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Part IV

Environmental Protection Agency

Friable Asbestos-Containing Materials in Schools; Identification and Notification

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 763

[OPTS 61004B; TSH-FRL 2064-3]

Asbestos; Friable Asbestos-Containing Materials in Schools; Identification and Notification

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: EPA issues this rule to reduce risks to human health from exposure to asbestos-containing materials in school buildings. The rule requires public and private elementary and secondary schools in the United States to identify friable asbestos-containing building materials, maintain records and notify employees of the location of the friable materials which contain asbestos, provide the employees with instructions on reducing exposures to asbestos, and notify the School's parent-teacher association of the inspection results. School districts are encouraged to consult with EPA Regional Asbestos Coordinators when complying with the rule and, where asbestos-containing materials are found, to consult with EPA regarding corrective actions. A school that has already inspected, sampled, and analyzed the friable asbestos-containing material according to the procedures in this regulation need only comply with the recordkeeping and notification provisions of the rule. Schools that determined that they contain no friable asbestos-containing materials prior to the effective date of this rule, need only certify these results and retain the certification statement in their files. Schools need not repeat sampling and analysis under any circumstances.

DATES: This rule becomes effective June 28, 1982. Local education agencies must comply with all portions of this rule by May 27, 1983.

ADDRESS: The public record for this rulemaking is located at Rm. E-107, Environmental Protection Agency, 401 M St. SW., Washington, D.C. 20460, and is open to the public from 8 a.m. to 4 p.m., Monday through Friday, except legal holidays.

FOR FURTHER INFORMATION CONTACT: Douglas G. Bannerman, Acting Director, Industry Assistance Office (TS-799), Office of Toxic Substances, Environmental Protection Agency, Rm. E-511, 401 M St. SW., Washington, D.C. 20460, Toll free: (800-424-9065), In Washington, D.C.: (554-1404), Outside the USA: (Operator—202-554-1404).

EPA has prepared several major support documents for this rule. These documents have been added to the rulemaking record. Copies may be obtained by calling EPA at the telephone numbers given above.

SUPPLEMENTARY INFORMATION: OMB Control Number: (2000-0463).

I. Introduction

The purpose of this rule is to protect users of school buildings from unwitting exposure to concentrations of airborne asbestos which occurs when friable asbestos-containing materials are damaged or disturbed. Compliance with this rule will both ensure that these materials are identified and that school users are notified of their presence so that they can prevent or reduce release of asbestos. This rule is needed because many school districts have not responded adequately to EPA's effort under the Technical Assistance Program (TAP) to encourage schools to identify these materials and notify employees of their presence.

Each local education agency is required to: (1) Inspect all areas of each school building within the agency for friable materials applied to structural surfaces in the building; (2) Take at least three samples of each distinct type of friable material found; and (3) Have those samples analyzed for their asbestos content using polarized light microscopy augmented by x-ray diffraction if necessary. Each local education agency shall also keep a record of the findings of all inspections, sampling, and analyses conducted in accordance with this rule.

After inspection, sampling and analysis have been completed, if a school does not have friable asbestos-containing material, no further action is required. However, in a school with friable asbestos-containing materials, the local education agency is required to inform all employees of the location of these materials and to provide each custodial or maintenance employee with a copy of "A Guide For Reducing Asbestos Exposure". See § 763.111 (b) and (c) of the rule (proposed § 763.6(b)). The parent-teacher groups of schools found to contain friable asbestos-containing materials shall be notified of the presence of friable asbestos. The purpose of notification is to inform people where there is a potential problem from the release of friable asbestos fiber in schools. In order to reduce the costs associated with notification, the Agency has decided not to require notification where there are no friable asbestos materials.

Compliance with these requirements will ensure that potentially hazardous materials are identified and that school users are notified of their presence so that they can reduce or prevent the release of asbestos from them. This should eliminate much unnecessary exposure due to lack of knowledge of the presence of asbestos.

Many of the friable asbestos-containing materials in schools do not require abatement or removal. A reasonable effort by school officials to manage the materials can prevent damage to or deterioration of them and the consequent release of asbestos and exposure of school users. This is particularly the case where access to the materials is limited (e.g., material in a boiler room or behind a false ceiling) and the persons using the area can be instructed to avoid contacting or disturbing the material and to take necessary precautions when their jobs require that they work with the material. EPA strongly recommends that, where a local education agency determines that a management program for friable asbestos-containing material is the most appropriate response, the local education agency should institute a program to advise and educate its employees of the need for caution and proper procedures. Such a management program should also include a provision for periodic reevaluation of the material to determine whether the management program has prevented further damage or deterioration.

Some asbestos-containing materials identified when complying with this rule may be determined to require corrective action such as removal, encapsulation with a sealant which improves the cohesive strength of the material, or enclosure behind a barrier to prevent access. EPA has issued guidance both for identifying materials which should be controlled because of greater exposure potential and for procedures to be used when engaging in corrective activities (see "Asbestos-Containing Materials In School Buildings: A Guidance Document," which can be obtained by calling the toll-free number. Supervisors of public school districts and private schools will be automatically sent the Guidance Document and need not call). Chapter 7 of the Guidance Document lists the factors which should be considered when determining whether to take corrective action.

Abatement is often needed whenever the friable asbestos-containing material is visibly damaged and easily accessible or has inherently poor cohesive strength. Material which is separating from the surface to which it is applied, is separating into layers, or is otherwise

heavily damaged should be considered for removal. If damage is due to water, the cause of the damage (e.g., a roof leak) should also be corrected. Again, the amount of asbestos-containing material requiring abatement compared to the total amount of material in school buildings is small.

Local education agencies which desire assistance in determining an appropriate course of action for particular materials should contact the Asbestos Coordinator at the USEPA Regional Office in their area. The addresses and phone numbers of the Asbestos Coordinators are:

EPA Region I

Asbestos Coordinator
Air and Hazardous Materials Division
JFK Federal Bldg.
Boston, MA 02203
(617) 223-0585

EPA Region II

Asbestos Coordinator
Room 1013
Woodbridge Avenue
Edison, NJ 08837
(201) 321-6668

EPA Region III

Asbestos Coordinator
Curtis Building
Sixth and Walnut Streets
Philadelphia, PA 19106
(215) 597-9859, 597-8663

EPA Region IV

Asbestos Coordinator
345 Courtland Street
Atlanta, GA 30365
(404) 881-3864

EPA Region V

Asbestos Coordinator
230 S. Dearborn St.
Chicago, IL 60604
(312) 886-6003

EPA Region VI

Asbestos Coordinator
First Internat'l Bldg.
1201 Elm Street
Dallas, TX 75270
(214) 767-2734

EPA Region VII

Asbestos Coordinator
324 East 11 Street
Room 1500
Kansas City, MO 64106
(816) 374-6538

EPA Region VIII

Asbestos Coordinator
1860 Lincoln Street
Denver, CO 80295
(303) 837-3928

EPA Region IX

Asbestos Coordinator
215 Fremont Street
San Francisco, CA 94105
(415) 974-8123

EPA Region X

Asbestos Coordinator
1200 Sixth Avenue
Seattle, WA 98101 (206) 442-2888.

Although this rule does not require reporting of information to EPA, school districts are encouraged to contact EPA for assistance. EPA has worked closely with many States in providing training and technical assistance to school districts. The Regional Asbestos Coordinator will provide technical recommendations, provide additional State or local asbestos experts for assistance, or, in some cases, be able to provide training to the local education agency on the factors affecting abatement decisions. EPA is extending the compliance period for this rule by six months to ensure that school districts have sufficient time to consult with the Agency, if desired, after finding asbestos in their schools.

A. Background

"Asbestos" refers to a group of hydrated mineral silicates which readily separate into fibers. Asbestos-containing materials have been used widely for fireproofing, thermal and acoustical insulation, and decoration in building construction and renovation. These materials usually were applied by spraying, but also have been trowelled onto overhead surfaces, steel beams, ceilings, walls, furnaces, and pipes.

Asbestos is a known human carcinogen. Extensive epidemiologic evidence demonstrates that inhalation of asbestos can lead to pleural and peritoneal mesothelioma, lung cancer, asbestosis, and other diseases which are serious, irreversible, and often fatal. Asbestos has been responsible for the premature deaths of many persons who worked with the types of insulating materials now found in some schools.

The potential for release of asbestos fibers from asbestos-containing materials depends in part upon the characteristics of the material which contains the asbestos fibers. Soft, crumbly materials tend to release fibers more easily than do hard, cementitious materials. This regulation addresses friable materials, which are defined as all materials that when dry may be crumbled, pulverized, or reduced to powder by hand pressure.

Asbestos fibers are extremely durable, and their size and shape permit them to remain airborne for long periods of time. Fibers become suspended in the air by disturbance of the friable asbestos-containing materials or deterioration causing the material to release fibers, and by resuspension of previously released fibers that have settled onto floors and other surfaces. Resuspension of asbestos fibers that have settled may result from many different activities, including dusting, sweeping, vacuuming, and even ordinary movement in the vicinity of the settled fibers. This process of release and resuspension of asbestos fibers results in continued dispersal of asbestos fibers throughout the building.

B. EPA's Program

EPA issued a Notice of Proposed Rulemaking in the Federal Register of September 17, 1980 (45 FR 61966) regarding the identification of friable asbestos-containing material in schools. EPA held a public hearing on this proposal on November 17, 1980, and has received comments from 63 parties on the proposal. EPA has analyzed and responded to these comments in "Analysis of Comments on the Proposed Rule for Identification and Notification of Friable Asbestos-Containing Materials in Schools" (hereinafter "Analysis of Comments").

EPA's Science Advisory Board (SAB) reviewed the "Support Document—Asbestos-Containing Materials in Schools—Health Effects and Magnitude of Exposure" (hereinafter "the Technical Support Document") which was published with the proposal and which presents EPA's findings on the risk of exposure to asbestos in schools. The SAB met on December 2-3, 1980, to discuss the document with EPA personnel. The SAB found the risk assessment scientifically credible and made several recommendations for improving the document. EPA has considered these recommendations when preparing the final Technical Support Document published with this rule. The transcript of the meeting and a report of the SAB's recommendations with respect to the document have been added to the rulemaking record.

This final rule implements that proposal, which was made after the Agency had operated a Technical Assistance Program (TAP) for 18 months to help school districts identify and correct potential hazards due to asbestos in schools. The TAP continues to provide assistance to schools. In each EPA Regional office, there is a person to respond to inquiries and help school officials locate necessary services. In addition, each EPA region has a technical advisor, hired and trained

under a grant to the National Retired Teachers Association/American Association of Retired Persons, to assist schools.

A number of comments on the proposal urged EPA not to impose regulations in this area, some arguing that the TAP is sufficient. EPA finds, however, that it is necessary to promulgate this rule because many schools have not been inspected adequately. For example, EPA estimates that 30 percent of the schools in the 11 States in EPA Regions V and VI had not been inspected as of August, 1981. If this proportion applies to the nation as a whole, 33,000 public and private schools remain uninspected. Further, a number of States either have not surveyed their schools at all or have not surveyed their schools adequately, such as the case in one State where analysis of samples looked only for chrysotile asbestos (see Analysis of Comments, pp. 2–3).

In May of 1979, EPA distributed "Asbestos-Containing Materials in School Buildings: A Guidance Document" (hereinafter "the Guidance Document") to school districts across the country. EPA also has prepared "Asbestos-Containing Materials in Schools: Guidance for Asbestos Analytical Programs," which provides additional guidance on taking samples of friable materials and on selecting laboratories to analyze these samples.

General information on EPA's TAP, copies of the Guidance Document, and a list of laboratories may be obtained by telephoning the numbers given above. Finally, EPA operates a toll-free, technical assistance number (800–334–8571, extension 6741) especially for school districts and laboratories which need up-to-date information on analysis, including results of subsequent rounds of the quality assurance program.

Comments on the rule stated that EPA should do more to ensure proper analysis of samples of friable material, perhaps including certification of laboratories or analysis by EPA laboratories. EPA finds that, with the guidance and assistance EPA provides, school districts can obtain satisfactory analysis of their samples when acting in accordance with the requirements of this rule (see Analysis of Comments, pp. 35–38).

C. Education Department Assistance

On May 18, 1980, the U.S. Congress passed the Asbestos School Hazard Detection and Control Act of 1980. In the Federal Register of January 16, 1981 (46 FR 4536), the Education Department (ED) issued rules to implement a Federal grant and loan program under the Act to assist local education agencies in detecting and controlling asbestos hazards. Funds have not been appropriated by Congress for this program.

Comments on EPA's rulemaking suggested that the ED program makes rules under the Toxic Substances Control Act (TSCA) unnecessary. EPA finds, however, that the availability of grants, if funding occurs, to cover one-half the cost of detection programs is not in itself sufficient incentive to ensure that schools will be inspected and school employees notified. Since ED does not have authority to require these actions, EPA is requiring them under TSCA (see Analysis of Comments, p. 2 and p. 7).

II. Legal Authority

TSCA section 6 requires the Administrator to regulate the use of a chemical substance or mixture that the Administrator finds presents an unreasonable risk of injury to human health or the environment. The finding of unreasonable risk involves a balancing of the risk, including the severity and probability of injury, with the adverse effects of possible regulatory action.

If the Administrator finds that a substance presents an unreasonable risk, TSCA section 6(a)(3) authorizes the Administrator to promulgate:

> A requirement that such substance or mixture be marked with or accompanied by clear and adequate warnings and instructions with respect to its use, distribution in commerce, or disposal or with respect to any combination of such activities. The form and content of such warnings and instructions shall be prescribed by the Administrator.

Thus section 6(a)(3) authorizes EPA to require school officials to provide warnings to school employees of the location of asbestos and instructions on how to reduce exposures. In order to determine whether a school is subject to the warning and instruction requirements, school officials will have to inspect for and identify friable asbestos-containing materials; therefore, such inspection and identification are required under this same provision of section 6 by this rule.

III. Findings

This unit summarizes the findings required by TSCA for the Administrator to regulate friable asbestos-containing materials under section 6(a) of TSCA.

A. Findings Required By Section 6(c) of TSCA

This part presents the statement required by section 6(c) of TSCA.

1. *Health effects of and magnitude of exposure to asbestos—*

a. *Health effects.* A detailed discussion of the health effects findings appears in Chapter 3 of the Technical Support Document. Although several comments strongly criticized several aspects of the Agency's proposed findings on the health effects of asbestos (see Analysis of Comments, pp. 9–10), no one contested the finding that exposure to asbestos increases risks of developing asbestosis, pleural and peritoneal mesothelioma, and cancers of the lung, larynx, oral cavity, esophagus, stomach, colon and kidney. Nor did anyone dispute the finding that the effects of exposure to asbestos are serious, irreversible, and often fatal.

EPA emphasizes the strength of the epidemiologic evidence that exposure to asbestos is a cause of cancer. In a major study of over 12,000 asbestos insulation workers, cancers induced by asbestos were responsible for elevating the overall mortality rate by approximately 50 percent. Seventeen percent of all deaths in this group were due to asbestosis, pleural mesothelioma, or peritoneal mesothelioma. These causes of deaths are virtually unheard of in the general population. The International Agency for Research on Cancer has listed asbestos among only 18 chemicals, groups of chemicals, and industrial processes for which the evidence of human carcinogenicity is conclusive.

In addition, EPA finds that adverse health effects of non-occupational exposure to asbestos have been amply demonstrated. Some persons whose only known exposure to asbestos has been from living in the same households as asbestos workers or in the neighborhoods of asbestos mines, mills, and processing facilities have developed mesothelioma and signs of asbestosis (see Technical Support Document, pp. 30–34 and 44–48).

b. *Magnitude of exposure in schools.* EPA finds that the prevailing airborne concentrations of asbestos (concentrations of asbestos present most of the time in occupied areas) in school buildings which have friable asbestos-containing materials are frequently higher than asbestos concentrations in the ambient air. The specific airborne concentration in a given building at a given time depends, however, on such factors as the condition and accessibility of the friable material, the amount of activity, and cleaning methods used in the building.

EPA estimates that the prevailing exposure to asbestos in schools with friable asbestos-containing materials ranges from 57 to 270 nanograms per cubic meter (ng/m^3). Prevalent levels

could become as high as 500 ng/m³ as friable asbestos-containing material further deteriorates or is damaged (see Technical Support Document, pp. 68–74). Several comments questioned EPA's method of estimating prevailing concentrations, noting that the data used came from buildings in Paris and that not all of the available data points were used. EPA has carefully reconsidered these estimates and finds that they are reasonable representations of exposure to asbestos in U.S. schools. Measurements of airborne asbestos in U.S. schools are not significantly different from the Paris data (see Analysis of Comments, pp. 23–25). EPA notes that measurements from Paris were selected from buildings in which friable asbestos-containing materials were exposed and in which there was normal activity, e.g. the simple comings and goings of people, at the time of measurement. These data most closely fit the situation in schools when students are present. Moreover, prevalent concentrations in schools with intact friable materials are not the main concern of this rule.

This rule is addressed to the control of "peak" exposures. Peak exposures can be much in excess of the prevailing concentration of asbestos in buildings and occur during damage, repair, renovation, or cleaning, when the friable asbestos-containing material is contacted, or settled asbestos fibers are resuspended.

Peaks up to 500,000 ng/m³ may be common due to simple maintenance or cleaning chores or to vandalism and other damage (see Technical Support Document, pp. 80–84). This is at least 1000 times higher than the prevalent levels discussed above. Although EPA has documented these high exposure levels and considers them significant, EPA has not been able to quantitatively estimate the contribution which peaks make to cumulative exposure among school children and teachers because of the extreme variability in the occurrence of such peaks.

However, EPA emphasizes that peaks contribute significantly to exposure, even if they occur intermittently and for short periods. As an illustration, a person exposed to a peak of 500,000 ng/m³ for one hour inhales as much asbestos as one exposed to 250 ng/m³ over a full work year. Given that these peak exposures are likely to be repetitive (unless proper precautions are taken), this mode of exposure may predominate.

Currently, an estimated 2,990,000 students and 289,000 teachers and staff, including 17,200 janitors and maintenance personnel, regularly use the 8,600 public schools estimated to have friable asbestos-containing materials in the United States (accurate estimates for non-public schools cannot be made at this time). Many of these persons, especially maintenance personnel, can be exposed regularly to peaks during routine repairs, cleaning, or renovation.

c. *Risks due to exposure in schools.* EPA finds it highly likely that exposure to asbestos in schools may increase the risk of developing numerous types of cancer, most notably pleural and peritoneal mesothelioma and lung cancer. This finding is based on:

(1) Incontrovertible epidemiologic evidence that occupational exposure to asbestos markedly increases the risk of developing several types of cancer and asbestosis.

(2) Evidence that both less intense and briefer exposures to asbestos, as may occur in the neighborhoods of asbestos processors or in the homes of asbestos workers, can produce mesotheliomas and cases of asbestosis in some males.

(3) Demonstrated airborne concentrations of asbestos in buildings with friable asbestos-containing material which can be above urban ambient levels, especially peaks which can exceed occupational standards.

The conclusion that a risk due to exposure in schools can exist is supported by studies that demonstrate a relationship between exposure to asbestos and the risk of cancer resulting from workplace concentrations of airborne fibers.

A key to EPA's assessment of the risk from asbestos exposure in schools is an epidemiologic study which covered more than 12,000 asbestos insulation workers who were exposed to asbestos for at least 10 years and who had survived at least 20 years after first exposure before their mortality experience was observed. The estimate of attributable cancer risk from this study is 7 deaths per 1000 workers per year of observation (7 deaths per 1000 person-years). The attributable risk is the difference between observed and expected death rates for asbestos-induced diseases in an exposed group. This difference represents the number of deaths resulting annually from asbestos exposure in a population of a given size. The 95 percent confidence interval for this estimate (a way of reflecting the role of chance variation) is a range of 6 to 8 deaths per 1000 person-years. The average exposure incurred by these workers is estimated to have been between 100,000 ng/m³ and 500,000 ng/m³ for 20 years.

The cumulative exposure of the insulation workers greatly exceeds exposures expected to occur in schools, especially that of students. EPA has considered plausible models for assessing risk at low levels, including the possibility that a threshold at or above the exposure levels in schools exists and that exposure below this threshold would not increase risk. Based on these considerations, EPA has determined that there is a non-zero risk of cancer due to exposure to asbestos in schools.

Especially important to EPA's assessment of risk are the peak exposures incurred by persons who, perhaps unknowingly, work on friable asbestos-containing material. It would not be unusual for a custodian to receive 10 times the cumulative exposure EPA has estimated for prevailing levels by sustaining peak exposures during normal custodial activities.

Comments on the proposed rule questioned both the estimate of exposure among the insulation workers (0.5–15,000,000 fibers per cubic meter (f/m³)) and EPA's factor for converting fibers to nanograms (30 fibers equal 1 nanogram). The comments stated that exposure among the workers may have been higher than estimated by EPA, so that the risk attributed to the asbestos exposure in schools would be greater than predicted by EPA. EPA finds that its estimated exposure levels are appropriate (see Analysis of Comments, pp. 4–10).

2. *Environmental effects.* Section 6(c) requires the Administrator to state the relevant factors and key considerations which form the basis for regulatory action under section 6(a). This regulation addresses risks to human health. EPA finds that the environmental effects of asbestos exposure are not relevant to this rulemaking, a finding not contested by public comment.

3. *Benefits of asbestos in schools and availability of substitutes.* EPA finds that it is not necessary for this rulemaking to publish a detailed review of the benefits of asbestos use in schools or the availability of substitutes. As noted in the proposal (45 FR 61971), this rule does not require schools to forego the benefits of asbestos, a point upon which there was no public comment.

4. *Economic effects.* This unit presents EPA's determinations of the economic consequences of the regulation as required by section 6(c)(1)(D) of TSCA.

Using data obtained from a variety of sources, EPA computed the unit costs of the major individual actions required by the rule (inspection, sampling and analysis of materials, recordkeeping,

and notification of employees), and estimated the rule's impact on individual schools.

EPA estimates that the overwhelming majority of schools will each spend less than $55 on compliance with the regulation, and that the total cost for all schools will be approximately $4.7 million. Table I presents the average school costs for the required actions. Details on these computations are in the preamble to the Proposed Rule (45 FR 61971) and in Chapters II and III of the "Economic Impact Analysis of the Final Identification and Notification Rule on Friable Asbestos-Containing Materials in Schools," a separate document EPA has entered into the rulemaking record.

TABLE I.—AVERAGE UNIT COSTS

Action	Unit Cost
Familiarization with rule	$10.00
Inspection	21.00
Sampling	25.00
Analysis	150.00
Recordkeeping:	
For schools with friable material	25.00
For schools without friable material	10.00
Certification statement for schools which determine no friable asbestos material prior to rule	5.00
Notification:	
For schools with asbestos	42.50
Recordkeeping (Unit cost for a school district)	20.00

There are approximately 91,000 public and 19,000 private elementary and secondary schools in the country. The 91,000 public schools are organized into about 16,000 school districts. Many schools have already been inspected and, where necessary, have sampled and analyzed friable materials, in response to State programs or to EPA's TAP. These schools will not have to repeat inspections, sampling, and analyses in order to comply with this rule. The number of public and private schools which remain to be inspected is approximately 44,000. EPA estimates that the total number of public and private schools with friable materials may be as high as 14,000.

Table II presents the total estimated cost of compliance.

Several comments on the proposal questioned the cost estimates, stating that the unit costs were either too high or too low, or that the impact analysis should also include the cost of corrective actions, e.g. removal of asbestos, which schools may be forced to take. One comment contested the estimated number of schools with friable asbestos-containing material.

TABLE II.—COMPLIANCE COSTS

Action	Unit cost	Schools affected	Total cost (in thousands)
Familiarization	$10.00	44,000	$440
Inspection	21.00	44,000	924
Sampling	25.00	5,600	140
Analysis	150.00	5,600	840
Recordkeeping:			
For schools with friable material	25.00	14,000	350
For schools without friable material	10.00	38,400	384
Certification statement for schools which determine no friable asbestos material prior to rule	5.00	57,600	288
Notification:			
For schools with asbestos	42.50	10,300	438
Recordkeeping (for school districts and private organizations)	20.00	19,000	380
Total cost			4,184

EPA finds no basis to conclude that the estimates should be changed (see Analysis of Comments, pp. 27–28).

5. *Other EPA statutes.* Section 6(c) of TSCA also requires that if the Administrator determines that a risk of injury to health or the environment could be eliminated or reduced to a sufficient extent by actions taken under another Federal law administered by EPA, the Agency may not promulgate a rule under section 6(a) of TSCA to protect against the risk unless the Administrator finds it is in the public interest to use TSCA. EPA finds no other law administered by the Agency that will enable it to eliminate or reduce the risks against which this rule protects. This proposed finding was not commented on by the public.

B. Findings Required by Section 6(a): Unreasonable Risk

On the basis of the foregoing factual information and on the information in the rulemaking record weighed against the minimal costs imposed by this rule, EPA finds that the presence of unidentified friable asbestos-containing materials in schools and the absence of notice of their presence and of instructions on proper handling and maintenance procedures to reduce exposure constitute an unreasonable risk of injury to school employees. These unreasonable risks can occur when school employees unknowingly disturb friable asbestos materials or such materials are allowed to deteriorate. When activities by school employees disturb or promote deterioration of friable asbestos materials, risk to users of school buildings may be elevated. Therefore, the Agency finds that this rule is needed to prevent such activities as lead to unreasonable risk.

The scientific evidence compiled by EPA demonstrates that asbestos is a human carcinogen. EPA places great weight on an epidemiologic study of a large cohort of asbestos insulation workers who were exposed to the same type of asbestos as that present in schools. The Agency finds it highly significant that, out of a group of over 12,000 persons, approximately one-half of those who died during the time the data were compiled died prematurely as compared to a non-exposed control population.

The study of asbestos insulation workers is especially valid for assessing risks. It covered a relatively large number of persons exposed to materials similar to those in schools. In addition, the study investigated all the known hazards of exposure to asbestos, verified cause of death for most of the cohort, included smoking history data, and compared the mortality rate of the cohort to that of a group selected to avoid confounding factors.

EPA also has substantial evidence of mesothelioma and asbestosis among persons exposed to asbestos because they lived in the same home as an asbestos worker or in the neighborhood of an asbestos plant. EPA has determined that this evidence, especially in light of the large number of persons exposed in schools, justifies imposing the very low cost requirements contained in this rule.

The presence of unidentified friable asbestos-containing materials in school buildings increases significantly the likelihood that peak exposures to asbestos will occur. Peaks will occur during disturbances of the friable material, either accidentally or during repair or renovation operations, and during resuspension of previously released fibers by cleaning and maintenance operations, such as sweeping, dusting, vacuuming, etc., or by general activities in the vicinity of fibers that have settled on floors and other surfaces.

Since peak exposures to asbestos in schools entail risks of serious injuries which may be reduced at extremely low costs, EPA finds that these exposures present an unreasonable risk and should be reduced accordingly.

The 3,600 public schools which EPA estimates contain friable asbestos-containing material employ over 17,000 custodians and other maintenance personnel. These custodians sweep in areas containing friable asbestos. They clean and dust in these areas; they change lights in ceilings covered with friable asbestos-containing materials; they undertake minor repairs and renovations. Without knowing that these areas contain asbestos, these custodians

will continue to undertake normal maintenance activities with no protection against unnecessary exposures, and may consequently risk serious injuries as a result.

Moreover, all of these activities which cause peak exposures further contaminate the building and increase the prevailing concentrations. Sweeping, dusting, and cleaning suspend previously released fibers and disperse them throughout the building. Minor repairs and disturbances to the friable asbestos-containing materials release additional fibers. Both types of activities will increase prevalent concentrations which, in turn, will increase the risk to the larger population of children, teachers, and school administrators who occupy the buildings.

EPA finds that the requirements of this regulation will reduce these risks. School officials and maintenance personnel, once informed of the risks of asbestos and of interim measures to avoid the risks, will act in their own best interests and the interests of school children to reduce the peak exposures as much as possible. If friable asbestos-containing materials in schools are identified, custodians will be able to avoid them during renovation projects and minimize disruptions of them during routine maintenance. If the custodians are provided with information on the use of wetting agents and on proper work practices when conducting necessary repairs and renovations, they will be able to reduce fiber release during such operations and reduce risks to themselves and to others. Instructions on proper cleaning activities in contaminated areas, including wet mopping and wet dusting, will reduce risks caused by unnecessary resuspension of asbestos fibers that would otherwise occur.

Finally, once local school officials know of the presence of friable asbestos-containing materials in buildings, they can take steps to ensure that occupants of the building avoid areas which contain the materials or avoid activities which unnecessarily disturb the materials.

Thus, by identifying friable asbestos-containing materials in school buildings and by implementing specific interim control procedures for reducing exposures, local school officials will reduce the risks of injury resulting from such exposures to school children, custodians, and other building occupants.

In addition to reducing peak exposures, the requirements of the regulation will reduce the prevalent level of fiber concentrations in schools by reducing the frequency of disturbances of the material and resuspension of released fibers. This present inspection regulation will enable school officials to complete the initial steps in a program which may lead to a determination at the local level that removal or abatement is needed and will, in the interim, reduce risks that would otherwise occur.

As reviewed above, the economic impacts of the rule are small. This regulation imposes costs upon all schools, but to varying degrees, as explained in the "Economic Effects" section above. In some instances, e.g. where there are friable materials which must be sampled because they are likely to contain asbestos, costs to individual schools may reach several hundred dollars. These costs are not unreasonable in view of the reduction in exposure to asbestos that will result from this rule. Furthermore, the identification of asbestos in schools, is a prerequisite to making the ultimate abatement determinations at the local level and will, therefore, contribute to the reduction in risk that will result from abatement.

C. Analysis Under Section 9 of TSCA

Section 9(a) of TSCA requires EPA to review other Federal authorities not administered by EPA to determine whether action under those authorities may prevent or sufficiently reduce unreasonable risks. EPA has reviewed other Federal authorities and finds that action under those authorities will not sufficiently reduce the risks addressed by this rule. Specifically, EPA has considered the regulatory authority of the Consumer Product Safety Commission (CPSC), the Occupational Safety and Health Administration (OSHA), and the Education Department (ED).

One comment stated the Agency had not adequately considered the authority of CPSC and ED (see Analysis of Comments, p. 5), a view with which the Agency disagrees. ED is not authorized to require detection of asbestos (the School Asbestos Hazard Detection and Control Act establishes a program to assist school districts financially). Further, as stated in the preamble to the proposal (45 FR 61973), EPA finds that it would be prohibitively difficult to identify companies which could be required to provide notice to schools under the authority of the Consumer Product Safety Act, sections 12 and 15. It is therefore necessary to regulate under TSCA (45 FR 61974).

IV. Discussion of the Rule

This section discusses modifications and clarifications of the rule as a result of public comment on and further analysis of the provisions of the proposed rule. The Agency's detailed analysis of major comments and the response to each are presented in the support document titled "Analysis of Comments," published with this rule and also added to the rulemaking record.

A. Definitions

Section 763.103 of the proposal (now § 763.103) defined various terms used in the regulation (45 FR 61986). The Agency finds that the definitions in the proposed rule are clear and adequate. They appear in § 763.103 of this final rule.

The Agency has received several comments on the definition of "friable material" (see Analysis of Comments, pp. 28–29). After reviewing the comments, EPA has decided to leave that definition unchanged. The operative language of the definition of a friable material is that it "may be crumbled, pulverized, or reduced to powder by hand pressure" (45 FR 61974). EPA stresses that materials rendered nonfriable, as by some methods of encapsulation, are not included under this definition.

B. Inspecting Schools

Regarding § 763.3 of the proposed rule (now § 763.105), "Inspection for friable materials," one comment pointed out that not all schools own the structure they use and may not be able, practically or legally, to take the steps required by the rule. EPA is clarifying the identification requirements in this final rule (§ 763.105) to indicate that local education agencies which lease or use a structure for school purposes must take steps to ensure that the required procedures are carried out, regardless of ownership (see Analysis of Comments, p. 29).

EPA has also changed the description of the inspection process to make it clear that an inspector must touch suspect material to determine whether it is friable.

C. Sampling Friable Materials

Section 763.4 of the proposed rule (now § 763.107) laid out the Agency's sampling requirements (45 FR 61987). The proposed rule stated that three samples must be taken from each area of friable asbestos-containing material (45 FR 61975). Section 763.107 of the rule adopts that requirement. EPA has published "Asbestos-Containing Materials in School Buildings—Guidance for Asbestos Analytical Programs" to provide guidance on a

method for randomly selecting these samples.

Several comments questioned the ability of only three samples to yield reliable results, citing instances where the analytical results from three or more analyses differed greatly. EPA recognizes that there may be instances in which the analysis of three samples of friable materials might produce inconclusive results. As stated in the preamble to the proposal, the requirements for three samples is based on the Agency's finding that most materials can be characterized by three samples and that requiring additional samples for all materials would be an unnecessary expense. Less than three samples, however, cannot accurately characterize the material, and in cases where only one sample was taken, additional samples will be required (see H. Exemptions below). The Agency does not intend to publish any additional rules at this time to address potential problems with sampling but recommends that local officials consult with their Regional Enforcement Office as to the Advisability of taking additional samples in specific instances (see Analysis of Comments, Definitions).

Comments on the proposal questioned whether inspectors could distinguish "sampling areas" from which to take the samples. EPA emphasizes that the definition is meant to provide guidance to inspectors who may find two or more distinct friable materials in a school. If two areas differ in appearance, the rule requires that three samples be taken from each. In this way, inspectors may be able to determine, for example, that one area contains asbestos and that another does not. If all the friable material in a building is homogeneous in appearance, then it should be treated as one sampling area.

EPA is also noting in the rule that the use of respirators is highly recommended when inspecting behind a false ceiling and when taking large numbers of samples of friable materials. One comment suggested respirators be required. EPA finds that sampling may lead to exposures up to 0.1 fibers per cubic centimeter (f/cc) and that the use of respirators during sampling may prevent such exposures. While it is always advisable to avoid unnecessary exposure to asbestos, EPA does not find the evidence sufficient to require the use of respirators (see Analysis of Comments, p. 34).

D. Analyzing Friable Materials

Section 763.5 of the proposal (now 763.109), "Analyzing friable materials," (45 FR 61987) required the use of specific analytical techniques for bulk materials. EPA described the analytical protocol to be followed as "Polarized Light Microscopy (PLM), supplemented where necessary by X-ray Diffraction * * *" This requirement (§ 763.109 of the rule) has not changed. In the preamble to the proposal, the word "supplemented" was accidentally omitted from the discussion of the analytical method (45 FR 61976). The Agency re-emphasizes that PLM is the preferred method, and that X-ray Diffraction is not in itself adequate to identify asbestos.

E. Warnings and Notifications

Section 763.6 of the proposal (now § 763.111), "Warnings and notifications," (45 FR 61987) presented proposals to require posting of a notice of inspection, provision of certain information on asbestos to employees, and direct notification of inspection results to parent-teacher associations. The Agency received comments concerning the duration of the posted warnings for school employees. EPA is dropping the requirement for the posting of notices in schools where there is no friable asbestos-containing material. Because [illegible] have parent-teacher associations [illegible] by [illegible] direct notification [illegible] inducement to perform such associations (see Analysis of Comments, pp. 36–38).

Several comments said that the notice to parents would incite over-reaction, perhaps forcing the removal of materials in good condition. EPA recommends that the notification [illegible] In addition to stating the results of inspections, include the statement: "It is important to note that not all friable asbestos-containing material need be removed from schools. Once such material has been identified, a program can be implemented to ensure that the material is maintained in good condition and that appropriate precautions are followed when the material is disturbed for any reason."

Finally, the content of the "Guide for Reducing Asbestos Exposure" has been changed slightly. Now included are recommendations that water to which a wetting agent has been added be used when asbestos-containing material is to be worked on and that debris from such work be disposed of in plastic bags (see Analysis of Comments, pp. 40–41).

F. Recordkeeping

Sections 763.7 and 763.8 of the proposal dealt with records to be kept by local education agencies (45 FR 61992). EPA is promulgating § 763.114, *Recordkeeping* (proposed § 763.7), without changes. However, the Agency has determined that the proposed § 763.8 *Optional Form*, should be eliminated from the regulation. Despite one comment to the effect that the Optional Form should be mandatory, the Agency finds that the material in the form is unnecessary for this rule.

EPA recommends that local education agencies institute a management system based on these records. The management system should be used to control access to friable asbestos-containing materials, such as when repair work is to be done. Local education agencies can then ensure, before maintenance or renovation is done, that workers are properly protected and that any debris from the work is cleaned up. Local education agencies should also periodically inspect friable asbestos-containing material to determine whether, due to deterioration or damage, the material requires corrective action.

G. Compliance

In § 763.9 of the proposal (now § 763.115), EPA stated the compliance date for the rule and proposed possible penalties for violations (45 FR 61997). Comments on the compliance section of the proposal indicated that some [illegible] aware of exemptions to the rule. To clarify the compliance provision under § 763.115, EPA is reminding local education agencies that they may be eligible for exemptions if they have conducted certain detection activities. Local education agencies are advised to refer to the exemption section.

H. Exemptions

Section 763.10 of the proposal (now § 763.117), provided exemptions to local education agencies which had undertaken certain activities (45 FR 61997). EPA has changed the exemptions section. The proposal exempted from §§ 763.2, 763.4, and 763.5 (now §§ 763.102, 763.107, and 763.109) schools in which past activities in compliance with the inspection, sampling and analysis provisions of the rule had been conducted (45 FR 61977). This exemption is adopted in § 763.117. EPA is now also exempting schools built after December 31, 1978 from all provisions of the rule because the application of friable asbestos-containing material was banned by EPA by that date. Little purpose would be served by inspecting these schools and keeping records of (presumably) negative findings.

However, EPA has decided that the exemption of past actions in compliance with the recommendations for inspections and sampling under the TAP is too broad in one respect: where a

finding of "no asbestos" is based on analysis of less than three samples of the friable material, EPA will require that the material be resampled in accordance with the rule. Less than three samples may have been analyzed in some schools because there were less than 15,000 square feet of friable materials which, according to TAP guidance to take one sample per 5,000 square feet, would have required only one or two samples.

This revision is made because, when the true asbestos content of a material is low, the analysis of only one or two samples may not detect asbestos. Some low content materials may have been incorrectly classified as nonasbestos merely because the one or two samples analyzed were taken from spots in which poor mixing of the original material resulted in very little asbestos being present. EPA finds that a total of three samples are necessary to provide a high degree of certainty that any asbestos present throughout the sampling area is detected. This revision should not affect the majority of schools which have already taken samples because many have more than 15,000 square feet of materials (and therefore took at least three samples) and many others have taken more samples than recommended under the TAP.

In addition, EPA has decided to specifically exempt from the inspection, sampling, analysis, notification and recordkeeping requirements schools which can meet one of two criteria. These criteria are: (1) Schools which, prior to the effective date of ths rule, have inspected, sampled and analyzed according to the procedures in this rule, and found no friable asbestos-containing materials. The school record must contain a copy of all laboratory reports, and all correspondence with laboratories, (letters discussing analyses, results, etc); (2) Schools that can document that, at the time of construction, modification, or renovation, no friable asbestos-containing building materials were used. To qualify for these exemptions, a school must keep the supporting records and a certification statement signed by the person responsible for compliance. The certification, found in § 763.117 of this rule, must state that, to the best of the official's knowledge, the school does not contain friable asbestos-containing materials.

The Agency is concerned that education agencies fully understand the exemption for schools which can document that no friable asbestos-containing building materials were used at the time of construction, modification, or renovation. The utility of building records often is extremely limited because the records are incomplete, if available at all. Records may indicate that a fireproofing spray was used without indicating its content, or they may incorrectly state that a material has asbestos when some other fiber was substituted during application. The records used as documentation for this exemption must clearly indicate that no friable asbestos-containing materials were used. For example, EPA's experience from the Technical Assistance Program was that architectural plans are insufficient documentation in themselves if they only state that asbestos-containing materials should not be used. Therefore, unless the records clearly show that the friable materials themselves used during construction, modification, or renovation did not include asbestos, a school should not consider the records sufficient jusitification to qualify for the exemption.

Schools in which school officials decided to treat friable materials as though they contain asbestos are also exempt from the inspection sampling and analysis requirements of this rule. EPA requires that, where a positive finding of asbestos is based either on records or on only one or two samples, local education agencies should take up to three samples. This will provide greater certainty and perhaps eliminate unnecessary treatment of nonasbestos materials.

One comment on the proposed rule pointed out wide variation in analytical results from three laboratories analyzing split samples of several friable materials. Analyses were apparently done prior to EPA's preparation of an interim analytical protocol for PLM (in mid-1980), and there is some question about the ability of the three laboratories to properly detect asbestos. EPA will not require that all analyses done before the protocol was prepared be repeated. However, EPA strongly recommends that school districts review their information on all earlier analyses' results to determine whether proper techniques were used.

The Agency has also determined that, in a school where previously discovered friable asbestos-containing material has been removed or satisfactorily encapsulated so that it is no longer friable, the provisions of this rule should not apply. By undertaking these corrective actions, school officials not only will have substantially complied with the identification requirements, they will also have removed the types of materials which are the focus of the recordkeeping and notification parts of this rule.

V. Export Reporting

Section 12(b)(2) of TSCA requires any person who exports or intends to export a chemical substance for which a rule exists under TSCA section 6 to notify the Administrator of such export or intent to export. This requirement applies to export of bulk asbestos and asbestos in mixtures which must be processed or fabricated before further distribution in commerce.

Regulations regarding this requirement were published in the Federal Register of December 18, 1980 (45 FR 82844). EPA issued a clarification on these requirements in the Federal Register of July 21, 1981 (46 FR 37609).

Notices shall be sent to: Document Control Officer, TS-793, Office of Pesticides and Toxic Substances, Environmental Protection Agency, 401 M St., SW., Washington, D.C. 20460.

VI. Rulemaking Record

EPA has established a Public Record for this rulemaking (docket number OPTS 61004) which along with a complete index is available for inspection in the OPTS reading room from 8:00 a.m. to 4:00 p.m., Monday through Friday, excluding legal holidays, at 401 M Street SW., Washington, D.C. The record was listed in the preamble to the proposed rule (45 FR 81980), and is hereby incorporated. Documents and letters have been added to appropriate sections of the record as listed below under each section's title:

E. Comments on the Proposal

The Agency received 45 main comments and 11 reply comments on the proposed rule.

G. Support Documents

1. USEPA, OPTS, OTS. Support Document for Final Rule on Friable Asbestos-Containing Materials in School Buildings—Health Effects and Magnitude of Exposure. Draft. August 3, 1981.

2. USEPA, OPTS, OTS. Support Document—Asbestos-Containing Materials in Schools—Health Effects and Magnitude of Exposure. Final Rule. January, 1982.

3. USEPA, OPTS, OTS. Support Document—Economic Impact Analysis of the Final Identification and Notification Rule on Asbestos-Containing Materials in Schools. January, 1982.

4. USEPA, OPTS, OTS. Analysis of Comments on Proposed Rule for Identification and Notification of

Asbestos-Containing Materials in Schools. January, 1982.

J. Other Federal Register Notices

1. 45 FR 61950. Department of Education. Asbestos Detection and Control: Local Educational Agencies; Asbestos Detection and State Plan: State Educational Agencies (September 17, 1980).

2. 46 FR 4536. Department of Education. Asbestos Detection and Control: Local Educational Agencies; Asbestos Detection and State Plan: State Educational Agencies; Final Regulations. (January 16, 1981).

K. USEPA News Releases

1. USEPA. "EPA Adopts Interim Cancer Assessment Procedures." (May 19, 1976).

L. Reports

1. Albert RE, Train RE, Anderson E. "Rationale Developed by the Environmental Protection Agency for the Assessment of Carcinogenic Risks." *JNCI.* 58 (1977): 1537–1541.

2. Atkins Research and Development. *Asbestos: Review Of Uses, Health Effects, Measurement and Control.* Epsom Surrey, England. (January 1977.)

3. Auerbach O, Conston A, Garfinkel L, Parks V, Kaslow HD, Hammond EC. "Presence of Asbestos Bodies in Organs Other Than the Lung." *Chest.* 77 (1980): 133–137.

4. Baris YI, Artvinli M, Sahin AA. "Environmental Mesothelioma in Turkey." *Ann NY Acad Sci.* 330 (1979): 423–432.

5. Churg A, Warnock ML. "Asbestos Fibers in the General Population." *Am Rev Respir Dis.* 122 (1980): 669–678.

6. Commission of European Communities. *Public Health Risks of Exposure to Asbestos: Report of a Working Group of Experts Prepared for the CEC, Directorate-General for Social Affairs, Safety and Health Directorate.* (1977): Elmsford, NY: Pergamon Press.

7. Corn M. "Sampling Strategy, Air Sampling Methods Analysis, and Airborne Concentrations of Fibrous Glass in Selected Manufacturing Plants." Paper presented at the Symposium on Occupational Exposure to Fibrous Glass held on 26–27 June 1974. Sponsored by the National Institute for Occupational Safety and Health, College Park, Maryland (1976): 91–96.

8. Davis JMG. "The Use of Animal Inhalation Experiments in the Study of Asbestos Bioeffects." *Staub-Reinhalt. Luft.* 40 (1980): 453–455.

9. Elmes PC, Simpson MJC. "Insulation Workers in Belfast. Mortality 1940–66." *Brit J Ind Med.* 28 (1971): 226–236.

10. Gehring PJ, Watanabe PG, Blau GE. "Risk Assessment of Environmental Carcinogens Utilizing Pharmacokinetic Parameters." *Ann NY Acad Sci.* 329 (1979): 137–152.

11. Harries, PG. "A Comparison of Mass and Fibre Concentrations of Asbestos Dust in Shipyard Insulation Processes." *Am. Occup. Hyg.* 14 (1971): 235–40.

12. Hinds MW. "Mesothelioma in the United States: Incidence in the 1970's." *J Occup Med.* 20 (1978): 469–471.

13. Hinds MW, Thomas DB, O'Reilly HP. "Asbestos, Dental X-Rays, Tobacco, and Alcohol in the Epidemiology of Laryngeal Cancer." *Cancer.* 44 (1979): 1114–1120.

14. Hirsch A, Bignon J, Sebastien P, Gaudichet A. "Asbestos Fibers in Laryngeal Tissues: Findings in Two Patients with Asbestosis Associated with Laryngeal Tumors." *Chest.* 76 (1979): 697–699.

15. Hurst GA, Spivey CG, Matlage WT, Miller JM, Faulk G, Hieger LR, McLarty JW, Greenberg SD. "The Tyler Asbestos Workers Program. I. A Medical Surveillance Model and Method." *Arch Environ Health.* 34 (1979): 432–439.

16. Knelson JH. "Problem of Estimating Respiratory Lead Dose in Children." *Environ Health Perspect.* 7 (1974): 53–57.

17. Knox JF, Holmes S, Doll R, Hill ID. "Mortality from Lung Cancer and Other Causes Among Workers in an Asbestos Textile Factory." *Brit J Ind Med.* 25 (1968): 293–303.

18. Lakowicz JR, Bevan DR, Riemer SC. "Transport of a Carcinogen, Benzo[a]Pyrene, from Particulates to Lipid Bilayers: A Model for the Fate of Particle-Absorbed Polynuclear Aromatic Hydrocarbons Which Are Retained in the Lungs." *Biochemica et Biophysica Acta* 629 (1980): 243–258.

19. McDonald JC. "Asbestos and Lung Cancer: Has the Case Been Proven?" *Chest.* 78:2 (1980): 374–376. (Supplement).

20. McDonald JC, Liddell FDK, Gibbs GW, Eyssen GE, McDonald AD. "Dust Exposure and Mortality in Chrysotile Mining, 1910–75." *Br J Ind Med.* 37 (1980): 11–24.

21. McMillan GHG, Pethybridge RJ, Sheers G. "Effect of Smoking on Attack Rates of Pulmonary and Pleural Lesions Related to Exposure to Asbestos Dust." *Brit J Ind Med.* 37 (1980): 268–272.

22. NAS, Committee on BEAP. *Asbestos: the Need for and Feasibility of Air Pollution Controls.* (1971): Washington, D.C. ISBN 0–309–01927–3.

23. Newhouse ML, Berry G. "Asbestos and Laryngeal Carcinoma" (letter). *Lancet.* (1973): 615.

24. Peto J. "Dose-Response Relationships for Asbestos-Related Disease: Implications for Hygiene Standards. Part II. Mortality." *Ann NY Acad Sci.* 330 (1979): 195–203.

25. Pooley FD. "Methods for Assessing Asbestos Fibers and Asbestos Bodies in Tissue by Electron Microscopy." In: Bogovski P, Gilson JC, Timbrell V, Wagner JC, eds. *Biological Effects of Asbestos.* (1973); WHO, IARC. Lyon, France.

26. Roggli VL, Greenberg SD, McLarty JL, Hurst GA, Spivey CG, Hieger LR. "Asbestos Body Content of the Larynx in Asbestos Workers: A Study of Five Cases." *Arch Otolaryngol.* 106 (1980): 533–535.

27. Rohl AN, Langer AM, Wolff MS, Weisman I. "Asbestos Exposure During Brake Lining Maintenance and Repair." *Environ Res.* 12: (1976) 110–128.

28. Rubino GF, Newhouse, M, Murray R, Scansetti G, Piolatto G, Aresini G. "Radiologic Changes after Cessation of Exposure Among Chrysotile Asbestos Miners in Italy." *Ann NY Acad Sci.* 330 (1979): 157–161.

29. Selikoff IJ, Hammond EC, Seidman H. "Latency of Asbestos Disease among Insulation Workers in the United States and Canada." *Cancer* 46 (1980): 2736–2740.

30. Selikoff IJ, Seidman H, Hammond EC. "Mortality Effects of Cigarette Smoking Among Amosite Asbestos Factory Workers." *JNCI* 65 (1980): 507–513.

31. Stopford W, Bundy SD, Goldwater LJ, Bittikofer JA. 1978. "Microenvironmental exposure to mercury vapor." *Am Ind Hyg Assoc J.* (1978) 39: 378–384.

32. USDHEW, PHS, CDC. "Survey of Teenage Smokers—United States, 1979." In: *Morbidity and Mortality Weekly Reports.* 28: 18 (1979): 206.

33. USDHEW, PHS, NCHS! *Vital Statistics of the United States, 1976.* Volume II—Mortality, Part A, Section 5, Table 5–3. (1980): Hyattsville, MD.

34. USDHEW, PHS, NIH. *Epidemiologic Analysis With A Programmable Calculator.* NIH Pub. #79–1649. (June 1979): Washington, D.C.

35. USDHEW, PHS, OHRST, NCHS. *Use Habits Among Adults of Cigarettes, Coffee, Aspirin, and Sleeping Pills: United States, 1976.* DHEW Pub. # (PHS) 80–1559. (October 1979): Hyattsville, MD.

36. USEPA, OTS, OTE. *Risk Assessment of Asbestos in Schools.* May 21, 1980. Life Systems, Inc.

37. USEPA, OPTS, OTS, EED. *Asbestos-Containing Materials in School Buildings: Bulk Sample Analysis*

Quality Assurance Program. Round Two. EPA 560/5–81–001. (March 1981.)

38. USEPA, OPTS, OTS, EED. *Characteristics of the Asbestos Exposure Assessment Algorithm.* Draft as prepared by RTI [November 1980].

39. USEPA, SAB. *Review of "Technical Support Document for Regulatory Action Against Friable Asbestos-Containing Materials in School Buildings" (Draft dated September 1980).* A report of the Toxic Substance Subcommittee EPA/SAB/81/001. (February, 1981) Washington, D.C.

40. Weill H, Hughes J, Waggenspack C. "Influence of Dose and Fiber Type on Respiratory Malignancy Risk in Asbestos Cement Manufacturing." *Am Rev Respir Dis.* 120 (1979): 345–354.

41. WHO, IARC. "An Evaluation of Chemicals and Industrial Processes Associated with Cancer in Humans Based on Human and Animal Data: IARC Monographs 1 to 20." *Cancer Research.* 40 (1980): 1–12.

N. Written Communications

1. State of Hawaii, Department of Health. Letter from MK Kolzum, D.D. for Env. Health, to John Ritch, Jr. Director, IAO, OTS USEPA. Subject: Response to J. Ritch's notice of May 15, 1981 re: Conference on Encapsulation of Asbestos-Containing Material. (05/22/81). With Enclosure—State of Hawaii, DOH, et al., *Report on House Resolution #358. Requesting a Report on the Status of Efforts to Remedy the Problem of Asbestos-Containing Materials in the Public Schools and Related Health Risks.* 10th Legislature, State of Hawaii, 1980.

2. Letter from T.S. Hardy, Kirkland and Ellis, Counsel for AIA. To E.A. Klein, Esq. Subject: Friable Asbestos-Containing Materials in Schools; Proposed ID, (specifically Quantitative Risk Assessment). (06–16–81).

Any person wishing to notify EPA of any errors or omissions in the rulemaking record must do so before the effective date of this rule.

VII. Executive Order 12291

Under Executive Order 12291, EPA must judge whether a regulation is "Major" and therefore subject to the requirement of a Regulatory Impact Analysis. This regulation is not major because: the overall economic impact of the rule is under $6 million; it imposes only a small increase in costs on the schools affected by the rule; and it has no adverse impact on competition, employment, investment, innovation, or on the ability of U.S.-based enterprises to compete with foreign-based enterprises in domestic or export markets.

This regulation was submitted to the Office of Management and Budget (OMB) for review as required by Executive Order 12291.

VIII. Paperwork Reduction Act

The Paperwork Reduction Act of 1980, 44 U.S.C. 3510 *et seq* (the "Act"), authorized the Director of the OMB to review certain information collection requests by Federal agencies. EPA has determined that the recordkeeping and reporting requirements of this rule constitute a "collection of information" as defined in 44 U.S.C. 3502(4). In accordance with the Act, the recordkeeping and reporting of this rule has been reviewed by OMB and the Federal Education Data Acquisition Council. The OMB control number is (2000–0483).

List of Subjects in 40 CFR Part 763

Environmental protection, Hazardous materials, Recordkeeping and reporting requirements, Asbestos.

Dated: May 21, 1982.

Anne M. Gorsuch,

Administrator.

Therefore, Chapter I of Title 40 of the Code of Federal Regulations is amended by adding a new Part 763 consisting at this time of Subpart F to read as follows:

PART 763—ASBESTOS

Subparts—A—E [Reserved]

Subpart F—Friable Asbestos-Containing Materials in Schools

Sec.

Authority: Sec. 6 of the Toxic Substances Control Act, Pub. L. 94–469, 90 Stat. 2020 (15 U.S.C. 2605).

Subparts—A–E [Reserved]

Subpart F—Friable Asbestos-Containing Materials in Schools

§ 763.100 Scope and purpose.

(a) This rule requires local education agencies to identify friable asbestos-containing material in public and private schools by visually inspecting school buildings for friable materials, sampling such materials, and having samples analyzed by appropriate techniques referred to in the rule. In addition, the rule requires local education agencies to post a notice of the results of inspections and analyses. The rule requires local education agencies to provide warnings on the health effects of asbestos and instructions on methods to avoid or reduce exposure to school employees of any school with friable asbestos-containing material and to notify parent-teachers associations of the results of inspections. The rule also includes recordkeeping requirements. Local education agencies may contractually delegate their duties under this rule, but they remain responsible for the proper performance of those duties. Local education agencies are encouraged to consult with EPA Regional Asbestos Coordinators for assistance in complying with this rule.

(b) The addresses and telephone numbers of the EPA Regional Asbestos Coordinators are:

(1) EPA Region I

Asbestos Coordinator
Air and Hazardous Materials Division
JFK Federal Bldg.
Boston, MA 02203
(617) 223–0585

(2) EPA Region II

Asbestos Coordinator
Room 1013, Woodbridge Avenue
Edison, NJ 08837
(201) 321–6668

(3) EPA Region III

Asbestos Coordinator
Curtis Building
Sixth and Walnut Streets
Philadelphia, PA 19106
(215) 597–8859, 597–8683

(4) EPA Region IV

Asbestos Coordinator
345 Courtland Street
Atlanta, GA 30365
(404) 881–3864

(5) EPA Region V

Asbestos Coordinator
230 S. Dearborn St.
Chicago, IL 60604
(312) 886–6003

(6) EPA Region VI

Asbestos Coordinator
First Internat'l Bldg.
1201 Elm Street
Dallas, TX 75270
(214) 767–2734

(7) EPA Region VII

Asbestos Coordinator
324 East 11 Street
Room 1500

Kansas City, MO 64106
(816) 374–6538

(8) EPA Region VIII

Asbestos Coordinator
1860 Lincoln Street
Denver, CO 80295
(303)\837–3926

(9) EPA Region IX

Asbestos Coordinator
215 Fremont Street
San Francisco, CA 94105
(415) 974–8123

(10) EPA Region X

Asbestos Coordinator
1200 Sixth Avenue
Seattle, WA 98101
(206) 442–2888

§ 763.103 Definitions.

For the purposes of this part:

(a) "Act" means the Toxic Substances Control Act (TSCA), 15 U.S.C. 2601, et seq.

(b) "Asbestos" means the asbestiform varieties of: chrysotile (serpentine); crocidolite (riebeckite); amosite (cummingtonite-grunerite); anthophyllite; tremolite; and actinolite.

(c) "Asbestos-containing material" means any material which contains more than 1 percent asbestos by weight.

(d) "Friable material" means any material applied onto ceilings, walls, structural members, piping, ductwork, or any other part of the building structure which, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure.

(e) "Local education agency" means:

(1) Any local education agency as defined in section 198(a)(10) of the Elementary and Secondary Education Act of 1965 (20 U.S.C. 2854).

(2) The governing authority of any nonprofit elementary or secondary school, where the term "nonprofit" means owned and operated by one or more nonprofit corporations or associations no part of the net earnings of which inures, or may lawfully inure, to the benefit of any private shareholder or individual.

(f) "Sampling area" means any area, whether contiguous or not, within a school building which contains friable material that is homogeneous in texture and appearance.

(g) "School" means any public or private day or residential school that provides elementary or secondary education for grade 12 or under as determined under State law, or any school of any Agency of the United States.

(h) "School buildings" means:

(1) Structures used for the instruction of school children, including classrooms, laboratories, libraries, research facilities and administrative facilities.

(2) School eating facilities, and school kitchens.

(3) Gymnasiums or other facilities used for athletic or recreational activities, or for courses in physical education.

(4) Dormitories or other living areas of residential schools.

(5) Maintenance, storage, or utility facilities essential to the operation of the facilities described in subparagraphs 1 through 4 of this paragraph.

(i) "Use of asbestos" means the presence of asbestos-containing material in school buildings.

§ 763.105 Inspection for friable material.

(a) Local education agencies shall inspect each school building which they lease, own, or otherwise use as a school building, to locate all friable material.

(b) This inspection shall consist of looking for and touching all suspect materials, including surfaces behind suspended ceilings or other non-permanent structures which may be entered during normal building maintenance or repairs. For further information on inspection procedures, officials should consult Chapter 5 of "Asbestos-Containing Materials in School Buildings: A Guidance Document," Part 1 (EPA no. 560/080). Particular attention should be paid to the recommendation regarding respirators. Copies of the document can be obtained by calling 800–424–9065 (in Washington, D.C. call 554–1404).

§ 763.107 Sampling friable material.

(a) If friable materials are found in a school building, local education agencies shall identify each distinct sampling area of friable materials within the school building, take at least three samples from locations distributed throughout the sampling area, and label each sample container with a sample identification number unique to the sampling location and building.

(b) Officials should consult "Asbestos-Containing Materials in School Buildings: A Guidance Document," Part 1, Chapter 5, for further information on sampling procedures. The requirement that three samples be taken in each sampling area supersedes the recommendation made in the Guidance Document to take one sample per 5000 square feet of friable material.

(c) Sampling locations should be randomly distributed within the sampling; the locations should not be selected simply for convenience or ease of reaching the sample, or because the sampler judges the location to be representative. Samples shall be taken using small sealable containers; samples shall penetrate the depth of the friable material to the substrate.

§ 763.109 Analyzing friable material.

Local education agencies shall have all samples of friable material analyzed for asbestos using Polarized Light Microscopy (PLM), supplemented where necessary by X-ray Diffraction, in accordance with "Interim Method for the Determination of Asbestiform Minerals in Bulk Insulation Samples," which is found under appendix A of this Subpart. Persons interested in analyzing bulk samples for asbestos can obtain copies of the document by calling 800–424–9065 (in Washington, D.C., call 554–1404). A list of laboratories capable of conducting analyses of friable materials can be obtained by calling 800–334–8571, extension 6741. Officials should consult "Asbestos-Containing Materials in School Buildings: A Guidance Document," Part 1, Chapter 6, for further information on analysis of friable materials.

§ 763.111 Warnings and notifications.

(a) Local education agencies shall post in the primary administrative and custodial offices and in the faculty common rooms of each school under their authority a completed copy of the following Notice to School Employees unless no friable asbestos-containing material is present in the school. The notice shall remain posted indefinitely in any school which has friable asbestos-containing material.

BILLING CODE 6560-38-M

NOTICE TO SCHOOL EMPLOYEES

In accordance with EPA regulations, this school has been inspected for friable (easily crumbled) materials which contain asbestos. Friable asbestos-containing material may cause health problems.

Friable asbestos-containing material is present in

_____
(Name of School)

A record of the inspection, a diagram of the location(s) of friable asbestos-containing materials, and a copy of relevant EPA regulations are available in

Building	Room

For further information, interested persons should call 800-424-9065 (554-1404 in the Washington, DC area).

Signed:

_____
(Name)

_____
(Title)

_____
Date

EPA Form 7730-3 (6-82)

BILLING CODE 6560-50-C

(b) Local education agencies shall provide to all persons employed in school buildings under their authority which contain friable asbestos-containing materials a written notice of the location, by room or building area, of all friable asbestos-containing materials in the school.

(c) The following information on interim procedures to reduce exposures, "A Guide for Reducing Asbestos Exposure," shall be provided to all custodial or maintenance employees:

BILLING CODE 6560-50-M

A GUIDE FOR REDUCING ASBESTOS EXPOSURE

PURPOSE

Your school building contains materials which contain asbestos and may release fibers into the air. Breathing asbestos fibers is dangerous. This fact sheet tells how to reduce exposure to asbestos fibers. Please read it carefully.

PROTECTING YOURSELF FROM ASBESTOS

Some of the friable building materials in your school contain asbestos. Friable asbestos-containing materials crumble easily and release fibers into the air. Breathing these fibers may cause cancer and other diseases. The more asbestos you breathe, the greater your chances are of getting disease. You can take precautions that will reduce or eliminate the risk of being exposed to asbestos.

Find out from your supervisor where these friable asbestos-containing materials are in your building. Do not touch or disturb them unless you have to. If you must handle an asbestos-containing material, first lightly spray it with water. (EPA recommends using water which contains wetting agents, if they are available.) Wet asbestos-containing materials will not release as many fibers.

Even if friable asbestos-containing materials are not disturbed, they may release asbestos fibers, which will fall slowly to the floor. If you are cleaning in areas which contain these materials, do not use a broom: it will stir the fibers into the air. Do not use a vacuum cleaner unless it is equipped with a High Efficiency Particulate Absolute filter. The fibers are so small they can pass through an ordinary vacuum cleaner and out into the room.

When cleaning in areas which contain friable asbestos-containing materials, use dampened mops and dustcloths. Dampened mops and dustcloths will hold the fibers much better than dry mops and dustcloths, and will reduce the number of fibers put back into the air. It is best to use mops with disposable heads and to throw away the mop head after use. Otherwise fibers will be released as the mop dries. Use either lightly dampened mops or cloths or a vacuum with a High Efficiency Particulate Absolute filter to clean areas where wet mopping cannot be used (such as carpeting or hardwood floors).

Clean tables and chairs in the area with damp cloths. Do not dust them with brushes or with dry cloths, and do not vacuum them.

After you use the mop heads and cloths, put them in a plastic bag while they are still wet. Dislodged materials should also be placed in plastic bags for disposal.

A LIST OF IMPORTANT POINTS TO REMEMBER

1. Do not handle or disturb friable asbestos containing materials unless necessary.

2. If you must handle asbestos-containing materials, wet them first.

3. If you must disturb asbestos (for example, to repair a light), see your supervisor before starting work. Then;

   a. Place a plastic dropcloth below the work area.

   b. Spray asbestos-containing material with water before you disturb it.

   c. Make sure that only those persons who are necessary for the job are in the area.

   d. Put all the asbestos you remove into a heavy plastic bag. Seal the bag and discard it.

   e. After the job, clean all the ladders and tools you used with a wet cloth.

   f. Roll up the dropcloth carefully and put it in a plastic bag. Discard the bag.

   g. Clean the floor below the work area with a wet mop.

   h. Put the mop head and the cloth used to clean the ladders in a plastic bag while they are still wet, seal the bag, and discard it.

4. If you must disturb or remove large sections of asbestos-containing material, see your supervisor before you begin. The National Institute for Occupational Safety and Health recommends that a respirator approved for toxic dusts be worn during such work.

You should make arrangements to turn off the school's ventilation system if you are disturbing or removing large sections of asbestos-containing material. The ventilation system should remain off until the work is completed and the area has been cleaned.

EPA Form 7730-2 (6-82)

BILLING CODE 6560-50-C

(d) Local education agencies shall provide notice of the results of inspections and analyses in each school in which friable asbestos materials are found to the appropriate parent-teacher association of that school. If there is no parent-teacher association for the school, the local education agency shall notify directly the parents of its pupils.

§ 763.114 Recordkeeping.

(a) Local education agencies shall compile and maintain in the administrative office of each school under their authority a record which shall include:

(1) The name and address of the school.

(2) A list of all school buildings associated with the school, indicating whether each building has been inspected for friable materials in compliance with § 763.105, and which buildings contain friable materials.

(3) Copies of the Notice to School Employees, found in § 763.111(a).

(4) For each school building which contains friable materials:

(i) A blueprint, diagram, or written description of the building which identifies clearly the location(s) and approximate area(s) in square feet of each sampling area of such material(s), the locations at which samples were taken, and the identification number of each sample, and which shows or describes clearly whether each sampling area of friable material contains asbestos, including an estimate of its percent asbestos content as determined by calculating the average of the percent asbestos contents of all samples taken in that area.

(ii) A copy of all laboratory reports and all correspondence with laboratories concerning the analysis of samples taken in accordance with § 763.107.

(5) If the school contains friable asbestos-containing materials, copies of the "Guide for Reducing Asbestos Exposure" contained in § 763.111(b), and one copy of "Asbestos-Containing Materials in School Buildings: A Guidance Document," Parts 1 and 2 (EPA No. C00090), which can be obtained by calling 800-426-4808.

(6) A statement that the requirements of the rule have been satisfied signed by the person responsible for compliance with the rule and including the date and the person's name and title.

(b) Each local education agency shall retain in the administrative office of the agency:

(1) A list of all schools under its authority, indicating whether schools were inspected in accordance with § 763.105, and which schools contain friable materials.

(2) A record of the friable materials in schools which were sampled and analyzed in accordance with §§ 763.107 and 763.109, indicating which materials contain asbestos.

(3) For each school which contains friable asbestos-containing materials, the total area of such materials in square feet, and the total number of school employees who regularly work in the school.

(c) *Form.* Each local education agency shall complete and retain in the administrative office of the local education agency the following form "Inspections for Friable Asbestos-Containing Materials."

BILLING CODE 6560-50-M

INSPECTIONS FOR FRIABLE ASBESTOS-CONTAINING MATERIALS

1. Please provide the following information about the local education agency:

NAME OF AGENCY	
CITY	COUNTY
STATE	ZIP CODE

Please fill in the following information about the schools under the authority of this local education agency:

2. The number of schools which have been inspected for friable materials in accordance with §763.105 of Title 40 of the Code of Federal Regulations.	
3. The number of schools where friable materials are present.	

If the answer to question 3 is none, disregard questions 4 — 7 and go on to the certification. Otherwise, fill in the following information about the schools enumerated in question 3:

4. The number of schools in which all friable materials have been sampled and analyzed in accordance with §§763.107 and 763.109 of Title 40 of the Code of Federal Regulations.	
5. The number of schools with friable material(s) that contain(s) asbestos.	

If the answer to question 5 is none, disregard questions 6 — 7 and go on to the certification. Otherwise, fill in the following information about the schools enumerated in question 5.

6. The total area in square feet of all friable asbestos-containing materials found in these schools.	
7. The total number of school employees who regularly work in schools where friable asbestos-containing materials are present.	

CERTIFICATION: Please read and sign below the following statement:

I hereby certify that this local education agency has complied with the EPA regulation 40 CFR 763.100 through 763.117, "Asbestos-Containing Materials in Schools Identification and Notification," and that the information on this form is, to the best of my knowledge, true and complete.

SIGNATURE	TYPED OR PRINTED NAME
TYPED OR PRINTED TITLE	DATE

Additional forms can be obtained by calling 800-424-9065 (554-1404 in the Washington, DC area).

EPA Form 7730-1 (6-82)

BILLING CODE 6560-50-C

CS014 2493

§ 763.115 Compliance.

(a) Local education agencies shall comply with all parts of this regulation by May 27, 1983. Local education agencies that have already conducted detection activities should consult § 763.117 *Exemptions.*

(b) Actions undertaken by municipal or State officials on behalf of local education agencies as a part of a municipal or State school asbestos program shall constitute compliance with this regulation to the extent that such actions conform to the requirements of this regulation.

(c) Section 15(1) of TSCA (15 U.S.C. 2614) makes it unlawful for any person to fail or refuse to comply with any rule promulgated or order issued under section 6 of TSCA (15 U.S.C. 2605). Thus, failure to comply with any aspect of this rule constitutes a violation as defined by section 15(1) of TSCA.

(d) Section 16(a) of TSCA (15 U.S.C. 2615) provides that any person who violates any provision of section 15 shall be liable to the United States for civil penalties. If a violation is knowing or willful, criminal penalties may also be assessed. Under section 17 of TSCA (15 U.S.C. 2616), the Agency may take injunctive action to restrain persons from violating a rule promulgated under section 6 of TSCA.

§ 763.117 Exemptions.

(a) *Schools that were inspected, sampled, and analyzed prior to this rule.* (1) Schools are exempt from §§ 763.105, 763.107, and 763.109, if, prior to the effective date of this rule, local education agencies, or municipal or State agencies, acting on their behalf, have:

(i) Visually inspected all areas of the school for friable materials.

(ii) Sampled each type of friable material found in the school, as distinguished by different appearance or texture.

(iii) Had the sample(s) analyzed using Polarized Light Microscopy supplemented by X-ray Diffraction where necessary, or by Electron Microscopy.

This exemption for previous sampling activity does not apply to school buildings where it was determined that a friable material does not contain asbestos based on fewer than three samples of the material.

(2) If a school was found to contain friable asbestos-containing materials, then §§ 763.111, 763.114 and 763.115, the recordkeeping and notification requirements, shall apply to the local education agencies.

(3) If a school was found to contain *no* friable asbestos-containing materials, the school also is exempt from §§ 763.111, 763.114, and 763.115, the recordkeeping and notification requirements, provided the school retains a copy of all laboratory reports and all correspondence with laboratories concerning the analyses of samples taken and maintains in the school record the following certifying statement, signed and dated by the person responsible for compliance with the rule: "I hereby certify that this school, to the best of my knowledge, does not contain friable asbestos-containing materials."

(b) *Schools which can document that no friable asbestos-containing building materials were used in construction, modification, or renovation.* A school is exempt from §§ 763.105, 763.107, and 763.109, the inspection, sampling, and analysis requirements, and §§ 763.111, 763.114, and 763.115, the recordkeeping and notification requirements, if:

(1) the school record contains documentation showing that, at the time of construction, modification, or renovation, no friable asbestos/containing building materials were used. To qualify for this exemption, documentation must clearly show that the friable materials used did not contain asbestos.

(2) the school record contains the following certifying statement, signed and dated by the person responsible for compliance with the rule: "I hereby certify that this school, to the best of my knowledge, does not contain friable asbestos-containing materials."

(c) *Other exemptions.* (1) Sections 763.105, 763.107, and 763.109 shall not apply to a school in which the record contains a signed statement certifying that any friable materials in the school shall be treated for purposes of this rule as asbestos-containing. In this case, the record shall also include information on the location of these materials.

(2) No provision of this subpart applies to any school if:

(i) The local education agency has conducted abatement programs that result in the elimination of all friable asbestos materials from the school either by removal or encapsulation of the materials.

(ii) No part of the school building was built before January 1979.

§ 763.119 References.

(a) *General.* The following reference contains detailed information on sampling and analysis of friable materials and provides a background on which this part is based. Copies may be obtained from the Document Control Officer, Management Support Division (TS-793), Office of Pesticides and Toxic Substances, Environmental Protection Agency, Room E-106, 401 M Street SW, Washington, D.C. 20460.

(1) USEPA. 1979. "Asbestos-Containing Materials in School Buildings: A Guidance Document" Part 1. [EPA no. 000000].

(2) [Reserved]

(b) [Reserved]

Appendix A—Interim Method of the Determination of Asbestos in Bulk Insulation Samples

Section 1. Polarized Light Microscopy

1.1 Principle and Applicability

Bulk samples of building materials taken for asbestos identification are first examined for homogeneity and preliminary fiber identification at low magnification. Positive identification of suspect fibers is made by analysis of subsamples with the polarized light microscope.

The principles of optical mineralogy are well established.[1,2] A light microscope equipped with two polarizing filters is used to observe specific optical characteristics of a sample. The use of plane polarized light allows the determination of refractive indices along specific crystallographic axes. Morphology and color are also observed. A retardation plate is placed in the polarized light path for determination of the sign of elongation using orthoscopic illumination. Orientation of the two filters such that their vibration planes are perpendicular (crossed polars) allows observation of the birefringence and extinction characteristics of anisotropic particles.

Quantitative analysis involves the use of point counting. Point counting is a standard technique in petrography for determining the relative areas occupied by separate minerals in thin sections of rock. Background information on the use of point counting [5] and the interpretation of point count data [6] is available.

This method is applicable to all bulk samples of friable insulation materials submitted for identification and quantitation of asbestos components.

1.2 Range

The point counting method may be used for analysis of samples containing from 0 to 100 percent asbestos. The upper detection limit is 100 percent. The lower detection limit is less than 1 percent.

1.3 Interferences

Fibrous organic and inorganic constituents of bulk samples may interfere with the identification and quantitation of the asbestos mineral content. Spray-on binder materials may coat fibers and affect color or obscure optical characteristics to the extent of masking fiber identity. Fine particles of other materials may also adhere to fibers to an extent sufficient to cause confusion in identification. Procedures that may be used for the removal of interferences are presented in Section 1.7.2.2.

1.4 Precision and Accuracy

Adequate data for measuring the accuracy and precision of the method for samples with various matrices are not currently available. Data obtained for samples containing a single asbestos type in a simple matrix are available in the EPA report *Bulk Sample Analysis for Asbestos Content: Evaluation of the Tentative Method.* [4]

1.5 Apparatus

1.5.1 *Sample Analysis*

A low-power binocular microscope, preferably stereoscopic, is used to examine the bulk insulation sample as received.

- *Microscope:* binocular, 10–45X (approximate).
- *Light Source:* incandescent or fluorescent.
- *Forceps, Dissecting Needles, and Probes*
- *Glassine Paper or Clean Glass Plate*

Compound microscope requirements: A polarized light microscope complete with polarizer, analyzer, port for wave retardation plate, 360° graduated rotating stage, substage condenser, lamp, and lamp iris.

- *Polarized Light Microscope:* described above.
- *Objective Lenses:* 10X, 20X, and 40X or near equivalent.
- *Dispersion Staining Objective Lens* (optional)
- *Ocular Lens:* 10X minimum.
- *Eyepiece Reticle:* cross hair or 25 point Chalkley Point Array.
- *Compensator Plate:* 550 millimicron retardation.

1.5.2 *Sample Preparation*

Sample preparation apparatus requirements will depend upon the type of insulation sample under consideration. Various physical and/or chemical means may be employed for an adequate sample assessment.

- *Ventilated Hood* or negative pressure glove box.
- *Microscope Slides*
- *Coverslips*
- *Mortar and Pestle:* agate or porcelain. (optional)
- *Wylie Mill* (optional)
- *Beakers and Assorted Glassware* (optional)
- *Centrifuge* (optional)
- *Filtration apparatus* (optional)
- *Low temperature asher* (optional)

1.6 Reagents

1.6.1 *Sample Preparation*

- *Distilled Water (optional)*
- *Dilute CH_3COOH:* ACS reagent grade (optional)
- *Dilute HCl:* ACS reagent grade (optional)
- *Sodium metaphosphate* $(NaPO_3)_6$ (optional)

1.6.2 *Analytical Reagents*

Refractive Index Liquids: 1.490–1.570, 1.590–1.720 in increments of 0.002 or 0.004.

- *Refractive Index Liquids for Dispersion Staining:* high-dispersion series, 1.550, 1.605, 1.630 (optional).
- *UICC Asbestos Reference Sample Set:* Available from: UICC MRC Pneumoconiosis Unit, Llandough Hospital, Penarth, Glamorgan CF6 1XW, UK, and commercial distributors.
- *Tremolite-asbestos* (source to be determined)
- *Actinolite-asbestos* (source to be determined)

1.7 Procedures

Note.—Exposure to airborne asbestos fibers is a health hazard. Bulk samples submitted for analysis are usually friable and may release fibers during handling or matrix reduction steps. All sample and slide preparations should be carried out in a ventilated hood or glove box with continuous airflow (negative pressure). Handling of samples without these precautions may result in exposure of the analyst and contamination of samples by airborne fibers.

1.7.1 *Sampling*

Samples for analysis of asbestos content shall be taken in the manner prescribed in Reference 5 and information on design of sampling and analysis programs may be found in Reference 6. If there are any questions about the representative nature of the sample, another sample should be requested before proceeding with the analysis.

1.7.2 *Analysis*

1.7.2.1 *Gross Examination*

Bulk samples of building materials taken for the identification and quantitation of asbestos are first examined for homogeneity at low magnification with the aid of a stereomicroscope. The core sample may be examined in its container or carefully removed from the container onto a glassine transfer paper or clean glass plate. If possible, note is made of the top and bottom orientation. When discrete strata are identified, each is treated as a separate material so that fibers are first identified and quantified in that layer only, and then the results for each layer are combined to yield an estimate of asbestos content for the whole sample.

1.7.2.2 Sample Preparation

Bulk materials submitted for asbestos analysis involve a wide variety of matrix materials. Representative subsamples may not be readily obtainable by simple means in heterogeneous materials, and various steps may be required to alleviate the difficulties encountered. In most cases, however, the best preparation is made by using forceps to sample at several places from the bulk material. Forcep samples are immersed in a refractive index liquid on a microscope slide, teased apart, covered with a cover glass, and observed with the polarized light microscope.

Alternatively, attempts may be made to homogenize the sample or eliminate interferences before further characterization. The selection of appropriate procedures is dependent upon the samples encountered and personal preference. The following are presented as possible sample preparation steps.

A mortar and pestle can sometimes be used in the size reduction of soft or loosely bound materials though this may cause matting of some samples. Such samples may be reduced in a Wylie mill. Apparatus should be clean and extreme care exercised to avoid cross-contamination of samples. Periodic checks of the particle sizes should be made during the grinding operation so as to preserve any fiber bundles present in an identifiable form. These procedures are not recommended for samples that contain amphibole minerals or vermiculite. Grinding of amphiboles may result in the separation of fiber bundles or the production of cleavage fragments with aspect ratios greater than 3:1.

Grinding of vermiculite may also produce fragments with aspect ratios greater than 3:1.

Acid treatment may occasionally be required to eliminate interferences. Calcium carbonate, gypsum, and bassanite (plaster) are frequently present in sprayed or trowelled insulations. These materials may be removed by treatment with warm dilute acetic acid. Warm dilute hydrochloric acid may also be used to remove the above materials. If acid treatment is required, wash the sample at least twice with distilled water, being careful not to lose the particulates during decanting steps. Centrifugation or filtration of the suspension will prevent significant fiber loss. The pore size of the filter should be 0.45 micron or less. Caution: prolonged acid contact with the sample may alter the optical characteristics of chrysotile fibers and should be avoided.

Coatings and binding materials adhering to fiber surfaces may also be removed by treatment with sodium metaphosphate.[7] Add 10 mL of 10g/L sodium metaphosphate solution to a small (0.1 to 0.5 mL) sample of bulk material in a 15-mL glass centrifuge tube. For approximately 15 seconds each, stir the mixture on a vortex mixer, place in an ultrasonic bath and then shake by hand. Repeat the series. Collect the dispersed solids by centrifugation at 1000 rpm for 5 minutes. Wash the sample three times by suspending in 10 mL distilled water and recentrifuging. After washing, resuspend the pellet in 5 mL distilled water, place a drop of the suspension on a microscope slide, and dry the slide at 110° C.

In samples with a large portion of cellulosic or other organic fibers, it may be useful to ash part of the sample and view the residue. Ashing should be performed in a low-temperature asher. Ashing may also be performed in a muffle furnace at temperatures of 500° C or lower. Temperatures of 550° C or higher will cause dehydroxylation of the asbestos minerals, resulting in changes of the refractive index and other key parameters. If a muffle furnace is to be used, the furnace thermostat should be checked and calibrated to ensure that samples will not be heated at temperatures greater than 550° C.

Ashing and acid treatment of samples should not be used as standard procedures. In order to monitor possible changes in fiber characteristics, the material should be viewed microscopically before and after any sample preparation procedure. Use of these procedures on samples to be used for quantitation requires a correction for percent weight loss.

1.7.2.3 Fiber Identification

Positive identification of asbestos requires the determination of the following optical properties.

- Morphology
- Color and pleochroism
- Refractive indices
- Birefringence
- Extinction characteristics
- Sign of elongation

Table 1-1 lists the above properties for commercial asbestos fibers. Figure 1-1 presents a flow diagram of the examination procedure. Natural variations in the conditions under which deposits of asbestiform minerals are formed will occasionally produce exceptions to the published values and differences from the UICC standards. The sign of elongation is determined by use of the compensator plate and crossed polars. Refractive indices may be determined by the Becke line test. Alternatively, dispersion staining may be used. Inexperienced operators may find that the dispersion staining technique is more easily learned, and should consult Reference 9 for guidance. Central stop dispersion staining colors are presented in Table 1-2. Available high-dispersion (HD) liquids should be used.

BILLING CODE 6560-50-M

TABLE 1-1. OPTICAL PROPERTIES OF ASBESTOS FIBERS

Mineral	Morphology, color[a]	Refractive indices[b] α	Refractive indices[b] γ	Birefringence	Extinction	Sign of elongation
Chrysotile (asbestiform serpentine)	Wavy fibers. Fiber bundles have splayed ends and "kinks". Aspect ratio typically >10:1. Colorless[c], nonpleochroic.	1.493-1.560	1.517-1.562[f] (normally 1.556)	.008	∥to fiber length	+ (length slow)
Amosite (asbestiform grunerite)	Straight, rigid fibers. Aspect ratio typically >10:1. Colorless to brown, nonpleochroic or weakly so. Opaque inclusions may be present.	1.635-1.696	1.655-1.729[f] (normally 1.696-1.710)	.020-.033	∥to fiber length	+ (length slow)
Crocidolite (asbestiform riebeckite)	Straight, rigid fibers. Thick fibers and bundles common, blue to purple-blue in color. Pleochroic. Birefringence is generally masked by blue color.	1.654-1.701	1.668-1.717[e] (normally close to 1.700)	.014-.016	∥to fiber length	- (length fast)
Anthophyllite-asbestos	Straight fibers and acicular cleavage fragments[d]. Some composite fibers. Aspect ratio <10:1. Colorless to light brown.	1.596-1.652	1.615-1.676[f]	.019-.024	∥to fiber length	+ (length slow)
Tremolite-actinolite-asbestos	Normally present as acicular or prismatic cleavage fragments[d]. Single crystals predominate, aspect ratio <10:1. Colorless to pale green.	1.599-1.668	1.622-1.688[f]	.023-.020	Oblique extinction, 10-20° for fragments. Composite fibers show ∥ extinction.	+ (length slow)

[a] From reference 5; colors cited are seen by observation with plane polarized light.

[b] From references 5 and 8.

[c] Fibers subjected to heating may be brownish.

[d] Fibers defined as having aspect ratio >3:1.

[e] ⊥ to fiber length.

[f] ∥ to fiber length.

Polarized light microscopy analysis: For each type of material identified by examination of sample at low magnification. Mount spacially dispersed sample in 1.550 RI liquid. (If using dispersion staining, mount in 1.550 HD.) View at 100X with both plane polarized light and crossed polars. More than one fiber type may be present.

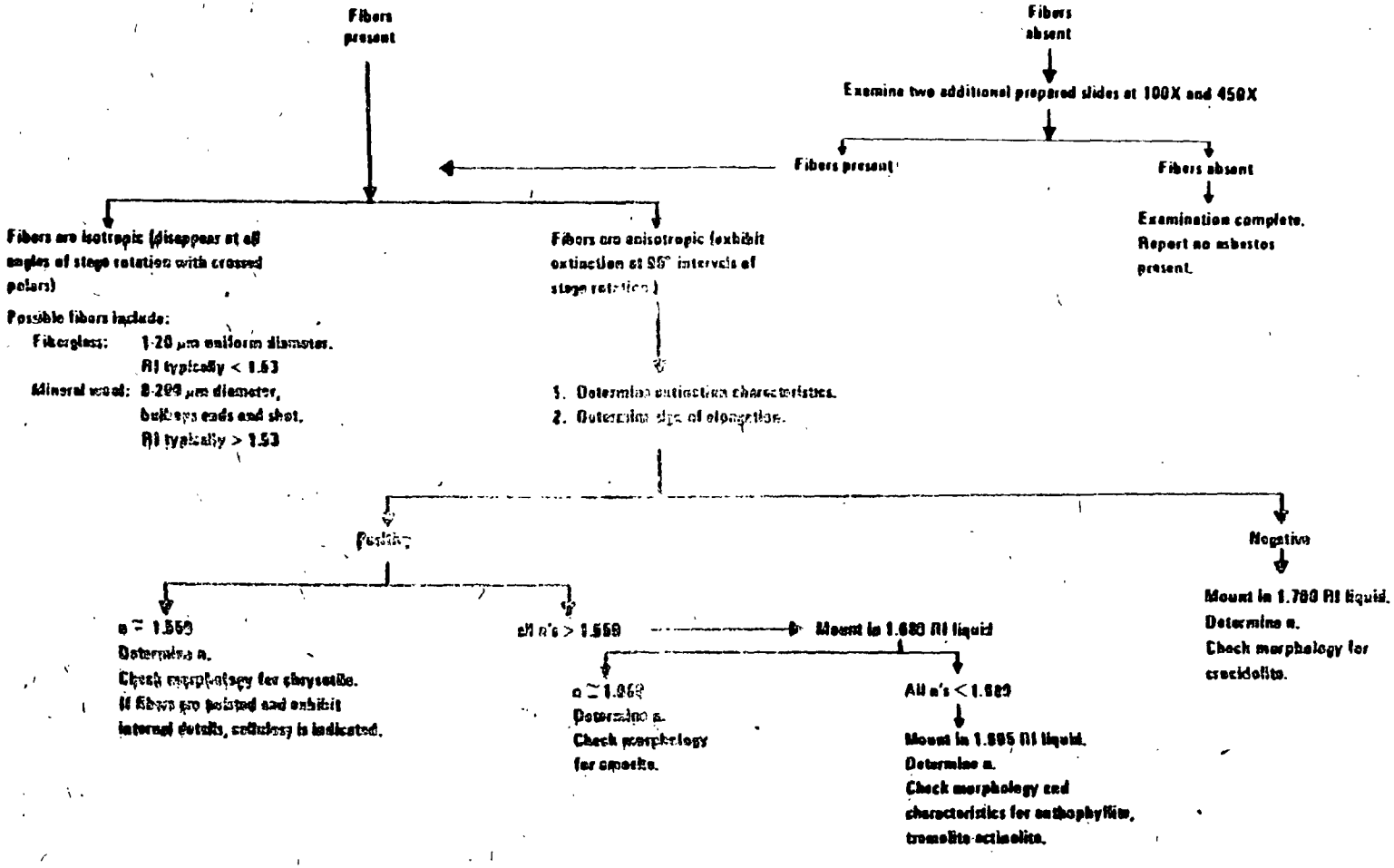

Figure 1-1. Flow chart for analysis of bulk samples by polarized light microscopy.

TABLE 1-2. CENTRAL STOP DISPERSION STAINING COLORS[a]

Mineral	RI Liquid	η ⊥	η ∥
Chrysotile	1.550^{HD}	Blue	Blue-magenta
Amosite	1.680	Blue-magenta to pale blue	Golden-yellow
	1.550^{HD}	Yellow to white	Yellow to white
Crocidolite[b]	1.700	Red magenta	Blue-magenta
	1.550^{HD}	Yellow to white	Yellow to white
Anthophyllite	1.605^{HD}	Blue	Gold to gold-magenta
Tremolite	1.605^{HD}[c]	Pale blue	Yellow
Actinolite	1.605^{HD}	Gold-magenta to blue	Gold
	1.630^{HD}[c]	Magenta	Golden-yellow

[a]From reference 9.

[b]Blue absorption color.

[c]Oblique extinction view.

BILLING CODE 6560-50-C

1.7.2.4 Quantitation of Asbestos Content

Asbestos quantitation is performed by a point-counting procedure. An ocular reticle (cross-hair or point array) is used to visually superimpose a point or points on the microscope field of view. Record the number of points positioned directly above each kind of particle or fiber of interest. Score only points directly over asbestos fibers or nonasbestos matrix material. Do not score empty points for the closest particle. If an asbestos fiber and a matrix particle overlap so that a point is superimposed on their visual intersection, a point is scored for both categories. Point counting provides a determination of the area percent asbestos. Reliable conversion of area percent to percent of dry weight is not currently feasible unless the specific gravities and relative volumes of the materials are known.

For the purpose of this method, "asbestos fibers" are defined as having an aspect ratio greater than 3:1 and being positively identified as one of the minerals in Table 1–1.

A total of 400 points superimposed on either asbestos fibers or nonasbestos matrix material must be counted over at least eight different preparations of representative subsamples. Take eight forcep samples and mount each separately with the appropriate refractive index liquid. The preparation should not be heavily loaded. The sample should be uniformly dispersed to avoid overlapping particles and allow 25–50 percent empty area within the fields of view. Count 50 nonempty points on each preparation, using either

- A cross-hair reticle and mechanical stage; or
- A reticle with 25 points (Chalkley Point Array) and counting at least 2 randomly selected fields.

For samples with mixtures of isotropic and anisotropic materials present, viewing the sample with slightly uncrossed polars or the addition of the compensator plate to the polarized light path will allow simultaneous discrimination of both particle types. Quantitation should be performed at 100X or at the lowest magnification of the polarized light microscope that can effectively distinguish the sample components. Confirmation of the quantitation result by a second analyst on some percentage of analyzed samples should be used as standard quality control procedure.

The percent asbestos is calculated as follows:

% asbestos = (a/n) 100%

where

a = number of asbestos counts,

n = number of nonempty points counted (400).

If a = 0, report "No asbestos detected." If 0 < a < 3, report "< 1% asbestos".

The value reported should be rounded to the nearest percent.

1.8 References

1. Paul F. Kerr, *Optical Mineralogy*, 4th ed., New York, McGraw-Hill, 1977.

2. E. M. Chamot and C. W. Mason, *Handbook of Chemical Microscopy, Volume One*, 3rd ed., New York: John Wiley & Sons, 1958.

3. F. Chayes, *Petrographic Modal Analysis: An Elementary Statistical Appraisal*, New York: John Wiley & Sons, 1956.

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Section 2. X-Ray Powder Diffraction

2.1 Principle and Applicability

The principle of X-ray powder diffraction (XRD) analysis is well established.[1,2] Any solid, crystalline material will diffract an impingent beam of parallel, monochromatic X-rays whenever Bragg's Law,

$\lambda = 2d \sin \theta$,

is satisfied for a particular set of planes in the crystal lattice, where

λ = the X-ray wavelength, Å;

d = the interplanar spacing of the set of reflecting lattice planes, Å; and

θ = the angle of incidence between the X-ray beam and the reflecting lattice planes.

By appropriate orientation of a sample relative to the incident X-ray beam, a diffraction pattern can be generated that, in most cases, will be uniquely characteristic of both the chemical composition and structure of the crystalline phases present.

Unlike optical methods of analysis, however, XRD cannot determine crystal morphology. Therefore, in asbestos analysis, XRD does not distinguish between fibrous and nonfibrous forms of the serpentine and amphibole minerals (Table 2–1). However, when used in conjunction with optical methods such as polarized light microscopy (PLM), XRD techniques can provide a reliable analytical method for the identification and characterization of asbestiform minerals in bulk materials.

For *qualitative analysis* by XRD methods, samples are initially scanned over limited diagnostic peak regions for the serpentine (~7.4 Å) and amphibole (8.2–8.5 Å) minerals (Table 2–2). Standard slow-scanning methods for bulk sample analysis may be used for materials shown by PLM to contain significant amounts of asbestos (>5–10[-1] percent). Detection of minor or trace amounts of asbestos may require special sample preparation and step-scanning analysis. All samples that exhibit diffraction peaks in the diagnostic regions for asbestiform minerals are submitted to a full (5°–60° 2θ; 1° 2θ/min) qualitative XRD scan, and their diffraction patterns are compared with standard reference powder diffraction patterns [3] to verify initial peak assignments and to identify possible matrix interferences when subsequent quantitative analysis will be performed.

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TABLE 2-1. THE ASBESTOS MINERALS AND THEIR NONASBESTIFORM ANALOGS

Asbestiform	Nonasbestiform
SERPENTINE	
Chrysotile	Antigorite, lizardite
AMPHIBOLE	
Anthophyllite asbestos	Anthophyllite
Cummingtonite-grunerite asbestos ("Amosite")	Cummingtonite-grunerite
Crocidolite	Riebeckite
Tremolite asbestos	Tremolite
Actinolite asbestos	Actinolite

TABLE 2-2. PRINCIPAL LATTICE SPACINGS OF ASBESTIFORM MINERALS[a]

Minerals	Principal d-spacings (Å) and relative intensities			JCPDS Powder diffraction file[3] number
Chrysotile	7.37_{100}	3.65_{70}	4.57_{50}	21-543[b]
	7.36_{100}	3.66_{80}	2.45_{65}	25-645
	7.10_{100}	2.33_{80}	3.55_{70}	22-1162 (theoretical)
"Amosite"	8.33_{100}	3.06_{70}	2.756_{70}	17-745 (nonfibrous)
	8.22_{100}	3.060_{85}	3.25_{70}	27-1170 (UICC)
Anthophyllite	3.05_{100}	3.24_{60}	8.26_{55}	9-455
	3.06_{100}	8.33_{70}	3.23_{50}	16-401 (synthetic)
Actinolite	2.72_{100}	2.54_{100}	3.40_{80}	25-157
Crocidolite	8.35_{100}	3.10_{55}	2.720_{35}	27-1415 (UICC)
Tremolite	8.38_{100}	3.12_{100}	2.705_{90}	13-437[b]
	2.706_{100}	3.14_{95}	8.43_{40}	20-1310[b] (synthetic)
	3.13_{100}	2.706_{60}	8.44_{40}	23-666 (synthetic mixture with richterite)

[a]This information is intended as a guide, only. Complete powder diffraction data, including mineral type and source, should be referred to, to ensure comparability of sample and reference materials where possible. Additional precision XRD data on amosite, crocidolite, tremolite, and chrysotile are available from the U.S. Bureau of Mines.[4]

[b]Fibrosity questionable.

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Accurate *quantitative analysis* of asbestos in bulk samples by XRD is critically dependent on particle size distribution, crystallite size, preferred orientation and matrix absorption effects, and comparability of standard reference and sample materials. The most intense diffraction peak that has been shown to be free from interference by prior qualitative XRD analysis is selected for quantitation of each asbestiform mineral. A "thin-layer" method of analysis [5,6] is recommended in which, subsequent to comminution of the bulk material to ~10 μm by suitable cryogenic milling techniques, an accurately known amount of the sample is deposited on a silver membrane filter. The mass of asbestiform material is determined by measuring the integrated area of the selected diffraction peak using a step-scanning mode, correcting for matrix absorption effects, and comparing with suitable calibration standards. Alternative "thick-layer" or bulk methods, [7,8] may be used for *semiquantitative analysis*.

This XRD method is applicable as a confirmatory method for identification and quantitation of asbestos in bulk material samples that have undergone prior analysis by PLM or other optical methods.

2.2 Range and Sensitivity

The range of the method has not been determined.

The sensitivity of the method has not been determined. It will be variable and dependent upon many factors, including matrix effects (absoprtion and interferences), diagnostic reflections selected, and their relative intensities.

2.3 Limitations

2.3.1 *Interferences*

Since the fibrous and nonfibrous forms of the serpentine and amphibole minerals (Table 2-1) are indistinguishable by XRD techniques unless special sample preparation techniques and instrumentation are used,[9] the presence of nonasbestiform serpentines and amphiboles in a sample will pose severe interference problems in the identification and quantitative analysis of their asbestiform analogs.

The use of XRD for identification and quantitation of asbestiform minerals in bulk samples may also be limited by the presence of other interfering materials in the sample. For naturally occurring materials the commonly associated asbestos-related mineral interferences can usually be anticipated. However, for fabricated materials the nature of the interferences may vary greatly (Table 2-3) and present more serious problems in identification and quantitation.[10] Potential interferences are summarized in Table 2-4 and include the following:

- *Chlorite* has major peaks at 7.19 Å and 3.58 Å that interfere with both the primary (7.36 Å) and secondary (3.66 Å) peaks for chrysotile. Resolution of the primary peak to give good quantitative results may be possible when a step-scanning mode of operation is employed.
- *Halloysite* has a peak at 3.63 Å that interferes with the secondary (3.66 Å) peak for chrysotile.
- *Kaolinite* has a major peak at 7.15 Å that may interfere with the primary peak of chrysotile at 7.36 Å when present at concentrations of >10 percent. However, the secondary chrysotile peak at 3.66 Å may be used for quantitation.
- *Gypsum* has a major peak at 7.5 Å that overlaps the 7.36 Å peak of chrysotile when present as a major sample constituent. This may be removed by careful washing with distilled water, or be heating to 300° C to convert gypsum to plaster of paris.
- *Cellulose* has a broad peak that partially overlaps the secondary (3.66 Å) chrysotile peak.[8]
- Overlap of major diagnostic peaks of the amphibole asbestos minerals, amosite, anthophyllite, crocidolite, and tremolite, at approximately 8.3 Å and 3.1 Å causes mutual interference when these minerals occur in the presence of one another. In some instances, adquate resolution may be attained by using step-scanning methods and/or by decreasing the collimator slit width at the X-ray port.

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TABLE 2-3. COMMON CONSTITUENTS IN INSULATION AND WALL MATERIALS[10]

A. Insulation materials

Chrysotile
"Amosite"
Crocidolite
*Rock wool
*Slag wool
*Fiber glass
Gypsum ($CaSO_4 \cdot 2H_2O$)
Vermiculite (micas)
*Perlite
Clays (kaolin)
*Wood pulp
*Paper fibers (talc, clay, carbonate fillers)
Calcium silicates (synthetic)
Opaques (chromite, magnetite inclusions in serpentine)
Hematite (inclusions in "amosite")
Magnesite
*Diatomaceous earth

B. Spray finishes or paints

Bassanite
Carbonate minerals (calcite, dolomite, vaterite)
Talc
Tremolite
Anthophyllite
Serpentine (including chrysotile)
Amosite
Crocidolite
*Mineral wool
*Rock wool
*Slag wool
*Fiber glass
Clays (kaolin)
Micas
Chlorite
Gypsum ($CaSO_4 \cdot 2H_2O$)
Quartz
*Organic binders and thickeners
Hydromagnesite
Wollastonite
Opaques (chromite, magnetite inclusions in serpentine)
Hematite (inclusions in "amosite")

*Amorphous materials--contribute only to overall scattered radiation and increased background radiation.

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TABLE 2-4. INTERFERENCES IN XRD ANALYSIS OF ASBESTIFORM MINERALS

Asbestiform mineral	Primary diagnostic peaks (approximate d-spacings, in Å)	Interference
Serpentine		
Chrysotile	7.4	Nonasbestiform serpentines (antigorite, lizardite)
		Chlorite
		Kaolinite
		Gypsum
	3.7	Chlorite
		Halloysite
		Cellulose
Amphibole		
"Amosite"	3.1	Nonasbestiform amphiboles (cummingtonite-grunerite, anthophyllite, riebeckite, tremolite)
Anthophyllite		
Crocidolite		
Tremolite		
		Mutual interferences
		Carbonates
		Talc
	8.3	Mutual interferences

- *Carbonates* may also interfere with quantitative analysis of the amphibole asbestos minerals, amosite, anthophyllite, crocidolite, and tremolite. Calcium carbonate ($CaCO_3$) has a peak at 3.035 Å that overlaps major amphibole peaks at approximately 3.1 Å when present in concentrations of >5 percent. Removal of carbonates with a dilute acid wash is possible; however, if present, chrysotile may be partially dissolved by this treatment.[11]
- A major *talc* peak at 3.12 Å interferes with the primary tremolite peak at this same position and with secondary peaks of crocidolite (3.10 Å), amosite (3.06 Å), and anthophyllite (3.05 Å). In the presence of talc, the major diagnostic peak at approximately 8.3 Å should be used for quantitation of these asbestiform minerals.

The problem of intraspecies and matrix interferences is further aggravated by the variability of the silicate mineral powder diffraction patterns themselves, which often makes definitive identification of the asbestos minerals by comparison with standard reference diffraction patterns difficult. This variability results from alterations in the crystal lattice associated with differences in isomorphous substitution and degree of crystallinity. This is especially true for the amphiboles. These minerals exhibit a wide variety of very similar chemical compositions, with the result being that their diffraction patterns are characterized by having major (110) reflections of the monoclinic amphiboles and (210) reflections of the orthorhombic anthophyllite separated by less than 0.2 Å.[12]

2.3.2 *Matrix Effects*

If a copper X-ray source is used, the presence of iron at high concentrations in a sample will result in significant X-ray fluorescence, leading to loss of peak intensity along with increased background intensity and an overall decrease in sensitivity. This situation may be corrected by choosing an X-ray source other than copper; however, this is often accompanied both by loss of intensity and by decreased resolution of closely spaced reflections. Alternatively, use of a diffracted beam monochromator will reduce background fluorescent radiation, enabling weaker diffraction peaks to be detected.

X-ray absorption by the sample matrix will result in overall attenuation of the diffracted beam and may seriously interfere with quantitative analysis. Absorption effects may be minimized by using sufficiently "thin" samples for analysis.[5 12 14] However, unless absorption effects are known to be the same for both samples and standards, appropriate corrections should be made by referencing diagnostic peak areas to an internal standard [7 8] or filter substrate (Ag) peak.[5 6]

2.3.3 *Particle Size Dependence*

Because the intensity of diffracted X-radiation is particle-size-dependent, it is essential for accurate quantitative analysis that both sample and standard reference materials have similar particle size distributions. The optimum particle size range for quantitative analysis of asbestos by XRD has been reported to be 1 to 10 μm.[15] Comparability of sample and standard reference material particle size distributions should be verified by optical microscopy (or another suitable method) prior to analysis.

2.3.4 *Preferred Orientation Effects*

Preferred orientation of asbestiform minerals during sample preparation often poses a serious problem in quantitative analysis by XRD. A number of techniques have been developed for reducing preferred orientation effects in "thick layer" samples.[7 8 15] However, for "thin" samples on membrane filters, the preferred orientation effects seem to be both reproducible and favorable to enhancement of the principal diagnostic reflections of asbestos minerals, actually increasing the overall sensitivity of the method.[12 14] (Further investigation into preferred orientation effects in both thin layer and bulk samples is required.)

2.3.5 *Lack of Suitably Characterized Standard Materials*

The problem of obtaining and characterizing suitable reference materials for asbestos analysis is clearly recognized. NIOSH has recently directed a major research effort toward the preparation and characterization of analytical reference materials, including asbestos standards;[16 17] however, these are not available in large quantities for routine analysis.

In addition, the problem of ensuring the comparability of standard reference and sample materials, particularly regarding crystallite size, particle size distribution, and degree of crystallinity, has yet to be adequately addressed. For example, Langer et al.[16] have observed that in insulating matrices, chrysotile tends to break open into bundles more frequently than amphiboles. This results in a line-broadening effect with a resultant decrease in sensitivity. Unless this effect is the same for both standard and sample materials, the amount of chrysotile in the sample will be underestimated by XRD analysis. To minimize this problem, it is recommended that standardized matrix reduction procedures be used for both sample and standard materials.

2.4 Precision and Accuracy

Precision of the method has not been determined.

Accuracy of the method has not been determined.

2.5 Apparatus

2.5.1 *Sample Preparation*

Sample preparation apparatus requirements will depend upon the sample type under consideration and the kind of XRD analysis to be performed.

- *Mortar and Pestle:* Agate or porcelain.
- *Razor Blades*
- *Sample Mill:* SPEX, Inc., freezer mill or equivalent.
- *Bulk Sample Holders*
- *Silver Membrane Filters:* 25-mm diameter, 0.45-μm pore size. Selas Corp. of America, Flotronics Div., 1957 Pioneer Road, Huntington Valley, PA 19006.
- *Microscope Slides*
- *Vacuum Filtration Apparatus:* Gelman No. 1107 or equivalent, and side-arm vacuum flask.
- *Microbalance*
- *Ultrasonic Bath or Probe:* Model W140, Ultrasonics, Inc., operated at a power density of approximately 0.1 W/mL or equivalent.
- *Volumetric Flasks:* 1-L volume.
- *Assorted Pipettes*
- *Pipette Bulb*
- *Nonserrated Forceps*
- *Polyethylene Wash Bottle*
- *Pyrex Beakers:* 50-mL volume.
- *Desiccator*
- *Filter Storage Cassettes*
- *Magnetic Stirring Plate and Bars*
- *Porcelain Crucibles*
- *Muffle Furnace or Low Temperature Asher*

2.5.2 *Sample Analysis*

Sample analysis requirements include an X-ray diffraction unit, equipped with:

- *Constant Potential Generator, Voltage and mA Stabilizers*
- *Automated Diffractometer with Step-Scanning Mode*
- *Copper Target X-Ray Tube:* High intensity, fine focus, preferably.
- *X-Ray Pulse Height Selector*
- *X-Ray Detector* (with high voltage power supply): Scintillation or proportional counter.
- *Focusing Graphite Crystal Monochromator, or Nickel Filter* (if copper source is used, and iron fluorescence is not a serious problem).
- *Data Output Accessories:*
  - *Strip Chart Recorder*
  - *Decade Scaler/Timer*
  - *Digital Printer*
- *Sample Spinner* (optional).
- *Instrument Calibration Reference Specimen:* α-quartz reference crystal. (Arkansas quartz standard, #180-147-00, Philips Electronics Instruments, Inc., 85 McKee Drive, Mahwah, NJ 07430) or equivalent.

2.6 Reagents

2.6.1 *Standard Reference Materials*

The reference materials listed below are intended to serve as a guide. Every attempt should be made to acquire pure reference materials that are comparable to sample materials being analyzed.

- *Chrysotile:* UICC Canadian, or NIEHS Plastibest. (UICC reference materials available from: UICC, MRC Pneumoconiosis Unit, Llandough Hospital, Penarth, Glamorgan, CF61XW, UK).
- *Crocidolite:* UICC
- *Amosite:* UICC
- *Anthophyllite:* UICC
- *Tremolite Asbestos:* Wards Natural Science Establishment, Rochester, N.Y.; Cyprus Research Standard, Cyprus Research, 2435 Military Ave., Los Angeles, CA 90064 (washed with dilute HCl to remove small amount of calcite impurity); India-tremolite, Rajasthan State, India.
- *Actinolite Asbestos*

2.6.2 *Adhesive*

Tape, petroleum jelly, etc. (for attaching silver membrane filters to sample holders).

2.6.3 *Surfactant*

1 percent aerosol OT aqueous solution or equivalent.

C5014 2504

2.6.4 *Isopropanol*

ACS Reagent Grade.

2.7 Procedure

2.7.1 *Sampling*

Samples for analysis of asbestos content shall be collected as specified in EPA Guidance Document #C0090, *Asbestos-Containing Materials in School Buildings.*[18]

2.7.2 *Analysis*

All samples must be analyzed initially for asbestos content by PLM. XRD should be used as an auxiliary method when a second, independent analysis is requested.

Note.—Asbestos is a toxic substance. All handling of dry materials should be performed in an operating fume hood.

2.7.2.1 Sample Preparation

The method of sample preparation required for XRD analysis will depend on: (1) the condition of the sample received (sample size, homogeneity, particle size distribution, and overall composition as determined by PLM); and (2) the type of XRD analysis to be performed (qualitative, quantitative, thin layer or bulk).

Bulk materials are usually received as inhomogeneous mixtures of complex composition with very wide particle size distributions. Preparation of a homogeneous, representative sample from asbestos-containing materials is particularly difficult because the fibrous nature of the asbestos minerals inhibits mechanical mixing and stirring, and because milling procedures may cause adverse lattice alterations.

A discussion of specific matrix reduction procedures is given below. Complete methods of sample preparation are detailed in Sections 2.7.2.2 and 2.7.2.3.

Note.—*All samples should be examined microscopically before and after each matrix reduction step* to monitor changes in sample particle size, composition, and crystallinity, and to ensure sample representativeness and homogeneity for analysis.

2.7.2.1.1 *Milling*—Mechanical milling of asbestos materials has been shown to decrease fiber crystallinity, with a resultant decrease in diffraction intensity of the specimen: the degree of lattice alteration is related to the duration and type of milling process.[19-22] Therefore, all milling times should be kept to a minimum.

For *qualitative analysis*, particle size is not usually of critical importance and initial characterization of the material with a minimum of matrix reduction is often desirable to document the composition of the sample as received. Bulk samples of very large particle size (>2–3 mm) should be comminuted to ~100 μm. A mortar and pestle can sometimes be used in size reduction of soft or loosely bound materials though this may cause matting of some samples. Such samples may be reduced by cutting with a razor blade in a mortar, or by grinding in a suitable mill (e.g., a microhammer mill or equivalent). When using a mortar for grinding or cutting, the sample should be moistened with ethanol, or some other suitable wetting agent, to minimize exposures.

For accurate, reproducible *quantitative analysis*, the particle size of both sample and standard materials should be reduced to ~10 μm (see Section 2.3.3). Dry ball milling at liquid nitrogen temperatures (e.g., Spex Freezer Mill, or equivalent) for a maximum time of 10 min. is recommended to obtain satisfactory particle size distributions while protecting the integrity of the crystal lattice.[5] Bulk samples of very large particle size may require grinding in two stages for full matrix reduction to <10 μm.[5,16]

Final particle size distributions should always be verified by optical microscopy or another suitable method.

2.7.2.1.2 *Low-temperature ashing*—For materials shown by PLM to contain large amounts of gypsum, cellulosic, or other organic materials, it may be desirable to ash the samples prior to analysis to reduce background radiation or matrix interference. Since chrysotile undergoes dehydroxylation at temperatures between 550° C and and 650° C, with subsequent transformation to forsterite,[23,24] ashing temperatures should be kept below 500° C. Use of a low temperature asher is recommended. In all cases, calibration of the oven is essential to ensure that a maximum ashing temperature of 500° C is not exceeded.

2.7.2.1.3 *Acid leaching*—Because of the interference caused by gypsum and some carbonates in the detection of asbestiform minerals by XRD (see Section 2.3.1), it may be necessary to remove these interferents by a simple acid leaching procedure prior to analysis (see Section 1.7.2.2).

2.7.2.2 Qualitative Analysis

2.7.2.2.1 *Initial screening of bulk material*—Qualitative analysis should be performed on a representative, homogeneous portion of the sample with a minimum of sample treatment.

1. Grind and mix the sample with a mortar and pestle (or equivalent method, see Section 2.7.2.1.1.) to a final particle size sufficiently small (~100 μm) to allow adequate packing into the sample holder.

2. Pack the sample into a standard bulk sample holder. Care should be taken to ensure that a representative portion of the milled sample is selected for analysis. Paticular care should be taken to avoid possible size segregation of the sample. (Note: Use of a back-packing method [25] of bulk sample preparation may reduce preferred orientation effects.)

3. Mount the sample on the diffractometer and scan over the diagnostic peak regions for the serpentine (~07.4 Å) and amphibole (8.2–8.5 Å) minerals (see Table 2–2). The X-ray diffraction equipment should be optimized for intensity. A slow scanning speed of 1° 2θ/min is recommended for adequate resolution. Use of a sample spinner is recommended.

4. Submit all samples that exhibit diffraction peaks in the diagnostic regions for asbestiform minerals to a full qualitative XRD scan (5°–30° 2θ; 1°2θ/min) to verify initial peak assignments and to identify potential matrix interferences when subsequent quantitative analysis is to be perform.

5. Compare the sample XRD pattern with standard reference powder diffraction patterns (i.e., JCPDS powder diffraction data [3] or those of other well-characterized reference materials). Principal lattice spacings of asbestiform minerals are given in Table 2–2; common constituents of bulk insulation and wall materials are listed in Table 2–3.

2.7.2.2.2 *Detection of minor or trace constituents*—Routine screening of bulk materials by XRD may fail to detect small concentrations (<5 percent) of asbestos. The limits of detection will, in general, be improved if matrix absorption effects are minimized, and if the sample particle size is reduced to the optimal 1 to 10 μm range, provided that the crystal lattice is not degraded in the milling process. Therefore, in those instances where confirmation of the presence of an asbestiform mineral at very low levels is required, or where a negative result from initial screening of the bulk material by XRD (see Section 2.7.2.2.1) is in conflict with previous PLM results, it may be desirable to prepare the sample as described for quantitative analysis (see Section 2.7.2.3) and step-scan over appropriate 2θ ranges of selected diagnostic peaks (Table 2–2). Accurate transfer of the sample to the silver membrane filter is not necessary unless subsequent quantitative analysis is to be performed.

2.7.2.3 Quantitative Analysis

The proposed method for quantitation of asbestos in bulk samples is a modification of the NIOSH-recommended thin-layer method for chrysotile in air.[5] A thick-layer or bulk method involving pelletizing the sample may be used for semiquantitative analysis; [7,8] however, this method requires the addition of an internal standard, use of a specially-fabricated sample press, and relatively large amounts of standard reference materials. Additional research is required to evaluate the comparability of thin- and thick-layer methods for quantitative asbestos analysis.

For quantitative analysis by thin-layer methods, the following procedure is recommended:

1. Mill and size all or a substantial representative portion of the sample as outlined in Section 2.7.2.1.1.

2. Dry at 100° C for 2 hr; cool in a desiccator.

3. Weigh accurately to the nearest 0.01 mg.

4. Samples shown by PLM to contain large amounts of cellulosic or other organic materials, gypsum, or carbonates, should be submitted to appropriate matrix reduction procedures described in Sections 2.7.2.1.2 and 2.7.2.1.3. After ashing and/or acid treatment, repeat the drying and weighing procedures described above, and determine the percent weight loss; L.

5. Quantitatively transfer an accurately weighed amount (50–100 mg) of the sample to a 1–L volumetric flask with approximately 200 mL isopropanol to which 3 to 4 drops of surfactant have been added.

6. Ultrasonicate for 10 min at a power density of approximately 0.1 W/mL to disperse the sample material.

7. Dilute to volume with isopropanol.

8. Place flask on a magnetic stirring plate. Stir.

9. Place a silver membrane filter on the filtration apparatus, apply a vacuum, and attach the reservoir. Release the vacuum and

add several milliliters of isopropanol to the reservoir. Vigorously hand shake the asbestos suspension and immediately withdraw an aliquot from the center of the suspension so that total sample weight, W_T, on the filter will be approximately 1 mg. Do not adjust the volume in the pipet by expelling part of the suspension; if more than the desired aliquot is withdrawn, discard the aliquot and resume the procedure with a clean pipet. Transfer the aliquot to the reservoir. Filter rapidly under vacuum. Do not wash the reservoir walls. Leave the filter apparatus under vacuum until dry. Remove the reservoir, release the vacuum, and remove the filter with forceps. (Note: Water-soluble matrix interferences such as gypsum may be removed at this time by careful washing of the filtrate with distilled water. Extreme care should be taken not to disturb the sample.)

10. Attach the filter to a flat holder with a suitable adhesive and place on the diffractometer. Use of a sample spinner is recommended.

11. For each asbestos mineral to be quantitated select a reflection (or reflections) that has been shown to be free from interferences by prior PLM or qualitative XRD analysis and that can be used unambiguously as an index of the amount of material present in the sample (see Table 2–2).

12. Analyze the selected diagnostic reflection(s) by step scanning in increments of 0.02° 2θ for an appropriate fixed time and integrating the counts. (A fixed count scan may be used alternatively; however, the method chosen should be used consistently for all samples and standards.) An appropriate scanning interval should be selected for each peak, and background corrections made. For a fixed time scan, measure the background on each side of the peak for one-half the peak-scanning time. The net intensity, I_a, is the difference between the peak integrated count and the total background count.

13. Determine the net count, I_{Ag}, of the filter 2.36 Å silver peak following the procedure in step 12. Remove the filter from the holder, reverse it, and reattach it to the holder. Determine the net count for the unattenuated silver peak, I^o_{Ag}. Scan times may be *less* for measurement of silver peaks than for sample peaks; however, they should be *constant* throughout the analysis.

14. Normalize all raw, net intensities (to correct for instrument instabilities) by referencing them to an external standard (e.g. the 3.34 Å peak of an α-quartz reference crystal). After each unknown is scanned, determine the net count, I^o_r, of the reference specimen following the procedure in step 12. Determine the normalized intensities by dividing the peak intensities by I^o_r:

$$\hat{I}_a = \frac{I_a}{I^o_r}, \quad \hat{I}_{Ag} = \frac{I_{Ag}}{I^o_r}, \text{ and } \hat{I}^o_{Ag} = \frac{I^o_{Ag}}{I^o_r}$$

2.8 Calibration

2.8.1 *Preparation of Calibration Standards.*

1. Mill and size standard asbestos materials according to the procedure outlined in Section 2.7.2.1.1. *Equivalent, standardized matrix reduction and sizing techniques should be used for both standard and sample materials.*

2. Dry at 100° C for 2 hr; cool in a desiccator.

3. Prepare two suspensions of each standard in isopropanol by weighing approximately 10 and 50 mg of the dry material to the nearest 0.01 mg. Quantitatively transfer each to a 1–L volumetric flask with approximately 200 mL isopropanol to which a few drops of surfactant have been added.

4. Ultrasonicate for 10 min at a power density of approximately 0.1 W/mL to disperse the asbestos material.

5. Dilute to volume with isopropanol.

6. Place the flask on a magnetic stirring plate. Stir.

7. Prepare, in triplicate, a series of at least five standard filters to cover the desired analytical range, using appropriate aliquots of the 10 and 50 mg/L suspensions and the following procedure.

Mount a silver membrane filter on the filtration apparatus. Place a few milliliters of isopropanol in the reservoir. Vigorously hand shake the asbestos suspension and immediately withdraw an aliquot from the center of the suspension. Do not adjust the volume in the pipet by expelling part of the suspension; if more than the desired aliquot is withdrawn, discard the aliquot and resume the procedure with a clean pipet. Transfer the aliquot to the reservoir. Keep the tip of the pipet near the surface of the isopropanol. Filter rapidly under vacuum. Do not wash the sides of the reservoir. Leave the vacuum on for a time sufficient to dry the filter. Release the vacuum and remove the filter with forceps.

2.8.2 *Analysis of Calibration Standards.*

1. Mount each filter on a flat holder. Perform step scans on selected diagnostic reflections of the standards and reference specimen using the procedure outlined in Section 2.7.2.3, step 12, and the same conditions as those used for the samples.

2. Determine the normalized intensity for each peak measured, $\hat{I}_{as}$, as outlined in Section 2.7.2.3, step 14.

2.9 Calculations

For each asbestos reference material, calculate the exact weight deposited on each standard filter from the concentrations of the standard suspensions and aliquot volumes. Record the weight, w, of each standard. Prepare a calibration curve by regressing $\hat{I}_{as}$ on w. Poor reproducibility (±15 percent RSD) at any given level indicates problems in the sample preparation technique, and a need for new standards. The data should fit a straight line equation.

Determine the slope, m, of the calibration curve in counts/microgram. The intercept, b, of the line with the $\hat{I}_{as}$ axis should be approximately zero. A large negative intercept indicates an error in determining the background. This may arise from incorrectly measuring the baseline or from interference by another phase at the angle of background measurement. A large positive intercept indicates an error in determining the baseline or that an impurity is included in the measured peak.

Using the normalized intensity, $\hat{I}_{Ag}$, for the attenuated silver peak of a sample, and the corresponding normalized intensity from the unattenuated silver peak, $\hat{I}^o_{Ag}$, of the sample filter, calculate the transmittance, T, for each sample as follows:[26 27]

$$T = \frac{\hat{I}_{Ag}}{\hat{I}^o_{Ag}}$$

Determine the correction factor, f(T), for each sample according to the formula:

$$f(T) = \frac{-R\ (\ln T)}{1-T^R}$$

where

$$R = \frac{\sin \theta_{Ag}}{\sin \theta_a}$$

θ_{Ag} = angular position of the measured silver peak (from Bragg's Law), and
θ_a = angular position of the diagnostic asbestos peak.

Calculate the weight, W_a, in micrograms, of the asbestos material analyzed for in each sample, using the appropriate calibration data and absorption corrections:

$$W_a = \frac{\hat{I}_a f(t) - b}{m}$$

Calculate the percent composition, P_a, of each asbestos mineral analyzed for in the parent material, from the total sample weight, W_T, on the filter:

$$P_a = \frac{W_a\ (1-.01L)}{W_T} \times 100$$

where

P_a = percent asbestos mineral in parent material;
W_a = mass of asbestos mineral on filter, in μg;
W_T = total sample weight on filter, in μg;
L = percent weight loss of parent material on ashing and/or acid treatment (see Section 2.7.2.3).

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