Designation: D7201 – 06 (Reapproved 2011)

Standard Practice for Sampling and Counting Airborne Fibers, Including Asbestos Fibers, in the Workplace, by Phase Contrast Microscopy (with an Option of Transmission Electron Microscopy)[1]

This standard is issued under the fixed designation D7201; 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.

1. Scope

1.1 This practice[2] describes the determination of the concentration of fibers, expressed as the number of such fibers per millilitre of air, using phase contrast microscopy and optionally transmission electron microscopy to evaluate particulate material collected on a membrane filter in the breathing zone of an individual or by area sampling in a specific location. This practice is based on the core procedures provided in the International Organization for Standardization (ISO) Standard ISO 8672 (**1**)[3], the National Institute for Occupational and Health (NIOSH) Manual of Analytical Methods, NIOSH 7400 (**2**), and the Occupational Safety and Health Administration (OSHA) Method ID 160 (**3**). This practice indicates the important points where these methods differ, and provides information regarding the differences, which will allow the user to select the most appropriate procedure for a particular application. However, selecting portions of procedures from different published methods generally requires a user to report that they have used a modification to a method rather than claim they have used the method as written.

1.2 The practice is used for routine determination of an index of occupational exposure to airborne fibers in workplaces. Workplaces are considered those places where workers are exposed to airborne fibers including asbestos. Additional information on sampling strategies, sample collection (including calibration) and use of sample results for asbestos abatement projects is provided in a standard Practice for Air Monitoring for Management of Asbestos-Containing Materials (WK 8951) currently being considered by ASTM subcommittee E06.24. A further practice has been approved for the specific purpose of sampling and counting airborne fibers in mines and quarries (Practice D7200), although the practice herein may also be used for this purpose. The current practice may be used as a means of monitoring occupational exposure to asbestos fibers when asbestos fibers are known *a priori* to be present in the airborne dust. The practice gives an index of airborne fiber concentration. This practice may be used in conjunction with electron microscopy (See Appendix X1) for assistance in identification of fibers. This practice may be used for other materials such as fibrous glass, or man-made mineral fibers by using alternate counting rules (see Annex A4).

1.3 This practice specifies the equipment and procedures for sampling the atmosphere in the breathing zone of an individual and for determining the number of fibers accumulated on a filter membrane during the course of an appropriately-selected sampling period. The practice may also be used to sample the atmosphere in a specific location or room of a building (area sampling), where this may be helpful in assessing exposure to workers handling fiber-containing products.

1.4 The ideal working range of this test practice extends from 100 fibers/mm^2 to 1300 fibers/mm^2 of filter area. For a 1000-L air sample, this corresponds to a concentration range from approximately 0.04 to 0.5 fiber/mL (or fiber/cm^3). Lower and higher ranges of fiber concentration can be measured by reducing or increasing the volume of air collected. However, when this practice is applied to sampling the presence of other, non-asbestos dust, the level of total suspended particulate may impose an upper limit to the volume of air that can be sampled if the filters produced are to be of appropriate fiber loading for fiber counting.

1.5 Users should determine their own limit of detection using the procedure in Practice D6620. For Reference the NIOSH 7400 method gives the limit of detection as 7 fibers/mm^2 of filter area. For a 1000 L air sample, this corresponds to a limit of detection of 0.0027 fiber/mL (or fiber/cm^3). For OSHA method ID 160 the limit of detection is given as 5.5 fibers/mm^2 of filter area. For a 1000 L air sample, this corresponds to a limit of detection of 0.0022 fiber/mL (or fiber/cm^3).

[1] 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 Oct. 1, 2011. Published October 2011. Originally approved in 2006. Last previous edition approved in 2006 as D7201 – 06. DOI: 10.1520/D7201-06R11.

[2] This test method is based on NIOSH 7400, OSHA Method ID 160, and ISO 8672. Users of this ASTM standard are cautioned that if they wish to comply with one of these specific procedures exactly they should follow that procedure, otherwise they should document the modification

[3] Boldface numbers in parentheses refer to the list of references appended to this method.

1.6 If this practice yields a fiber concentration that does not exceed the occupational limit value for the particular regulated fiber variety, no further action may be necessary. If the fiber concentration exceeds the occupational limit value for a specific fiber variety, and there is reason to suspect that the specific fiber variety is mixed with other fibers not covered under the same standard or regulation, the optional method specified in Appendix X1 may be used to measure the concentration or proportion of the fibers counted that are of the regulated variety.

1.7 The mounting medium used in this practice has a refractive index of approximately 1.45. Fibers with refractive indices in the range of 1.4 to 1.5 will exhibit reduced contrast, and may be difficult to detect.

1.8 Fibers less than approximately 0.2 µm in diameter will not be detected by this practice. (4)

1.9 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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. For specific precautionary statements, see Section 7.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D1357 Practice for Planning the Sampling of the Ambient Atmosphere

D3670 Guide for Determination of Precision and Bias of Methods of Committee D22

D5337 Practice for Flow Rate Adjustment of Personal Sampling Pumps

D6620 Practice for Asbestos Detection Limit Based on Counts

D7200 Practice for Sampling and Counting Airborne Fibers, Including Asbestos Fibers, in Mines and Quarries, by Phase Contrast Microscopy and Transmission Electron Microscopy

2.2 *Other Standards*

NIOSH 7400 National Institute for Occupational Health and Safety (NIOSH), (Revised 1994)[5]

Recommended Technical Method No.1 (RTM 1) Asbestos International Association (AIA)[6]

ID 160 Occupational Safety and Health Administration (OSHA)

ISO 8672 International Organization for Standardization (ISO)

3. Terminology

3.1 *Description of terms specific to this practice, in addition to those found in Terminology:*D1356

3.1.1 *asbestos*—a term applied to six specific silicate minerals belonging to the serpentine and amphibole groups, which have crystallized in the asbestiform habit, causing them to be easily separated into long, thin, flexible, strong fibers when crushed or processed (5). The Chemical Abstracts Service Registry Numbers of the most common asbestos varieties are: chrysotile (12001-29-5), riebeckite asbestos (crocidolite) (12001-28-4), grunerite asbestos (Amosite) (12172-73-5), anthophyllite asbestos (77536-67-5), tremolite asbestos (77536-68-6) and actinolite asbestos (77536-66-4).

The precise chemical composition of each species varies with the location from which it was mined. Other amphibole minerals that exhibit the characteristics of asbestos have also been observed (6).

The nominal compositions of the most common asbestos varieties are:

Chrysotile	$Mg_3Si_2O_5(OH)_4$	
Crocidolite	$Na_2\ Fe_3^{2+}Fe_2^{3+}\ Si_8O_{22}(OH)_2$	
Amosite	$(Mg,Fe)_7\ Si_8O_{22}\ (OH)_2$	
Anthophyllite	$(Mg,Fe)_7\ Si_8O_{22}\ (OH)_2$	
Tremolite	$Ca_2(Mg,Fe)_5\ Si_8O_{22}\ (OH)_2$	$(Mg/(Mg + Fe^{2+})$ 0.9 - 1.0)
Actinolite	$Ca_2(Mg,Fe)_5\ Si_8O_{22}\ (OH)_2$	$(Mg/(Mg + Fe^{2+})$ 0.5 - 0.9)

NOTE 1—Actinolite compositions in which $Mg/(Mg + Fe^{2+})$ is between 0 and 0.5 are referred to as ferroactinolite. See Reference (7) for the full naming conventions specified by the International Mineralogical Association.

3.1.2 *area sample*—an air sample collected so as to represent the concentration of airborne dust in a specific area or room, which, in the case of this practice, refers to an area or room of a workplace.

3.1.3 *asbestiform*—a specific type of fibrous mineral growth habit in which the fibers and fibrils exhibit a polyfilamentous growth habit and possess high tensile strength and flexibility. All materials regulated as asbestos are asbestiform, but not all asbestiform minerals are classified as asbestos. Characteristics such as tensile strength and flexibility cannot be ascertained from microscopic evaluation.

3.1.4 *asbestos fiber*—a fiber of asbestos, which meets the criteria specified below for a fiber. Phase Contrast Microscopy (PCM) does not identify fibers as asbestos. Under the light microscope, a population of asbestos fibers may appear as a mixture of fiber agglomerates, fiber bundles (polyfilamentous growth, unique to asbestiform fibers), fibers with split ends, and single fibers, the relative occurrence and frequency of each type depending on the situation.

3.1.5 *aspect ratio*—the ratio of the length of a fiber to its width.

3.1.6 *limit of detection*—the number of fibers necessary to be 95 % confident that the result is greater than zero.

3.1.7 *differential counting*—a term applied to the practice of excluding certain kinds of fibers from the fiber count because

[4] For 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.

[5] This standard is available from US Department of Health and Human Services, 4676 Columbia Parkway, Cincinnati, OH 45226.

[6] Available from Asbestos International Association, 68 Gloucester Place, London, W1H 3HL, England.

they do not appear to be morphologically consistent with fibers of a specific variety thus modifying the definition of fiber given below.

3.1.8 *fiber*—an elongated particle that is longer than 5.0 µm, with a minimum aspect ratio of 3:1, and sometimes also classified as having a maximum width of 3.0 µm as this latter dimension may equate to the size of fiber, of the density of many silicate minerals, capable of penetrating to the lung. An asbestos fiber should further exhibit the asbestiform habit, although analysis of airborne fibers by PCM may not be sufficient to determine asbestiform habit.

3.1.9 *fibril*—a single fiber of asbestos that cannot be further separated longitudinally into smaller components without losing its fibrous properties or appearances.

3.1.10 *fibrous*—a habit of minerals composed of parallel, radiating, or interlaced aggregates of fibers, from which the fibers are sometimes separable. A crystalline aggregate may be referred to as fibrous even if it is not composed of separable fibers, but has that distinct appearance. The term "fibrous" in mineralogy is used to describe aggregates of mineral grains that crystallize in a needle-like habit and appear to be composed of fibers. Asbestos minerals are fibrous, exhibiting a specific type of fibrous habit termed asbestiform. However, not all minerals having fibrous habit are asbestos.

3.1.11 *field (of view)*—the area within a graticule circle that is superimposed on the microscope image.

3.1.12 *habit*—the characteristic crystal growth form or combination of these forms of a mineral, including characteristic irregularities.

3.1.13 *personal sample*—a sample taken by a collection apparatus (membrane filter) positioned in the breathing zone of the subject (near the nose and mouth) such that the collected particles are representative of airborne dust that is likely to enter the respiratory system of the subject in the absence of respiratory protection.

3.1.14 *set*—a group of samples that are collected, submitted to the laboratory, and analyzed for a report that is generated.

3.1.15 *Walton Beckett Graticule*—an eyepiece graticule specifically designed for asbestos fiber counting. It consists of a circle with a nominal projected diameter of 100 µm (nominal area of 0.00785 mm^2) with a cross-hair having tick-marks at 3-µm intervals in one direction and 5-µm intervals in the orthogonal direction. There are also examples around the periphery of the circle to illustrate specific sizes and shapes of fibers. This design of the graticule is shown in Fig. A1.1. The graticule is placed in one of the microscope eyepieces so that the design is superimposed on the field of view.

3.1.16 *HSE/NPL*[7] test slide—a calibration slide designed to determine the limit of visibility of a PCM and an observer.

4. Summary of Practice

4.1 The sample is collected by drawing air through a 25-mm diameter, mixed cellulose ester (MCE) membrane filter, housed in a conductive polypropylene cassette. After sampling, a sector of the membrane filter is converted to an optically transparent homogeneous gel. Fibers longer than 5 µm are counted by observing them with a PCM at a magnification between 400 and 500.

5. Significance and Use

5.1 Users of this practice must determine for themselves whether the practices described meet the requirements of local or national authorities regulating asbestos or other fibrous hazards.

5.2 Variations of this practice have been described by the Asbestos Research Council in Great Britain (**8**), the Asbestos International Association (AIA) RTM 1 (**9**), NIOSH 7400, OSHA (Reference Method ID 160), and ISO 8672. Where the counting rules of the latter three methods differ, this is noted in the text.

5.3 *Advantages*

5.3.1 The technique is specific for fibers. PCM is a fiber counting technique that excludes non-fibrous particles from the analysis.

5.3.2 The technique is inexpensive, but requires specialized knowledge to carry out the analysis for total fiber counts, at least in so far as the analyst is often required under regulations to have taken a specific training course (for example, NIOSH 582, or equivalent).

5.3.3 The analysis is quick and can be performed on-site for rapid determination of the concentrations of airborne fibers.

5.4 *Limitations*

5.4.1 The main limitation of PCM is that fibers are not identified. All fibers within the specified dimensional range are counted. Differential fiber counting may sometimes be used to discriminate between asbestos fibers and fibers of obviously different morphology, such as cellulose and glass fiber. In most situations, differential fiber counting cannot be used to adequately differentiate asbestos from non-asbestos fibers for purposes of compliance with regulations without additional positive identification. If positive identification of asbestos is required, this must be performed by polarized light or electron microscopy techniques, using a different portion of the filter.

5.4.2 A further limitation is that the smallest fibers visible by PCM are about 0.2 µm in diameter, while the finest asbestos fibers may be as small as 0.02 µm in diameter.

5.4.3 Where calculation of fiber concentration provides a result exceeding the regulatory standard, non-compliance is assumed unless it can be proven that the fibers counted do not belong to a member or members of the group of fibers regulated by that standard.

6. Interferences

6.1 If the practice is used to monitor a specific type of fiber, any other airborne fibers present will interfere because all particles meeting the counting criteria are counted. Some common fibers that may create interference, are: gypsum, plant fibers, cellulose, perlite veins, diatoms, cellular plastic, mold mycelium, and cleavage fragments of minerals.

6.2 Particle aggregates consisting of chains of small particles, such as smoke or welding fume, may be perceived to be fibers and give rise to elevated results.

[7] Health and Safety Executive/National Physical Laboratory – United Kingdom