

PERSONAL RESPIRABLE MASS SAMPLING PROCEDURE

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FOREWORD

The Committee on Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (ACGIH) has proposed a threshold limit value (TLV) for dust in terms of respirable mass concentration. A sampling procedure for use with such a TLV is described in detail herein. It is hoped that this information will be helpful in the initiation of a program by those who have not previously used the respirable mass sampling technique.

PERSONAL RESPIRABLE MASS SAMPLING PROCEDURE

SUMMARY AND RECOMMENDATIONS

A procedure developed after taking over 1200 samples at 90 operations in 50 foundries is described for collecting personal respirable mass samples. If this procedure is used, it should be followed in detail.

INTRODUCTION

The evaluation of inhalation hazards by means of size-selective sampling and weight concentration of "respirable" dust has been discussed by Hatch and Gross (1) and Morrow (2). Ayer et al. (3) stated in regard to the use of size-selective sampling in foundries: "1) Size-selective personal sampling would be easier, cheaper and results would be more reproducible for most industrial hygiene units. 2) In metal foundries, where the greatest number of dust exposures occur, silicosis hazard evaluations using as a limit the formula

$$\text{Resp. mg/m}^3 = \frac{10}{\% \text{ Resp. SiO}_2 + 2}$$

will generally be consistent with evaluations using the current ACGIH (American Conference of Governmental Industrial Hygienists) threshold limit. 3) The 10-mm cyclone is a suitable size-selector for personal sampling, but in taking samples for free silica analysis a horizontal elutriator designed according to MRC* criteria may be required until other instruments are demonstrated to be equivalent."

The Committee on TLV's of the ACGIH has tentatively approved a respirable mass limit for quartz containing dusts and has placed it on the list of intended changes for 1968. The description and assembly of the equipment required and a procedure recommended for collecting samples to be used with this limit are included in this report. These are consistent with the recommendations of the TLV committee. The procedure is intended to represent a standardized method so that results may be reproducible.

*British Medical Research Council

RESPIRABLE MASS SAMPLING

EQUIPMENT*

SAMPLER EQUIPMENT**

The following equipment, or equal, is required to collect a personal respirable mass sample:

<u>Item</u>	<u>Approximate Price</u>
1. 10-mm Nylon Cyclone-Assembly, Part No. 01B11480-01. Dorr-Oliver Inc., Stamford, Conn., consisting of: a. Grit Pot, Part No. 01A13862-01. b. 10-mm Cyclone, Part No. 01B11476-01. c. Vortex Finder, Part No. 01A13861-01.	\$9.00 ea.
2. Aerosol Field Monitor (2 pieces), Cat. M 000 037 PO. Millipore Filter Corp., Bedford, Mass.	\$7.50/ctn. of 48
3. Opaque White Cellulose Band 41 X 25 mm. Walter H. Jelly & Co., Franklin Park, Ill.	\$10.00/1000
4. 37-mm Membrane Filter. a. Vinyl Metrical Filter No. VM-4 (0.8 μ pore size). Gelman Inst. Co., Ann Arbor, Mich., or Polyvic Filter Cat. No. BSWP03700 (2.0 μ pore size). Millipore Filter Corp., Bedford, Mass. or b. Silver Membrane Filter (0.8 μ pore size). Selas Flotronics, Spring House, Penn.	\$20.00/100 \$51.00/100
5. 37-mm Absorbent Pad, Cat. No. AP 100 3700. Millipore Filter Corp., Bedford, Mass.	\$3.00/100

*Mention of commercial concerns or products does not constitute endorsement by the Public Health Service or the U. S. Department of Health, Education, and Welfare.

**The equipment listed below is pictured unassembled in Figure 1 and assembled in Figure 2. The numbers in the figures correspond to the listing numbers below.

RESPIRABLE MASS SAMPLING

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|--|--------------|
| 6. Elastic Band with Clothing Clip.
(Can be made up from 1/2"-elastic band and clip No. S-66. Plastic Services and Supply Co., Alexandria, Va.) | \$10.00/100 |
| 7. Aerosol Adaptor (1/4"-hose connector to male luer slip), Part No. LH/L. Becton-Dickinson Co., Rutherford, N. J. | \$0.35 ea. |
| 8. 32"-length of 1/4"-I.D. rubber tubing | \$0.25 ea. |
| 9. Nylon Band with Clothing Clip
(Can be made up from 1/2"-nylon band and clip No. 2-66. Plastic Services and Supply Co., Alexandria, Va.) | \$18.00/100 |
| 10. Battery Operated Diaphragm Pump (with belt clip). Personal Sampler Mark II (without sampling head), Willson Products Div., Reading, Pa.; Lapel Sampler Model 4000, Electro-Neutronics, Inc., Berkeley, Cal.; Monitaire Sampler, Mine Safety Appliances Co., Pittsburgh, Pa.; Model BC35 Lapel Sampler, Radiation Detection Equipment, Inc., Pleasant Hill, Cal.; or Unico Telematic Model C-110, Unico Environmental Instruments, Inc. Fall River, Massachusetts 02720
Note: Above pumps are from catalog listing. User should assure himself that sampler will operate 4-5 hours continuously at 1.7 lpm and 20 cm water resistance. | \$120.00 ea. |
| 11. Aluminum Disc (1/8" thick, 1 5/8" diameter with 9/16" hole). | \$0.25 ea. |
| 12. Spring Connectors. | \$0.50 ea. |

ADDITIONAL EQUIPMENT

<u>Item</u>	<u>Approximate Price</u>
1. Battery Charger for each diaphragm pump having rechargeable batteries.	\$35.00

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2. Balance (should have a sensitivity of 0.01 mg). \$1000.00 ea.
Semi-micro analytical balance or Cahn Electro-
balance. Cahn Instrument Co., 7500 Jefferson
St., Paramount, Cal. 90723
3. Supply of pre-weighed membrane filters See equipment
(assembled in banded field monitors and list.
identified).
4. Web belt (military style). Should be avail- \$1.00 ea.
able for each sampling unit so that one can
be supplied to the subject in the event he
is not wearing a belt.
5. Small brush for cleaning cyclone-assembly \$0.25 ea.
(e.g., electric razor brush).
6. Pair of tweezers for handling membrane filters. \$1.00 ea.
Note: A second pair of tweezers or a small
spatula is helpful in removing used
membrane filters from the field monitors
and placing them on the balance for
weighing.
7. Voltmeter for checking the state of charge \$15.00 ea.
of the batteries in the diaphragm pumps
prior to their being placed in operation
(prevents loss of samples due to poor
batteries).

EQUIPMENT PREPARATION IN SHOP

Field Monitors and Plastic Plugs

1. Clean all parts thoroughly prior to assembly.
 - a. Wash with a detergent, rinse repeatedly with tap water, and use distilled water for final rinse.
 - b. Dry all parts in dust-free atmosphere.
2. Assemble parts as follows:
 - a. Insert the blue plastic plug into the top (male) section and the red plastic plug into the bottom (female) ribbed-base section of the field monitor to avoid any subsequent contamination. (The use of different colored plugs permits quick identification of used and unused field monitors as the plugs will be reversed after the sample has been collected.)

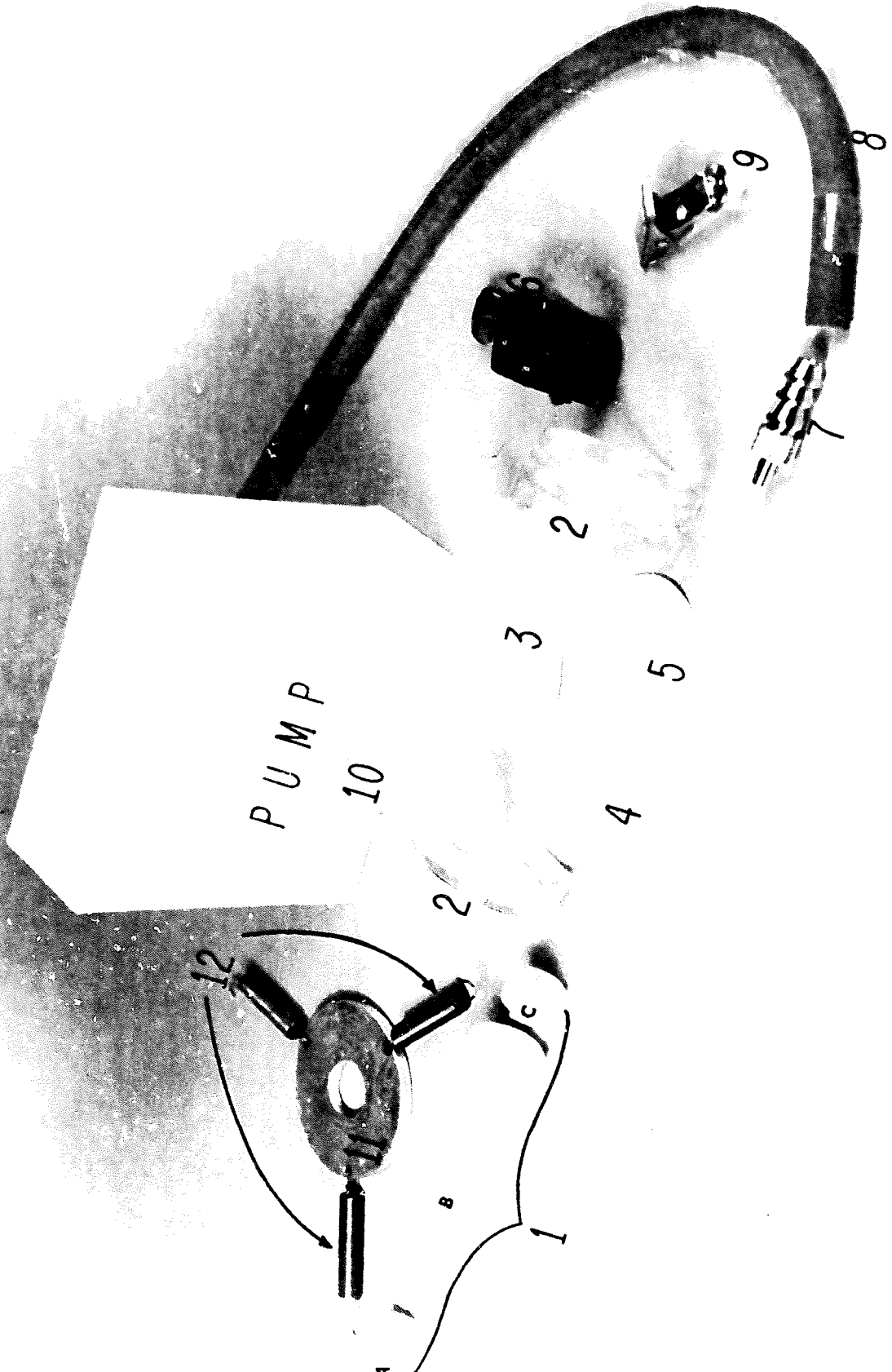


Figure 1. Sample Equipment Unassembled

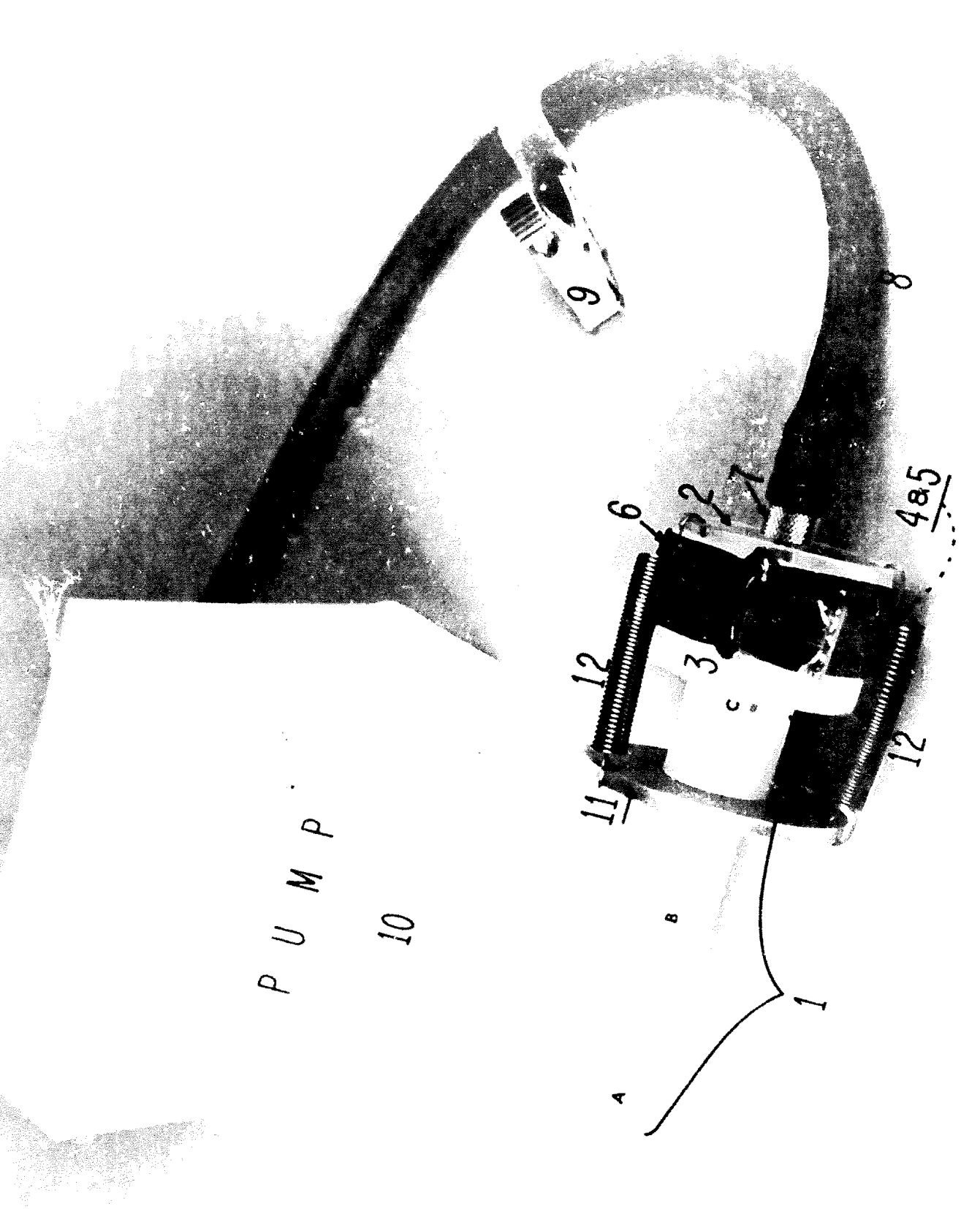


Figure 2.

Sample Equipment Assembled

RESPIRABLE MASS SAMPLING

- b. Assemble each field monitor without a support pad or membrane filter.
 - c. Check each assembled field monitor to see that the top (male) section is making uniform contact with the seating surface (entire circumference) of the bottom (female) section. DO NOT USE monitors that fail this test because the sample will probably be invalid due to leakage around the filter.
3. The weighing procedure is as follows:
- a. Disassemble a field monitor and place it on a table convenient to the balance so that the ribbed base of the bottom (female) section is exposed.
 - b. Place a support pad in the bottom (female) section with the tweezers.
 - c. Weigh a membrane filter and record the initial weight.
 - 1.) Weigh all units in a dust-free atmosphere.
 - 2.) Avoid all possible contamination of the filters.
 - 3.) Handle the membrane filters carefully as they are very fragile.
 - 4.) Always use tweezers, and touch only the edge of the filter.
 - d. Place the membrane filter on the support pad in the bottom (female) section of the field monitor.
 - 1.) Each membrane filter should be loaded into the field monitor and identified before the next one is weighed.
 - 2.) This minimizes the possibility of the membrane filters being contaminated from exposure or erroneously identified.
 - e. Place the top (male) section of the field monitor in position.
 - f. Label the field monitor on the top (male) section with the proper identification number and record it in the log book with the membrane filter's initial weight.
4. Repeat the weighing procedure (Step 3) until all membrane filters to be used have been weighed.
5. Reweigh all membrane filters (minimum - two weighings).
6. Record all weights measured - always verify the identification number and its corresponding weight reading.
7. Calculate an average initial filter weight for each membrane filter, and record.
8. Place the opaque white cellulose band in position on the field monitor and allow it to shrink into position to insure a tight seal at the joint.
9. After the band has dried, transfer the identification number from the top (male) section of the field monitor to the white band with a felt-tip marking pen (or other similar device). Position the number so that it is not covered by the elastic band with the clothing clip and can be easily read in the field.

RESPIRABLE MASS SAMPLING

Cyclone Assembly

1. Clean each unit prior to using.
2. Remove the grit pot and vortex finder.
3. Empty the contents of the grit pot.
4. Use the small brush to clean the inner wall of the cyclone and the mating surfaces of the cyclone and vortex finder.
5. Air-blow all parts to remove loose particles.

Battery-Operated Diaphragm Pump

1. Charge all batteries prior to taking units into the field.
2. In the field, place the batteries on charge if there has been an interval of 48 hours or more between the time they were charged in the laboratory and used in the field.
3. Pumps should be calibrated to provide 1.7 lpm flow.
 - a. Calibration should be done with a wet or dry test meter. Rotameters tend to give incorrect results on the pulsating-type flows encountered with these pumps.
 - b. Each pump should be checked prior to using it in the field.

EQUIPMENT ASSEMBLY IN FIELD

Numbers in parentheses refer to the part numbers in Figures 1 and 2.

Cyclone-Assembly and Field Monitor

1. Screw the grit pot (1-a) onto the threaded end of the cyclone (1-b).
2. Insert the vortex finder (1-c) into the open end of the cyclone (1-b).
3. Remove the blue plastic plug from the inlet port of a clean field monitor (2).
4. Insert the cyclone-assembly (1) (grit pot end) into the aluminum disc (11) with the spring connectors (12) attached.
5. Put inlet of the field monitor into the vortex finder, and then position the spring connectors on the flange of the field monitor to hold it together.
6. Place the elastic band with the clothing clip (6) around the field monitor and on top of the spring connectors.

Personal Sampler

1. Insert the aerosol adaptor (7) into the rubber tubing (8).
2. Position the nylon band with the clothing clip (9) about mid-way on the rubber tubing (8).

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3. Remove the red plastic plug from the outlet of the field monitor (2), and insert the aerosol adaptor (7) with the rubber tubing (8).
4. Slip the other end of the rubber tubing (8) over the inlet of the diaphragm pump (10).
5. Check all connections for proper fit and determine that each pump is functioning properly.

SAMPLING METHOD

SELECTION OF SUBJECT

1. It is important to make a good selection for the placement of the initial personal sampler.
 - a. If you are successful in getting the first worker approached to wear it, you will find most of the other workers will accept it.
 - b. Virtually all workers approached have consented to wear the personal sampler.
2. After a subject has been selected, briefly outline the sampling procedure (noting the type of sample being collected, description of equipment, and length of sampling period).
3. Inform the subject that the personal sampler will not interfere with his normal duties.
4. Emphasize the importance of continuing to work in a routine manner.

PLACEMENT OF EQUIPMENT

1. Attach the pump to the subject's belt, generally at his back.
 - a. Supply him with a belt if he does not have one.
 - b. Position the pump so that it does not interfere with the working operations of the subject.
2. If the subject is right-handed, place field monitor cyclone unit over left shoulder and attach clothing clip with elastic band to left shirt lapel. If the subject is left-handed, reverse the procedure.
3. Attach the clothing clip with the nylon band to the back of the subject's collar, arranging the tubing for best fit.

OPERATION OF EQUIPMENT

1. Turn on the pump, and note the time.
2. Adjust the flow rate to 1.7 lpm, if necessary.

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3. Observe the pump operation for a minute to check the flow rate.
4. Record the following information:
Note: #Type of sample, filter number, starting time, and location must be recorded immediately. The other information can be filled in later.
 - a. Plant name.
 - b. Date.
 - c. Sample number.
 - d. Type of sample#.
 - e. Pumping rate.
 - f. Pump number#.
 - g. Filter number#.
 - h. Time pump turned on (starting time)#.
 - i. Type of operation being performed by subject.
 - j. Location in plant of subject's work area#.
 - k. List of simultaneous samples being collected.
 - l. Name of person collecting sample.
 - m. Any remarks about the sample that will help in future review of the data.
5. Special precautions.
 - a. Consider times for break and lunch periods in scheduling placement and removal of samplers.
 - b. Check equipment operation every 30-60 minutes to determine whether units are operating satisfactorily.
 - c. Schedule each sample for a collection of at least three hours.

EQUIPMENT REMOVAL

1. Before shutting off the pump, check the unit to be sure it is operating properly.
2. Turn off the pump, and note the time.
3. Unfasten the clothing clips.
4. Remove the pump from the belt.
5. Collect the belt if one was issued to subject.
6. Check pump and filter numbers with the numbers previously recorded for each location and operation.
7. Record the following information:
 - a. Time pump turned off.
 - b. Total time covered by sample, in minutes.
 - c. Total volume of air pumped, in cubic meters.

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SAMPLE HANDLING - IN PLANT

1. Place the pump batteries on charge.
2. Disassemble unit.
 - a. Remove aerosol adaptor from field monitor.
 - b. Place the blue plastic plug into the bottom (female) section and the red plastic plug into the top (male) section. This enables you to determine which field monitors have been used since the colored plugs have been reversed from their original positions.
3. Put the used field monitor in separate containers from the clean ones so as to prevent re-using a filter and thus ruining both samples.

DETERMINATION OF CONCENTRATION

WEIGHING SAMPLE

1. Cut the cellulose band at the joint, leaving the band on.
2. Remove top (male) section.
3. Remove the membrane filter and weigh it on the same balance that was used to get the initial weight.
 - a. If the filter sticks to the support pad, remove the support pad and membrane filter from the field monitor by pushing the support pad through the sample port in the bottom (female) section. Then use the tweezers to pry the membrane filter away from the support pad.
 - b. Handle membrane filters only with tweezers at the unexposed edge. Care should be taken not to lose any of the sample or tear the membrane filter, which is very fragile. A second pair of tweezers or a spatula can be used to help place the membrane filters on the balance.
 - c. Care should be taken not to lose any of the sample during this procedure.
4. Check the membrane filter number on the cellulose band and record the filter weight in the log book.
5. Return the membrane filter to the field monitor and replace the top (male) section.
6. Repeat steps 1 to 5 above until all membrane filters have been weighed.

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7. Reweigh all membrane filters - a minimum of two weighings for each membrane filter.
8. Check all numbers.
9. Calculate the average final membrane filter weight and record in the log book.

CALCULATIONS

1. Subtract the average initial membrane filter weight from the average final membrane filter weight for each membrane filter and record the difference in milligrams.
2. Divide the membrane filter weight difference in milligrams by the sample volume in cubic meters.
3. The result is the respirable mass concentration in milligrams per cubic meter (mg/m^3).

REFERENCES

1. Hatch, T. F., and P. Gross: Pulmonary Deposition and Retention of Inhaled Aerosols. Academic Press, New York (1964).
2. Morrow, P. E.: Evaluation of Inhalation Hazards Based Upon the Respirable Dust Concept and the Philosophy and Application of Selective Sampling. Am. Ind. Hyg. Assn. J. 25: 213 (May-June 1964).
3. Ayer, H. E., G. W. Sutton, and I. H. Davis: Report on Size-Selective Gravimetric Sampling in Foundries. TR-39, Occupational Health Program, NCUH, Cincinnati, Ohio. April, 1967