Preliminary Summary of the Mack T10 Precision/BOI Matrix

jar for the PC-9 Statistical Task Group

Presented to the HDEOCP July 11, 2001

Changes due to deletion of CMIR 38815 or other correction noted

Summary

- This is a very preliminary summary. One more test will enter the data set. Others might leave. When the Task Force approves the data set, the statistical task group will reach consensus analysis.
- Delta lead {DELETED “and top ring weight loss”} benefits from natural log transformations.
- No other transformations seem necessary.
- The matrix data were not evaluated for ACC precision requirements or for determination of LTMS parameters.

Summary
(continued)

- Labs had significant effects for delta lead, upper bearing weight loss, and oil consumption.
- The Technology by Base Oil interaction was significant for delta lead.
- Technology had a significant effect for delta lead and upper bearing weight loss.
- Base Oil had a significant effect for cylinder liner wear.
- Observations with large Studentized residuals were seen for delta lead, top ring weight loss, and oil consumption.

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 1		Lab 2	Lab 3		Lab 4	Lab 5
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 07/05/01

Obs	CMIR	Lab	Stand	EOT Date	Oil	Tech	Base Oil	DPBFNL	ABWLU	ATRWLFNL	CLWFNL	OILCON
1	38809	A	1	20001219	A	X	1	23	206	158	33	52
2	38810	A	2	20010313	A	X	1	19	159	168	38	46
3	38942	A	2	20010408	A	X	1	16	182	87	27	41
~~x~~	~~38815~~	~~B~~	~~1~~	~~20001231~~	~~A~~	~~X~~	~~1~~	~~11~~	~~165~~	~~349~~	~~24~~	~~32~~
4	41410	B	1	20010618	A	X	1	34	229	140	35	42
5	38811	D	1	20001224	A	X	1	12	195	139	38	52
6	38814	F	1	20001211	A	X	1	33	257	139	36	79
7	41135	F	1	20010611	A	X	1	28	248	128	26	60
8	38951	G	2	20010330	A	X	1	37	218	125	33	53
9	40230	G	2	20010602	A	X	1	25	197	108	34	48
10	40919	B	1	20010529	B	X	2	34	234	121	24	54
11	38943	D	1	20010401	B	X	2	17	182	125	31	44
12	38939	A	1	20010305	C	X	3	33	243	116	25	63
13	38949	G	1	20010420	C	X	3	77	336	133	35	66
14	38957	B	1	20010403	D	Y	1	25	183	204	46	54
15	38946	G	1	20010517	D	Y	1	206	344	108	33	71
16	38937	A	1	20010329	E	Y	2	18	151	118	21	53
17	38940	A	2	20010528	E	Y	2	22	184	67	20	45
18	38950	G	2	20010512	E	Y	2	52	317	109	28	55
19	38945	D	1	20010215	F	Y	3	21	222	69	27	56
20	38952	F	1	20010419	F	Y	3	62	321	106	26	51
21	38941	A	1	20010422	G	Z	1	71	324	107	29	52
22	38944	D	1	20010504	G	Z	1	27	238	154	39	47
23	38953	F	1	20010217	H	Z	2	73	364	150	33	61
24	38947	G	1	20010318	H	Z	2	115	378	156	34	64
25	38938	A	2	20010504	J	Z	3	44	278	153	31	58
26	38956	B	1	20010509	J	Z	3	50	314	127	30	35
27	38948	G	2	20010419	J	Z	3	90	343	119	35	47

Transformations

- Box-Cox procedure was applied using all matrix data.
- Delta lead {DELETD “and top ring weight loss”} benefits from a natural logarithm transformation.
- No data transformations are indicated for other responses analyzed.

Precision Estimates

- Ln(delta lead): s_{pp} = 0.35; df = 14
- Upper bearing weight loss: s_{pp} = 38; df = 14
- Top ring weight loss: s_{pp} = 29; df = 14
- Cylinder liner wear: s_{pp} = 4; df = 14
- Oil consumption: s_{pp} = 9; df = 14

Where

- Spp = Pooled standard deviation (Root MSE from the fitted model) assuming that lab differences are minimized by an LTMS severity adjustment system.
- df = Degrees of freedom.

Ln(Delta Lead)
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, Technology by Base Oil interaction, and Lab were significant.
  - Root MSE from the model was 0.36 (14 df).
  - The R^2 for the model was 0.85.
  - Figure 1 illustrates the least squares means by oil.
  - Figure 2 shows the least squares means for labs.
  - From residual analyses:
    - Log transformation was appropriate.
    - The two observations with Oil D had large Studentized residuals.

Figure 1
Least Squares Means for Oils

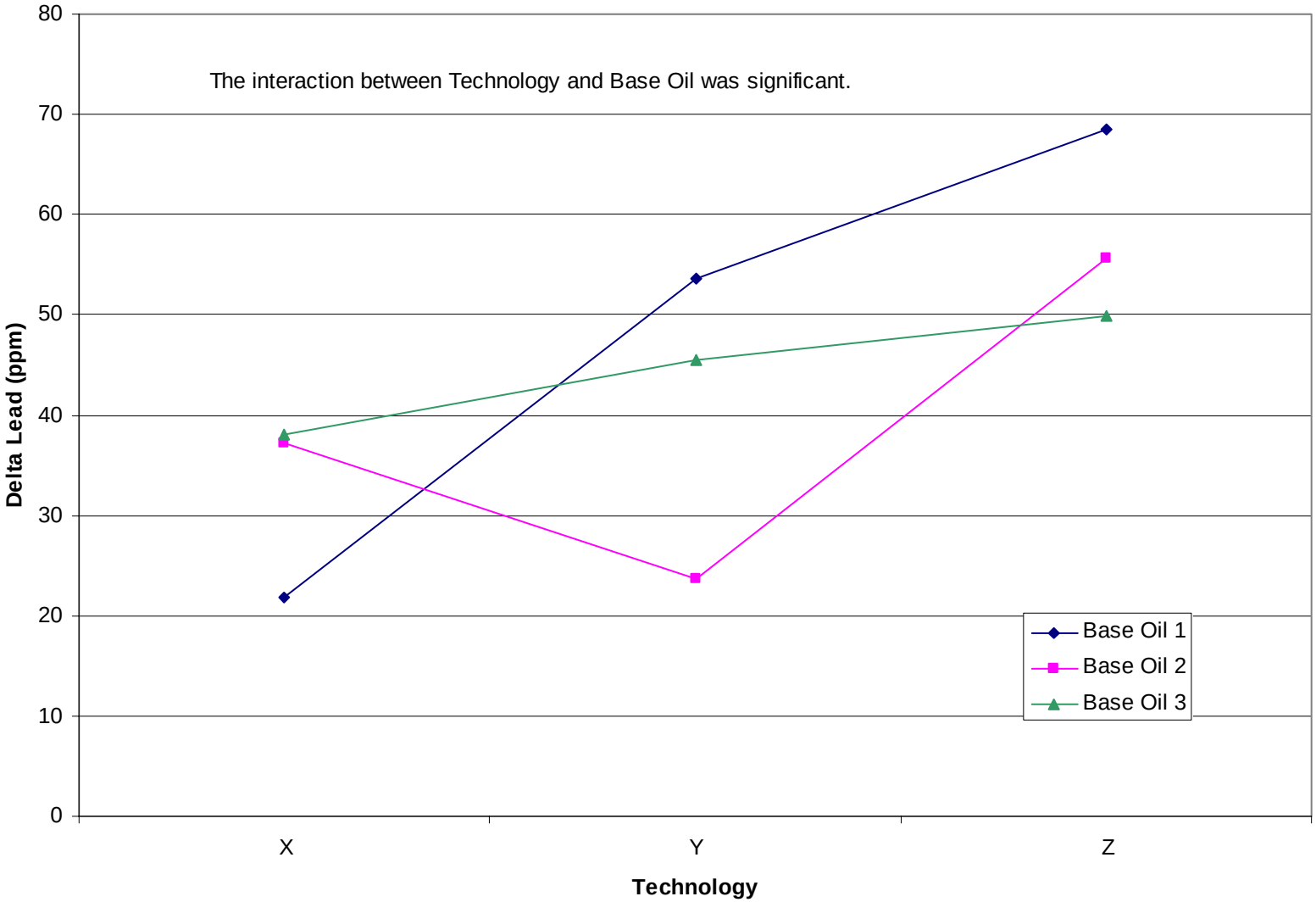
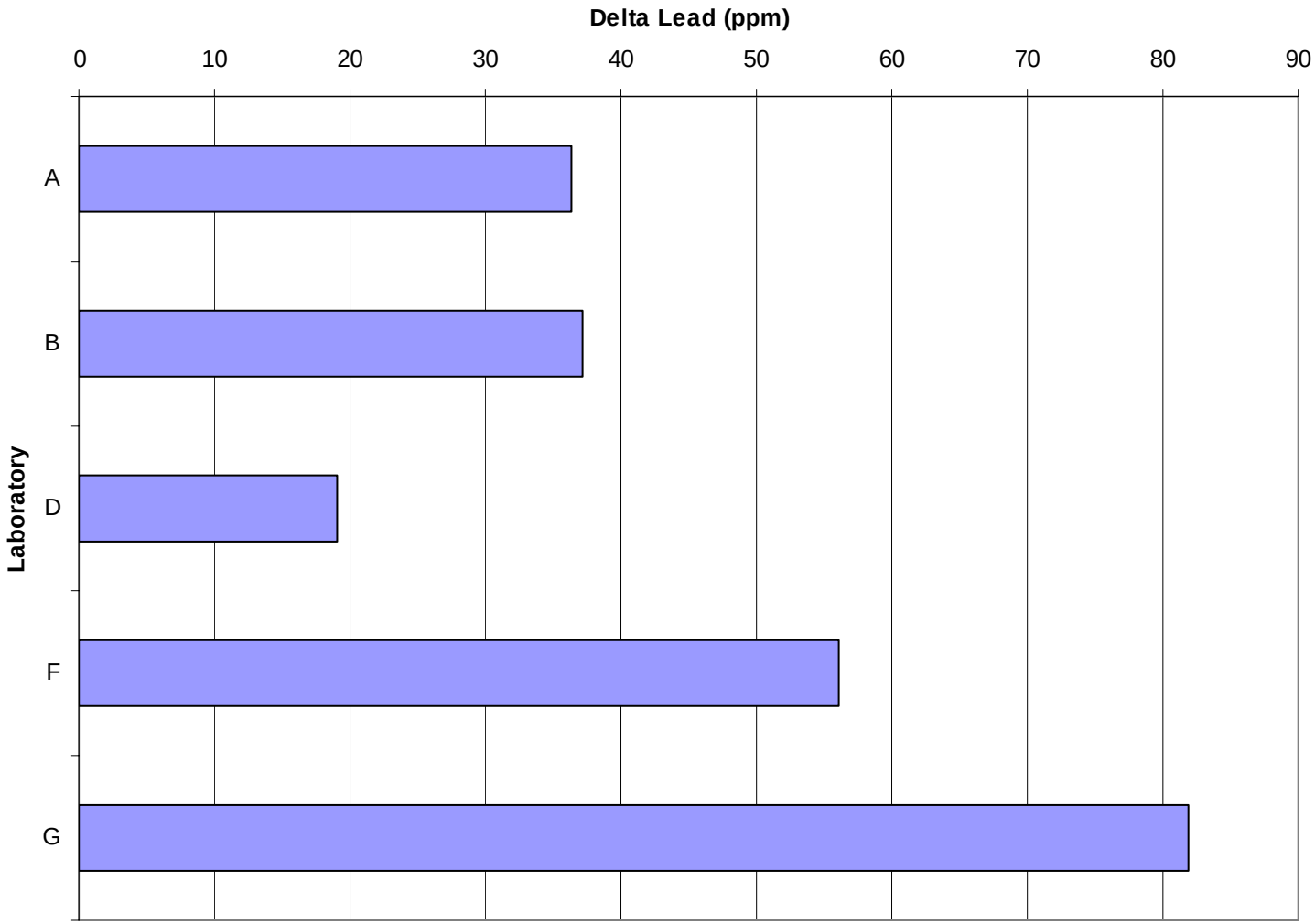


Figure 2
Least Squares Means for Labs



Upper Bearing Weight Loss
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 and Lab were significant.
  - Root MSE from the model was 38 (14 df).
  - The R^2 for the model was 0.83.
  - Figure 3 illustrates the least squares means by oil.
  - Figure 4 shows the least squares means for labs.
  - From residual analyses:
    - No observations had large Studentized residuals.

Figure 3
Least Squares Means for Oils

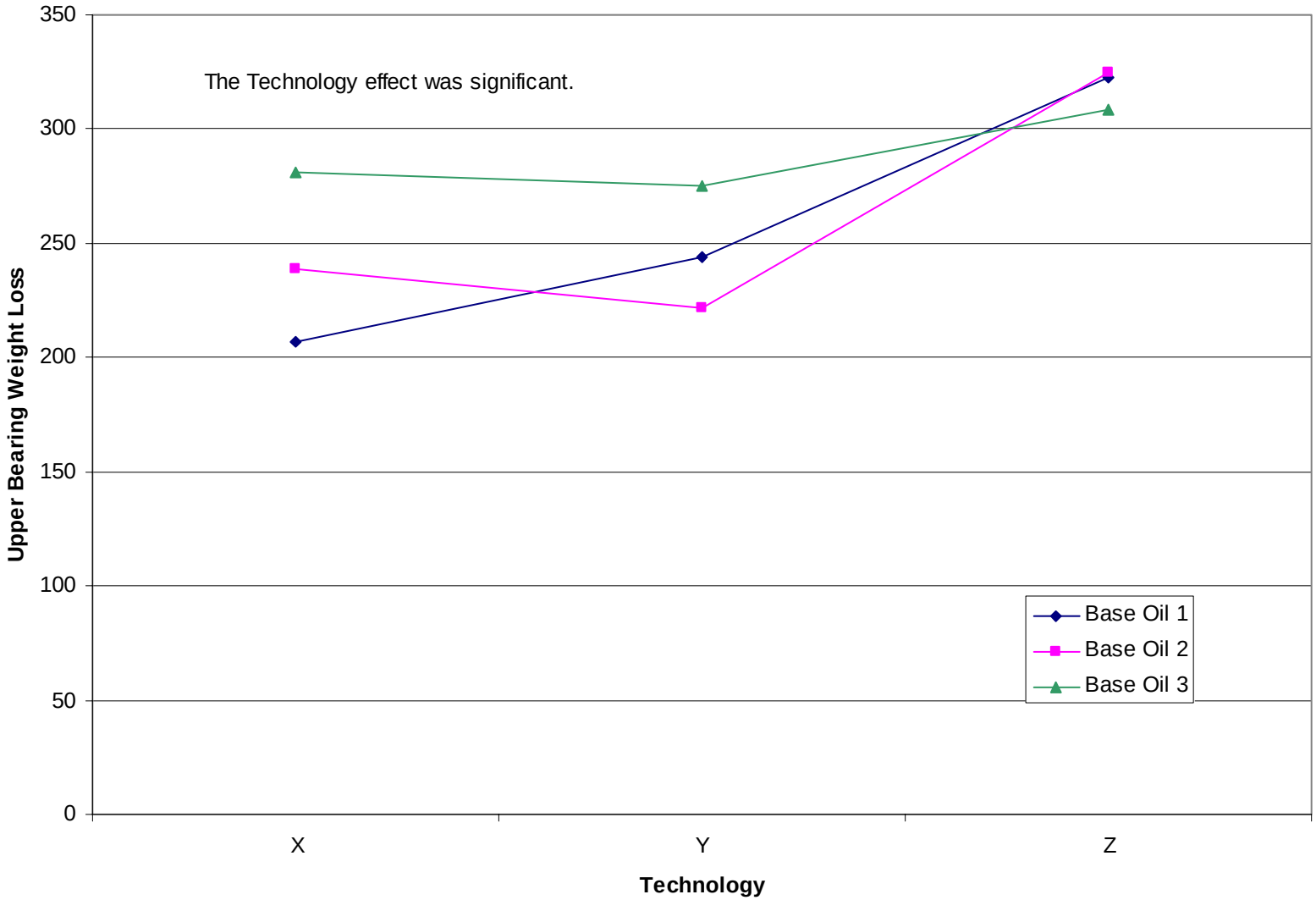
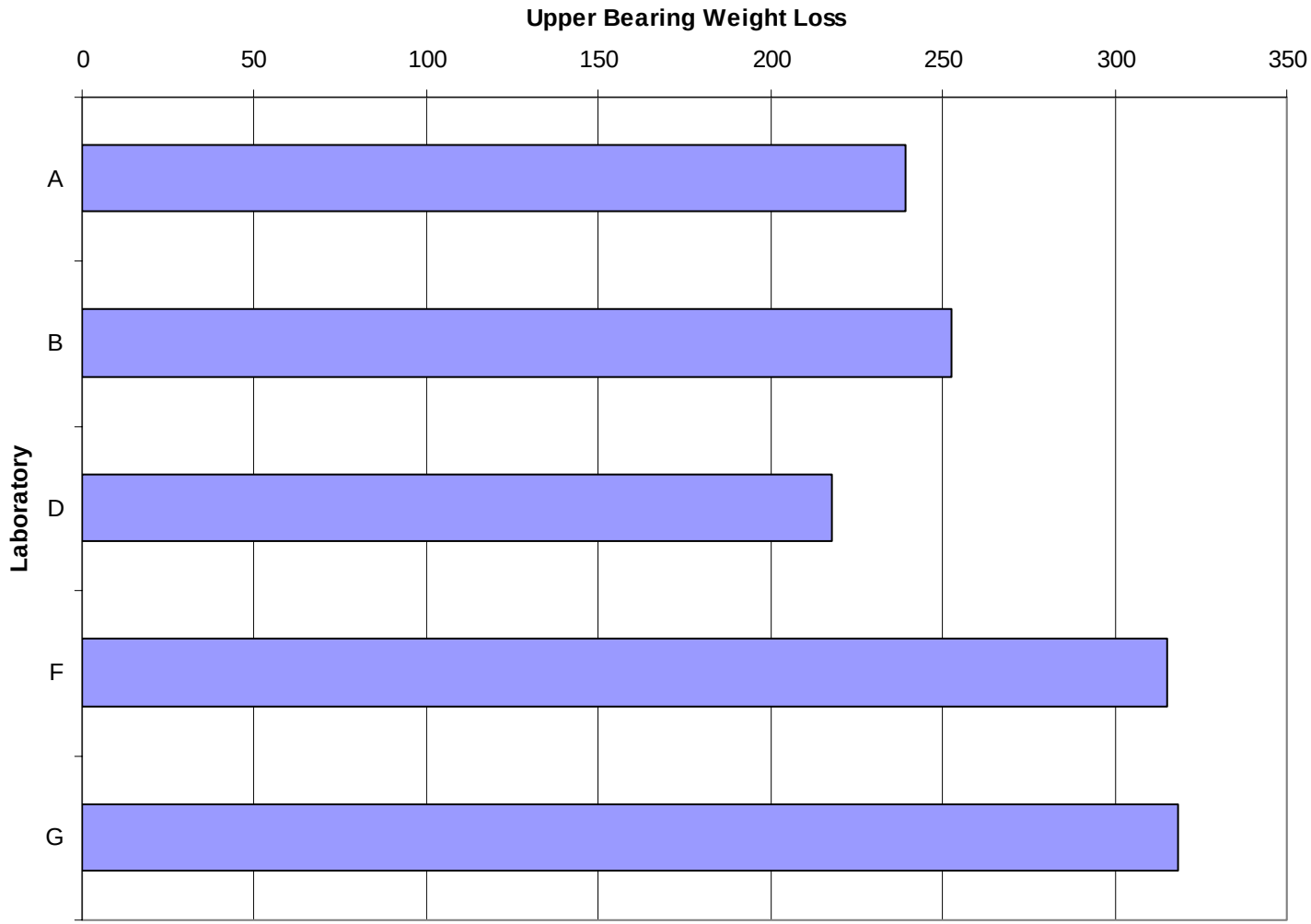


Figure 4
Least Squares Means for Labs

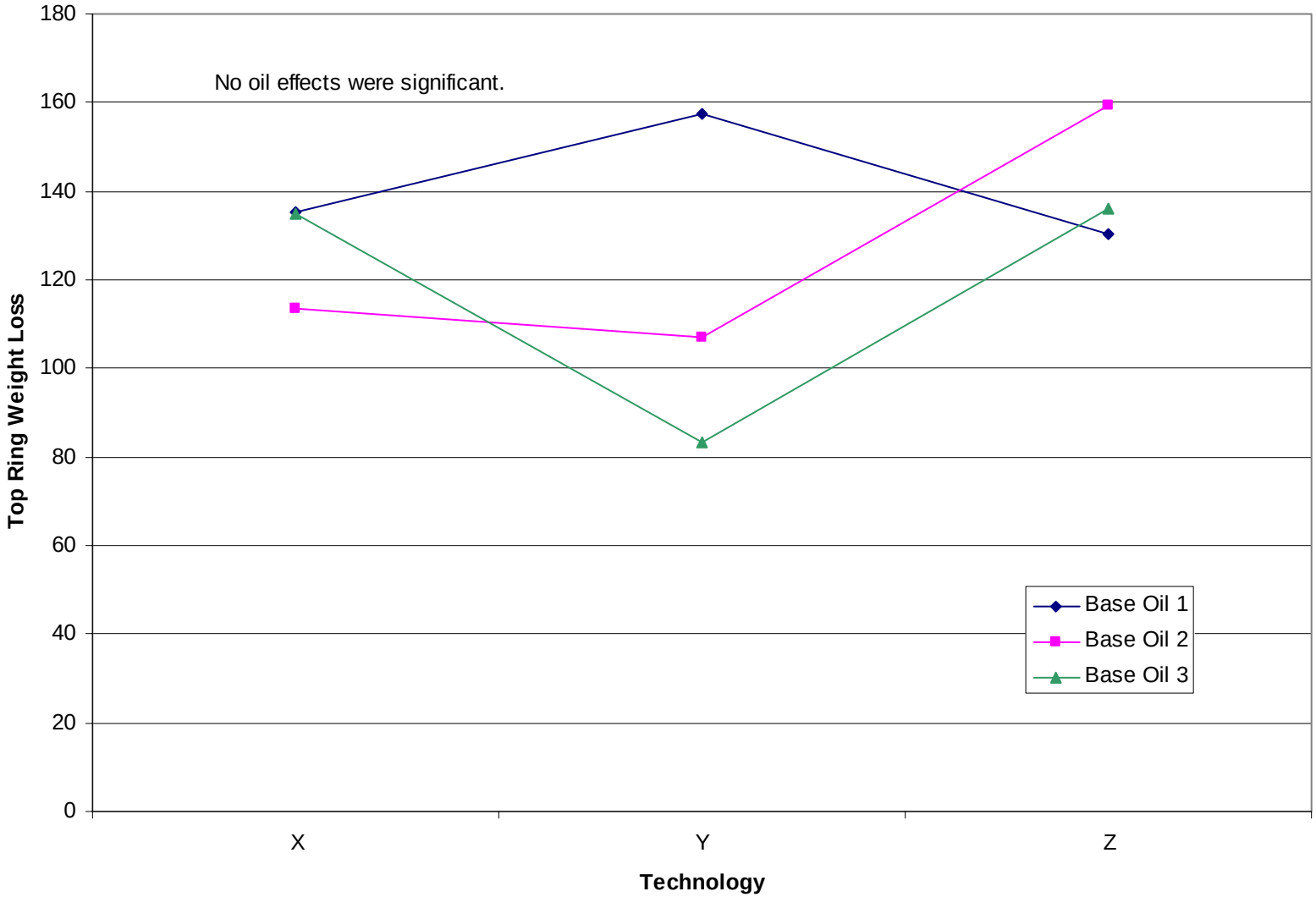


Top Ring Weight Loss
Summary of Model Fit

- Model factors include Laboratory (A,B,D,F,G), Technology (X,Y,Z), Base Oil (1,2,3) and Technology by Base Oil interaction.

- No effects were significant.
  - Root MSE from the model was 29 (14 df).
  - The R^2 for the model was 0.49.
  - Figure 5 illustrates the least squares means by oil.
  - From residual analyses:
    - There were no large Studentized residuals.

Figure 5
Least Squares Means for Oils

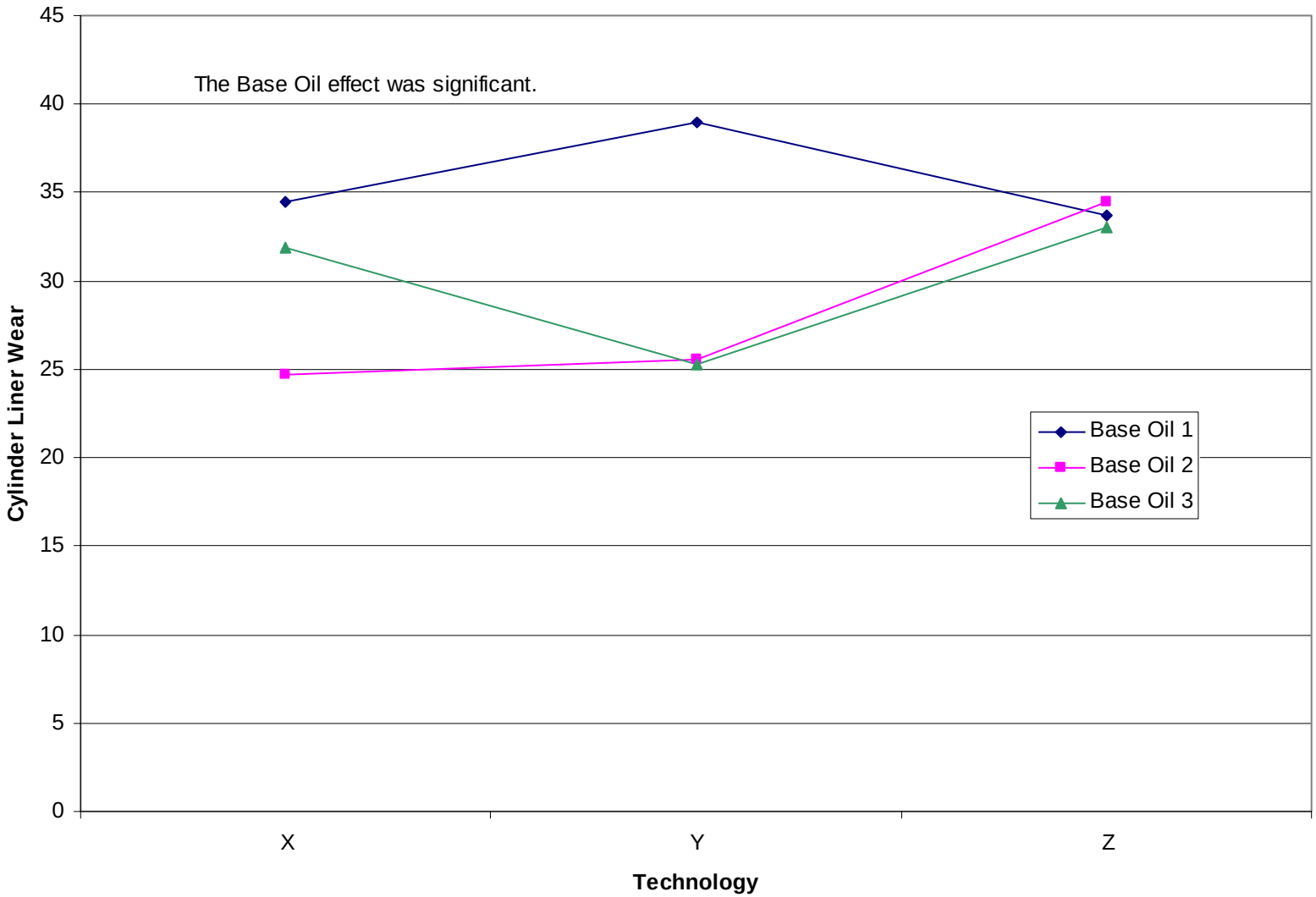


Cylinder Liner Wear
Summary of Model Fit

- Model factors include Laboratory (A,B,D,F,G), Technology (X,Y,Z), Base Oil (1,2,3) and Technology by Base Oil interaction.

- The Base Oil effect was significant.
  - Root MSE from the model was 4 (14 df).
  - The R^2 for the model was 0.69.
  - Figure 6 illustrates the least squares means by oil.
  - From residual analyses:
    - There were no large Studentized residuals.

Figure 6
Least Squares Means for Oils



Oil Consumption
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.

- No effects were significant.
  - Root MSE from the model was 9 (14 df).
  - The R^2 for the model was 0.58.
  - Figure 7 illustrates the least squares means by oil.
  - Figure 8 shows the least squares means by Lab.
  - From residual analyses:
    - The first test on Oil A at Lab F had a large Studentized residual.

Figure 7
Least Squares Means for Oils

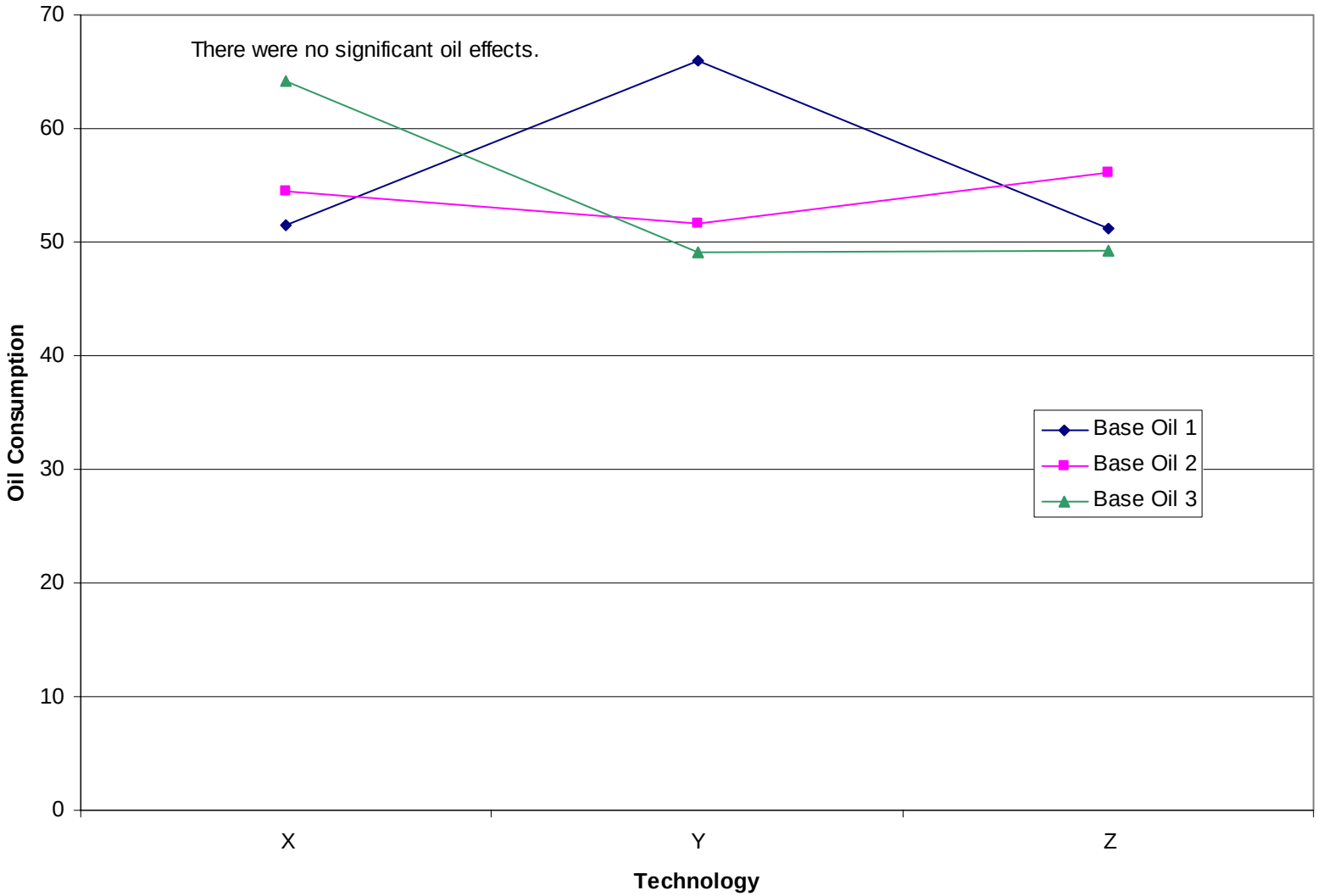


Figure 8
Least Squares Means for Labs