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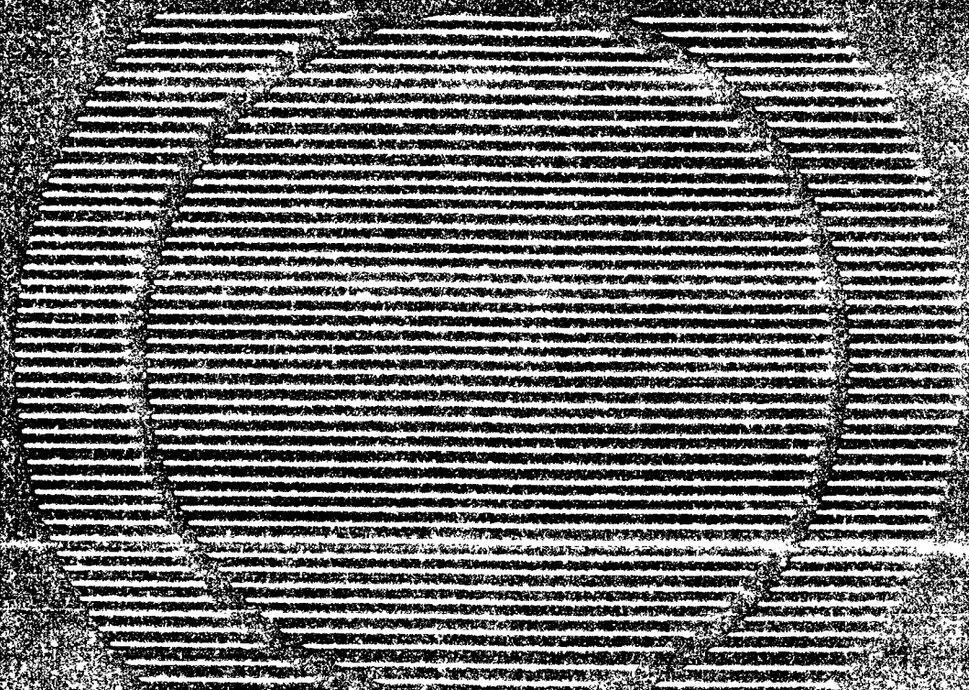
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RECOMMENDED WORK PRACTICES

Fabrication And Use Of Asbestos Friction Materials



ASBESTOS INFORMATION ASSOCIATION, 1660 L Street, N.W., Washington, D.C. 20036

Exhibit No. 38
Date 4/24/86 By AAO

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Introduction

The Occupational Safety and Health Act was signed into law on December 29, 1970 and became effective on April 28, 1971. The Act has the stated objective of assuring every American worker a safe and healthy workplace.

On December 7, 1971 the Secretary of Labor issued an emergency-temporary standard for exposure to asbestos dust. As required by the Act, a permanent standard for asbestos exposure was promulgated six months later, on June 7, 1972. The present OSHA Asbestos Standard, discussed in this booklet, became effective July 7, 1972. Thorough understanding of the standard is important to management of any company utilizing asbestos in its manufacturing or processing operations.

The work practices on the following pages have been prepared by the Standards and Technical Committee of the Asbestos Information Association/North America. They are intended as general guidance for safe and clean workplace conditions in keeping with the spirit and intent of the OSHA Standard for Occupational Exposure to Asbestos Dust.

These practices have been developed through careful study and consultation and are recommended as good procedure. It is recognized that manufacturing conditions vary. Implementation of the practices contained herein cannot be considered as a guarantee of OSHA compliance. Where there may be a question of compliance, OSHA personnel should be consulted.

A proposed revision to the OSHA Asbestos Standard was published in the *Federal Register* on October 9, 1975. This work practice booklet will be revised, as necessary, to reflect any approved changes to the standard.

Products and Operations

The types of asbestos friction material products covered by these work practice recommendations are:

Clutch facings	Disc Brake pads
Brake lining segments	Brake band materials
Brake blocks	Automotive transmission discs

Operations to which these work practices may apply are:

- Clutch assembly and rebuilding operations
- Brake assembly or relining operations
- Automatic transmission assembly and rebuilding operations

Summary of OSHA Asbestos Standard

General Comments

OSHA published a "Standard for Exposure to Asbestos Dust" in the *Federal Register*, Vol. 37, No. 110, dated June 7, 1972. The standard was recodified from 1910.93a to 1910.1001 in the *Federal Register*, Vol. 40, No. 103, dated May 28, 1975. The standard is reproduced as Appendix A. The standard applies to any manufacturing, fabricating or handling process or operation utilizing asbestos fiber or materials containing asbestos fiber.

The standard is divided into eight major sections:

1. **1910.1001 (b)—Permissible Exposure Limits**
Sets maximum allowable asbestos fiber concentration in the workplace air.
2. **1910.1001 (c)—Methods of Compliance**
Recommends procedures to meet permissible exposure limits.
3. **1910.1001 (d)—Personal Protective Equipment**
Specifies types of personal protective equipment and defines circumstances under which they are required.
4. **1910.1001 (e)—Method of Measurement 1910.1001 (f)—Monitoring**
Specifies monitoring procedures to determine if work places meet permissible exposure limits.
5. **1910.1001 (g)—Caution Signs and Labels**
States when caution signs and labels are required, and wording to be used.
6. **1910.1001 (h)—Housekeeping**
Specifies results to be obtained from housekeeping and methods of waste disposal.
7. **1910.1001 (i)—Recordkeeping**
Specifies type and duration of monitoring recordkeeping. States requirements for employee notification of monitoring results if exposure is in excess of permissible exposure limits and of corrective action being taken.
8. **1910.1001 (j)—Medical Examinations**
Details requirements for medical examinations and duration of medical recordkeeping.

Specific Comments

1. Exposure Limits (1910.1001 (b))

It is the employer's responsibility to assure that exposure of employees to airborne concentrations of asbestos fibers does not exceed the limits prescribed by the standard.

The OSHA standard maximum permissible exposure limits of asbestos fiber in the workplace air are:

a. **Eight-hour time-weighted average:**
   (1) **At present: 5 fibers, longer than 5 micrometers, per cubic centimeter.**
   (2) **Effective July 1, 1976: 2 fibers, longer than 5 micrometers, per cubic centimeter.**
b. **Ceiling concentration:**
   (1) **At present: 10 fibers, longer than 5 micrometers, per cubic centimeter.**
   (2) **Effective July 1, 1976: No change.**

2. Methods of Compliance (1910.1001 (c))

- *Engineering Methods*

Engineering controls such as isolation, enclosure, exhaust ventilation and dust collection shall be used to meet the prescribed permissible exposure limits.

All hand operated and power operated tools which may produce airborne asbestos fibers in excess of permissible exposure limits shall be provided with local exhaust systems.

• *Wet Methods*

When practicable, asbestos products shall be handled in a wet state sufficient to prevent the emission of dust to the atmosphere. This procedure is not required where the usefulness of the product might be diminished by wetting. The applicability of wet methods is limited. In most situations, engineering controls provide more efficient procedure.

3. Personal Protective Equipment and Clothing (1910.1001 (d))

• *Respiratory Protection*

Respiratory protection is required whenever the airborne concentrations of asbestos fiber exceed either the permissible time weighted average level or permissible ceiling concentration. The type of respirator to be used is determined by the fiber concentration in the workplace.

a. Fiber concentrations up to, but not exceeding, 10 times the allowable limit: Air purifying respirator — reusable or single use.
b. Fiber concentrations up to, but not exceeding, 100 times the allowable limit: Powered air purifying respirator.
c. Fiber concentrations exceeding 100 times the allowable limit: Type "C" supplied air respirator.

• *Protective Clothing*

Whenever airborne fiber concentrations exceed the prescribed ceiling level, the employer shall provide and require the use of special clothing, such as coveralls or similar whole body clothing, head coverings, gloves, and foot coverings. When the employer provides and requires the use of special clothing, he shall also provide for the laundering or disposal of the special clothing.

Whenever airborne fiber concentrations exceed either the permissible time-weighted average concentration or permissible ceiling concentration, the employer shall provide change rooms for his employees. Change rooms shall be equipped with two separate lockers or containers for each employee so separated or isolated as to prevent contamination of the employee's street clothes from his work clothes.

4. Measurement and Monitoring (1910.1001 (e) (f))

The standard requires that all workplaces where asbestos fiber may be released shall be monitored to determine exposure levels. After initial determination of airborne concentrations, monitoring shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure. Monitoring must be repeated at no less than six-month intervals where exposure to asbestos dust may reasonably be foreseen to exceed permissible exposure limits.

All monitoring shall be done by the membrane filter method. Appendix B provides a description of this procedure.

Affected employees or their representatives shall be given a reasonable opportunity to observe any required monitoring and shall have access to the monitoring records.

Any employee found to have been exposed at any time to airborne concentrations of asbestos fibers in excess of the prescribed limits shall be notified in writing of the exposure as soon as practicable but not later than five days of the finding.

5. Caution Signs and Labels (1910.1001 (g))

Caution signs shall be displayed at each workplace where asbestos fiber concentrations exceed permissible exposure limits. Caution labels shall be applied to all materials and products which during any reasonably foreseeable use might release concentrations of asbestos fibers in excess of permissible exposure limits.

Signs and labels are described in detail in Appendix A.

6. Housekeeping (1910.1001 (h))

All external surfaces, machinery and equipment shall be maintained free of asbestos fiber accumulations that might, if dispersed, create asbestos fiber concentrations above permissible exposure limits.

For recommendations on housekeeping procedures, see "Housekeeping" section under General Recommendations.

7. Recordkeeping (1910.1001 (i))

Every employer shall maintain records of personal and environmental monitoring required by the standard. Records shall be maintained for a period of at least three years.

8. Medical Examinations (1910.1001 (j))

Preplacement, annual, and termination medical examinations must be provided or made available by the employer for any employee ". . . engaged in occupations exposed to airborne concentrations of asbestos fibers." These medical records must be kept for 20 years and are available to the employee's physician.

General Recommendations

Exhaust and Dust Collection Systems

The OSHA Asbestos Standard requires that exhaust and dust collection systems be designed and maintained in accordance with American National Standard, "Fundamentals Governing the Design and Operation of Local Exhaust Systems," ANSI Z9.2-1971. This publication is available from:

American National Standards Institute
1430 Broadway
New York, N.Y. 10018

The National Emissions Standards for Hazardous Air Pollutants (NESHAPS), as published by the Environmental Protection Agency in the *Federal Register,* Vol. 38, No. 66, dated April 6, 1973, and amended October 14, 1975, state that **there must be no visible emissions to the outside air from asbestos mills or from buildings in which commercial asbestos is used in the manufacture of:**

textile materials
cement products
fireproofing and insulating materials
friction products
paper, millboard and felt
floor tile
plastics and rubber materials
chlorine
shotgun shells
asphalt concrete
paints, coatings, caulks, adhesive and sealants

Visible emissions are defined as emissions which contain asbestos and which are visually detectable without the aid of instruments. Rather than meet the no-visible-emission requirement, air cleaning procedures using a fabric filter collector may be employed. When the use of fabric filters creates a fire or explosion hazard, use of a high energy wet collector may be authorized by EPA.

For small and intermittent production and fabrication operations, major dust collection systems of the high volume, low velocity type design described in the references above may not be necessary. Instead, systems of the low volume, high velocity type utilizing as their exhaust air source a high efficiency vacuum cleaner could be suitable. For design information on these systems, attention is invited to the AIA/NA booklet, "Recommended Work Practices on Shop and Field Fabrication of Asbestos Sheet Products." This booklet is available on request to AIA/NA.

All exhaust and dust collection systems should be inspected periodically for proper

functioning. For continuous operations, it is recommended that the system operation and the interior of the baghouse be checked daily. A scheduled maintenance program that includes bag replacement should be prepared and followed.

Wherever possible, operations involving asbestos-containing materials should be isolated from other work areas by partitions, curtains or other means. If central exhaust systems are utilized, the work areas should be maintained under a slight negative pressure.

Housekeeping

Housekeeping is an essential part of any manufacturing operation. It is even more essential in an asbestos-using plant because airborne dust created by lack of good housekeeping has the potential for harm to employees.

The OSHA Asbestos Standard stipulates that "all external surfaces in any place of employment shall be maintained free of accumulations of asbestos fiber [...] with their dispersion there would be excessive concentration."

Surface cleaning should be accomplished by a vacuum process. Portable vacuum cleaning units should be equipped with internal filtration and disposable dust bags. Single or multi-hose stationary vacuum cleaning systems designed for use with asbestos [illegible]

[illegible] should never be dry swept, [illegible] shall be removed in those circumstances where blooms are used.

Information and Training

Employees assigned to a work area where exposure to airborne concentrations of asbestos fibers may exceed the maximum permissible limits should be fully informed of the possible hazards to health associated with asbestos dust. It is important that both new employees and employees with tenure have information concerning the safe use of asbestos brought to their attention at periodic intervals. Each employee should be informed of:

a. Operations which could result in exposure to excessive asbestos fibers;
b. Engineering controls and workplace practices for employee protection;
c. Purpose and proper use of respiratory equipment;
d. Medical examination requirements, and
e. Provisions of the OSHA asbestos standard.

A copy of the OSHA Asbestos Standard should be available to employees. The AIA/NA pamphlet, "What Every Employee Should Know About Asbestos and Health," is recommended for distribution to employees. The pamphlet is available at minimal cost from the Association. Posters may be effectively used to [illegible] A series of asbestos health hint posters designed for this purpose are also available from AIA/NA.

A record of employee training should be kept. The record may appropriately include for each employee, name, social security number and job title, along with the date and description of training including materials distributed.

Waste Disposal

Generation of asbestos waste resulting from manufacturing, fabrication, removal, renovation and servicing operations are responsible for ensuring that the waste is disposed of at a proper, operated disposal site as described in the NESHAPS amendment dated October 14, 1975. The OSHA Asbestos Standard requires that asbestos waste, which when handled or transported could generate airborne fibers in excess of the permissible exposure limits, be disposed of in sealed bags or closed containers impermeable to asbestos fibers.

No visible emissions to the outside air may result from collection, processing, packaging, transporting or deposition of any asbestos-containing waste material. Alternatively, wastes may be mixed with water and sealed in a labeled, leak-tight container and deposited at a disposal site or they may be formed into non-friable forms and deposited at a disposal site.

Specific Recommendations

Normally, friction materials should be obtained from the manufacturer in finished form; cut, machined and/or drilled to fit particular requirements. This procedure avoids additional fabricating operations.

Fabricating equipment such as grinders, lathes, drill presses working on large capacity operations should be equipped with high volume, low velocity exhaust and dust collection systems. See General Recommendations on page 8

Intermittent, short duration machining operations might be equipped with high velocity, low volume exhaust and dust collection systems.

All dust control systems which discharge exhaust air to atmosphere must be equipped with fabric filter collection devices (U.S. Environmental Protection Agency "National Emission Standards for Hazardous Air Pollutants—Asbestos", *Federal Register*, Vol. 38, No. 66, dated April 6, 1973).

If dust control by means of exhaust ventilation is not feasible or practicable, wet machining utilizing fluid cutting lubricants might be a suitable alternate.

Dust and chips generated by the machining operations should be removed regularly, preferably by vacuum methods and disposed in accordance with "housekeeping" paragraph in the General Recommendations.

After fabricating and before shipping, all excess dust and chips should be removed from the surfaces of friction material to prevent dust contamination of the fabricator's workplace and his customer's workplace

Personal Hygiene

In the preparation of asbestos-containing products, unless good procedures are followed, dust conditions can result. Employees must be aware that inhalation of asbestos dust may be a serious risk to health. Every effort should be made to eliminate dust conditions and avoid exposure to dust.

Good personal hygiene practices are important in every working situation. When working with asbestos, workers are urged to observe the following personal hygiene practices for their own health protection, their families, and those with whom they work:

- Do not smoke
- Wash before eating
- Shower after work
- **Respirators and special clothing are provided for worker protection under certain excessive dust level conditions. These items of personal protective equipment deserve the highest respect of the worker and should be worn properly, when required.**
- **Change to work clothes upon arrival at work and change from work clothes at conclusion of work. Use change rooms for this purpose.**
- **If work clothing is taken home, carry in a bag impermeable to asbestos fibers and wash separately from other clothing. Never shake dusty clothing. Use a washing machine.**

Appendix A

RULES AND REGULATIONS

Title 29—LABOR

Chapter XVII—Occupational Safety and Health Administration, Department of Labor

PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Standard for Exposure to Asbestos Dust

On December 7, 1971, an emergency temporary standard concerning exposure to asbestos fibers was published in the FEDERAL REGISTER (36 F.R. 23207). In accordance with section 6(c)(3) of the Williams-Steiger Occuptaional Safety and Health Act of 1970, a notice of proposed rulemaking regarding a permanent standard for exposure to asbestos fibers was published in the FEDERAL REGISTER on January 12, 1972 (37 F.R. 466). The notice invited interested persons to submit both orally and in writing, data, views, and arguments concerning the proposal.

On or about January 24, 1972, the Advisory Committee on Asbestos Dust was established and requested to make written recommendations with regard to the proposed standard on asbestos. On or about February 1, 1972, the Department of Health, Education, and Welfare transmitted to the Secretary of Labor a criteria document containing Recommendations for an Occupational Exposure Standard for Asbestos by the National Institute for Occupational Safety and Health (NIOSH). Public notice was given of the receipt of the recommendations and their availability for inspection and copying. On or about February 25, 1972, the Advisory Committee on Asbestos Dust submitted its written recommendations to the Assistant Secretary of Labor for Occupational Safety and Health.

Note: Federal Register, Vol. 40, No. 103, May 28, 1975, p. 23072, announced that the OSHA standard for Exposure to Asbestos Dust was recodified from 1910.93a to 1910.1001.

Pursuant to the notice of rule making, a hearing was held on March 14 through 17, 1972, for the purpose of receiving oral data, views, and arguments concerning the proposed standard. On or about March 31, 1972, the presiding hearing examiner certified to the Assistant Secretary of Labor for Occupational Safety and Health the record of the proceeding. The record includes prehearing written comments, a transcript of the oral presentations made at the hearing, and numerous exhibits received during the course of the hearing or within the period allowed after the close of the hearing.

The proposed standard dealt with (1) permissible concentrations of asbestos fibers; (2) methods of compliance; (3) warning signs; (4) monitoring; (5) medical examinations; and (6) recordkeeping. Each of these major proposals elicited comments, arguments, objections, and counterproposals. They all have been examined and considered.

1. *Acceptable concentrations of asbestos dust.* The proposed standard would limit occupational exposure to 8-hour time-weighted average (TWA) airborne concentrations of asbestos dust not exceeding five fibers longer than five micrometers per milliliter. Concentrations above five fibers but not to exceed 10 fibers (ceiling concentration) would be permitted up to 15 minutes in an hour, but for not more than 5 hours in any one 8-hour day.

NIOSH in effect has recommended that the five-fiber TWA and 10-fiber peak concentrations be permitted only for 2 years; thereafter, TWA concentrations should be not more than 2 fibers per cubic centimeter ($cm.^3$) of air, and peak concentrations should not exceed 10 fibers/$cm.^3$, with no time restriction. Numerous objections and counterproposals have been made, with regard to both the limits of asbestos fiber concentrations and the time periods to comply with them. Some, for example, have recommended return to a 12-fiber standard of an earlier day; i.e., a level adopted under the Walsh-Healey Public Contracts Act in 1969. Others have recommended a two-fiber standard to become effective in 6 months, then a one-fiber standard for 2 years, and finally a zero-fiber standard after 3 years. These recommendations give a fair indication of the wide spread of the counterproposals.

No one has disputed that exposure to asbestos of high enough intensity and long enough duration is causally related to asbestosis and cancers. The dispute is as to the determination of a specific level below which exposure is safe. Various studies attempting to establish quantitative relations between specific levels of exposure to asbestos fibers and the appearance of adverse biological manifestations, such as asbestosis, lung cancers, and mesothelioma, have given rise to controversy as to the validity of the measuring techniques used and the reliability of the relations attempted to be established. Because of the long lapse of time between onset of exposure and biological manifestations, we have now evidence of the consequences of exposure, but we do not have, in general, accurate measures of the levels of exposure occurring 20 or 30 years ago, which have given rise to these consequences. There are also controversies concerning the relative toxicity of the various kinds of asbestos, and varying hazards in different workplaces.

It is fair to say that the controversy has centered in the area between a two-fiber TWA concentration and five-fiber TWA concentration, with variations on the time needed for compliance. Many employers support a five-fiber TWA. Most medical opinion is divided between a two-fiber standard and a five-fiber standard.

In view of the undisputed grave consequences from exposure to asbestos fibers, it is essential that the exposure be regulated now, on the basis of the best evidence available now, even though it may not be as good as scientifically desirable. An asbestos standard can be reevaluated in the light of the results of ongoing studies, and future studies, but cannot wait for them. Lives of employees are at stake.

It is concluded that there should be one minimum standard of exposure to asbestos applicable to all workplaces exposed to any kind, or mixture of kinds, of asbestos. Reasons of practical administration preclude a variety of standards for different kinds of asbestos and of workplaces. Also, while the evidence tends to show that crocidolite, for instance, is more harmful than chrysotile, the evidence is not sufficient to establish separate standards for varieties of asbestos.

Because there must be one standard governing exposure to all varieties of asbestos, and in workplaces apparently more hazardous than others; because some present employees with regular exposure to asbestos have probably already accumulated great doses of asbestos fibers, due to higher levels of exposure in the past; because it appears that levels of exposure which may be safe with regard to asbestosis are not safe with regard to mesothelioma; because the statute requires the protection of every employee, even of one who may have regular exposure to asbestos during a working life which may reach, or even exceed, 40 years; and because of several other considerations which have been urged and are reflected in the record of the proceeding, the conflict in the medical evidence is resolved in favor of the health of employees. As of July 1, 1976, TWA concentrations of asbestos fibers longer than 5 micrometers will not be allowed to exceed two fibers/cc., with a ceiling value of 10 fibers/cc. The current TWA concentrations of five fibers, and ceiling concentrations of 10 fibers/cc, will be permitted until July 1, 1976, during what will be a transitional period deemed necessary to allow employers to make the needed changes for coming into compliance with the more stringent standard.

The record shows that the many work operations subject to the single asbestos standard (textile, manufacturing, industrial, and marine installation, etc.) will meet yarying degrees of difficulty in complying with the standard. In some plants, extensive redesign and relocation of equipment may be needed. It appears, however, the delay in the effective date of the two-fiber standard will provide all employers a reasonable time to comply. At the same time, so long as the ceiling limit is complied with, no harm is reasonably expected to result from exposures during the transitional period.

2. *Methods of compliance.* It has been pointed out by many persons, that protection against asbestos fibers is best obtained by controlling the generation of fibers first, and secondly, by controlling the dispersion of released fibers into the ambient air of the workplaces. Therefore, the standard requires feasible technological controls and appropriate work practices as the primary means of compliance. Rotation of employees as a way of meeting the TWA concentration requirement is allowed only in stated exceptional circumstances, because, as a general rule, it would be difficult to implement. Personal protective equipment, such as respirators, cannot be relied upon because, among other reasons, they may be so uncomfortable as to be burdensome, except for short periods of time. Therefore, it is expected that respirators and shift rotation will be used during the period necessary to install engineering controls and to train employees in sound work practices, but, after technological compliance has been achieved, their use must be limited to special work situations and emergencies. Where both are practicable, shift rotation is required.

3. *Labeling.* The proposed standard stopped short of requiring labeling asbestos and asbestos-containing products. The proposed standard would have required only warning signs at locations where asbestos hazards are present. However, labeling, rather than warning signs, has proved to be a point of controversy. Both NIOSH and the Advisory Committee on Asbestos Dust recommended labels for asbestos products and containers, and these recommendations became very controversial in the course of the proceeding. Many counterproproposals have been made as to the language of the warning as well as to the products to be subject to the labeling requirements. Employers, in general, strongly contend that (1) finished products which effectively entrap asbestos fibers, so that these would not be released in the normal use of the products, should not be required to be labeled; and (2) words such as "danger" and "cancer" are unwarrantedly alarming.

Both contentions have merit, and the standard has been changed accordingly.

4. *Monitoring.* The proposed standard would have required personal monitoring and environmental monitoring. Many issues have been raised concerning the availability and reliability of measuring instruments, frequency of monitoring, and conditions in which monitoring should be required. The adopted standard takes the objections into consideration. It requires periodic monitoring at intervals no longer than 6 months, thus allowing considerable time and discretion, and prescribes the use of the membrane filter method, which is an acceptable method for determination of asbestos fibers.

It has also been recommended that employees or their representatives should have an opportunity to observe the monitoring. The recommendation has been accepted.

5. *Medical examinations.* The proposed standard would only require an appropriate medical examination on a periodic basis. The generality of the proposal has attracted many objections and also many helpful comments. The recommendations of NIOSH and of the Advisory Committee on Asbestos Dust were much more specific with respect to both frequency and type of medical examinations to be required. The comments vary as to the class of employees to be examined and as to the frequency of the examinations.

The adopted standard requires medical examinations both at the beginning and the termination of employments exposed to concentrations of asbestos fibers, and also requires annual medical examinations of every employee exposed to airborne concentrations of asbestos. It has been pointed out that in certain industries, such as construction, an employee may work for several employers during the same year. Accordingly, the standard does not require either preemployment, or termination, or periodic examinaton of any employee who has been examined in accordance with the standard within the past year.

One question which has been raised goes to whether the employer or the employee should be allowed to choose the examining physician. The standard gives the option to the employer. Since some employers already have a medical examination program in operation, and, also, have medical departments with some expertise in the diagnosis of abestos-related diseases, it seems more reasonable to permit them to utilize the present programs and expertise, than to permit an employee to choose a private general practitioner.

6. *Records.* The standard, as proposed and as adopted, requires maintenance of records of monitoring and of medical examinations. Most of the controversy in this area has revolved around the question whether an employer should be allowed to have access to the results of the required medical examinations. The apprehension of those who have argued against employer access is based on the expectation that some employers will use the medical examinations as a means of screening employment applicants, and worse, as grounds for discharging current employees, who show signs of being affected by exposure to asbestos. Since the purpose of the medical examinations is to monitor the health of employees exposed to the hazards of abestos, employees cannot in reason be granted the privilege of refusing to disclose to their employers results of occupational exposure. It does not make sense to require employers to provide medical examinations if they cannot know and use the results of the examinations. For these

reasons the standard provides that employers may have a restricted access to some medical information.

On the other hand, there is no intention to allow employers to abuse medical information obtained pursuant to the Act, to the detriment of employees. Therefore, the administration of the medical records requirement will be closely watched, and, in cases of abuse, appropriate action will be considered.

The issues discussed above are believed to be the major ones. Numerous other issues have been raised in the rulemaking proceedings. Some have been referred to incidentally. Many recommendations, for instance, about work practices, are so obviously meritorious that their adoption needs no exposition here. Other recommendations and many objections have not been adopted for a variety of reasons which should be manifest. Several, for instance, have recommended the use of respirators only pursuant to a variance, or in cases of emergency and occasional short-term exposures. The recommendation with respect to variances undoubtedly has many merits, but is considered administratively impractical.

Accordingly, after consideration of the whole record of the proceeding, and pursuant to sections 6 (b) and (c) and 8(c) of the Williams-Steiger Occupational Safety and Health Act of 1970 (84 Stat. 1593, 1596, 1599; 29 U.S.C. 655, 657), 29 CFR 1910.4, and to Secretary of Labor's Order No. 12–71 (36 F.R. 8754), Part 1910 of Title 29 of the Code of Federal Regulations is amended as set forth below.

§1910.1001 Asbestos

(a) *Definitions.* For the purpose of this section, (1) "Asbestos" includes chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.

(2) "Asbestos fibers" means asbestos fibers longer than 5 micrometers.

(b) *Permissible exposure to airborne concentrations of asbestos fibers*—(1) *Standard effective July 7, 1972.* The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed five fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(2) *Standard effective July 1, 1976.* The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed two fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(3) *Ceiling concentration.* No employee shall be exposed at any time to airborne cencentrations of asbestos fibers in excess of 10 fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(c) *Methods of compliance*—(1) *Engineering methods.* (i) *Engineering controls.* Engineering controls, such as, but not limited to, isolation, enclosure, exhaust ventilation, and dust collection, shall be used to meet the exposure limits prescribed in paragraph (b) of this section.

(ii) *Local exhaust ventilation.* (a) Local exhaust ventilation and dust collection systems shall be designed, constructed, installed, and maintained in accordance with the American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2–1971, which is incorporated by reference herein.

(b) See § 1910.6 concerning the availability of ANSI Z9.2–1971, and the maintenance of a historic file in connection therewith. The address of the American National Standards Institute is given in § 1910.100.

(iii) *Particular tools.* All hand-operated and power-operated tools which may produce or release asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section, such as, but not limited to, saws, scorers, abrasive wheels, and drills, shall be provided with local exhaust ventilation systems in accordance with subdivision (ii) of this subparagraph.

(2) *Work practices*—(i) *Wet methods.* Insofar as practicable, asbestos shall be handled, mixed, applied, removed, cut, scored, or otherwise worked in a wet state sufficient to prevent the emission of airborne fibers in excess of the exposure limits prescribed in paragraph (b) of this section, unless the usefulness of the product would be diminished thereby.

(ii) *Particular products and operations.* No asbestos cement, mortar, coating, grout, plaster, or similar material containing asbestos shall be removed from bags, cartons, or other containers in which they are shipped, without being either wetted, or enclosed, or ventilated so as to prevent effectively the release of airborne asbestos fibers in excess of the limits prescribed in paragraph (b) of this section.

(iii) *Spraying, demolition, or removal.* Employees engaged in the spraying of asbestos, the removal, or demolition of pipes, structures, or equipment covered or insulated with asbestos, and in the removal or demolition of asbestos insulation or coverings shall be provided with respiratory equipment in accordance with paragraph (d) (2) (iii) of this section and with special clothing in accordance with paragraph (d) (3) of this section.

(d) *Personal protective equipment*—(1) Compliance with the exposure limits prescribed by paragraph (b) of this section may not be achieved by the use of respirators or shift rotation of employees, except:

(i) During the time period necessary to install the engineering controls and to institute the work practices required by paragraph (c) of this section;

(ii) In work situations in which the methods prescribed in paragraph (c) of this section are either technically not feasible or feasible to an extent insufficient to reduce the airborne concentrations of asbestos fibers below the limits prescribed by paragraph (b) of this section; or

(iii) In emergencies.

(iv) Where both respirators and personnel rotation are allowed by subdivisions (i), (ii), or (iii) of this subparagraph, and both are practicable, personnel rotation shall be preferred and used.

(2) Where a respirator is permitted by subparagraph (1) of this paragraph, it shall be selected from among those approved by the Bureau of Mines, Department of the Interior, or the National Institute for Occupational Safety and Health, Department of Health, Education, and Welfare, under the provisions of 30 CFR Part 11 (37 F.R. 6244, Mar. 25, 1972), and shall be used in accordance with subdivisions (i), (ii), (iii); and (iv) of this subparagraph.

(i) *Air purifying respirators.* A reusable or single use air purifying respirator, or a respirator described in subdivision (ii) or (iii) of this subparagraph, shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average airborne concentrations of asbestos fibers are reasonably expected to exceed no more than 10 times those limits.

(ii) *Powered air purifying respirators.* A full facepiece powered air purifying respirator, or a powered air purifying respirator, or a respirator described in subdivision (iii) of this subparagraph, shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average concentrations of asbestos fibers are reasonably expected to exceed 10 times, but not 100 times, those limits.

(iii) *Type "C" supplied-air respirators, continuous flow or pressure-demand class.* A type "C" continuous flow or pressure-demand, supplied-air respirator shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average airborne concentrations of asbestos fibers are reasonably expected to exceed 100 times those limits.

(iv) *Establishment of a respirator program.* (a) The employer shall establish a respirator program in accordance with the requirements of the American National Standards Practices for Respiratory Protection, ANSI Z88.2–1969, which is incorporated by reference herein.

b. See § 1910.6 concerning the availability of ANSI Z88.2–1969 and the maintenance of an historic file in connection therewith. The address of the American National Standards Institute is given in § 1910.100.

(c) No employee shall be assigned to tasks requiring the use of respirators if, based upon his most recent examination, an examining physician determines that the employee will be unable to function normally wearing a respirator, or that the safety or health of the employee or other employees will be impaired by his use of a respirator. Such employee shall be rotated to another job or given the opportunity to transfer to a different position whose duties he is able to perform with the same employer, in the same geographical area and with the same seniority, status, and rate of pay he had just prior to such transfer, if such a different position is available.

(3) Special clothing: The employer shall provide, and require the use of, special clothing, such as coveralls or similar whole body clothing, head coverings, gloves, and foot coverings for any employee exposed to airborne concentrations of asbestos fibers, which exceed the

ceiling level prescribed in paragraph (b) of this section.

(4) Change rooms: (i) At any fixed place of employment exposed to airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section, the employer shall provide change rooms for employees working regularly at the place.

(ii) Clothes lockers: The employer shall provide two separate lockers or containers for each employee, so separated or isolated as to prevent contamination of the employee's street clothes from his work clothes.

(iii) Laundering: (*a*) Laundering of asbestos contaminated clothing shall be done so as to prevent the release of airborne asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section.

(*b*) Any employer who gives asbestos-contaminated clothing to another person for laundering shall inform such person of the requirement in (*a*) of this subdivision to effectively prevent the release of airborne asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section.

(c) Contaminated clothing shall be transported in sealed impermeable bags, or other closed, impermeable containers, and labeled in accordance with paragraph (g) of this section.

(e) *Method of measurement.* All determinations of airborne concentrations of asbestos fibers shall be made by the membrane filter method at 400–450 × (magnification) (4 millimeter objective) with phase contrast illumination.

(f) *Monitoring*—(1) *Initial determinations.* Within 6 months of the publication of this section, every employer shall cause every place of employment where asbestos fibers are released to be monitored in such a way as to determine whether every employee's exposure to asbestos fibers is below the limits prescribed in paragraph (b) of this section. If the limits are exceeded, the employer shall immediately undertake a compliance program in accordance with paragraph (c) of this section.

(2) *Personal monitoring*—(i) Samples shall be collected from within the breathing zone of the employees, on membrane filters of 0.8 micrometer porosity mounted in an open-face filter holder. Samples shall be taken for the determination of the 8-hour time-weighted average airborne concentrations and of the ceiling concentrations of asbestos fibers.

(ii) Sampling frequency and patterns. After the initial determinations required by subparagraph (1) of this paragraph, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of employees. In no case shall the sampling be done at intervals greater than 6 months for employees whose exposure to asbestos may reasonably be foreseen to exceed the limits prescribed by paragraph (b) of this section.

(3) *Environmental monitoring*—(i) samples shall be collected from areas of a work environment which are representative of the airborne concentrations of asbestos fibers which may reach the breathing zone of employees. Samples shall be collected on a membrane filter of 0.8 micrometer porosity mounted in an open-face filter holder. Samples shall be taken for the determination of the 8-hour time-weighted average airborne concentrations and of the ceiling concentrations of asbestos fibers.

(ii) *Sampling frequency and patterns.* After the initial determinations required by subparagraph (1) of this paragraph, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of the employees. In no case shall sampling be at intervals greater than 6 months for employees whose exposures to asbestos may reasonably be foreseen to exceed the exposure limits prescribed in paragraph (b) of this section.

(4) *Employee observation of monitoring.* Affected employees, or their representatives, shall be given a reasonable opportunity to observe any monitoring required by this paragraph and shall have access to the records thereof.

(g) *Caution signs and labels.* (1) *Caution signs.* (i) *Posting.* Caution signs shall be provided and displayed at each location where airborne concentrations of asbestos fibers may be in excess of the exposure limits prescribed in paragraph (b) of this section. Signs shall be posted at such a distance from such a location so that an employee may read the signs and take necessary protective steps before entering the area marked by the signs. Signs shall be posted at all approaches to areas containing excessive concentrations of airborne asbestos fibers.

(ii) *Sign specifications.* The warning signs required by subdivision (i) of this subparagraph shall conform to the requirements of 20″ x 14″ vertical format signs specified in § 1910.145(d)(4), and to this subdivision. The signs shall display the following legend in the lower panel, with letter sizes and styles of a visibility at least equal to that specified in this subdivision.

Legend	*Notation*
Asbestos	1″ Sans Serif, Gothic or Block.
Dust Hazard	¾″ Sans Serif, Gothic or Block.
Avoid Breathing Dust	¼″ Gothic.
Wear Assigned Protective Equipment.	¼″ Gothic.
Do Not Remain In Area Unless Your Work Requires It.	¼″ Gothic.
Breathing Asbestos Dust May Be Hazardous To Your Health.	14 point Gothic.

Spacing between lines shall be at least equal to the height of the upper of any two lines.

(2) *Caution labels*—(i) *Labeling.* Caution labels shall be affixed to all raw materials, mixtures, scrap, waste, debris, and other products containing asbestos fibers, or to their containers, except that no label is required where asbestos fibers have been modified by a bonding agent, coating, binder, or other material so that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section will be released.

(ii) *Label specifications.* The caution labels required by subdivision (i) of this subparagraph shall be printed in letters of sufficient size and contrast as to be readily visible and legible. The label shall state:

CAUTION

Contains Asbestos Fibers
Avoid Creating Dust
Breathing Asbestos Dust May Cause Serious Bodily Harm

(h) *Housekeeping*—(1) *Cleaning.* All external surfaces in any place of employment shall be maintained free of accumulations of asbestos fibers if, with their dispersion, there would be an excessive concentration.

(2) *Waste disposal.* Asbestos waste, scrap, debris, bags, containers, equipment, and asbestos-contaminated clothing, consigned for disposal, which may produce in any reasonably foreseeable use, handling, storage, processing, disposal, or transportation airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section shall be collected and disposed of in sealed impermeable bags, or other closed, impermeable containers.

(i) *Recordkeeping*—(1) *Exposure records.* Every employer shall maintain records of any personal or environmental monitoring required by this section. Records shall be maintained for a period of at least 3 years and shall be made available upon request to the Assistant Secretary of Labor for Occupational Safety and Health, the Director of the National Institute for Occupational Safety and Health, and to authorized representatives of either.

(2) *Employee access.* Every employee and former employee shall have reasonable access to any record required to be maintained by subparagraph (1) of this paragraph, which indicates the employee's own exposure to asbestos fibers.

(3) *Employee notification.* Any employee found to have been exposed at any time to airborne concentrations of asbestos fibers in excess of the limits prescribed in paragraph (b) of this section shall be notified in writing of the exposure as soon as practicable but not later than 5 days of the finding. The employee shall also be timely notified of the corrective action being taken.

(j) *Medical examinations*—(1) *General.* The employer shall provide or make available at his cost, medical examinations relative to exposure to asbestos required by this paragraph.

(2) *Preplacement.* The employer shall provide or make available to each of his employees, within 30 calendar days following his first employment in an occupation exposed to airborne concentrations of asbestos fibers, a comprehensive medical examination, which shall include, as a minimum, a chest roentgenogram (posterior-anterior 14 x 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(3) *Annual examinations.* On or before January 31, 1973, and at least annually thereafter, every employer shall provide, or make available, comprehensive medical examinations to each of his employees engaged in occupations exposed to airborne concentrations of asbestos fibers. Such annual examination shall include, as a minimum, a chest roentgenogram (posterior-anterior 14 x 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(4) *Termination of employment.* The employer shall provide, or make available, within 30 calendar days before or after the termination of employment of any employee engaged in an occupation exposed to airborne concentrations of

asbestos fibers, a comprehensive medical examination which shall include, as a minimum, a chest roentgenogram (posterior-anterior 14 x 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(5) *Recent examinations.* No medical examination is required of any employee, if adequate records show that the employee has been examined in accordance with this paragraph within the past 1-year period.

(6) *Medical records*—(i) *Maintenance.* Employers of employees examined pursuant to this paragraph shall cause to be maintained complete and accurate records of all such medical examinations. Records shall be retained by employers for at least 20 years.

(ii) *Access.* The contents of the records of the medical examinations required by this paragraph shall be made available, for inspection and copying, to the Assistant Secretary of Labor for Occupational Safety and Health, the Director of NIOSH, to authorized physicians and medical consultants of either of them, and, upon the request of an employee or former employee, to his physician. Any physician who conducts a medical examination required by this paragraph shall furnish to the employer of the examined employee all the information specifically required by this paragraph, and any other medical information related to occupational exposure to asbestos fibers.

§ 1910.19 Special provisions for air contaminants.

(a) *Asbestos dust.* Section 1910.1001 shall apply to the exposure of every employee to asbestos dust in every employment and place of employment covered by § 1910.12, § 1910.13, § 1910.14, § 1910.15, or § 1910.16, in lieu of any different standard on exposure to asbestos dust which would otherwise be applicable by virtue of any of those sections.

Note: Following defines additional occupational areas affected by section 1910.19 above:

§1910.12 — Construction Work (construction, alteration, and/or repair, including painting and decorating)
§1910.13 — Ship Repairing
§1910.14 — Shipbuilding
§1910.15 — Shipbreaking
§1910.16 — Longshoring

Appendix B

USPHS/NIOSH Membrane Filter Method For Evaluating Airborne Asbestos Fibers

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This report describes the equipment and procedures for collecting, mounting, sizing, and counting asbestos fibers on cellulose ester membrane filters for the evaluation of breathing zone samples of airborne asbestos fibers. The purpose of the method presented is to determine an employee's exposure to airborne asbestos fibers.

This is the method of test referenced in the Federal standard on occupational exposure to asbestos (29 CFR 1910.1001, formerly 29 CFR 1910.93a) and the MESA (Mining Enforcement Safety Administration) air quality standards (30 CFR 55.5-1 (b)). It is used by the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA).

Preface

It has been almost seven years since the last detailed information was published by NIOSH concerning an asbestos counting method (Edwards and Lynch, 1968). In the interim, this method passed from a recommended status to one required by federal occupational health standard 29 CFR 1910.1001 (formerly 1910.93a).

This report was prepared to expand on the 1968 paper. It incorporates much of the sampling and analytical experience of the last seven years accumulated by counts made by NIOSH laboratories and the OSHA Analytical Services Laboratory. The report attempts to answer many of the practical questions concerning the method. A draft of this report has been used for the last two years by the NIOSH Division of Training in a course on asbestos sampling and analysis.

Recently a report prepared by the Joint AIHA-ACGIH Aerosol Hazards Evaluation Committee was published in the *AIHA Journal* (Recommended Procedures for Sampling and Counting Asbestos Fibers, AIHAJ, *36,* pp. 83-90 (1975)). The AIHA-ACGIH report was not submitted for technical review to either NIOSH or OSHA personnel responsible for technical procedures of the USPHS/NIOSH asbestos count method. The AIHA-ACGIH report contains conflicting and possibly confusing guidelines. This NIOSH report contains the NIOSH technical guidelines and procedures referenced in the Federal asbestos standard 29 CFR 1910.1001 (formerly 29 CFR 1910.93a).

The guidelines of this NIOSH report should be carefully and consistently followed by personnel collecting and evaluating asbestos samples in order to yield accurate results.

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I SCOPE

A. This method describes the equipment and procedures for collecting, mounting, sizing, and counting asbestos fibers on cellulose ester membrane filters in the evaluation of breathing zone samples of airborne asbestos fibers. The purpose of the method is to determine an employee's exposure to airborne asbestos fibers. The method is primarily a personal monitoring technique, but can be used for area monitoring.

B. The method has been successfully applied using 37 mm Millipore AA filters and small battery operated personal sampling pumps at a flow rate of 1.0 to 2.5 liters per minute (lpm) for time periods of a few minutes to 150 minutes at concentrations of 1 to 20 fibers (longer than 5 micrometers)/cubic centimeter. Large deviations from these conditions may result in samples with either too few or too many fibers, which will yield air concentration estimates of low statistical precision and accuracy.

C. This method considers only fibers with a length to width ratio of 3 to 1 or greater and a length greater than 5 micrometers.

II SUMMARY OF METHOD

The sample is collected by drawing air through a membrane filter by means of a battery powered personal sampling pump. The filter is transformed from an opaque solid membrane to a transparent, optically homogeneous gel. The fibers are sized and counted by phase-contrast microscope at 400-450X magnification.

III SIGNIFICANCE

This type method was first used by the Asbestosis Research Council in Great Britain (1) and later was slightly modified by the U.S. Public Health Service for asbestos dust studies in the United States (2). It has been referenced as the method of test (3) for the Federal standard for asbestos in industrial air (29 CFR Part 1910.-1001, formerly 29 CFR 1910.93a), and the MESA air quality standard 30 CFR 55.5-1(b) in the NIOSH Criteria Document on occupational exposure to asbestos (4), in sampling procedures of the Occupational Safety and Health Administration, Department of Labor (5). It is the method used by NIOSH and taught in NIOSH Division of Training, Course 582, "Sampling and Evaluating Airborne Asbestos Dust". Finally, the procedure has been submitted to the ASTM for consideration as an ASTM Method of Test.

IV DEFINITIONS

"Asbestos fibers" means asbestos fibers longer than 5 micrometers. "Asbestos" includes chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite. For definitions of terms used in this report, refer to ASTM Definitions D 1356, Terms Relating to Atmospheric Sampling and Analysis.

V INTERFERENCES

All particulates with a length to width ratio of 3 to 1 or greater and length greater than 5 micrometers should, in the absence of other information, be considered to be asbestos fibers and counted as such.

VI APPARATUS

A. Sampling Equipment

The personal sampling equipment train consists of: 1) personal sampling pump, 2) tubing, 3) clothing spring clip, 4) tubing-to-field monitor metal adaptor, and 5) field monitor (collecting filter and holder).

1. *Personal sampler pump.* The pump must be battery powered and weigh less than 2 pounds (0.9 kg). The pump must be capable of sampling at 1.0 to 2.5 lpm against a flow resistance of 7.5 inches of water (1.4 cm Hg) for 8 continuous hours on a fully charged battery.

2. *Tubing.* Laboratory tubing such as rubber or plastic with 6 mm bore (¼ inch) and about 90 cm length (3 feet).

3. *Clothing spring clip.* This clip attaches the rubber tubing to the lapel or shirt of the individual being monitored. Large spring paperclips will also work.

4. *Tubin-to-field monitor adaptor.* A short adaptor with ridges on one end to grip the inside of the tubing. The other end is designed for a pressure fit into the field monitor.

5. *Field monitor (collecting filter and holder).* The only field monitor currently considered acceptable by NIOSH is manufactured by the Millipore Corporation. The unit consists of: 1) a three-section styrene plastic case designated Millipore aerosol Monitor Case, 2) a 37 mm diameter plain white cellulose ester membrane filter designated Millipore AA (nominal pore size of 0.8 micrometer), 3) a support pad, and 4) two plastic sealing caps. If a large number of samples are to be taken it will be less expensive to reuse the plastic cases. Great care must be taken in the cleaning and reassembly process. The outside mating surfaces of the field monitors should be covered with "shrink-fit" sealing bands to seal the units and provide a writing surface for filter identification.

B. Optical Equipment

1. Microscope body with binocular head.

2. 10X Huygenian eyepieces are recommended. Other eyepieces can be substituted if necessary.

3. Koehler illumination (preferably built in and having provisions for adjusting light intensity).

4. A Porton reticle is recommended. Others such as the Patterson Globe and Circle can be substituted, if necessary.

5. Mechanical stage.

6. Abbe and Zernike condenser fitted with phase ring (or Heine) with a numerical aperture (N.A.) equal to or greater than the N.A. of the objective.

7. 40-45X (N.A. 0.65 to 0.75) positive phase contrast achromatic objective.

8. Phase-ring centering telescope or Bertrand lens.

9. Green filter, if recommended by microscope manufacturer.

10. Stage micrometer with 0.01 mm subdivisions.

For general guidance on microscopes consult Needham (6) and Clark (7) under phase contrast microscopes and accessories.

C. Filter Mounting Equipment

Experience has shown that certain equipment is useful for efficient sample mounting. The following items are recommended for extracting and mounting a portion of the filter onto the microscope.

1. *Microscope slides:* 2.5 by 7.5 cm (one inch by three inches) glass slides are most commonly used. Sample number, data, initials, etc., can be conveniently written on a frosted end slide.

2. *Cover slips:* Cover slips are a necessary part of the slide mount and optical system. The shape should be appropriate for the size of the filter wedge. The appropriate cover slip depends upon the objective to be used. Ordinarily objectives are optically corrected for a #1½ (0.17 millimeter) thickness cover slip. Improper cover glass thickness

3. *Scalpel:* A scalpel is needed to remove a portion of the filter to be examined. A number-ten curved blade scalpel works very well.

4. *Tweezers:* A pair of fine-tipped tweezers is used to remove the membrane filter slice from the field monitor and place it upon the slide.

5. *Lens tissue:* To insure cleanliness, use of a lint-free tissue is recommended. This tissue should also be used for wiping mounting tools and for cleaning slides and cover slips.

6. *Glass rod or spatula:* A spatula or fire-polished glass rod is needed to spread the mounting solution on the slide.

7. *Wheaton Balsam bottle:* This special glass container has a glass top which prevents contamination of the mounting solution. A glass rod is included for dispensing the solution.

VII REAGENTS

Chemicals should be reagent grade, free from particles and color, conforming to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Chemicals required are:

A. Dimethyl phthalate

B. Diethyl oxalate

VIII SAFETY PRECAUTIONS

Avoid getting the mounting solution on the skin. Wash skin promptly with soap and water if skin contact occurs.

IX SAMPLING

A. General Information

General guidelines for the monitoring of employee exposures to industrial atmospheres are given in reference (8). The Federal requirements regarding employee exposure monitoring for airborne asbestos are given in 29 CFR 1910.1001.

B. Calibration

The personal sampling pump should be recharged prior to calibration and then calibrated (9) against a bubble meter, wet test meter, spirometer, or smiilar device at 1.0 to 2.5 lpm. The sampling train used in the calibration (pump, hose, filter) should be the same as the one used in the field. The calibration should be of sufficient accuracy that the 95% confidence limits on the flowrate are ±10% (... two standard deviations).

C. Mounting the Sampling Pump on the Worker

Fasten the sampling pump to the worker's belt and fasten the field monitor to the lapel or shirt front (as close to the face as is practical). Remove the top cover of the plastic monitor, then invert the monitor making certain the exposed filter is facing downward. Turn on the pump and adjust to the previously calibrated flowrate (1.0 to 2.5 lpm). Immediately record the following information in a logbook.

1. Filter number
2. Pump start time and date
3. Flow rate
4. Subject's name
5. Type of operation
6. Ventilation controls and/or if worker is wearing a respirator approved for asbestos.

The pump should be checked periodically during the sampling period for proper operation and flowrate.

D. Optimum Sampling Times

The requirement for a minimum count of 100 fibers or 20 fields in Section XI(D)(3) below was determined to be the optimum chioce to achieve low variability of the fiber count (as approximated by the Poisson distribution) and reduced counting times. Another way of looking at this requirement is that the optimum fiber density on the filter should be one to five fibers per microscope counting field. To estimate optimum sampling times one must know in advance the approximate field area of the counting scope and the pump flow rate.

The following equation is used to calculate the range of optimum sampling times which can then be plotted on log-log paper:

$$\text{Minutes} = \frac{(FB/FL)(ECA/MFA)}{(FR)(AC)(1000)}$$

where FB/FL = 1 to 5 fibers/field
ECA = effective collecting area of filter (855 mm² for 37 mm filter)
MFA = microscope field area (generally 0.003 to 0.006 mm²)
FR = Pump flow rate (generally 1.0 to 2.5 lpm)
AC = Air concentration of fibers in fibers/cc

Figures 1 and 2 show typical sampling times for a pump flow rate of 1.7 lpm. Figure 1 is for a microscope field area of 0.003 mm². In Figure 2, we see that the sampling times which yield an optimum fiber density on the filter are in the range 40 to 80 minutes for a 1.7 lpm sampling rate and 0.006 mm² field area. Each individual responsible for sampling asbestos should prepare a similar chart for his particular pump flow rate and field area before sampling is performed to avoid filters that are too light for reliable statistics or too heavily loaded to count. However, note that the upper limit on the optimum counting density of 5 fibers/field is an arbitrary one. This upper limit is highly dependent on the background particulate density. Under very light background conditions the upper limit for reliable counts may extend to 25-30 fibers/field.

From Figures 1 and 2, it can be seen that there are certain sampling times which will yield optimum fiber densities on the filter for almost all airborne fiber concentrations from 1 to 10 fibers/cu.cm. These optimum times have been calculated and are presented in Figure 3. Note that the optimum times given by Figure 3 are approximate and can be varied by as much as ±25 percent. The nomogram is intended as a guide to be used where no prior knowledge of the air concentration is available. If, after sampling for the times recommended by Figure 3, the sample is very heavily loaded (greater than 10 fibers/field), then the air concentration probably greatly exceeded the ceiling standard of 10 fibers/cu.cm. Conversely if the filter fiber density is very low (less than 1 fiber/field) then the air concentration probably was less than the 1976 Federal 8-hour average standard of 2 fibers/cu.cm. (29 CFR 1910.1001(b)(2) effective July 1, 1976). The nomogram gives the sampling times which produce optimum fiber densities on the filter (1 to 5 fibers/field) for air concentrations of 1 to 10 fibers/cu.cm.

E. End of Sampling Period

Remove the field monitor, replace the plastic top cover and the small end caps, and store the monitor. Always shut off the pump when changing monitors to avoid contaminating or damaging the pump. Record the pump shutoff time and flowrate in the logbook.

F. Blanks

With each batch (25 to 50 filters) of samples submit two unopened filters which have been subjected to the same handling as the samples except that no air has been drawn through them. Label these as blanks. If the blanks yield fiber counts greater than about 5 fibers/100 fields, then the entire sampling procedure should be examined carefully for the cause of contamination.

Figure 1 — Optimum sampling times for airborne asbestos where microscope field area = 0.003 sq mm.

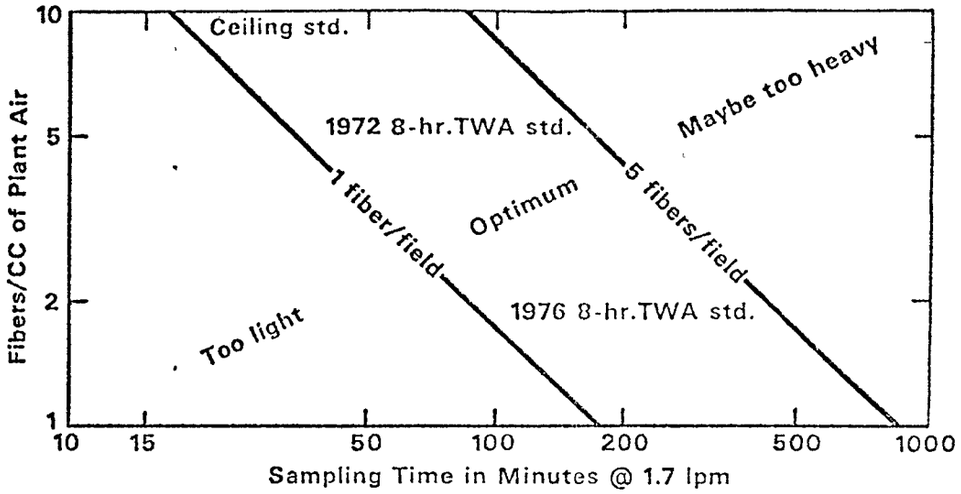


Figure 2 — Optimum sampling times for airborne asbestos where microscope field area = 0.006 sq. mm.

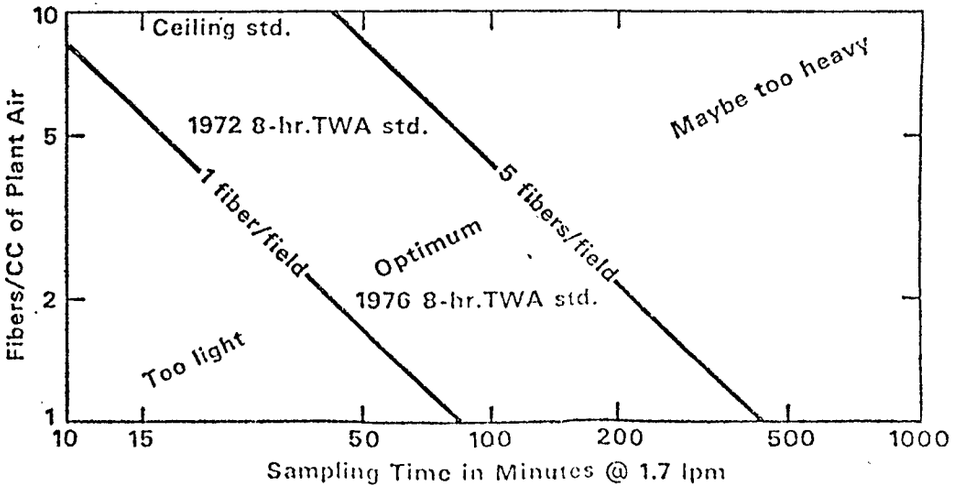
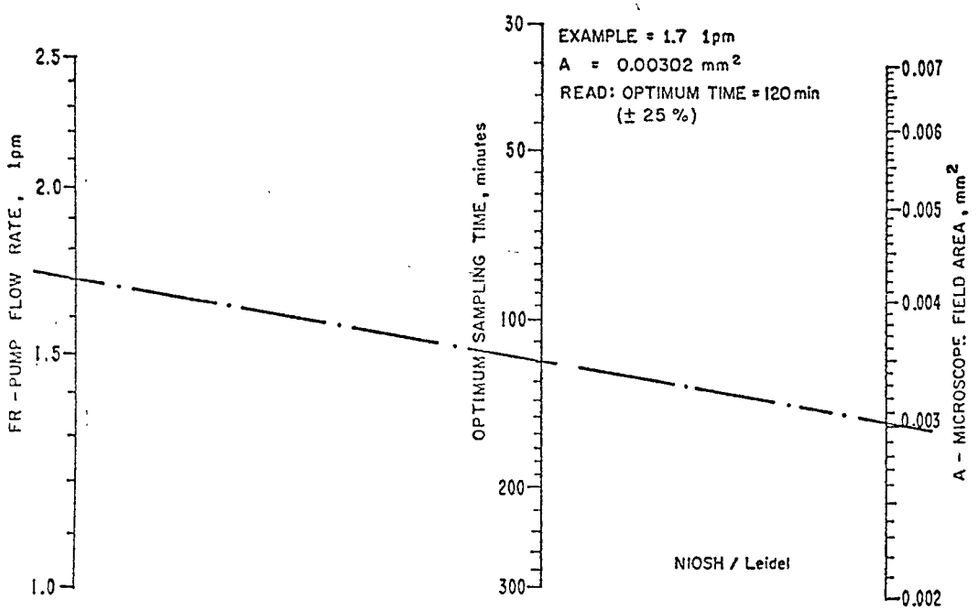


Figure 3 — Nomogram for optimum sampling times for airborne asbestos fibers.



G. Shipping

The field monitors in which the samples are collected should be shopped in a rigid container with sufficient packing material to prevent crushing.

H. Numbers of Samples

When sampling for the ceiling standard (29 CFR 1910.1001(b)(3) effective July 7, 1972) only one sample (15-minute maximum duration) is theoretically necessary. However, several samples should be taken during expected periods of peak air concentrations to allow for detection of gross sampling or counting errors.

When sampling for determination of noncompliance with the 8-hour TWA standard one should continuously sample as large a portion of the work day as is feasible. (29 CFR 1910. 1001(b)(1) or (b)(2)) Normally this would mean 6 to 10 consecutive samples on the same man. However, if this is not feasible the 8-hour TWA air concentration can be estimated from fewer than 6-10 samples. Leidel and Busch (10) have shown an optimum number would be 4 to 7. Refer to reference (10) for treatment of the data for the determination on noncompliance. See the NIOSH handbook (8), and Jones and Brief (11) for how to treat data taken for an employee exposure monitoring program.

X CALIBRATION AND STANDARDIZATION

A. Porton Reticle and the Counting Field

The asbestos fiber count procedure consists of comparing fiber length with calibrated circles, and counting all fibers greater than 5 micrometers in length within a given counting field area. It is recommended that a Porton reticle be used for this purpose. The Porton reticle is a glass plate inscribed with a series of circles and rectangles. The square on the left, divided into six rectangles, is defined as the counting field.

B. Placement in Eyepiece

The Porton reticle is placed inside the Huygenian eyepiece where it rests on the field-limiting diaphragm. The reticle should be kept clean, since dirt on the reticle is in focus and will complicate the counting and sizing process. For mounting in other eyepieces such as a Ramsden, a counting collar must be used.

C. Stage Micrometer

The Porton reticle cannot be used for counting until it has been properly calibrated with a stage micrometer. Most stage micrometer scales are approximately two millimeters long and are divided into units of one-hundredth of a millimeter or ten micrometers.

D. Microscope Adjustment

When adjusting the microscope follow the manufacturer's instructions while observing the following guidelines:

1. The light source image must be in focus and centered on the condenser iris or annular diaphragm.
2. The object for examination must be in focus.
3. The illuminator field iris must be in focus, centered on the sample, and opened only to the point where the field of view is illuminated.
4. The phase rings (annular diaphragm and phase-shifting elements) must be concentric.

E. Porton Reticle Calibration Procedure

Each eyepiece-objective-reticle combination on the microscope must be calibrated. Should any of the three be changed (disassembly, replacement, zoom adjustment, etc.) the combination must be recalibrated. Calibration may change if interpupillary distance is changed. For proper calibration, the following procedure should be followed closely.

With a 10X objective in place, place the stage micrometer on the mechanical stage, focus, and center the image. Change to the 40-45X objective and adjust the first scale division to coincide with the left boundary of the Porton rectangle. Count the number of divisions between the left and right boundaries of the long horizontal dimension of the largest rectangle, estimating any portion of the final division. This measurement represents 200 L units and one divides the measurement by 200 to find "L". The large rectangle is 100 L units long on the short vertical dimension. The calculated "L" is inserted into the formula $D = L\,(2^N)^{1/2}$ where "N" is the circle number (indicated on the reticle) and "D" is the circle diameter. Since the circle diameters vary logarithmically, every other circle doubles in diameter. For example, number three is twice the diameter of number one; number four is twice the diameter of number two. When the circle sizes have been determined, the counting field area consisting of the left six smaller rectangles can be calculated from the relation 10,000 L. This completes the reticle calibration for this specific objective-eyepiece-reticle combination.

XI PROCEDURE

A. Preparation of Mounting Solution

A very important part of the sample evaluation is the mounting process. This process involves a special mounting medium of prescribed viscosity. The proper viscosity is important in order to expedite filter clearing and minimize particle migration. Once the sample has been mounted, an elapsed time of approximately fifteen minutes is needed before the sample is ready for evaluation.

Combine the dimethyl phthalate and diethyl oxalate in one to one ratio by volume and pour into a Wheaton balsam bottle. Add 0.05 gram of new membrane filter per milliliter of solution to reach the necessary viscosity. The mixture must be stirred periodically until the filters have dissolved and a homogeneous mixture is formed. The normal shelf life of the mounting solution is about six months. Twenty milliliters of mounting solution will prepare approximately 300 samples.

B. Sample Mounting

Cleanliness is important! A dirty working area may result in sample contamination and erroneous counts. The following steps should be followed when mounting a sample.

1. Clean the slides and cover slips with lens tissue. Lay the slide down on a clean surface with the frosted end up. It is a good practice to rest one edge of the cover slip on the slide and the other edge on the working surface. By doing this, you keep the bottom surface (the one which contacts the filter) from becoming contaminated.
2. Wipe all the mounting tools clean with lens tissue and place them on a clean surface (such as lens tissue). When mounting a series of filters the scalpel should be wiped clean before cutting each sample.
3. Using a glass rod which is supplied with the Wheaton balsam bottle, apply a small drop of mounting solution onto the center of the slide. It may be necessary to adjust the quantity of solution used or the size of the wedge. The correct amount will result in the

solution extending only slightly beyond the filter boundary. If the quantity is greater than this, adverse particle migration will occur.

4. With the spatula or a supplemental glass rod, spread the mounting media into a triangular shape. The size of this triangle should coincide with the dimension of the filter wedge.

5. Separate the middle and bottom sections of the field monitor case to expose the fragile filter. Cut a triangular wedge from the center to the edge of the filter using the scalpel. The size of the wedge should approximate one-eighth of the filter surface.

6. Grasp the filter wedge with the tweezers in the outer area of the filter which was clamped between the monitor case sections. Do not touch the filter with your fingers. Place the wedge, *sampled side up,* upon the mounting medium.

7. Pick up the cover slip with the tweezers and carefully place it on the filter wedge. Once this contact has been made, *do not reposition the cover slip.*

8. Label the slide with the sample number and current date before proceeding to the next filter.

9. The sample should become transparent after about fifteen minutes. If the filter appears cloudly, it may be necessary to press *very lightly* on the cover slip. This is rarely necessary.

10. Discard the sample mount after three days if it has not been counted. Crystals which appear similar to asbestos fibers may begin to grow at the mounting media/air interfaces. They seldom present any problems if the slide is examined before three days. In any case, stay away from the filter's edges when counting and sizing.

C. Counting and Sizing

Finding and inspecting counting fields. Place the slide on the mechanical stage and positoin the center of the wedge under the objective lens and focus upon the sample. Nearly all of the particulates (particles and fibers) will be found in the upper ten to fifteen micrometers of the filter surface. When counting and sizing, continual use of the fine focus control is required to insure that nothing is missed. Start counting from one end of the wedge and progress along a radial line to the other end (count in either direction from circumference to wedge tip). Random fields are selected, without looking into the eyepieces, by slightly advancing the slide in one direction with the mechanical stage control.

D. Achieving Comparable Results

1. Size only fibers with a length to width ratio greater than or equal to 3:1.

2. Count only fibers greater than 5 micrometers in length. (Be as accurate as possible in accepting or rejecting fibers near this length). Measure curved fibers along the curve to estimate the total length.

3. Count as many fields as necessary to yield a total count of at least 100 fibers. Exceptions: a) count at least 20 fields even if you count more than 100 fibers, and b) stop at 100 fields even if you haven't reached 100 fibers.

4. Select the field of view without looking through the microscope's eyepieces to eliminate unconsciously selecting "heavy" or "light" areas.

5. The fields are selected along the entire length of a radial line running between the outside perimeter and the tip of the wedge.

6. When an agglomerate (mass of material) covers a significant portion of the field of view (approx. 1/6 or greater) reject the field and select another. (Do not include it in the number of fields counted.) However, report the fact as it may have meannig to sampling or medical personnel.

7. Bundles of fibers are counted as one fiber unless both ends of a fiber crossing another can be clearly resolved.

8. For fibers that cross either one or two sides of the counting field, the following procedure is used to obtain a representtaive count. First, arbitrarily select: a) the left and bottom sides, and b) the upper and lower left corners and vertical direction as "decision aids."

Then count any fiber greater than 5 micrometers in length, but only if the fiber:

a. lies entirely within the counting area or,
b. crosses the left or bottom sides, or
c. crosses the upper or lower left corners, or
d. crosses both the top and bottom sides.

Reject and do not count all other fibers. Refer to Figures 4 through 9.

Figure 4. COUNT, fiber crosses both top and bottom sides.

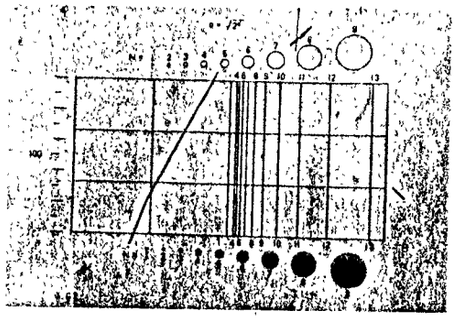


Figure 5. COUNT as one fiber.

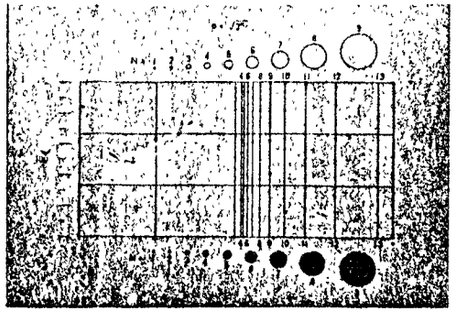


Figure 6. COUNT, fiber crosses left side.

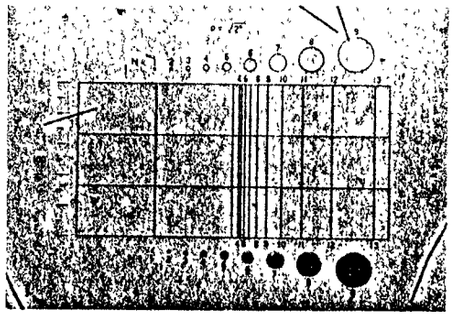


Figure 7. COUNT, fiber crosses bottom side.

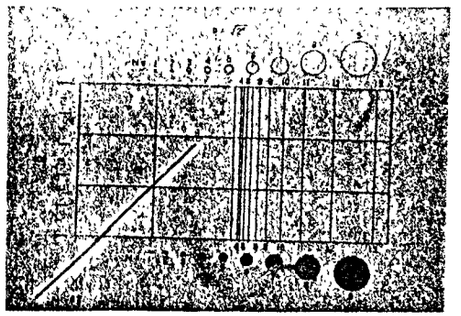


Figure 8. COUNT, fiber crosses lower left corner.

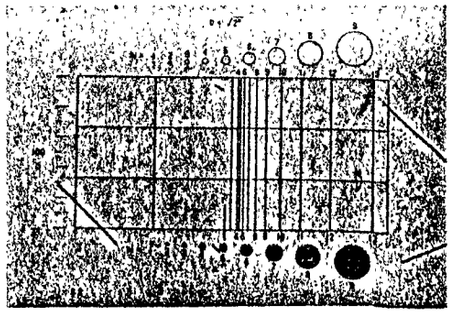
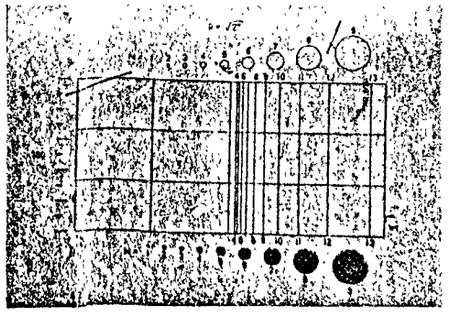


Figure 9. COUNT, fiber crosses upper left corner.



XII CALCULATIONS OF AIRBORNE CONCENTRATIONS

Asbestos fiber airborne concentration may be calculated from the following formula:

$$C = \frac{(F - B)(W)}{(A)(V)}$$

Where:

C = Airborne fiber concentrations in fibers >5 μm/cm³.

F = Average fiber count in fibers >5 μm/field.

B = Average fiber count of blank(s) or control filter(s) in fibers >5 μm/field. (It is subtracted to eliminate the error or background contamination.)

W = 855 mm² for 37 mm diameter filter (the portion of the Millipore filter which is exposed when mounted in the field monitor case, i.e., the effective filter area).

A = The area of the counting field of a calibrated reticle expressed in mm²/field.

V = Total air volume collected through filter expressed in milliliters.

XIII PRECISION AND ACCURACY

A. An accuracy and precision study of the membrane filter counting procedure for asbestos has been conducted by Conway and Holland (12). They conducted an intralaboratory study involving six counters. Three of the counters were experienced while the other three had only a short familiarization with the rules for fiber counting. The conclusions of the study included:

1. The precision of the procedure for filters not containing an abundance of fine fibers can be estimated by a standard deviation of 16.2%. This value includes variation among counters and observed interaction effects.

2. The accuracy of the procedure for similar filters may be estimated for a 100-fiber count by a standard deviation of 21.4%. This assumes that the contribution of the overall variance from the nonuniform fiber distribution is additive.

3. The fiber concentration varies significantly between angular sectors on a given filter. Where approximately 100 fibers are counted, the standard deviation of the fiber count distribution for the whole filter appears to be represented by $1.6 \cdot (n)^{1/2}$, rather than $(n)^{1/2}$ which is a property of the Poisson distribution, where (n) is the total number of fibers counted.

4. A high percentage of very fine fibers on the filter can significantly affect the standard deviation and confidence limits for counts by different counters. After combining variations in fiber concentrations over the entire filter with those for different counters it was concluded:

   a. For filters with a low concentration of the fibers, the standard deviation is estimated at 21% and the 95% confidence interval is ±43%.

   b. For filters with a high concentration of fine fibers, the standard deviation is estimated at 25% and the 95% confidence interval is ±50%.

B. Lynch, Kronoveter, and Leidel (13) have also reported on the precision of the method. Their intralaboratory study utilized the data from a large number of dust counts made by different methods by experienced counters over a period of years in an epidemiologic study of the asbestos products industry. They concluded that the standard deviation of counts of fibers longer than 5 micrometers on membrane filters could be estimated from the relation $\sigma = (n)^{0.591}$. Thus for counts of about 100 fibers, the standard deviation could be estimated at about 15.2% and the 95% confidence limits at ±30.4%. These values are lower than the precision values reported by Conway and Holland (12).

C. Systematic inaccuracies can be introduced by the improper choice of microscope or by not checking a particular individual's counts in relation to other counters. Leidel and Busch (14) found that one particular microscope tested yielded counts that were approximately 45% higher on the average than counts from four other microscopes in a phase contrast michoscope evaluation. Also, one particular counter produced counts that were 27% higher on the average. Leidel and Busch (14) concluded that a significant difference in asbestos fiber counts can result when the same filters are counted on different makes and models of microscopes. Significant differences can also exist between trained counters. They concluded that any laboratory counting asbestos on membrane filters should be part of an interlaboratory collaborative quality program. This participation will insure that: 1) equipment is properly adjusted and calibrated; 2) counters are properly trained and their counting efficiency is continually evaluated; and 3) comparable results are obtained from each laboratory. This type of quality control program is conducted by NIOSH as the Proficiency Analytical Testing (PAT) program. The PAT program is used by the AIHA as part of their Laboratory Accreditation Program which is partially funded by NIOSH.

XIV REFERENCES

1 Asbestos Research Council: "The Measurement of Airborne Asbestos Dust by the Membrane Filter Method: Technical Note," Dr. S. Holmes (Secretary) P.O. Box 40, Rockdale Lancashire, Great Britain (1969).

2 Edwards, G. H., and J. R. Lynch: "The Method Used by the U.S. Public Health Service for Enumeration of Asbestos Dust on Membrane Filters," *Annals of Occupational Hygiene, 11,* 1-6 (1968).

3 *Federal Register, 39,* 23543-23545 (June 27, 1974).

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5 U.S. Department of Labor, Occupational Safety and Health Administration, "OSHA Sampling Data Sheet No. 2 — Asbestos," (Unpublished — Jan. 1972).

6 Needham, G. H.: "The Practcial Use of the Microscope," Charles C. Thomas Publishing Corp., Springfield, Illinois (1958).

7 Clark, G. L.: "The Encyclopedia of Microscopy," Rheinhold Publishing Corp., N.Y. (1961).

8 Handbook for Compliance Determinations of Employee Exposure to Industrial Atmospheres, USPHS, NIOSH Technical Publication (to be published 1975).

9 American Conference of Governmental Industrial Hygienists: "Air Sampling Instruments for Evaluation of Atmospheric Contaminants," Fourth Edition, Section K, Air Movers and Samplers, pp K-26-K-31, P.O. Box 1937, Cincinnati, Ohio (1972).

10 Leidel, N. A., and K. A. Busch: "Statistical Methods for the Determination of Noncompliance with Occupational Health Standards," NIOSH Technical Publication 75-159 (1975).

11 Jones, A. R., and R. S. Brief: "Evaluating Benzene Exposures," AIHA J., *32,* 610-613 (1971).

12 Conway, R. E., and Holland, W. D.: "Statistical Evaluation of the Procedure for Counting Asbestos Fibers on Membrane Filters," LFE Corporation, Richmond, CA. Prepared for Asbestos Information Assoc./North America, New York, N.Y. (1973).

13 Lynch, J. R., K. H. Kronoveter, and N. A. Leidel: "Validity of the Poisson Distribution in Dust Counting," USPHS (NIOSH unpublished in-house report TR-83).

14 Leidel, N. A., and K. A. Busch: An Evaluation of Phase Contrast Microscopes for Asbestos Counting, presented at the 1974 American Industrial Hygiene Conference, Miami Beach, Florida, 18 May 1974 (NIOSH unpublished in-house report TR-92).

Notes

A. SOURCES OF PERSONAL SAMPLER PUMPS

1. Mine Safety Appliance Company
   201 North Braddock Avenue
   Pittsburgh, PA 15208
2. National Environmental Instruments, Inc.
   P.O. Box 590
   Warwick, RI 02888
3. Willson Products Divsiion
   ESB Incorporated
   P.O. Box 622
   Reading, PA 19603

B. SOURCE OF CLOTHING SPRING CLIP
   Catalog number 1140
   John F. McGuire Company
   120 Bacon Street
   Pawtucket, RI 02860

C. SOURCE OF TUBING-TO-FIELD MONITOR ADAPTOR
   Catalog number LH/L
   Bection, Dickinson, & Company
   Rutherford, NJ

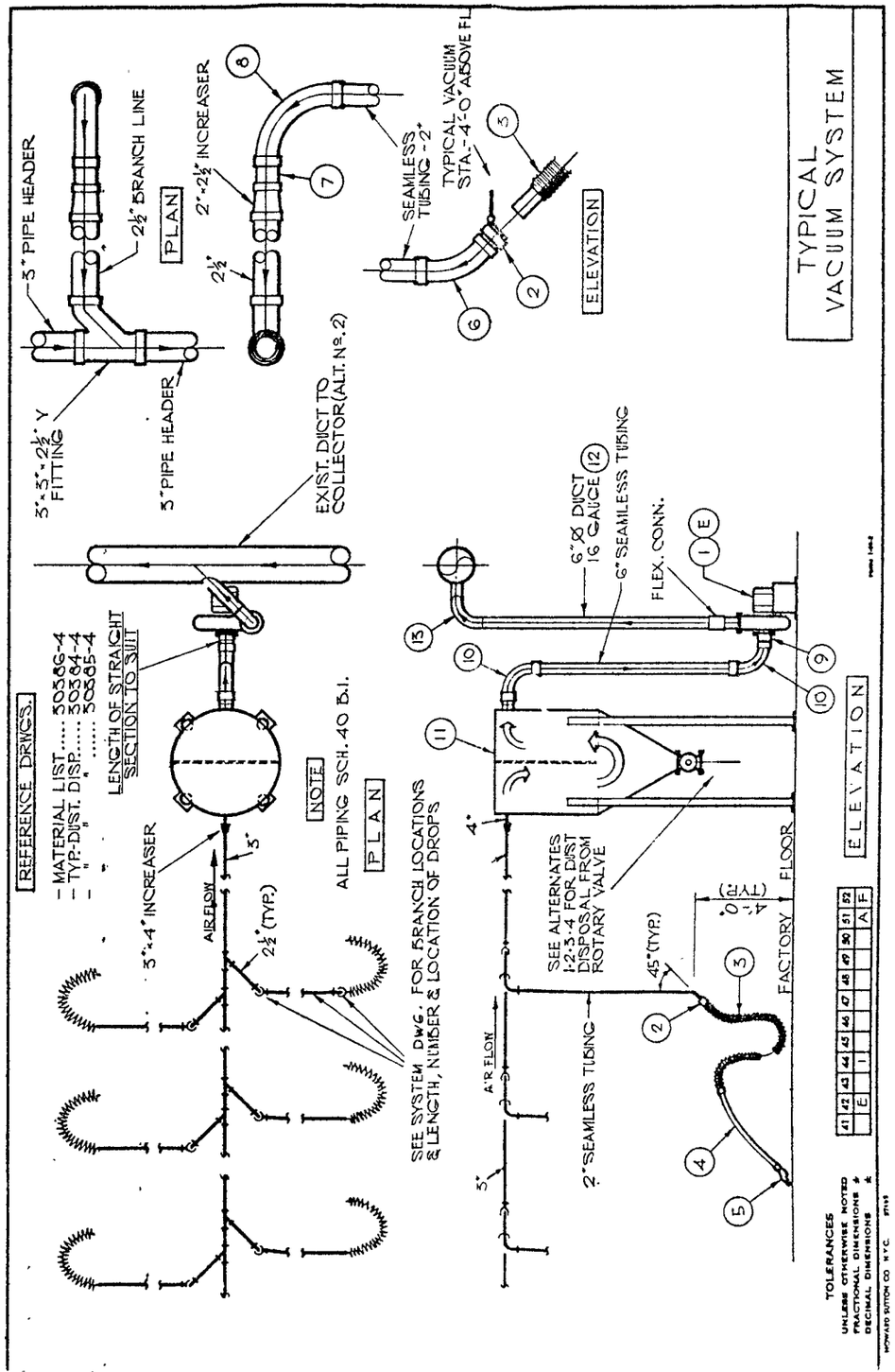
D. SOURCE OF FIELD MONITOR

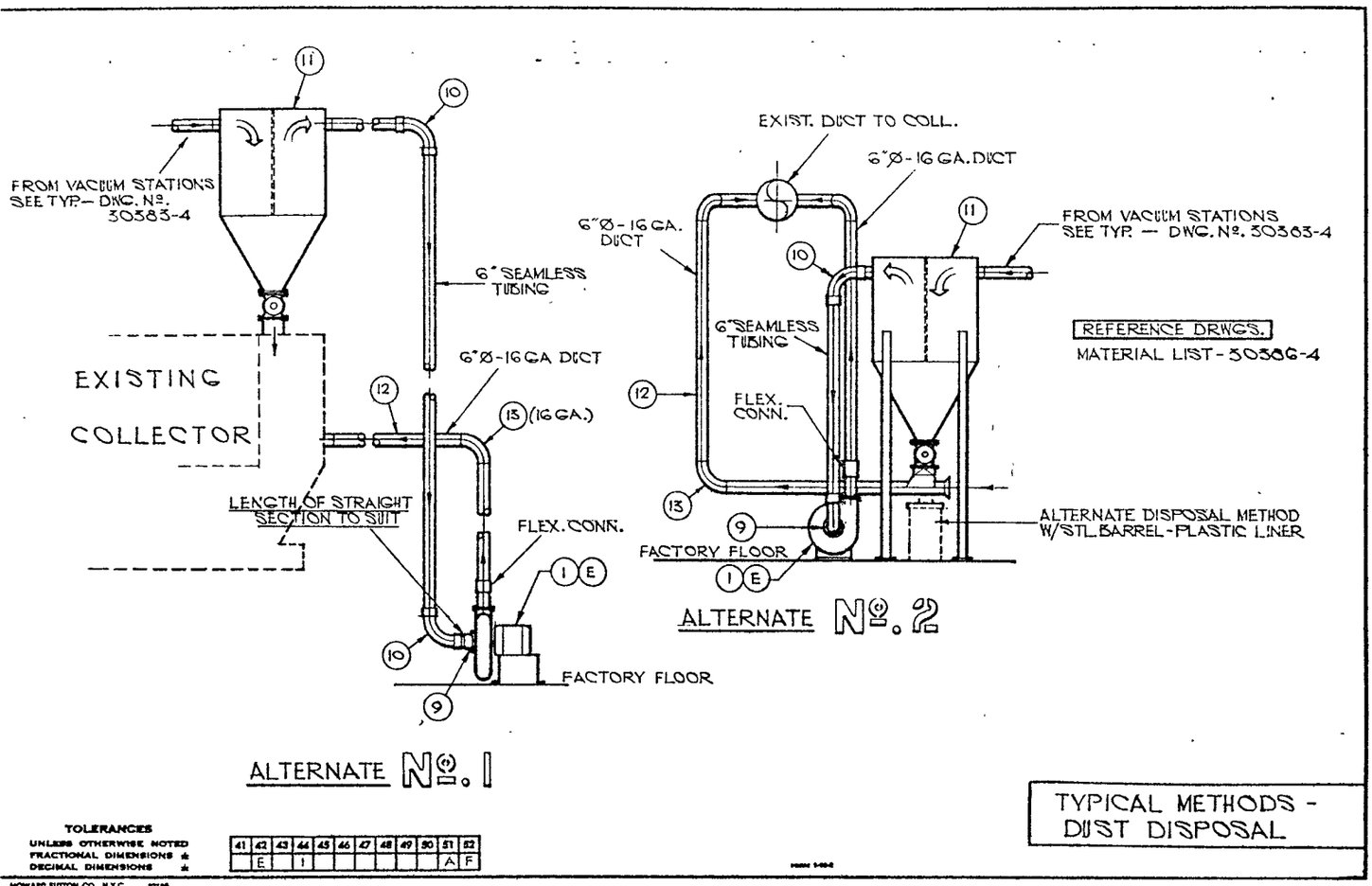
1. Complete monitor (plastic case, filter, pad, and caps), catalog number MAWP 037A0 /50/box).
2. Filters and pads only, catalog number AAWP 03700 (100/box).
3. Monitors only, catalog number M0000 37A0 (50/box), from the Millipore Corporation
   Ashby Road
   Bedford, MA 01730

E. SOURCE OF SEALING BANDS
   Cellulose bands, white, opaque, 41x25, #28 (minimum order 2500).
   Walter H. Jelly & Company
   2822 Birch Street
   Franklin Park, IL 80131

It is recognized that equipment and services other than those cited in this report may be available. Mention of company or product names is not to be considered an endorsement by NIOSH.

For definitions of terms used in this report, refer to ASTM Definitions D 1356, Terms Relating to Atmospheric Sampling and Analysis.

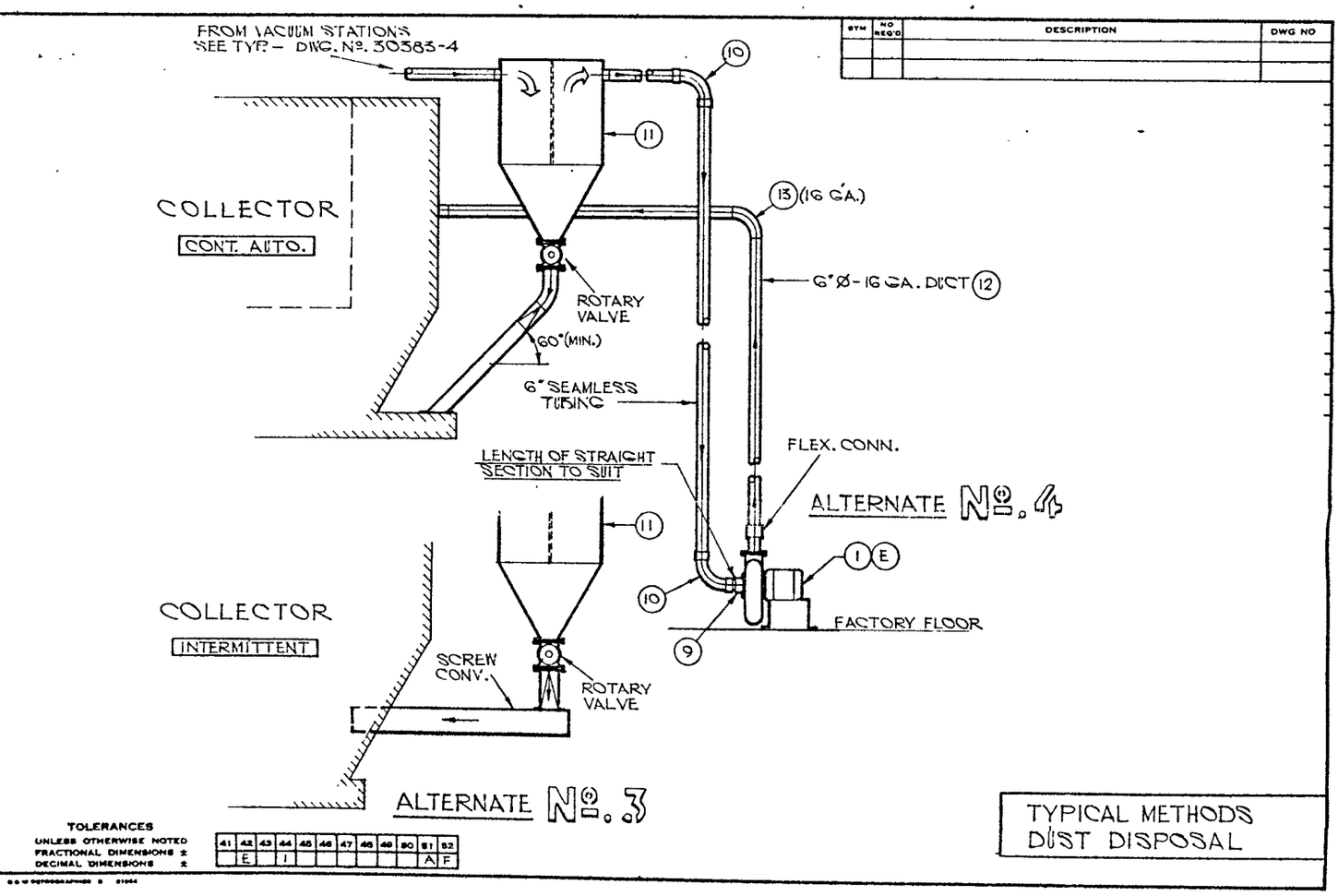




TOLERANCES
UNLESS OTHERWISE NOTED
FRACTIONAL DIMENSIONS ±
DECIMAL DIMENSIONS ±

41	42	43	44	45	46	47	48	49	50	51	52
	E		I							A	F

HOWARD SUTTON CO N.Y.C. 21196



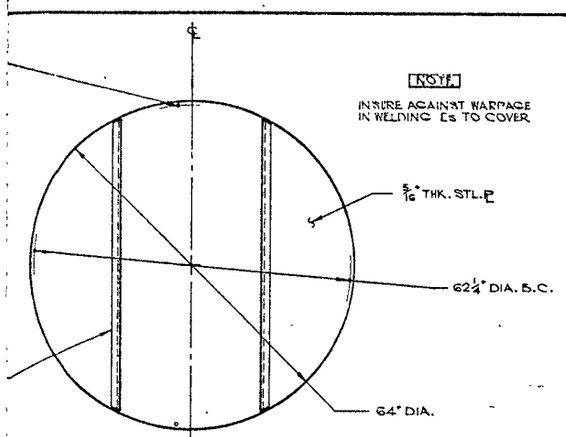
TOLERANCES
UNLESS OTHERWISE NOTED
FRACTIONAL DIMENSIONS ±
DECIMAL DIMENSIONS ±

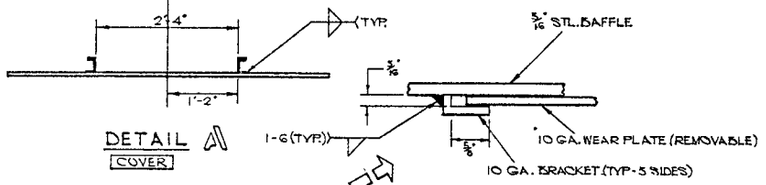
41	42	43	44	45	46	47	48	49	50	51	52
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SYM	NO REQ'D	DESCRIPTION	DWG. NO
1	1	COMB. POKE HOLE/INSPECT. WINDOW	2545-2

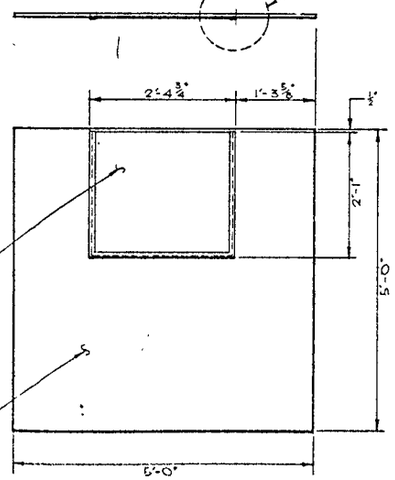
ROYF

INSURE AGAINST WARPAGE IN WELDING Es TO COVER

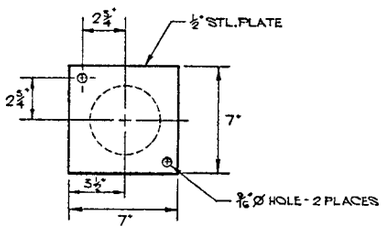




DETAIL A
COVER



DETAIL B
BAFFLE



DETAIL C
PLATE - 4 REQ'D.

DUST TRAP
VACUUM SYSTEM

⚠1 RATINGS

	Nº. STATIONS BEING USED	EXTREME DISTANCE	CAPACITY & TOTAL PRESS
STANDARD SYSTEM	TWO	150 FT.	300 CFM-40"
TWO PARALLEL SYSTEMS	FOUR	150 FT.	600 CFM-40"
THREE " " " "	SIX	150 FT.	900 CFM-40"
EXTENDED SYSTEM	TWO	300 FT.	300 CFM-60"
" "	FOUR	300 FT.	600 CFM-60"
" "	SIX	300 FT.	900 CFM-60"

⚠2 QUANTITIES LEFT OPEN IN MATERIAL LIST WILL BE DETERMINED TO SUIT SPECIFIC SYSTEMS

SYM	NO REQ'D	DESCRIPTION	DWG NO
.		FAN - BUFFALO, LAMSON, CLARAGE, NEW YORK	
1	1	BLOWER, OR EQUAL. LOW-VOLUME, HIGH-PRESSURE, DIRECT-CONN'D., ARR. Nº. 4.	
2	-	INLET VALVE - HOFFMAN Nº. 39463 OR EQUAL	
3	-	HOSE - FLEXIBLE, REINFORCED W/2" STEEL NIPPLES, 25 FT. LG., HOFFMAN STYLE VF OR EQUAL	
4	-	FLOOR ROD, CURVED, 2" I.D. FEMALE SLIP-JOINTS, HOFFMAN Nº. 39447 OR EQUAL	
5	-	FLOOR NOZZLE, GILPER STYLE, 2" O.D. MALE END, HOFFMAN Nº. 38410 OR EQUAL	
6	-	ELBOW, 2⅛" BELL END × 2" FPT, STD. RADIUS, 45°, HOFFMAN Nº. SA-2011 OR EQUAL	
7	-	ADAPTER, MALE, 2" PIPE THRD. × 2⅛" NIPPLE × 4" LG. HOFFMAN Nº. SA-202 OR EQUAL	
8	-	ELBOW, 2⅛" BELL ENDS, STD. RADIUS, 90° HOFFMAN Nº. S-202 OR EQUAL	
9	1	FLEXIBLE CONNECTION, 6" Ø I.D., FLANGED, NEW YORK BLOWER CO. OR EQUAL	
10		ELBOW, 6" BELL ENDS, STD. RADIUS, 90°, HOFFMAN Nº. S-602 OR EQUAL	
11	1	DUST TRAP - J-M STD.	
12	-	DUCT CONSTR. " GAUGE AS NOTED	D-201.1
13	-	ELBOW, RD., " " "	D-202.3-1
E	-	DIRECT CONN'D., OPEN DRIP-PROOF MOTOR	

TOLERANCES
UNLESS OTHERWISE NOTED
FRACTIONAL DIMENSIONS ±
DECIMAL DIMENSIONS ±

41	42	43	44	45	46	47	48	49	50	51	52
	E		T							A	F

MATERIAL LIST AND SYSTEM RATINGS

