ERT HELPFUL HINTS for
ACTIVITY-BASED SAMPLING FOR ASBESTOS IN AIR

Asbestos fibers pose a risk to human health overwhelmingly by way of the inhalation pathway. A relationship between the concentration of asbestos in a source material (typically soil) and the concentration of fibers in air that results when the source is disturbed is very complex and depends on a broad range of variables. Many have tried and all have failed to produce a "rule" describing this complex relationship. That is, no method has been found to predict the concentration of asbestos in air reliably as it relates to a measured concentration of asbestos in the source material. Suffice it to say, a small concentration of asbestos in source material may, when disturbed, produce a substantial airborne exposure. Not always, but sometimes. Therefore, personal monitoring in the form of activity-based sampling (ABS) for asbestos in air is the most appropriate technique to estimate exposure. Personal exposure is influenced by the activities performed, the duration of the activity, and the site-specific soils of interest. EPA has developed ABS to mimic the activities of a potential receptor.

The official guidance document for assessing asbestos impact at sites is *Framework for Investigating Asbestos-Contaminated Superfund Sites*, OSWER Directive #9200.0-68 (September 2008), referred to in this document simply as the Framework. It is an important document and must be read before engaging in ABS. All steps explained in the Framework should be considered thoroughly before conducting screening (Step 4 of the Framework).

The Environmental Response Team (ERT) strives to make asbestos ABS projects less stressful from every aspect: planning, execution, outcome, and reporting. With this document, we hope to provide OSCs, RPMs, and other Regional personnel with the benefit of our collective experience dealing with ABS for asbestos in air. ERT has provided assistance for ABS evaluation at many sites and has encountered a fair share of misunderstanding, misinterpretation, and general "what do I do now" questions to compile this tip sheet to steer investigators. While ERT does not make policy decisions regarding ABS for asbestos in air, these helpful hints are provided as an extra service to those whom we assist.

A. General Tips

This Section provides general recommendations that we believe will make any ABS event much easier. The other Sections provide more detailed tips concerning some of the more complex aspects of ABS for asbestos in air.

- Establish a project team with a cross section of the necessary skills and experience early on in the planning process. For example, it is very important to engage the assistance of a Regional risk assessor and/or personnel from ATSDR, especially at the outset when you are coming up with exposure assumptions to calculate risk. Calculations to determine the air screening level and resultant risk are not difficult but are based on concepts and assumptions that may be beyond the scope of the OSC's or RPM's regular duties.
- Use spun-bonded polyethylene (SBP) outer suits, also known as "dust suits", during ABS activities, especially during warm/hot months. The ubiquitous Tyvek® suits are vapor-permeable but it is important to understand that while water vapor is a gas, sweat is bulk

water and moisture in liquid form. Therefore, liquid from the wearers sweat will accumulate inside the suit. SBP suits are breathable (water moves both ways unimpeded) and lightweight. SBP coveralls are used in the asbestos abatement industry and are protective against particulate matter and present a minor heat stress hazard when compared to Tyvek® suits.

- Have sufficient staff available to assign one person to equipment handling and pump calibration; one to assist the activity personnel with dressing out and performing the activity; and one person for data management.
- Utilize more than one person in the ABS activity and practice the backpack switching process in advance to assure a smooth transition during the actual timed activity.
- Instruct the activity personnel to perform the activity in a manner that represents "reality", and advise them that exaggerated and over-stressed behavior is counter-productive and may lead to overloading of the air filter cassettes. For example, raking should be realistic but not unnecessarily aggressive or repetitive; lawn mowing should progress at a usual speed, etc.

B. Conceptual Site Model and Decision Unit

Guidance for the development of conceptual site models (CSMs) is available in USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988) and USEPA's *Data Quality Objectives Process for Hazardous Waste Site Investigations* (USEPA, 2000). Note that examples of CSMs in these guidance documents focus on human health or ecological risk assessment concerns and may need to be modified to address additional, non risk-related environmental hazards.

It is important to develop the CSM early in the planning process and to carefully define the decision unit (DU) and the decision(s) which the data collected from the DU are expected to support (DQO process!). A DU is defined as a physical area of soil where a decision is to be made based on data specific to the targeted soil. Decision units are established so large-scale variability of soil conditions across a site will be adequately isolated and characterized through designation of separate DUs. DUs can be focused on areas of potential exposure as well as areas of contamination like backyards, play areas, a driveway, a former waste pile area, or a road. The appropriate type, size, shape and number of DUs for a given project is site-specific and must take into consideration the historical, current, and future use of the site and the specific type of environmental hazards posed by the targeted contaminants. Investigation objectives can change as a project proceeds and in some cases, additional or alternate DUs may need to be established. For example, DUs established for site characterization purposes may need to be refined for the remedial phase of the project to isolate high-priority areas.

An important goal of the site investigation is to estimate the representative, mean concentration of a targeted chemical for the designated volume of DU soil. In an ideal world, the entire DU would be analyzed as a single, laboratory aliquot. However, this is not possible in the real world.

The raking-screening protocol (Step 4 of the Framework) applied on a DU can be thought of as an exercise in incremental sampling. By raking the entirety of the decision unit, one is effectively averaging the very high contamination areas with the moderate and low contamination areas to end up with an area–weighted result that automatically provides the mean concentration of asbestos in air due to that activity. This is the easiest and most straightforward method. Smaller-scale variability of asbestos concentrations within a targeted DU volume of soil does not normally need to be determined or evaluated, at least at the initial phase of an investigation when a screening risk level is not exceeded. If a greater resolution of contaminant concentration variability within the soil is in fact needed to address the objectives of the site investigation then, by definition, the DU is too large and the area should be re-divided into smaller decision units.

As an alternative, "representative" air samples are collected through ABS within a portion of the DU and submitted for analysis. The data generated are then used to make a decision for the entire volume of soil represented by the DU. This method assumes that the distribution of asbestos across the DU is fairly uniform and the mean asbestos content in one part of the DU is the same across the entire DU. This assumption may or may not be true. This is when the investigator has to rely on a robust CSM.

Establishing decision units early in the site investigation process helps to ensure that the objectives of a site investigation are clearly thought out and defined, well before screening or site specific ABS samples are collected. This aids in the preparation of an effective sampling and analysis plan and helps ensure that the data collected will be adequate to meet the objectives of the investigation. It is important to ask basic questions about the intent of a site investigation as potential DUs are identified and designated.

- How does the DU fit into the overall objectives of the investigation?
- How will data from the DU be used to address these objectives and what decisions will it inform?
- Have screening risk values been determined for the DU?
- What further action will be taken if the screening risk values are exceeded? If the values are not exceeded?

If you find yourself reducing the size of a decision unit down to a single, discrete sample (e.g., making removal/remedial decisions for individual sample points) then adequate thought has probably not been given to the objectives of the site investigation.

C. Perimeter Air Sampling

The ERT SOP 2084, *Activity-Based Air Sampling for Asbestos*, states that perimeter air sampling should be performed to ensure that ABS activities do not result in excessive airborne asbestos emissions from the site. In practice, ERT usually collects air samples downwind of the entire site to ascertain if activities on the site are causing offsite emissions. Likewise, ERT usually collects air samples upwind of an activity to determine background asbestos concentrations or if there is an upwind source. Simply stated, ERT typically recommends that air samples be collected and analyzed to determine the concentrations of asbestos at a site's perimeter. These perimeter air samples are generally collected over the entire work day which allows for a large volume of air and a very low sensitivity value.

If the project team is interested in ascertaining whether an activity would affect anyone nearby, ERT recommends collecting air samples immediately adjacent to the perimeter of the area where the activity is occurring. Perimeter air samples such as these should be collected during the duration of an individual ABS event and therefore would involve a low volume of air and a high sensitivity value. These air samples may provide a qualitative indication of whether or not an activity would expose anyone nearby to a possible asbestos inhalation risk.

Keep in mind, however, that either form of perimeter air sampling has some shortcomings. For example, windblown asbestos fibers may be highly directional and may not spread out laterally (i.e., the asbestos plume may go between the air samplers and no fibers may be collected on the filters). Also, in many situations, the wind changes direction due to daily shifts and seasonal changes or there may be little to no measurable wind present during sampling. These conditions may confound what is considered upwind/downwind or coming from background. Because of this, the ERT ABS SOP 2084 recommends that historical and real-time meteorological conditions be taken into consideration and recorded to assist in data interpretation. Unfortunately, in many cases, the meteorological data collected has shown that wind direction is highly variable and upwind and downwind directions are poorly defined.

To confound the issue even more, at several sites there have been asbestos fibers detected in both types of perimeter samples while the ABS personal air samples have had no observable fibers. The interpretation of perimeter samples such as these is very difficult and can lead to some spirited debate within the project team.

So where does this leave you and your project team? Simply put, perimeter air samples, even with the issues noted above can provide clues as to the possibility of a risk to anyone adjacent to an activity or the possibility of off-site asbestos fiber releases. It is recommended that perimeter air samples not be used directly for risk assessment, but rather as a qualitative indication of the presence or absence of asbestos fiber migration due to a site activity.

In the end, any asbestos fiber detection in perimeter air samples would need to be considered from both a public perception and a site management perspective. Each project team should weigh the value of collecting perimeter air samples against the cost when developing the data quality objectives. While ERT generally recommends the collection of perimeter air samples at site boundaries and around ABS activities, they may not be necessary or appropriate at all sites depending upon the site-specific sampling objectives.

D. Sensitivity, Detection Limit, and Reporting Limit

One issue that ERT is repeatedly asked to provide guidance on involves the determination/selection of an analytical sensitivity value. Before starting any ABS work, the required analytical sensitivity should be determined and included in Sampling and Quality Assurance Project Plans. Do not simply rely on the information provided by the analytical lab in their quote proposal. The best approach is for the project team, including risk assessor, to meet before preparation of the QAPP and decide *a priori* (and consistent with the Data Quality Objective process for site investigation) what fiber concentration in air will yield a risk value of interest, whether it be 10^{-4} or 10^{-6}, or some other risk level. Not all EPA Regions (or States) evaluate risk in the same manner so it is important to involve the risk assessor ahead of time (before you mobilize to the field and collect samples or find a laboratory to analyze samples).

Some confusion persists regarding the word “sensitivity”; at least in relation to asbestos filter microscopy. Asbestos analysis consists of counting fibers (or structures, it’s not that important a distinction here). Counting fibers produces an integer (whole number) or nothing. *Sensitivity* is a discrete variable while *limit of detection* (or detection limit) is continuous. With sensitivity, there is no “gray area”. Either a fiber is present in the optical field or it isn’t. Stated simply, the concept of “below the limit of detection” does not apply exactly to asbestos filter microscopy.

For other analytical methods, for example, gas chromatography, the detection limit is the smallest amount of a contaminant that can be measured reliably. Values measured below the detection limit are “flagged” because although the contaminant is present, it is not possible to accurately quantify. However, with asbestos filter microscopy, either a fiber is observed or it is not. For this reason, it is intuitive that there is no substantive difference between “sensitivity” and “detection limit” when discussing asbestos microscopy. So to keep things simple when “messaging” to the public which may be familiar with the concept of “detection limit”, it would be sufficient to state that no asbestos was observed above the detection limit when explaining a result of no asbestos fibers detected at a calculated sensitivity.

As explained in the Framework, a risk-based action level for asbestos in air is the concentration of asbestos in air that corresponds to a specified risk level for a specified exposure scenario of concern. This action (or screening) level for asbestos in air is an appropriate metric for making the determination of whether a response action, no action, or further, more detailed investigation at a given site is warranted. So, before sampling, you must determine what sensitivity value must be obtained from the laboratory in order to evaluate whether or not the air action level has been exceeded. In other words, you don’t want to receive data from the lab where the sensitivity was so high that you can’t determine if an unacceptable risk is present.

For asbestos filter analysis, in principle, the sensitivity value for any sample of air with a given volume can be reduced to any value desired simply by examining more of the sample (i.e., by counting more grid openings), and there is no inherent (hypothetical) limit imposed by the instrument. Looking at more grid openings decreases the sensitivity value (i.e., 0.01 to 0.001) and by corollary lowers the limit of what can be detected. The alternate method of reducing the sensitivity would be to increase the volume of air collected but this often leads to filter overloading which is discussed in the next section.

Many Regional risk assessors have suggested that a sensitivity value of no greater than ~0.001 f/cc be used since this equates to a default Baseline Residential Exposure (BRE) risk of 1 in 10,000 or 10^{-4}. The BRE assumes exposure to a resident 350 days a year, 24 hours a day from birth to 30 years old. This is a very conservative approach and arguably an unlikely exposure scenario in most settings. While it is possible in theory to continually decrease the sensitivity value by counting more grid openings, it may not be economically feasible or reasonable. The cost difference between analyzing an asbestos air filter to a sensitivity of 0.001 f/cc rather than 0.01 f/cc may be too high for your budget, depending on the quality of the sample.

To demonstrate, consider the following that is based on the analytical subcontracting of ERT’s contractor over the past few years. The typical analytical SOW will require the laboratory to examine up to 10 grids with the precise number included in the standard per sample fee. The majority of the labs have included a charge of $6-$10 per grid for additional grid openings counted over 10. Counting rules for analysis generally will cease counting at 100 grid openings. So while your base analytical per sample fee may be $100, at $6-$10 per extra grid when stopping rules apply (point at which the microscopist can stop counting fibers = end of analysis) and up to 100 grid openings are counted, you might pay up to an extra $900 and still have “none detected” reported or a value that is less than the sensitivity. Again, this is an issue that should be discussed with the project team before any ABS samples are collected.

Prior planning will help prevent unnecessary and excessive costs for analysis and potentially unusable data. Due to the nature of risk assessment, the risk assessors will make a number of assumptions regarding the site and it may serve you well to understand the reasoning behind these assumptions to ensure they match your project objectives. Ask questions and get answers and gain understanding. Will the risk assessors use a mean and maximum fiber value for their assessment? What scenarios will be useful in assessing risk for the likely population of concern? For example, if the site is a mine does it make sense to do a "child digging scenario"? If the site is a railroad siding does it make sense to calculate risk for a child starting at birth? How much effort will be involved to examine scenarios that will intuitively produce no measurable risk like standing or sitting for prolonged periods? It is important to be realistic in your planning and choose scenarios that make sense or time, energy, and funding may be needlessly wasted.

E. Filter Overloading

The sampling method used to collect asbestos fibers in air is an extension of the NIOSH nuisance dust method that uses an air filter with an open face cassette. In their traditional incarnation, NIOSH sampling methods anticipated a preponderance of contaminant with little if any interfering matrix. In most situations you will encounter, the conditions will be exactly the opposite; there will be an atmosphere skewed toward mostly interfering matrix with a small concentration of asbestos fibers. Simply said, far more non-asbestos particulate than asbestos fibers will be present on the filter. Sampling under these conditions makes it easy to overload the sample filter with particulate matter.

The recommended analytical method for asbestos air samples, ISO 10312, states that the direct preparation analytical method cannot be used if the general particulate loading obscures more than 10% of the filter. Usually, EPA directs the laboratory to waive the 10% value and instead stipulates an acceptable value of 25%. If the particulate loading is over 25%, the indirect method, ISO 10374, is used for the analysis. The direct preparation method is simpler, faster, and less expensive than the indirect method. It also avoids problems with data interpretation and over-estimation of exposure from sampling frangible fibers/structures that may disassociate under sonication during filter preparation using the indirect method. Measured fiber concentrations have been shown to be significantly higher for chrysotile (up to 2,000x) when an ultrasonic treatment is applied during the indirect preparation process (Kauffer, 1996). However, amphibole asbestos does not appear to show a similar problem of equal magnitude.

Also note that some Regions and/or regional risk assessors prefer not to use indirect method results for quantitative risk assessment purposes but may use the results for a qualitative judgment in decision making. The project team should determine its position on filter overloading and the use of indirect values when setting up the sampling and analytical approach.

F. Flow Rate Considerations

Sampling larger volumes of air and/or analyzing greater areas of the filter media can theoretically lower the analytical sensitivity value. Of course, doing either of these can lead to increased filter loading or increased analytical costs. There is a definite tradeoff between improving sensitivity through larger sample volume (cheaper than counting more grid openings) and the downside of increasing the potential for overloading (the subject of Section E). For sites with the possibility to entrain a lot of non-asbestos particulate (dirt/dust), the sample collection flow rate may need to be decreased in your attempt to avoid overloading the sample filter. As discussed, too much particulate in the presence of a very small amount of asbestos inevitably obscures fibers that may be present.

Therefore, it may be more efficient to collocate two sampling trains using different flow rates and collect a high- and low-volume of air. This increases the likelihood that at least one of the two samples can be analyzed using the direct preparation analytical method rather than losing the sample due to overloading or having to analyze by the indirect method. However, the disadvantage of this approach is a potential reduction in representativeness of the sample for the exposure of interest.

It is not possible to design a rigid decision matrix for deciding the best sample collection rate. While the use of two sampling trains has worked for some in the past, it is also possible that the low-volume sampling train may also become overloaded with particulate. Therefore, it is best for the project team to develop an early strategy to assess the proper flow rate to avoid overloading.

One strategy for assessing the likelihood of filter overloading is doing a "dry-run" ABS event. It is easy to observe the degree of loading simply by looking at the filter. If the filter appears to be "dirty" or discolored, it is probable that it is overloaded with extraneous particulate matter. It is even possible to have a phase-contrast (PCM) microscopist on site to examine the filters. Using the onsite microscopist, it was easy to determine that a sample collection rate of 3.0 lpm was most effective at one site while riding ATVs on dusty soil, while elevated soil moisture and low available particulate on another site permitted a higher sample collection rate of 5.0 lpm. Collecting a required volume of air to meet the sensitivity required to meet the data quality objectives is simply a matter of flow rate multiplied by time.

G. Difference between Screening (Step 4 of the Framework) and Site-Specific Activity-Based Sampling (Step 5 of the Framework) Scenarios

ERT has observed substantial misunderstanding regarding Step 4 of the Framework as it applies to sites without plausible current or future activities. First, Step 4 is a screening procedure using a "worst case" activity to disturb soil. The idea is a worst-case soil disturbance will entrain asbestos from the soil in the air and make it available for an inhalation exposure. If the air value is above the screening level risk, there may be more investigation (Step 5 of the Framework) using activities that are plausible at the site. There may be no further action at the site if the risk is below the screening criteria.

Step 4 of the Framework is a corollary method for determining if asbestos in soil is releasable; that is, a relationship between an activity onsite and asbestos becoming entrained in air as a result. It has been demonstrated that trace amounts of asbestos in soil are almost always releasable when a very aggressive method of disturbing soil (such as raking for several hours) is employed. Suffice it to say then that a reported soil concentration of "trace" by polarized light microscopy (PLM) is equivalent to Step 4 as means to determine if there is enough asbestos in the soil to exceed the default air action level of 10^{-6} risk (>0.00001 f/cc in air), although it may be difficult to achieve because of issues related to overloading and cost. If soil data indicate the concentration is "trace" by PLM, it makes sense to skip step 4 and proceed to step 5, "assessment by site-specific scenario".

The misunderstanding is circulating that the “canned” scenarios as presented in the ERT ABS SOP 2084 are the only ones available to use. This is not so! ERT believes that the ABS scenarios used in Step 5 should be site-specific and plausible. It would not be possible to include all possible scenarios in the ABS SOP so it should be understood that the SOP’s scenarios are simply examples. Developing your site-specific scenarios exactly as described in the ABS SOP would be a costly mistake. The ABS SOP’s “raking” scenario is perhaps the most overused and most misapplied. For example, does a lot of “raking” go on at an abandoned mine site? In many cases where the site is remote and industrial, “walking around” or “trespassing” may be the only realistic scenarios.

Previous documentation has included incredibly prescriptive scenario behavior such as “rake a 10’ x 10’ area for 2 hours, switching direction through N, E, S, W every 15 minutes”. This is not the correct approach because the area, type of activity, level of effort during the activity, and time should be decided based on site specific conditions and the site objectives. The project team must rely on their developed CSM to guide them through the selection of plausible scenarios. Please refer to the Section B on “Conceptual Site Models and Decision Unit” for further details.

H. Sample Handling, Containers, and Storage Procedures

Air sample cassettes must be oriented with the open face pointing down at a 45° angle to preclude large particles from falling or settling onto the filter media. Using a cassette opener (from SKC, Inc. or equivalent) prevents fumbling.

Do not put the inlet cap on the cassette or remove the cassette from the tubing before turning off the pump. The quick change in pressure (suction) can pop the filter out of place or tear it and ruin (void) the sample.

When preparing the air sample cassettes for shipping, be sure to place them right side up so that the cassette inlet cap is on top and cassette base is on bottom. Samples must be handled gently so as not to disturb the dust deposited on the filter media. Place samples into a shipping container and use enough packing material to prevent jostling or damage. Do not use vermiculite or any other type of fibrous packing material.