IV. SAMPLING METHODOLOGY

A. SURFACE WIPE SAMPLING

The most common surface testing technique is surface wipe sampling. The Chemical Sampling Information (CSI) file contains wipe sampling information for many of the chemicals regulated by the expanded health standards, including the type of wipe to use.

Frequently, the wipe is dipped in distilled water or other suitable solvent prior to wiping the surface of interest. This technique facilitates transfer of the contaminant from the surface to the wipe. It is best to use a minimum of water/solvent on the wipe so that all of the water/solvent will be picked up by the wipe and not left behind on the sampled surface.

The percent recovery of the contaminant of interest from the sampled surface may vary with the characteristics of the surface sampled (e.g., rough or smooth), the solvent used, and the technique of the person collecting the sample. Consequently, surface wipe sampling may be only semi-quantitative. No OSHA standards currently specify acceptable surface limits. Results of surface wipe sampling are used qualitatively to support alleged violations of housekeeping standards and requirements for cleanliness of PPE. Enforcement guidance is described in more detail in Section VI.

Templates may be used to define a relatively constant surface area for obtaining a wipe sample, but are not always helpful. Templates can only be used on flat surfaces, and they can cause cross-contamination if the template is not thoroughly cleaned between each use. Constructing single-use 10-cm x 10-cm templates is recommended (e.g., using cardstock or file folders). The CSHO may want to sample a much larger surface area than the area covered by a template (e.g., the CSHO may want to determine the cleanliness of a lunch table or other large surface area). In all cases, the CSHO should measure the dimensions of the area being sampled and record this value on the OSHA Information System (OIS) sampling worksheet because the mass amount of chemical measured by the laboratory will be used to determine the mass per unit area for the wipe sample.

Appendix C provides general procedures for collecting surface wipe samples, including wipe sampling procedures for hexavalent chromium.

Other surface testing techniques include direct-reading swab and wipe tests and vacuum dust collection to collect bulk samples of dust for analysis. Swab and wipe test kits with colorimetric indicators are available for contaminants, including lead, chromate, cadmium, amines, aliphatic and aromatic isocyanates, and others. These nonquantitative assessments can be used to provide an immediate indication in the field of the presence of a contaminant on a surface or the general level of surface contamination. The presence of contamination can be used to provide evidence for housekeeping deficiencies.

Lead, chromate and other test swabs are self-contained units with a fiber tip at one end and glass ampoules with reactive materials inside the swab barrel. The swabs are activated by squeezing at the crush points marked on the barrel of the swab, shaking well to mix the reagents, and then squeezing until the reactive liquid comes to the tip of the swab. While squeezing gently, the tip of the swab is rubbed on the surface to be tested for 30 to 60 seconds. The tip of the swab turns color in the presence of the chemical (for example pink to red for lead and pink to purple for chromates). Color development depends on the concentration of chemical present. Potential limitations associated with swabs include:
• Interferences in color development from chemicals or other materials that may be present (e.g., dark colored dust or dirty surfaces obscuring color development on the lead swab tip; rubbing too long or too hard causing a metallic film to collect on the lead swab tip which obscures the color change; bleeding occurring on the lead swab tip when the test surface is painted red; and high concentrations of mercuric chloride or molybdate interfering with the color development of chromate swabs).

• Delayed results (e.g., up to 18 hours for the detection of lead chromate in marine and industrial paints).

• Destruction or damage to the testing surface to assess multiple layers on metal parts or painted surfaces.

Contact the SLTC to discuss wipe sampling before considering use of these methods.

B. SKIN SAMPLING METHODS

Skin sampling methods are classified as “interception” and “removal” methods. Interception methods use a “dosimeter” such as a sorbent pad placed on the skin or clothing, which “intercepts” the contaminant before it reaches the skin. After the exposure period ends, the dosimeter is removed, and either extracted in the field to recover and stabilize the analyte of interest, or sealed and sent for laboratory analysis to determine the mass of contaminant collected on the pad. In some cases, direct reading pads are available which undergo a colorimetric change when exposed to the contaminant of interest.

“Removal” methods remove the contaminant of interest after it has deposited on the skin. Either the skin is rinsed with distilled water or mild washing solution and the rinsate is collected and analyzed for the contaminant of interest, or the skin is wiped with a dry or wetted wipe, and the analyte of interest is then extracted from the wipe. One approach is to place the hands inside a bag that is partially filled with the washing solution, such as distilled water, distilled water with surfactant, or isopropanol diluted with distilled water. The hand is then dipped in the solution and shaken a specified number of times to recover the contaminant from the hand.

Both of these types of methods are generally qualitative in nature. The percent recovery may be variable or not quantitatively established. Further, no OSHA standards currently specify quantitative limits for dermal exposure. Qualitative documentation of the presence of a contaminant on the skin is sufficient to determine whether PPE is inadequate, whether due to inappropriate selection, maintenance, or cleaning.

When considering dermal sampling, consult OSHA’s webpages at the following link: Dermal Dosimetry.

1. Direct Reading Patches/Charcoal Felt Pads

In some instances, direct reading patches and/or bandage-type patches can be worn inside a glove to demonstrate directly through a color change that an exposure has occurred. In other instances, charcoal felt patches or bandages can be worn which can be analyzed by a laboratory to establish the presence of glove permeation by volatile organic chemicals. These charcoal pads may also be used for detection of less volatile organic chemicals. However, poor sample recoveries from a charcoal surface for higher molecular weight substances may result in underestimating the extent of skin exposure for these types of chemicals.
When sampling inside a glove, OSHA recommends that workers being sampled wear disposable gloves inside their normal PPE, with the indicator/charcoal felt pads being placed on the disposable glove surface. Placing the pad on the disposable glove between the skin surface and the regular PPE eliminates any potential skin exposure from the chemicals used in the colorimetric pads, and also reduces any effects that perspiration might have on the sampling pads.

For inside-the-glove sampling, it also is advisable to use a control pad to measure the concentration of airborne volatile chemicals. This control pad should be attached to the worker’s clothing while the worker performs his/her normal tasks. The glove sample result would then be corrected for the amount of the organic chemical in the airborne sample to determine the amount of organic chemical actually permeating the protective glove relative to the amount of organic chemical entering the glove opening. This procedure, therefore, would allow the sampler to identify the possible route of glove contamination.

2. **Wipe Sampling of Skin**

Skin wipe samples taken on potentially exposed areas of a worker’s body are a useful technique for demonstrating exposure to a recognized hazard. For water-soluble chemicals, a wipe pad moistened with distilled water can be used to wipe the skin. Generally, the best procedure is to allow workers to use the wipe pad to clean their skin surfaces, and then have them insert the wipe pad into a clean container, which is labeled and sealed. Hands, forearms, faces, and possibly feet may be exposed to contaminants that a wipe sample of the skin can be used to establish exposure. Include a blank water sample and use only distilled water, or another source of water approved by the laboratory, for analysis purposes.

C. **BIOLOGICAL MONITORING METHODOLOGY**

In the event that a CSHO believes biological monitoring would be valuable to assess and evaluate worker exposure to a substance or mixture of substances, he or she should first contact their Regional Office, the SLTC and the Office of Occupational Medicine to determine the most effective approach and technique to obtain the desired result. Biological sampling requires special consideration and will be addressed on a case-by-case basis.

Biological monitoring results can be used to demonstrate significant skin absorption, ingestion or airborne exposures. For instance, when wipe/skin sampling has indicated exposure, a voluntarily obtained worker biological sample may prove useful in documenting that skin exposure to the chemical of concern has occurred. Ideally, it is desirable to have samples from a number of workers who are suspected of being exposed. Also, control samples from individuals who do not have skin exposure, or are suspected of much less exposure, are valuable. Note that skin sampling conducted just prior to biological monitoring may result in decreased biological uptake.

1. **Carboxyhemoglobin Evaluation**

Biological monitoring can also be used to estimate the degree of exposure after an emergency. Table 2 shows the relationship between airborne carbon monoxide (CO) concentrations and steady state carboxyhemoglobin (COHb) levels.
TABLE 2. CARBON MONOXIDE (CO) CONCENTRATION VERSUS BLOOD CARBOXYHEMOGLOBIN (COHb) LEVELS*

<table>
<thead>
<tr>
<th>CO Concentration (ppm)</th>
<th>Steady-State Blood COHb Levels (percent)</th>
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<tbody>
<tr>
<td>0.1</td>
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<tr>
<td>0.5</td>
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<td>1,000</td>
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</table>

*Predicted using the Coburn-Forster-Kane (CFK) model.
Source: ATSDR, 2009

Post-exposure COHb measurements can be used to back-calculate airborne CO concentrations in order to determine whether a citation is warranted. COHb values provided by a non-OSHA medical professional are submitted to the SLTC for evaluation using a special algorithm online worksheet on the OSHA Intranet. COHb values may be determined either from a blood sample, a breath analyzer, or a Pulse CO-Oximeter™ finger measurement. No physical samples are sent to the SLTC, but chain-of-custody must be documented in the OIS.

The SLTC employs a modified, more accurate version of the Coburn-Forster-Kane equation than the closed-form version used in the 1972 NIOSH Criteria Document. The SLTC equation calculates the eight-hour TWA. Poisoning cases generally involve levels above five percent COHb. The calculation also provides an incident-specific sampling and analytical error designed to deal with the uncertainties in the data. The calculation is performed at the SLTC and the results are critically assessed for accuracy by the SLTC staff prior to reporting. The SLTC carbon monoxide experts are available to assist CSHOs in acquiring data and in interpreting results.

The following are suggestions to help ensure that the most accurate calculations will be performed.

- Before going on site, download, print and read the Carbon Monoxide Worksheet ("Submitting Data for the Carbon Monoxide Calculation at the OSHA Salt Lake Technical Center (SLTC)"). Take the worksheet to the site.

- If possible, call one of the SLTC carbon monoxide experts before going to the site, especially if methylene chloride is used. The Carbon Monoxide Worksheet lists the SLTC contact persons on the worksheet.

- Collect vital statistics for the victim(s) (age, weight, sex, living or deceased).
• Detail smoking activity (first-hand, second-hand tobacco smoke).
• Document oxygen saturation-affecting conditions such as pre- and post-exposure activity levels and oxygen therapy.

• Provide accurate timelines (how long the worker was exposed, when the worker was removed, how long resuscitation was performed, the time between removal and when the COHb was taken, etc.).

• List signs and symptoms of suspected exposure.

• Review the document for accuracy and completeness before submitting it to the SLTC.

2. Hydrogen Sulfide

For evaluation of suspected hydrogen sulfide (H$_2$S) overexposures, blood thiosulfate monitoring is recommended (Ballerino-Regan and Longmire, 2010). Blood sulfide levels are useful only if obtained within two hours of exposure, and sulfhemoglobin levels are not useful for documenting H$_2$S exposure. Urinary thiosulfate levels are frequently used as a biomarker, however, a quantitative relationship between hydrogen sulfide exposure levels and urinary thiosulfate levels has not been established (ATSDR, 2006). Urine thiosulfate elevation does not occur in the case of rapid fatalities but may be elevated in nonfatally exposed workers. Analysis of COHb may also be useful, since this is a reported metabolite of H$_2$S (NIOSH 2005-110, 2004).

For biological monitoring, proper sampling containers and a protocol for handling and shipping samples need to be followed. In general, a qualified laboratory which is experienced in the analysis of biological samples will provide sample vials, shipping containers, and the technical expertise to properly collect, store and ship specimens.

3. Review of Employer Biological Monitoring Results

In instances in which an employer has been conducting biological monitoring, the CSHO shall evaluate 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. However, the total body burden is composed of all modes of exposure (e.g., inhalation, ingestion, absorption and injection). For the CSHO to assess the results of the biological monitoring, all the data (including any air monitoring results) must be evaluated to determine the source(s) of the exposure and the most likely mode(s) of entry.

Results of biological monitoring which have been voluntarily conducted by an employer shall not be used as a basis for citations. In fact, OSHA promotes the use of biological monitoring by employers as a useful means for minimizing exposures and for evaluating the effectiveness of control measures.

Citations, in consultation with the Regional Office, would be appropriate when biological monitoring results indicate an unacceptable level of exposure, and the employer is unable to demonstrate that meaningful efforts to reduce or control the exposure(s) were taken.