

# Draft Addendum to the Statistical Summary of the Mack T10 Precision/BOI Matrix Including Low Temperature Vicsometrics

# Summary

- This is a preliminary analysis. A draft analysis of the MRV numbers is presented in this draft. It is not a consensus analysis.
- The MRV numbers were not significantly correlated with any potential criterion.
- Technology, Base Oil, and their interaction had significant effects.
- There were no observations with large Studentized residuals.
- Oil means and standard deviations are given for potential use in LTMS.

# Data Set

- Table 1 shows the design for the matrix.
- All operationally valid data with the exception of CMIR 38815 are included.
- The T10 Task Force decided to eliminate CMIR 38815 from the analysis.
  - This was an early test in Lab B on Oil A which had high silicon and aluminum in the used oil. It also had high ring weight loss with low cylinder liner wear. The lab ran Oil A again with non-anomalous results. The matrix remains intact as planned.
- D4684 MRV @ -20° of samples at 75 hours have been added.

# Table 1. Mack T10 Precision Matrix Plan

Base Oil	Technology		
	X	Y	Z
Base Oil 1	PC-9A	PC-9D	PC-9G
Base Oil 2	PC-9B	PC-9E	PC-9H
Base Oil 3	PC-9C	PC-9F	PC-9J

Lab/Stand						
Lab A		Lab D	Lab G		Lab F	Lab B
1	2	3	4	5	6	7
A	A	A	A	A	A	A
G	A	G	D	A	A	D
E	E	B	H	E	H	B
C	J	F	C	J	F	J

## Table 2. Mack T10 Precision Matrix Data from TMC 07/16/01 (MRV from Jim Wells 08/06/01)

Test	CMIR	Lab	Stand	EOT Date	Oil	Tech	Base Oil	DPBFNL	ABWLU	ATRWLFNL	CLWLFNL	OILCON	M2IR300	M5IR300	MRV@-20
1	38814	F	1	20001211	A	X	1	33	257	139	36	79	2048	452	14300
2	38809	A	1	20001219	A	X	1	23	206	158	33	52	1520	348	14400
3	38811	D	1	20001224	A	X	1	12	195	139	38	52	1320	210	13600
4	38945	D	1	20010215	F	Y	3	21	222	69	27	56	1674	347	15000
5	38953	F	1	20010217	H	Z	2	73	364	150	33	61	2326	1042	9800
6	38939	A	1	20010305	C	X	3	33	243	116	25	63	1750	458	14600
7	38810	A	2	20010313	A	X	1	19	159	168	38	46	1592	334	14200
8	38947	G	1	20010318	H	Z	2	115	378	156	34	64	3923	1949	11000
9	38937	A	1	20010329	E	Y	2	18	151	118	21	53	1550	342	14800
10	38951	G	2	20010330	A	X	1	37	218	125	33	53	1741	497	14700
11	38943	D	1	20010401	B	X	2	17	182	125	31	44	1376	294	13400
12	38957	B	1	20010403	D	Y	1	25	183	204	46	54	1917	477	21000
13	38942	A	2	20010408	A	X	1	16	182	87	27	41	1368	280	14200
14	38948	G	2	20010419	J	Z	3	90	343	119	35	47	2952	1292	17000
15	38952	F	1	20010419	F	Y	3	62	321	106	26	51	3041	1244	15200
16	38949	G	1	20010420	C	X	3	77	336	133	35	66	3696	1454	10700
17	38941	A	1	20010422	G	Z	1	71	324	107	29	52	2300	910	24400
18	38938	A	2	20010504	J	Z	3	44	278	153	31	58	2418	980	11300
19	38944	D	1	20010504	G	Z	1	27	238	154	39	47	1346	348	27000
20	38956	B	1	20010509	J	Z	3	50	314	127	30	35	2308	1106	11900
21	38950	G	2	20010512	E	Y	2	52	317	109	28	55	2771	991	17200
22	38946	G	1	20010517	D	Y	1	206	344	108	33	71	7555	3551	17000
23	38940	A	2	20010528	E	Y	2	22	184	67	20	45	1639	373	14400
24	40919	B	1	20010529	B	X	2	34	234	121	24	54	1671	415	12400
25	40230	G	2	20010602	A	X	1	25	197	108	34	48	1607	200	14900
26	41135	F	1	20010611	A	X	1	28	248	128	26	60	1876	482	14800
27	41410	B	1	20010618	A	X	1	34	229	140	35	42	1557	347	13200
28	41412	G	1	20010703	A	X	1	66	295	123	39	64	3547	1372	16000

# Transformations

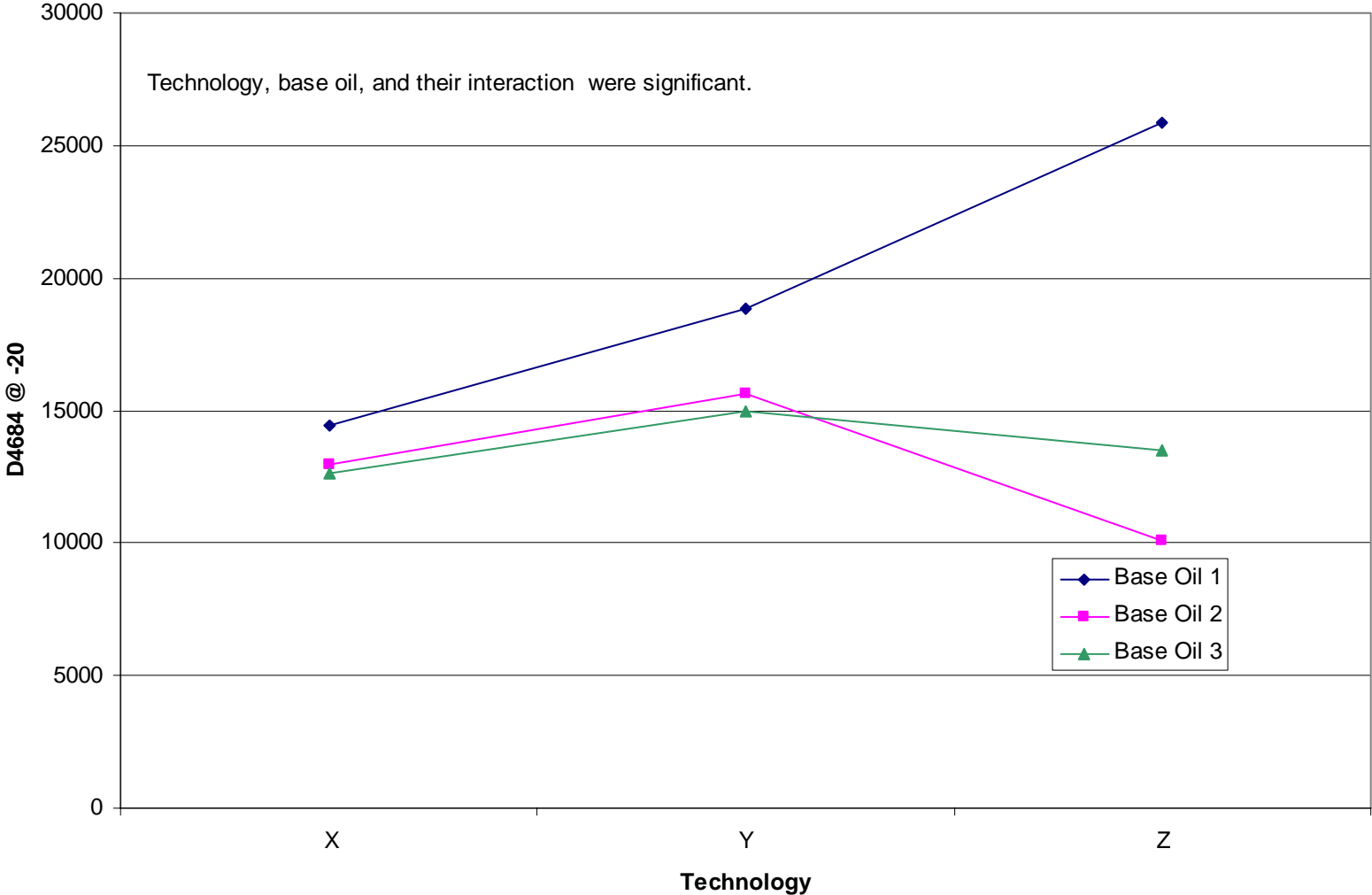
- Box-Cox procedure was applied using all matrix data.
- Delta lead benefits from a natural logarithm transformation.
- Method 2 IR at 300 hours is best raised to a power of  $-0.8$  for analyses.
- Method 5 IR at 300 hours likes a natural logarithm transformation.
- No data transformations are indicated for other responses analyzed.

# D4684 MRV @ -20° C

## Summary of Model Fit

- Model factors include Laboratory (A,B,D,F,G), Technology (X,Y,Z), Base Oil (1,2,3) and Technology by Base Oil interaction.
- Technology, Base Oil, and Technology by Base Oil interaction were significant.
  - Root MSE from the model was 1727 (15 df).
  - The  $R^2$  for the model was 0.88.
  - Figure 1 illustrates the least squares means by oil.
  - Figure 2 summarizes least squares means for oils.
  - There were no large Studentized residuals.

**Figure 1**  
**Least Squares Means for Oils**





# Figure 2

## Oil Least Squares Means for D4684 MRV @ -20° C

Technology	Base Oil	Least Squares Mean	p-value for test of equal means (Tukey)								
			vs X1	vs x2	vs X3	vs Y1	vs Y2	vs Y3	vs Z1	vs Z2	vs Z3
X	1	14414		0.98	0.92	0.12	0.98	1.00	<.0001	0.12	1.00
X	2	12952	0.98		1.00	0.10	0.86	0.97	0.00	0.86	1.00
X	3	12624	0.92	1.00		0.07	0.63	0.95	<.0001	0.89	1.00
Y	1	18866	0.12	0.10	0.07		0.64	0.59	0.05	0.01	0.08
Y	2	15623	0.98	0.86	0.63	0.64		1.00	0.00	0.10	0.86
Y	3	14974	1.00	0.97	0.95	0.59	1.00		0.00	0.25	0.99
Z	1	25860	<.0001	0.00	<.0001	0.05	0.00	0.00		<.0001	<.0001
Z	2	10088	0.12	0.86	0.89	0.01	0.10	0.25	<.0001		0.58
Z	3	13484	1.00	1.00	1.00	0.08	0.86	0.99	<.0001	0.58	

# Correlations Among the Criteria

Raw Data	ln(Delta Pb)	URBWL	TRWL	CLW	OC	t(M2IR)	ln(M5IR)	D4684at_20
ln(Delta Pb)	1.00	<b>0.92</b>	0.01	0.10	<b>0.44</b>	<b>-0.93</b>	<b>0.95</b>	-0.01
URBWL	<b>0.92</b>	1.00	0.00	0.07	<b>0.40</b>	<b>-0.85</b>	<b>0.89</b>	-0.08
TRWL	0.01	0.00	1.00	<b>0.72</b>	0.12	0.01	0.03	0.05
CLW	0.10	0.07	<b>0.72</b>	1.00	0.14	-0.10	0.07	0.25
OC	<b>0.44</b>	<b>0.40</b>	0.12	0.14	1.00	<b>-0.54</b>	<b>0.43</b>	-0.11
t(M2IR)	<b>-0.93</b>	<b>-0.85</b>	0.01	-0.10	<b>-0.54</b>	1.00	<b>-0.96</b>	0.10
ln(M5IR)	<b>0.95</b>	<b>0.89</b>	0.03	0.07	<b>0.43</b>	<b>-0.96</b>	1.00	-0.07
D4684at_20	-0.01	-0.08	0.05	0.25	-0.11	0.10	-0.07	1.00

Residuals	ln(Delta Pb)	URBWL	TRWL	CLW	OC	t(M2IR)	ln(M5IR)	D4684at_20
ln(Delta Pb)	1.00	<b>0.68</b>	-0.32	-0.22	0.10	<b>-0.68</b>	<b>0.78</b>	-0.26
URBWL	<b>0.68</b>	1.00	-0.25	-0.17	0.31	<b>-0.70</b>	<b>0.69</b>	-0.35
TRWL	-0.32	-0.25	1.00	<b>0.77</b>	0.13	-0.03	-0.02	0.27
CLW	-0.22	-0.17	<b>0.77</b>	1.00	0.08	-0.16	-0.03	0.32
OC	0.10	0.31	0.13	0.08	1.00	-0.29	0.00	-0.17
t(M2IR)	<b>-0.68</b>	<b>-0.70</b>	-0.03	-0.16	-0.29	1.00	<b>-0.78</b>	0.11
ln(M5IR)	<b>0.78</b>	<b>0.69</b>	-0.02	-0.03	0.00	<b>-0.78</b>	1.00	-0.09
D4684at_20	-0.26	-0.35	0.27	0.32	-0.17	0.11	-0.09	1.00

Oil LS Means	ln(Delta Pb)	URBWL	TRWL	CLW	OC	t(M2IR)	ln(M5IR)	D4684at_20
ln(Delta Pb)	1.00	<b>0.80</b>	0.11	0.20	-0.22	<b>-0.74</b>	<b>0.88</b>	0.45
URBWL	<b>0.80</b>	1.00	0.24	0.22	-0.14	-0.41	0.60	0.13
TRWL	0.11	0.24	1.00	<b>0.87</b>	0.56	0.19	-0.01	-0.04
CLW	0.20	0.22	<b>0.87</b>	1.00	0.47	0.00	0.09	0.26
OC	-0.22	-0.14	0.56	0.47	1.00	0.24	-0.30	-0.05
t(M2IR)	<b>-0.74</b>	-0.41	0.19	0.00	0.24	1.00	<b>-0.94</b>	-0.29
ln(M5IR)	<b>0.88</b>	0.60	-0.01	0.09	-0.30	<b>-0.94</b>	1.00	0.31
D4684at_20	0.45	0.13	-0.04	0.26	-0.05	-0.29	0.31	1.00

# Oil Least Squares Means and Standard Deviations

<b>Oil</b>	<b>InDeltaPb</b>	<b>URBWL</b>	<b>TRWL</b>	<b>CLW</b>	<b>OilCon</b>	<b>tM2IR</b>	<b>InM5IR</b>	<b>MRV@-20</b>
<b>A</b>	3.1683	210.2	135	34.9	52.5	0.002694	5.8709	14414
<b>B</b>	3.6333	239.6	114	24.8	54.8	0.002407	6.3253	12952
<b>C</b>	3.3968	278.7	135	31.7	63.6	0.002507	6.0928	12624
<b>D</b>	3.7706	242.0	157	38.7	65.4	0.002067	6.6280	18866
<b>E</b>	3.2942	220.7	107	25.4	51.3	0.002371	6.2920	15623
<b>F</b>	3.8216	277.3	83	25.5	49.6	0.001978	6.6472	14974
<b>G</b>	4.2122	323.8	130	33.9	51.6	0.002183	6.7337	25860
<b>H</b>	3.7972	323.2	159	34.3	55.7	0.002466	6.4090	10088
<b>J</b>	4.0624	307.5	136	32.8	49.0	0.001818	7.1393	13484
<b>Std Dev</b>	0.2946	38.0	28	4.4	8.6	0.000223	0.3215	1727