North Carolina Department of Labor
Occupational Safety and Health Division
Bureau of Compliance

Field Operations Manual
Chapter XV – Industrial Hygiene Compliance

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Chapter XV

Industrial Hygiene Compliance

A. **Responsibility and Authority**.

1. District Supervisor.

   a. Supervisors are responsible for all equipment assigned to them or to the persons under their direction and are jointly responsible for all shared equipment and furniture assigned to their location.

   b. Supervisors are responsible for exhausting all efforts to locate any items reported to be lost.

   c. In the event that any items are stolen, a report must be file immediately with the appropriate law enforcement agency and the bureau chief and assistant director. The report must describe in detail the events surrounding the theft.

2. Compliance Safety and Health Officer.

   The compliance safety and health officer (CSHO) is responsible for the proper care of individuallly assigned equipment, as well as the care and return of any shared equipment used for compliance inspections.

3. Inter-departmental Loan.

   a. Supervisors are authorized to loan equipment belonging to the compliance bureau to other state agencies. The agency borrowing the equipment must sign it out.

   b. While the equipment is in the possession of another state agency, that agency is responsible for the proper care of it, as well as repair or replacement if the equipment is damaged or lost.

B. **Equipment Inventory**.

1. Receiving Equipment.

   a. Equipment received by the supervisor from the bureau chief may be assigned to a CSHO or placed in a pool of shared equipment. The supervisor will establish procedures for checking in/out shared equipment.

   b. When equipment is shipped from the vendor directly to the district office, a supervisor or his designee must sign for the equipment and send the packing (receiving) slip to the bureau administrative assistant. If the designee picks up the equipment, the designee must sign a slip acknowledging receipt.

   c. The administrative assistant will provide a bar code and/or fixed asset number. Bar codes and/or fixed asset numbers are affixed to all items with a value of $1000.00 or greater.

2. Physical Inventory.

   a. A CSHO in each district office will be assigned to manage the technical equipment in their district. The CSHO will also assist with the yearly physical inventory of equipment in their district.

b. After the inventory is complete, the supervisor, when requested, will submit a written response to the bureau chief concerning any missing/lost items.

3. Inventory Management at the Administrative Office Level. The administrative assistant will conduct a yearly on-site physical inventory in all district offices and the Raleigh adminstrative office, maintain a current computerized inventory list, and periodically provide same to the district offices.

4. Equipment Calibration and Repair. The electronics technician is responsible for performing or coordinating on-going repair of all OSH technical equipment, as well as the annual calibrations required for equipment such as sound level meters, noise dosimeters, velometers, and air pressure gauges. The technician will coordinate calibration and repair through the equipment officers in each district office.

C. **Inspection Activity.**

1. Information Required of the Employer.

a. Monitoring Program. Information required for the review of the industrial hygiene monitoring programs includes the personnel responsible for such activities, sampling and calibration procedures, ventilation measurements and laboratory services. The use of industrial hygiene personnel and of accredited laboratories will be noted. Compliance with the monitoring requirement of any applicable standard will be determined.

b. Medical Program. Information concerning the employer's medical program will be requested as required. The CSHO will determine whether the employer provides the employees with preplacement and periodic medical examinations. The medical examination protocol will be requested to determine the extent of the medical examinations and, if applicable, compliance with the medical surveillance requirements of any applicable standard.

c. Protective Devices. The CSHO will determine whether an effective personal protective equipment program exists in the plant. A detailed evaluation of the program will be made to determine compliance with the specific standards which require the use of protective equipment (e.g., 29 CFR 1910.95, 1910.132, and 1910.134.)

d. Regulated Areas. The CSHO will investigate compliance with the requirements for regulated areas as specified by certain standards. (e.g., 29 CFR 1910.1001 or 1926.1101 for asbestos)

i. Regulated areas must be clearly identified and known to all appropriate employees.

ii. The regulated area designations must be maintained according to the prescribed criteria of the applicable standard.

2. Collecting Samples. The CSHO will determine whether sampling is required by using the information collected during the walkaround and the preinspection review. If sampling is necessary, the CSHO will develop a sampling strategy by considering potential chemical and physical hazards, number of samples to be taken and the operations and locations to be sampled. Sampling procedures should be conducted for all complaints and referrals alleging exposure to substances. If the CSHO determines that sampling is not necessary, the CSHO will discuss this with their supervisor. If sampling is not conducted, the CSHO will document the reasons in the case file.

a. Representative jobs must be selected for sampling and personal sampling devices prepared accordingly. Employees with the highest expected exposures at specific operations should be monitored. It is not necessary to monitor every employee that may be over-exposed.

b. All sampling equipment will be checked and calibrated according to the procedures described in The OSHA Technical Manual or the manufacturer's instructions. A record of each calibration must be recorded on the appropriate sampling sheet (e.g., OSHA-91s).

Note: The CSHO is responsible for the reasonable care of equipment issued and for its field calibration.

c. Once sampling equipment is established; i.e. after a 30 minute check and a 1-hour check, each sampling device should be checked about every 2 hours.

d. Although it is not essential that the CSHO continuously observe each employee being monitored, an account must be made for each monitored employee's movements and duties in each area of the establishment which may significantly affect the total exposure. Comments on employee movements, work activities, use of personal protective equipment, and sampling equipment will be documented on the appropriate sampling sheet. A CSHO will remain at the workplace while the samples are being collected.

i. Samples collected by a trainee are acceptable if such samples are collected under the guidance of an accompanying "field qualified" CSHO. All sampling will be done according to the methods and protocols documented in the OSHA Technical Manual, NIOSH analytical methods, the laboratory analyzing the samples or established as good industrial hygiene practice.

ii. In certain situations, it may not always be necessary for the "field qualified" CSHO to be present for the entire inspection, provided the trainee has sufficient experience to adequately complete the inspection.

3. Personal Exposure Determination.

a. The determination of noncompliance with PELs requires measurement and documentation of an overexposure to at least one employee. For air contaminants having PELs, sampling must be conducted within the breathing zone. (Some standards; e.g., cotton dust, may necessitate area sampling.) The "breathing zone" is defined as a sphere approximately 2 feet in diameter surrounding the head.

b. If the employee refuses to wear the sampling equipment and another employee who is similarly exposed cannot be sampled, the CSHO will collect the sample by means which provide a representative sample of the employee's exposure (possibly an area sample). If it becomes obvious that the employer has instructed the employees not to wear the sampling equipment, the CSHO will inform the supervisor who will begin the warrant process.

c. In some instances (e.g., the carcinogens in 29 CFR 1910.1002 through 29 CFR 1910.1014) personal sampling is not necessary to establish the presence of the material in order to substantiate a violation.

4. Sampling Types. To eliminate error associated with fluctuations in exposure, full-shift sampling for air contaminants is the preferred method.

a. Full-shift sampling is defined to be a minimum of the total time of the shift less 1 hour; e.g., 7 hours of an 8-hour work shift or 9 hours of a 10-hour work shift. Every attempt will be made to sample the periods of greatest exposure. Such exposure may occur during set-up and take-down.

i. Pumps may be changed to avoid pump failure due to excessive sampling periods.

ii. Monitoring may be accomplished with a full shift single sample or continuous multiple samples taken to determine any 8 hours of exposure for comparison with the PEL. A separate sample should be used to determine any additional exposure beyond 8 hours. Reference Appendix XV-B for a specific example.

iii. Lunch Breaks.

A. Generally, it is not advisable to sample during lunch breaks unless employees eat their lunches in areas where potential exposure exists. In most cases, the device should simply be turned off by the CSHO prior to lunch and then turned on again after lunch.

B. Generally, it is not necessary to remove the equipment unless the employee leaves the company premises. Care may be taken to assure that contamination of the collection medium does not occur (i.e. the sample should be capped and removed).

C. If the pump is turned off for lunch, the time it is off should not be counted as sample time for calculation of the TWA.

iv. See Appendicies XV-B and XV-C for additional information about air sampling for work shifts that extend beyond eight hours, as well as guidance on writing AVDs for air sampling overexposures.

b. Less than Full-shift Sampling (e.g., less than 7 hours of an 8-hour shift). Professional judgment is necessary for making any conclusions or assumptions regarding the unsampled period (i.e. the set-up and/or take-down time which is not to exceed 1 hour). For example, if the work shift is 8 hours, and sampling was conducted for 7 hours and 15 minutes, the CSHO needs to make some professional judgment regarding the unsampled 45-minute period.

i. A zero exposure will be assumed unless the CSHO can defend a professional judgment on the magnitude of the exposure for the unsampled period. Thus, a TWA should generally be calculated by dividing the sample results by 8 hours (or 480 minutes) rather than the actual time sampled.

ii. Given sufficient information, a professional judgment on estimated exposure for the unsampled period could be defended.

A. For example, if an 8-hour operation is continuous and the concentration of the substance would not be likely to vary substantially due to the process; and if the employee by virtue of the job could be assumed to be exposed continuously to essentially the same concentration, it would then be acceptable to assume that the exposure for the unsampled time would be the same as that measured for the actual sample time.

B. In this situation, it would be acceptable to calculate a TWA by dividing the sample results by the actual time sampled and compare the resulting TWA with the 8-hour standard.

iii. The CSHO should carefully document the rationale for any professional judgment regarding unsampled exposure periods. A determination that any employer is in compliance will not be made in any case unless the sampled period is representative of the employee's normal exposure.

c. Grab Sampling for 8-Hour TWA Determination. If technology has not been developed to allow full-shift sampling, a series of "grab" or "spot" samples taken throughout the work shift is acceptable. Grab sampling is defined as collecting a number of short-term samples at various times during the sample period which, when combined, provide an estimate of exposure over the total period. Common examples include the use of detector tubes or direct-reading instrumentation (with intermittent readings). One defensible statistical approach would be to take 32 samples throughout the day, with one being taken every 15 minutes.

d. Area samples. Area samples may be taken to identify sources and their relative contributions to employee exposure (e.g., to assist in the determination of the effectiveness of or need for engineering controls).

e. Wipe Sampling. In general, wipe sampling may be used to establish the presence of hazardous quantities of a toxic material with potential skin or ingestion hazard. In arriving at a determination of what constitutes a hazardous quantity of a toxic material, reliance is placed on the professional judgment of the CSHO and the supervisor. Further guidance on wipe sampling can be found in the OSHA Technical Manual.

f. Biological Monitoring. If the employer has been conducting biological monitoring, the CSHO should review the results of such testing. The results may assist in determining whether a significant quantity of the toxic material is being ingested or absorbed through the skin. If biological testing is determined to be necessary to document a hazard, medical support should be arranged through the bureau chief.

g. Noise Sampling.

i. Many of the procedures for noise sampling are outlined in Section III, Chapter 5 of the OSHA Technical Manual, published by the U.S. Department of Labor, Occupational Safety and Health Administration.

ii. All noise sampling will be performed using datalogging noise dosimeters on the "A" weighting scale, with a criterion level of 90 dBA and an exchange rate of 5 dBA. Compliance officers will use the 90 dBA threshold level to document all noise overexposures, and the 80 dBA threshold level to document employee noise exposures in terms of the Action Level. See Section D.1.g below for details about instrument accuracy.

iii. Sound level meters (SLMs) will be used for the following purposes:

A. As a pre-dosimetry screening tool for noise exposure;

B. To spot-check noise dosimeter performance;

C. To identify and evaluate individual noise sources for abatement purposes;

D. To evaluate hearing protectors;

E. Octave band analysis;

F. Measurement of background sound levels in audiometric booths

iv. In reference to Section C.4.g.iii.B above, CSHOs are expected to take 5-8 SLM readings for each dosimeter during noise sampling shifts. These readings should be used as a quality check to determine whether the noise dosimeter appears to have accurately captured the noise profile. The CSHO is not expected to compute a relative-weighted TWA from the SLM readings, as it would not be accurate when compared to dosimeter readings. The number of readings a CSHO with an SLM could take would not be large enough for statistical significance.

v. For less than full shift sampling, use the rules as stated in C.4.b. above for determining whether to consider the unsample time as zero-exposure time, or to extrapolate previous exposure to this time. Dosimeters will calculate both the average sound level for the time sampled (L_{AVG}) and the 8-hour average sound level (L_{TWA}), which assumes zero exposure for the unsampled time period. Some dosimeters (e.g. Quest M-27) will calculate both the actual dose and projected 8-hour dose.

vi. For further information on evaluating noise exposures and guidance on writing noise AVDs, see Appendicies XV-D and XV-E.

h. Determination of Source. Prior to the issuance of a citation, the CSHO must carefully investigate the source or cause of the observed hazards to determine if some type of engineering, administrative or work practice control, or combination thereof, may be applied which would reduce employee exposure. The CSHO is expected to list example control measures in the AVD of all citations requiring the implementation of engineering and/or administrative controls (e.g. 29 CFR 1910.1000(e), 29 CFR 1910.95(b)(1), 29 CFR 1926.55(b)).

5. Closing Conference. The general procedure for closing conferences as described in the Inspection Procedures chapter will be followed. An immediate explanation of available inspection results will be given along with general guidelines in controlling the hazards.

a. Since the CSHO may not have the results of collected samples prior to the first closing conference, a second closing conference will be held by telephone or in person to inform the employer and the employee representative of any alleged violations.

i. If the results indicate noncompliance, discussions will be held on apparent violations, correction procedures and interim methods of control. Alleged violations will be discussed at that time.

ii. If the employer is in compliance, discussion will include the results, and any recommendations of the CSHO on good industrial hygiene practices.

b. The strengths and weaknesses of the employer's occupational health program, as previously noted, will be discussed at the closing conference.

D. **Evaluation of Sampling Data.** The CSHO and supervisor must use professional judgment in the evaluation of the data and conditions. The CSHO should examine the data for unusual deviations. Further sampling may be required to explain such deviations, or justification for using the results will be documented in the case file.

1. Calculations.

a. Actual time weighted average (airborne contaminants).

$$TWA = \frac{C_1T_1+C_2T_2+C_3T_3+...C_nT_n}{T_1+T_2+T_3+...T_n}$$

Where C is concentration, and

Where T is the actual duration of time sampled.

b. 8-hour time weighted average (airborne contaminants).

$$TWA = \frac{C_1T_1+C_2T_2+C_3T_3+...C_nT_n}{T_1+T_2+T_3+...T_n}$$

Where $T_1+T_2+T_3+...T_n$ = 8 hours (or 480 min.)

c. Chemical concentrations.

$$ppm = \frac{(mg/m^3)x24.45}{MW} \quad \text{or} \quad mg/m^3 = \frac{ppm \times MW}{24.45}$$

Where ppm is parts contaminant per cubic meter of air,

Where mg/m^3 is concentration in milligrams per cubic meter of air,

Where 24.45 is a volume constant based on a temperature of 70 degrees F and a pressure of 1 atmosphere, and where MW is the molecular weight of the chemical in question.

d. Air contaminant mixture. Substances which have a known additive effect and therefore result in a greater probability of risk will be evaluated using this formula. The use of this approach requires that the exposures have an additive effect on the same body organ or system. Caution must be used in applying the additive formula, and consultation with the supervisor is recommended.

$$E_m = (C_1/L_1) + (C_2/L_2) + (C_3/L_3) + ... (C_n/L_n)$$

Where E_m is the equivalent exposure for the mixture (not to exceed 1),

Where C is the measured concentration for a particular contaminant, and

Where L is the PEL for that particular contaminant.

e. Noise dose.

% Dose = 100 $(C_1/T_1) + (C_2/T_2) + ... (C_n/T_n)$

Where C is the exposure duration for the nth sound level, and

Where T is the corresponding allowed noise exposure.

f. Time weighted average sound level

TWA (dBA) = 16.61 log (D/100) + 90

Where TWA is the time weighted average sound level,

Where dBA is decibels measured on the "A" weighted scale, and

Where D is the noise dose.

g. Noise measurement accuracy. The accuracy of noise measuring equipment must be considered when using readings for compliance purposes. The instrumentation used in the division is Type 2, meaning the accuracy is +/- 2 dBA. To prove an overexposure, both the average sound level (L_{AVG}) and 8-hour TWA sound level (L_{TWA}) must be 2 dBA over the PEL. In practice, the employees are overexposed to noise with an 8-hour TWA of 92 dBA (a dose of 132% as measured at the 90 dBA threshold setting of the dosimeter) and an average sound level of 92 dBA. Employees must be included in a hearing conservation program when measured noise levels are 87 dBA as an 8-hour TWA (a dose of 66% as measured at the 80 dBA threshold setting).

h. Modification of PELs for Prolonged Exposure. The ACGIH TLVs that were adopted for the OSHA PELs are directly related to assumed conventional exposure periods of no more than 8 hours per day and 40 hours per week, with 16 hours of recovery time between shifts. Today, the workforce works more overtime and extended workshifts. Therefore, information on adjusted PELs should be provided to employers. Citations will be issued on adjusted PELs for lead and cotton dust only, until rulemaking for adjusting all PELs is complete. However, adjusted PELs for substances with acute and/or cumulative toxicity should be calculated (see iii-iv below) and given to the employer as advisory information. Thus, the employer will know what levels should not be exceeded during extended work shifts, as intended by the PEL for the particular substance.

i. Ceiling limit standards are intended never to be exceeded at any time, and so, are independent of the length or frequency of the workshift. The ceiling PELs will not be adjusted.

ii. Some standards have been set primarily to prevent acute irritation or discomfort. They have no known cumulative effects resulting from exposures for extended periods of time. PELs for such substances should not be adjusted.

iii. Substances with acute toxicity have PELs which prevent excessive accumulation of the substance in the body during the day (e.g., carbon monoxide). The following equation determines a level which ensures that employees exposed more than 8 hours per day will not receive a dosage (concentration x exposure time) in excess of that intended by the

PEL, and accounts for the fact that employees who work extended shifts generally do not have 16 hours of recovery time before being exposed again.

Adjusted PEL = 8-hr PEL x [(8/h) x (24 - h)/16], where h = hours worked per day. Reference Patty's Industrial Hygiene and Toxicology 3rd Edition, Volume III, Part A, pp. 248-252.

iv. Substances with cumulative toxicity (e.g., mercury) have PELs designed to prevent excessive accumulation in the body resulting from days or even years of exposure. The following equation ensures that workers exposed more than 40 hours per week will not receive a dosage in excess of that intended by the PEL, and accounts for the fact that employees who work extended shifts generally do not have 16 hours of recovery time before being exposed again.

Adjusted PEL = 8-hr PEL x [(40/h) x (168 - h)/128], where h = hours worked per week. Reference Patty's Industrial Hygiene and Toxicology 3rd Edition, Volume III, Part A, pp. 248-252.

v. The PELs for substances with both acute and cumulative toxicity should be adjusted by the equation which provides the greatest protection to the employee. Remember that citations can be issued on adjusted PELs for lead and cotton dust only.

vi. See Appendix XV-B for additional information about air sampling for work shifts that extend beyond eight hours.

vii. See Appendix XV-D for additional information about noise sampling for work shifts that extend beyond eight hours.

i. Severity of exposure.

Y = Employee Exposure/PEL.

Where Employee Exposure is the result of sampling,

Where Y is severity, (not to exceed 1), and

Where PEL is the permissible exposure limit.

j. 95% confidence limits for air contaminants The LCL and UCL are calculated differently depending upon the type of sampling method used.

i. Calculation for a single sample, (full-period or ceiling).

UCL (95%) = (Y) + SAE

LCL (95%) = (Y) - SAE

Where SAE is sampling and analytical error,
Where Y is severity, and
Where UCL and LCL are upper and lower confidence limits.

If LCL > 1, a violation exists.
If LCL ≤ 1 and the UCL > 1, classify as possible overexposure.
If the UCL ≤ 1, a violation does not exist.

A. If the measured exposure exceeds the PEL, but the LCL of that exposure is below the PEL, we cannot be 95 percent confident that the employer is out of compliance. (See example B1 in Figure XV-2.) Likewise, if the measured exposure does not exceed the PEL, but the UCL of that exposure does exceed the PEL, we cannot be 95 percent confident that the employer is in compliance. (See example B2 in Figure XV-2.) In both of these cases, our measured exposure falls into a region which is termed "possible overexposure".

1. A citation should not be issued if the measured exposure falls into the "possible overexposure" region. It should be noted that the closer the LCL comes to exceeding the PEL, the more probable it becomes that the employer is out of compliance.

2. If measured results are in this region, the CSHO should consider further sampling, taking into consideration the seriousness of the hazard, pending citations, and how close the LCL is to exceeding the PEL.

3. If further sampling is not conducted, or if additional measured exposures still fall into the "possible overexposure" region, the CSHO should carefully explain to the employer and employee representative in the closing conference that the exposed employee(s) may be overexposed but that it cannot be established. The employer should be encouraged to voluntarily reduce the exposure and/or to conduct further sampling to assure that exposures are not in excess of the PEL.

B. If the measured results do not exceed the PEL and the UCL also does not exceed the PEL, we can be 95 percent confident that the employer is in compliance. (See Example C in Figure XV-2.)

C. Sampling and Analytical Error (SAE).

1. For personal sampling with pumps and media, the SAE will be based on the analytical method used on the sample by the laboratory service provider.

2. The SAE must be calculated in every situation where the severity (Y) is between 1.0 and 1.3. For other situations, calculating the SAE is recommended, but optional.

3. Determining the SAE for an analytical method:

a. For OSHA methods, the SAE can be read directly from the Chemical Sampling Information page on the OSHA website.

b. For NIOSH methods, consult the NIOSH Manual of Analytical Methods on the NIOSH website.

The SAE must be calculated by multiplying the Overall Precision (S_{rT}) by the statistical constant 1.645. Example: NIOSH Method 7500 for Methylene Chloride. SAE = 1.645 x S_{rT}, S_{rT} = 0.076, SAE = 1.645 x 0.076 = 0.125.

c. For NIOSH methods with no calculated SrT (e.g. Method 7300 for Lead and Other Elements), and methods from ASTM or other organizations, contact the laboratory service provider directly to get the SAE. Another possible solution is to use the SAE from a known method (such as an OSHA method) that uses the same media, quantification technique, etc. as the method with the unknown SAE.

D. Direct Reading Instrument Error.

1. Direct-reading instruments do not have an SAE per se, but do have instrument error, which must be taken into account when determining if an overexposure exists with 95% confidence.

2. For direct reading instruments (e.g. SafeLog 100, Toxilog, detector tubes), the instrument error will be the manufacturer's listed performance tolerances. Examples: Quest Safelog 100 detectors with CO sensors have a manufacturer-listed accuracy of 5%. Therefore, the instrument error (equivalent to SAE) would be 0.05, and an overexposure can be documented if severity (Y) is greater than 1.05 (meaning the LCL > 1). The Sensidyne Gastec MEK Detector Tube lists an accuracy of tolerance of 25%. The instrument error is thus 0.25, and overexposures can be documented if Y > 1.25.

3. For noise dosimetry using Type 2 instruments, the instrument error is +/- 2 dBA (see Evaluation of Sampling Data, Section D.1.g) above.

ii. Calculation method for consecutive samples. The use of multiple consecutive samples will result in slightly lower SAEs than the use of one continuous sample since the inherent errors tend to partially cancel each other. However, the calculations are somewhat more complicated. If preferred, the CSHO may first determine if compliance or noncompliance can be established using the calculation method noted for a single sample measurement. If results fall into the "possible overexposure" region using this method, the more exact calculations should be performed. To compute the (95%) UCL and LCL, see Figure XV-3.

2. Interpretation of 29 CFR 1910.1000, Tables Z-1, Z-2 and Z-3, and 29 CFR 1926.55 Appendix A. **Remember that 29 CFR 1926.55 is used for construction inspections**.

a. The nuisance dust (particulates) standard applies to both organic and inorganic dusts. The standard should not be used when evaluating an exposure to a substance listed in 29 CFR 1910.1000 Table Z-1 or 1926.55.

b. Where toxicity information exists for a substance with no PEL and a serious hazard exists below the nuisance dust standard, protective limits recommended by other agencies will be reviewed (i.e., ACGIH TLVs, NIOSH RELs, AIHA WEELs, EPA, IARC, etc.). If a recommended limit is

set, a citation under NCGS 95-129(1) for general duty should be considered. The employer will be required to reduce employee exposures to appropriate levels.

c. Where there is a recommended limit set by another agency that is lower than the OSHA PEL, the PEL will be used. The exceptions are:

i. If the other agency sets a ceiling limit (higher than the PEL) and OSHA has only a PEL, then the ceiling limit may be enforced using the general duty clause.

ii. If the CSHO can demonstrate that the PEL is not providing adequate protection and the other agency limit is more likely to provide proper protection, then the use of the general duty clause may be considered.

d. Interpretation of Ceiling Limits.

i. Contaminants in 29 CFR 1910.1000 Table Z-1 may have a STEL (short term exposure limit) or a ceiling limit. The STEL is the employee's 15 min TWA exposure (unless another time limit is specified) which will not be exceeded at anytime during the day. The ceiling limit will not be exceeded at any time during the day. If instantaneous monitoring is not feasible, then the CSHO will use a 15 minute sample to determine compliance with the ceiling limit.

ii. Contaminants in 29 CFR 1910.1000 Table Z-1 preceded by a "C" are ceiling limits which theoretically should never be exceeded, even instantaneously. Practically, the CSHO should use a 15-minutes sampling period to evaluate compliance with ceiling standards, unless direct-reading instrumentation or methods with sufficient analytical accuracy are available.

iii. Contaminants in 29 CFR 1910.1000 Table Z-2 have both "acceptable ceiling concentrations" (column 2) and "maximum peak concentrations" (column 3) up to which exposures are allowed for the period specified in column 4. Generally OSHA uses a 15-minute sample to evaluate ceiling limits due to analytical accuracy.

A. All the time periods specified in column 4 are less than 15 minutes. Therefore, if a 15-minute continuous exposure exceeds the ceiling value in column 2, noncompliance is established.

B. Where less than a 15-minute sample is taken, a citation may be issued if one of two conditions exists:

1. Column 2 is exceeded and the sampling time is beyond the time allowed by column 4.

2. Column 3 is exceeded, even instantaneously.

Note: When sampling for substances with ceiling or STEL limits, consider the analytical method to be used. Will the 15-minute sampling time provide enough volume to quantify the contaminant? A small sample volume can result in a higher detection limit.

e. *Interpretation of 29 CFR 1910.1000, Table Z-3 and 29 CFR 1926.55, Appendix A (Mineral Dusts).* This table contains the PELs for respirable dusts. The primary concern is the silica content of the dusts involved. Silica is evaluated from respirable dust samples. Where the employee is exposed to combinations of silica dust (i.e. quartz, cristobalite, and tridymite), the additive effects of the mixture must be considered. The lab results give the weight of the respirable dust, as well as the weight of quartz, cristobalite and tridymite. It is necessary to calculate the PEL from this information.

Note: When using a 10mm nylon cyclone to collect a respirable dust sample, the required flow rate is 1.7 lpm. In accordance with the OSHA Technical Manual and NIOSH Analytical Method No. 7500, the flow rate should remain at 1.7 L/min ±5%. This ensures that the respirable and non-respirable sized particles are separated properly. If the pre and post-sampling calibration flow rates differ more than 5%, the sample is considered to be invalid and is to be voided.

To determine employee exposures, the concentration of total respirable dust is evaluated against the calculated PEL. Example calculations can be found in Appendix XV-A.

i. General Industry. To calculate the PEL for silica-containing respirable dust, use the following formulas:

PEL for respirable dust containing quartz = $10mg/m^3$ / Qu% + 2

PEL for respirable dust containing a silica mixture = $10mg/m^3$ / Qu%+2(Cr%)+2(Tr%)+2

Where Qu is Quartz,
Where Cr is Cristobalite, and
Where Tr is Tridymite.

ii. *Construction Industry. To calculate the PEL for silica-containing respirable dust, use the following (reference CPL 03-00-007, National Emphasis Program – Crystalline Silica, Appendix E):*

PEL for respirable dust containing quartz = 250 mppcf / (%Quartz + 5)

mppcf = millions of particles per cubic foot (mppcf).

OSHA-adopted conversion factor of 1 mppcf = 0.1 mg/m^3 or 1 mg/m^3 = 10 mppcf (multiply mg/m^3 by 10 to convert to mppcf)

For OSH Division reporting purposes, the calculated PEL (in mppcf) will be converted to mg/m^3 to compare to the sampling results in mg/m^3. Determine the 8-hour time-weighted average exposure of respirable dust in mg/m^3 from the lab data. Calculate the applicable construction PEL in mppcf and then apply the OSHA-adopted conversion factor (i.e. divide by 10) to convert the PEL to units of mg/m^3. The exposure concentration can then be compared directly to the PEL to evaluate for compliance purposes.

E. **Carcinogen Inspections.** Most inspections for the evaluation of carcinogens will be assigned in the usual manner. However, certain standards regulating carcinogenic materials require employers to report in writing to the Director all regulated areas. Upon receipt of such reports, inspections will be conducted. These will be considered programmed inspections.

1. Investigation of potential employee exposure to known or suspect carcinogens requires that special precautions be taken by the HCO. Respiratory equipment and protective clothing must be carefully selected based on potential exposure.

2. Air sampling will be conducted when necessary to help define employee exposure. Prior to entry into any contaminated area, the HCO will consider the following:

   a. If the substance can be absorbed through the skin, impervious protective clothing (foot, body, head, hand covering) must be worn. Respiratory protection and personal protective equipment should be carefully selected based on the properties of the substance and potential exposure.

   b. Disposable clothing is preferable and will be disposed of at the worksite or transported in an impervious bag to an appropriate disposal site. Nondisposable clothing will be removed at the worksite and transported in an impervious bag to an appropriate decontamination or cleaning site.

   c. Where contamination of equipment or personal protective clothing is possible, decontamination procedures must be prepared in advance. Industrial cleaning services with appropriate expertise and facilities may be contracted on a local basis for cleaning of contaminated clothing. The cleaner will be informed of the potential hazard in writing.

   d. The type of respiratory protection used must be approved and appropriate for the exposure and must be selected to protect against the maximum potential exposure. Assistance from the supervisor is available for making this decision.

      i. Normally, the HCO will not enter an area where a self-contained breathing apparatus is required. When possible, sampling equipment will be placed on an employee in a clean area prior to the employee's entry into a regulated area.

      ii. A self-contained breathing apparatus (positive pressure, demand) may be required where:

         A. There is an unknown concentration of a known airborne carcinogen, and other respiratory protection equipment may not be effective.

         B. The employer requires the use of self-contained breathing apparatus.

         C. An emergency (i.e. fatality/catastrophe) investigation involving potential hazardous exposures requires entry into unknown concentrations in containment.

         HCOs **will not** place themselves in situations that may risk their health or life.

   e. Wipe sampling may be necessary to define the extent of contaminated areas and to evaluate the effectiveness of decontamination procedures. Special precautions must be taken when collecting wipe samples. Gloves used to collect wipe samples must be impervious to the chemical collected.

The analytical laboratory should be contacted to discuss collection and analytical methods for non-routine chemical wipe sampling.

f. Special regulations must be followed for shipment of bulk samples. (Refer to the OSHA Technical Manual.)

F. **Citation Guidance.**

1. Citation of Ventilation Standards. In cases where a citation of a ventilation standard may be appropriate, consideration will be given to standards intended to control exposure to recognized hazardous levels of air contaminants, to prevent fire or explosions, or to regulate operations which may involve confined space or specific hazardous conditions. In applying these standards, the following guidelines will be observed:

a. Health-Related Ventilation Standards. An employer is considered in compliance with a health-related airflow ventilation standard when the employee exposure does not exceed appropriate airborne contaminant standards; e.g., the PELs prescribed in 29 CFR 1910.1000.

i. Where an over-exposure to an airborne contaminant is detected, the appropriate air contaminant engineering control requirement will be cited; e.g., 29 CFR 1910.1000(e). In no case will citations of this standard be issued for the purpose of requiring specific ventilation systems to control such exposures.

ii. Other requirements contained in health-related ventilation standards will be evaluated without regard to the concentration of airborne contaminants. Where a specific standard has been violated and an actual or potential hazard has been documented, a citation will be issued.

EXAMPLE: Welding or cutting on several specialty metals (e.g., lead, beryllium, zinc, etc.) indoors or in a confined space requires the use of local exhaust ventilation or an airline respirator, regardless of the air concentration of the metal.

b. Fire and Explosion Related Ventilation Standards. Although they are not technically health violations, the following guidelines will be observed when citing fire and explosion related ventilation standards:

i. Adequate Ventilation. In the application of fire and explosion related ventilation standards, an operation has adequate ventilation when both of the following criteria are met:

A. The requirement of the specific standard has been met.

B. The concentration of flammable vapors is 25 percent or less of the lower explosive limit (LEL).

EXCEPTION: Certain standards specify violations when 10 percent of the LEL is exceeded. These standards are found in maritime and construction exposures.

CAUTION: If explosive atmospheres are suspected, suitable (e.g., mechanical or explosion proof) equipment must be used.

CAUTION: While obtaining LEL readings for citation documentation is desirable, remember that these concentrations may be well over the PEL for that chemical. For example, the LEL for methane is 5.4% and 25% LEL is 1.35%. This is equivalent to 13,500 ppm. The CSHO must not put him/herself in a hazardous situation. Thus, the CSHO may only be able to document the potential for exceeding 25% LEL unless the equipment has remote sampling capability.

ii. If 25 percent (10 percent when specified for construction operations) of the LEL has been exceeded and:

A. The standard requirements have not been met; the violation normally will be cited as serious.

B. There is no applicable specific ventilation standard; NCGS 95-129 (1) will be cited in accordance with the guidelines given in the violations chapter.

iii. If 25 percent (10 percent when specified for construction operations) of the LEL has **not** been exceeded and:

A. The standard requirements have not been met; the violation normally will be cited as nonserious.

B. The standard requirements have been met; no citation will be issued.

c. Special Conditions Ventilation Standards. The primary hazards in this category are those resulting from confined space operations.

i. Overexposure need not be shown to cite ventilation requirements found in the standards themselves. However, an actual or potential hazard must be documented.

ii. Other hazards associated with confined space operations, such as potential oxygen deficiency or toxic overexposure, must be adequately documented before a citation may be issued.

2. Violations of the Noise Standard. Current enforcement policy regarding 29 CFR 1910.95 does not allow employers to rely on personal protective equipment and a hearing conservation program rather than engineering and/or administrative controls.

a. Violations of 29 CFR 1910.95(b)(1) will be cited when both the average sound level (L_{AVG}) and eight-hour TWA (L_{TWA}) exceeds 92 dBA (a dose of 132%) and engineering or administrative controls are feasible but not utilized.

i. 29 CFR 1910.95(b)(1) will be classified as serious when;

A. Hearing protection is not provided or properly utilized; and/or

B. The hearing conservation program is deficient or nonexistent. This citation can be assigned an abatement time of up to one year with progress reports required every 120 days.

ii. 29 CFR 1910.95(b)(1) will be classified as nonserious when;

A. Effective hearing protection is provided and is being utilized; and,

B. The hearing conservation program is effective; and

C. The employer has an effective training program and is following it.

b. A violation of 29 CFR 1910.95(c)(1) will be cited when an employee's exposure *equals or exceeds* an eight-hour TWA of 87 dBA (a dose of 66%) and the hearing conservation program is nonexistent. The AVD should list the elements of an effective hearing conservation program.

Note: The provision of ear plugs does not constitute a hearing conservation program. If there is an overexposure to noise and the employer has provided ear plugs only, 29 CFR 1910.95(c)(1) will be cited.

i. 29 CFR 1910.95(c)(1) will be cited as serious when the 8-hour TWA (L_{TWA}) is 92 dBA or more (dose > 132%), and the hearing conservation program is nonexistent.

A. When portions of 29 CFR 1910.95(c)(1) are deficient, then those parts of 29 CFR1910.95(d) through (o) will be cited specifically as serious.

ii. 29 CFR 1910.95(c)(1) will be cited as nonserious when the TWA *is equal to or greater than* 87 dBA, but less than 92 dBA, and the hearing conservation program is nonexistent.

A. When portions of 29 CFR1910.95(c)(1) are deficient, then those parts of 29 CFR 1910.95(d) through (o) will be cited specifically as nonserious.

iii. Abatement times of up to 120 days can be assigned with progress reports at 60 days; however, earliest possible times should be assigned for deficiencies in the hearing conservation program.

c. When an employee is overexposed, but effective hearing protection is being provided and used, an effective hearing conservation program has been implemented, and no feasible engineering or administrative controls exist, a citation will not be issued.

3. Violations of the Respirator Standard. When considering a citation for respirator violations, note that the standard applies whenever the employer requires the use of respirators or if the employee uses a respirator on a voluntary basis. Thus, overexposures are not necessary to document a violation. (See the compliance directive CPL 02-00-158~~.120~~ for interpretation and application of the standard.)

a. Exception. The exception to this is that the employer is not required to include in a written respiratory protection program those employees whose only use of respirators involves the voluntary use of filtering face pieces (dust masks). [See 29 CFR 1910.134(c)(2)(ii)]

b. In Situations Where Overexposure Does Occur. In cases where an overexposure to an air contaminant has been established, the following principles apply to citations of 29 CFR 1910.134:

i. 29 CFR 1910.134(a)(2) is the general section requiring employers to provide respirators when such equipment is necessary to protect the health of the employee and requiring the establishment and maintenance of a respiratory protection program which meets the requirements outlined in 29 CFR 1910.134(c). Thus, if no respiratory program at all has

been established, 29 CFR 1910.134(a)(2) alone will be cited. The AVD should contain an abatement note which outlines all the elements required for an effective program.

ii. An acceptable respiratory protection program includes all of the elements of 29 CFR 1910.134. If a program has been established and some, but not all, of the requirements under 29 CFR 1910.134(c-o) are being met, the specific standards under 29 CFR 1910.134(c-o) that are not implemented will be cited and grouped as one item.

4. Violations of Air Contaminant Standards. The standard itself provides several requirements.

a. 29 CFR 1910.1000 Table Z-1 provides ceiling values and 8-hour time weighted averages (threshold limit values) applicable to employee exposure to air contaminants.

b. 29 CFR 1910.1000(e) provides that to achieve compliance with those exposure limits, administrative or engineering controls will first be identified and implemented to the extent feasible. When such controls do not achieve full compliance, protective equipment will be used. Whenever respirators are used, their use will comply with 29 CFR 1910.134.

c. 29 CFR 1910.134(a) provides that when effective engineering controls are not feasible, or while they are being instituted, appropriate respirators will be used. Their use will comply with requirements contained in 29 CFR 1910.134 which provide for the type of respirator and the proper maintenance.

d. The situation may exist where an employer must provide feasible engineering controls as well as feasible administrative controls (including work practice controls) and personal protective equipment. 29 CFR 1910.1000(e) has been interpreted to allow employers to implement feasible engineering controls and/or administrative and work practice controls in any combination the employer chooses provided the abatement means chosen eliminates the overexposure.

e. Where engineering and/or administrative controls are feasible but do not or would not reduce the air contaminant levels below the applicable ceiling value or threshold limit value, the employer, nevertheless, must institute such controls. Only where the implementation of all feasible engineering and administrative controls fails to reduce the level of air contaminants below applicable levels will the use of personal protective equipment constitute satisfactory abatement. In such cases, usage of personal protective equipment will be mandatory.

5. Classification of Violations of Air Contaminant Standards. When it has been established that an employee is exposed to a toxic substance in excess of the PEL established by OSH standards (without regard to the use of respiratory protection), a citation for exceeding the air contaminant standard will be issued. The violation will be classified as serious or nonserious on the basis of the requirements in the OSHA Chemical Sampling Information on the OSHA website, and the use of respiratory protection at the time of the violation. Classification of violations is dependent upon the determination that the illness is reasonably predictable at that exposure level, whether the illness is serious or nonserious and that the employer knew or could have known through reasonable diligence that a hazardous condition existed.

a. Principles of Classification. The Chemical Sampling Information page on the OSHA website provides "health codes" for each substance listed based upon the expected toxicity.

i. In general, substances having a single health code of 13 or less will be considered as serious at any level above the PEL. Substances in categories 6, 8 and 12, however, are not considered serious at levels where only mild, temporary effects would be expected to occur.

ii. Substances causing irritation (i.e., categories 14 and 15) will be considered non-serious up to levels at which moderate irritation could be expected.

iii. For a substance (e.g., cyclohexanol), having multiple health codes covering both serious and nonserious effects, a classification of nonserious will be applied up to the level at which a serious effect(s) could be expected to occur.

iv. For a substance having an ACGIH Threshold Limit Value (TLV) or a NIOSH recommended value, but no OSHA PEL, a citation for exposure in excess of the recommended value will be considered under NCGS 95-129(1) if the exposure (dose) and toxicity of the substance would result in a serious illness or injury.

v. If an employee is exposed to concentrations of a substance below the PEL, but in excess of a recommended value (e.g., ACGIH TLV or NIOSH recommended value), a citation for inhalation cannot normally be issued. The CSHO will advise the employer that a reduction of the PEL has been recommended.

vi. For a substance having an 8-hour PEL with no ceiling limit but for which a ACGIH TLV ceiling and/or NIOSH ceiling value has been recommended, the case will be discussed with the supervisor and the bureau chief. If no citation is to be issued, the CSHO will, nevertheless, advise the employer that a ceiling value has been recommended.

b. Effect of Respirator Protection Factors. The CSHO will consider protection factors for the type of respirator in use as well as the possibility of overexposure if the respirator fails. If protection factors are exceeded and if the potential for overexposure exists, a citation for failure to control excessive exposure will be issued.

c. Additive and Synergistic Effects. Substances which have a known additive effect and, therefore, result in a greater probability/severity of risk when found in combination will be evaluated using the formula found in 29 CFR 1910.1000(d)(2).

i. The use of this formula requires that the exposures have an additive effect on the same body organ or system. Caution must be used in applying the additive formula and prior consultation with the supervisor and bureau chief is required.

ii. If the CSHO suspects that synergistic effects are possible, it will be brought to the attention of the supervisor, who will refer the question to the bureau chief. If it is decided that there is a synergistic effect of the substances found together, the violations will be grouped, when appropriate, for purposes of increasing the violation classification severity and/or the penalty.

6. Guidelines for Issuing Citations of Air Contaminant Violations .

a. Grouping.

i. In situations where an overexposure is documented, feasible engineering and/or administrative controls have not been implemented, and respiratory protection has not been provided or is insufficient or ineffective, the CSHO will issues citations for each and group the violations as one item.

A. When the overexposure is for a contaminant in General Industry, the CSHO will cite 29 CFR 1910.1000(a), (b) or (c) for the overexposure, 29 CFR 1910.1000(e)

for engineering/administrative controls, and 29 CFR 1910.134 paragraphs for respirator violations (see Section F.3.b for information on the specific respirator sections to cite), and group the violations together.

B. When the overexposure is for a contaminant in the Construction Industry, the CSHO will cite 29 CFR 1926.55(a) for the overexposure, 29 CFR 1926.55(b) for engineering/administrative controls, and 29 CFR 1910.134 paragraphs (verbatim with 29 CFR 1926.103) for respirator violations (see Section F.3.b for information on the specific respirator sections to cite), and group the violations together.

ii. For overexposures of contaminants covered under an expanded health standard (e.g. 29 CFR 1910.1025 for lead), grouping of violations will be done in accordance with FOM Chapter 5, Section C.3.

b. No violation of the 29 CFR 1910.1000 series would exist and no citation would be issued in the following circumstances:

i. Where no identified employee exposure level is above that specified in the standard, whether or not engineering controls, administrative controls or personal protective equipment are utilized.

ii. Where the exposure level of an identified employee is above that specified in the standard, but all feasible engineering and administrative controls are utilized and personal protective equipment is provided, worn and maintained in accordance with the provisions of 29 CFR 1910.134.

7. Violations of the Hazard Communication Standard. For HAZCOM citation guidance, the CSHO will use CPL 02-02-038 or the most current HAZCOM CPL.

8. Citing Improper Personal Hygiene Practices. The following guidelines apply when citing personal hygiene violations:

a. Ingestion Hazards. A citation under 29 CFR 1910.141(g)(2) and (g)(4)will be issued where there is reasonable probability that in areas where employees consume food or beverages (including drinking fountains), a potentially hazardous amount of toxic material may be ingested and subsequently absorbed.

i. A "toxic material" is defined in 29 CFR 1910.141 (a) (2) (viii) as "... a material in concentration or amount which exceeds the applicable limit established by a standard, such as 29 CFR 1910.1000 and 29 CFR 1910.1001 or, in the absence of an applicable standard, which is of such toxicity so as to constitute a recognized hazard that is causing or is likely to cause death or serious physical harm."

A. There are presently no standards defining an ingestion hazard. The PELs are not applicable because they establish limits for inhalation only. Thus, citations do not depend on measurements of airborne concentrations.

B. The material must be a recognized hazard, and since, by the definition, must cause or be likely to cause death or serious physical harm by ingestion, violations

of 29 CFR 1910.141(g) (2), when dealing with a toxic material, cannot be cited unless a serious violation is documented.

ii. For citations under 29 CFR 1910.141(g)(2) or (4) wipe sampling results will be adequately documented to establish a serious hazard.

iii. Where, for any substance, a serious hazard is determined to exist due to the potential of ingestion or absorption of the substance for reasons other than the consumption of contaminated food or drink (e.g., smoking materials contaminated with the toxic substance), a serious citation will be considered under NCGS 95-129(1).

iv. A citation under 29 CFR 1910.141(g) (4) will be considered where there is reasonable probability that a potentially hazardous amount of a toxic material may be ingested due to storage of food or beverages in a contaminated area.

b. Absorption Hazards. A citation for exposure to materials which can be absorbed through the skin or which can cause a skin effect (e.g., dermatitis) will be issued where appropriate personal protective equipment (clothing) is necessary but not worn. (See 29 CFR 1910.1000 Table Z-1, substances marked "skin".) The citation will be issued under 29 CFR 1910.132(a) as either a serious or nonserious citation according to the hazard.

i. Such citations do not depend on measurements of airborne concentrations.

ii. If a serious skin absorption or dermatitis hazard exists which cannot be eliminated with protective clothing, a NCGS 95-129(1) citation may be considered. Engineering or administrative (including work practice) controls will be required in these cases to prevent the hazard.

c. Regulated Substances. Citations for specific work practices and personal hygiene requirements for highly toxic or carcinogenic substances, e.g., 29 CFR 1910.1004, 29 CFR 1910.1025, will be issued under the applicable standard. The CSHO will review the appropriate substance specific CPL, if available, for citation guidance.

d. Issuing Citation. There are two primary considerations when issuing a citation of an ingestion or absorption hazard, such as a citation for lack of protective clothing:

i. A health risk exists as demonstrated by one of the following:

A. A potential for an illness, such as dermatitis, and/or

B. The presence of a toxic material that can be ingested or absorbed through the skin or in some other manner. (See the OSHA website for Chemical Sampling Information.)

ii. The potential that the toxic material can be ingested or absorbed, e.g., that it can be present on the skin of the employee can be established by evaluating the conditions of use and determining the possibility that a health hazard exists.

iii. The conditions of use can be documented by taking both qualitative and quantitative results of wipe sampling into consideration when evaluating the hazard.

e. Supporting Citation. There are four primary considerations which must be met to support a citation:

i. The potential for ingestion or absorption of the toxic material must exist.

ii. The ingestion or absorption of the material must represent a health hazard.

iii. The toxic substance must be of such a nature and exist in such quantities as to pose a serious hazard. The substance must be present on surfaces which have hand contact (such as lunch tables, cigarettes, etc.) or on other surfaces which, if contaminated, present the potential for ingestion or absorption of the toxic material (e.g., a water fountain).

iv. The protective clothing or other abatement means would be effective in eliminating or significantly reducing exposure.

G. **Feasible Administrative, Work Practice and Engineering Controls.**

1. Administrative Controls. Any procedure which significantly limits daily exposure by control or manipulation of the work schedule is considered a means of administrative control. The use of personal protective equipment is not considered a means of administrative control.

2. Work Practice Controls. Work practice controls are the actions of the employee which result in the reduction of exposure through such methods as effective use of engineering controls, sanitation and hygiene practices, or other changes in the way the employee performs the job.

3. Engineering Controls. Engineering controls consist of substitution, isolation, ventilation and equipment modification.

a. Substitution may involve process change, equipment replacement or material substitution.

b. Isolation results in the reduction of the hazard by providing a barrier around the material, equipment, process or employee. This barrier may consist of a physical separation or isolation by distance.

c. A detailed discussion of ventilation controls can be found in the OSHA Technical Manual.

d. Equipment modification will result in increased performance or change in character, such as the application of sound absorbent material.

4. Feasibility. Feasibility is the existence of general technical knowledge as to materials or methods which are available or adaptable to specific circumstances and which can be applied with a reasonable possibility that employee exposure to occupational health hazards will be reduced.

a. Technical Feasibility.

i. The HCO (following available directions and guidelines provided by the supervisor and bureau chief, if necessary) will determine whether engineering controls are feasible. Sources which can provide information useful in making this determination are the following:

A. Similar situations observed elsewhere where adequate engineering controls do, in fact, reduce employee exposure.

B. Written source materials or conference presentations that indicate that equipment and designs are available to reduce employee exposure in similar situations.

C. Studies by a qualified consulting firm, professional engineer, industrial hygienist, or insurance carrier that show engineering controls are technically feasible.

D. Equipment catalogs and suppliers that indicate engineering controls are technically feasible and are available.

ii. OSHA's experience indicates that feasible engineering controls exist for most hazardous exposures.

b. Economic Feasibility. The employer's economic cost of correction is generally not considered to be a factor in the issuance of a citation. However, there may be instances where calculating the cost of abatement would be beneficial in order to prove feasibility.

i. If the cost of implementing effective engineering, administrative or work practice controls, or combination, would so seriously jeopardize the employer's financial condition so as to result in the probable shut down of the establishment or a substantial part of it, an extended correction date may be set.

ii. Abatement periods greater than 1 year in a single request or 4 years in cumulative time requires the approval of the bureau chief.

5. Reducing Employee Exposure. Whenever feasible engineering, administrative, or work practice controls can be instituted, and yet are not sufficient to reduce exposure to, or below the PEL, they will be used nonetheless, to reduce exposure to the lowest practical level.

6. Infeasibility. A determination that engineering controls are infeasible will not be made without consultation with and approval of the director's office.

APPENDIX XV-A: Sample Calculations for Silica Exposure

EXAMPLE #1

Sampling Data and Lab Results				
Sample	**Sampling Period**	**Volume**	**Weight**	**Concentration**
#1	134 min.	336.6 liters		
Respirable Dust			0.398 mg	1.182 mg/m^3
Quartz			0.18 mg	0.53 mg/m^3
#2	93 min.	233.6 liters		
Respirable Dust			1.362 mg	5.83 mg/m^3
Quartz			1.00 mg	4.3 mg/m^3

Step A: Calculate the percentage of quartz

(Wt. Quartz #1 + Wt. Quart #2 / Wt. Resp. Dust #1 + Wt. Resp. Dust #2) X 100 = Quartz %

(0.18mg + 1.0 mg / 0.398 mg + 1.362 mg) X 100 = (1.18 mg / 1.76 mg) X 100 = 67 = Quartz %

Step B: Calculate the PEL

(10 mg/m^3 / Quartz% + 2) = PEL

(10 mg/m^3 / 67 + 2) = (10 mg/m^3 / 69) = 0.145 mg/m^3 = PEL

Step C: Calculate employee exposure {*assume zero exposure for unsampled time.}

[(Conc #1)(Time #1) + (Conc #2)(Time#2)] / (Time #1 + Time #2) {*or 480 min.} = employee exposure

[(1.182 mg/m^3)(134 min) +(5.83 mg/m^3)(93 min) + (0 mg/m^3)(253 min)] / 480 min =

(158.4 min-mg/m^3 + 542.2 min-mg/m^3) / 480 min. = 700.6 mg/m^3 / 480 min. = 1.46 mg/m^3

Step D: Calculate the severity

Employee exposure / PEL = 1.46 mg/m^3 /0.145 mg/^{3} = 10.07 = Severity

Step E: Determine 95% confidence limits, Standard Analytical Error (SAE) = 0.20

UCL (95%) = Severity (Y) + SAE = 10.07 + 0.20 = 10.27

LCL (95%) = Severity (Y) + SAE = 10.07 - 0.20 = 9.87

LCL > 1, an overexposure exists.

EXAMPLE #2

Sampling Data and Lab Results				
Sample	**Sampling Period**	**Volume**	**Weight**	**Concentration**
#1	238 min	405 liters		
Respirable Dust			0.855 mg	2.1mg/m^3
Quartz			0.044 mg	0.11 mg/m^3
Cristobalite			0.020 mg	0.05 mg/m^3
Tridymite			None Detected	None Detected
#2	192 min.	326 liters		
Respirable Dust			0.619 mg	1.9 mg/m^3
Quartz			0.030 mg	0.09 mg/m^3
Cristobalite			0.011 mg	0.03 mg/m^3
Tridymite			None Detected	None Detected

Step A: Calculate the percentages of Quartz and Critobalite

(Wt. #1 + Wt. #2 / Wt. Resp. Dust #1 + Wt. Resp. Dust #2) X 100 = Quartz or Cristobalite %

(0.044mg + 0.030 mg / 0.855 mg + 0.619 mg) X 100 = (0.074 mg / 1.474 mg) X 100 = 5.0 = Quartz %

(0.020 mg + 0.011 mg/ 0.855 mg + 0.619 mg) X 100 = (0.031 mg / 1.474 mg) X 100 = 2.1 = Cristobalite %

Step B: Calculate the PEL for the mixture

[10 mg/m^3 / Quartz % + 2(Cristobalite %) + 2] = PEL

[10 mg/m^3 / (5 + 2(2.1) + 2)] = (10 mg/m^3 / 11.2) = 0.89 mg/m^3 = PEL

Step C: Calculate employee exposure {*assume zero exposure for unsampled time.}

[(Conc #1)(Time #1) + (Conc #2)(Time#2)] / (Time #1 + Time #2) {*or 480 min.} = employee exposure

[(2.1 mg/m^3)(238 min) +(1.9 mg/m^3)(192 min) + (0 mg/m^3)(50 min)] / 480 min =

(499.8 min-mg/m^3 + 364.8 min-mg/m^3) / 480 min. = 864.6 mg/m^3 / 480 min. = 1.80 mg/m^3

Step D: Calculate the severity

Employee exposure / PEL = 1.80 mg/m^3 /0.89 mg/^{3} = 2.0 = Severity

Step E: Determine 95% confidence limits, Standard Analytical Error (SAE) = 0.20

UCL (95%) = Severity (Y) + SAE = 2.0 + 0.20 = 2.2

LCL (95%) = Severity (Y) - SAE = 2.0 - 0.20 = 1.8

LCL > 1, an overexposure exists.

APPENDIX XV-B: Sampling for Extended (> 8 Hour) Work Shifts

A. Sampling Procedures

From Chapter XV, Section (C)(4) above:

"Monitoring may be accomplished with a full shift single sample or continuous multiple samples taken to determine any 8 hours of exposure for comparison with the PEL. A separate sample should be used to determine any additional exposure beyond 8 hours."

The CSHO should attempt to capture "the worst" 8 hours of the extended work shift by changing the media at fixed intervals throughout the day. For example, during an evaluation of total welding fume exposure over a 12-hour shift, the PVC filters were changed every 4 hours with the following results:

Sample #	Sampling Time	Results
1	4 hours	2.5 mg/m^3
2	4 Hours	5.2 mg/m^3
3	4 Hours	6.4 mg/m^3

In this situation, the second and third samples would be used to calculate the employee's 8-hour Time Weighted Average (TWA) exposure of 5.8 mg/m^3, which exceeds the 8-hour TWA Permissible Exposure Limit of 5.0 mg/m^3. The results from the first sample should be presented to the employer, but would not be used in exposure calculations for comparison to the 8-hour TWA PEL. Clearly, this procedure is preferred to using only two filters (8 hours + 4 hours) or only one filter (all 12 hours) to calculate the employee's 12-hour TWA. While a 12-hour TWA can be compared directly to an 8-hour TWA PEL, it may underestimate "the worst" 8 hour exposure. In this case, the 12-hour TWA would be 4.7 mg/m^3, which is below the 8-hour TWA PEL.

Note: In cases where the PEL is adjusted (lead in general industry & construction, cotton dust for respiratory protection), the CSHO must calculate an actual time weighted average for the extended work shift.

B. Calculating Extended Shift Time-Weighted Averages

In cases where samples collected for longer than 480 minutes will be used to calculate the employee's average exposure, the CSHO must ensure the total sampling time, and not 480 minutes, is used in the denominator of the TWA calculation equation:

$$[(C_1 \times T_1) + (C_2 \times T_2) + \ldots\ldots + (C_n \times T_n)] / [T_1 + T_2 + \ldots\ldots + T_n]$$

Where: Cn = Concentration for the nth sampling period
Tn = Time duration of nth sampling period

Since the contaminant was collected over an extended work shift, the use of 480 minutes in the denominator will artificially inflate the calculated result for average exposure. For example, an employee works a 10-hour shift and is exposed to acetone vapors. Sampling was conducted using three charcoal tubes spread out over the full shift, with the following results:

Sample #	Sampling Time	Results
1	224 minutes	700 ppm
2	162 minutes	650 ppm
3	184 minutes	725 ppm

In this example, the TWA exposure for this employee is calculated using 570 minutes of total time:

TWA=[(224 min. x 700 ppm)+(162 min. x 650 ppm)+(184 min. x 725 ppm)] / (224 min. + 162 min. + 184 min.)

TWA = 694 ppm.

This result is then compared directly to the 8 hour TWA PEL of 750 ppm to show that this is not an overexposure. In the future, if the decision is made to adjust PELs (other than lead & cotton dust) based on extended work shifts, then this exposure may, in fact, be over an adjusted limit for acetone.

In the above example, if the CSHO mistakenly uses 480 minutes in the denominator, the TWA is calculated to be 824.0 ppm, which is over the PEL. This result is artificially inflated, as contaminants collected over 570 minutes are represented as if they had been collected over only 480 minutes. This error would result in citations and penalties mistakenly being assessed against the employer.

APPENDIX XV-C: AVDs for Air Contaminant Overexposures.

When a citation for an overexposure is written, it is important to include enough detail to accurately describe the nature of the violation. The CSHO should include the specific location at the site, sampling date, job title of the exposed employee, exposure concentration, PEL, and sampling duration. In situations where sampling is conducted for 8 hours or less, AVD language similar to the following example should be used.

> 1910.1000(c): Employees were exposed to respirable crystalline quartz (silica) at a concentration exceeding the 8-hour time weighted average limit listed in Table Z-3:
>
> a) gravel plant, on February 5, 2002, a crusher operator was exposed to respirable dust containing 30.4% crystalline quartz (silica) at an 8-hour time-weighted average of 0.732 mg/m^3 [2.37 times the permissible exposure limit of 0.309 mg/m^3]. This exposure was derived from one sample collected over 415 minutes, with zero concentration assumed for the remainder of the shift.

When sampling is conducted for more than 8 hours, the CSHO must use caution to ensure the language in the AVD is appropriate based on the sampling duration and averaging time. Terms such as "8-hour time-weighted average" should be avoided in situations where an "actual time weighted average" is used. In these cases, AVD language similar to the following example should be used:

> a) gravel plant, on February 5, 2002, a grounds man was exposed to respirable dust containing 29.0% crystalline quartz (silica) at an average concentration of 1.04 mg/m^3 [3.32 times the permissible exposure limit of 0.322 mg/m^3]. This exposure was derived from two samples collected over 499 minutes.

APPENDIX XV-D: Evaluating Noise Sampling Results

A. Dose vs. L_{AVG} vs. L_{TWA}

When evaluating noise sampling results, the CSHO can get an accurate picture of the exposure by recording eight parameters: Dose, L_{AVG}, and L_{TWA} for both threshold settings, as well as the peak sound level and sampling time. Dose is a measure of cumulative noise exposure over a stated time period, and takes into account both the intensity of sound and the duration of exposure. It begins at 0.0% at the start of the sampling event and increases when sounds above the threshold level are measured.

L_{AVG} (or L_A) is the average sound level (in dBA) for the time sampled. It is represented by the following equation, with t being the time sampled (in hours):

$$L_A = 16.61 \log_{10} \frac{D}{12.5t} + 90$$

L_{TWA} is the time-weighted average sound level (in dBA) and is based on 8 hours, regardless of the sampling time. It is represented by the formula below (same as above, except with t = 8 hours). The CSHO should take note of the direct relationship between dose and L_{TWA}. A dose of 100% is always equivalent to an L_{TWA} of 90 dBA, a dose of 200% to 95 dBA, a dose of 50% to 85 dBA, and so on. If you know one parameter, you can solve for the other.

$$TWA = 16.61 \log_{10} \frac{D}{100} + 90$$

L_{TWA} will always be less than L_{AVG} if the sampling time is less than 8 hours, and greater than L_{AVG} if the sampling time is greater than 8 hours. The use of L_{TWA} is analogous to dividing by 480 minutes in the TWA formula for air contaminants. If the CSHO conducts noise sampling for less than 8 hours, L_{TWA} assumes zero exposure for the unsampled time period. If sampling time is greater than 8 hours, L_{TWA} becomes artificially inflated as dose accumulated during an extended work shift is compressed back into 8 hours. Based on these properties of L_{TWA}, **CSHOs should primarily use Dose and L_{AVG} to describe employee noise exposure for extended work shifts (> 8 hours).** CSHOs also should use caution to ensure dose, L_{TWA}, and L_{AVG} are not confused, and that they are explained accurately to the employer and appropriately referenced in the violation worksheet and workplace measurement summary.

B. Compliance Information

1. Compliance with the PEL (90 dBA)

As discussed in Section C.4.G.ii above, noise sampling for determining compliance with the 8-hour TWA PEL of 90 dBA is conducted with a Type 2 dosimeter, with a criterion of 90 dBA, a threshold of 90 dBA (aka HTL - High Threshold Level), and an exchange rate of 5 dBA. With that threshold setting, only sound levels above 90 dBA will be recorded by the dosimeter. Table G-16 of the noise standard (29 CFR 1910.95) specifies the Permissible Noise Exposures for various time durations up to 8 hours. Employees exposed greater than 90 dBA for 8 hours, 95 dBA for 4 hours, 100 dBA for two hours, and so on (based on the 5 dBA exchange rate) are said to have exceeded the PEL. Table G-16 does not address exposure durations greater than 8 hours. As a result, the PEL is <u>not</u> adjusted for extended work shifts. For any 8-hour period of exposure within the extended work shift, exposures are required to be limited to a TWA of 90 dBA.

Based on the two decibel error factor, the CSHO must show that the 8-hour TWA (L_{TWA}) sound level exceeds the PEL by 2 dBA (i.e. 92 dBA) before a citation can be issued for the lack of engineering or administrative controls or PPE. This sound level is equivalent to a dose of 132%. Additionally, if the sampling time exceeds 480 minutes (extended work shift), the CSHO must show the average sound level (L_{AVG}) also exceeds 92 dBA. The table below shows the different situations that may be found when evaluating noise exposure for compliance with the PEL and the result for each.

Dose (L_{TWA}) - HTL	**L_{AVG} - HTL**	**Result**
<= 132% (<= 92 dBA)	> or <= 92 dBA	Exposure < PEL - **No Violation**
> 132% (> 92 dBA)	<= 92 dBA	Extended work shift situation. Average exposure does not exceed PEL + error factor - **No Violation**
	> 92 dBA	Exposure > PEL - **Violation**

2. **Compliance with the Action Level (85 dBA)**

The Hearing Conservation amendment to 29 CFR 1910.95 established an Action Level of 85 dBA as an 8-hour TWA or, equivalently, a noise dose that is 50% of the PEL. When evaluating employee noise exposure in terms of the Action Level, a threshold level of 80 dBA (aka LTL - Low Threshold Level) is used. This lower threshold allows for adjustment of the Action Level based on an extended work shift (see Table G-16a of the standard). As a result, an employee exposed to 80 dBA for 16 hours will be exposed at the Action Level, with a dose of 50%.

In order to overcome the 2 dBA error factor, the CSHO must document an 8-hour *TWA equal to or exceeding* 87 dBA (*or a dose equal to or exceeding 66%)* to issue citations for hearing conservation violations. Since the Action Level is adjusted downward for extended work shifts, the CSHO only needs to document a *dose equal to or exceeding 66%* to show an exposure above the Action Level when sampling is conducted for longer than 480 minutes. Unlike determining compliance with the PEL, It is not necessary to show an L_{AVG} exceeding 87 dBA in an extended work shift situation. The table below shows the different situations that may be found when evaluating noise exposure for compliance with the Action Level and the result for each.

Dose (L_{TWA}) - LTL	**L_{AVG} - LTL**	**Result**
< 66% (<87 dBA)	> or <= 87 dBA	Exposure < Action Level - **No Violation**
>= 66% (>=87 dBA)	> or <= 87 dBA	Exposure > Action Level - **Violation**

APPENDIX XV-E: AVDs for Noise Exposures Exceeding the PEL or Action Level

Whether sampling is conducted for greater or less than 8 hours, it is important to list the dose, L_{AVG}, and L_{TWA} in the AVD. All three values are important in understanding the overall noise exposure. In order to properly present the exposure information to the employer, the following SAVE/AVD language should be used.

A. **Exposures Exceeding the PEL**:

Sampling data from the high (90 dBA) threshold level (HTL) will be used when documenting noise exposures above the PEL. All HTL data (dose, L_{AVG}, and L_{TWA}) should be presented in the AVD, along with the location in the facility, job title of the exposed employees, sampling date, and sampling duration (in minutes). The CSHO will also list some example engineering and/or administrative controls that may be feasible in reducing employee noise exposure. The following example shows a template AVD for a violation of 29 CFR 1910.95(b)(1):

> 29 CFR 1910.95(b)(1): Employees were subjected to sound levels exceeding those listed in Table G-16 of Subpart G of 29 CFR 1910 and feasible administrative controls or engineering controls were not utilized to reduce sound levels:
>
> a) [**Location in the facility**], for the [**Job Title**] who, on [**Sampling Date**], was exposed to noise at [**Dose - HTL**] of the permissible daily dose, or an average sound level of [**L_{AVG} - HTL**], as measured over [**Sampling Time in minutes**] of sampling. This dose is equivalent to an 8-hour TWA exposure of [**L_{TWA} - HTL**].
>
> Feasible engineering and/or administrative controls include, but are not limited to, the following:
>
> 1. Highest priority engineering control (e.g. source substitution, modification)
> 2. Next highest priority engineering control (e.g. booth or enclosure)
> 3. Administrative or work practice control

B. **For Exposures between the Action Level and PEL**:

AVDs for hearing conservation citations should be similar to those for overexposures, except the low (80 dBA) threshold data (LTL) should be used. The following example shows a template AVD for a violation of 29 CFR 1910.95(c)(1).

> 29 CFR 1910.95(c)(1): A continuing, effective hearing conservation program as described in 29 CFR 1910.95(c) through (n) was not instituted when employee noise exposures equaled or exceeded an eight-hour time weighted average sound level (TWA) of 85 dBA:
>
> a) [**Location in the facility**], for the [**Job Title**] who, on [**Sampling Date**], was exposed to noise at [**Dose - LTL**] of the permissible daily dose, or an average sound level of [**L_{AVG} - LTL**], as measured over [**Sampling Time in minutes**] of sampling. This dose is equivalent to an 8-hour TWA exposure of [**L_{TWA} - LTL**].

Note: The HTL values for Dose, L_{AVG}, and L_{TWA} can also be used when citing 1910.95(c)(1) provided the Dose-HTL exceeds 66%. This will mainly occur when 1910.95(c)(1) or the other hearing conservation paragraphs are being cited along with 1910.95(b)(1) and the HTL has already been referenced in the AVD for the preceding violation. This will ensure two sets of noise exposure data (HTL and LTL) are not listed in the citation.

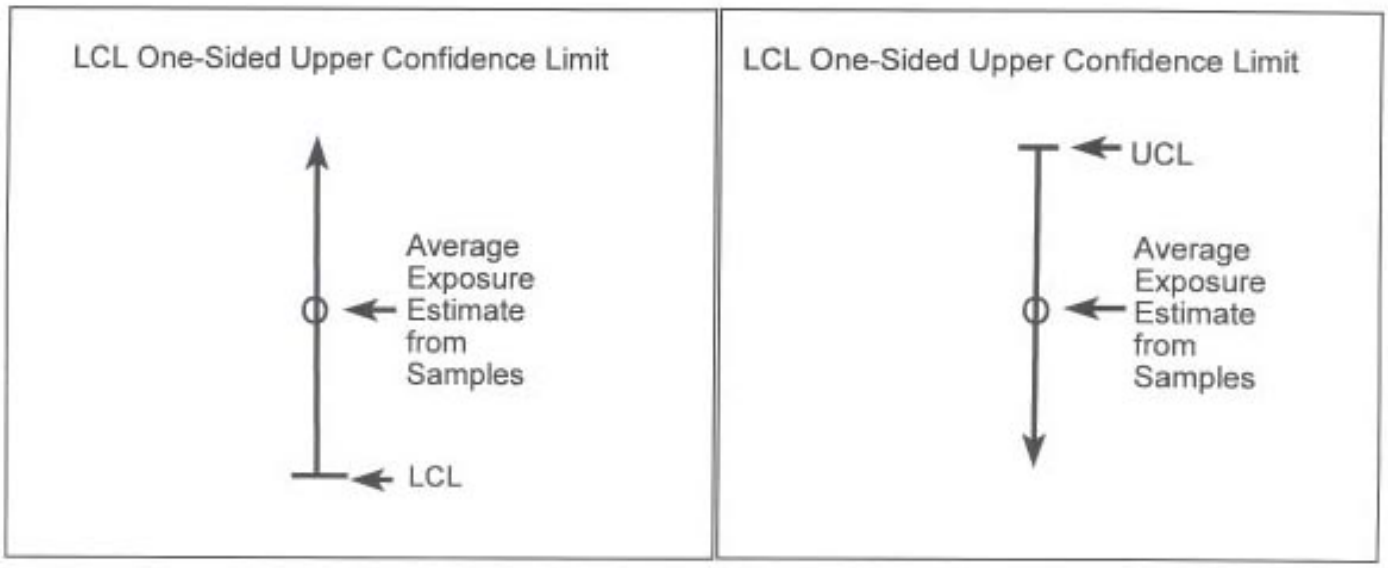

Figure XV-1 Example of one-sided LCL and UCL.

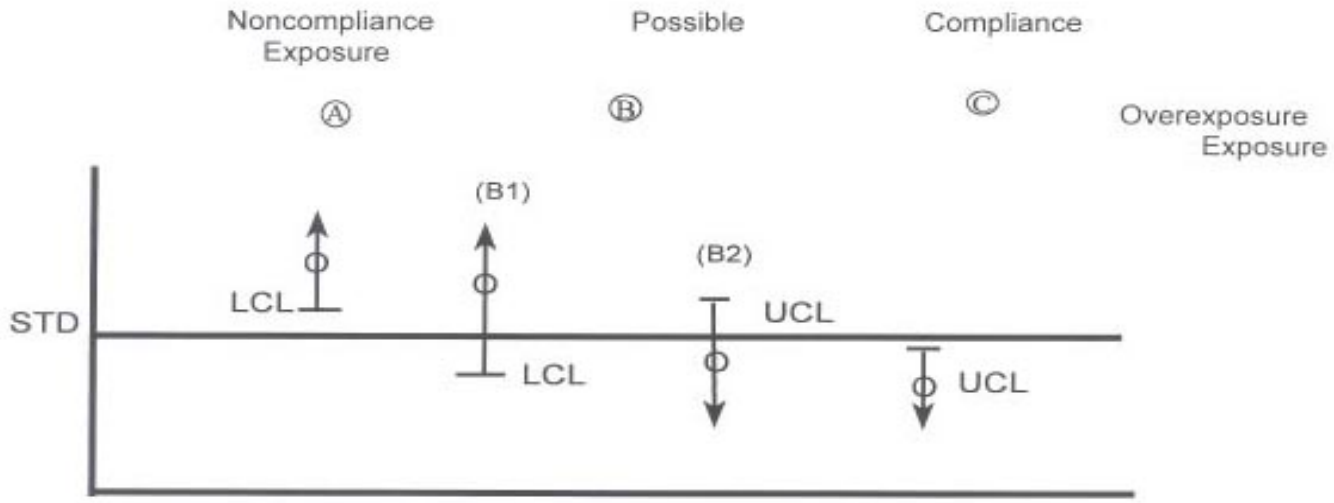

Figure XV-2 Classification according to one-sided confidence limits.

$$LCL = Y - SAE \frac{\sqrt{T_1^2 X_1^2 + T_2^2 X_2^2 + \ldots T_n^2 X_n^2}}{PEL \quad (T_1 + T_2 + \ldots T_n)}$$

$$UCL = Y + SAE \frac{\sqrt{T_1^2 X_1^2 + T_2^2 X_2^2 + \ldots T_n^2 X_n^2}}{PEL \quad (T_1 + T_2 + \ldots T_n)}$$

Figure XV-3 Calculation of LCL and UCL with Multiple Samples