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Standard Practice for Sampling Atmospheres to Collect Organic Compound Vapors (Activated Charcoal Tube Adsorption Method)¹

This standard is issued under the fixed designation D 3686; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

^{ε1}Note—SI statement was added and part of Footnote F of Table A1.1 was deleted editorially in October 2001.

1. Scope

1.1 This practice covers a method for the sampling of atmospheres for determining to determine the presence of certain organic vapors by means of adsorption on activated charcoal using a charcoal tube and a small portable sampling pump worn by a worker. A list of some of the organic chemical vapors that can be sampled by this practice is provided in Annex A1. This list is presented as an information guide and should not be considered as absolute or complete.

1.2 This practice does not cover any method of sampling that requires special impregnation of activated charcoal or other adsorption media.

1.3 The values stated in SI units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* A specific safety precaution is given in 9.4.

2. Referenced Documents

2.1 *ASTM Standards:*²

D 1356 [Terminology Relating to Sampling and Analysis of Atmospheres](#)

D 3687 [Practice for Analysis of Organic Compound Vapors Collected by the Activated Charcoal Tube Adsorption Method](#)²

[Practice for Analysis of Organic Compound Vapors Collected by the Activated Charcoal Tube Adsorption Method](#)

D 5337 [Practice for Flow Rate Calibration of Personal Sampling Pumps](#)

2.2 *NIOSH Standards:*

CDC-99-74-45 Documentation of NIOSH Validation Tests³ HSM-99-71-31 Personnel Sampler Pump for Charcoal Tubes; Final Report³

HSM-99-71-31 Personal Sampler Pump for Charcoal Tubes; Final Report³

NIOSH Manual of Analytical Methods, Fourth Edition⁴

2.3 ~~OSHA Standard:~~ *OSHA Standards:*

CFR1910 General Industrial OSHA Safety and Health Standard 29 CFR 1910 Code of Federal Regulations Relating to Labor, Occupational Safety and Health Administration, Department of Labor⁵

[OSHA Chemical Sampling Information](#)⁶

¹This practice is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.04 on Workplace Atmospheres. Current edition approved January 15, 1995. Published March 1995. Originally published as D3686-78. Last previous edition D3686-89.

¹This practice is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.04 on Workplace Air Quality. Current edition approved Dec. 15, 2008. Published January 2009. Originally approved in 1978. Last previous edition approved in 2001 as D 3686 - 95(2001)^{ε1}.

²Annual Book of ASTM Standards, Vol 11.03.

²For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

³Available from the U.S. Department of Commerce, National Technical Information Service, Port Royal Road, Springfield, VA 22161.

³Available from National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, VA 22161, <http://www.ntis.gov>.

⁴Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

⁴NIOSH Manual of Analytical Methods. <http://www.cdc.gov/niosh/nmam/>

⁵The boldface numbers in parentheses refer to the list of references at the end of this standard.

⁵Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

⁶Heitbrink, W. A., "Diffusion Effects Under Low Flow Conditions," American Industrial Hygiene Association Journal, Vol 44, No. 6, 1983, pp. 453-462.

⁶OSHA Chemical Sampling Information. http://osha.gov/dts/chemicalsampling/toc/toc_chemsamp.html

OSHA Sampling and Analytical Methods ⁷

2.4 UK Health and Safety Executive.⁸ *Methods for Determination of Hazardous Substances (MDHS)*

2.5 Berufsgenossenschaftliches Institut für Arbeitsschutz (BGIA)⁹

GESTIS Analytical Methods

3. Terminology

3.1 For definitions of terms used in this method, refer to Terminology D 1356.

3.2 Activated charcoal refers to properly conditioned coconut-shell-charcoal.

4. Summary of Practice

4.1 Air samples are collected for organic vapor analysis by aspirating air at a known rate through sampling tubes containing activated charcoal, which adsorbs the vapors.

4.2 Instructions are given to enable the laboratory personnel to assemble charcoal tubes suitable for sampling purposes.

4.3 Instructions are given for calibration of the low flow-rate sampling pumps required in this practice.

4.4 Information on the correct use of sampling devices is presented.

4.5 Practice D3687

4.1 Air samples are collected for organic vapor analysis by aspirating air at a known rate and for an appropriate time through sampling tubes containing activated charcoal.

4.2 Instructions are given to enable assembly of charcoal tubes suitable for sampling purposes.

4.3 Information on the correct use of the charcoal tube sampling device is presented.

4.4 Practice D 3687 describes a practice for the analysis of these samples.

5. Significance and Use

5.1 Promulgations by the Federal U.S. Occupational Safety and Health Administration (OSHA) in 29 CFR 1910.1000 designate that certain organic compounds must not be present in workplace atmospheres at concentrations above specific values.

5.2 This practice, when used in conjunction with Practice D3687, will provide the needed accuracy and precision in the determination of airborne time-weighted average concentrations of many of the organic chemicals given in 29 CFR 1910.1000, CDC-99-74-45 and HSM-99-71-31.

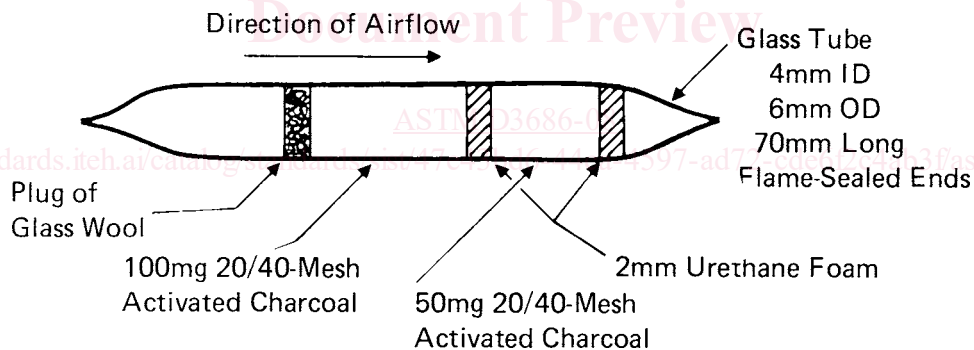


FIG. 1 Activated Charcoal Adsorption Sampling Tube

5.2 This practice, when used in conjunction with Practice D 3687, will provide the needed accuracy and precision for the determination of airborne time-weighted average concentrations of many of the organic chemicals cited in CDC-99-74-45, HSM-99-71-31, NIOSH Manual of Analytical Methods, 29 CFR 1910.1000, OSHA Chemical Sampling Information, OSHA Sampling and Analytical Methods, HSE Methods for the Determination of Hazardous Substances, and BGIA GETIS Analytical Methods.

5.3 A partial list of chemicals for which this method is applicable is given in Annex A1, along with their OSHA permissible exposure limits.

⁷ Two studies that present information pertinent to this section are: Saalwaechter, A. T., et al, "Performance Testing of the NIOSH Charcoal Tube Technique for the Determination of Air Concentrations of Organic Vapors," *American Industrial Hygiene Association Journal*, Vol 38, No. 9, September 1977, pp. 476-486. Hill, R. H., Jr., et al, "Gas Chromatographic Determination of Vinyl Chloride in Air Samples Collected on Charcoal," *Analytical Chemistry*, Vol 48, No. 9, August 1976, pp. 1395-1398.

⁷ OSHA Sampling and Analytical Methods. <http://osha.gov/dts/sltc/methods/toc.html>

⁸ Taylor, D. G., Kupel, R. E., and Bryant, J. M., "Documentation of NIOSH Validation Tests," DHEW (NIOSH), Pub. No. 77-185. Available from National Technical Information Service, Springfield, VA 22161 (PB274-248).

⁸ Health Safety Executive. *Methods for the Determination of Hazardous Substances (MDHS) guidance*. <http://www.hse.gov.uk/pubns/mdhs/index.htm#>

⁹ Berufsgenossenschaftliches Institut für Arbeitsschutz. *GESTIS Analytical methods*. http://www.hvbg.de/e/bia/gestis/analytical_methods/index.html

6. Interferences

6.1 Water mist and vapor can interfere with the collection of organic compound vapors. Humidity greater than 60 % can reduce the adsorptive capacity of activated charcoal up to 50 % for some chemicals (1).¹⁰ Presence of condensed water droplets in the sample tube will indicate a suspect sample.

6.2 High levels of organic vapors can interfere by reducing the amount of time a workplace can be sampled before the charcoal sampler becomes saturated.

7. Apparatus

7.1 Charcoal Tube:

7.1.1 A sampling tube consists of a length of glass tubing usually containing two sections of activated charcoal which that are held in place and separated by nonadsorbent material and material. The tube is sealed at each end.

7.1.1.1 Sampling tubes are commercially available. The tubes range in size from 100/50 to 800/400 mg, which means the tubes are usually divided into two sections with the front section containing 100 to 800 mg of activated charcoal and the back section containing 50 to 400 mg of activated charcoal. The 100/50-mg tube (**2-4**) and Fig. 1) which is the one most frequently used, it consists of a glass tube, tube that is 70-mm long, 6-mm outside diameter, 4-mm inside diameter, and contains two sections of 20/40 mesh-activated coconut-shell charcoal but separated by a 2-mm section of urethane foam. The front section of 100 mg is retained by a plug of glass wool, and the back section of 50 mg is retained by either a second 2-mm portion of urethane foam or by a plug of glass wool. Both ends of the tube are usually flame-sealed.

NOTE 1—Urethane foam is known to adsorb certain pesticides (**5**), for which this practice is contraindicated. Contaminated urethane foam should not be used for this practice.

7.1.1.2 When it is desirable to sample highly volatile compounds for extended periods, or at a high volume flow rate, a larger device capable of efficient collection can be used, provided the proportions of the tube and its charcoal contents are scaled similarly to the base dimensions; to provide nominally the same linear flow rate and contact time with the charcoal bed.

7.1.2 The back portion of the sampler tube, which may contain between 25 and 100% tube usually contains 50 % of the mass of activated charcoal present in the front section. The back section adsorbs vapors that penetrate the front section and serves as a warning that breakthrough may have occurred. (Annex A1 gives recommended maximum tube loading information for many chemicals.)

7.1.2.1 Should analysis of the back portion show it to contain more than 10% of the amount found in the front section, the possibility exists that solvent vapor penetrated both sections of charcoal, and the sample must be considered suspect. These percentages apply to 100/50-mg tubes. For other size tubes having disproportionate amounts of charcoal in the front and back sections, the percentages used to indicate potential breakthrough must be adjusted to take into account different ratios of charcoal. If results from the analysis of suspect samples are used to calculate vapor concentrations, the results must be reported as equal to or greater than the calculated concentrations. In such cases, the test must be repeated for confirmation of vapor concentration.

NOTE 2—Reportings from suspect samples would have significance when health standards are clearly exceeded and the amount by which they are exceeded is academic. (See 9.5.)

7.1.3 The adsorptive capacity and desorption efficiency of different batches of activated charcoal may vary. Commercial tubes, if used, should be purchased from the same batch and in sufficient number to provide sampling capacity for a definite period of time.

7.1.3 The adsorptive capacity and extraction efficiency (also called desorption efficiency) of different batches of activated charcoal can vary. Commercial tubes, if used, should be purchased from the same batch and in sufficient number to provide sampling capability for an adequate period of time. *Care must be taken to have enough tubes from the same batch for a given study.*

7.1.3.1 The desorption efficiency and contamination level of a batch of tubes should be determined, following the procedure outlined in Practice D3687 for activated charcoal. A random selection of at least five charcoal tubes from a specified lot should be taken for these checks.

7.1.4 Pressure drop across the sampling tube should be less than 25 mm Hg (3.3 kPa) at a flow rate of 1000 mL/min and less than 4.6 mm Hg (0.61 kPa) at a flow rate of 200 mL/min.

7.1.5 Charcoal sampling tubes prepared in accordance with this practice and with sealed glass ends may be stored indefinitely.

7.1.4 Pressure drop across the sampling tube should be less than 25 mm Hg (3.3 kPa) at a flow rate of 1000 mL/min and less than 4.6 mm Hg (0.61 kPa) at a flow rate of 200 mL/min.

7.1.5 Charcoal sampling tubes prepared in accordance with this practice and with sealed glass ends can be stored indefinitely. Accrediting bodies, such as American Industrial Hygiene Association, may require that sampling media have an expiration date. Accredited facilities must abide by this date.

7.2 Sampling Pumps:

7.2.1 Any pump whose with a flow rate that can be accurately determined, that can be set at the desired sampling rate, and that can maintain the desired sampling rate for a sufficient time is suitable. Primarily though, this practice is intended for use with small personal sampling pumps.

¹⁰ The boldface numbers in parentheses refer to the list of references at the end of this standard.

7.2.2 Pumps having stable low flow rates (10 to 200 mL/min) are preferable for long period sampling (up to 8 h) or when the concentration of organic vapors is expected to be high. Reduced sample volumes will prevent avoid exceeding the adsorptive capacity of the charcoal tubes. (Suggested flow rates and sampling times are given in Annex A1 for anticipated concentration ranges.) (Sample volumes are also discussed in 9.5.)

~~7.2.3 Pumps are available that will provide stable flow rates between $\pm 5\%$. Pumps should be calibrated before and after sampling. If possible, flow rates should be checked during the course of the sampling procedure.~~

~~7.2.4 All sampling pumps must be carefully calibrated with the charcoal tube device in the proper sampling position. (See Annex A2 for calibration procedure.)~~

7.2.3 Pumps are available that will provide stable flow rates between $\pm 5\%$ of the desired flow rate. Pumps should be calibrated before and after sampling.

7.2.4 All sampling pumps must be carefully calibrated with the charcoal tube device in the proper sampling position.

7.2.5 A sampling tube holder with flexible tubing is used to connect the sampling tube to the sampling pump. The sampling tube holder is used to protect the worker from the sharp end of the sampling tube.

8. Reagents

~~8.1 *Activated Coconut-Shell Charcoal*—Prior to being used to make sampling devices the charcoal should be heated in an inert gas to 600°C and held there for 1 h. Commercially available coconut charcoal (20/40 mesh) has been found to have adequate adsorption capacity. Other charcoals can be used for special applications.~~ Activated Charcoal—Prior to being used to make sampling devices the charcoal should be heated in an inert gas at an appropriate temperature for a sufficient time. Commercially available coconut-shell charcoal (20/40 mesh) has been found to have adequate adsorption capacity for many volatile chemicals. Other charcoals, such as JXC charcoal, petroleum-based charcoal, and proprietary charcoals, can be used for appropriate applications.

9. Sampling with Activated Charcoal Samplers

~~9.1 *Calibration of the Sampling System*—Calibrate the sampling system, including pump, flow regulator, tubing to be used, and a representative charcoal tube (or an equivalent induced resistance) with a primary or calibrated secondary flow-rate standard to $\pm 5\%$.~~

~~9.1.1 A primary standard practice is given for the calibration of low flow-rate pumps in Annex A2 and Fig. A2.1. — Calibrate the sampling system, including pump, flow regulator, tubing to be used, and a representative charcoal tube (or an equivalent induced resistance) with a primary flow-rate standard or with a calibrated secondary standard to within $\pm 5\%$ of the desired flow rate as described in Practice D 5337. Calibrate the sampling pump in a clean location with similar temperature and barometric pressure as the sampling site. Normally, calibrated pump flow rates or sample air volumes are not corrected for temperature or barometric pressure.~~

9.2 Break open both ends of the charcoal tube to be used for sampling, ensuring that each opening is at least one half the inside diameter of the tube.

~~9.3 Insert the charcoal tube into the sampling line, placing the back-up section nearest to the pump. At no time should there be any tubing ahead of the sampling tubes.~~

9.3 Insert the charcoal tube into the connective flexible tubing, placing the back-up section nearest to the pump. At no time should there be any tubing ahead of the sampling tubes. Use a sampling tube holder to protect the worker from the sharp end of the sampling tube.

9.4 For a breathing zone sample, fasten the sampling pump to the worker, and attach the sampling tube as close to the worker's breathing zone as possible. Position the tube in a vertical position to avoid channeling of air through the adsorber/charcoal sections. ~~Note 3—(Warning: Warning—Assure that the presence of the sampling equipment is not a safety hazard to the worker.~~

~~9.4.1 Turn on worker and that the pump and adjust the flow rate to the recommended sampling rate. equipment will not interfere with the worker's duties.)~~

9.4.1 Turn on the pump.

9.4.2 Record the flow rate and rate, the starting time or time, and depending on the make of pump used, the register reading.

9.5 *Sampling Volumes*—The minimum sample volume will be governed by the detection limit of the analytical method, and the maximum sample volume will be determined by either the adsorptive capacity of the charcoal or limitations of the pump battery.

9.5.1 One method of calculating required sample volumes is to determine first the concentration range, over which it is important to report an exact number, for example from 0.2 to 2 times the permissible exposure concentration, and then calculate the sample volumes as follows:

Minimum sample volume, m³ _____ (1)

=3=

$$\frac{\text{minimum detection limit, mg}}{0.2 \times \text{permissible exposure limit, mg/m}^3}$$

Maximum sample volume, m³ _____ (2)

=3=

$$\frac{\text{tube capacity for vapors, mg}}{2 \times \text{permissible exposure limit, mg/m}^3}$$

9.5.2 Select a sampling rate that, in the sampling time desired, will result in a sample volume between the minimum and maximum calculated in 9.5.1.

9.5.2.1 Generally a long sampling time at a low flow rate is preferable to short-term high-volume sampling. This is consistent with the fact that most health standards are based on 8-h/day time-weighted averages of exposure concentrations.

9.5.2.1.1 Generally a long sampling time at a low flow rate is preferable to short-term, high-volume sampling. This is consistent with the fact that most health standards are based on 8-h/day time-weighted averages of exposure concentrations. Often, two 4-h samples are preferable to a single 8-h sample so that if one is lost then the other can be used to partially document exposure. Work practices may change during the day and be better documented with two samples.

9.5.2.2 A sample flow rate of less than 10 mL/min, however, should not be used. Calculations based upon diffusion coefficients for several representative compounds indicate that sampling at less than 10 mL/min may not give accurate results.

9.5.2.3 Approximate sample volumes and sample times are given in Annex A1.

9.5.3 When spot checks are being made of an environment, a sample volume of 10 L is adequate for determining vapor concentrations in accordance with exposure guidelines.

9.6 At the end of the sampling period recheck the flow rate, turn off the pump, and record all pertinent information: time, register reading, and if pertinent, temperature, barometric pressure, and relative humidity.¹¹

9.5.2.3 Sampling information for a large number of organic chemicals is given in Annex A1, in the NIOSH Manual of Analytical Methods, OSHA Chemical Sampling Information file and methods, UK HSE MDHS database, and German BGIA GESTIS Analytical Methods database. Other appropriate sources of information and guidance, including Annex A1, can also be used.

9.5.3 When spot checks are being made of an environment, a sample volume of 10 L is adequate for determining vapor concentrations in accordance with exposure guidelines. Particularly volatile organic chemicals may require a lesser sample volume to prevent sampler saturation. Consult the above sources for sampling information before sampling.

9.6 At the end of the sampling period, turn off the pump, and record all pertinent information: time, register reading, and if pertinent, sampling site temperature, barometric pressure, and relative humidity.

9.6.1 Seal the charcoal tube with the plastic caps provided.

9.6.2 Label the tube with the appropriate information to identify it.

9.7 At least one charcoal sampling tube should be presented for analysis as a field blank with every 10 or 15 samples, or for each specific inspection or field study.

9.7.1 Break the sealed ends off the tube and cap it with the plastic caps. Do not draw air through the tube, but in all other ways treat it as an air sample.

9.7.2 The purpose of the field blank is to assure that if the sampling tubes adsorb vapors extraneous to the sampling atmosphere, the presence of the contaminant will be detected.

9.7.3 Results from the field blanks shall not be used to correct sample results. If a field blank shows contamination, the samples taken during the test must be assumed to be contaminated.

9.7.1 Break the sealed ends off the field blank tube and cap it with the plastic caps. Do not draw air through the blank tube, but in all other ways treat it as an air sample.

9.7.2 The purpose of the field blank is to assure that if the sampling tubes adsorb vapors extraneous to the sampling atmosphere, the presence of the contaminant will be detected on the field blank.

9.8 Calculation of Sample Volume :

9.8.1 For sample pumps with flow-rate meters:

9.8.1

$$\text{Sample volume, mL} = f \times t \left(\sqrt{\frac{P_1 \times T_2}{P_2 \times T_1}} \right) \quad (3)$$

where:

¹¹ This practice is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.04 on Workplace Air Quality . Current edition approved Dec. 15, 2008. Published January 2009. Originally approved in 1978. Last previous edition approved in 2001 as D 3686 - 95(2001)^{e1} .

- f = flow rate sampled, mL/min;
 t = sample time, min;
 P_1 = pressure during calibration of sampling pump (mm Hg or kPa)
 P_2 = pressure of air sampled (mm Hg or kPa)
 T_1 = temperature during calibration of sampling pump (K), and
 T_2 = temperature of air sampled (K).

9.8.2 For sample pumps with counters:

$$V = \frac{(R_2 - R_1) \times V}{I} \times \frac{P_1}{760} \times \frac{298}{T_1 + 273} \quad (4)$$

where:

- R_2 = final counter reading;
 R_1 = beginning counter reading;
 V = volume, (1) mL-count (1)
 P_1 = barometric pressure, mm Hg;
 T_1 = temperature, °C, and
 V = total sample volume, mL.

Sample volume, mL = calibrated pump flow rate (mL/min) × sampling time (min)

Typically, sampling pumps should be calibrated at or near the sampling site. Sample air volumes should not be corrected for sampling site temperature or barometric pressure.

10. Handling and Shipping of Samples Collected on Charcoal Sampling Tubes

10.1 There is a paucity of information on the possible fate of the many different chemical species that can be collected in activated charcoal and the variety of conditions to which these samples may be exposed. Good practice suggests the following:

10.1.1 Samples should be capped securely and identified clearly.

10.1.2 Samples collected in charcoal tubes should not be kept in warm places or exposed to direct sunlight.

10.1.3 Samples of highly vaporous or low-boiling materials, such as vinyl chloride, should be stored and transported in dry ice.

10.1.4 At present there are no published test data on the effect of conditions in aircraft cargo holds on capped samples. The preferred procedure is to carry the samples on board.

10.1.5 Samples should be shipped as soon as possible, stored under refrigeration until they are analyzed, and analyzed if possible within five working days.

10.1.6 Migration or equilibration of the sampled material within the sampling tube during prolonged or adverse storage or handling could be interpreted as break-through. This can be prevented by separating the front and back sections immediately after sampling, by having each section in a separate tube and capping them separately.

10.1.7 In some situations, circumstances and facilities may permit making up calibration standards at the facility where the study is being made and submitting these standards as quality control checks. (See Practice D3687 for recommended procedure for making up standards.)

10.1.8 Bulk solvent samples should never be shipped or stored with the collected air samples.

10.1 There is a lack of information on the stability of the many different chemical species that can be collected on activated charcoal and the variety of conditions to which these samples may be exposed. Good practice suggests the following:¹²

10.1.1 Use validated NIOSH and OSHA methods (or other validated methods) whenever possible.

10.1.2 Samples should be securely capped and clearly identified.

10.1.3 Samples collected in charcoal tubes should not be kept in warm places or exposed to direct sunlight.

10.1.4 Samples of highly vaporous or low-boiling materials, such as vinyl chloride, should be stored and transported in dry ice or in another acceptable material. These samples should be shipped using an overnight delivery service.

10.1.5 At present there are no published test data on the effect of conditions in aircraft cargo holds on capped samples.

10.1.6 Samples should be shipped to the analytical laboratory as soon as possible, stored under refrigeration until they are analyzed, and analyzed if possible within five working days.

10.1.7 Migration or equilibration of the sampled material within the sampling tube during prolonged or adverse storage or handling could be interpreted as break-through.

10.1.8 Bulk solvent samples should never be shipped or stored with air samples or with sampling media.

11. Keywords

11.1 activated charcoal tube; air monitoring; charcoal tube; organic vapors; sampling and analysis; workplace atmospheres

¹² Two studies that present information pertinent to this section are:

Saalwaechter, A. T., et al., "Performance Testing of the NIOSH Charcoal Tube Technique for the Determination of Air Concentrations of Organic Vapors," *American Industrial Hygiene Association Journal*, Vol 38, No. 9, September 1977, pp. 476-486.

Hill, R. H., Jr., et al., "Gas Chromatographic Determination of Vinyl Chloride in Air Samples Collected on Charcoal," *Analytical Chemistry*, Vol 48, No. 9, August 1976, pp. 1395-1398.