

**Mack T-10
EGR Engine Oil Test**

Report Packet Version No.

Conducted For

T-10:	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.
T-10A:	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

Stand:	Stand Run:	Engine:	Engine Hours:
End Of Test Date:		End Of Test Time:	
Oil Code:			
Formulation/Stand Code:			
Alternate Codes			

<p>In my opinion this test _____ been conducted in a valid manner in accordance with the Test Method Dxxx and the appropriate amendments through the information letter system. The remarks included in this report describe the anomalies associated with this test.</p>
--

Submitted By: _____

_____ **Testing Laboratory**

_____ **Signature**

_____ **Typed Name**

_____ **Title**

**Mack T-10
EGR Engine Oil Test
Form 2**

Table of Contents

1.	Final Report Cover Sheet	Form 1
2.	Table of Contents	Form 2
3.	Summary of Test Method	Form 3
4.	Test Results Summary	Form 4
5.	Operational Summary	Form 5
6.	Test Results Summary	Form 6
7.	Ring Weight Loss	Form 7
8.	Oil Analysis Summary	Form 8
9.	Liner Surface Roughness & Bore Diameter	Form 9
10.	Liner Wear Summary	Form 10
11.	Unscheduled Downtime & Maintenance Summary	Form 11
12.	Test Fuel Analysis (Last Batch)	Form 12
13.	Characteristics of the Data Acquisition System	Form 13
14.	Build-up and Hardware Information	Form 14
15.	Rating Summary: Piston 1	Form 15
16.	Rating Summary: Piston 2	Form 16
17.	Rating Summary: Piston 3	Form 17
18.	Rating Summary: Piston 4	Form 18
19.	Rating Summary: Piston 5	Form 19
20.	Rating Summary: Piston 6	Form 20

**Mack T-10
EGR Engine Oil Test
Form 3**

The Mack T-10 EGR Engine Oil Test is a fuel engine-dynamometer test which evaluates the ability of a lubricant to minimize piston ring wear, cylinder liner wear, lead corrosion, oil consumption, and oxidation. This test is a two-phase, steady state test (constant speed and load). The first phase is 75 h and is run with retarded fuel injection timing to produce elevated soot levels in the oil. The second phase is 225 h and is run under heavy load conditions to induce piston ring and cylinder liner wear.

The test engine is a Mack E-TECH V-MAC III diesel engine with EGR. It is an in-line six-cylinder, four stroke, turbocharged engine. It has electronically controlled fuel injection with six individual electronic pumps. A one h break-in is conducted prior to each test since a new engine build is used for each test.

Mack T-10 Test Conditions

Parameter	Phase I	Phase II
Time, h	75	225
Injection Timing, °BTDC	Variable	18
Speed, r/min	1800	1200
Fuel Flow, kg/h	59.2	63.5
Exhaust O ₂ Level, %	Record	Record
Intake CO ₂ , %	1.5	0.2
Exhaust CO ₂ , %	Record	Record
Inlet Manifold Temp., °C	70	66
Coolant Out Temp., °C	66	85
Fuel In Temp., °C	40	40
Oil Gallery Temp., °C	88	113
Intake Air Temp., °C	25	25
Intake Air Restriction, kPa	3.5 – 4.0	3.5 – 4.0
Inlet Manifold Pressure, kPa	tbd	tbd
Exhaust Back Pressure, kPa	2.7 – 3.5	2.7 – 3.5
Crankcase Pressure, kPa	0.25 – 0.75	0.25 – 0.75
Power, kW	~257	~324
Torque, Nm	Record	Record
Pre-Turbine Exhaust Temp., °C	Record	Record
Tailpipe Exhaust Temp., °C	Record	Record
Oil Sump Temp., °C	Record	Record
EGR Pre-Venturi Temp., °C	Record	Record
Inlet Air Dew Point, °C	Record	Record
Inlet Air Humidity, kg/kg	Record	Record
Main Gallery Oil Pressure, kPa	Record	Record
Oil Filter Delta P, kPa	Not to exceed 138	Not to exceed 138

**Mack T-10
EGR Engine Oil Test
Form 4
Test Results Summary**

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

Test Results						
Date Test Started:		Start Time:			Test Length:	
TMC Oil Code: ^A		Laboratory Oil Code:			SAE Viscosity:	
Average TGA Soot % at 75 h						
Centrifugal Oil Filter Mass Gain, g						
Oil Filter Delta P, kPa (138 maximum)						
EOT TBN						
MRV Yield Stress (Pa) ^C						
	Delta Pb@ EOT (ppm)	Avg Liner Wear (µm)	Avg Top Ring Weight Loss (mg)	Oil Consumption (g/h)	Delta Pb 250-300h (ppm)	MRV^C Viscosity @75h (cP)
Original Result						
Transformed Result ^B						
Correction Factor ^B						
Corrected Transformed Result ^B						
Severity Adjustment ^B						
Final Transformed Result ^B						
Final Original Unit Result ^B						
Mack Merits ^D						
Total Mack Merits ^D						

Last Stand Reference Results						
Test Number:						
Oil Code:						
Test Length:				TMC Oil Code:		
EOT Date:				EOT Time:		
Stand Calibration Expiration Date:						
Average TGA Soot % at 75 h						
	Delta Pb@ EOT (ppm)	Avg Liner Wear (µm)	Avg Top Ring Weight Loss (mg)	Oil Consumption (g/h)	Delta Pb 250-300h (ppm)	MRV^C Viscosity @75h (cP)
Original Result						
Transformed Result ^B						
Correction Factor ^B						
Corrected Transformed Result ^B						
Final Transformed Result ^B						
Final Original Unit Result ^B						

^A Reference Tests only.

^B Transformed Units for Delta Pb only.

^C For T-10A use only.

^D Non-reference Tests only.

**Mack T-10
EGR Engine Oil Test
Form 5
Operational Summary**

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

	Parameter	Units	QI		Target		Average		Samples ^B	BQD ^C	Over/Under Range ^D
			Threshold	EOT QI ^A							
Controlled Parameters	Speed	r/min	0.000		1800	1800					
	Fuel Flow	kg/h	0.000		59.2	59.2					
	Inlet Manifold Temp.	°C	0.000		70	66					
	Coolant Out Temp.	°C	0.000		66	85					
	Fuel In Temp.	°C	0.000		40						
	Oil Gallery Temp.	°C	0.000		88	113					
	Inlet Air Temp.	°C	0.000		25						
	Inlet Air Restriction	kPa			3.5 – 4.0						
	Inlet Man. Pressure	kPa			TBD	TBD					
	Exh. Back Pressure	kPa			2.7 – 3.5						
	Crankcase Pressure	kPa			0.25 – 0.75						
	Intake CO ₂	%			1.5±.05	0.2±.05					
Non-controlled Parameters	Parameter	Units	Typical Values ^E		Average						
	Power	KW	230 – 255	308 – 326							
	Torque	Nm	1223 – 1351	2456 – 2593							
	Exhaust O ₂	%	7.0 – 8.5	5.5 – 6.8							
	Exhaust CO ₂	%	7.18 – 9.97	9.60 – 11.09							
	Pre-Turbine Temp. (L)	°C	518 – 655	547 – 730							
	Pre-Turbine Temp. (R)	°C	572 – 674	540 – 726							
	Tailpipe Temp.	°C	421 – 464	477 – 510							
	Oil Sump Temp.	°C	91 – 101	117 – 127							
	EGR Pre-Venturi Temp.	°C	210 – 253	91 – 111							
	Blowby	L/min	53 – 120	70 – 200							
	Inlet Air Dew Point	°C	6 – 25	8 – 28							
Inlet Air Humidity	g/kg	4.5 – 20.3	3.5 – 24.1								
Main Gallery Oil Pressure	kPa	398 – 489	174 – 263								

^A 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

^B Total number of data points taken. Minimum acceptable value is 3000

^C Number of Bad Quality Data points not used in the calculation of the statistical measures.

^D Number of points clipped by over/under range limits.

^E Typical values determined from reference oil test database

**Mack T-10
EGR Engine Oil Test
Form 6
Rod Bearing Weight Loss**

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 ^A		

^A 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				

**Mack T-10
EGR Engine Oil Test
Form 7
Ring Weight Loss**

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
Top Ring Average Weight Loss, mg		
Top Ring Weight Loss Std. Dev., mg		
Top Ring Minimum Weight Loss, mg		
Top Ring Maximum Weight Loss, mg		
Outlier Ring ^B		

^A Results calculated without rings with plasma flanking.

^B Ring number wear results are not currently outlier screened.

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

Cylinder #	Oil Ring SOT Weight, g	Oil 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			

**MACK T-10
EGR Engine Oil Test
Form 8
Oil Analysis Summary**

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	TAN	Integrated IR Oxidation	Metal Elements (ppm)							
							Fe	Pb	Cu	Cr	Al	Si	Sn	Na
75 (2nd)														
75 AVG.														

Summary	As Measured	Outlier Bearing Adjusted
Delta Pb @ EOT, ppm		
Delta Pb @ 250-300h, ppm		
75-h MRV		

**Mack T-10
EGR Engine Oil Test
Form 9
Liner Surface Roughness & Bore Diameter**

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-10
EGR Engine Oil Test
Form 10
Liner Wear Summary**

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
Average, μm		
Std. Dev., μm		
Minimum, μm		
Maximum, μm		
Outlier Liners ^A		

^A Cylinder Number.

**Mack T-10
EGR Engine Oil Test
Form 12
Test Fuel Analysis (Last Batch)**

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	0.04 – 0.05			D 2622
Gravity, °API	34.5 – 36.5			D 287 or D 4052
Hydrocarbon Composition				
Aromatics % Vol.	28 – 33			D 1319
Olefin	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
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
Viscosity, cSt @ 40°C	2.4 – 5.0			D 445
Total Acid Number	0.05 Maximum			D 664
Strong Acid Number	0.00 Maximum			D 664
Accelerated Stability	Tbd			D 2274
Distillation, °C				
IBP	Report			D 86
10%	Report			D 86
50%	Report			D 86
90%	282 – 338			D 86
EP	Report			D 86

**Mack T-10
EGR Engine Oil Test
Form 13
Characteristics of the Data Acquisition System**

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)
Temperatures							
Oil @ Filt.							
Fuel In.							
Intake Air							
Intake Man.							
Pre-Turb.							
Cool. Out							
Other							
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**

**Mack T-10
EGR Engine Oil Test
Form 14
Build-up and Hardware Information**

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

Injection Timing

Timing Hours	Timing (Deg)
Total Timing Changes	

Hardware

Part	Part Number	Serial Number
Primary Turbocharger		
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	

**Mack T-10
EGR Engine Oil Test
Form 15
Rating Summary: Piston #1**

Laboratory:	EOT Date:	EOT Time:
Test Number:		
Oil Code:		
Formulation/Stand Code:		
Date Rated:	Rater Initials:	Verified By:

Total Piston Ratings Summary																				
	Grooves									Lands						Oil Cooling		Under Crown		
	Dep. Factor	No. 1		No. 2		No. 1		No. 2		Groove No. 3		Lands No. 3		Lands No. 4		A,%	Dem.	A,%	Dem.	
		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%		Dem.	A,%	Dem.	A,%	Dem.	A,%					Dem.
C a r b o n	HC -1.0									7.5										
	MC -0.5																			
	LC - .25																			
	Total																			
V a r n i s h	8 - 9									4.5										
	7 - 7.9																			
	6 - 6.9																			
	5 - 5.9																			
	4 - 4.9									1.5										
	3 - 3.9																			
	2 - 2.9																			
	1 - 1.9									Clean										
	>0 - 0.9																			
	Clean		0		0		0		0		0		0		0		0		0	
Total																				
Rating																				
Location Factor	2		3		1		3			20		20		60		0.5		1		
Ind Rating																				
WDP		TGC				TLC				Unweighted Deposits				T.L. Flaked Carbon %						

**Mack T-10
EGR Engine Oil Test
Form 17
Rating Summary: Piston #3**

Laboratory:	EOT Date:	EOT Time:
Test Number:		
Oil Code:		
Formulation/Stand Code:		
Date Rated:	Rater Initials:	Verified By:

Total Piston Ratings Summary																					
	Grooves									Lands						Oil Cooling		Under Crown			
	Dep. Factor	No. 1		No. 2		No. 1		No. 2		Dep. Factor	Groove No. 3		Lands No. 3		Lands No. 4		A,%	Dem.	A,%	Dem.	
		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%			Dem.	A,%	Dem.	A,%	Dem.	A,%					Dem.
C a r b o n	HC -1.0																				
	MC -0.5																				
	LC - .25																				
	Total																				
V a r n i s h	8 - 9									7.5											
	7 - 7.9																				
	6 - 6.9																				
	5 - 5.9																				
	4 - 4.9									4.5											
	3 - 3.9																				
	2 - 2.9																				
	1 - 1.9									1.5											
	>0 - 0.9																				
	Clean		0		0		0		0	Clean		0		0		0		0		0	
Total																					
Rating																					
Location Factor	2		3		1		3			20		20		60		0.5		1			
Ind Rating																					
WDP		TGC				TLC				Unweighted Deposits				T.L. Flaked Carbon %							

**Mack T-10
EGR Engine Oil Test
Form 18
Rating Summary: Piston #4**

Laboratory:	EOT Date:	EOT Time:
Test Number:		
Oil Code:		
Formulation/Stand Code:		
Date Rated:	Rater Initials:	Verified By:

Total Piston Ratings Summary																					
	Grooves				Lands					Groove		Lands				Oil Cooling		Under Crown			
	Dep. Factor	No. 1		No. 2		No. 1		No. 2		Dep. Factor	No. 3		No. 3		No. 4		A,%	Dem.	A,%	Dem.	
		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%			Dem.	A,%	Dem.	A,%	Dem.	A,%					Dem.
C a r b o n	HC -1.0																				
	MC -0.5																				
	LC - .25																				
	Total																				
V a r n i s h	8 - 9									7.5											
	7 - 7.9																				
	6 - 6.9																				
	5 - 5.9																				
	4 - 4.9									4.5											
	3 - 3.9																				
	2 - 2.9																				
	1 - 1.9									1.5											
	>0 - 0.9																				
	Clean		0		0		0		0	Clean		0		0		0		0		0	
Total																					
Rating																					
Location Factor	2		3		1		3			20		20		60		0.5		1			
Ind Rating																					
WDP		TGC				TLC				Unweighted Deposits				T.L. Flaked Carbon %							

**Mack T-10
EGR Engine Oil Test
Form 20
Rating Summary: Piston #6**

Laboratory:	EOT Date:	EOT Time:
Test Number:		
Oil Code:		
Formulation/Stand Code:		
Date Rated:	Rater Initials:	Verified By:

Total Piston Ratings Summary																			
C a r b o n	Grooves				Lands				D e p. F a c t o r	Groove		Lands				Oil Cooling		Under Crown	
	No. 1		No. 2		No. 1		No. 2			No. 3		No. 3		No. 4		A,%	Dem.	A,%	Dem.
	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.
C a r b o n	HC -1.0																		
	MC -0.5																		
	LC - .25																		
	Total																		
V a r n i s h	8 - 9																		
	7 - 7.9																		
	6 - 6.9								7.5										
	5 - 5.9																		
	4 - 4.9																		
	3 - 3.9								4.5										
	2 - 2.9																		
	1 - 1.9																		
	>0 - 0.9								1.5										
	Clean		0		0		0		0	Clean		0		0		0		0	
Total																			
Rating																			
Location Factor		2		3		1		3		20		20		60		0.5		1	
Ind Rating																			
WDP		TGC				TLC				Unweighted Deposits				T.L. Flaked Carbon %					