



MILLIPORE

Monitoring Airborne Asbestos with the Millipore Membrane Filter

Prolonged exposure to high levels of airborne asbestos dust has been linked to a number of occupational diseases, including asbestosis (pulmonary fibrosis), mesotheliomas and certain lung cancers.

Recognition of this hazard has prompted many countries to impose strict limits on exposure, based on the number of fibers per milliliter of air. The United States, for instance, enacted regulatory legislation under the broadly worded Occupational Safety and Health Act of 1970.

The standard for exposure to asbestos dust, adopted under this act, prescribes the use of the membrane filter method for the determination of asbestos fibers. The current standard states that the 8-hour time-weighted average (TWA) airborne concentration of asbestos dust to which employees are exposed shall not exceed 5 fibers longer than 5 micrometers (μm) per milliliter (Federal Register, Vol. 37, No. 467). However, the standard was amended (Federal Register, Vol. 37, No.

110) June 7, 1972, to read: "As of July 1, 1976, TWA concentrations of asbestos fibers longer than 5 micrometers will not be allowed to exceed two fibers/ml, with a ceiling value of 10 fibers/ml."

THE MEMBRANE FILTER METHOD

The standards differ from country to country, but the most generally accepted method of monitoring airborne asbestos is based on use of the membrane filter for sample collection. A vacuum pump is used to draw a measured volume of air through the filter. Because of the uniformity of its pore openings, a Millipore® membrane filter retains on its surface 100% of all fibers or particles larger than its rated pore size (e.g., $0.80 \pm 0.05 \mu\text{m}$). These fibers are retained in a single plane, so they may be examined readily under the microscope. The filter is then mounted and examined under a microscope to determine the size distribution and number of fibers in the sample.



Fig. 1. For personal sampling, the Millipore Aerosol Monitor is usually clipped to the worker's clothing. Vacuum is provided by a battery powered pump worn in a special belt. (Photo courtesy of Raybestos-Manhattan, Inc., Manheim Division, Manheim, Pa.)

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Application Procedure **AP501**

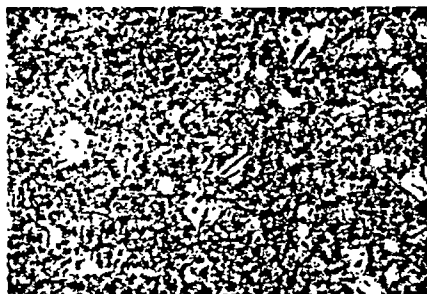


Fig. 2. Photomicrograph of asbestos dust trapped on a Millipore membrane filter showing particles and fibers (400x).

SAMPLING

For detailed instructions on sampling, the reader is urged to study the most recent accredited procedures (see references 1, 2 and 3). In general, the procedure calls for drawing air through the filter at a sampling rate of 2 liters/min. for a period of 15 minutes to 8 hours, depending on the expected fiber concentration. Personal sampling is recommended. This is usually accomplished by attaching the sampling device to the worker's shirt pocket with a clip. The sampler is then connected to a battery-operated vacuum pump worn in a special belt (Fig. 1). (Table I contains ordering information for those items produced by Millipore.)

Air can also be sampled from a fixed location in the room by connecting the Aerosol Monitor to a vacuum pressure pump plugged into an electrical outlet. When using a Millipore Vacuum-Pressure Pump, be sure to install the appropriate flow-limiting orifice in the Aerosol adapter. The flow-limiting orifice is not necessary with the battery powered pump.

The following steps will serve as a general guide in sampling:

1. Check the flow rate of the pump (see manufacturer's recommendation regarding frequency of calibration) and be sure the battery has been fully recharged.
2. Attach a 3' length of flexible rubber hose.
3. Remove the red (outlet) plastic plug from the Aerosol Monitor and insert the Aerosol Adapter (Fig. 3).



Fig. 3. The Aerosol Adapter is inserted into Aerosol Monitor.

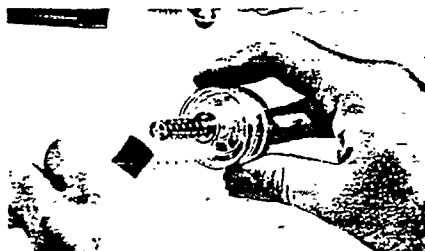


Fig. 4. The Aerosol Adapter allows a hose to be attached to the Monitor. Install a flow-limiting orifice in the adapter when sampling with the Vacuum-Pressure Pump.

4. Remove the top section of the Monitor as shown in Figure 5.
5. Attach the other end of the hose to the Adapter and clip the Monitor/hose assembly to the vest pocket area of the wearer. (The inlet should point downward or to the side and no clothing should obstruct it.)

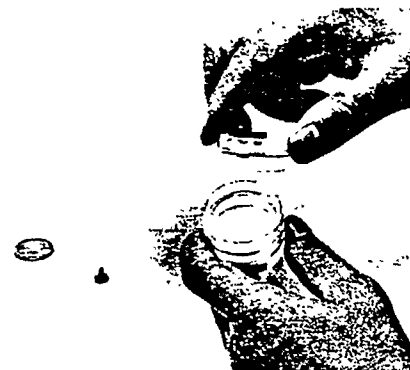


Fig. 5. The top of the Monitor is removed for "open" aerosol sampling.

6. After sampling, replace the top portion of the Monitor and remove it from the Adapter and hose. Label the Monitor appropriately.

MOUNTING THE SAMPLE

Normally, the Monitors are accumulated in a laboratory facility for analysis. To count fibers on a filter, it must first be mounted and rendered transparent. Two mounting media have been used. The following technique (described in Reference 1) is most commonly used in the U.S.:

1. Dissolve clean membrane filter material in a 1:1 solution of dimethylphthalate and diethyl oxalate (0.1 gm filter material per ml of solution).
2. To mount the sample, place a drop of this medium on a freshly cleaned 25mm x 75mm glass microscope slide (see Fig. 6).
3. Next, pry apart the Monitor and remove both the top and the retaining ring. Leave the filter in the Monitor.
4. Use a scalpel to cut from the filter a wedge-shaped piece with an arc length of about 1 cm.

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Fig. 6. Here, a glass slide is being washed with ultra-clean Freon from a Millipore Solvent Filtering Dispenser.



Fig. 7. Mounting medium can be ultra-cleaned as it is dispensed, using a Micro-Syringe Filter Holder containing a solvent resistant Fluoropore™ (PTFE) filter.

5. Remove this wedge-shaped piece from the Monitor using smooth-tipped MF Forceps, and replace the top of the Monitor. This will prevent damage or contamination of the remaining portion, should it become necessary to cut a second wedge.

6. Place this wedge, sample side up, on the mounting solution and cover it with a No. 1½ coverslip. Slight pressure on the coverslip will bring it into uniform

contact with the mounting medium. The filter will become "water-white" transparent in about 15 minutes.

Reference 2 describes a similar procedure developed in the U.K., using triacetin (glycerol triacetate).

In low-fiber-count work, perform this procedure in a clean environment such as a clean bench. In this case, the clearing medium should also be filtered as it is dispensed (Fig. 7).

COUNTING PROCEDURE

Fibers retained on the filter surface must be counted using a research-quality binocular microscope equipped with phase-contrast accessories. Use flat field objectives. Fiber counting requires a substage condenser with centerable annular diaphragms and at least 20 watts of tungsten illumination. Counting should be carried out at 400 to 450x magnification (typically, a 40x phase contrast objective and 10x Huygens eyepieces). One eyepiece must contain a Porton or Paterson Globe and Circle reticle or equivalent size reference. Use a hand activated counter.

Note: Good microscope techniques are critically important in resolving asbestos fibers. Consult the manufacturer of the microscope if you are not current on phase contrast microscopy.

The fibers to be counted have the characteristic shape shown in Figure 2. For purposes of counting, however, a fiber is defined as having an aspect ratio of at least 3:1 (i.e., it is at least three times longer than it is wide). All other particles are considered as background and should not be counted. Most standards require counting of all fibers 5 μm or longer as determined by comparison with the reticle size reference.

The following steps will serve as a general guide to counting:

1. Using 400x phase contrast illumination, adjust the microscope for optimum illumination and focus.

2. Scan several fields of view to assure that fiber distribution is random (you may also do this at lower magnification, say 100x).

3. Count the number of fibers 5 μm and longer in 20 randomly selected fields of view.

4. Record results and calculate the number of fibers/ml.

5. Label the mounted slides.

HANDLING DATA

To calculate the numbers of fibers/ml, use the following formulas:

$$F = \frac{N_f \times A_f}{EFA}$$

Where:

F = Fraction of the filter analyzed

N_f = Number of fields of view counted (typically 20)

A_f = Area of any field of view in mm² (as determined with a stage micrometer)

EFA = Effective Filtration Area in mm² (this value is 855 mm² for the Aerosol Monitor described).

Note: Once calculated, F will become a constant for a fixed number of fields (N_f).

The total number of fibers is:

$$N_t = \frac{N_c}{F \times V \times 1,000}$$

Where:

N_t = Total number of fibers/ml.

N_c = Number of fibers counted in N_f fields.

V = Volume of air in liters.

You will find it advisable to prepare a standard data sheet to simplify calculations and the recording of data.

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REFERENCES

1. Edwards, G.H. and Lynch, J.R., "The Method Used by the U.S. Public Health Service for Enumeration of Asbestos Dust on Membrane Filters," *Annals of Occupational Hygiene*, Vol. 11, pp. 1-6, Pergamon Press, Great Britain (1968). Reprints are available from the U.S. Dept. of Health, Education, and Welfare, Public Health Service, 1014 Broadway, Cincinnati, Ohio 45202.
2. "Technical Note 1: The Measurement of Airborne Asbestos Dust by the Membrane Filter Method," (Sept. 1971); available from the Asbestosis Research Council, P.O. Box 40, Rochdale, Lancashire, England.
3. "Criteria for a Recommended Standard - Occupational Exposure to Asbestos," U.S. Department of Health, Education, and Welfare, Public Health Service, National Institute for Occupational Safety and Health, Washington, D.C. (1972).
4. Bayer, S.G., Zumwalde, R.D., and Brown, T.A., "Equipment and Procedures for Mounting Millipore Filters and Counting Asbestos Fibers by Phase Contrast Microscopy," (July 1969). Available from U.S. Dept. of Health, Education, and Welfare, National Institute for Occupational Safety and Health, 1014 Broadway, Cincinnati, Ohio 45202.

Table I: Apparatus described in the procedure available from Millipore Corporation

Product	Description	Millipore Cat. No.	Price
Aerosol Monitor	Disposable filter holder containing 0.8 μ m filter	MAWP 037 AO (50/box)	\$ 33.00
Aerosol Adapter	Fits into Monitor and accepts rubber tubing	XX62 000 04	9.50
MF-Forceps	Smooth tipped forceps for handling filters	XX62 000 06	2.75
Solvent Filtering Dispenser	For cleaning glass microscope slides	XX66 025 00	42.00
MF-Millipore Filters	Filters for solvent filtering dispenser	HAWP 025 00 (100/pkg.)	12.50
Glass Microscope Slides	25 mm x 75 mm slides for mounting filters	XX10 076 15 (pkg. of 72)	5.00
Counter	2-gang hand activated counter	XX75 000 02	45.00
Micro-Syringe Filter Holder	Attaches to a syringe to dispense clean mounting medium	XX30 025 00	22.00
Fluoropore Filters	Solvent resistant 1.0 μ m pore size filters for Micro-Syringe	FALP 025 00 (100/pkg.)	40.00
Vacuum-Pressure Pump	For sampling of room air from a fixed location (not for personal sampling)	XX60 110 50, 115V/50 Hz or XX60 220 50, 230V/50 Hz	110.00 129.00
Gum Rubber Hose	4' length 12' length	XX71 000 04 XX71 000 12	4.00 9.00
Flow-Limiting Orifice	2 liters/min.	XX50 000 20	3.50
Flow-Limiting Orifices	Set of five: 1.0, 3.0, 4.9, 10.0, 14.0 liters/min.	XX50 000 00	13.50

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