DU PONT
ESTABLISHED 1802
E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
WILMINGTON, DELAWARE 19898

ENGINEERING DEPARTMENT
LOUVIERS BUILDING

bcc: D. R. Diggs - Orchm,PetLab
A. J. Pahnke - Orchm,Wilm
E. S. Jacobs - Orchm,PetLab
W. H. Walsh
R. W. Kennard
D. W. Marquardt
J. M. Lucas
IC 31 - Applied Statistics

October 26, 1977

Dr. F. Gordon Hueter, Associate Director
Health Effects Research Laboratory, MD-51
Environmental Protection Agency
Research Triangle Park, NC 27711

Dear Dr. Hueter:

At the October 7, 1977, meeting of the EPA Science Advisory Board Subcommittee on Lead, Dr. Piomelli and others expressed concern that the slope of the blood lead-air lead relationship may be larger at low air lead levels (i.e. $\leq 1.0\ \mu g/m^3$) than at high air lead levels. Their concern was based on the predictions of the log-log model for the relationship between blood lead and air lead.

I have studied this question, comparing the results obtained when the Azar data are modeled using both a log-log model and a model similar to that used by Yankel and von Lindern in the Idaho study. Both models fit the data equally well; however, the log-log model predicts blood lead-air lead slopes for air lead levels $\leq 1.0\ \mu g/m^3$ which are two to three times larger than the predicted slopes of the other model.

In my judgment the large blood lead slope obtained with the log-log model at low air lead values is an artifact of the model and is not consistent with the actual situation. For instance, the log-log model predicts minus infinity blood lead for zero air lead (log-log form) or zero blood lead for zero air lead (exponential form). Neither result is correct, hence the log-log model cannot be considered valid for low air lead values.

It should be noted that originally we used the log-log model in the analysis of the Azar data so that we could compare our results with those of Goldsmith and Hexter and test the statistical significance of the blood lead-air lead relationship. We did not intend for this log-log model to be used for predicting at low air lead levels. Philosophically, the principal objective of any analysis is to find a model which gives a good fit to the data and is consistent with the biological response being studied. I believe the "lead exposure" model, which has been discussed in several of our reports on the Air Quality Criteria Document for Lead (see attached discussion) is the most realistic model for the Azar data.

A discussion of the analyses described above is attached. Please contact me if you have any questions concerning this work.

Very truly yours,

ENGINEERING SERVICE DIVISION

R. D. Snee

R. D. Snee, Consultant Supervisor
Applied Statistics

chm

Atch

cc: Dr. Sergio Piomelli
Dr. Victor Hasselblad

# TABLE 1

## Azar Blood Lead-Air Lead Data
## Air Lead Range 0.2-6.0 μg/m3
## Log-Log Model

$\ell n$ (Blood Pb) = $B_i$ + .1936 $\ell n$ (Air Pb)

| Group | B |
|---|---|
| Philadelphia Cab Drivers | 2.8869 |
| Starke, Florida | 2.8139 |
| Barksdale, Wisconsin | 2.6355 |
| Los Angeles Cab Drivers | 2.8439 |
| Los Angeles Office Workers | 2.7319 |

Model Goodness of Fit (1)

Res. Std. Dev. = .2640, $R^2$ = .48, $R_A^2$ = .46

| Air Pb (μg/m3 | Predicted Blood Lead (μg/100g) Phila. Cab | Starke | Barksdale | LA Cab | LA Office |
|---|---|---|---|---|---|
| 0 | 13.1 | 12.2 | 10.2 | 12.6 | 11.2 |
| 1 | 17.9 | 16.7 | 14.0 | 17.2 | 15.4 |
| 2 | 20.5 | 19.1 | 16.0 | 19.7 | 17.7 |
| 5 | 24.5 | 22.8 | 19.1 | 23.5 | 21.0 |
| Slope .2-1* | 6.0 | 5.6 | 4.8 | 5.8 | 5.2 |
| Slope .2-2* | 4.1 | 3.8 | 3.2 | 3.9 | 3.6 |

*Change in blood lead per unit change in air lead over the air lead range 0.2-1.0 and 0.2-2.0 μg/m3, respectively.

(1) $R^2$ = fraction of the total sum of squares explained by the model, $R_A^2$ = adjusted $R^2$ = fraction of the total variance explained by the model.

## TABLE 2

**Azar Blood Lead-Air Lead Data**
**Air Lead Range 0.2-6.0 $\mu g/m^3$**
**Log-Quadratic Model (1)**

$\ln$ (Blood Pb) = $B_i$ + .1752 Air Pb - .00866 $(\text{Air Pb})^2$

| Group | B |
|---|---|
| Philadelphia Cab Drivers | 2.6730 |
| Starke, Florida | 2.5834 |
| Barksdale, Wisconsin | 2.3933 |
| Los Angeles Cab Drivers | 2.4833 |
| Los Angeles Office Workers | 2.4922 |

Model Goodness of Fit (2)

Res. Std. Dev. = .2640, $R^2$ = .48, $R_A^2$ = .46

| Air Pb ($\mu g/m^3$) | Predicted Blood Lead ($\mu g/100g$) Phila. Cab | Starke | Barksdale | LA Cab | LA Office |
|---|---|---|---|---|---|
| 0 | 14.5 | 13.2 | 10.9 | 12.0 | 12.1 |
| 1 | 17.1 | 15.6 | 12.9 | 14.2 | 14.3 |
| 2 | 19.9 | 18.2 | 15.0 | 16.4 | 16.6 |
| 5 | 28.0 | 25.6 | 21.2 | 23.2 | 23.4 |
| Slope 0-1* | 2.6 | 2.4 | 2.0 | 2.2 | 2.2 |
| Slope 0-2* | 2.7 | 2.5 | 2.0 | 2.2 | 2.2 |

(1) Predicted maximum blood Pb at Air Pb = -(.1752)/(2(-.00866)) = 10.1 $\mu g/m^3$. Quadratic coefficient not statistically significant ($p > .50$).

* Change in blood lead per unit change in air lead over the air lead range 0-1 and 0-2 $\mu g/m^3$, respectively.

(2) $R^2$ = fraction of the total sum of squares explained by the model, $R_A^2$ = adjusted $R^2$ = fraction of the total variance explained by the model.

TEH 0470672

DUP050083489

TABLE 3

Azar Blood Lead-Air Lead Data
Air Lead Range 0.2-9.1 μg/m$^3$
Log-Quadratic Model (1)

$$\ln (\text{Blood Pb}) = B_i + .1795 (\text{Air Pb}) - .0156 (\text{Air Pb})^2$$

| Group | B |
|---|---|
| Philadelphia Cab Drivers | 2.7103 |
| Starke, Florida | 2.5889 |
| Barksdale, Wisconsin | 2.3849 |
| Los Angeles Cab Drivers | 2.6639 |
| Los Angeles Office Workers | 2.5473 |

Model Goodness of Fit (2)

Res. Std. Dev. = .2577, $R^2$ = .50, $R_A^2$ = .48

| Air Pb (μg/m$^3$) | Predicted Blood Lead (μg/100g) Phila. Cab | Starke | Barksdale | LA Cab | LA Office |
|---|---|---|---|---|---|
| 0 | 15.0 | 13.3 | 10.9 | 14.4 | 12.8 |
| 1 | 17.7 | 15.7 | 12.8 | 16.9 | 15.0 |
| 2 | 20.2 | 17.9 | 14.6 | 19.3 | 17.2 |
| 5 | 25.0 | 22.1 | 18.0 | 23.8 | 21.2 |
| 10 | 19.0 | 16.8 | 13.7 | 18.2 | 16.2 |
| Slope 0-1* | 2.7 | 2.4 | 1.9 | 2.5 | 2.2 |
| Slope 0-2* | 2.6 | 2.3 | 1.8 | 2.4 | 2.2 |

(1) Predicted maximum blood lead at air lead = -.1795/(2(-.0156)) = 5.8 μg/m$^3$. Quadratic coefficient statistically significant ($p < .05$)

* Change in blood lead per unit change in air lead over the air lead range 0-1 and 0-2 μg/m$^3$, respectively.

(2) $R^2$ = fraction of the total sum of squares explained by the model, $R_A^2$ = adjusted $R^2$ = fraction of the total variance explained by the model.

TABLE 4

Azar Blood Lead-Air Lead Data
Air Lead Range 0.2-9.1 μg/m3
Lead Exposure Model

$$\ln(\text{Blood Pb}) = 2.4965 + .2669\,(\text{Air Pb} + B_i)$$
$$\text{or}\quad \text{Blood Pb} = 12.1\,(\text{Air Pb} + B_i)^{.2669}$$

| Group | B |
|---|---|
| Philadelphia Cab Drivers | 6.00 |
| Starke, Florida | 1.46 |
| Barksdale, Wisconsin | .44 |
| Los Angeles Cab Drivers | 6.26 |
| Los Angeles Office Workers | 2.23 |
| Average | 3.28 |

Model Goodness of Fit (1)

Res. Std. Dev. = .2597, $R^2$ = .49, $R_A^2$ = .47

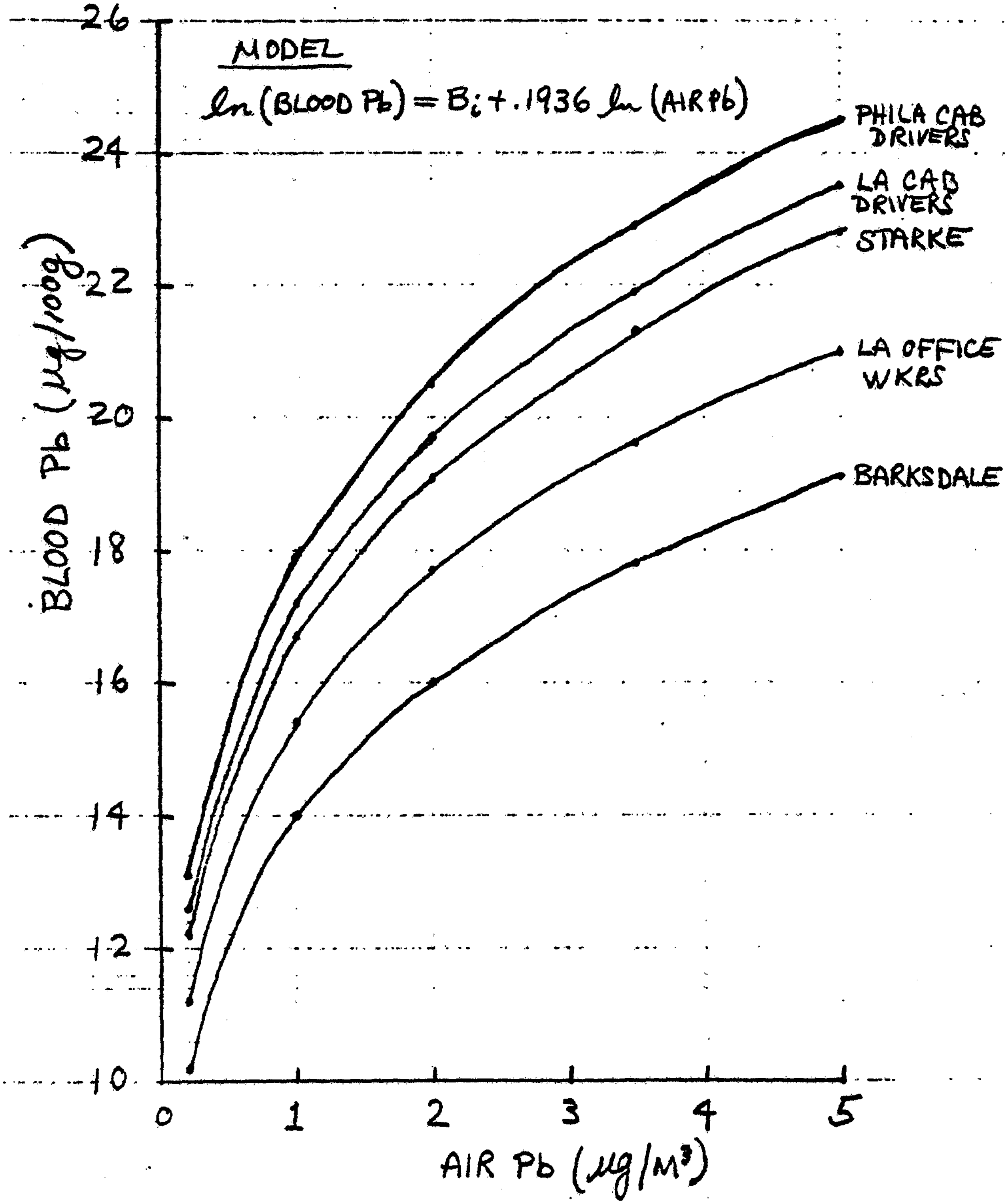
| Air Pb (μg/m3) | Predicted Blood Lead (μg/100g) Phila. Cab | Starke | Barksdale | LA Cab | LA Office |
|---|---|---|---|---|---|
| 0 | 19.6 | 13.4 | 9.8 | 19.8 | 15.0 |
| 1 | 20.4 | 15.4 | 13.4 | 20.6 | 16.6 |
| 2 | 21.1 | 16.9 | 15.4 | 21.3 | 17.8 |
| 5 | 23.0 | 20.0 | 19.1 | 23.2 | 20.6 |
| Slope 0-1* | 0.8 | 2.0 | 3.6 | 0.8 | 1.6 |
| Slope 0-2* | 0.8 | 1.8 | 2.8 | 0.8 | 1.4 |

*Change in blood lead per unit change in air lead over the air lead range 0-1 and 0-2 μg/m3, respectively.

(1) $R^2$ = fraction of the total sum of squares explained by the model, $R_A^2$ = adjusted $R^2$ = fraction of the total variance explained by the model.

FIGURE 1

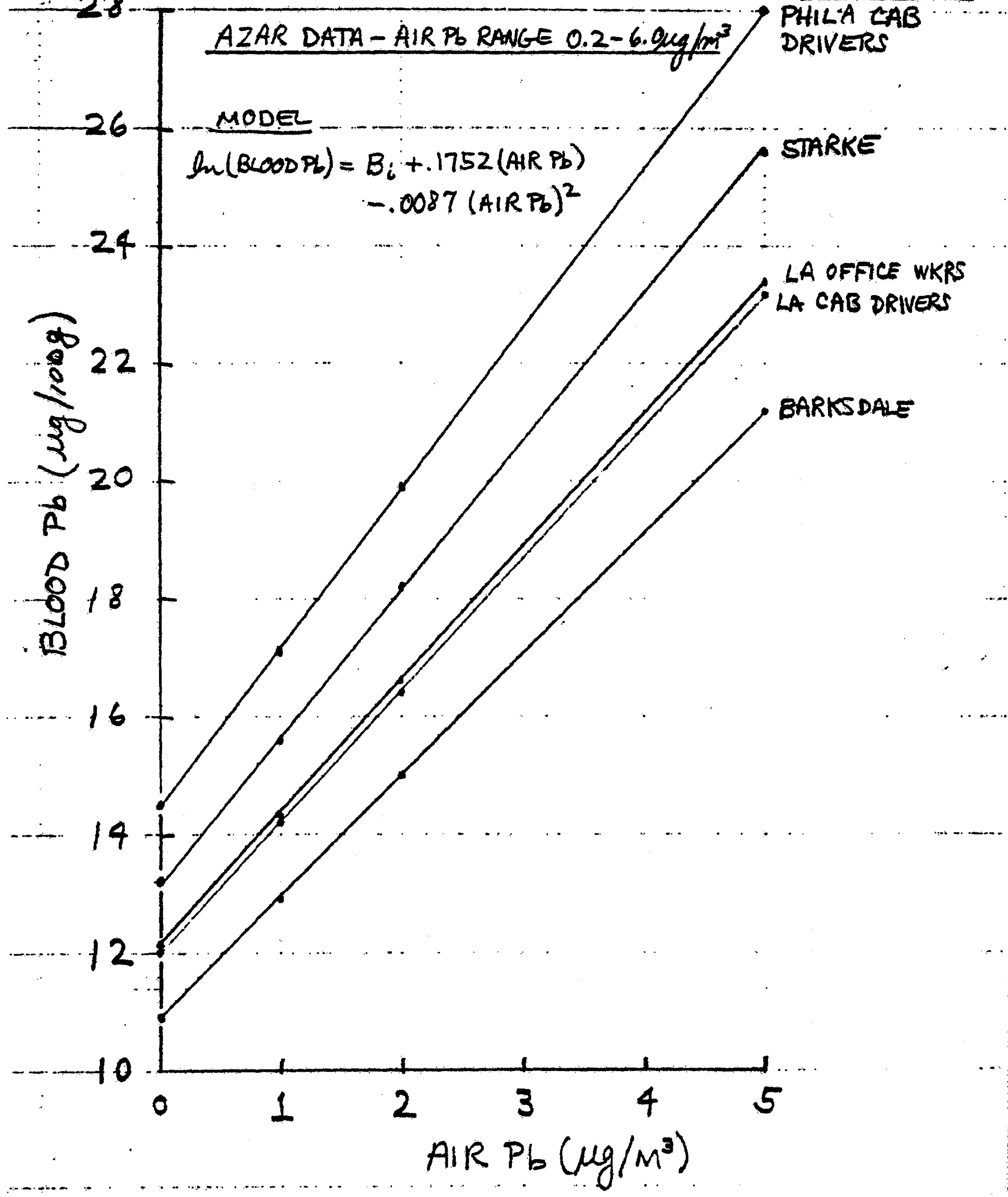
AZAR DATA - AIR LEAD RANGE 0.2-6.0 $\mu g/m^3$




TEH 0470675

DUP050083492

FIGURE 2




TEH 0470676

DUP050083493

FIGURE 3

AZAR DATA – AIR LEAD RANGE 0.2–9.1 μg/m³

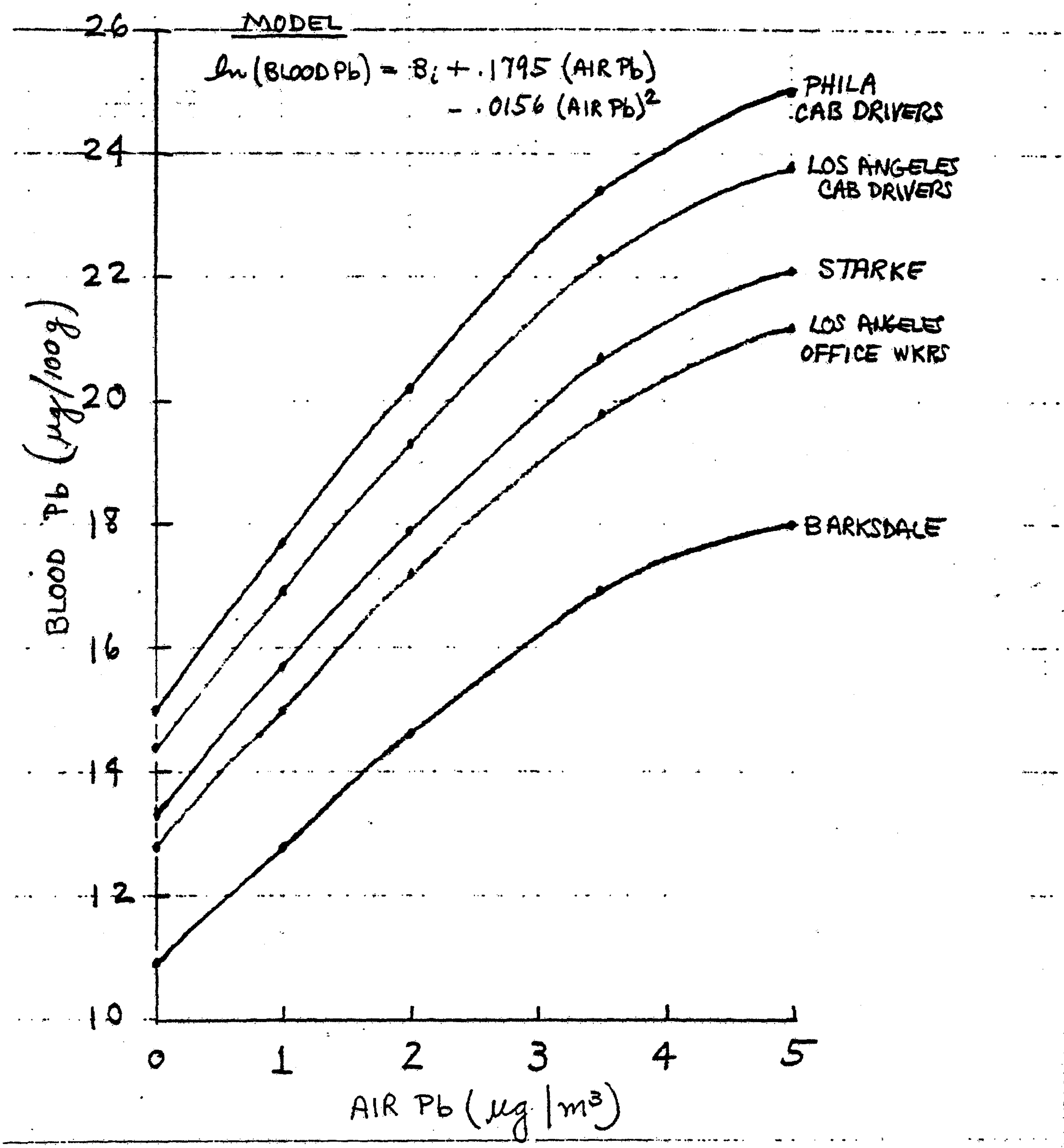


FIGURE 4

AZAR DATA - AIR LEAD RANGE 0.2-9.1 $\mu g/m^3$

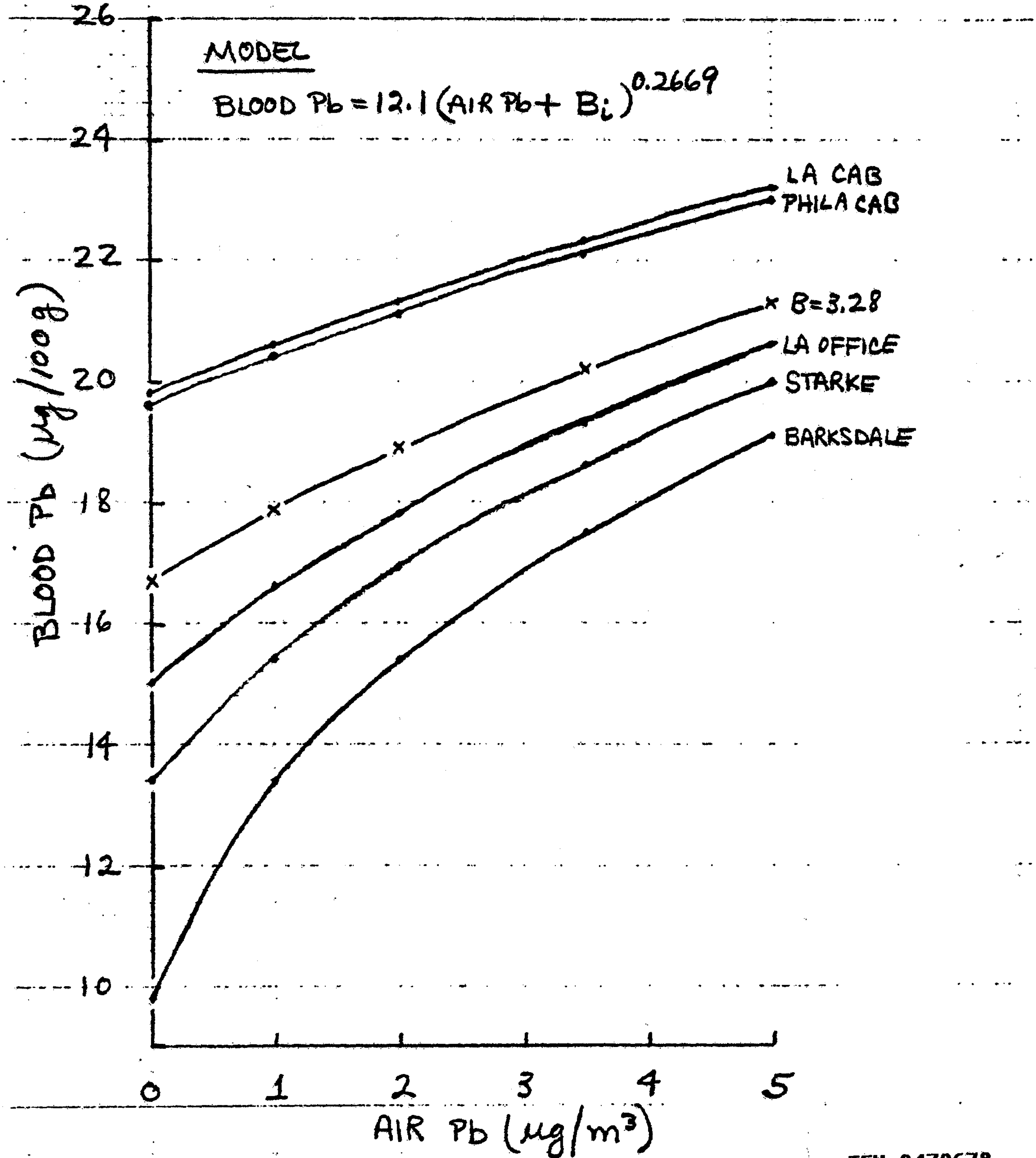
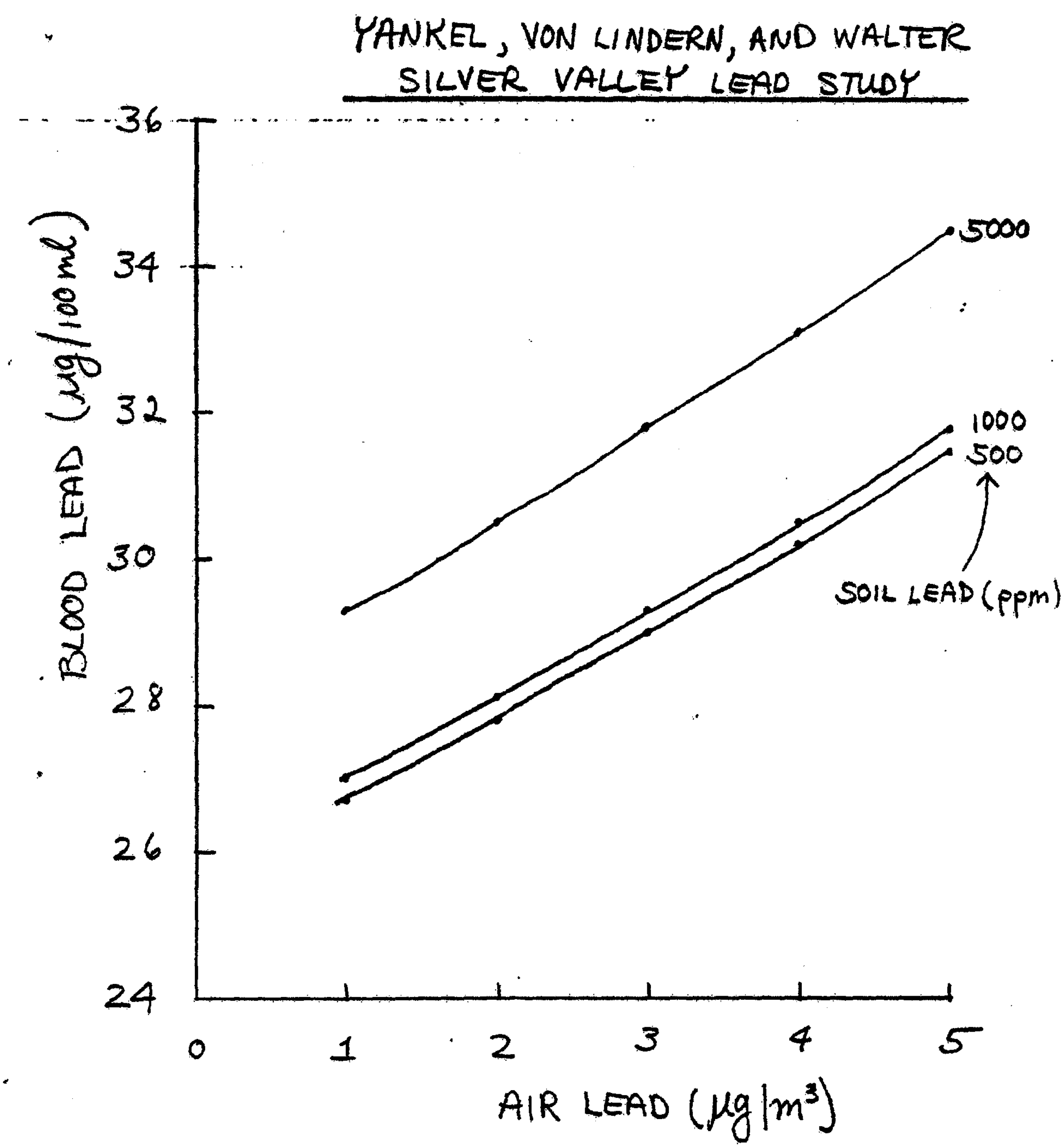


FIGURE 5




TEH 0470679

DUP050083496

Blood Pb = f $\left(\begin{array}{l}\text{on duty} \\ \text{+ Off Duty}\end{array}\right)$

DUP050083498

DELAWARE SECTION

# AMERICAN SOCIETY FOR QUALITY CONTROL