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GUIDANCE FOR THE SAMPLING AND ANALYSIS OF LEAD IN INDOOR RESIDENTIAL DUST FOR USE IN THE INTEGRATED EXPOSURE UPTAKE BIOKINETIC (IEUBK) MODEL

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1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

The purpose of this guidance document is to recommend methods for collecting and analyzing indoor residential dust data to estimate the mean concentration of lead in dust for use in the Integrated Exposure Uptake Biokinetic (IEUBK) model. The recommendations apply to applications of the IEUBK model in Superfund lead risk assessments and may not be appropriate for other applications (e.g., HUD lead risk assessments). Implementation of the sampling and analysis recommendations in this document will enhance consistency in lead risk assessments at Superfund sites. It is recommended that EPA risk assessors and risk managers consult with the Lead Committee of the Technical Review Workgroup (TRW) for Metals and Asbestos if site sampling plans specify (or existing data were obtained using) sampling methods that differ from those recommended in this document.

This document provides technical and policy guidance to EPA staff on making risk management decisions for contaminated sites. It also provides information to the public and to the regulated community on how EPA intends to exercise its discretion in implementing its regulations at contaminated sites. This document does not substitute for statutes that EPA administers, EPA implementing regulations, nor is it a regulation itself. This document does not impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the specific circumstances. Rather, the document suggests approaches that may be used at particular sites, as appropriate, given site-specific circumstances.

1.2 BACKGROUND

Due to the widespread use and ubiquitous nature of lead, humans are exposed to lead from multiple exposure pathways including ingestion of lead-contaminated soil, dust, water, and food, as well as inhalation of lead-containing particles of soil or dust in air. The predominant pathway for lead exposure in young children is ingestion of indoor surface dust, as a result of the hand-to-mouth pathway (U.S. EPA, 1986; Lanphear et al., 1998, 2002; Sterling et al., 1998; Succop et al., 1998; ATSDR, 1999; Manton, et al., 2000). Studies have shown that lead-contaminated house dust is the strongest predictor of blood lead (PbB) levels in children (Roberts and Dickey, 1995; Lanphear et al., 1998, 2002; Succop et al., 1998; Jacobs et al., 2002).

In Superfund lead risk assessments, lead in indoor dust typically is accounted for in the IEUBK model as an input parameter. By default, indoor dust lead concentrations are estimated from outdoor soil lead concentrations using the mass fraction of soil in indoor dust variable (M_{SD}). However, the accuracy of the IEUBK model estimates for a specific site will improve when site-specific exposure data for media concentrations, such as indoor dust, are used. When feasible, the use of site-specific residential dust lead data is preferred over the use of the default IEUBK model's indoor dust calculations. The intent of collecting indoor dust is to better characterize risk at the site, not necessarily for indoor dust remediation. There are limitations on EPA's authority to abate interior lead dust contamination to the extent they are not related to releases or threatened releases to the environment.[1] Remediation of outdoor soil contamination using preliminary remediation goals (PRGs) informed by the IEUBK model would be expected to reduce the concentration of lead in indoor dust over time.

Site-specific indoor dust sampling data, under appropriate circumstances (e.g., considerations of data quality and representativeness), can also be used to develop a site-specific M_{SD} (U.S. EPA, 1998). A site-specific M_{SD} may then be used to calculate risk as well as in the development of a PRG for outdoor soil at the site.

1.3 DUST DATA

1.3.1 Dust Lead Metrics and IEUBK Model Input

The amount of lead in residential dust may be quantified by two metrics: lead loading and lead concentration. For the purposes of this guidance:

- Lead loading is the concentration of lead per unit area measured in micrograms per square meter (µg/m^2).
- Dust loading is the amount of dust per unit area expressed as micrograms per square meter (µg/m^2) or micrograms per square foot (µg/ft^2).
- Lead concentration is the mass concentration of lead per mass of dust (C_D), typically reported as micrograms per gram (µg/g or ppm). The IEUBK model uses lead concentration data as the metric to represent the extent and magnitude of lead in residential dust at a site. Dust lead concentration (C_D) can be calculated from lead loading (L_{Pb}) and dust loading (L_D) as follows:

$$C_D = \frac{L_{Pb}}{L_D} \qquad \text{Eq. (1)}$$

However, the model also accepts inputs of lead intake (e.g., µg Pb in dust ingested/day) in the Alternate Source module. In this case, the transformation from concentration or lead loading to lead intake (I_{Pb}) would be as follows:

$$I_{Pb} = C_D \cdot I_D \qquad \text{Eq. (2)}$$

$$I_{Pb} = \frac{L_{Pb}}{L_D} \cdot I_D \qquad \text{Eq. (3)}$$

where I_D is the dust intake (µg dust ingested/day).

[1] As part of the larger risk management strategy, EPA should strive to work with HUD, state and local governments, PRPs, or individual homeowners to address these interior dust risks unrelated to site releases (U.S. EPA, 1998).

Although the IEUBK model only accepts inputs on dust lead in units of lead concentration, both the dust lead concentration and the dust lead loading metric have been correlated with PbB levels in children (e.g., Clark et al., 1996; Lanphear et al., 1996) and the dust lead loading metric is used by the U.S. Department of Housing and Urban Development (HUD) for determining the level of lead health hazard (HUD, 2004) and effectiveness of abatement activities (i.e., lead clearance standards) (HUD, 1995).

Using a single metric (i.e., dust lead concentration or dust lead loading) to represent a child's exposure has its limitations. Multiple measures can provide complementary information. For instance, dust lead concentration is the ratio of lead mass to dust mass; it does not provide a measure of the mass of lead that is available for exposure. In contrast, dust lead loading accounts for the mass of lead per unit area; however, it does not measure the amount of dust present, and therefore does not provide a measurement of the concentration of lead that is present.

2.0 RECOMMENDED DUST SAMPLING METHODS

2.1 APPROACHES FOR COMPARING SAMPLING METHOD TYPES/BASIS FOR RECOMMENDATIONS

Various dust sampling methods, protocols, and analyses were evaluated against several recommended criteria that are desirable for lead risk assessment using the IEUBK model and are shown in Table 1. The recommended criteria are divided into *primary criteria*, which identify methods that are capable of producing data that can be used with the IEUBK model (see Section 1), and *secondary criteria,* which were developed to aid in choosing between the alternative methods that satisfy the primary criteria. If a method did not satisfy either of the primary criteria, it was not considered further. Those sampling methods that satisfied the primary criteria were evaluated qualitatively against the secondary criteria as shown in Table 1.

Table 1 Recommended Criteria For Selecting Sampling Methods For Residential Dust.

Primary Criteria	**Rationale**
1. Measures lead concentration	Current IEUBK model accepts dust lead data as concentration of lead in dust (mass basis).
2. Samples fine particles of dust (representative of hand-to-mouth exposure)	Sampling methods are recommended that can adequately measure the lead concentration in the <250 µm size fraction (fine fraction) of dust particles, which is the size fraction that has been associated with ingestion (U.S. EPA, 2000). (See Section 3.3 for additional information).
Secondary Criteria	**Rationale**
3. Useful for a variety of surfaces: hard/nonporous and soft/porous	The recommended method should be compatible with a variety of surface types.
4. Accuracy and precision (sampler	The goal is to have low variability in sampling results,

variability, sampling method precision, sampling method bias)	i.e., consistent from person to person. Methods with high accuracy and precision will produce better predictions of risk using the IEUBK.
5. Validation of method	The recommended method is supported by several studies that document testing its accuracy and precision.
6. Sampling cost / Ease of implementing method	Lower per-sample cost will allow more data to be collected that will tend to yield better estimates of dust lead concentration.

2.2 DUST WIPE SAMPLING

Protocols for using wipe methods typically utilize a premoistened towelette or paper wipe to collect a sample within a measured sampling area using a specific wipe pattern or number of passes. Most wipe methods for sampling lead in house dust do not collect lead concentration or dust loading data. (For more discussion of calculation of lead concentration, see Section 1.3.1.)

Because most dust wipe methods generally do not measure lead concentration or produce data that can be used to calculate lead concentration, most wipe methods do not satisfy primary criterion #1. Hence, most dust wipe methods are not appropriate sampling methods for use with the IEUBK model. However, there are exceptions, such as the Vostal, Farfel, Lioy-Wiesel-Wainman (LWW) (Adgate et al., 1995) and the Edwards/Lioy (EL) (Edwards and Lioy, 1999)[2] wipe methods, which do allow for collection of data that can be used to calculate lead concentration, and thus satisfy primary criteria #1. These wipe methods, however, do not sample fine particles of dust (<250 µm) and thus do not satisfy criterion #2. Hence, these methods are not recommended for collecting data for use in the IEUBK model.

Although dust wipe methods are routinely used for HUD and produce data that are informative for HUD, dust wipe methods are not recommended dust sampling methods for Superfund lead risk assessments using the IEUBK model. They do not satisfy primary criterion #1 and/or #2.

2.3 VACUUM METHODS

A large variety of vacuum devices are available that range from commercial vacuums to hand-held personal air sampling pumps. The following discussion presents an overview and evaluation of low flow and high flow methods.

[2] The LWW and EL wipe methods have been used to measure lead concentration. The LWW method was designed for bare, smooth surfaces. The EL method has been used for bare and carpeted surfaces, although there are insufficient data available to evaluate the precision of the EL method.

2.3.1 Low Flow

Several low flow vacuum approaches have been described in the literature. For example, the University of Cincinnati Method low flow vacuum was described by Que Hee et al. (1985). This method has two variants, referred to as the DVM ("dust vacuum method") and the MVM ("modified vacuum method"). The sampling device is constructed from common industrial hygiene sampling materials (U.S. EPA, 1995a) by attaching a filter cassette with Tygon tubing to a standard industrial hygiene vacuum pump (Reynolds et al., 1997). The pump flow rate is 2.5 to 3.0 liters per minute (0.11 cubic feet per minute) and is designed to collect the particle size fraction of dust (<250 µm) that has been found to stick to a child's hands (U.S. EPA, 1995a). (See Section 3.3 for additional information.)

2.3.2 High Flow

There are a wide variety of high flow vacuum methods available. In general, the high flow samplers provide flexibility for sampling in large or small areas, and because of their high flow rate may require less time to sample as compared to low flow methods. Selected high flow methods are discussed below in terms of their distinguishing characteristics that relate to the secondary criteria.

The Comprehensive Abatement Performance Study (CAPS) cyclone is a portable sampler with a hand-held cyclone vacuum attached to an AC-powered particle separation chamber with PVC piping and fittings. Advantages of this device are that it is easy to use, very portable, inexpensive, and can be made from parts that are readily available in hardware stores. This device was used in the EPA Comprehensive Abatement Performance Study and developed by the Midwest Research Institute (Battelle, 1995).

Commercial vacuums have also been used in a variety of ways for sampling house dust for lead concentration and lead loading. One method requires the use of preweighed vacuum cleaner bags as described in the modified American Society Testing and Materials (ASTM) method F608-79 (ASTM, 1987). The dust collected in the vacuum bag is analyzed for lead concentration per gram of dust (µg/g). Using this method, the metric lead loading can be estimated for an area of the home such as the floor. The estimated lead concentration is multiplied by the mass of dust per unit area, or dust loading. Samples taken from vacuums of residential homes, particularly the fine dust that has settled at the bottom of the vacuum bag, have been used for lead concentration analysis (Kaye et al., 1987; Moffat, 1989; Davies et al., 1990; Thornton et al., 1990; Jensen, 1992; U.S. EPA, 1995a). Commercial vacuums such as the GS80 (NILFISK of America, Inc.) have also been used for house dust lead sampling. The GS80 is a high-efficiency industrial vacuum with a three-filter system — a pre-filter vacuum bag, microfilter, and high efficiency particulate air (HEPA) filter. Another type of commercial vacuum used for sampling lead in house dust is the "Omega Vac", a hand-held vacuum with a HEPA filter produced by ATRIX International, Inc.

There are also high volume surface samplers (HVS series) that were first designed to assess pesticide concentrations in carpet dust (Roberts et al., 1993). The HVS2 is a high powered vacuum cleaner designed to sample dust from carpeted and uncarpeted surfaces. It has a nozzle that can be adjusted to a specific static pressure and air flow rate. The HVS2 was incorporated into the ASTM method "Standard Practice for Collection of Floor Dust for Chemical Analysis (D5438-93)" (1993). The HVS3 is a lighter version of the HVS2 due to the removal of the quartz fiber filter; it has a flow rate of 20 cubic feet per minute. The ASTM method for collection of floor dust for chemical analysis has also been updated (ASTM, 2005). The ASTM method is generally recommended as an appropriate method for collection of indoor dust at Superfund sites. The BRM-HVS3 is a smaller and more portable version of the HVS3. It has the same cyclone vacuum as the standard HVS3, but uses a hand-held vacuum as the particle separator. Its flow rate is 15-15.5 cubic feet per minute. Another version of the HVS3 that can be used to sample surfaces in small areas is an HVS3 with an attachable small wand. It was developed by Lewis at EPA in 1993 (Lewis, 1993).

2.3.3 Evaluation of Vacuum Methods

In general, vacuum methods allow for the collection of dust lead concentration, lead loading, and dust loading. Vacuum methods also typically collect and allow users to sample fine particles of dust by sieving. Thus, vacuum methods satisfy the primary criteria. Both low-flow and high-flow vacuum methods satisfy secondary criteria #3 – they are generally useful for a variety of surfaces (hard/nonporous and soft/porous). The remaining secondary criteria (e.g., sampler accuracy and efficiency) were evaluated using published reports of studies that compared vacuum devices.

In a study (Bero et al., 1997) comparing the efficiencies of low and high flow cyclonic vacuums, the HVS3 (upright version) had a 101% dust lead concentration efficiency compared to the actual concentration of lead applied to the sampling surface. The two low-flow vacuums (MVM and Sirchee-Spittler) had lead concentrations 10% higher than the actual concentration. The particle size distribution of collected soil particles and dust removal efficiency was comparable for the high-flow cyclonic vacuums (including the HVS3), but much lower for the low-flow vacuums. In another study (Sterling et al., 1999) comparing collection efficiency and precision, the HVS3 had a higher collection efficiency and precision than the DVM (also called MVM) and the wipe sampling method for hard and soft surfaces. In a similar study (Lanphear et al., 1995), the BRM version of the HVS3 reported greater collection efficiency than the DVM or MVM method.

These studies indicate that high-volume cyclonic vacuums methods have greater precision and collection efficiency than low flow vacuum methods. High flow-vacuum methods satisfy secondary criteria #4 and #5.

3.0 SAMPLING AND ANALYSIS RECOMMENDATIONS

Because IEUBK model accuracy is improved when site-specific information is used, it is recommended that residential dust samples be collected from all residences or as many residences as possible for Superfund site risk assessment. When it is not feasible to sample all homes, it is recommended that residences be randomly selected from the population of the residences where soil samples will be collected. Under appropriate circumstances, these data from representative homes may be appropriate to form the basis of a site-specific M_{SD} to estimate an indoor dust concentration for those homes where no indoor dust lead concentration data are available (U.S. EPA, 1998). A site-specific M_{SD} may also be used when developing a PRG number for the site.

High-volume cyclonic vacuums are recommended for collecting house dust lead data according to the ASTM method (ASTM, 2005; with the modification of using a sieve size of 250 µm) for the IEUBK model because they provide concentration data that can be directly entered into the model; they allow for the sampling of fine particles of dust; they are useful for a variety of surfaces; and they have documented greater precision and collection efficiency than other sampling methods.

3.1 SELECTION OF RESIDENCES TO SAMPLE

When it is not feasible to sample all homes, it is recommended that residences be randomly selected from the population of the residences where soil samples will be collected. Ideally, residences are selected using a stratified random sampling plan to increase the likelihood of obtaining a representative sample. For the purposes of this guidance, a representative sample is defined as a sample that contains ranges of values for attributes (e.g., PbB, soil lead concentration, etc.) that are deemed important and that are consistent with the range of values for the attributes that are found in the population. For example, the sampling strategy would generally avoid homes with lead-based paint due to confounding of the determination of a site-specific M_{SD}. Also, it is generally recommended that paired outdoor soil and indoor dust samples should be collected to develop a site-specific M_{SD}. If PbB data are available, then the population may be stratified by PbB to ensure the range of PbB levels in residences that are included in the sample is approximately equal to the range of PbB levels in the population. For lead case management and preventive efforts, it is preferable to maximize dust sampling in homes occupied by pregnant women or young children.

If soil concentration data are available from previous sampling efforts (e.g., from preliminary assessments/site investigations), then residences may also be stratified by soil concentration. In the absence of, or in conjunction with, soil concentration data, strata may be defined based on distance from the sources(s). This assumes the transport mechanisms are known with some certainty (e.g., aerial deposition from a smelter), and the pattern of contamination has not been greatly disturbed (e.g., partial cleanups). Other site-specific variables that could be used to define strata include building age (older buildings may have lead-based paint) and direction from the source (to account for prevailing wind directions when aerial transport may be an important mechanism for contaminant transport at the site).

The expertise of a statistician is recommended for assistance in designing the sampling plan. Ideally, environmental samples (and PbB samples, if collected) will be collected within the same period of time (see Section 3.5 for discussion).

3.2 SELECTION OF SAMPLING LOCATIONS WITHIN RESIDENCES

For site-specific Superfund risk assessment using the IEUBK model, the purpose of collecting dust samples generally is to estimate the exposure concentration (the arithmetic mean) of lead in dust. A schematic drawing of a residence (Figure 1) and flowchart (Figure 2) have been prepared to illustrate the selection of sampling locations within a residence. The location of samples within the residence may be selected to assess the variability of dust lead concentration within the residence while also characterizing the dust lead concentration in areas of the home where children <7 years (<84 months) of age spend most of their time. Dust sample collection may be conducted on hard or carpeted surfaces, depending on the location where children spend their time. The committee recommends sampling from floors because these areas best represent average long-term dust exposure for children.

Parents may be able to provide information on what areas of the home the children spend the most time. If the activity patterns of a child are known with some certainty, a time-weighted average dust lead concentration could be estimated by collecting samples in the areas of the home that are frequented by the child. In addition, a weighted average of these sample measurements could be calculated by using the fraction of the day the child spends in each area of the home as the weights.

When information on children's activity patterns is not known (e.g., future exposure scenarios and current exposure scenarios for homes without children), judgment can be used to locate samples where children would be likely to spend most of their time. If children are not present in the home, it is recommended that samples be collected from areas that are most frequently used by the residents. At a minimum, it is recommended that sample locations include 1) either a bedroom of a child who is <7 years old (<84 months) or any bedroom, if children are not present in the home, 2) the most frequently used living space (preferably by children <7 years old (<84 months), if present), and 3) just inside the most frequently used entrance to the home (see Table 2 and Figures 1 and 2). Special consideration for sampling attic dust is discussed in the Appendix.

Table 2. Recommendations For Sampling Locations Within Residences For Dust Lead Concentration.

Room	Selection of **Room**	Selection of **Sampling Location Within the Room**
A bedroom used by a <84-month child or any bedroom (when no children occupy the home)	Typically sample at least one child's bedroom[a]	Based on activity patterns or random method
The living space most frequently used (e.g., living room, kitchen)	Typically sample	Based on activity patterns or random method
An entrance most frequently used	Typically sample	Sample just inside most frequently used entrance, in main traffic pattern
Other various rooms	Optional, based on activity patterns of child <84 months	Use random method

[a]If there are no children <84 months old in the residence, a bedroom may be selected at random for sampling. Bedrooms that are used as offices, dens, etc. may be the most frequently used living space and as such, are recommended sampling locations.

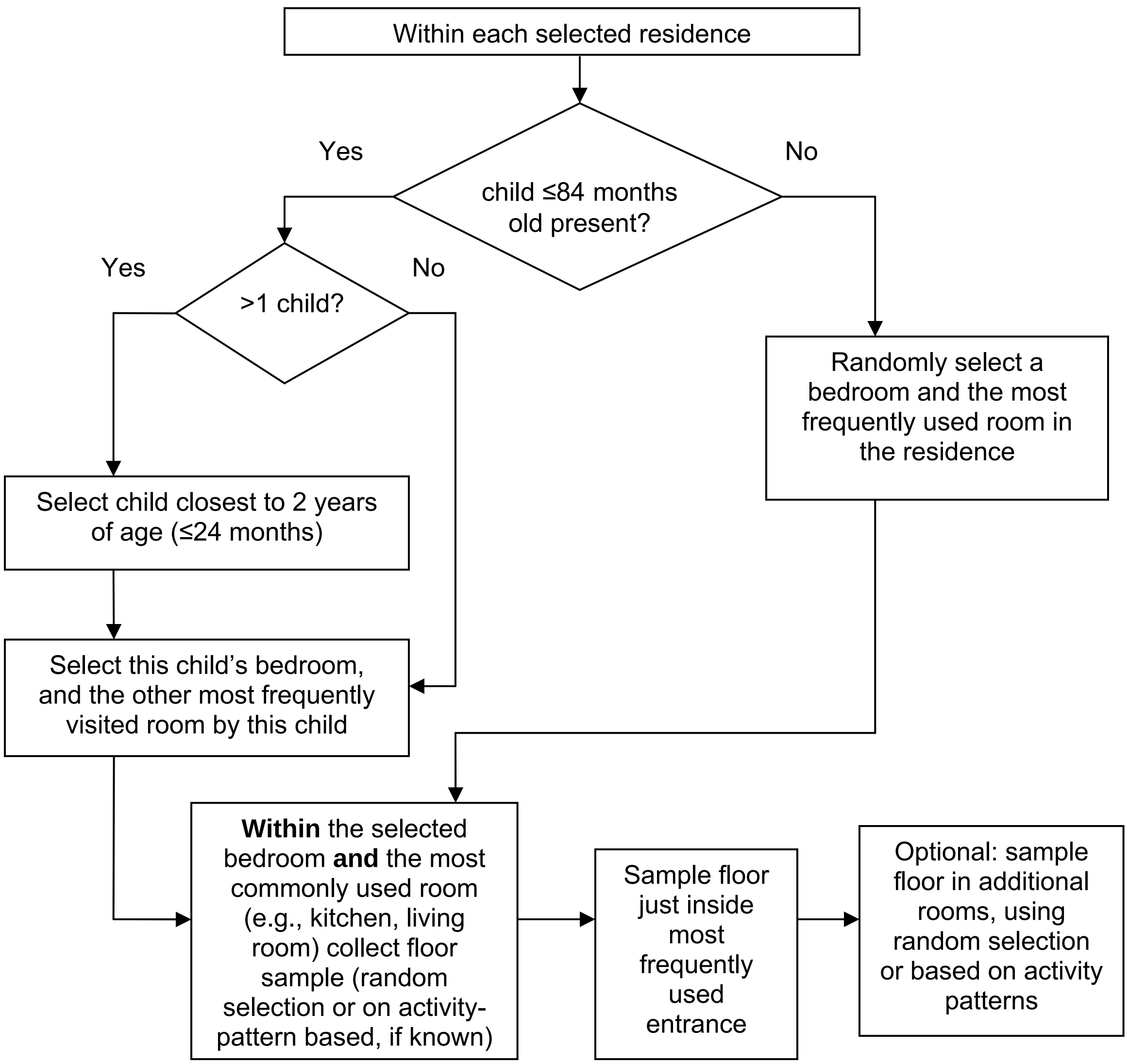

Figure 1. Recommendations for selecting rooms, and room components, for dust lead sampling. The purpose of sampling is to estimate the average residential dust lead concentration for use with the IEUBK model. The sampling design should employ a mixture of activity patterns (when known) and random sampling methods.

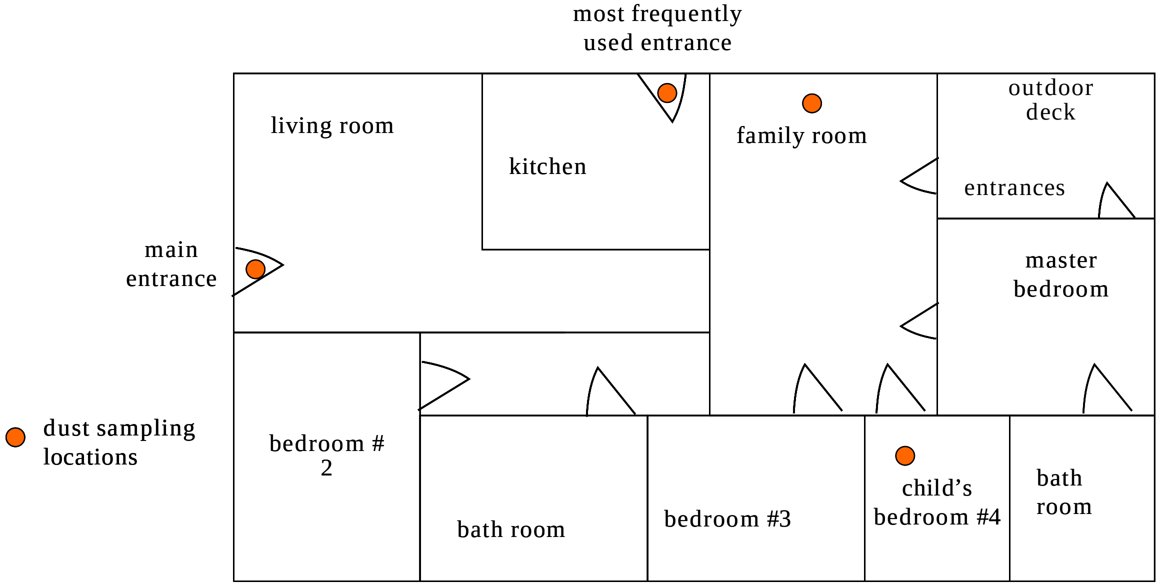

Figure 2. Typical sampling locations for residential dust sampling. The sample locations and the number of samples are hypothetical. The actual sample locations should be selected based on the general activity patterns of the children. In some residences the most frequently used entrance may be the garage. Laundry rooms may be sources of substantial exposure to young children, particularly when one or more members of the residence are employed in an occupation, or participate in a hobby, where lead contamination is present. It is recommended that samples be collected: 1) from either a bedroom of a child who is <7 years old (<84 months) or any bedroom if children are not present in the home, 2) in the most frequently used living space (preferably by children <7 years old (<84 months), if present, and 3) just inside the most frequently used entrance to the home.

3.3 Sample Preparation and Analysis

3.3.1 Sieving

It is strongly recommended to analyze the portion of the dust sample that passes through a No. 60 sieve (250 µm). Researchers who have examined the particle size distribution of dust and soil on children's hands have found that dust particles <200–250 µm are most likely to stick to a child's hands (U.S. EPA, 1995a, 2000). Sieving will also remove non-dust material from the sample (e.g., lint, hair). Studies have also shown that there is generally an enrichment of lead in the fine fraction of soil and dust particles (U.S. EPA, 1995a, 2000). Enrichment of lead in the coarse fraction has also been observed, although it is thought to be far less common (U.S. EPA, 1995a).

3.3.2 Sample Digestion and Analysis

There are currently four laboratory (*wet chemistry*) methods that are used to measure dust lead concentration: flame atomic absorption spectroscopy (FAA; SW846-7420), graphite furnace atomic absorption (GFAA; SW846-7421) spectroscopy, inductively couple plasma-atomic emission spectroscopy (ICP-AES; SW846-6010B), and inductively couple plasma-mass spectroscopy (ICP-MS; SW846-6020). It is recommended that dust samples be prepared for analysis by digestion according to EPA SW846-3050B or 3051. Instrument detection limits for the digestion extract vary between 0.1 (FAA) – 1 mg/L (GFAA) (U.S. EPA, 1992, 1996); method detection limits will be higher than the instrument detection limits, and will vary depending upon many factors related to the analytical equipment and the sample matrix. In addition, laboratory (stationary) X-ray fluorescence (XRF) may also be used to measure dust lead concentration. Dust samples for XRF should be prepared using the same approach as for outdoor soil samples (e.g., sieved, homogeneous, dried).

3.4 Data Analysis

It is recommended that an estimate of the (arithmetic) mean dust lead concentration be used as an input to the IEUBK model. Variability in other exposure parameters (e.g., dust ingestion rate) is represented by the geometric standard deviation (GSD) term in the IEUBK model. It is also recommended to review each sample result individually to decide if specific areas of the residence pose a potential lead hazard.

3.5 Seasonal Variation (in Blood Lead and Dust Lead Concentration)

Due to frequently observed seasonal patterns in PbB levels and transport of lead indoors (Hunter, 1977; Billick et al., 1979; Rabinowitz et al., 1985; Blatt and Weinberger, 1993; U.S. EPA, 1995b; Johnson et al., 1996; Rothenberg et al., 1996; Edwards et al., 1998; Lorenzana et al., 2003; Laidlaw et al., 2005), recommendations on the seasonal timing of sampling are important for the IEUBK model. It is recommended that house dust samples be taken during the late summer months to early fall, in order to capture peak house dust lead concentrations and loadings potentially responsible for peak PbB concentrations reported in numerous studies

(Hunter, 1977; Billick et al., 1979; Rabinowitz et al., 1985; Johnson et al., 1996; Lorenzana et al., 2003).[3]

3.6 COMPOSITE SAMPLING ISSUES

In general, the analysis of discrete samples is preferred over composite samples to avoid losing information on the variability of dust lead concentration within the residence. In particular, it is not recommended to composite samples from areas of the residence with little or no dust (low dust loading) with samples from areas with high dust loading, because exposure is related to dust loading.

4.0 CONCLUSION

High-volume cyclonic vacuums are recommended for collecting house dust lead data (according to ASTM methodology with a 250 µm sieve) for the IEUBK model because they provide concentration data that can be directly entered into the model. Table 1 can be used to evaluate the appropriateness of other methods; however, it is recommended that the TRW be consulted prior to using data collected with other methods in Superfund lead risk assessments. It is recommended that dust samples be collected from floors. Samples may be collected from carpeted and bare floors. It is recommended that residential dust samples be collected from all residences when feasible to do so. The location of samples within the residence may be selected to assess the variability of dust lead concentration within the residence while also characterizing the dust lead concentration in areas of the home where children <7 years of age (<84 months) spend most of their time. Generally, it is recommended to collect samples from the following locations: 1) either a bedroom of a child who is <7 years old (<84 months) or any bedroom if children are not present in home, 2) the most frequently used living space (preferably by children <7 years old (<84 months), if present), and 3) just inside the most frequently used entrance to the home (see Table 2 and Figures 1 and 2).

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[3] For some locations, it may be appropriate to sample at other times of the year (e.g., wet weather season to capture season when track-in is anticipated to be greatest). The timing of sampling is a site-specific decision.

APPENDIX

Attic Dust Sampling and Analysis

The purpose of this appendix is to recommend methods for collecting and analyzing dust lead data from attics or areas of the attics that are not used for living space. Attics or areas of attics that are used for living space (e.g., bedroom[s]) should be sampled according to the recommendations provided in Section 2.0. Data on dust lead concentrations in non-living space areas of attics can provide useful information for risk management decisions, but should not be used with the IEUBK model if exposure to the dust in these non-living space areas occurs very sporadically (i.e., <1 day/week for 3 months; U.S. EPA, 2003).

Risk management issues related to the cleanup of attic dust are not addressed in this appendix. This appendix assumes the decision to sample attic dust has already been made and does not address how to make that determination. However, some of the factors to consider when making that determination include:

- historical site information that suggests contamination may have occurred as a result of outdoor soil or air sources,
- a complete exposure pathway exists between the attic dust and potentially exposed individuals (as defined by the site conceptual exposure model),
- there is no other plausible explanation for observed elevated PbB concentrations,
- attic dust is likely to recontaminate residences that have been cleaned or have been proposed for cleaning.

Background

Recent studies indicate that residential attic spaces can contain a number of contaminants, including pollutants such as plutonium, pesticides, and lead. In a sampling of homes near a nuclear test site in Nevada, Cizdziel et al. (1998) encountered plutonium in attic dust that the authors attributed to above ground nuclear detonations that occurred in the 1950s and 1960s. During a later resampling of the same locations, Cizdziel and Hodge (2000) detected pesticides, some of which had been banned for many years (e.g., DDT). Cizdziel and Hodge (2000) also found that pollutants in attic dust were enriched relative to surrounding soil. Lead was consistently the pollutant with the highest enrichment factor; concentrations of lead in attic dust were up to 10 times greater than the lead concentrations in nearby soils (Cizdziel and Hodge, 2000). Ilacqua et al. (2003) also detected lead in attic dust in samples of 201 houses of varying age located in Dover Township, NJ. The study observed a positive correlation between home age and the amount of lead in attic dust. Temporal variability of lead in attic dust closely followed the temporal variability in lead emissions from leaded gasoline combustion.

Contamination of attic dust occurs when ambient air containing pollutants enters the attic and airborne particulate matter settle on attic surfaces such as the floor, insulation, roof, and rafters. In a typical attic, warm air is vented near the peak of the roof. As the warm air is vented, cooler outside air is drawn into the attic through vents and other openings located lower in the attic (e.g., soffit/eave vents). Reduced air flow promotes increased particulate deposition rate and less re-entrainment. Over time, contaminated particles build up in the attic and may remain in the attic for the life of the home if left undisturbed. In some cases where attic dust has been undisturbed, studies have shown that attic dust can provide a historical record of ambient air pollution (Ilacqua et al., 2003).

Potential exposure to attic dust

Although pollutants have been observed in attic dust, the potential for exposure may be minimal if the attic is well-sealed from the living space. In making the determination to sample attic dust, consider the potential exposure to attic dust. If a completed exposure pathway for attic dust has been identified, or when elevated PbB concentrations observed in children living on the site cannot be explained by other sources, there may be a potential exposure to attic dust.

In a complete exposure pathway, children may be exposed to attic dust through direct or indirect exposure. Direct exposure occurs when a person enters the attic space and is exposed directly to lead contaminated dust. This is most likely to occur in homes where attics are easily accessible (e.g., via stairways). Direct exposure can occur when bedrooms or other living spaces are located in the attic, or through intermittent activities such as placing or retrieving storage items in the attic. Home renovations that require entry into the attic (e.g., wiring and insulating) or intrude into the attic (e.g., ceiling replacement, installation of skylights, or installation of attic ladders) may result in intermittent direct exposure to attic dust (e.g., during construction) and may represent a temporary source of lead in dust in the living spaces of the home. Indirect exposure to attic dust can occur when attic dust enters the primary living space. An example of this is when a directly exposed individual transports lead contaminated dust on their personal effects (e.g., clothing, shoes, articles retrieved from attic, etc.) back into the living spaces or when attic dust penetrates the living areas via cracks or crevices in the walls or ceilings.

There may also be a potential exposure to lead in attic dust if there are elevated PbB concentrations[4] observed in children living on the site that cannot be explained by other sources and, one or more of the following conditions are met:

- Transport of site-related lead contamination via air is known or suspected to be or to have been a significant means of contaminant transport.
- It is known that the attic dust contains high concentrations of lead (e.g., through previous sampling efforts).
- The individual has lived in the residence for an extended period of time (e.g., 3 months or longer).
- Soil lead concentrations on the property are low (e.g., <400 ppm).
- Dust lead concentrations are low (e.g., <280 ppm).
- Dust lead concentrations in the residence are high (e.g., >280 ppm) and lead-based paint is not present (or the paint is in good condition and there is no known pica behavior).
- Sources of lead exposure outside of the residence have not been identified.
- The residence is an older home.

[4] Blood lead concentration data for people who are potentially exposed to site-related contamination are not available for many sites.

Recommendations for sampling and analysis

A sampling plan should be developed after the determination to sample attic dust has been made. Investigators considering sampling attics should proceed with caution to minimize physical hazards to the sampler, prevent damage to the structure, and prevent potential contamination of living spaces. The recommendations for sampling indoor dust given in Section 2.0 also may be useful when sampling attic dust; however, attics often present unique sampling requirements. For example, some houses may not have access to the attic, while others may permit only limited access to certain parts of the attic.

Factors should be considered when deciding which houses will be sampled such as sample locations within the attic, sample size, and sampling equipment. The sampling method and equipment that is used for attic dust should be the same as, or sufficiently consistent with, the methods and equipment that are used in the other areas of the residence to support valid comparisons between the attic dust data and the dust data collected from other areas of the residence.[5]

Sample locations and sample size (within each attic)

This section addresses attics, or portions thereof, that are not used for living space. If any areas of the attic that are used for living space (e.g., bedroom[s]), these areas should be sampled according to the recommendations provided in Section 3.0.

Determining sampling locations within each attic should be done on a site-by-site basis, as each attic will have different physical constraints. When possible, samples should be collected from multiple points within the attic. In some cases access will be restricted to areas near the attic entry (e.g., attics with a trap door entry). Obstacles such as hazardous attic floor conditions (e.g., lack of decking), insulation, limited crawl space, and the potential to damage the structure or household contents may prevent access to all areas of the attic.

If access to the attic is available, the attic should be inspected for potential health and safety hazards. Samples should not be collected where attic floors are not adequately supported, electrical hazards exist, or where damage to the ceiling may result. When possible, samples should be located near the attic entry as it is expected that this would represent the dust that is most likely to be tracked into the living space. Samples may also be collected near eave vents and where attic dust disturbance has been unlikely, as these areas may contain higher concentrations and volumes of dust. When possible, consider sampling attic surfaces such as beams, floors, insulation, roofs, and rafters.

In some cases, indoor access to the attic may not exist. In these cases, it is presumed that the contamination of the living space from attic dust will be via indirect exposure. If it is determined that attic sampling is required, but indoor access is not feasible, an alternative access point may be through exterior attic vents.

[5] It should be noted that for instances when attic dust is infiltrating into the residence, current risk to residents would be represented by indoor dust lead sampling. Sampling of the attic would, in this instance, provide information concerning potential future exposure.

Sample equipment

Numerous types of sampling equipment exist for collecting dust samples including a paint brush and dust pan, high-volume cyclone vacuums, and dust wipes. In previous studies, a dustpan and fine-haired brush or paint brush have been used to sample attic dust (Cizdziel and Hodge, 2000; Ilacqua et al., 2003); however, it is recommended to use a high-volume cyclone vacuum like the HVS3 to collect samples whenever feasible. The vacuum should also be thoroughly decontaminated between samples following the manufacturer's recommendations. When it is not feasible to use a high-volume cyclone vacuum, samples may be collected using a paint brush and dust pan, or other appropriate receptacle (e.g., polypropylene scoop). New sampling equipment should be used for each sample, or sample equipment should be thoroughly decontaminated between samples to avoid cross-contamination of samples. In addition, sharp objects should not be used to sample attic dust as they may damage electrical wires in the attic. Where dust has collected in large quantities, a disposable spoon may be used to collect a sample. Dust samples may be stored in clean antistatic plastic containers such as bags or HDPE bottles and delivered to an EPA certified lab for analysis.

Evaluating dust concentration data for attics

It is anticipated that attic dust samples may contain larger particles of debris such as fiberglass, cellulose, or vermiculite insulation and that sieving normally would be appropriate. Sample preparation and analysis should follow the recommendations provided in Section 3.0.

Attic dust lead concentration data may provide useful information for risk management decisions. The attic dust lead concentration data should not be used with the IEUBK model if exposure to the attic dust occurs very sporadically (i.e., <1 day/week for 3 months [U.S. EPA, 2003]). If the potential exists in the future that attic dust will impact indoor exposures, as determined on a residence-specific basis, this potential exposure to attic dust should be further evaluated. If the attic is used for living space (e.g., as a bedroom) these data may be used in the IEUBK model as indoor dust concentration to estimate risk from the exposure.

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