	TEST STAND RUN NO.	ENGINE BLOCK SERIAL NO.	ENGINE HOURS
DATE TEST STARTED:				
START TIME:				
DATE TEST COMPLETED:				
EOT TIME:				
STAND CALIBRATION EXPIRATION DATE:				
LABORATORY OIL CODE				
SAE VISCOSITY				

AVERAGE TGA SOOT % AT 75 h	
AVERAGE TGA SOOT % 75 – 500 h	
AVERAGE OIL CONSUMPTION (0.304 g/Kw-h max.)	
CENTRIFUGAL OIL FILTER MASS GAIN, g	
OIL FILTER DELTA P, kPa (138 max.)	
EOT TBN	

	DELTA Pb @ EOT (ppm)	ADJUSTED AVG. LINER WEAR (µm)	AVG. TOP RING WEIGHT LOSS (mg)
ORIGINAL RESULT			
TRANSFORMED RESULT <sup>A</sup>			
CORRECTION FACTOR <sup>A</sup>			
FINAL TRANSFORMED RESULT <sup>A</sup>			
FINAL ORIGINAL UNIT RESULT			

<sup>A</sup> Delta Pb Value in Transformed Units

FIG 1.3 – REFERENCE OIL TEST SUMMARY

**MACK T-9  
RING/LINER WEAR TEST  
Operational Summary  
FORM 2**

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

Controlled Parameters	Parameter	Units	QI Threshold	EOT QI <sup>A</sup>	Target	Average	Samples <sup>B</sup>	BQD <sup>C</sup>	Over/Under Range <sup>D</sup>
	Speed	r/min	0.000		1800	1250			
Fuel Flow	kg/h	0.000		63.28	55.00				
Coolant Out	°C	0.000			85				
Fuel In	°C	0.000			40				
Oil Gallery	°C	0.000			25				
Intake Manifold	°C	0.000			43				
Exhaust	kPa	0.000			3.1				
Inlet Air Res.	KPa	0.000			2.5				
Non-controlled Parameters	Parameter	Units	Typical Values <sup>E</sup>		Average				
	Torque	N-m	1361 - 1457	2118 - 2208					
	Power	kW	258 - 267	280 - 288					
	Humidity	g/kg	4.2 - 78.6						
	Blowby	L/min	41.2 - 184.3	23.6 - 148.7					
	Coolant In	°C	76 - 82						
	Oil Gallery	°C	101 - 109						
	Pre-Turb. (F)	°C	605 - 658						
	Pre-Turb. (R)	°C	613 - 674						
	Tailpipe	°C	428 - 474	514 - 559					
	Oil Gallery	kPa	365 - 436	227-284					
	Crankcase	kPa	0.27 - 0.60						
	Intake Manifold	kPa	185 - 201	149 - 164					
Compressor Discharge	kPa	193 - 205	152 - 159						
Intercooler Delta	kPa	13.6 Maximum							

<sup>A</sup> QI values above the threshold are acceptable by the Mack Surveillance Panel. QI values below the threshold may not be considered acceptable based on an engineering review. Refer to Annex A5

<sup>B</sup> Total number of data points taken. Minimum acceptable value is 3000

<sup>C</sup> Number of Bad Quality Data points not used in the calculation of the statistical measures.

<sup>D</sup> Number of points clipped by over/under range limits.

<sup>E</sup> Typical values determined from reference oil test database

**MACK T-9  
RING/LINER WEAR TEST  
Rod Bearing Weight Loss  
Form 3**

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

Cylinder #	Location	SOT Weight, g	EOT Weight, g	Weight Change, mg
1	Upper			
2	Upper			
3	Upper			
4	Upper			
5	Upper			
6	Upper			

SUMMARY	As Measured	Outlier Screened
Upper Bearing Average Weight Loss, mg		
Upper Bearing Weight Loss Std. Dev., mg		
Upper Bearing Minimum Weight Loss, mg		
Upper Bearing Maximum Weight Loss, mg		
Outlier Upper Rod Bearing <sup>A</sup>		

<sup>A</sup> Cylinder number

Cylinder #	Location	SOT Weight, g	EOT Weight, g	Weight Change, mg
1	Lower			
2	Lower			
3	Lower			
4	Lower			
5	Lower			
6	Lower			
Upper Bearing Average Weight Loss, mg				
Upper Bearing Weight Loss Std. Dev., mg				
Upper Bearing Minimum Weight Loss, mg				
Upper Bearing Maximum Weight Loss, mg				

FIG A1.5 – Rod Bearing Weight Loss

**MACK T-9  
RING/LINER WEAR TEST  
Ring Weight Loss  
Form 4**

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

Cylinder #	Top Ring SOT Weight, g	Top Ring EOT Weight, g	Weight Loss, mg
1			
2			
3			
4			
5			
6			

SUMMARY	As Measured	Outlier Screened
Upper Bearing Average Weight Loss, mg		
Upper Bearing Weight Loss Std. Dev., mg		
Upper Bearing Minimum Weight Loss, mg		
Upper Bearing Maximum Weight Loss, mg		
Outlier Ring <sup>B</sup>		
Top Rings with Plasma Flaking <sup>C</sup>		

- <sup>A</sup> Results calculated without rings with plasma flanking.  
<sup>B</sup> Ring number wear results are not currently outlier screened.  
<sup>C</sup> Ring numbers: 1,2, etc. separated by commas. Example: 2,3,5

Cylinder #	2nd Ring SOT Weight, g	2 <sup>nd</sup> Ring EOT Weight, g	Weight Loss, mg
1			
2			
3			
4			
5			
6			
			2 <sup>nd</sup> Ring Average Weight Loss, mg
			2 <sup>nd</sup> Ring Weight Loss Std. Dev., mg
			2 <sup>nd</sup> Ring Min. Weight Loss, mg
			2 <sup>nd</sup> Ring Max. Weight Loss, mg

Cylinder #	2nd Ring SOT Weight, g	2nd Ring EOT Weight, g	Weight Loss, mg
1			
2			
3			
4			
5			
6			
			Oil Ring Average Weight Loss, mg
			Oil Ring Weight Loss Std. Dev., mg
			Oil Ring Minimum Weight Loss, mg
			Oil Ring Maximum Weight Loss, mg

FIG A1.6 – Ring Weight Loss

# MACK T-9 RING/LINER WEAR TEST Oil Analysis Summary Form 5

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

HOURS	SOOT Wt.% TGA	Viscosity At 100°C cSt	Viscosity Increase cSt	TBN Annex A7	TBN D2896	TAN Annex A8	Metals in Parts per Millions							
							Elements							
							Fe	Pb	Cu	Cr	Al	Si	Sn	Na
75 AVG														

Summary	As Measured	Outlier Bearing Adjusted
Delta Pb @ EOT, ppm		

FIG A1.7 – Oil Analysis Summary

**MACK T-9**  
**RING/LINER WEAR TEST**  
**Liner Surface Roughness & Bore Diameter**  
**Form 6**

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

LINER NO.	LOCATION	Ra (µm)	BORE DIAMETER (mm)		Ra (µm)	DIA. (mm)
1	Top Ring Travel @ 0°C			AVG		
	Top Ring Travel @ 90°C			STD DEV		
	Top Ring Travel @ 180°C			MIN		
	Top Ring Travel @ 270°C			MAX		

2	Top Ring Travel @ 0°C			AVG		
	Top Ring Travel @ 90°C			STD DEV		
	Top Ring Travel @ 180°C			MIN		
	Top Ring Travel @ 270°C			MAX		

3	Top Ring Travel @ 0°C			AVG		
	Top Ring Travel @ 90°C			STD DEV		
	Top Ring Travel @ 180°C			MIN		
	Top Ring Travel @ 270°C			MAX		

4	Top Ring Travel @ 0°C			AVG		
	Top Ring Travel @ 90°C			STD DEV		
	Top Ring Travel @ 180°C			MIN		
	Top Ring Travel @ 270°C			MAX		

5	Top Ring Travel @ 0°C			AVG		
	Top Ring Travel @ 90°C			STD DEV		
	Top Ring Travel @ 180°C			MIN		
	Top Ring Travel @ 270°C			MAX		

6	Top Ring Travel @ 0°C			AVG		
	Top Ring Travel @ 90°C			STD DEV		
	Top Ring Travel @ 180°C			MIN		
	Top Ring Travel @ 270°C			MAX		

	Ra (µm)	BORE DIAMETER (mm)
Average Surface Roughness & Bore Diameter		
Standard Deviation Surface Roughness & Bore Diameter		
Minimum Surface Roughness & Bore Diameter		
Maximum Surface Roughness & Bore Diameter		



**MACK T-9  
RING/LINER WEAR TEST  
Liner Wear Summary  
Form 7**

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

POSITION	WEAR STEP (µm)					
	Cylinder Number					
	1	2	3	4	5	6
1:00						
2:00						
3:00 (Thrust)						
4:00						
5:00						
6:00 (Rear)						
7:00						
8:00						
9:00 (Anti-Thrust)						
10:00						
11:00						
12:00 (Front)						
Average						

Summary	As Measured	Outlier Screened	Adjusted to 1.75% Soot
Average, µm			
Std. Dev., µm			
Minimum, µm			
Maximum, µm			
Ring Flaked Outliers <sup>B</sup>			
Outlier Liners <sup>C</sup>			

<sup>A</sup> Do not use data from liners with top ring plasma flaking for determining "As Measured" result.

<sup>B</sup> Cylinder Number: 1,2, etc. separated by commas. Example: 2,3

<sup>C</sup> Cylinder Number.

FIG A1.9 – Liner Wear Summary



**MACK T-9**  
**RING/LINER WEAR TEST**  
**Unscheduled Downtime & Maintenance Summary**  
**Form 8A**

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

Number of Downtime Occurrences			
Test Hours	Date	Downtime	Reasons
			Total Downtime (hours)

Other Comments		
Number of Comment Lines		

FIG A1.10A – Unscheduled Downtime and Maintenance Summary

**MACK T-9  
RING/LINER WEAR TEST  
Unscheduled Downtime & Maintenance Summary  
Form 8B**

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

Number of Downtime Occurrences			
Test Hours	Date	Downtime	Reasons
Total Downtime (hours)			

Other Comments	
Number of Comment Lines	

FIG A1.10B – Unscheduled Downtime and Maintenance Summary

**MACK T-9**  
**RING/LINER WEAR TEST**  
**Test Fuel Analysis (Last Batch)**  
**Form 9**

Laboratory:	EOT Date:	EOT Time:
Test Number:	Oil Code:	
Formulation/Stand Code:		
Supplier:	Batch Identifiers:	

Measurement	Specs.	Analysis		Test Method
		NEW	EOT	
Total Sulfur, % Weight	0.03 – 0.05			D 2622
Gravity, °API	32 – 36			D 287 or D 4052
<b>Hydrocarbon Composition</b>				
Aromatics % Vol.	28 – 35			D 1319
Olefin	Report			D 1319
Saturates	Report			D 1319
Cetane Index	Report			D 976 & D 4737
Cetane No.	42 – 48			D 613
Copper Strip Corrosion	1 Maximum			D 130
Flash Point, °C	54 Minimum			D 93
Cloud Point, °C	-12 Maximum			D 2500
Pour Point, °C	-18 Maximum			D 97
Carbon Residue on 10% Residuum, %	0.35 Maximum			D 524 (10% Bottoms)
Water & Sediment, % Vol.	0.05 Maximum			D 2709
Ash, % Wgt.	0.01 Maximum			D 482
Viscosity, cSt @ 40°C	2.0 – 3.2			D 445
<b>Distillation, °C</b>				
IBP	177-199			D 86
10%	210-232			D 86
50%	249-277			D 86
90%	299-327			D 86
EP	327-360			D 86

**MACK T-9**  
**RING/LINER WEAR TEST**  
**Characteristics of the Data Acquisition System**  
**Form 10**

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

PARAMETER (1)	SENSING DEVICE (2)	CALIBRATION FREQUENCY (3)	RECORD DEVICE (4)	OBSERVATION FREQUENCY (5)	RECORD FREQUENCY (6)	LOG FREQUENCY (7)	SYSTEM RESPONSE (8)
<b>Temperatures</b>							
Oil @ Filt.							
Fuel In.							
Intake Air							
Intake Man.							
Pre-Turb.							
Cool. Out							
<b>Other</b>							
Fuel Flow							
Engine RPM							
Load							
Inlet Restr.							
Exh. Press.							
Oil Gal. Press.							

**LEGEND:**

- (1) Operating Parameter
- (2) The type of device used to measure temperature, pressure or flow
- (3) Frequency at which the measurement system is calibrated
- (4) The type of device where data is recorded  
 LG - Handlog Sheet  
 DL - Automatic Data Logger  
 SC - Strip Chart Recorder  
 C/M - Computer, Using Manual Data Entry  
 C/D - Computer, Using Direct I/O Entry
- (5) Data are observed but only if recorded off spec.
- (6) Data are recorded but are not retained at EOT
- (7) Data are logged as permanent record, note specify if:  
 SS - Snapshot Taken at Specified Frequency  
 AG/X - Average of X Data Points at Specified Frequency
- (8) Time for the output to reach 63.2% of final value for step change at input

FIG A1.12 - Characteristics of the Data Acquisition System

**MACK T-9  
RING/LINER WEAR TEST  
Build-up and Hardware Information  
Form 11**

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

**STATIC INJECTION TIMING**

Timing Hours	Timing (Deg)
	Total Timing Changes

**HARDWARE**

Part	Part Number	Serial Number
Injection Pump		
Secondary Charger		
Cylinder Head (front)		
Cylinder Head (rear)		
Pistons		
Injection Nozzles		
Rod Bearings		
Liners		
Ring Set		

Cylinder Kit Location	CPD ID Number
Cylinder 1	
Cylinder 2	
Cylinder 3	
Cylinder 4	
Cylinder 5	
Cylinder 6	

FIG A1.13 - Build-up and Hardware Information

**MACK T-9  
RING/LINER WEAR TEST  
Build-up and Hardware Information  
Form 11A**

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

**STATIC INJECTION TIMING**

Timing Hours	Timing (Deg)
Total Timing Changes	

**HARDWARE**

Part	Part Number	Serial Number
Injection Pump		
Secondary Charger		
Cylinder Head (front)		
Cylinder Head (rear)		
Pistons		
Injection Nozzles		
Rod Bearings		
Liners		
Ring Set		

Cylinder Kit Location	CPD ID Number
Cylinder 1	
Cylinder 2	
Cylinder 3	
Cylinder 4	
Cylinder 5	
Cylinder 6	

FIG A1.13A - Build-up and Hardware Information



