Mack T13 Task Force Meeting:

Location: San Antonio, TX at IAR and SwRI

Date: 8/27/13

Summary:

Stand Inspections and Setup Discussion

Stand inspections were conducted in the morning at both IAR and SwRI. The location of measurement probes for the intake air and exhaust were found to have a large discrepancy between labs. It was asked that labs share location information to develop a specification.

- EGR Outlet thermocouple was found to be commonly located between IAR and SwRI at ~5" above the crossover pipe clamp on the right side of the engine.
- It was brought up that exhaust probe measurements should be located at a distance from the end of the factory turbo diffuser (21040354) rather than the turbine outlet.
- For intake air, each lab will define pipe diameter, total distance from compressor inlet, straight length which temperature and pressure are measured, and number of elbows/bends after ports.
- The length of lines running to the external oil cooler need to be defined. It was noted that the same cooler is used for the C13 (ASTM D7549). For reference, the following wording is used in Annex A12 of D7549:
    - A12.3 Oil Lines and Fittings—Use two size No.16 oil lines with a maximum length of 914 mm (Total of both lines), preferably made from stainless steel braided hose . Use size No.16 NPT threaded fittings for the line connections.
- Oil Samples should be taken from the engine so that analysis can continue if/when the oil adder system is empty. The method IAR is using, pulling sample from the external oil cooler, was presented as a possible option. The option of pulling directly off the galley to obtain post-filter oil was mentioned, but there was concern that a sample taken here may result in galley pressure protection limits to be tripped and result in unintended engine shutdowns.
- A pressurized fill location for the engine needs to be defined for commonality between labs.
- Coolant outlet was measured at different locations between labs. Each lab is to report the distance from the factory outlet block for thermocouple location
    - Jim Moritz had placed two thermocouples in the coolant outlet stream, offered to provide data on the delta between measurement directly on the outlet block compared to a measurement taken downstream of his sight gage.
- The auxiliary oil system setup should utilize the same size lines as the T12 test procedure. A ½" threaded coupling is being used by Riccardo in his pan that has a fixed pickup location.
- The charge air intercooler differs lab to lab. It was mentioned that it may be beneficial to specify a delta pressure from inlet to outlet rather than a Modine part number requirement.
    - Jim Moritz has used another type of intercooler with theT13 test with positive results

    - Jim McCord mentioned another Modine-like cooler available from a supplier near San Antonio at a reduced cost.
- The mounting of the engine should be flat front-to-back with a 4° tilt to the ECM side of the engine.
- Oil Sump thermocouple location in the pan is set based upon the documentation provided by Riccardo. The adder pickup location is still being developed based on targeting a specific oil adder volume at one hour of test time
- CO2 measurements should be conducted using a sampling device which cools to <5°C to remove moisture.

Test Operation Discussion:

Currently, tests run at XOM, IAR, and SwRI have been conducted using an adjustable oil adder pickup which is set to target an adder system volume of 3000-3500grams at a test time of one hour. The "full level" utilized for the oil adds/drains during the test is set as the adder system volume at 4 hours of test time. There was some discussion if this was too early in the test to establish a full mark. Both IAR and SwRI had a much larger volume of oil force drained at the first oil add (24 hours) than XOM did in the test data that was presented.

For oil consumption calculations, a value should be calculated each 12-hour interval (sample interval later in test) rather than 24 hour interval (oil addition interval)

Bob Campbell brought up the question of what parameter actually ranks the oils. Looking at the various chemical data presented, different oils may have different oxidation peak, area, PDSC, and other parameter responses which could rank oils differently depending on the importance of each.

It is desired that labs report piston deposit ratings along with other post-test data at this point for possible future use. At this point, Riccardo has been using the Volvo method for ratings. Greg will be looking into the distribution of this method which differs from the CRC method.

A lack of power at the start of test can be indicative of incorrect cam/crank timing. Riccardo provided a method for checking this with a scope once the engine is built.

Pre/post test cylinder head inspections have, so far, shown that a head will last about 2 runs. At this point they should be rebuilt with new seats, guides, valves, seals, etc. The procedure for seat replacement in the service manual involves notching and welding onto the valve seat, however this may not be necessary to remove the component.

Operational Data Presented:

A comparison of operational data between the three labs which have run the T12 reference oil was presented and is attached. There seems to be consistency between labs in engine operation.

The first run at SwRI showed a very mild response compared to those conducted at IAR and Exxon. Mark Cooper (Oronite) presented findings related to the large copper level seen over the first 125 hours of the test. This copper appeared to be tied back to an anti-seize compound used for injector installation. The compound was dissolved in ULSD and ICP run on it. Findings showed very high levels of Cu, which Bob Campbell pointed out sometimes has an impact on Pb readings from ICP testing. Pat Fetterman also noted that the levels of moly seen in the anti-seize may have played a part in driving the test mild, although they did not show up in the used oil like the copper did.

Greg Shank covered the data that was presented to the NCDT group the prior week. Oils are beginning to be run which show a differing response from the T12 reference oil in oxidation. These oils are using a PC11A technology. Some liner wear may be measured on EOT components as well.

Engine Control, Vision, CAN communications:

John Doub (Volvo) called in to address some of the questions regarding the CAN throttle which will be utilized on stands going forward in the PC-11 matrix. The two largest concerns were:

- Output signals for correct throttle response
- Control of VGT and EGR position outside of using Vision software

John indicated that the main component required in each lab was a bridge from whatever data acquisition and control system the labs use to a CAN bus for the pedal demand. Since each lab has unique installation set-up, John will be working with each individually to address specific issues.

There is concern with the long term use of Vision on both license updates and cost. John may have a windows passed application to provide similar control of just these two items. He indicated that as long as the proper memory location was being written to, there shouldn't be any issue with providing this control outside of Vision.

The list of fault codes seen while running was presented. John indicated that a number of these can be eliminated by providing additional signals through the CAN bus along with the desired throttle output. This information is covered in the CAN application documented he provided to the labs. He may be able to create a new flash file which hides these flags.

Riccardo brought up further flattening the engine response to manifold boost, compressor discharge, and ambient pressure sensors. Since the boost and compressor discharge is varied throughout the test to control the CO2 rates, the engine operation may shift based on these parameters.

Kevin indicated that there may be a chance of limiting engine response in the calibration, but we may also want to look at providing the sensors with false signals (resistor in the harness or voltage from instrumentation stand) to accomplish this goal.

Critical Parts and Hardware Issues:

Mark Sutherland (TEI) informed the group that the T13 power assembly is currently available as a kit. There are some items in the kit which will not be used, but it is the only way that some of the required components are currently available.

Mark will be determining how many sets of components can be ordered for T13 rebuilds at once. Based upon this, a decision will be made on receiving batch quantities and sizes.

Other Business:

Riccardo and Sean Moyer (TMC) will work on the development of a data dictionary based on the T12 form. They will indicate what changes are needed on each page of the report to modify it for T13 purposes

Mike Birke (SwRI) will be addressing the need to tighten up the chemical test results from the various labs. He will need a contact at each lab to discuss test methodology and consistency. Please provide this contact to Jim McCord or Robert Warden

Scope and Objectives were reviewed and will be updated to include an expected completion date for each of the listed objectives. Lubricant oxidation will become a primary test parameter, while top ring side wear will be removed. Piston deposits will be added to the list of secondary test parameters.

A workshop will be organized, preferably at one of the San Antonio labs, to develop commonality of approach in rebuilding engines and cylinder heads.

The next Face-to-Face meeting will be hosted by Afton in Richmond before 11/12/2013

Key Action Item Recap:

- **All labs: instrumentation measurement ports**
- **All labs: Provide point-of-contact information for chemistry test discussions to Robert Warden**
- **TEI: determine how many kits are available for distribution**
- **Riccardo: provide final oil pickup location once validated**
- **Volvo: Distribution of information regarding Volvo piston rating method**
- **John Doub: Supporting lab transition to CAN**

Volvo T13
CPD Report

Mark Sutherland 8/25/2013

Volvo T13 CPD Report Contents

- Issues/Updates/Observations
  - Engine Parts

Volvo T13 CPD Report
Parts

- No parts currently on order

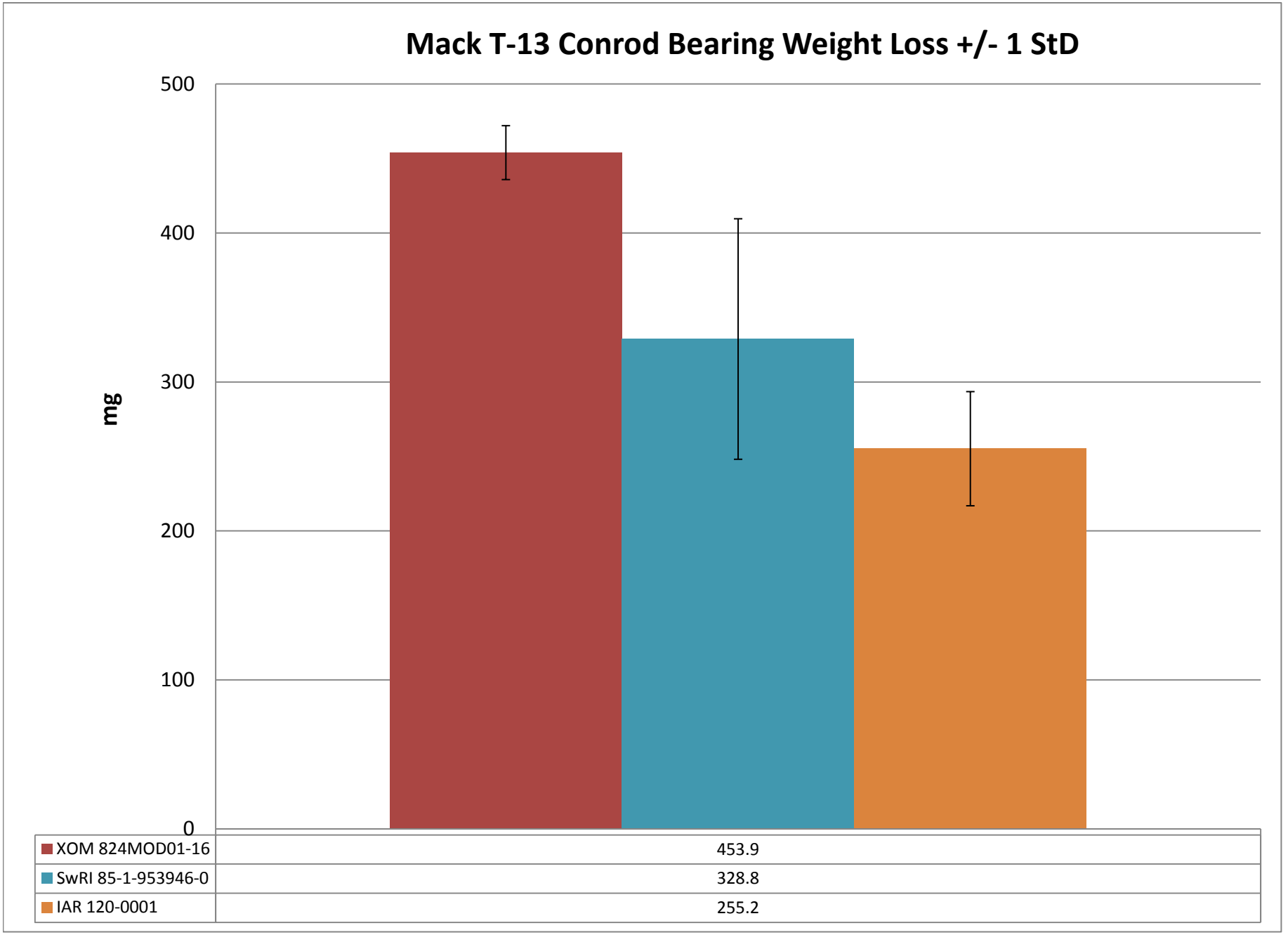
Volvo T13 CPD Report
Parts List

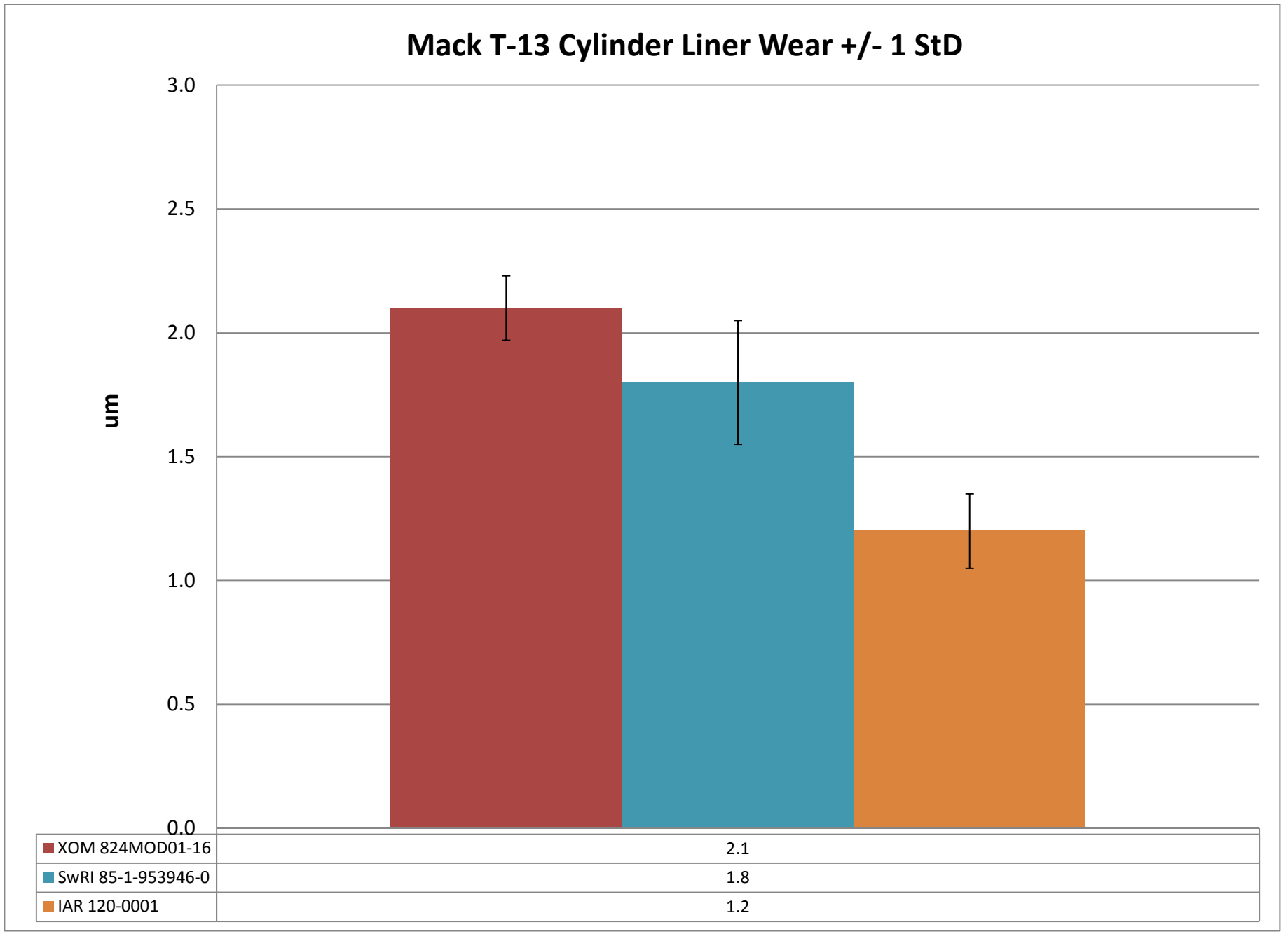
MACK MP8 T-13 OVERHAUL KIT

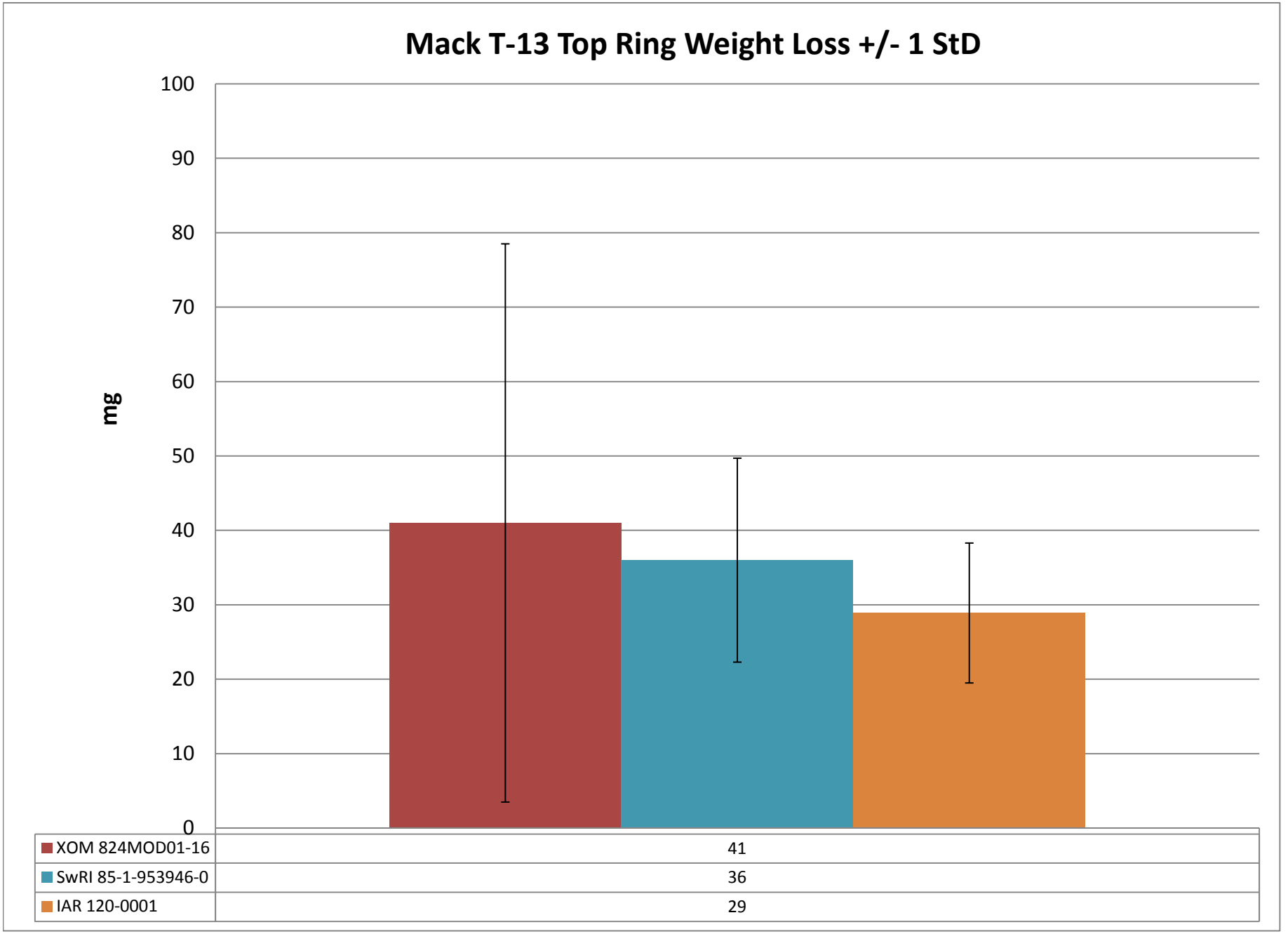
PART No.	Combine	DESCRIPTION
21170742 P06	85124806	Piston
20852790 P05		Liner
21251596 P03		Ring – top
20590309 P32		Ring - second
20568155 P34		Ring - oil
20569833 P32		Pin
914531 P01		Snap Rings
470922 P03		Liner Seal – top at flange
470190 P05		Liner Seal – lower – top and middle
21430623 P01		Liner Seal – lower – bottom
20530902	20530916	Main Bearings – Upper
20530900		Main Bearings – Lower
20508264	20580558	Rod Bearings – Upper
20530094		Rod Bearings – Lower
276948		KIT, Injector O-Ring
469846		O-RING, Oil Pressure Relief INNER
471626		SEAL, Oil Filter Hsng. Tubes (rear adptr plug)
943177		O-RING, Gear Plate Stud (Lwr idler gear mounting block)
947760		BOLT, Crank Gear
948610		SEAL. Oil Press. Relief COVER
967343		O-RING, Venturi /EGR X-over
974320		PETCOCK, EGR Cooler
975675		O-RING, Coolant Pipe (lower extension)
977030		O-RING, Fuel Pmp/Pwr. Strng Combination Pump
983475		BOLT, Idler Gear
984735		BOLT, Gear Plate (attaches to rear cyl head)
984738		FLANGE, Screw
984761		BOLT, Cam Cap (outboard)
984815		BOLT, Vibration Damper
990861		BOLT, Crankcase Girdle
992065		O-RING, Crank Gear/Comp. block-off plate
993167		SPACER, Exh. Manifold
994445		BOLT, Piston Oil Jet
1544733		CLAMP, Turbo Inlet Elbow (SMALL end)
1547254		SEAL, Upper Coolant Manifold
1547255		SEAL, Oil Supply/Return Tubes
1677370		SEAL, Crossover Tube (dummy oil solnd)
8192804		BOLT, Cam Gear/Inj. Hold-Down
20412482		BOLT, Rear Cam Cap
20430678		SEAL, Water Pmp to Oil Cooler
20451487		SEAL, Oil Pump (p/u tube)
20483919		BOLT, Dual Idler to Block
20486228		BOLT, Connecting Rod
20504408		CLAMP, Venturi/EGR Crossover Pipe
20526428		SEAL, Turbo, EGR, Oil Dummy Solnd. Supply
20532891		GASKET, CC Separator to Block
20538793		SEAL, Rocker Cover
20551483		SEAL, Oil Cooler (utilized for internal cooler block-offs)
20590125		CLAMP, Turbo Inlet Elbow (BIG end)
20781146		GASKET, Turbo to Exh. Manifold
20787167		GASKET, Oil Filter Housing
20805850		SEAL, Intake Manifold
20817742		GASKET, Rear Upper Timing Cvr.
20852765		SEAL, Fuel System Banjos
20855371		Gasket, Exhhaust Manifold
20972295		FILTER, Fuel
20999623		BEARING, Cam (Caps 1 - 6)
21007187		GASKET, Turbo to Diffuser Pipe (metal shim-type)
21050240		BOLT, Lwr. Idler (small) Gear
21092243		SEAL, Oil Pump Tubes
21095721		GASKET, Diffuser (pipe end)
21119814		PIPE, EGR rear
21122541		OIL SEPARATOR Assm.
21164790		SENSOR, EGR Temp.
21185132		SEAL, End Cap (rear upper timng cvr.)
21228220		HOSE, Turbo Inlet
21293367		GASKET, Oil Pan
21294062		SEAL, Oil Cooler Hsng. Cover
21298915		SEAL, Coolant Housing to Cyl. Head
21344746		BOLT, Flywheel
21344778		BOLT, Cam Caps (1 thru 6)
21344787		BOLT, Exh. Manifold
21345129		BOLT, Main BEARING
21345131		BOLT, Cyl. Head
21347087		SEAL, Crankshaft Front
21510072		GASKET, Cyl Head
21532258		O-RING, CC Separator Tube (to Valv. Cvr.)
21707135		FILTER, Oil - Bypass
21707136		FILTER, Oil - Full Flow
21713917		SENSOR, Diiferential Press.
21780371		O-RING, Oil Fltr. Hsng Cooling Tube (front adptr)
21937327		FILTER, Coolant
21948053		VENTURI
85131446		BEARING, Cam (Cap #7)
85133799		KIT, EGR Valve Replacement
		CORE DEPOSIT
85136428		KIT, EGR Cooler
		CORE DEPOSIT

Mark Sutherland 8/25/2013

Questions ?


Mack T-13 Conrod Bearing Weight Loss +/- 1 StD
500
400
300
200
100
0
mg
XOM 824MOD01-16
453.9
SwRI 85-1-953946-0
328.8
IAR 120-0001
255.2


Mack T-13 Cylinder Liner Wear +/- 1 StD
um
3.0
2.5
2.0
1.5
1.0
0.5
0.0
XOM 824MOD01-16
2.1
SwRI 85-1-953946-0
1.8
IAR 120-0001
1.2


Mack T-13 Top Ring Weight Loss +/- 1 StD
mg
100
90
80
70
60
50
40
30
20
10
0
XOM 824MOD01-16
41
SwRI 85-1-953946-0
36
IAR 120-0001
29

Test #	CLW		TRWL		UBWL	
TMC 821-3	Ave.	SD	Ave.	SD	Ave.	SD
XOM 824MOD01-16	2.1	0.13	41	37.5	453.9	18.1
SwRI 85-1-953946-0	1.8	0.25	36	13.7	328.8	80.7
IAR 120-0001	1.2	0.15	29	9.4	255.2	38.3
			40.3	29.2		

Mack T-13 Test Instructions Outline, 20130821 Rev.2

- Engine Configuration
    - Engine mounted with flywheel perpendicular to floor and tilted 4° side-to-side toward intake manifold
    - PVD Coated Exhaust Rocker Arms, P/N 21809012 (now standard part)
    - Thermostat blocked open
    - US07 Oil Filter Housing P/N 21183257 with mods. Run with fault codes (running fault codes in attached table)
    - No-Brake Camshaft P/N 21219818 with "Dummy" Solenoid Valve P/N 21105100
    - Front Mount Steel Oil Pan P/N 21585801 with Gasket P/N 21293367, pick up height, oil sump thermocouple and oil drain set per attached dimensions
    - Coolant, Chevron Delo Extended Life Coolant diluted 50/50
        - P/N 227811 (50/50 pre-mixed)
        - P/N 227808 (concentrated)
    - Coolant Filter w/o additives, Volvo P/N 21388479
    - Full Flow Oil Filter (2), P/N 21707136
    - By-Pass Oil filter, P/N 21707135
    - Compressor Block-Off Plate, P/N 21226107
    - Damper Cooling Fan
    - Injector (6), P/N 21458369
    - Turbocharger, P/N 85128135 with Gasket with large opening P/N 20781146
    - Oil Cooler, ITT Model SSCF 5-160-03-014-004 Two pass, All Stainless steel
        - Remove cooler core and baffle from engine (right side)
    - Remove gears of steering pump from fuel&steering pump assembly
    - External Oil System Pumps, same as Mack T-12. Return line from external oil vessel connected to center of compressor block-off plate.
    - Flywheel, P/N 20941525
    - Crank pulley P/N 20799474 and related hardware for correct water pump speed
    - Compressor Discharge Temp Sensor (see attached table)
    - Boost Pressure Sensor, (see attached table)
    - Leave Ambient Temp Sensor disconnected
    - Engine coolant through turbocharger (standard factory set-up)
    - Aftertreatment fuel doser removed. Connector jumper? Yes. Run with fault codes (running fault codes in attached table)
    - Intertek Design EGR cooler adaptor

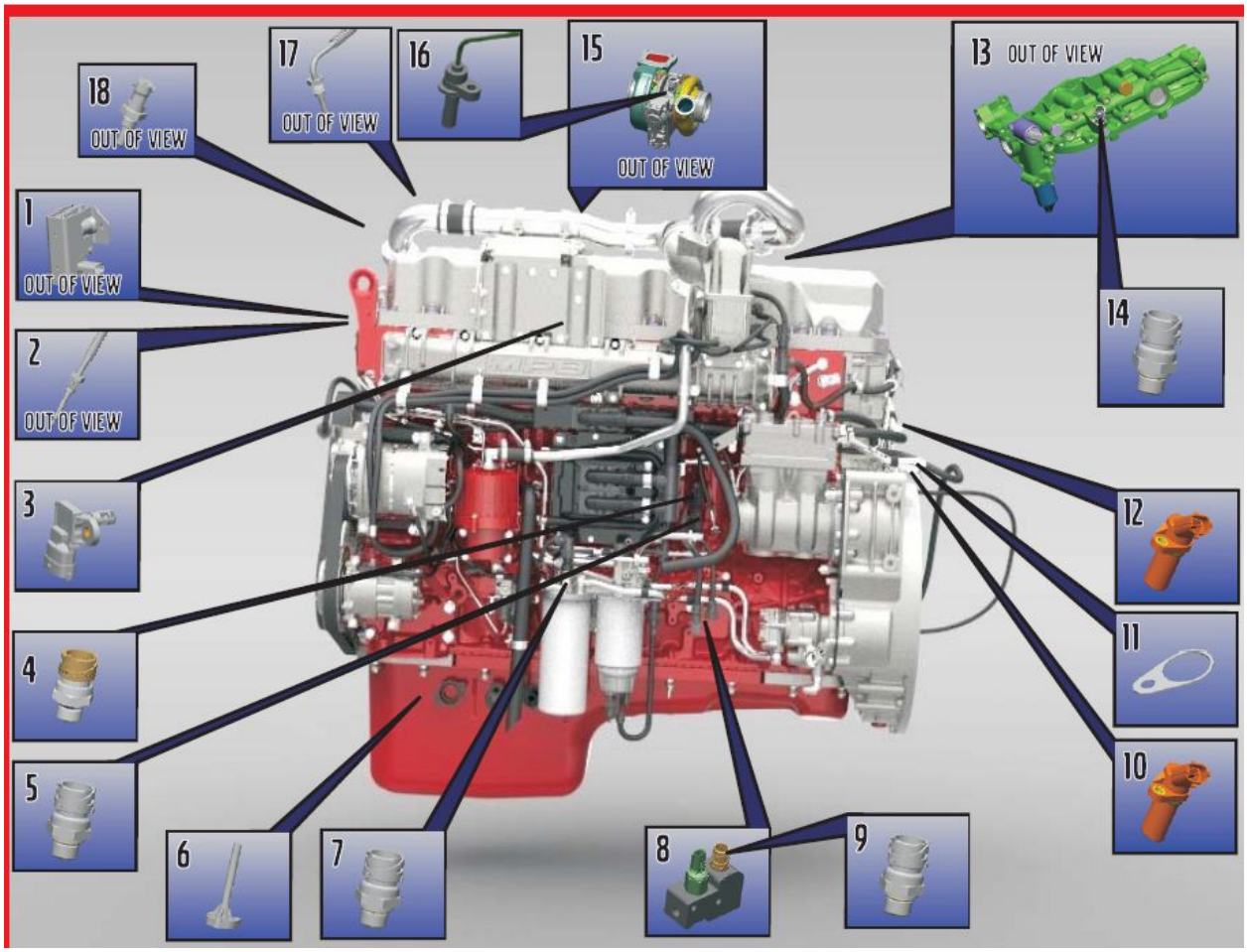
- List of PCU and Bearing P/N's provided by Ken (needs to be verified against the list provided by Allison):
    - Piston – 21170742 P06 (6)
    - Liner – 20852790 P05 (6)
    - Rings – top – 21251596 P03 (6)
        - second – 20590309 P32 (6)
        - oil - 20568155 P34(6)
    - Pin – 20569833 P32 (6)
    - Snap Rings – 914531 P01 (12)
    - Liner Seals – top at flange – 470922 P03 (6)
        - lower – top and middle – 470190 P05 (12)

        - lower – bottom – 21430623 P01 (6)
    - Main Bearings – Upper – 20530902 (7)
        - Lower – 20530900 (7)
    - Rod Bearings – Upper – 20508264 (6)
        - Lower – 20530094 (6)

- Test Stand Configuration and Test Operation
    - 1500 rpm, 2200 Nm, 3000 psi, "3573E09A59_t13_Rev9_1500_3000psi_ " Flash file
    - Mack T13 Test Development AL824MOD01 V8a.xls test protocol
    - Cam-Crankshaft Timing Verification
    - CO_2 Targets:
        - Intake Manifold: 2.06%±0.05
        - Exhaust Pipe: TBD
    - Active or Default EGR and VGT Control
        - Use VGT to control Intake Manifold CO_2
        - Leave EGR valve at 90% (default position)
        - Log CO_2 Exhaust and Boost pressure
    - Test Length: tentatively set at 360-h
    - Both external oil vessel and external oil cooler to be drained at completion of Break-In
    - Anything else?

Mack T-13 Running Test Fault Codes						
Description	**MID**	**PID**	**PPID**	**SID**	**PSID**	**FMI**
Ambient Air Temperature	**128**	**171**				**9**
Ambient Air Temperature	**128**	**171**				**12**
Total Vehicle Distance	**128**	**245**				**9**
Clock	**128**	**251**				**2**
Clock	**128**	**251**				**9**
Clock	**128**	**251**				**12**
Clock	**128**	**251**				**13**
Date	**128**	**252**				**9**
Nox Sensor Gas Outlet	**128**		**270**			**9**
Aftertreatment Fuel Injector	**128**		**329**			**5**
Compressor Recirculation Valve	**128**		**330**			**5**
NOX Sensor Gas Intake	**128**		**348**			**9**
Fan Clutch Output	**128**			**33**		**5**
Piston Cooling Valve	**128**			**85**		**5**
Program Memory	**128**			**240**		**14**
Thermostat Bypass Valve	**128**				**72**	**5**
DPF Switch	**128**				**114**	**9**
Critical MSW Error or Improper Shutdown	**144**				**230**	**4**

EPA2010 MP7/MP8 Engine Sensors



#1 – EGR Delta Pressure Sensor - Must use sensor PN# 21713917 with new harness.

EPA2010 MP7/MP8 Engine Sensors

Position	Description	Part number
1.	EGR Delta Pressure Sensor	~~21304786~~
2.	EGR Temperature Sensor	21164790
3.	Intake Air Temperature / Boost Pressure Sensor	21097978
4.	Crankcase Pressure Sensor	20796744
5.	Engine Oil Pressure Sensor	21302639
6.	Engine Oil Level / Temperature Sensor	~~21042447~~
7.	Fuel Pressure Sensor	21302639
8.	Fuel Control Solenoid	20942984
9.	Aftertreatment Fuel Pressure Sensor	21302639
10.	Crankshaft Speed Sensor	20513343
11.	Shim	20556179
12.	Camshaft Speed Sensor	20513343
~~13.~~	~~Engine Oil Thermal Management System~~	~~Check Per VIN~~
~~14.~~	~~OBD Oil Pressure Sensor~~	~~21302639~~
15.	Turbocharger	Check Per VIN
16.	Turbine Shaft Speed Sensor	24427413
17.	Turbocharger Discharge Temperature Sensor	21164792
18.	Engine Coolant Temperature Sensor	20513340

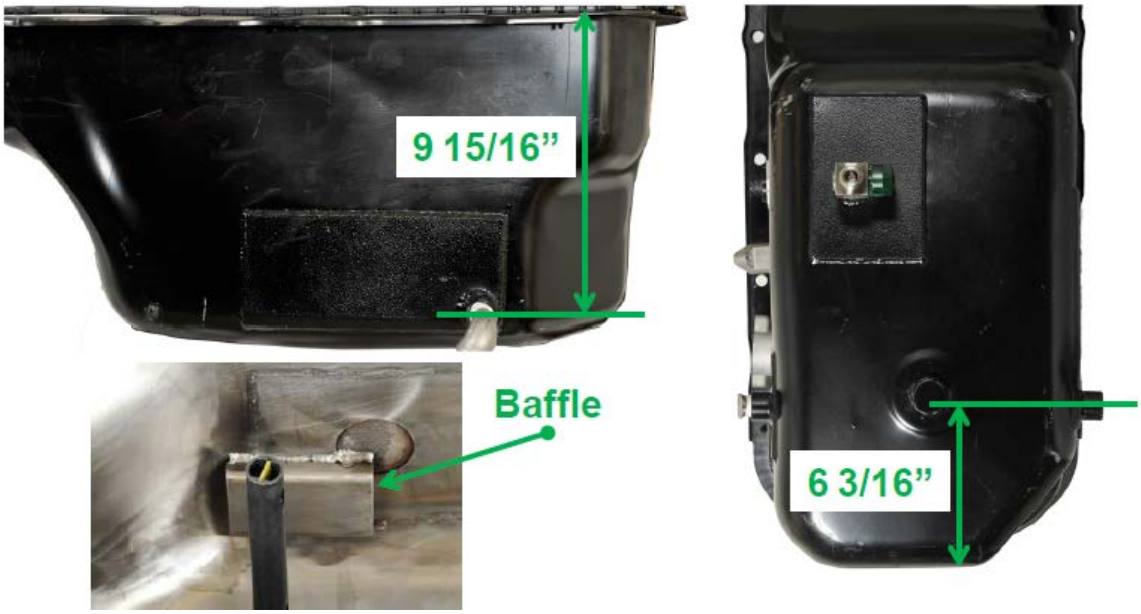
NOTE: Images, Locations and Part numbers are for reference only!
Refer to the VIN number in Impact for the latest information.

DATE: 9/08/2009 PUBLICATION: PV776-SENSOR10-MP7-MP8

NOTES

1.) **FYI - #4 and #5 Position sensors - are reversed for position on MP8 Engine /Sensor display above.**
2.) **#6 sensor FYI - we are using PN# 21521353**
3.) **#13 – is not used**
4.) **#14 – is not used**

***Ambient Air Temperature Sensor for a US 10 Truck engine is PN# 25155016**
(to be left disconnected)



External Oil System Suction Port

Oil Sump Thermocouple Location

Oil Drain

MACK MP8 (T-13) SPECIAL TOOLS

TOOL No.	***DESCRIPTION***
PV776-K-MP8	MP8 US10 Service Information Engine Kit Volume 1 - 2
J 47038-3	Engine Lifting Assembly (4 parts)
J 47038-4	" " "
J 47038-6	" " "
J 47038-8	" " "
88800188	Cylinder Head Lifting Tool
J 49002	Crankshaft Lifting Tool
85109034	Camshaft Lifting Bar
85109250	Rocker Arm Shaft Lifting Tool
88800014	Flywheel Turning Tool
9996599	Cyl. Liner Installation Plate
9996454	Handle for Liner Install. Plate (9996599)
9996966	Cyl. LinerHold-Down Tool
J 26948	Cyl. Liner Height/Depth Gauge Assm.
9998531	Piston Ring Compressor
9998267	Timing Gear Plate Locating Dowels
J-44514-B	Engine Timing Kit
9990013	Slide Hammer
9990114	Main Bearing Cap Puller (used w/ slide hammer 9990013)
85109980	Cam Bearing Cap Puller (used w/ slide hammer 9990013)
9998238	Rear Main Seal Remover / Installer
9992000	Handle (used with 9998238)
88800021	Front Main Seal Remover / Installer
9998487	Oil Filter Socket
9998691	Oil Filter Nipple Repair / Installer Kit
J 43051	Oil Pressure Reduction Valve Socket
85109208	Cam Bearing Cap Hold-Down
85111422-A,B	Timing Cover Alignment Tools
88800031	Cam Sensor Depth Gauge
J 48922	Heavy-Duty Unit Injector Puller
9998251	Unit Injector Sealing Plug
J 42855	Injector Bore Cleaning Kit

MACK MP8 (T-13) SPECIAL TOOLS

****** CYLINDER HEAD RECONDITIONING SERVICE TOOLS ******

TOOL No:	***DESCRIPTION***	***Qty.***
2012-A	Cyl Head Stand	1
J 47364	Cyl. head Stand Mounting Fixture	1
	VALVE GUIDE R&R TOOLS	
9990176	Press Tool	1
9809726	Hydraulic Pump Unit	1
9809729	Hydraulic Cylinder	1
9996159	Adapter Pin	1
8880014	Guide Removal Drift	1
88800062	Guide Installation Tool	1
9998246	Valve Spring Compressor	1
J 37809	Manual Driver	1
	*** VALVE SEAL INSTALLATION ***	
88800011	Seal Guide Tool	1
85112460	Seal Installation Tool	1
	CONICAL INJ. SLEEVE REMOVE & RE-INSTALL	
9998250	Sealing Rings	2
88800289	8.3mm Forming Tap	1
9998252	Tap Handle	1
88800285	Sleeve Hold-Down	1
88800191	Extractor	1
88800288	Replacement Tip	1
1161059	Conical Sleeve Sealant	1
88800409	Sleeve Swaging Tool	1
8880054	Replacement Swage Tip	3
	*** VALVE SEATS ***	
PT-6391	KENT-MOORE Universal Valve Seat Removal Tool	1

"3573E09A59_t13_Rev9_1500_3000psi_" Flash with:
1. Throttle Linearizer; 2. Standard Fuel Injector Trims; 3. Manual Control of EGR and VGT;
4. Fixed Injection Timing above 75% Throttle Position in 1400-1600rpm Range.

ExxonMobil | SwRI | Intertek

			Test Engine S/N	122410008	931857	122410008	953946	1006190
			Oil Code	TMC 821-3	TMC 821-3	TMC 821-3	TMC 821-3	TMC 821-3
			Stand #	3102	309	3102	85	120
			Run #	***824MOD01-13***	***824MOD01-15***	***824MOD01-16***	85-1-953946-0	120-0001
			EGR Position	90% (default)	90% (default)	90% (default)	90% (default)	90% (default)
			VGT Position	58.1% (default)	58.1% (default)	*Variable*	*Variable*	Variable
			Targets	-	-	-	-	-
Cell Data	**Speed**	*rpm*	1500	1500	1500	1500	1500	1499
	Torque	*Nm*	2200	2200	2200	2200	2199.4	2200
	Throttle Position	*%*	-	84.2	88.3	82.9	-	84.6
	Fuel Rate	*kg/h*	-	68.2	68.1	68.5	68.16	68.2
	Coolant Out	*°C*	110	110	110	110	110.0	110
	Oil Gallery	*°C*	130	130	130	130	130.0	130
	Oil Sump	*°C*	-	138	137	139	138.0	138
	Intake Manifold	*°C*	78	78	78	78	78.0	78
	EBP	*kPaA*	115.3	115.3	115.3	115.2	115.3	115.3
	IAR	*kPaA*	94.0	94.0	94.0	93.9	94.01	94
	Compressor Out	*KPa*	-	-	-	-	-	-
	Average	*KPa*	-	226	237	234	233.2	239.6
	Standard Deviation	*KPa*	-	0.99	3.14	1.97	2.21	3.48
	Intake Manifold	*KPa*	-	-	-	-	-	-
	Average	*KPa*	-	224	236	231	228.3	233.1
	Standard Deviation	*KPa*	-	0.95	3.03	1.94	2.02	3.44
	Exhaust Tailpipe	*°C*	-	437	422	435	441	432.2
	EGR Out	*°C*	120	120	120	121	120.0	120
	CO_2 Intake (1)	*%*	2.06±0.05	-	-	-	-	-
	Average	*%*	-	2.06	1.90	2.04	2.06	2.04
	Standard Deviation	*%*	-	0.0292	0.0661	0.0329	0.031	0.017
	CO_2 Exhaust (1)	*%*	TBD	-	-	-	-	-
	Average	*%*	-	11.17	10.60	10.98	10.98	11.23
	Standard Deviation	*%*	-	0.0653	0.0770	0.1216	0.1780	0.0810
	EGR Fraction	*%*	TBD	19.7	19.1	19.8	20.02	19.4
	AFR	*:1*	TBD	19.9	20.9	20.2	20.128	19.8
	Oil Consumption	*g/h*	-	22.7	37.1	28.7	24.6	30.0
Vision	**EGR Mass Flow**	*kg/s*	-			0.1011		
	EGR Differential	*kPa*	-			5.52		
	VGT Position Demand	*%*	-			57.5	58.3	56.84
	Turbo Speed	*rpm*	-			108834		
	Fuel Angle	*deg*	-			20.8		
	Fuel Value	*mg/str*	-			230.1		
	NOP Angle	*deg*	-			14.6		
	Timing Advance	*deg*	-			12.4		
	Pedal Position	*%*	-			82.7	78.8	
	AFR	*:1*	-			24.4		
	Air Mass Flow	*kg/s*	-			0.4300		
	Boost Pressure	*kPaA*	-			337		

Controlled Parameters

(1) Sample Dew Point: ≤ 5°C

	XOM Run# 824MOD01-16				*SwRI Run# 85-1-953946-0*				*IAR Run# 120-0001*		
Initial Charge, Kg	22.8				22.8				22.8		
Test Hour	**Fresh Oil Add (g)**	**Sample (g)**	**Oil Removed (g)**	**OC Rate (g/h)**	**Fresh Oil Add (g)**	**Sample (g)**	**Oil Removed (g)**	**OC Rate (g/h)**	**Fresh Oil Add (g)**	**Sample (g)**	**Oil Removed (g)**
24	750	44	111	33.1	750	88	626	26.31	750	17	593
48	750	148	0	34.4	750	36	0	26.15	750	64.6	0
72	750	0	0	29.0	750	107	5	18.68	750	0	145
96	750	80	0	28.2	750	86	0	21.97	750	76.3	0
120	750	83	0	26.4	750	88	1	18.29	750	62	100
132	0	52	0		0	22	0		0		0
144	750	92	0	30.6	750	88	47	20.56	750	83.7	0
156	0	36	0		0	23	0		0		0
168	750	97	0	29.9	750	88	87	22.74	750	84.4	0
180	0	49	0		0	25	0		0		0
192	750	91	0	30.0	750	88	0	19.2	750	91.2	0
204	0	37	0		0	45	0		0		0
216	750	93	0	26.7	750	92	0	20.7	750	89.7	0
228	0	31	0		0	40	0		0		0
240	750	115	0	25.3	750	88	58	23.32	750	86.8	0
252	0	76	0		0	57	0		0		0
264	750	114	0	25.0	750	88	0	20.14	750	96.7	0
276	0	65	0		0	54	0		0		0
288	750	112	0	27.1	750	88	0	19.89	750	90	0
300	0	62	0		0	54	0		0		0
312	750	106	0	27.3	750	88	0	20.97	750	90	0
324	0	65	0		0	68	0		0		0
336	750	94	0		750	88	0	20.86	0	95.5	0
348	0	113	0		0	68	0				