

CHAPTER 9
SORBENT MEDIA SAMPLING

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Chapter 9

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I. Introduction

Sorbent tubes and passive monitors (badges) may be used to determine the airborne concentration of certain vapors and gases. These samplers contain media such as charcoal, silica gel, florasil, and hopcalite. Collection on sorbent media can be done by active sampling, where a sampling pump is used to draw contaminated air slowly through the media, or by passive sampling, where a monitor collects a contaminant by natural diffusion of air.

II. Definitions

Active Sampling - a method of sampling which requires the use of a sampling pump and sorbent tubes to assess short-term and full-shift exposures.

Adsorbent Media - substances inside sorbent tubes or passive badges that collect specific contaminants. The contaminants condense or attach to the surface of the collecting substance, rather than being absorbed into a filter, liquid, or other absorbent media.

Adsorption - the attachment of gases and vapors to the surface of a solid.

Breakthrough - also called “overload.” When contaminated air is not captured in the primary section of a sorbent media sampler and passes through to the secondary “backup” section. This condition can occur because: the primary section is saturated and cannot adsorb additional contaminant; or the flow rate is too high and the primary section does not have sufficient time to adsorb the contaminant.

Charcoal tube - most common type of sorbent tube. It is used extensively for sampling organic contaminants (e.g., solvents). The glass tube contains two sections of activated charcoal: the larger section is the sampling section and the smaller section is the back-up section. Charcoal tubes come in various sizes.

Diffusion - the natural passage of gas or vapor from an area of high concentration to an area of lower concentration. When gases or vapor pass through a membrane, the rate of diffusion depends on the concentration of contaminants on each side of the membrane. In a passive monitor, the gases or vapors will diffuse across the barrier membrane into the monitor and be collected on a sorbent media.

Diffusion tube - a detector tube that is a special type of passive monitor in which the gas being sampled (carbon monoxide, carbon dioxide, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, cyanide, etc.) enters the tube by natural diffusion of air. As gases or vapors diffuse through the tube, the chemicals within react and produce a color change or stain which varies in length according to the concentration (for description and use, see Chapter 11).

Passive monitor - a sampling device which collects a contaminant (organic vapors, mercury, various mine gases) by the principle of diffusion, without the use of a sampling pump (“passive sampling”).

Passive Sampling - a method of sampling that uses passive monitors and does not require the use of a sampling pump.

Sorbent tube - glass tube with both ends flame sealed, containing two sections of adsorbent material (e.g., charcoal, silica gel, florisil, hopcalite, etc.). The larger section is the sampling section and the smaller section is the back-up section. Sorbent tubes come in various sizes. A sampling pump is used to draw air through the sorbent tube (“active sampling”).

III. Exposure Limits

The full-shift threshold limit values (TLV[®]) and short-term exposure limits (STEL) for contaminants sampled with sorbent media are listed or referenced in the *TLVs[®] Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973* and incorporated by reference in MSHA standards. For the exposure limits of specific contaminants, refer to Chapter 3.

IV. Sampling Equipment

Shelf Life: Sorbent media samplers have a shelf life that is normally found on the box or on the sampler itself. Do not use samplers for enforcement that cannot be analyzed before their shelf life expires.

Temperature and Humidity: The collection efficiency of the media may be dependent on the temperature and the relative humidity. Refer to the manufacturer’s instructions or contact the District Health Specialist or Industrial Hygienist for the applicable ambient operating conditions before using sorbent media.

Interferences: Sorbent media samplers may be adversely affected by other contaminants present. Depending on the type of sampler used, other contaminants may interfere with the measurement or the analysis. Refer to the manufacturer’s instructions or contact the

District Health Specialist or Industrial Hygienist for possible interferences before using sorbent media.

A. Active Sampling

1. Personal Sampling Pump

Sorbent tube sampling requires a sampling pump capable of maintaining the specified flow rate for the respective sampling period found in Chapter 3. The flow rate is dependent on the contaminant being collected. Some contaminants are sampled using extremely low flow rates which require the use of special “low flow” adaptors. The adaptors are normally supplied with the sampling pump as part of the tube holder assembly. Contact the District Office to coordinate specific sampling needs.

2. Sorbent Tube

Sorbent tubes come in various sizes. The type of tube used for exposure sampling depends on the contaminant (see Chapter 3.)

3. Tube Holder

Tube holders vary depending on the manufacturer. They are available in various sizes to accommodate the different sizes of sampling tubes, and have a clothing clip to use when conducting personal sampling and are designed to protect the wearer should the ends of the sampling tubes break.

B. Passive Sampling

1. Organic Vapor Monitor (activated charcoal adsorbent badges)

Organic Vapor Monitors are used to assess exposure to a wide variety of organic chemicals. Some contain a single charcoal filter, while others contain two: one for collection and a second as a back-up. Refer to Chapter 3 for the preferred monitor for a specific organic vapor, or contact your District Office for assistance.

2. Mercury Vapor Monitor (adsorbent badge) - A mercury vapor monitor unit is used only to assess exposure to mercury vapors.

3. **Diffusion tube** - A diffusion tube is a direct-read detector tube used to assess personal exposures to common mine gases (nitrogen dioxide, sulfur dioxide, hydrogen sulfide, carbon monoxide, carbon dioxide, cyanide, ammonia, etc.). Refer to Chapter 11 for further discussion and the field application of diffusion tubes.

V. Sampling Strategy

A. Full-Shift Samples

Full-shift sampling should be conducted to determine if the respective TLVs[®] have been exceeded when miners will be exposed to vapors or gases during their scheduled workshift. Refer to Chapter 3 for TLVs[®] and specific sampling guidelines for individual contaminants.

1. **Active Sampling** - The number of sorbent tubes used during the sampling shift is dependent on the concentration of the contaminant in the mine environment. That is, in higher concentrations the sorbent tube may become overloaded and it may be necessary to perform consecutive sampling by changing the sorbent sampler at short time intervals. Refer to Chapter 3 for guidance on required pump flow rates and the maximum allowable volume for the sorbent tube specified for each contaminant.
2. **Passive Sampling** - one organic vapor badge is sufficient for sampling up to 8 hours. The mercury vapor badge is also sufficient for up to 8 hours. For shifts exceeding 8 hours, use two monitors consecutively to assess a full-shift exposure.

B. Short-term Samples (Sorbent tubes only)

Short-term samples can be taken independently or in conjunction with full-shift samples to determine if short-term (STEL) or ceiling limits have been exceeded during suspected periods of peak exposure. When monitoring for short-term exposure limits, refer to the minimum sampling times listed in Chapter 3. When sampling for more than one of these contaminants, the sample duration should be for the longest listed time to encompass all of the specified time periods. However, if sampling for one specific contaminant, the duration should correspond to the listed time for the respective STEL. This can be accomplished by:

1. Taking an additional sample in the miner's breathing zone using the sampling setup described below, or

2. Interrupting the full-shift sample to take a short-term sample. This method requires taking consecutive samples. Each sampling period requires a separate sorbent tube; and the contaminant amounts (determined by analysis) on each tube must be added to obtain the full-shift exposure for each contaminant.

VI. Sampling Procedures

A. Sorbent Tubes (Active Sampling)

1. Pre-Survey Calibration of Sampling Pump

Prepare and calibrate the sampling pump using the procedures in Chapter 4.

2. Prepare a Blank (Control) Tube

Blanks are submitted to determine contamination of the tube from sample handling, storage, and shipping. Prepare one blank tube for each type of analysis desired. For example, “benzene” analysis requires one blank and “sulfuric acid” would require another. In addition, separate blanks must be submitted for each shift sampled. Blanks must come from the same lot or envelope used for the exposure sampling period.

- Carefully break each end of the tube and immediately attach a cap on both ends. **Note:** Use a tube scorer/breaker device to avoid the risk of injury. Place a sample seal on the blank tube(s). Date, sign, and mark “BLANK” on the sample seal. Record all blank tube information in the Health Field Notes.
- Treat the blank tube(s) the same as the exposed tubes. That is, the blank tube should be subjected to the same temperature and handling conditions as the ones that are used for sampling. Carry the blank control tube in a shirt or coverall pocket while making rounds to check on the samples, and submit the blank tube(s) to the MSHA Laboratory with the exposure samples.

3. Assemble the Sampling Train (see Figures 9-1 and 9-2)

- a.** Number or uniquely identify the sorbent tubes, using a unique number for that event. This will be the sample number recorded on the Request for Laboratory Analysis, MSHA Form 4000-29.
- b.** Immediately before sampling, use a tube scorer/breaker device to carefully break off each end of the tube to provide openings approximately one-half the internal diameter of the tube.
- c.** Place the sampling tube in the tube holder with the back-up (smaller) section positioned nearest the sampling pump. Usually there is an arrow on the tube to show the direction of the air flow.
 - The air being sampled must enter directly into the open end of the sorbent sample tube.
 - Tubing or other materials must not be placed on the open end of the tube.
 - Tube holders are designed to protect the wearer from the broken glass tip.



**Figure 9-1. Sorbent Tube Sampling Train
(SKC Pump)**



Figure 9-2. Sorbent Tube Sampling Train (Gilian Pump)



Figure 9-2a. Charcoal Tube

4. Attach the Sampling Train to the Miner

- a.** Attach the sampling pump and sampling train to the miner so that it will not create a safety hazard to him or her or anyone else while performing normal activities. If the miner is not wearing a shirt or belt, the inspector should provide a belt or vest to facilitate

sampling. Coordinate this purchase with your District Office if needed.

- b.** Attach the tube holder to the miner's clothing within the breathing zone.
- c.** Clip, pin, or tape the tubing to the miner's clothing so that it does not interfere with the miner's job performance and does not present a safety hazard (such as tubing catching on a moving machine part or railing).

5. Instructions to the Miner

- a.** Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.
- b.** Instruct the miner not to remove the sampling pump or sampling train at any time or cover the tube holder inlet with a coat or other garment. If the miner must leave the mine property or work area during the shift, the inspector should remove the sampling train and turn the sampling pump off. Sampling should resume once the miner returns.
- c.** Instruct the miner not to bump, drop, abuse, or tamper with the sampling pump or sampling train.
- d.** Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.
- e.** Inform the miner when and where you will remove the sampler and that you will be checking the equipment throughout the shift.

6. Collect the Sample

- a.** Turn on the sampling pump and replace the cover plate.
- b.** When the sampling train has been attached, record the following in the Health Field Notes:
 - Time the sampling pump was started;

- Pump and sorbent tube identification numbers;
 - Miner's name, job title, and work location(s);
 - Shift hours per day and days per week worked;
 - Record the flow rate for the sampling pump;
 - Any respirator worn or expected to be worn (brand, model, type of filters); and
 - Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating a respiratory protection program).
- c.** Observe the sampling pump operation for a short time to check the flow rate.
- d.** During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities.
Check the sampling pump and sampling train to make sure the sampling pump is operating properly and the tubing and connections are not leaking. Do not adjust the flow rate at any time while sampling. Record what tasks the miner has performed in the time between subsequent checks, so that the completed Health Field Notes describe the miner's full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.
- e.** Throughout the shift, record all other pertinent information in the Health Field Notes, including:
- Times that the sampling train was checked and condition of sampling equipment; if the sampling pump needs to be changed out, stopped, or restarted for any reason, record the times involved;
 - If consecutive samples were taken, record the number of any additional cassettes used during sampling period;
 - Activity of miner, equipment operating in the area, and approximate time spent at each activity;
 - General description of controls in use and whether or not they seem adequate;
 - Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;

- Any other samples taken and the results if available (e.g., noise, detector tubes, organic vapor badges); and
 - Environmental conditions (such as wind conditions, temperature, and humidity).
- f. Collect the sampling train from the miner.
- Turn off the sampling pump. Record the time that the pump was turned off.
 - Carefully remove the sampling train.
 - Remove the sorbent tube from the holder and place a cap on each end of the tube. Place a sample seal on the tube. Date and sign the sample seal.

B. Organic Vapor and Mercury Badges (Passive Sampling)

Each type of badge (see Figures 9-3 and 9-4) comes with a unique number and an instruction booklet or insert in the original container. For proper field sampling, follow the manufacturer's recommended procedures. Submit mercury badges directly to Assay Technology for analysis.



**Figure 9-3. Passive Monitor Badge
(Organic Vapors)**



Figure 9-4. Passive Monitor Badge (Mercury Vapor)

1. **Prepare a blank Badge** - Controls are submitted to determine if there has been any contamination of the badge from sample handling, storage, and shipping. Prepare one blank badge for each type of badge submitted for analysis. In addition, separate blanks must be submitted for each shift sampled. Blanks must come from the same lot or box used for the exposure sampling period.
 - a. Open the badge in the area where personal exposure samples will be collected and quickly cap it. Place a sample seal on the blank badge. Date, sign, and mark “BLANK” on the sample seal. Record all blank badge information in the Health Field Notes.
 - b. Treat the blank badge the same as the exposed badges. That is, the blank badge should be subjected to the same temperature and handling conditions as the ones that are used for sampling. Carry the blank(s) in a shirt or coverall pocket while making rounds to check on the samples and submit the blank badge(s) to the MSHA Laboratory with the exposure samples.
2. **Position the Badge** - Clip the badge(s) to the miner’s clothing within the breathing zone. The sorbent media side should face away from the miner (see Figure 9-5).



Figure 9- 5. Position of Passive Monitor Badge

3. Instructions to the Miner

- a.** Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.
- b.** Instruct the miner not to remove the badge at any time or cover it with a coat or anything else. If the miner must leave the mine property or work area during the shift, the inspector should remove the sampling badge and cap it. Sampling should resume once the miner returns.
- c.** Instruct the miner not to abuse or tamper with the badge.
- d.** Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.
- e.** Inform the miner when and where you will remove the badge and that you will be checking the badge throughout the shift.

4. Collect the Sample

- a. When the badge has been attached, record the following in the Health Field Notes:
 - Time the badge was opened and attached;
 - Badge identification number;
 - Miner's name, job title, and work location(s);
 - Shift hours per day and days per week worked;
 - Any respirator worn or expected to be worn (brand, model, type of filters); and
 - Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating a respiratory protection program).
- b. Check the condition and positioning of the badge as frequently as practical to determine that a representative sample is being conducted of the normal activities. Record what tasks the miner has performed in the time between subsequent checks, so that the completed Health Field Notes describe the miner's full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.
- c. Throughout the shift, record all other pertinent information in the Health Field Notes:
 - Times the badge was checked; if the badge needs to be removed or replaced for any reason, record the times involved;
 - Activity of miner, equipment operating in the area, and approximate time spent at each activity;
 - General description of controls in use and whether or not they seem adequate;
 - Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
 - Any other samples taken and the results, if available (e.g., noise, detector tubes, sorbent tubes); and
 - Environmental conditions (such as wind conditions, temperature, and humidity).

- d. Collect the badge from the miner. Cap the badge and record the time. If the badge has a sample container, place a sample seal on the container. Date and sign the seal (see Figure 9-6). Otherwise, place a sample seal on the badge. Date and sign the sample seal.



Figure 9- 6. Sealed Passive Monitor Badge Container

C. Bulk Samples

It is not necessary to collect bulk samples during sorbent media sampling, unless stated in Chapter 3 for the specific contaminant. However, when unknown substances are encountered during an inspection and analysis would help to identify specific contaminants for future exposure sampling, collect a bulk sample.

When a bulk is required:

1. Collect a minimum of one bulk sample of the suspected source of the contaminant. **Do not collect bulk samples of highly flammable or extremely toxic materials.**
2. Wear appropriate personal protection when collecting the bulk sample.
3. Label the container as the "bulk sample." Containers for liquid samples must be glass with Teflon[®]-lined caps to prevent leaching of components from a plastic container by solvents.

4. Place a sample seal on the bulk sample.
5. Place the bulk sample in a separate container from the sample tubes or badges to prevent contamination. Ship the bulk sample(s) to the MSHA Laboratory for analysis.

VII. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all necessary information in the Health Field Notes (MSHA Form 4000-31); refer to Chapter 21, Section V.

B. Post-Survey Calibration of Sampling Pump (when necessary)

Check the sampling pump calibration using the procedures in Chapter 4.

C. Transport Samples for Analysis

1. Complete the Request for Laboratory Analysis Form (MSHA Form 4000-29) for air samples and blanks (refer to Chapter 21, Section VII).
 - Item No. 15 (sample type) - designate “OV” for organic vapor sample passive badge, “HG” for mercury vapor sample (hopcalite tube), “CT” for charcoal tube, “ST” for silica gel tube, “MISC” for florisil tubes, or “CB” for blank sorbent tubes or badges.
 - Item No. 16 (analysis desired) - identify analysis desired. For example, “mercury,” “BTEX” (benzene/toluene/xylene group), “alcohols” (e.g., ethanol, isopropyl, methanol), “petroleum distillates” (e.g., gasoline, kerosene, mineral spirits), or the name of the individual contaminant(s). Refer to Chapter 3.
2. Ship the Request for Laboratory Analysis Form(s) and samples to the MSHA Laboratory. Blank sorbent tubes and badges should be shipped together with the exposure samples if space allows.

VIII. Compliance Determination

A. Sorbent Tubes

The laboratory will return an analytical report that will include the sample weight, concentration, TLV[®] or STEL, error factor, and calculated enforcement TLV[®] (TLV[®] times error factor). A PEDS or ASDS will also be generated as appropriate. Determine compliance by comparing calculated exposure concentrations with respective exposure limits. Exposure concentrations are calculated using the following formulae (round concentrations to two decimal places). The error factors for sorbent media sampling will be supplied by the MSHA Laboratory.

1. Full-Shift Sample - Shift-Weighted Average (SWA)

Calculate full-shift exposure using the following formula with 480 minutes regardless of the actual duration of the sample:

$$\frac{\text{weight of contaminant (mg)*}}{\text{Flow rate (Lpm) x 480 (min) x 0.001 (m}^3\text{/L)}} = \text{SWA in mg/m}^3$$

***Note: weight of contaminant is the weight of the full-shift tube or the sum of the weights of consecutive tubes.**

2. Short-Term Sample - Time-Weighted Average (TWA)

Calculate the concentration for each contaminant from the following:

$$\frac{\text{weight of contaminant (mg)}}{\text{Flow rate (Lpm) x sampling time (min)* x 0.001 (m}^3\text{/L)}} = \text{TWA in mg/m}^3$$

***Note: sampling time should not exceed 30 minutes.**

For organic solvents with TLVs[®] expressed in units of ppm, the MSHA laboratory reports the concentrations as ppm. The following formula is used to convert mg/m³ to ppm concentrations:

$$\frac{\text{mg/m}^3 \times 24.45}{\text{MW}} = \text{ppm}$$

where: MW = molecular weight of the compound.

B. Badges

For each badge, the results received from the MSHA laboratory will indicate the concentration (ppm, mg/m³, etc.) for each contaminant requested and the appropriate error factor and associated TLV[®]. Refer to Chapter 3. Assay Technology will provide results of mercury badge analyses to both the inspector and the MSHA laboratory.

C. Additive Effects

See Chapter 2 for a discussion of additive effects and calculation examples.

IX. Report Writing

- A.** Inspection reports should include a copy of the Health Field Notes, the request for laboratory analysis form, laboratory reports, the completed Personal Exposure Data Summary (PEDS), calculation worksheets, citation/orders, and any other supplemental information collected during the inspection.
- B.** When completing the PEDS (refer to Chapter 21, Section VIII), be sure that the concentration and exposure limit units of measurement are the same as those listed for the contaminant code (refer to Chapter 3).