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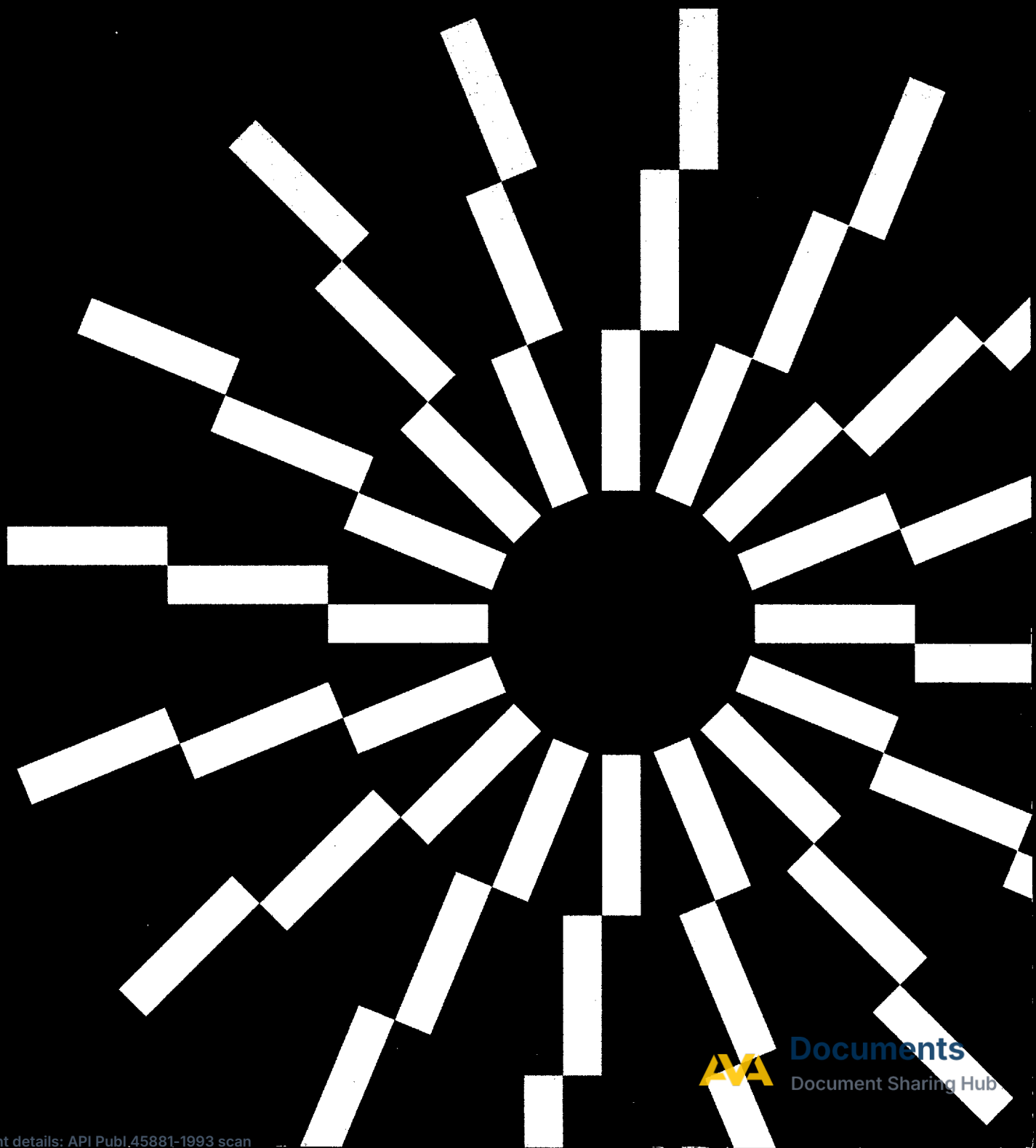
## Development of Fugitive Emission Factors and Emission Profiles for Petroleum Marketing Terminals



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### Volume II: Appendices



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# **Development of Fugitive Emission Factors and Emission Profiles for Petroleum Marketing Terminals**

## **Volume II: Appendices**

**Health and Environmental Sciences Department**  
**PUBLICATION NUMBER 45881**

**PREPARED UNDER CONTRACT BY:**

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**APPENDIX A**  
**STATISTICAL EVALUATIONS**  
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### A.1 Least Squares Estimate of a Linear Regression

The fitting of a line to describe the relationship between two variables (X and Y) via the method of least squares involves estimating a Y-intercept ( $\beta_0$ ) and a slope ( $\beta_1$ ). The method of least squares chooses the parameter estimates for  $\beta_0$  and  $\beta_1$ , as those values which minimize the sum of squares of the vertical distances from the data points to the presumed regression line. In addition, these parameters are estimated so that the average residual ( $r_i = Y_i - \beta_0 - \beta_1 X_i$ ,  $i=1, \dots, n$ ) is zero.

Let

$$Y_i = \text{Log}_{10} (\text{Leak Rate determined by bagging component } i),$$

and

$$X_i = \text{Log}_{10} (\text{Maximum Screening Value for component } i).$$

So that:

$$\text{Log}_{10} (\text{Leak Rate}) = \beta_0 + \beta_1 \text{Log}_{10} (\text{Screening Value}),$$

or

$$Y_i = \beta_0 + B_1 X_i$$

describes the regression line.

Then the least square regression estimators can be given by:

$$\hat{\beta}_1 = \frac{(\bar{XY}) - (\bar{X})(\bar{Y})}{\bar{X}^2 - (\bar{X})^2},$$

and

$$\hat{\beta}_0 = \bar{Y} - \hat{\beta}_1 \bar{X},$$

where:

$$\bar{X} = \frac{\sum X_i}{n}$$

$$\bar{Y} = \frac{\sum Y_i}{n}$$

$$\bar{XY} = \frac{\sum X_i Y_i}{n}$$

$$\bar{X}^2 = \frac{\sum X_i^2}{n}$$

$n$  = number of parameters.

Once these have been calculated, then the Mean Squared Error (MSE) can be given by:

$$MSE = \frac{1}{n-2} \sum_{i=1}^n r_i^2,$$

where:

$$r_i = Y_i - \hat{\beta}_0 - \hat{\beta}_1 X_i$$

The MSE is a measure of how well the data fit the predicted values of the least-squares regression equation.

## A.2 Scale-Bias Correction Factor

In order to predict the mean emission rate for a given screening value, one must first transform the results of the least-squares analysis from log-log space back to arithmetic scales. To do this, a scale bias correction factor (SBCF) is required to obtain the following predictive correlation equation:

$$\text{Mean Leak Rate} = \text{SBCF} \times 10^{\hat{a}_0} \times (\text{Screening Value})^{\hat{a}_1}$$

The SBCF is obtained by summing a sufficient number (generally 10-15) of terms of the infinite series given below. Specifically, the SBCF is estimated by:

$$\text{SBCF} = 1 + \frac{(m-1)t}{m} + \frac{(m-1)^2 t^2}{m^2 2! (m+1)} + \frac{(m-1)^3 t^3}{m^3 3! (m+1)(m+3)} + \dots,$$

where:

$$t = \left( \frac{\text{MSE}}{2} (\ln 10)^2 \right)$$

and

$$m = \text{number of sources bagged} - 1.$$

The equation for the mean emission rate, given above, is the best, unbiased estimator and also provides an efficient estimate for the mean of a lognormal distribution [Finney (1941), Atchinson (1955)].

### A.3 Standard Error

The standard error of an estimate is a statistical measure of the amount of variation of the actual values of the dependent variable from their predicted values, as estimated by the regression equation. Its formula may be written:

$$SE_Y = \sqrt{MSE}$$

The  $SE_Y$  possesses the same units as the response variable,  $Y_i$  (for emission rates, this is lbs/hr). The standard error is also used in developing confidence intervals around the mean predicted values.

### A.4 Confidence Intervals

A confidence interval for a parameter  $\Theta$  is an interval:

$$a < \Theta < b,$$

where:

$a$  and  $b$  are numbers calculated partially from sample data, within which we feel reasonably certain the unknown parameter lies. A confidence interval is derived from a probability statement that involves the unknown parameter  $\Theta$ . These confidence intervals should be interpreted as follows:

When we state that the parameter falls within the computed confidence limits, we expect to be correct about  $100 \times (1-\alpha)$  percent of the time.

For example, suppose a sample is drawn from some population and a 95% confidence interval ( $\alpha = 0.05$ ) is computed for some parameter, say the mean. If a 100 samples are drawn from that population, and 100 of these confidence intervals for the mean are computed, then 95 of these intervals should contain the true population mean  $\Theta$  as an interior point.

Confidence intervals for the intercept of the least-squares regression equation can be specified as:

$$\hat{\beta}_0 \pm t_{(1 - \alpha/2, n - 2)} \hat{\sigma}_{\beta_0}$$

Confidence intervals for the slope of the least-squares regression equation can be specified as:

$$\hat{\beta}_1 \pm t_{(1 - \alpha/2, n - 2)} \hat{\sigma}_{\beta_1}$$

where:

$$SXX = \sum (X_i - \bar{X})^2$$

$$\bar{X} = \frac{\sum X_i}{n}$$

$$MSE = \frac{\sum (Y_i - \hat{\beta}_0 - \hat{\beta}_1 X_i)^2}{n - 2}$$

$$\hat{\sigma}_{\beta_0} = \sqrt{MSE} \left( \frac{1}{n} + \frac{(\bar{X})^2}{SXX} \right)^{1/2}$$

$$\hat{\sigma}_{\beta_1} = \left( \frac{MSE}{SXX} \right)^{1/2}$$

and

$$t_{\left(1 - \frac{\alpha}{2}, n-2\right)}$$

is the  $1 - \alpha/2$  probability point of the student's  $t$  distribution with  $(n-2)$  degrees of freedom.

Confidence intervals for the predicted mean value of  $Y$  for a given  $X_k$  can be specified as:

$$\hat{Y}_K \pm t_{(1 - \alpha/2, n - 2)} \hat{\sigma}_{Y_K} \quad ,$$

where:

$$\hat{\sigma}_{Y_K} = SE_Y \left( \frac{1}{n} + \frac{(X_K - \bar{X})^2}{\sum (X_i - \bar{X})^2} \right)^{1/2}$$

$$\hat{Y}_K = \hat{\beta}_0 + \hat{\beta}_1 X_K \quad ,$$

and

$$SE_Y = \sqrt{MSE} \quad \text{as given in Appendix A.1.}$$

The confidence intervals for the predicted values are smallest when  $X_k = \bar{X}$  and increase as  $X_k$  moves away from  $\bar{X}$  in either direction. That is, the greater the distance an  $X_k$  is (in either direction) from  $\bar{X}$ , the larger the expected error is when predicting the mean value of  $Y$  at  $X_k$ .

## A.5 Correlation Coefficient

The sample correlation coefficient is a statistical measure of the linear relationship between two variables. The correlation between two variables, X and Y, is computed as:

$$r_{XY} = \frac{\sum (X_i - \bar{X}) \cdot (Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \cdot \sum (Y_i - \bar{Y})^2}},$$

and is bounded:

$$-1 \leq r_{XY} \leq 1.$$

The correlation coefficient squared ( $r_{XY}^2$ ) can be interpreted as the fraction of the total variation which is explained by the least-squares regression line. In other words,  $r_{XY}$  measures how well the least-squares regression line fits the sample data. If the total variation is all explained by the regression line, i.e., if  $r_{XY}^2 = 1$  or  $r_{XY} = \pm 1$ , we say there is a perfect linear correlation. On the other hand, if there is no linear relationship between sample values of X and Y, then  $r_{XY}$  will have a value near zero. In addition, if  $r_{XY} > 0$ , then the response variable (Y) increases as the independent variable (X) does. If  $r_{XY} < 0$ , the response decreases as the independent variable increases.

## A.6 Wilcoxon Rank Sum Test

The Wilcoxon rank sum test for paired data compares two population distributions by ranking the absolute magnitudes of the differences of these paired observations. Under the null hypothesis of no difference in the distributions A and B, the expected number of negative differences between pairs would be  $n/2$  (where  $n$  is the number of data pairs), and positive and negative differences of equal absolute magnitude should occur with equal probability. Thus, if one were to order the differences according to their absolute

values and rank them from smallest to largest, the expected rank sums for the positive and negative differences would be equal. Large departures of the rank sum of the positive (or negative) differences from its expected value would provide evidence to indicate a difference between the distribution of the responses for A and B.

Let populations A and B be the logarithm of the leak rates determined by bagging and those determined by the established EPA-SOCMI equations respectively. Say, for example, five baggings were done. For the given screening values, five responses can also be calculated from the EPA-SOCMI regression equation for a particular source, say pump seals:

$$\text{Log}_{10}(\text{Leak Rate}) = -5.34 + 0.898 \text{ Log}_{10}(\text{Screening Value})$$

These observed and calculated responses, the differences of the two, and the ranking of the magnitude of these differences are given below.

| Measured Values       |                 | Calculated Values<br>from<br>EPA-SOCMI Equations |       | Difference | Rank |
|-----------------------|-----------------|--------------------------------------------------|-------|------------|------|
| Log (Screening Value) | Log (Leak Rate) | Log (Leak Rate)                                  |       |            |      |
| 1.78                  | -3.53           | -3.68                                            | 0.15  |            | 1    |
| 1.63                  | -4.06           | -3.87                                            | -0.19 |            | 2    |
| -1.39                 | -6.79           | -6.59                                            | -0.20 |            | 3    |
| 1.84                  | -3.53           | -3.74                                            | 0.21  |            | 4    |
| -0.82                 | -6.42           | -6.08                                            | -0.34 |            | 5    |

As stated, the null hypothesis is that the populations are equal, and the alternative hypothesis is that they're not equal, which implies a 2-tailed test. From a Wilcoxon Table, the critical value  $T_0$  for a 2-tailed test with  $\alpha = 0.10$  and  $n=5$  is  $T_0 = 1$ . Hence, reject the null hypothesis if the Wilcoxon statistic,  $T \leq 1$ . The sum of the ranks of the positive differences is 5 and of the negative differences is 10. The smaller of the two

rank sums will be the Wilcoxon statistic,  $T$ . Since  $5 > T_0$ , we cannot reject  $H_0$ , the hypothesis that the population distributions are different.

#### A.7 Regression Estimates for Emission Rates from SOCM Processes (U.S. EPA, 1988)

- Flanges

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (3.731)(10^{-5})(\text{OVA\_SV})^{0.82}$$

Least-Square Results (in log-log space):

$$\text{Log}_{10}(\text{Emission Rate}) = -4.73 + 0.818 \text{Log}_{10}(\text{OVA Screening Value});$$

$$\text{Correlation Coefficient } (r) = 0.77;$$

$$\text{Number of Data Pairs} = 52;$$

$$\text{Standard Error of Estimate} = 0.52;$$

$$95\% \text{ Confidence Interval for Intercept } (-5.9, -4.5);$$

$$95\% \text{ Confidence Interval for Slope} = (0.68, 1.08); \text{ and}$$

$$\text{Scale Bias Correction Factor} = 2.02.$$

- Valves - Light Liquid Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (3.74)(10^{-4})(\text{OVA\_SV})^{0.47}$$

Least-Square Results (in log-log space):

$$\text{Log}_{10}(\text{Emission Rate}) = -4.342 + 0.470 \text{Log}_{10}(\text{OVA Screening Value});$$

$$\text{Correlation Coefficient } (r) = 0.47;$$

$$\text{Number of Data Pairs} = 129;$$

$$\text{Standard Error of Estimate} = 0.902;$$

$$95\% \text{ Confidence Interval for Intercept } (-5.0, -3.7);$$

$$95\% \text{ Confidence Interval for Slope} = (0.31, 0.63); \text{ and}$$

$$\text{Scale Bias Correction Factor} = 8.218.$$

- Valves - Gas Vapor Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (1.68)(10^{-5})(\text{OVA\_SV})^{0.69}$$

Least-Square Results (in log-log space):

$\text{Log}_{10}(\text{Emission Rate}) = -5.35 + 0.693 \text{ Log}_{10}(\text{OVA Screening Value})$ ;

Correlation Coefficient (r) = 0.66;

Number of Data Pairs = 99;

Standard Error of Estimate = 0.716;

95% Confidence Interval for Intercept (-6.0, -4.7);

95% Confidence Interval for Slope = (0.53, 0.85) ; and

Scale Bias Correction Factor = 3.766.

- Pump Seals - Light Liquid Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (1.34)(10^{-5})(\text{OVA\_SV})^{0.898}$$

Least-Square Results (in log-log space):

$\text{Log}_{10}(\text{Emission Rate}) = -5.34 + 0.898 \text{ Log}_{10}(\text{OVA Screening Value})$ ;

Correlation Coefficient (r) = 0.81;

Number of Data Pairs = 52;

Standard Error of Estimate = 0.650;

95% Confidence Interval for Intercept (-6.1, -4.6);

95% Confidence Interval for Slope = (0.71, 1.1) ; and

Scale Bias Correction Factor = 2.932.

## A.8 Regression Estimates for Emission Rates from Refinery Processes (Radian, 1980 and Radian, 1989)

- Flanges

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (3.730)(10^{-5})(\text{OVA\_SV})^{0.82}$$

$$\text{Emission Rate} = (1.275)(10^{-5})(\text{TLV\_SV})^{0.88}$$

Least-Square Results (in log-log space) using OVA Screening Instrument:

$$\text{Log}_{10}(\text{Emission Rate}) = -4.73 + 0.818 \text{Log}_{10}(\text{OVA Screening Value});$$

95% Confidence Interval for Intercept (-5.43, -4.03); and

95% Confidence Interval for Slope = (0.63, 1.00).

Least-Square Results (in log-log space) using TLV Screening Instrument:

$$\text{Log}_{10}(\text{Emission Rate}) = -5.20 + 0.88 \text{Log}_{10}(\text{TLV Screening Value});$$

Correlation Coefficient (r) = 0.77;

Number of Data Pairs = 52;

Standard Error of Estimate = 0.52;

95% Confidence Interval for Intercept (-5.9, -4.5);

95% Confidence Interval for Slope = (0.68, 1.08); and

Scale Bias Correction Factor = 2.02.

- Valves - Light Liquid Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (8.46)(10^{-5})(\text{OVA\_SV})^{0.74}$$

$$\text{Emission Rate} = (3.19)(10^{-5})(\text{TLV\_SV})^{0.80}$$

Least-Square Results (in log-log space) using OVA Screening Instrument:

$$\text{Log}_{10}(\text{Emission Rate}) = -4.48 + 0.74 \text{Log}_{10}(\text{OVA Screening Value});$$

95% Confidence Interval for Intercept (-4.88, -4.08); and

95% Confidence Interval for Slope = (0.641, 0.845).

Least-Square Results (in log-log space) using TLV Screening Instrument:

$$\text{Log}_{10}(\text{Emission Rate}) = -4.90 + 0.80 \text{ Log}_{10}(\text{TLV Screening Value});$$

$$\text{Correlation Coefficient } (r) = 0.79;$$

$$\text{Number of Data Pairs} = 119;$$

$$\text{Standard Error of Estimate} = 0.60;$$

$$95\% \text{ Confidence Interval for Intercept } (-5.3, -4.5);$$

$$95\% \text{ Confidence Interval for Slope} = (0.69, 0.91); \text{ and}$$

$$\text{Scale Bias Correction Factor} = 2.53.$$

- Valves - Gas Vapor Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (2.16)(10^{-6})(\text{OVA\_SV})^{1.14}$$

$$\text{Emission Rate} = (4.81)(10^{-7})(\text{TLV\_SV})^{1.23}$$

Least-Square Results (in log-log space) using OVA Screening Instrument:

$$\text{Log}_{10}(\text{Emission Rate}) = -6.35 + 1.14 \text{ Log}_{10}(\text{OVA Screening Value});$$

$$95\% \text{ Confidence Interval for Intercept } (-7.45, -5.25); \text{ and}$$

$$95\% \text{ Confidence Interval for Slope} = (0.92, 1.37).$$

Least-Square Results (in log-log space) using TLV Screening Instrument:

$$\text{Log}_{10}(\text{Emission Rate}) = -7.00 + 1.23 \text{ Log}_{10}(\text{TLV Screening Value});$$

$$\text{Correlation Coefficient } (r) = 0.76;$$

$$\text{Number of Data Pairs} = 79;$$

$$\text{Standard Error of Estimate} = 0.78;$$

$$95\% \text{ Confidence Interval for Intercept } (-8.1, -5.9);$$

$$95\% \text{ Confidence Interval for Slope} = (0.99, 1.47); \text{ and}$$

$$\text{Scale Bias Correction Factor} = 4.81.$$

- Pump Seals - Light Liquid Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (5.022)(10^{-4})(\text{OVA\_SV})^{0.771}$$

$$\text{Emission Rate} = (1.823)(10^{-4})(\text{TLV\_SV})^{0.830}$$

Least-Square Results (in log-log space) using OVA Screening Instrument:

$\text{Log}_{10}(\text{Emission Rate}) = -3.96 + 0.771 \text{Log}_{10}(\text{OVA Screening Value})$ ;  
 95% Confidence Interval for Intercept (-3.46, -4.46); and  
 95% Confidence Interval for Slope = (0.67, 0.87).

Least-Square Results (in log-log space) using TLV Screening Instrument:

$\text{Log}_{10}(\text{Emission Rate}) = -4.40 + 0.830 \text{Log}_{10}(\text{TLV Screening Value})$ ;  
 Correlation Coefficient (r) = 0.68;  
 Number of Data Pairs = 259;  
 Standard Error of Estimate = 0.760  
 95% Confidence Interval for Intercept (-4.9, -3.9);  
 95% Confidence Interval for Slope = (0.72, 0.94) ; and  
 Scale Bias Correction Factor = 4.58.

#### A.9 Regression Estimates for Petroleum Marketing Terminals

- Flanges (Connectors) - All Services

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (4.652)(10^{-5})(\text{OVA\_SV})^{0.426}$$

Least-Square Results (in log-log space):

$\text{Log}_{10}(\text{Emission Rate}) = -4.73 + 0.426 \text{Log}_{10}(\text{OVA Screening Value})$ ;  
 Correlation Coefficient (r) = 0.41;  
 Number of Data Pairs = 36;  
 Standard Error of Estimate = 0.604;  
 95% Confidence Interval for Intercept (-5.48 -3.98);  
 95% Confidence Interval for Slope = (0.097, 0.754); and  
 Scale Bias Correction Factor = 2.50.

- Valves - Light Liquid Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (6.34)(10^{-6})(\text{OVA\_SV})^{0.708}$$

Least-Square Results (in log-log space):

$\text{Log}_{10}(\text{Emission Rate}) = -5.433 + 0.708 \text{ Log}_{10}(\text{OVA Screening Value})$ ;  
 Correlation Coefficient (r) = 0.845;  
 Number of Data Pairs = 46;  
 Standard Error of Estimate = 0.460;  
 95% Confidence Interval for Intercept (-5.81, -5.06);  
 95% Confidence Interval for Slope = (0.57, 0.84); and  
 Scale Bias Correction Factor = 1.72

- Loading Arm Valves - All Services

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (8.24)(10^{-6})(\text{OVA\_SV})^{0.955}$$

Least-Square Results (in log-log space):

$\text{Log}_{10}(\text{Emission Rate}) = -5.469 + 0.955 \text{ Log}_{10}(\text{OVA Screening Value})$ ;  
 Correlation Coefficient (r) = 0.825;  
 Number of Data Pairs = 24;  
 Standard Error of Estimate = 0.601;  
 95% Confidence Interval for Intercept (-6.03, -4.91);  
 95% Confidence Interval for Slope = (0.67, 1.24); and  
 Scale Bias Correction Factor = 2.43

- Open-Ended Lines - All Services

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (5.69)(10^{-6})(\text{OVA\_SV})^{0.995}$$

Least-Square Results (in log-log space):

$$\text{Log}_{10}(\text{Emission Rate}) = -5.743 + 0.995 \text{ Log}_{10}(\text{OVA Screening Value});$$

Correlation Coefficient (r) = 0.859;

Number of Data Pairs = 16;

Standard Error of Estimate = 0.701;

95% Confidence Interval for Intercept (-6.53, -4.95);

95% Confidence Interval for Slope = (0.65, 1.34); and

Scale Bias Correction Factor = 3.14

- Pump Seals - Light Liquid Service

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (6.567)(10^{-5})(\text{OVA\_SV})^{0.534}$$

Least-Square Results (in log-log space):

$$\text{Log}_{10}(\text{Emission Rate}) = -4.619 + 0.534 \text{ Log}_{10}(\text{OVA Screening Value});$$

Correlation Coefficient (r) = 0.757;

Number of Data Pairs = 12;

Standard Error of Estimate = 0.667;

95% Confidence Interval for Intercept (-5.43, -3.81);

95% Confidence Interval for Slope = (0.209, 0.859) ; and

Scale Bias Correction Factor = 2.729.

- Valves (Light Liquid Services) and Connectors (All Services), Combined

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (1.255)(10^{-5})(\text{OVA\_SV})^{0.635}$$

Least-Square Results (in log-log space):

$\text{Log}_{10}(\text{Emission Rate}) = -5.22 + 0.635 \text{ Log}_{10}(\text{OVA Screening Value})$ ;

Correlation Coefficient (r) = 0.729;

Number of Data Pairs = 82;

Standard Error of Estimate = 0.532;

95% Confidence Interval for Intercept (-5.56, -4.88);

95% Confidence Interval for Slope = (0.502, 0.768) ; and

Scale Bias Correction Factor = 2.083.

- Loading Arm Valves (All Services) and Open-Ended Lines (All Services), Combined

Equation for predicted mean emission rate is:

$$\text{Emission Rate} = (7.663)(10^{-6})(\text{OVA\_SV})^{0.959}$$

Least-Square Results (in log-log space):

$\text{Log}_{10}(\text{Emission Rate}) = -5.55 + 0.959 \text{ Log}_{10}(\text{OVA Screening Value})$ ;

Correlation Coefficient (r) = 0.838;

Number of Data Pairs = 40;

Standard Error of Estimate = 0.632;

95% Confidence Interval for Intercept (-5.98, -5.12);

95% Confidence Interval for Slope = (0.755, 1.164) ; and

Scale Bias Correction Factor = 2.743.

## **A.10      Effects of Load and Service on Screening Value Concentrations**

It was considered desirable to determine whether the service or the load conditions had an effect on the screening value concentrations. Table A-1 presents statistics for the mean screening value concentrations by service (gas vapor, heavy liquid, or light liquid) and load (load or no load). "Load" is defined as process fluid flowing through the component and "no load" is defined as a liquid-filled component but with no flow. The mean concentrations and sample sizes by category are also presented for the different component types in Figures A-1 through A-6.

Statistical hypothesis tests were performed to determine whether the effects of service and load on screening value concentrations were statistically significant. An effect is said to be "statistically significant" if it is too large to be explained by random chance; i.e., a statistically significant effect is one that appears to be repeatable on the basis of trends seen in the data.

To test the effects of service and load for each component type, the number of screened values within each service and load must be sufficiently large. As shown in Table A-1 and in Figures A-1 through A-6, most of the screened components were connectors and valves. In addition, there were sufficient numbers of connectors and valves representing each of the service types and load conditions. For the remaining four component types (i.e., loading arm valves, open-ended lines, pump seals, and "other"), there was not a large number of screened values representing each of the service types and load conditions. Therefore, whereas reliable statistical conclusions about the effects of service and load can be drawn for connectors and valves, results given for the remaining four component types should be regarded with caution due to the small sample sizes.

When a response variable (concentration) is computed as a function of two possible explanatory variables (load and service), a technique called "analysis of variance" is often used to determine the significance or lack of significance of the effects. Conventional

Table A-1

## Summary Statistics for Phase and Load Screening Concentrations by Component

| Component Type<br>and<br>Phase | Load               |               |                    |                    |                 |                    |
|--------------------------------|--------------------|---------------|--------------------|--------------------|-----------------|--------------------|
|                                | No                 |               |                    | Yes                |                 |                    |
|                                | Number<br>Screened | Mean<br>(ppm) | Std. Dev.<br>(ppm) | Number<br>Screened | Mean<br>(ppm)   | Std. Dev.<br>(ppm) |
| Connectors:                    |                    |               |                    |                    |                 |                    |
| Gas Vapor                      | 100                | 199.4         | 1352.9             | 57                 | 46.8            | 331.2              |
| Heavy Liquid                   | 281                | 0.8           | 5.0                | 3                  | 15.7            | 27.1               |
| Light Liquid                   | 2,302              | 7.8           | 88.7               | 259                | 8.0             | 78.1               |
| Valves:                        |                    |               |                    |                    |                 |                    |
| Gas Vapor                      | 67                 | 8.1           | 50.4               | 47                 | 59.1            | 241.6              |
| Heavy Liquid                   | 269                | 1.1           | 4.9                | 8                  | 2.3             | 4.2                |
| Light Liquid                   | 1874               | 363.3         | 4435.0             | 371                | 842.0           | 7768.6             |
| Loading Arm Valves:            |                    |               |                    |                    |                 |                    |
| Gas Vapor                      | 32                 | 15194.7       | 40026.1            | 11                 | 423.2           | 1194.7             |
| Heavy Liquid                   | 7                  | 10.4          | 6.9                | 1                  | 2700.0          | -- <sup>a</sup>    |
| Light Liquid                   | 93                 | 147.0         | 494.8              | 15                 | 166.5           | 296.0              |
| Open-Ended Lines:              |                    |               |                    |                    |                 |                    |
| Gas Vapor                      | 16                 | 1343.2        | 3804.7             | 1                  | 0.0             | -- <sup>a</sup>    |
| Heavy Liquid                   | 16                 | 20.2          | 36.3               | 0                  | -- <sup>b</sup> | -- <sup>b</sup>    |
| Light Liquid                   | 73                 | 4952.7        | 39783.1            | 19                 | 4.5             | 14.0               |
| Pump Seals:                    |                    |               |                    |                    |                 |                    |
| Gas Vapor                      | NA                 | NA            | NA                 | NA                 | NA              | NA                 |
| Heavy Liquid                   | 11                 | 6.6           | 12.2               | 1                  | 0.0             | -- <sup>a</sup>    |
| Light Liquid                   | 65                 | 2165.2        | 12661.2            | 23                 | 185.5           | 831.9              |
| *Other**:                      |                    |               |                    |                    |                 |                    |
| Gas Vapor                      | 8                  | 10021.6       | 24271.5            | 11                 | 10655.5         | 29766.7            |
| Heavy Liquid                   | 5                  | 0.0           | 0.0                | 2                  | 1050.0          | 1484.9             |
| Light Liquid                   | 102                | 918.4         | 4053.3             | 11                 | 409.1           | 1356.8             |

<sup>a</sup> Not sufficient data to calculate standard deviation.

<sup>b</sup> No screening value data obtained for given load and phase.

\* "Other" includes components such as hatches, covers, manholes, thermal wells, and pressure relief valves.

# Connectors

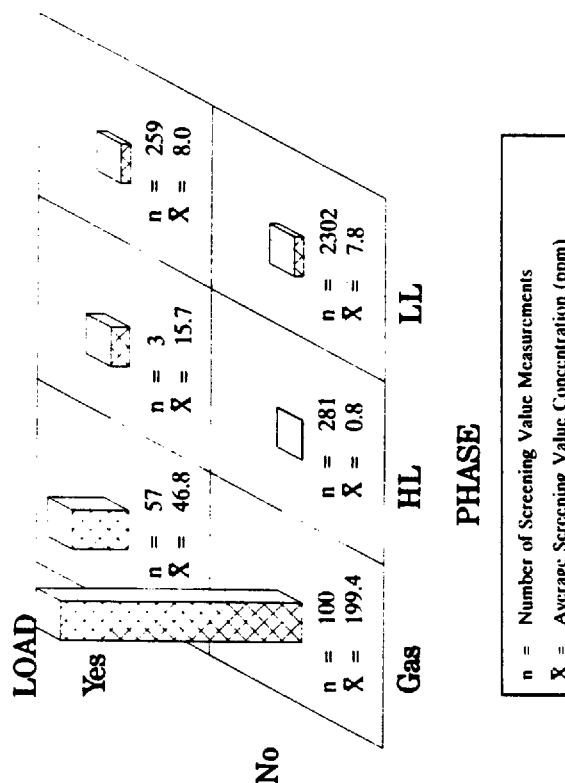


Figure A-1. Average Screening Value Concentrations by Load and Phase - Connectors.

# Valves

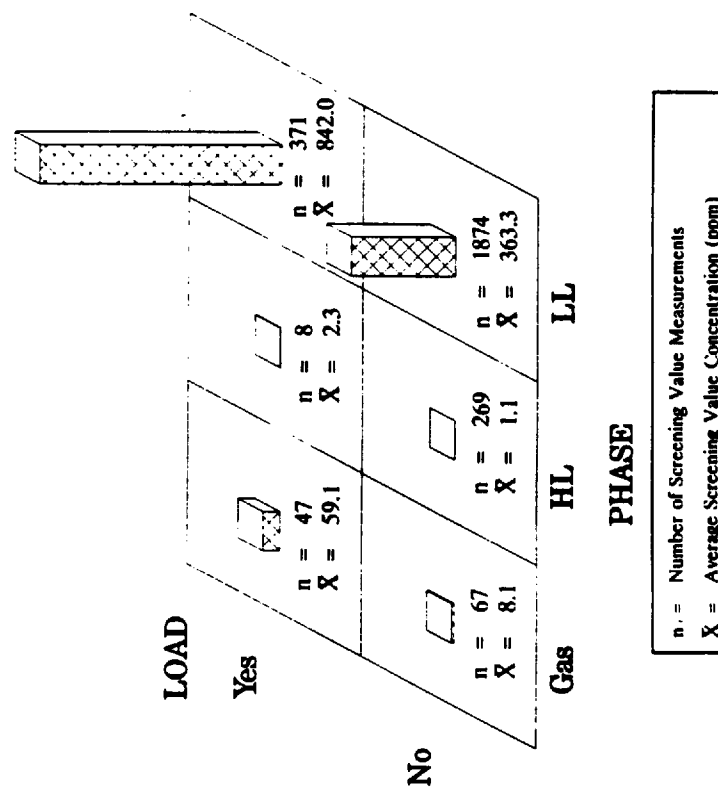


Figure A-2. Average Screening Value Concentrations by Load and Phase - Valves.

# Loading Arm Valves

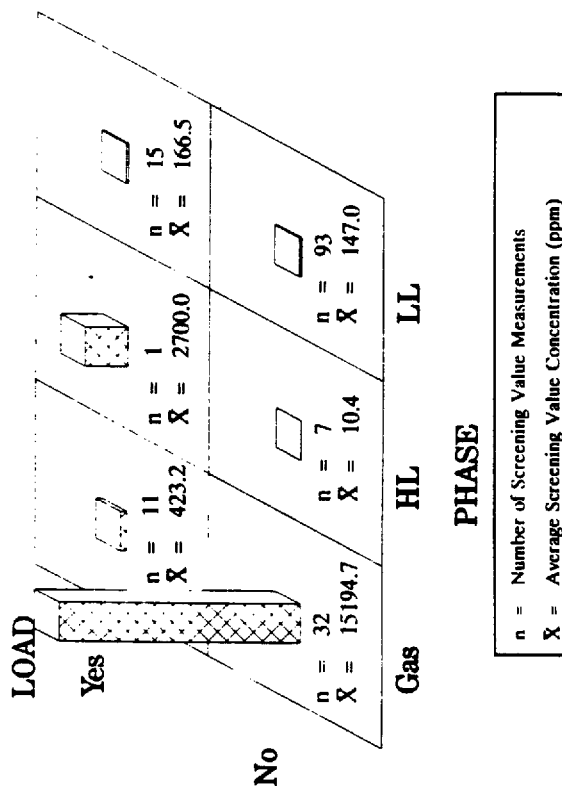


Figure A-3. Average Screening Value Concentrations by Load and Phase - Loading Arm Valves.

# Open – Ended Lines

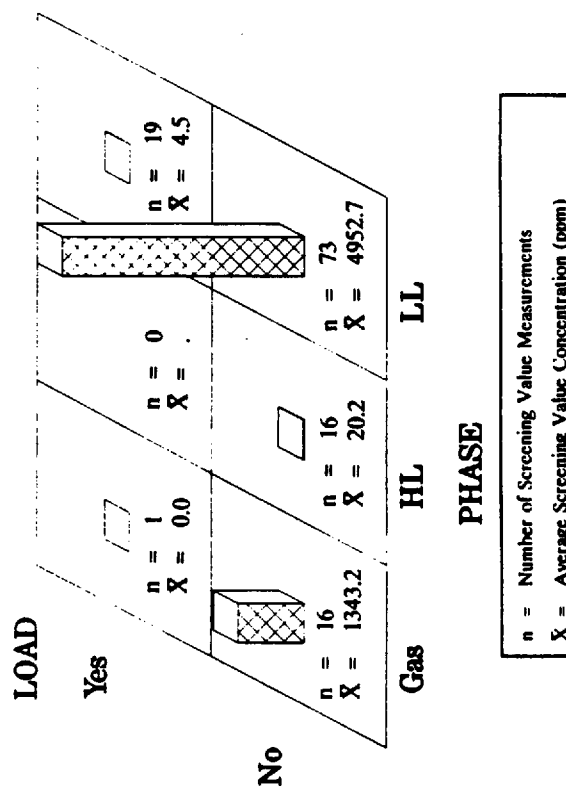


Figure A-4. Average Screening Value Concentrations by Load and Phase - Open-Ended Lines.

# Pump Seals

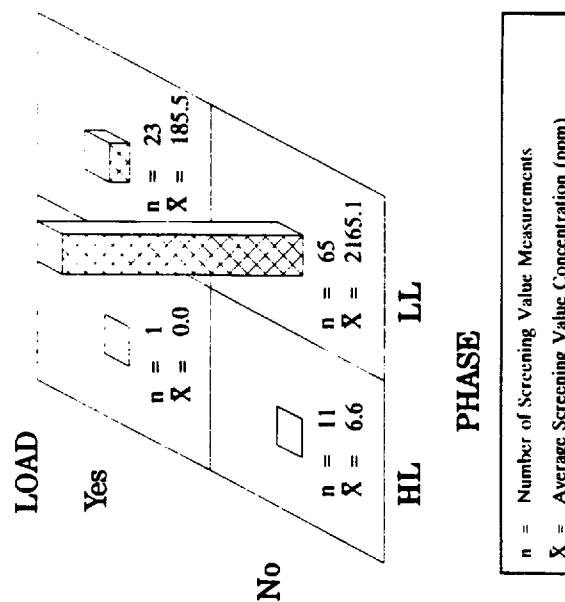


Figure A-5. Average Screening Value Concentrations by Load and Phase - Pump Seals.

Other

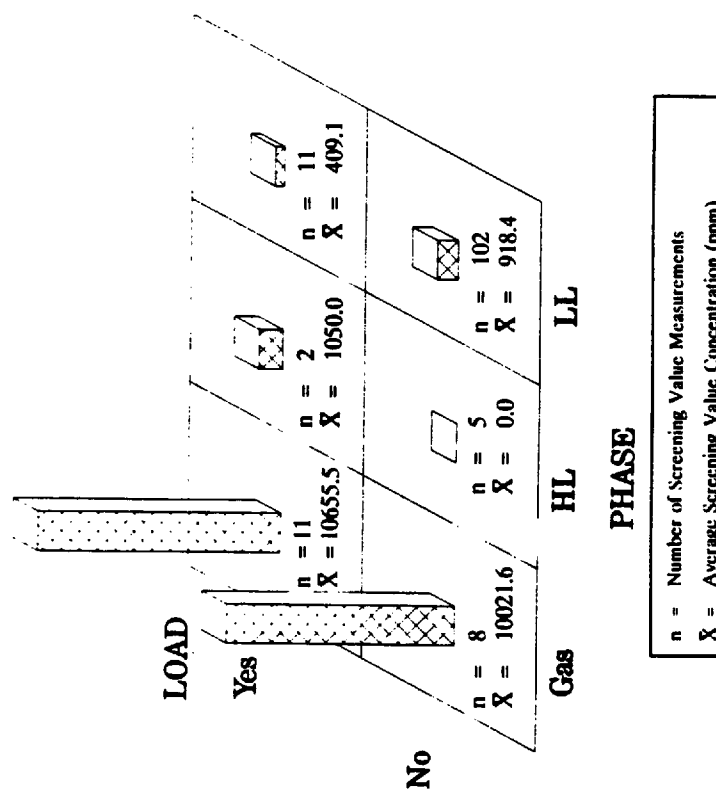


Figure A-6. Average Screening Value Concentrations by Load and Phase - "Other" Components.

analysis of variance could be used to determine whether the mean concentration varies significantly as a function of load or service. In Figure A-1, for example, it is seen that concentration is larger for the gas service with no load than for the other data cells (i.e., other load-service combinations). The question is, are the cell-to-cell differences in the mean concentrations too large to be explained by random chance?

Analysis of variance, strictly speaking, is based on the assumption that the data are normally distributed. The concentrations observed here are markedly non-normal. As discussed in Section 5.6.2, the distributions are strongly asymmetric (positively skewed). With this type of distribution, it is often possible to take logarithms of the values and produce an approximately normal distribution. Because of the large number of concentration values reported as zero, however, the log transformation was not feasible in this case. For this and other reasons, there was some doubt about the advisability of using conventional analysis of variance.

For this reason, a nonparametric analysis of variance was performed. A "nonparametric" statistical analysis is one that is designed so that a rigorous assumption regarding the type of statistical distribution is not required.

To perform the nonparametric test, the complete set of concentrations for a given component were first ordered from low to high. The lowest concentration was assigned the rank 1, the next lowest was assigned the rank 2, and so on. Average ranks were used whenever ties occurred. An analysis of variance was then performed on the ranks of the concentrations.

A fundamental difference between the parametric and nonparametric tests is as follows: In the parametric test, the mean concentrations for the different data cells are compared. In the nonparametric test based on ranks, the means are not directly compared. The question is, are the concentrations consistently (more often) higher in some cells than in others?

The nonparametric tests were preferred for theoretical reasons. Also, however, the nonparametric tests produced results which are generally more consistent with the visual effects observed in the figures.

A nonparametric test based on ranks of the type used here strictly should be based on data with equal variances in all cells (all load-service combinations). This condition is not met here, and so the significance levels discussed below in connection with the test are not strictly correct. The nonparametric test used is still preferable to the parametric test, however, and is believed to be the best readily available. The parametric test also requires the assumption of equal variances. Moreover, the reasonableness of all nonparametric results is discussed in view of graphical displays and other considerations. Thus, the results of the significance tests are believed to provide useful information, although the confidence levels are not numerically exactly correct.

The goal of a hypothesis test is not to draw conclusions with absolute certainty; this is not feasible when random variability is present in the data. The goal is to draw the most reasonable conclusions possible and to assess the confidence with which these conclusions can be drawn.

Table A-2 presents the results of the nonparametric hypothesis tests. Certain notations appear regarding instances in which a significant result was found by the parametric test but not by the nonparametric test. Factors that are not significant are denoted as "NS." For those factors that are significant, the p-value at which the indicated factor is statistically significant is given. The p-value is the probability of incorrectly concluding that there is a significant difference between the mean concentrations. Thus, for example, a p-value of 0.0001 for a phase effect would indicate that there is only a 0.01% chance of incorrectly concluding that the mean concentrations of the three phases differ significantly and thus there is a 99.99% (i.e.,  $1 - p\text{-value}$ ) chance that the mean concentrations for the three phases actually differ significantly.

**Table A-2**

**Results of Non-parametric Tests to Determine  
Significance of Effects of Service and Load  
on Screening Value Concentrations**

| Component Type     | Service | Load | Service x Load |
|--------------------|---------|------|----------------|
| Connectors         | NS*     | NS   | NS*            |
| Valves             | 0.0343  | NS   | NS             |
| Loading Arm Valves | 0.0409  | NS   | 0.0231         |
| Open-Ended Lines   | NS      | NS   | NS             |
| Pump Seals         | NS      | NS   | NS             |
| "Other"            | 0.0001  | NS   | NS             |

**Note:** The values in the table are p-values at which the indicated effect is statistically significant. Where NS appears, the effect is not statistically significant at the 0.05 level.

\* Significant at the 0.05 level on the basis of a parametric test.

\* "Other" includes components such as hatches, covers, manholes, thermal wells, and pressure relief valves.

Consider first the results for connectors (Figure A-1). As noted earlier, it is evident that the mean for gas service with no load is much higher than the means for the other cells. It is also evident that the concentrations are much higher on the average for the gas service than for the other services. Table A-2 indicates, however, that the service effect is not significant. As indicated by the footnote in Table A-2, however, the parametric test indicates that the service effect is significant. The same type of disparity occurs for the phase\*load interaction, with the nonparametric test indicating that this is not a significant effect, whereas, the parametric test indicates that this is a significant effect.

Thus, there is an apparent anomaly for connectors in that (1) the plot and the parametric test results suggest that there is a service effect and a service\*load effect, but (2) the nonparametric hypothesis tests reveal that there is no significant service and service\*load effect. This is not a contradiction, however. Recall that the figure presents the mean values, and the mean values are strongly affected by a small percentage of the points that have much higher than average concentrations. The nonparametric test, being based on ranks, is not sensitive to a small number of very large values. The nonparametric test is affected by cells that more frequently have higher concentrations than do other cells. Thus, the mean values in the plots and the nonparametric results characterize two aspects of the problem, and both aspects are of some practical interest.

Further investigation reveals that the high average screening value for connectors in gas service with no load can be attributed to a two large screening concentrations of 8,000 and 11,000 ppm. In fact, of the 100 screening concentrations obtained for this category, 84 screened at 0 ppm, 11 were less than 100 ppm, one each screened at 130 ppm, 160 ppm and 340 ppm. For the gas connectors with the load on, the large average screening concentration is due primarily to a single high screening value of 2500 ppm. Of the 47 components screened in this category, 51 screened at 0 ppm and 5 screened at concentrations less than 130 ppm.

The parametric test for connectors also indicated that there was a significant difference between for the service\*load interactive term. As is indicated above, however, there is some doubt as to the validity of the parametric test. The nonparametric test did not reveal a significant difference for this interaction. This result does not prove that there is no service\*load interaction; the conclusion is only that there is insufficient evidence on the basis of the nonparametric test to conclude with confidence that a service\*load effect exists.

The results for valves are shown in Figure A-2. Notice that the average concentrations are noticeably higher for light liquids for both load conditions than for other data cells. Note also that the average concentrations for the gas service are higher than those for the heavy liquid service. Consistently with these observations, Table A-2 indicates that the concentrations differ significantly among the different services.

The results for valves, however, do not indicate a severe imbalance in concentrations for the same service but for different load conditions. Again, the hypothesis test results are consistent with the visual observations. The interaction effect for valves is not significant, and neither is the load effect.

The results for loading arm valves are presented in Figure A-3. The results here are very similar to the results of the parametric test performed on connectors. Notice, however, that the sample sizes for loading arm valves are much smaller than those for connectors. Thus, the conclusions for loading arm valves are drawn with much less confidence. The results of the test on loading arm valves shows there is evidence of a service effect. This is consistent with the plot showing large differences in screening values for different services.

Table A-2 also indicates that the service\*load interaction effect is significant for loading arm valves. As a general statement, this result means that either (1) concentration does not vary uniformly with service for a given load, (2) concentration does not vary uniformly with load for a given service, or (3) both. This result is very consistent with the data as depicted in

Figure A-3. It is evident that the higher concentration for the gas service does not occur uniformly for the cases with and without load.

The results for open ended lines are presented in Figure A-4. The results here are similar to those for the loading arm valves, in that the sample sizes are very small when the load is on. Thus, the failure to detect a significant load effect is partly due to the small sample sizes. No significant service effects were detected for open ended lines. This may seem counter intuitive in view of the appearance of Figure A-4, which shows large differences in average concentrations for different services when the load is off. However, as shown in Table A-1, the variability within each service is very large. The lack of significant service results is therefore explainable in part by the large variability within each service and in part by the small sample sizes.

Figure A-5 presents the results for pumps. There is a noticeably large mean value for light liquids with no load. The results are affected, however, by small sample sizes (one cell has only one observation). As a result, neither the parametric nor the nonparametric tests revealed a significant service, load, or service\*load difference.

Figure A-6 presents the results for "other" components. "Other" components includes hatches, hoses, covers, man holes, thermal wells, and pressure relief valves. This figure reveals high mean values for the gas service for both load conditions. This seems to imply that a significant service effect exists. This is consistent with the results of the non-parametric test given in Table A-2 which shows a significant service effect for service type.

It is interesting to note that valves showed statistically significant service effects. Higher screening value concentrations were observed more often for valves in light liquid service than the other two services. Typically it would be expected that the gas service would show higher concentrations of screening values, as was shown for connectors. Further evaluation of the valve data however, showed that virtually all of the light liquid valves with large

screening values, also were larger in size (i.e., greater than 2 inches). Thus, the size of the valve appears also to have an effect on the screening value distribution.

The average concentrations for valves with different services and sizes are shown in Figure A-7. A second ANOVA was performed on valves to determine whether there were statistically significant effects on the screening value concentrations due to the valve size, service, and service\*size interactions. Load was not included in this second ANOVA because it was not shown to be a significant factor in the first ANOVA. In addition, 19 valves that did not have a recorded size variable were not included in this second ANOVA. The results of this second ANOVA are given in Table A-3. As shown before, service appears to have a significant effect on screening value concentrations for valves. This ANOVA also shows that size and the service\*size interactions are significant effects. It is of interest to note that all of the 15 leakers (screening values of greater than 10,000 ppm) for valves occurred in the light liquid service. Of these leakers, 1 was in the 0-2" size category, 4 were in the 2-4" category, 5 were in the 4-6" size category, 3 were in the 6-8" size category, and 2 were in the >8" size category.

In summary, reliable significant statistical conclusions were only shown for valves. For connectors there was no strong service or load effect. For valves, however, the service effect was significant. There were also indications for valves that size and the service\*size interactions were significant. Loading arm valves showed statistically significant effects between service\*load and load, respectively. However, the results for loading arm valves are not as reliable due to the small sample sizes obtained. In addition, the category of "other" showed a significant service effect. It should also be noted that the statistical tests performed determine whether there are systematic variations in the screening values for different parameters (e.g., service and load). In some cases, the indicated significant effects may run counter to those expected from analysis of physical principles. Thus, the results from the statistical analysis should also be viewed from a practical perspective.

# Valves, All Loads

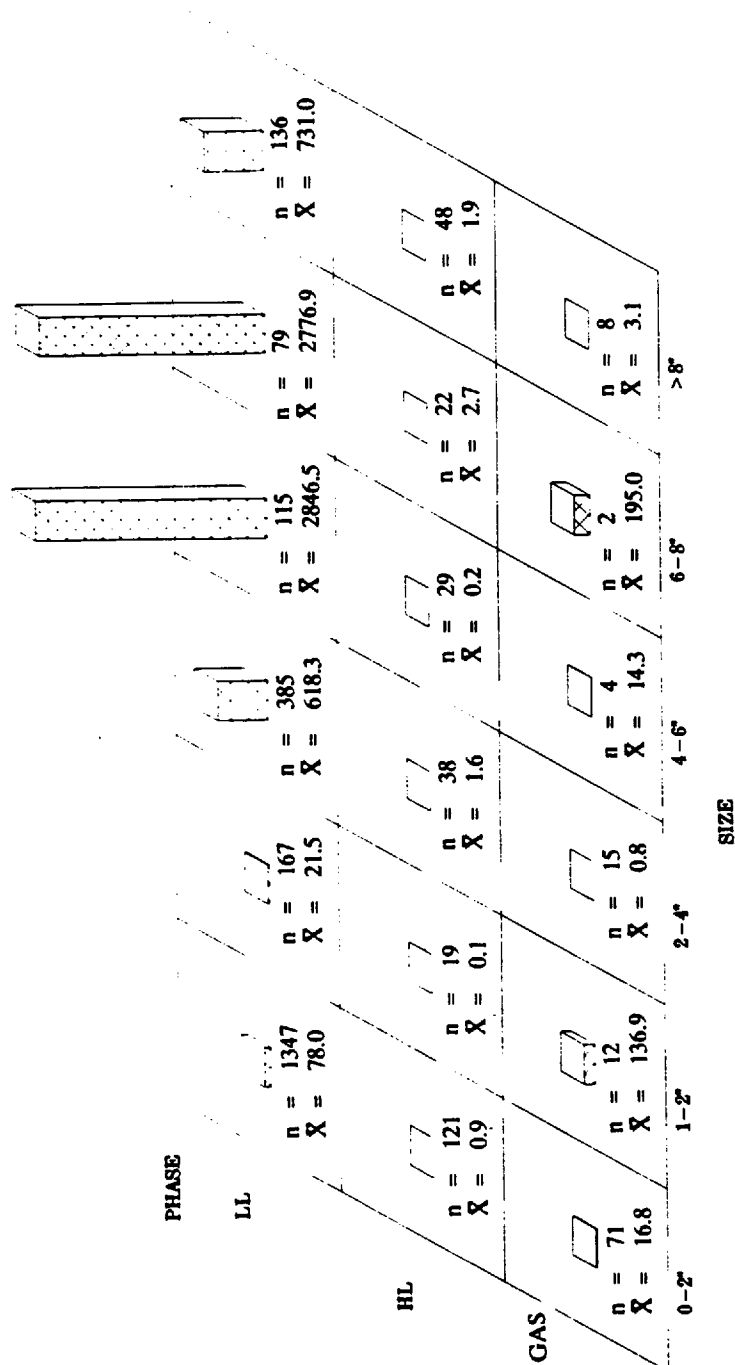


Figure A-7. Average Screening Value Concentrations by Phase and Size - Valves, All Loads.

**Table A-3**

**Results of Nonparametric ANOVA to Determine Significance  
of Effects of Phase and Size on Screening Value Concentrations for Valves**

| <b>Component</b> | <b>Phase</b> | <b>Size</b> | <b>Phase*Size</b> |
|------------------|--------------|-------------|-------------------|
| Valves           | 0.0001       | 0.0001      | 0.0004            |

**APPENDIX B**

**RAW DATA USED FOR STATISTICAL EVALUATIONS**

## **B.1**

### **DEFAULT ZERO EMISSIONS DATA**

## Data for Default Zeros Emission Estimates

1  
15:45 Tuesday, October 20, 1992

----- Component\*Type=Conct Service=LL -----

| Terminal | Sample ID | Component ID | Load | Product | OVA SV (ppm) | Emission Rate (lbs/hr) |
|----------|-----------|--------------|------|---------|--------------|------------------------|
| A        | 032       | A356         | N    | Regular | 0.00         | .000005707             |
| A        | 033       | A361         | N    | Supreme | 0.00         | .000007327             |
| A        | 036       | A291         | N    | Supreme | 0.00         | .000019031             |
| A        | 043       | A147         | N    | Supreme | 0.25         | .000006936             |
| A        | 044       | A92          | N    | Plus    | 0.00         | .000003923             |
| B        | 136       | D.ZER        | N    | Premium | 0.20         | .000002613             |
| B        | 137       | D.ZER        | N    | Premium | 0.25         | .000002999             |
| B        | 138       | D.ZER        | N    | Premium | 0.10         | .000001940             |
| B        | 142       | D.ZER        | N    | Regular | 0.25         | .000002743             |
| B        | 149       | D.ZER        | N    | Regular | 0.50         | .000003076             |
| B        | 152       | D.ZER        | N    | Premium | 0.00         | .000003042             |
| B        | 153       | D.ZER        | N    | Premium | 0.00         | .000023157             |

N = 12

----- Component\*Type=OEL Service=All -----

| Terminal | Sample ID | Component ID | Load | Product   | OVA SV (ppm) | Emission Rate (lbs/hr) |
|----------|-----------|--------------|------|-----------|--------------|------------------------|
| A        | 030       | A509         | N    | Interface | 0.75         | .0000017499            |
| A        | 037       | A1679        | N    | Regular   | 0.00         | .0000063686            |
| A        | 038       | A1502        | N    | Regular   | 0.10         | .0000026643            |
| A        | 040*      | A972         | N    | Supreme   | 0.10         | .0000057232            |
| A        | 041       | A1519        | N    | VRU       | 0.00         | .0000073704            |
| A        | 042       | A1523        | N    | VRU       | 0.00         | .0000066932            |
| B        | 144       | D.ZER        | N    | Premium   | 0.75         | .0000013937            |
| B        | 145       | D.ZER        | N    | Premium   | 0.35         | .0000030918            |

N = 8

----- Component\*Type=Pump Service=LL -----

| Terminal | Sample ID | Component ID | Load | Product | OVA SV (ppm) | Emission Rate (lbs/hr) |
|----------|-----------|--------------|------|---------|--------------|------------------------|
| A        | 052*      | A193         | N    | Regular | 0.00         | .00001710              |
| A        | 055       | A110         | N    | Plus    | 0.35         | .00004448              |
| A        | 056*      | A80          | Y    | Plus    | 0.00         | .00001059              |
| A        | 058*      | A80          | N    | Plus    | 0.00         | .00002202              |
| B        | 139       | D.ZER        | N    | Premium | 0.00         | .00003646              |
| B        | 140       | D.ZER        | N    | Clear   | 0.00         | .00003167              |
| B        | 146       | D.ZER        | N    | Premium | 0.00         | .00002910              |
| B        | 147       | D.ZER        | N    | Regular | 0.00         | .00013821              |

N = 8

## Data for Default Zeros Emission Estimates

15:45 Tuesday, October 20, 1992<sup>2</sup>

----- Component\*Type=Valve Service=Gas -----

| Terminal | Sample ID | Component ID | Load | Product | OVA SV (ppm) | Emission Rate (lbs/hr) |
|----------|-----------|--------------|------|---------|--------------|------------------------|
| D        | 76        | 235          | N    | VRU     | 0.00         | .000004327             |
| D        | 77        | 151          | N    | VRU     | 0.00         | .000004447             |
| D        | 78        | 68           | N    | VRU     | 0.00         | .000017608             |
| D        | 79        | 344          | Y    | VRU     | 0.00         | .000004590             |
| D        | 81        | 344          | Y    | VRU     | 0.00         | .000005261             |
| D        | 82        | 345          | Y    | VRU     | 0.75         | .000004334             |
| D        | 83        | 343          | Y    | VRU     | 0.00         | .000002774             |
| D        | 84        | 346          | Y    | VRU     | 0.25         | .000005840             |

N = 8

----- Component\*Type=Valve Service=LL -----

| Terminal | Sample ID | Component ID | Load | Product | OVA SV (ppm) | Emission Rate (lbs/hr) |
|----------|-----------|--------------|------|---------|--------------|------------------------|
| A        | 045       | A72          | N    | Plus    | 0.30         | .000002516             |
| A        | 046       | A181         | N    | Regular | 0.20         | .000001948             |
| A        | 047       | A178         | N    | Regular | 0.10         | .000001453             |
| A        | 048       | A191         | N    | Regular | 0.00         | .000004315             |
| A        | 049       | A3           | N    | Plus    | 0.15         | .000011740             |
| A        | 050*      | A33          | N    | Supreme | 0.00         | .000004301             |
| B        | 132       | D.ZER        | N    | Premium | 0.25         | .000002037             |
| B        | 133       | D.ZER        | N    | Premium | 0.00         | .000002277             |
| B        | 134       | D.ZER        | N    | Premium | 0.00         | .000002491             |
| B        | 135       | D.ZER        | N    | Premium | 0.10         | .000002085             |
| B        | 141       | D.ZER        | N    | Regular | 0.00         | .000004856             |

N = 11

## **B.2**

### **CORRELATION EQUATION EMISSIONS DATA**

## Data for LOG10 Correlation Equations

15:46 Tuesday, October 20, 1992

----- Source\*Type=Conct Service=All -----

| Terminal | Sample Id | Phase | Measured Emission Rate (lbs/hr) | Log(Conc) | Screening Value (ppm) | Log(SV) |
|----------|-----------|-------|---------------------------------|-----------|-----------------------|---------|
| A        | 008       | LL    | .0007019                        | -3.15370  | 171.5                 | 2.23426 |
| A        | 010       | LL    | .0006776                        | -3.16904  | 270.0                 | 2.43136 |
| A        | 012*      | LL    | .0004731                        | -3.32509  | 621.5                 | 2.79344 |
| A        | 019       | LL    | .0019859                        | -2.70204  | 37.5                  | 1.57403 |
| A        | 022       | LL    | .0010145                        | -2.99375  | 372.5                 | 2.57113 |
| A        | 023       | LL    | .0005724                        | -3.24231  | 94.0                  | 1.97313 |
| A        | 025       | LL    | .0001528                        | -3.81585  | 141.5                 | 2.15076 |
| A        | 027*      | LL    | .0008281                        | -3.08191  | 27.5                  | 1.43933 |
| A        | 061       | Gas   | .0000208                        | -4.68154  | 37.5                  | 1.57403 |
| B        | 074       | LL    | .0000942                        | -4.02612  | 670.0                 | 2.82607 |
| B        | 076       | LL    | .0021289                        | -2.67184  | 997.0                 | 2.99870 |
| B        | 078       | LL    | .0000337                        | -4.47223  | 23.0                  | 1.36173 |
| B        | 085       | LL    | .0001204                        | -3.91941  | 96.0                  | 1.98227 |
| B        | 086       | LL    | .0001197                        | -3.92183  | 112.0                 | 2.04922 |
| B        | 089       | LL    | .0003064                        | -3.51377  | 392.0                 | 2.59329 |
| B        | 098       | LL    | .0016740                        | -2.77624  | 940.0                 | 2.97313 |
| B        | 100       | Gas   | .0006099                        | -3.21478  | 30.0                  | 1.47712 |
| B        | 103       | LL    | .0001938                        | -3.71258  | 511.0                 | 2.70842 |
| B        | 104       | LL    | .0000575                        | -4.24006  | 45.0                  | 1.65321 |
| B        | 105       | Gas   | .0000382                        | -4.41791  | 30.0                  | 1.47712 |
| B        | 119       | LL    | .0001126                        | -3.94842  | 87.0                  | 1.93952 |
| B        | 122       | LL    | .0000416                        | -4.38042  | 50.0                  | 1.69897 |
| B        | 123       | LL    | .0000319                        | -4.49670  | 34.5                  | 1.53782 |
| B        | 124       | LL    | .0000092                        | -5.03537  | 35.0                  | 1.54407 |
| B        | 127       | LL    | .0000123                        | -4.90992  | 46.0                  | 1.66276 |
| B        | 128       | LL    | .0005671                        | -3.24636  | 41.0                  | 1.61278 |
| B        | 129       | LL    | .0000865                        | -4.06305  | 42.5                  | 1.62839 |
| B        | 130       | LL    | .0000355                        | -4.44964  | 23.0                  | 1.36173 |
| D        | 47        | LL    | .0000711                        | -4.14798  | 1096.5                | 3.04001 |
| D        | 50        | LL    | .0001389                        | -3.85742  | 1096.5                | 3.04001 |
| D        | 51        | LL    | .0015803                        | -2.80126  | 6996.0                | 3.84485 |
| D        | 60        | LL    | .0003076                        | -3.51203  | 420.0                 | 2.62325 |
| D        | 88        | LL    | .0000627                        | -4.20273  | 321.0                 | 2.50651 |
| D        | 91        | LL    | .0000228                        | -4.64231  | 317.0                 | 2.50106 |
| D        | 93        | LL    | .0000981                        | -4.00820  | 446.5                 | 2.64982 |
| D        | 95        | LL    | .0000988                        | -4.00523  | 542.0                 | 2.73400 |

N = 36

## Data for LOG10 Correlation Equations

2  
15:46 Tuesday, October 20, 1992

----- Source\*Type=LA Service=All -----

| Terminal | Sample Id | Phase | Measured Emission Rate (lbs/hr) | Log(Conc) | Screening Value (ppm) | Log(SV) |
|----------|-----------|-------|---------------------------------|-----------|-----------------------|---------|
| A        | 017       | Gas   | 0.00877                         | -2.05716  | 1096.0                | 3.03981 |
| A        | 018       | Gas   | 0.00296                         | -2.52834  | 2498.5                | 3.39768 |
| A        | 060       | LL    | 0.00048                         | -3.32233  | 145.5                 | 2.16286 |
| A        | 062       | Gas   | 0.00080                         | -3.09657  | 19.5                  | 1.29003 |
| B        | 113       | Gas   | 0.00016                         | -3.78513  | 70.0                  | 1.84510 |
| B        | 114       | LL    | 0.00004                         | -4.40076  | 33.0                  | 1.51851 |
| B        | 117       | LL    | 0.00001                         | -4.97196  | 75.0                  | 1.87506 |
| B        | 118       | LL    | 0.00001                         | -4.84552  | 76.0                  | 1.88081 |
| B        | 121       | Gas   | 0.00649                         | -2.18806  | 387.0                 | 2.58771 |
| B        | 125       | LL    | 0.00001                         | -4.84967  | 18.0                  | 1.25527 |
| B        | 126       | LL    | 0.00006                         | -4.23108  | 45.0                  | 1.65321 |
| D        | 41        | LL    | 0.00017                         | -3.75923  | 70.0                  | 1.84510 |
| D        | 43        | LL    | 0.00013                         | -3.89486  | 15.0                  | 1.17609 |
| D        | 44        | LL    | 0.00028                         | -3.55385  | 10.5                  | 1.02119 |
| D        | 52        | LL    | 0.00024                         | -3.62344  | 96.0                  | 1.98227 |
| D        | 56        | LL    | 0.00001                         | -5.23597  | 3.0                   | 0.47712 |
| D        | 57        | LL    | 0.00006                         | -4.24408  | 79.0                  | 1.89763 |
| D        | 59        | Gas   | 0.10398                         | -0.98305  | 15594.5               | 4.19297 |
| D        | 61        | LL    | 0.00006                         | -4.18785  | 26.5                  | 1.42325 |
| D        | 64        | LL    | 0.00003                         | -4.54076  | 5.5                   | 0.74036 |
| D        | 66        | LL    | 0.00003                         | -4.59813  | 4.5                   | 0.65321 |
| D        | 67        | LL    | 0.00004                         | -4.39535  | 6.0                   | 0.77815 |
| D        | 68        | LL    | 0.00009                         | -4.03077  | 46.5                  | 1.66745 |
| D        | 69        | LL    | 0.00002                         | -4.65326  | 6.0                   | 0.77815 |

N = 24

## Data for LOG10 Correlation Equations

3

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----- Source\*Type=OEL Service=All -----

| Terminal | Sample Id | Phase | Measured Emission Rate (lbs/hr) | Log(Conc) | Screening Value (ppm) | Log(SV) |
|----------|-----------|-------|---------------------------------|-----------|-----------------------|---------|
| A        | 003       | LL    | 0.00182                         | -2.74067  | 210.00                | 2.32222 |
| A        | 031       | LL    | 0.00001                         | -5.19435  | 8.00                  | 0.90309 |
| A        | 039*      | LL    | 0.00001                         | -5.16172  | 1.75                  | 0.24304 |
| A        | 059       | LL    | 0.00010                         | -3.99853  | 51.00                 | 1.70757 |
| B        | 066       | LL    | 0.00062                         | -3.20776  | 142.00                | 2.15229 |
| B        | 068       | LL    | 0.00124                         | -2.90553  | 93.00                 | 1.96848 |
| B        | 072       | LL    | 0.00002                         | -4.61934  | 175.50                | 2.24428 |
| B        | 073       | Gas   | 0.00008                         | -4.11233  | 296.00                | 2.47129 |
| B        | 079       | LL    | 0.00118                         | -2.92904  | 495.00                | 2.69461 |
| B        | 084       | LL    | 0.00169                         | -2.77312  | 1186.00               | 3.07408 |
| B        | 095       | LL    | 0.00191                         | -2.72001  | 1039.00               | 3.01662 |
| B        | 096       | LL    | 0.00387                         | -2.41263  | 990.00                | 2.99564 |
| B        | 108       | LL    | 0.11072                         | -0.95577  | 7992.00               | 3.90266 |
| B        | 111       | LL    | 0.00003                         | -4.54679  | 545.50                | 2.73679 |
| B        | 143       | LL    | 0.00000                         | -5.61789  | 1.00                  | 0.00000 |
| B        | 150       | LL    | 0.00000                         | -5.40235  | 2.00                  | 0.30103 |

N = 16

----- Source\*Type=Pump Service=LL -----

| Terminal | Sample Id | Phase | Measured Emission Rate (lbs/hr) | Log(Conc) | Screening Value (ppm) | Log(SV) |
|----------|-----------|-------|---------------------------------|-----------|-----------------------|---------|
| A        | 014       | LL    | 0.000147                        | -3.83203  | 7.5                   | 0.87506 |
| A        | 015       | LL    | 0.000144                        | -3.84312  | 5.0                   | 0.69897 |
| B        | 069       | LL    | 0.000056                        | -4.25003  | 20.0                  | 1.30103 |
| B        | 071       | LL    | 0.001468                        | -2.83336  | 43.0                  | 1.63347 |
| D        | 02        | LL    | 0.000764                        | -3.11671  | 8945.5                | 3.95160 |
| D        | 03        | LL    | 0.029050                        | -1.53685  | 4488.0                | 3.65205 |
| D        | 05        | LL    | 0.003893                        | -2.40976  | 10995.0               | 4.04120 |
| D        | 17        | LL    | 0.002037                        | -2.69097  | 6868.0                | 3.83683 |
| D        | 18        | LL    | 0.000084                        | -4.07401  | 45.5                  | 1.65801 |
| D        | 20        | LL    | 0.000055                        | -4.25839  | 2.0                   | 0.30103 |
| D        | 34        | LL    | 0.000068                        | -4.16816  | 95.0                  | 1.97772 |
| D        | 35        | LL    | 0.000013                        | -4.90125  | 24.5                  | 1.38917 |

N = 12

## Data for LOG10 Correlation Equations

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----- Source\*Type=Valve Service=LL -----

| Terminal | Sample Id | Phase | Measured Emission Rate (lbs/hr) | Log(Conc) | Screening Value (ppm) | Log(SV) |
|----------|-----------|-------|---------------------------------|-----------|-----------------------|---------|
| A        | 004       | LL    | .0029656                        | -2.52789  | 2257.50               | 3.35363 |
| A        | 005       | LL    | .0008128                        | -3.09001  | 4545.00               | 3.65753 |
| A        | 006       | LL    | .0000052                        | -5.28050  | 10.00                 | 1.00000 |
| A        | 007       | LL    | .0001188                        | -3.92533  | 205.00                | 2.31175 |
| A        | 020       | LL    | .0000600                        | -4.22215  | 75.00                 | 1.87506 |
| A        | 021       | LL    | .0000353                        | -4.45197  | 34.00                 | 1.53148 |
| A        | 024       | LL    | .0001295                        | -3.88776  | 124.00                | 2.09342 |
| A        | 028       | LL    | .0001538                        | -3.81293  | 71.50                 | 1.85431 |
| A        | 029       | LL    | .0013766                        | -2.86119  | 2147.50               | 3.33193 |
| A        | 034       | LL    | .0006447                        | -3.19065  | 187.50                | 2.27300 |
| B        | 067       | LL    | .0009157                        | -3.03824  | 3243.00               | 3.51095 |
| B        | 075       | LL    | .0000336                        | -4.47356  | 22.00                 | 1.34242 |
| B        | 077       | LL    | .0001137                        | -3.94432  | 22.00                 | 1.34242 |
| B        | 080       | LL    | .0001106                        | -3.95644  | 109.00                | 2.03743 |
| B        | 081       | LL    | .0000217                        | -4.66364  | 18.00                 | 1.25527 |
| B        | 082       | LL    | .0000766                        | -4.11578  | 45.00                 | 1.65321 |
| B        | 083       | LL    | .0001081                        | -3.96621  | 116.00                | 2.06446 |
| B        | 087       | LL    | .0000864                        | -4.06335  | 181.00                | 2.25768 |
| B        | 088       | LL    | .0000356                        | -4.44887  | 28.50                 | 1.45484 |
| B        | 090       | LL    | .0000316                        | -4.50066  | 59.50                 | 1.77452 |
| B        | 092       | LL    | .0000532                        | -4.27398  | 588.00                | 2.76938 |
| B        | 093       | LL    | .0000842                        | -4.07489  | 119.00                | 2.07555 |
| B        | 094       | LL    | .0001279                        | -3.89299  | 691.00                | 2.83948 |
| B        | 097       | LL    | .0003157                        | -3.50073  | 132.00                | 2.12057 |
| B        | 099       | LL    | .0007034                        | -3.15283  | 52.50                 | 1.72016 |
| B        | 106       | LL    | .0001372                        | -3.86277  | 116.00                | 2.06446 |
| B        | 107       | LL    | .0001397                        | -3.85487  | 61.00                 | 1.78533 |
| B        | 109       | LL    | .0002649                        | -3.57692  | 496.50                | 2.69592 |
| B        | 116       | LL    | .0000099                        | -5.00559  | 11.50                 | 1.06070 |
| B        | 151       | LL    | .0000045                        | -5.34470  | 4.25                  | 0.62839 |
| D        | 08        | LL    | .0006059                        | -3.21758  | 4996.50               | 3.69867 |
| D        | 09        | LL    | .0043482                        | -2.36169  | 5494.00               | 3.73989 |
| D        | 11        | LL    | .0052703                        | -2.27816  | 3844.00               | 3.58478 |
| D        | 12        | LL    | .0061519                        | -2.21099  | 3389.00               | 3.53007 |
| D        | 14        | LL    | .0067283                        | -2.17209  | 3302.00               | 3.51878 |
| D        | 16        | LL    | .0035476                        | -2.45007  | 5434.00               | 3.73512 |
| D        | 21        | LL    | .0022909                        | -2.63999  | 2745.00               | 3.43854 |
| D        | 23        | LL    | .0041507                        | -2.38188  | 8994.00               | 3.95395 |
| D        | 25        | LL    | .0031483                        | -2.50192  | 10981.00              | 4.04064 |
| D        | 27        | LL    | .0015669                        | -2.80496  | 8091.00               | 3.90800 |
| D        | 32        | LL    | .0005156                        | -3.28767  | 20897.00              | 4.32008 |
| D        | 33        | LL    | .0009667                        | -3.01471  | 21994.00              | 4.34230 |
| D        | 73        | LL    | .0000190                        | -4.72088  | 524.00                | 2.71933 |
| D        | 85        | LL    | .0009272                        | -3.03282  | 4246.50               | 3.62803 |
| D        | 90        | LL    | .0005467                        | -3.26224  | 2744.00               | 3.43838 |
| D        | 92        | LL    | .0000505                        | -4.29713  | 74.00                 | 1.86923 |

N = 46

### **B.3**

## **PEGGED SOURCES EMISSIONS DATA**

## Pegged Emission Estimates

15:50 Tuesday, October 20, 1992

1

----- Component\*Type=Conct Phase=Gas -----

| TERMINAL | Sample ID | Component ID | Load | OVA SV (ppm) | Pegged SV (ppm) | Measured Emission Rate (lbs/hr) | Calculated Emission Rate (at 100,000) |
|----------|-----------|--------------|------|--------------|-----------------|---------------------------------|---------------------------------------|
| A        | 013       | A1067        | N    | 100000       | 100000          | .0061182                        | 0.46958                               |
| B        | 120       | B984         | N    | 100000       | 100000          | .0007895                        | 0.46958                               |

N = 2

----- Component\*Type=LA Phase=Gas -----

| TERMINAL | Sample ID | Component ID | Load | OVA SV (ppm) | Pegged SV (ppm) | Measured Emission Rate (lbs/hr) | Calculated Emission Rate (at 100,000) |
|----------|-----------|--------------|------|--------------|-----------------|---------------------------------|---------------------------------------|
| B        | 112       | B615         | N    | 100000       | 100000          | 0.000464                        | 0.39013                               |
| D        | 39        | B315         | N    | 310000       | 100000          | 0.096954                        | 0.39013                               |
| D        | 42        | B232         | N    | 400000       | 100000          | 0.095242                        | 0.39013                               |

N = 3

----- Component\*Type=OEL Phase=LL -----

| TERMINAL | Sample ID | Component ID | Load | OVA SV (ppm) | Pegged SV (ppm) | Measured Emission Rate (lbs/hr) | Calculated Emission Rate (at 100,000) |
|----------|-----------|--------------|------|--------------|-----------------|---------------------------------|---------------------------------------|
| D        | 110       | B1077        | N    | 127475       | 100000          | .0064414                        | 0.39013                               |
| D        | 07        | B1077        | N    | 300000       | 100000          | .0047877                        | 0.39013                               |

N = 2

----- Component\*Type=Other Phase=LL -----

| TERMINAL | Sample ID | Component ID | Load | OVA SV (ppm) | Pegged SV (ppm) | Measured Emission Rate (lbs/hr) | Calculated Emission Rate (at 100,000) |
|----------|-----------|--------------|------|--------------|-----------------|---------------------------------|---------------------------------------|
| B        | 102       | B568         | N    | 100000       | 100000          | 0.037675                        | 0.46958                               |
| B        | 131       | B1507        | N    | 100000       | 100000          | 0.039889                        | 0.46958                               |

N = 2

## Pegged Emission Estimates

2

15:50 Tuesday, October 20, 1992

----- Component\*Type=Valve Phase=Gas -----

| TERMINAL | Sample<br>ID | Component<br>ID | Load | OVA<br>SV<br>(ppm) | Pegged<br>SV<br>(ppm) | Measured<br>Emission<br>Rate<br>(lbs/hr) | Calculated<br>Emission<br>Rate<br>(at 100,000) |
|----------|--------------|-----------------|------|--------------------|-----------------------|------------------------------------------|------------------------------------------------|
| D        | 54           | 71              | Y    | 300000             | 100000                | 0.13351                                  | 1.08256                                        |
| D        | 96           | 71              | N    | 300000             | 100000                | 0.00612                                  | 1.08256                                        |

N = 2



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