IV. POST-INSPECTION ACTIVITIES

A. POST-CALIBRATION

1. Post-calibrate sampling pumps as described in Appendix F.

2. Record results of post-calibration for all pumps used in the OIS air sampling worksheet.

B. COMPLETE DOCUMENTATION

1. Complete the OIS sampling worksheet before sending samples to the lab. CSHOs should be especially diligent in completing the following items:

    - Reporting ID
    - Inspection number
    - Sampling number
    - Establishment name
    - Sampling date
    - Shipping date
    - Person performing sampling
    - CSHO ID
    - Weather conditions
    - Photo(s)
    - Pump checks and adjustments
    - Job location, operation, work location(s), ventilation, and controls
    - Pre-sampling - calibration location temperature and pressure
    - Post-sampling - calibration location temperature and pressure

1. Indicate in the OIS air sampling worksheet if analytical results are to be reported using the actual time sampled (e.g., ceiling or STEL sampling) or if they are to be reported as 8-hour TWA results calculated using zero exposure for non-sampled time portions of the 8-hour period. OSHA TWA-PELs are defined as 8-hour TWA exposures. The SLTC will report sample results using the air volume reported on the OIS sampling worksheet unless otherwise requested by the CSHO.

C. PACKAGE AND SHIP SAMPLES

- Prepare the samples for transport to the SLTC.

- Submit bulk samples and air samples separately to avoid cross-contamination.

- If any submitted materials could be considered hazardous, consult and follow appropriate shipping regulations to assure safe handling during shipment (See internal procedures or contact the SLTC for instructions).

- Pack the samples securely in a box or other sturdy container to avoid any rattle or shock damage. For asbestos samples, do not use expanded polystyrene packing (Styrofoam™) or other static-producing packaging material. Place samples in a plastic bag so that they do not move freely. Use bubble sheeting or other material as packing. Put identifying paperwork in every package. Do not send samples in unpadded envelopes.

- Ensure that you include a printout of the OIS air sampling worksheet and any applicable SDSs with the samples.

D. RECEIVE SAMPLE RESULTS

Calculate the exposure severity, which is the ratio of the sampling results to the PEL. Add the SAE to the severity to determine the upper confidence limit, and subtract the SAE from the severity to determine the lower confidence limit. The SAE is reported by the SLTC on the OIS air sampling worksheet. If there is none listed for a specific substance, contact the SLTC.

For mixtures, the CSHO must determine the SAE as described below in Section IV.D.5. If the PEL violation is confirmed, apply the health effects codes as per Appendix L.

All sampling and analytical methods have some degree of uncertainty. The total uncertainty depends on the combined effects of the contributing uncertainties inherent in sampling and analysis, and has historically been called sampling and analytical error or SAE by OSHA. The SAE is used to determine the upper and lower confidence limits as described below. Correct application of the SAE enables CSHOs to make reliable compliance assessments of sample results. The SAE is especially important when sample results are near the PEL.

Error factors determined by statistical methods shall be incorporated into the sample results to obtain the lowest value of the true exposure (with a stated degree of statistical confidence) and also the highest value of the true exposure (also with a stated degree of statistical confidence).

Confidence limits are values at each end of the confidence interval, which is the probable range of the true value. The lower value is called the lower confidence limit (LCL), and the upper value is the upper confidence limit (UCL). The LCL and the UCL are each termed one-sided because the main concern is with being confident that the true exposure is either less or greater than the PEL.

OSHA applies the LCL and UCL with a 95% statistical confidence limit and they are expressed here as $LCL_{95\%}$ and $UCL_{95\%}$. SAEs that provide a one-sided 95% confidence limit have been developed and are reported out on the Air Sampling Report.

If the $UCL_{95\%} < 1.0$, a violation does not exist.

If $LCL_{95\%} < 1.0$ and the $UCL_{95\%} > 1.0$, classify as possible overexposure.

If $LCL_{95\%} > 1.0$, a violation exists.

The $LCL_{95\%}$ and $UCL_{95\%}$ are calculated differently depending upon the type of sampling method used:

1. Sampling Methods

   Sampling methods can be classified into one of two categories:

   - Full-period, Continuous, Single Sampling. Full-period, continuous, single sampling is defined as sampling over the entire sample period with only one

sample. The sampling may be for a full-shift sample or for a short period ceiling determination.

- Full-period, Consecutive Sampling. Full-period, consecutive sampling is defined as sampling using multiple consecutive samples of equal or unequal duration that, if combined, equal the total duration of the sample period. An example would be taking four two-hour charcoal tube samples. There are several advantages to this type of sampling:

    - If a single sample is lost during the sampling period due to pump failure, gross contamination, etc., at least some data will have been collected to evaluate the exposure.

    - The use of multiple samples should result in slightly lower sampling and analytical errors.

    - Collection of several samples allows conclusions to be reached concerning the manner in which differing segments of the workday affect overall exposure.

    - This practice also allows for monitoring peak and ceiling exposures for the appropriate time. Note that there is some loss of sensitivity with consecutive sampling as compared to continuous sampling.

2. Calculations

If the initial and final sampling pump calibration flow rates are different, use of the highest of the two calibration flow rates will provide the lowest analytical results for compliance purposes. Generally, sampling is conducted at approximately the same temperature and pressure as calibration, in which case no correction for temperature and pressure is required and the sample volume reported to the SLTC is the volume actually measured. Where sampling is conducted at a substantially different temperature or pressure than calibration, consult the operating manual for the sampling pump to determine if the air volume needs to be adjusted. If possible, calibrate the equipment at the site. The air volume reported by the CSHO is used in all subsequent calculations.

For particulates, the SLTC reports milligrams per cubic meter (mg/m^3) of contaminant using the actual volume of air sampled at the sampling site as reported by the CSHO.

The SLTC normally does not measure concentrations of gases and vapors directly in ppm. Rather, most analytical methods determine the total weight of contaminant in the collection medium. Using the air volume provided by the CSHO, the lab calculates concentration in mg/m^3 and then converts it to ppm at 25°C and 760 mmHg using Equation M-1 in Appendix M. This ppm result is to be compared with the PEL without adjustment for temperature and pressure at the sampling site. Additional supporting equations are also found in Appendix M.

3. Calculations for Full-Period, Continuous Single Samples

Obtain the full-period sampling result (X), the PEL, and the SAE. The SAE can be obtained from the OIS air sampling worksheet or by contacting the SLTC. Divide the

full-period sampling result X by the PEL to determine the exposure severity, Y. From Equation 9:

$$Y = \frac{X}{PEL}$$

Compute the upper confidence level at the 95% confidence level ($UCL_{95\%}$) as follows (from Equation 11):

$$UCL_{95\%} = Y + SAE$$

Compute the lower confidence level at the 95% confidence level ($LCL_{95\%}$) as follows (from Equation 10):

$$LCL_{95\%} = Y - SAE$$

Classify the exposure according to the following classification system:

- If the $UCL_{95\%} < 1.0$, a violation does not exist.
- If $LCL_{95\%} < 1.0$ and the $UCL_{95\%} > 1.0$, classify as possible overexposure.
- If $LCL_{95\%} > 1.0$, a violation exists.

If the results are in the "possible overexposure" category, consider further sampling, taking into consideration the seriousness of the hazard and pending citations. If further sampling is not conducted, or if additional measured exposures still fall into the "possible overexposure" category, the CSHO may wish to carefully explain to the employer and employee representative at the closing conference that the exposed employee(s) may be overexposed, but that there is insufficient data to document noncompliance. The employer should be encouraged to voluntarily reduce the exposure and/or to conduct further sampling to ensure that exposures are not in excess of the PEL.

See Appendix N for an example calculation for a full-period, continuous single sample using the equations above.

4. Calculations for Full-Period Consecutive Samples

The use of multiple consecutive samples should result in slightly lower sampling and analytical errors than the use of one continuous sample because the inherent errors tend to partially cancel each other. The mathematical calculations, however, are somewhat more complicated. The CSHO should first determine if compliance or noncompliance can be established using a calculation method similar to that noted for a full–period, continuous, single sample measurement, following the instructions in the "Compliance/ Noncompliance Method" box below.

Compliance/Noncompliance Method
Obtain the results of consecutive samples taken during the workshift. Let X_n be the concentration for a given sample, and T_n be the sampling duration for that sample, and n be the sample number: Also obtain the SAE listed in the OIS air sampling worksheet. 1. Compute the TWA exposure, X. **Equation 13** $$X = \frac{(X_1T_1) + (X_2T_2) \ldots + (X_nT_n)}{480\ min}$$ 2. Divide the TWA exposure by the PEL to find Y, the standardized average (TWA/PEL). 3. Compute the $UCL_{95\%}$ as follows: $UCL_{95\%} = Y + SAE$ (Equation 11) 4. Compute the $LCL_{95\%}$ as follows: $LCL_{95\%} = Y - SAE$ (Equation 10)

Classify the exposure according to the following classification system:

If $UCL_{95\%} < 1.0$, a violation does not exist.

If $LCL_{95\%} < 1.0$, and the $UCL_{95\%} > 1.0$, classify as possible overexposure and recalculate using the more exact calculation found in Equation 14 below.

If $LCL_{95\%} > 1.0$, a violation exists.

When the $LCL_{95\%} < 1.0$ and $UCL_{95\%} > 1.0$, the results are in the "possible overexposure" region and the CSHO must analyze the data using the more exact calculation for full-period consecutive sampling, as follows:

Equation 14

$$LCL_{95\%} = Y - \frac{SAE\sqrt{(T_1X_1)^2 + (T_2X_2)^2 + \cdots + (T_nX_n)^2}}{PEL(T_1 + T_2 + \cdots + T_n)}$$

See Appendix O for an example calculation for a full-period consecutive sampling using the equations above

5. SAEs for Exposure to Chemical Mixtures

As described above in Section III, often an employee is simultaneously exposed to a variety of chemical substances, which may result in additive or synergistic health effects. 29 CFR 1910.1000(d)(2)(i) and 29 CFR 1915.1000(d)(2)(i) specify the computational approach for assessing exposure to a mixture.

Whether using a single PEL or the mixture calculation, the SAE of the individual constituents must be considered before arriving at a final compliance decision. These SAEs can be pooled and weighted to give a control limit for the additive mixture. To illustrate this control limit, the mixture calculation is expressed in the following equation (Equation 3 from above).

$$E_m = \left(\frac{C_1}{L_1} + \frac{C_2}{L_2}\right) + \cdots \left(\frac{C_n}{L_n}\right)$$

Where:

E_m = equivalent exposure for the mixture (E_m should be less than or equal to 1 for compliance)
C = concentration of a particular substance
L = PEL

If $E_m > 1$, indicating that an overexposure has occurred, then the SAE for each substance also needs to be considered:

Exposure ratio (for each substance)

Equation 15

$$Y_n = \frac{C_n}{L_n}$$

Ratio to total exposure

Equation 16

$$R_1 = \frac{Y_1}{E_m}, \ldots R_n = \frac{Y_n}{E_m}$$

The SAEs (95% confidence) of the substances comprising the mixture can be pooled to give the SAE of the mixture using:

Equation 17

$$R_{st} = \sqrt{[(R_1 \times SAE_1)^2 + (R_2 \times SAE_2)^2 + \cdots (R_n \times SAE_n)^2]}$$

Equation 18

$$UCL = 1 + R_{St}$$

Equation 19

$$LCL = 1 - R_{St}$$

If E_m < LCL then no overexposure has occurred at the 95% confidence level.

If LCL ≤ E_m ≤ UCL then the exposure cannot be classified as either under or over the PEL at the 95% confidence level; further sampling may be necessary.

If E_m > UCL then an overexposure has occurred (95% confidence).

See Appendix H for an example calculation.