III. WIPE SAMPLING, FIELD PORTABLE X-RAY FLUORESCENCE SAMPLING, DERMAL SAMPLING AND BIOLOGICAL MONITORING

A. SURFACE WIPE SAMPLING

Surface wipe sampling is conducted to assess the presence of a contaminant on surfaces in the workplace that may lead to worker exposure. Surfaces contaminated with a hazardous liquid, particles, or dried residue may be contacted by workers, leading either to dermal exposure or transfer to foodstuffs and accidental ingestion. Settled dusts containing toxic material may be disturbed and resuspended, resulting in inhalation exposure.

In instances where surface contamination is suspected and the employer has not required the use of effective PPE for workers in these areas, wipe sampling may be an effective means of documenting that a skin hazard exists. Wipe sampling can help establish that a significant amount of surface contamination is present in areas in which workers are not effectively protected by PPE. Wipe samples taken inside the sealing surface of "cleaned" respirators can establish the absence of an effective respiratory protection program.

In areas where exposures to toxic metals such as lead (Pb) occur, wipe sampling of settled dust can demonstrate that a reservoir for potential exposure exists; resuspension of such settled dusts can lead to inhalation exposure. This is particularly true if improper housekeeping techniques are used, such as: dry sweeping; blowing off surfaces with compressed air; or using a shop vac instead of a HEPA-rated vacuum cleaner.

In break areas, the presence of surface contamination can lead to contamination of foodstuffs and hence, accidental ingestion of toxic material. The same is true for contamination on drinking fountains. Contamination found on the clean side of a shower or locker area could suggest the potential for take-home contamination, resulting in additional toxic exposures occurring while away from work. All of these types of wipe sampling results can be used to support violations of the housekeeping requirements found in the expanded health standards in Subpart Z of 29 CFR 1910.

In many instances, several wipe samples taken in an area suspected of being contaminated may be useful. For example, some surfaces which would be expected to be contaminated with chemicals because of airborne deposition of a non-volatile chemical may actually be relatively free of surface contamination because of frequent contact of the surface by workers (i.e., frequently contacted surfaces may be expected to be "clean" because of contaminant removal by frequent worker contact). Wipe samples of frequently contacted surfaces in conjunction with less frequently contacted surfaces in the same vicinity can be useful to establish the likelihood that skin exposure is occurring in "clean" areas in which PPE is not being used, or is being improperly used.

Housekeeping deficiencies may also be demonstrated by wipe samples which show major differences in surface contamination between work areas that have been routinely cleaned and areas which have not been recently cleaned. This sampling would allow the CSHO to demonstrate the employer’s failure to maintain a clean work area. A reference control wipe sample or samples taken from areas in which exposure is not anticipated will also help to establish the relative amount of surface contamination.

Surface wipe sampling can be conducted qualitatively, for example, wiping irregular surfaces such as a doorknob, tool handle or faucet handle, or quantitatively, in which an area of specified size is wiped. Wiping an area of a specified size is necessary to determine the concentration of a contaminant on a surface. This is needed for estimating the amount of contamination to which
workers are potentially exposed. The customary size of the surface area to be wiped is a 10 cm x 10 cm square, i.e., 100 cm². The 100 cm² value approximates the surface area of a worker’s palm. Thus, the amount of contaminant in a 100 cm² sample could all be transferred to a worker’s hand upon contact.

In industries such as the pharmaceutical industry, a common rule of thumb is to use the maximum allowable dose (based on the chemical’s airborne exposure limit in units of µg/m³) and the approximate area of a worker’s hand (100 cm²) to arrive at an acceptable value for surface contamination in work areas (i.e., a housekeeping standard). For example, if the eight-hour TWA exposure limit for a chemical is 1 µg/m³, the maximum allowable dose for that chemical is 10 µg. As noted in Section II.C., the chemical’s eight-hour time-weighted average (TWA) airborne exposure limit is multiplied by 10 m³, the volume of air inhaled by an average worker in an eight-hour workday, to determine the maximum acceptable dose (i.e., 1 µg/m³ x 10 m³ = 10 µg). The maximum acceptable dose is then divided by the area of a worker’s hand to determine the acceptable surface limit of 10 µg/100 cm² or 0.1 µg/cm². By this rule of thumb, the amount of contaminant picked up by one hand contacting the contaminated surface is equivalent to the toxic dose allowed by the eight-hour TWA airborne exposure limit (determined by multiplying by the 10 m³ of air breathed by an average worker in an eight-hour workday).

For highly toxic materials, hazardous levels of surface contamination will often be invisible to the unaided eye, while limits of detection for wipe sampling will be considerably more sensitive. For example, the limit of visible residue for active pharmaceutical ingredients is typically 1–5 µg/cm², whereas good surface wipe sampling techniques can have limits of detection in the low nanogram range. This underscores the essential value of surface wipe sampling in areas where highly toxic materials such as lead or chromium (VI) are present.

B. FIELD PORTABLE X-RAY FLUORESCENCE SAMPLING

X-ray fluorescence (XRF) provides real-time measurements of elemental metal on surfaces. This may be useful to measure metal in settled dust on contaminated surfaces, or in surface coatings such as on painted metal or wood. A real-time XRF analyzer and operator are available from the Health Response Team. XRF uses the interaction of x-rays with a target material to determine the elements present and their relative concentrations. When the target material has been excited by being bombarded with high-energy x-rays (or gamma rays), the material emits secondary or fluorescent x-rays that are characteristic of each element present. The rate of generation of the emitted fluorescent x-rays is proportional to the elemental concentration and is used to quantify the results.

Because x-rays will penetrate an object, the XRF will detect metals both on the surface and within the substrate of the material. To determine the quantity of removable metal contamination on a work surface, a reading is first taken on the uncleaned surface. The surface is then cleaned with a metal removal wipe until all visible dust, dirt, and debris is removed. After cleaning, a second reading is taken at the same spot and its value is subtracted from the initial reading to determine the surface concentration of metals.

The same sampling and citation strategies used for wipe sampling apply to XRF sampling. The advantage of XRF over wipe sampling is its rapid (approximately one minute per reading) sampling rate and the real-time results. For laboratory confirmation of XRF results, the area sampled with the XRF can be wipe-sampled using the traditional methods described in this chapter and submitted to the SLTC for analysis.
C. DERMAL SAMPLING

Skin sampling is used to estimate the amount of material which contacts the skin and is relevant both for materials that affect the skin, such as corrosive materials, and for materials which absorb through the skin and have systemic effects.

Dermal exposure may be assessed through either direct or indirect methods. Direct methods measure the amount of material which contacts the skin, for example, through wipe tests which remove and recover the material from exposed skin, or use of sorbent patches (dosimeters) which are placed over the skin and capture material which would have contaminated the skin. Indirect methods measure the amount of contaminant that enters the body. Indirect methods are also known as biological monitoring.

D. BIOLOGICAL MONITORING

Biological monitoring is used to assess uptake into the body of a contaminant of concern. Biological monitoring is defined by the American Industrial Hygiene Association Committee on Biological Monitoring as "the assessment of human exposure through the measurement of internal chemical markers of exposure, such as the chemical agent itself and/or one of its metabolites or an exposure related biochemical change unrelated or related to disease, in human biological samples" such as urine, blood, or exhaled breath (AIHA, 2004). Biological monitoring by itself does not indicate the route of exposure to the material. Airborne sampling, skin sampling, and/or surface sampling would be needed to pinpoint the source of exposure.

Biological monitoring can be a useful technique for determining if dermal exposure is a significant contributor to the worker's overall exposure. For example, in a work environment in which the air exposure to a specific chemical is well controlled, an abnormally elevated biological monitoring result will likely indicate that skin or ingestion is a major mode of exposure. Coupled with evidence of surface contamination, and documentation of poor or non-existent personal protection against chemical skin exposure, biological monitoring can be a valuable means of documenting dermal exposure to a chemical. Biological monitoring could also be used to assess the effectiveness of PPE, such as chemical protective clothing or gloves, or the effectiveness of cartridge change schedules for air-purifying respirators. Prior to conducting biological monitoring, determine the variables that may affect the results including the potential for interferences (e.g., diet, over-the-counter drugs, personal care products, existing medical conditions, other).

Biological monitoring data can hypothetically be used to back-calculate an estimate of the corresponding airborne exposure that would have resulted in observed biological exposure. This requires the availability of adequate exposure modeling for the toxic material of interest. For example, this is done in cases of overt carbon monoxide poisoning, as described below in Section IV.C.1.

Biological monitoring by itself does not indicate that a toxic or adverse health effect has occurred, only that the material has entered the body. Biological exposure guidelines, such as the ACGIH BEIs, are numerical values below which it is believed nearly all workers will not experience adverse health effects. Where measured levels exceed a BEI, this finding provides evidence that exposures have occurred which can result in an adverse health effect. Further, a number of the OSHA expanded health standards in Subpart Z contain biological monitoring provisions. Appendix B summarizes the 2012 ACGIH BEIs and the biological monitoring guidelines contained in the OSHA expanded health standards.
In addition, NIOSH offers guidance for biological monitoring, which may be found at the following link: NIOSH Biological Monitoring Summaries. The NIOSH Biomonitoring Summaries provide a brief overview of the usage, environmental pathways, sources of exposure, toxicology, health effects, and human exposure information for most of the chemicals or chemical groups evaluated in the National Report on Human Exposure to Environmental Chemicals.

Finally, there are many studies in the peer-reviewed literature that report exposure levels for numerous chemicals measured as biological matrices for workers in a variety of occupations and industries. These studies can be useful, in a comparative fashion, for assessing the extent of exposure between exposed and unexposed workers when the workplace in the study involves the same conditions (e.g., chemical exposure, type of work) as the workplace being inspected.