DEPARTMENT OF LABOR

Occupational Safety and Health Administration

29 CFR Parts 1910 and 1926

[Docket No. H-033C]

Occupational Exposure to Asbestos, Tremolite, Anthophyllite, and Actinolite

AGENCY: Occupational Safety and Health Administration, U.S. Department of Labor.

ACTION: Final rules.

SUMMARY: In these final standards, the Occupational Safety and Health Administration (OSHA) amends its present standard (29 CFR 1910.1001) regulating occupational exposure to asbestos. The standards published today establish a permissible exposure limit of 0.2 fiber per cubic centimeter of air (f/cc), determined as an 8-hour time-weighted average airborne concentration. The standards apply to all industries covered by the Occupational Safety and Health Act, including the construction and maritime industries and general industry. Separate standards and separate statements of reasons (Summary and Explanation sections) have been developed to apply to general industry (including maritime) and to construction, because the differences in exposure and workplace conditions in general industry and construction worksites warrant separate treatment. The standards will be codified in 29 CFR Parts 1910 and 1926, OSHA's General Industry and Construction standards, respectively. The basis for promulgation of these regulations is a determination by the Assistant Secretary that employees exposed to asbestos, tremolite, anthophyllite, and actinolite face a significant risk to their health and that these final standards will substantially reduce that risk. The record in this rulemaking demonstrates that employees occupationally exposed to asbestos are at risk of developing such chronic diseases as asbestosis, lung cancer, pleural and peritoneal mesothelioma, and gastrointestinal cancer.

The standards also provide for requirements for methods of compliance, personal protective equipment, employee monitoring, medical surveillance, communication of hazards to employees, regulated areas, housekeeping procedures, and recordkeeping. An "action" level of 0.1 f/cc as an 8-hour time-weighted average is established as the level above which employers must initiate certain compliance activities, such as employee training and medical surveillance. Where the employer can demonstrate, by means of exposure monitoring results or historical data, that the exposures of his or her employees do not exceed the action level, the employer is not obligated to comply with many of the standard's requirements. The 0.2 f/cc 8-hour limit reduces significant risk from exposure and is considered by OSHA, based upon substantial evidence in the record as a whole, to be the lowest level feasible.

EFFECTIVE DATE: The amended standards published today take effect July 21, 1986, except the following paragraphs which contain information collection requirements which are under review at the Office of Management and Budget: 29 CFR 1910.1001 (d)(2), (d)(3), (d)(5), (d)(7), (f)(2), (g)(3)(i), (j)(5), (l), and (m); 29 CFR 1926.58 (f)(2), (f)(3), (f)(6), (h)(3)(i), (k)(3), (k)(4), (m), and (n).

ADDRESS: For additional copies of these final standards, contact: OSHA Office of Publications, U.S. Department of Labor, Room S-4203, 200 Constitution Avenue, NW., Washington, DC 20210. Telephone (202) 523-9667.

FOR FURTHER INFORMATION CONTACT: Mr. James F. Foster, Director, Office of Information and Consumer Affairs, OSHA, U.S. Department of Labor, Room N-3637, 200 Constitution Avenue, NW., Washington, DC 20210. Telephone (202) 523-8151.

SUPPLEMENTARY INFORMATION:

I. Introduction

A. The Format of This Document (the Preamble)

The preamble accompanying these revised standards is divided into 13 parts, numbered I through XIII. The following is a table of contents:

References to the rulemaking record are in the text of the preamble, and the following abbreviations have been used:

1. Ex.: Exhibit number in Docket H-033C. Docket H-033C is located in Room N3670 at the Department of Labor.
2. TR.: Transcript date and page number.

B. Summary

Pursuant to sections 4(b)(2), 6(b), 6(c), and 8(c) of the Occupational Safety and Health Act of 1970 (the Act) (84 Stat. 1592, 1593, 1596, 1599; 29 U.S.C. 653, 655, 657), the Construction Safety Act (40 U.S.C. 333), the Longshoremen's and Harbor Workers' Compensation Act (33 U.S.C. 941), the Secretary of Labor's Order No. 9-83 (48 FR 35736), and 29 CFR Part 1911, these final standards hereby amend and revise the current asbestos standard, 29 CFR 1910.1001.

This action follows publication of proposed notices on November 4, 1983 (48 FR 51085) and on April 10, 1984 (49 FR 14116) and the holding of a public hearing to provide the public with an opportunity to comment on these proposed revisions. The hearings were held from June 19 to July 10, 1984, in Washington, DC. More than 55,000 pages of testimony and comments were received into the record of this rulemaking and have been analyzed by the Agency in developing these final standards. Based on this record, OSHA has determined that employees exposed to asbestos, tremolite, anthophyllite, and actinolite at the existing permissible exposure limit (PEL) of 2 fibers per cubic centimeter of air (2 f/cc) at worksites in the construction and maritime industries and in general industry workplaces face a significant risk to their health and that these final standards will substantially reduce that risk. Evidence in the record of this proceeding has shown that employees exposed at the revised standards' PEL of 0.2 fiber/cc remain at significant risk of incurring a chronic exposure-related disease, but considerations of feasibility have constrained OSHA to set the revised PEL at the 0.2 fiber/cc level.

The standard issued in 1971 defined asbestos as chrysotile, crocidolite, amosite, tremolite, anthophyllite, and actinolite. All of these minerals represent a hazard to workers, and the revised standard continues to regulate all of them. However, some forms of these minerals are no longer included in the definition of the word "asbestos". The regulatory text clearly specifies that the standards apply to occupational exposure to asbestos, tremolite, anthophyllite, and actinolite. In the preamble, however, where the word "asbestos" is used this should be interpreted as applying to tremolite, anthophyllite, and actinolite as well.

OSHA has decided to issue two separate standards regulating occupational exposure to asbestos, tremolite, anthophyllite, and actinolite: One that applies to workplaces in general industry (including maritime) and another covering construction worksites. In promulgating two separate standards for general industry and construction, OSHA is acting in accordance with the recommendations of the Advisory Committee for Construction Safety and Health (CACOSH), which has reviewed and commented on several versions of the new standard in the construction industry, most recently during CACOSH's deliberations on October 17, 1985, in Washington, DC. These standards will be codified at 29 CFR 1910.1001 for general industry and at 29 CFR 1926.58 for the construction industry. OSHA has developed separate standards for these two industry groupings in recognition of the vastly different conditions prevailing in the workplaces covered by general industry and construction standards. As the April 1984 notice pointed out (49 FR 14127 et seq.). OSHA's existing asbestos standard (29 CFR 1910.1001) was more suitable for fixed-site manufacturing workplaces and a workforce composed of long-term employees, rather than for the short-term projects and highly mobile workforce characteristic of the construction industry.

Support for a separate OSHA standard for construction came from all interested parties in this rulemaking, including the Building and Construction Trades Department (BCTD) of the AFL-CIO (Ex 87-2); CACOSH (Ex. 84-424); the Asbestos Information Association (EX. 84-307); the Associated General Contractors of America (AGC) (Ex. 84-457): The Safe State Program, University of Alabama (Ex. 601.X); and the AFL-CIO Steering Committee on Safety and Occupational Health (Ex. 606.X). These commenters supported separate standards for these two industry groupings because employee exposures to asbestos, tremolite, anthophyllite, and actinolite, appropriate methods of controlling exposures, and prevailing workplace conditions are substantially different in workplaces in construction and general industry.

Although the Summary and Explanation section of the preamble for the construction industry (Section XI of the preamble) discusses the record evidence as it applies to specific provisions of the final rule for construction, the reasons given by these commenters in support of a separate standard for.construction can be summarized briefly as follows:

(1) The construction industry is characterized by non-fixed worksites that are temporary in nature and differ from those in general industry in regard to site conditions, size and scope of tasks, methods of operation, and environmental conditions.

(2) Employees in the construction industry often do not remain in construction or in the employ of the same employer for a long period of time, in contrast to employees in fixed-site manufacturing facilities.

(3) The unique characteristics of construction operations may make it necessary to tailor some of the requirements traditionally included in OSHA health standards to the specific needs of the construction industry.

OSHA finds merit in these arguments, and in response to the nearly unanimous support for separate standards for general industy and construction, the Agency is issuing separate final rules covering these respective workplaces. In addition, OSHA has tailored the requirements of the final construction standard to reflect differences in operations of various types within the construction industry itself. The record demonstrated these intra-industry differences in construction exposure and work conditions by pointing to the generally low exposures and well-controlled conditions prevailing in construction operations involving the installation of new asbestos-containing products and comparing them with those typical of major demolition, renovation, and asbestos removal construction operations. In recognition of this wide diversity in construction projects, the Agency has specifically identified in the final rule those additional requirements that apply to construction operations involving asbestos abatement activities. Requirements governing these potentially high-hazard operations are grouped separately in the construction standard under a heading clearly labeled "for removal, demolition, and renovation operations." For example, paragraphs (i)(1) through (i)(3) of the standard are grouped under the title "Protective clothing" and apply to all construction operations other than removal, demolition, and renovation operations, while paragraph (i)(4) is titled "Protective clothing *for asbestos removal, demolition, and renovation operations*" and applies only to such operations. Similarly, paragraphs (e)(1) through (e)(5) contain OSHA's requirements for regulated areas on construction projects other than removal, demolition, and renovation operations, while paragraph (e)(6) specifies the more extensive and stringent requirements for the enclosed negative-pressure regulated areas required for removal, demolition, and renovation operations. OSHA believes that tiering the construction standard to reflect differences in workplace conditions within this industry will simultaneously provide appropriate employee protection and encourage voluntary employer compliance with the final rule.

In publishing these two revised standards governing occupational exposure to asbestos, tremolite, anthophyllite, and actinolite in construction and in general industry, OSHA is acting to regulate a hazard widely recognized by other Federal agencies, health experts, and the general public. The U.S. Environmental Protection Agency (EPA) has promulgated regulations controlling asbestos under the Clean Air Act, the Toxic Substances Control Act, and the Clean Water Act. Under section 6 of the Toxic Substances Control Act (TSCA), EPA is proposing to prohibit the manufacture, importation, and processing of asbestos-cement pipe and fittings, roofing felts, flooring felts (and felt-backed sheet flooring), vinyl-asbestos floor tile, and asbestos clothing (51 FR 3738-3759). These uses would be prohibited because EPA believes that safer, economically competitive substitutes for these products are available, and that "the manufacture, processing, and use of asbestos products leaves a legacy of asbestos in the ambient air" (51 FR 3739).

In addition, EPA is proposing to establish a permit system to phase out all other asbestos products. Under this system, EPA would permit current miners or importers to mine or import a specific quantity of asbestos. EPA would require this quantity to decline every year until, after 10 years, mining or importation would only be permitted under a specific exemption for those asbestos applications for which no substitutes had been developed. EPA is also considering requiring labeling for all asbestos products that are not banned, including products manufactured pursuant to permits issued by EPA during the phase-down period, or pursuant to an exemption process.

Emissions of asbestos to the ambient air are controlled under section 112 of the Clean Air Act, which establishes National Emissions Standards for Hazardous Air Pollutants. Regulations in 40 CFR Part 61, Subpart M, specify control requirements for most asbestos emissions, including work practices that must be followed to minimize the release of asbestos fibers during the handling of asbestos waste materials. EPA regulations promulgated under the Toxic Substances Control Act (40 CFR Part 763, Subpart F) address the problem of asbestos construction materials used in schools. These regulations require that all schools be inspected to determine the presence and quantity of asbestos-containing materials in school facilities. Corrective actions are left to the discretion of school officials. EPA regulations promulgated under the Clean Water Act set standards for asbestos levels in effluents to navigable waters.

Throughout this rulemaking, OSHA has consulted with the EPA on various regulatory aspects of dealing with the asbestos hazard. EPA has reviewed and critiqued OSHA's quantitative risk assessment for asbestos (Exs. 84–292, 86–6), and both EPA and OSHA belong to the Federal Asbestos Task Force, established in June 1983, to coordinate Federal regulatory actions with regard to asbestos. The Consumer Product Safety Commission is also a member of this task force because of its mandate to protect consumers from health and safety hazards.

C. State Plan Revisions

The 25 states and territories with their own OSHA-approved occupational safety and health plans must revise their existing standard within 6 months of this publication date or show OSHA why there is no need for action; for example, because an existing State standard covering this area is already "at least as effective" as the revised Federal standards. These states or territories are: Alaska, Arizona, California, Connecticut, Hawaii, Indiana, Iowa, Kentucky, Maryland, Michigan, Minnesota, Nevada, New Mexico, New York, North Carolina, Oregon, Puerto Rico, South Carolina, Tennessee, Utah, Vermont, Virginia, the Virgin Islands, Washington, and Wyoming. (In Connecticut and New York, the plan covers only State and local government employees.)

II. Regulatory History

OSHA has regulated asbestos since 1971. A 12 f/cc permissible exposure limit (PEL) for asbestos was included in the initial promulgation on May 29, 1971 (36 FR 10466) of OSHA standards pursuant to Section 6(a) of the Act. In Response to a petition by the Industrial Union Department of the AFL–CIO, OSHA issued an ETS on asbestos on December 7, 1971, which established a PEL of 5 f/cc as an 8-hour time-weighted average (TWA) and a peak exposure level of 10 f/cc.

In June 1972, OSHA promulgated a new final standard that established an 8-hour time-weighted average PEL of 5 f/cc and a ceiling limit of 10 f/cc. These limits were intended primarily to protect employees against asbestosis, and it was hoped that they would provide some incidental degree of protection against asbestos induced forms of cancer. Effective July 1976, OSHA's 8-hour TWA limit was reduced to 2 f/cc and this limit remained in effect up to the present; the final rules published today revise the PEL for 8-hour employee exposures to asbestos, tremolite, anthophyllite, and actinolite to a level of 0.2 fiber/cc.

OSHA's 1972 asbestos standard was reviewed by the court and upheld in all major respects; however, the court remanded two issues for OSHA's reconsideration (*IUD* v. *Hodgson,* 449 F. 2d 467 (CADC 1974)). These issues were whether the July 1976 effective date for the 2 f/cc standard should be accelerated for some industries and whether the standard's 3-year retention period for employee exposure monitoring records was adequate. In response to the remand, OSHA increased the record retention period to 20 years (41 FR 11504), and the passage of time mooted the acceleration issue.

In October 1975, OSHA published a notice of proposed rulemaking (40 FR 47652) to revise the asbestos standard because the Agency believed that "sufficient medical and scientific evidence has been accumulated to warrant the designation of asbestos as a human carcinogen" and that advances in monitoring and protective technology made reexamination of the standard "desirable." This proposal would have reduced the 8-hourtime-weighted average to 0.5 f/cc and imposed a ceiling limit of 5 f/cc for 15 minutes.

The basis for the 1975 proposal's reduction in the permissible exposure limit to 0.5 f/cc was OSHA's then-current policy for carcinogens that assumed that no safe threshold level was demonstrable and therefore that the Act required the Agency to set the PEL at a level as low as technologically and economically feasible. This policy was rejected by the Supreme Court in the benzene decision (*IUD* v. *API,* 448 U.S. 601 (1980)) (see the discussion of the implications of the benzene decision for OSHA rulemaking in the Significance of Risk section of the preamble, section VI). The 1975 proposal would have applied to all industries except construction. Further, although OSHA announced its intention to develop a separate proposal applicable to the construction industry, no such proposal was published.

In 1976, the National Institute for Occupational Safety and Health (NIOSH), and in 1980 a NIOSH/OSHA task force, recommended that OSHA reduce the permissible exposure limit for asbestos to 0.1 f/cc, based on evidence of the carcinogenicity of asbestos (Ex. 84–320). OSHA has considered these recommendations in determining what regulatory response is necessary to provide exposed employees with effective protection.

On May 24, 1983, OSHA consulted with the Advisory Committee for Construction Safety and Health (referred to as "CACOSH") concerning the applicability of any new asbestos standard to the construction industry. CACOSH endorsed OSHA's position that any new PEL adopted for general industry should also apply to the construction industry (Ex. 84–424). On November 4, 1983, OSHA published an Emergency Temporary Standard (ETS) for asbestos (48 FR 51086). The ETS marked a new regulatory initiative, related to, but not part of, the 1975 proceeding. The ETS was held invalid by the U.S. Circuit Court of Appeals for the Fifth Circuit on March 7, 1984.

Subsequently, OSHA published a notice of proposed rulemaking (49 FR 14116, April 10, 1984) for a standard covering occupational exposure to asbestos in all of the industries governed by the Act: maritime, construction, and general industry. Pursuant to Section 6(c) of the Act, the ETS also served as a proposed rule. Public hearings were held in Washington, D.C., from June 19 to July 10, 1984, to provide interested parties and the public with the opportunity to comment on the proposed revisions, pursuant to notice and section 6(b) of the Act (29 U.S.C. 655(b)(3)). The hearings were presided over by Administrative Law Judge Robert G. Mahoney. Post-hearing submissions of data, comments, and briefs were received through November 1, 1984. The entire record, including over 340 exhibits and approximately 55,000 pages of material, was certified by Judge Mahoney on September 27, 1985, in accordance with 29 CFR 1911.17. Copies of materials contained in the record may be obtained from the OSHA Docket Office, Room N3670, U.S. Department of Labor, 200 Constitution Avenue, NW., Washington, DC 20210. These final standards on occupational exposure to asbestos in construction and general industry are based on a thorough consideration of the entire record of this proceeding, including materials discussed or relied on in the November 1983 and April 1984 notices, the record of the informal hearing, and all written comments and exhibits received.

III. Pertinent Legal Authority

The primary purpose of the Occupational Safety and Health Act (29 U.S.C. 651 et seq.) (the Act) is to assure, so far as possible, safe and healthful working conditions for every American worker over the period of his or her working lifetime. One means prescribed by the Congress to achieve this goal is the mandate given to, and the concomitant authority vested in, the Secretary of Labor to set mandatory safety and health standards. The Congress specifically mandated that:

The Secretary, in promulgating standards dealing with toxic materials or harmful physical agents under this subsection, shall set the standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life. Development of standards under this subsection shall be based upon research, demonstrations, experiments, and such other information as may be appropriate. In addition to the attainment of the highest degree of health and safety protection for the employee, other considerations shall be the latest available scientific data in the field, the feasibility of standards, and experience gained under this and other health and safety laws. (Section 6(b)(5))

Where appropriate, OSHA standards are required to include provisions for labels or other appropriate forms of warning to apprise employees of hazards, suitable protective equipment, exposure control procedures, monitoring and measuring of employee exposure, employee access to the results of monitoring, appropriate medical examinations, and training and education. Moreover, where a standard prescribes medical examinations or other tests, they must be available at no cost to the employee (Section 6(b)(7)). Standards may also prescribe recordkeeping requirements where necessary or appropriate for the enforcement of the Act or for developing information regarding occupational accidents and illnesses (Section 8(c)).

In vacating OSHA's revision to its benzene standard, the Supreme Court required in *Industrial Union Department, AFL–CIO* v. *American Petroleum Institute,* 448 U.S. 601, 65 L. Ed. 2d 1010, 100 S. Ct. 2844 (1980), that before the issuance of a new or revised standard pursuant to section 6(b)(5) of the Act, OSHA must make two threshold findings. OSHA must find that a significant risk exists under the current standard and that the issuance of a new standard would reduce or eliminate that risk. The Court stated:

We agree . . . that subsection 3(8) requires the Secretary to find, as a threshold matter, that the toxic substance in question poses a significant health risk in the workplace and that a new, lower standard is therefore "reasonably necessary or appropriate to provide safe and healthful employment and places of employment." 448 U.S. 607 at 614–15; 65 L. Ed. 2d 1010 at 1018–19.

The Court also stated:

. . . Before he can promulgate any permanent health or safety standard, the Secretary [of Labor] is required to make a threshold finding that a place of employment is unsafe—in the sense that significant risks are present and can be eliminated or lessened by a change in practices. . . . (448 U.S. at 642, 65 L. Ed. 2d at 1035)

The decision, although it recognized the uncertainties involved, indicated that the determination of "significant risk" should, if at all possible, be established on the basis of an analysis of the best available evidence through such means as quantitative risk assessments. However, in making that determination, the Supreme Court in its general guidance for the future noted that

. . . The requirement that a "significant" risk be identified is not a mathematical straitjacket. It is the Agency's responsibility to determine, in the first instance, what it considers to be a "significant risk." (448 U.S. at 655, 65 L. Ed. 2d at 1043)

It pointed out that while OSHA

. . . must support its findings that a certain level of risk exists by substantial evidence, we recognize that its determination that a particular level of risk is "significant" will be based largely on policy considerations. (448 U.S. at 656, 65 L. Ed. 2d at 1043, n. 62)

Finally, the Court pointed out that

. . . OSHA is not required to support its finding that a significant risk exists with anything approaching scientific certainty.

Although the Agency's findings must be supported by substantial evidence . . . OSHA [has] some leeway where its findings must be made on the frontiers of scientific knowledge. (448 U.S. at 656, 65 L. Ed. 2d at 1043)

In the only concrete example of significance, the Court stated:

Some risks are plainly acceptable and others are plainly unacceptable. If, for example, the odds are one in a billion that a person will die from cancer by taking a drink of chlorinated water, the risk clearly could not be considered significant. On the other hand, if the odds are one in a thousand that regular inhalation of gasoline vapors that are 2% benzene will be fatal, a reasonable person might well consider the risk significant and take appropriate steps to decrease or eliminate it. (Id. at 655, 656 L. Ed. 2d at 1043.)

After OSHA has determined that a significant risk exists and that such risk can be reduced or eliminated by the proposed standard, it must set the standard "which most adequately assures, to the extent feasible on the basis of the best available evidence, that no employees will suffer material impairment of health . . ." (section 6(b)(5) of the Act). The Supreme Court has interpreted this section to mean that OSHA must enact the most protective standard possible to eliminate a significant risk of material health impairment, subject only to the constraints of technological and economic feasibility. (*American Textile Manufacturers Institute, Inc.* v. *Donovan,* 452 U.S. 490 (1981)).

Moreover, section 4(b)(2) of the Act provides for OSHA standards to apply to construction, maritime, and other workplaces where the Secretary determines that these standards are more effective than the existing standards that would otherwise apply to these workplaces. The Secretary so finds, and these standards will therefore apply to all workplaces where the Secretary has authority to regulate.

IV. Health Effects

A. Overview of Asbestos-Related Diseases

OSHA is aware of no instance in which exposure to a toxic substance has more clearly demonstrated detrimental health effects on humans than has asbestos exposure. The diseases caused by asbestos exposure are life-threatening or disabling. Among these diseases are lung cancer, cancer of the mesothelial lining of the pleura and peritoneum, asbestosis, and gastrointestinal cancer. Of all of the diseases caused by asbestos, lung cancer constitutes the greatest health risk for American asbestos workers. Lung cancer has been responsible for more than half of the excess mortality from asbestos exposure in some occupational cohorts.

The relationship between lung cancer and asbestos exposure has been established in numerous epidemiologic studies of diverse groups. Asbestos-induced lung cancer usually has a latency period in excess of 20 years, and this cancer may be manifested at a younger age than is true for lung cancer victims who are not exposed to asbestos (Craighead et al., Ex. 84–033). Few cases of lung cancer are curable, despite advances in medical and surgical oncology. Only 9 percent of lung cancer patients survive for 5 or more years after diagnosis (American Cancer Society, Ex. 84–160). Asbestos exposure acts synergistically with cigarette smoking to multiply the risk of developing lung cancer.

Many studies have also shown conclusively that mesothelioma is associated with asbestos exposure. In some asbestos-exposed occupational groups, 10–18 percent of deaths have been attributable to malignant mesotheliomas. Malignant mesotheliomas of the pleura and peritoneum are extremely rare in persons not exposed to asbestos. Generally, a latency period of at least 25–30 years is required before mesotheliomas are observed in an occupational cohort, although some victims of mesothelioma have had latency periods exceeding 40 years (Craighead et al., Ex. 84–033). This form of cancer is rarely curable and is usually fatal within a year after diagnosis.

Some epidemiologic studies of asbestos-exposed persons have shown increases in esophageal, stomach, colo-rectal, kidney, laryngeal, pharyngeal, and buccal cavity cancers. Although the increased risk of incurring cancers at these sites is not as great as the increased risk of lung cancer and mesothelioma, the increase is of considerable importance because of the high background rates, and therefore the large number of victims, associated with some of these tumors in the general population. For example, a 50 percent increase in a common cancer such as colo-rectal cancer results in many more deaths than a 50 percent increase in a rare cancer.

Asbestosis is pulmonary fibrosis caused by the accumulation of asbestos fibers in the lungs. The adverse effects of asbestosis range from shortness of breath during exertion to cyanosis, effusions of serous fluid, respiratory failure, cardiac decompensation, and death. Asbestosis is often a progressive disease, even in the absence of continued exposure. The symptoms of the disease are shortness of breath, cough, fatigue, and vague feelings of sickness. When the fibrosis worsens, shortness of breath occurs even at rest. One clinical feature of early asbestosis as well as other lung diseases is end-inspiratory crackles (rales). Diagnosis of asbestosis is based on the presence of characteristic radiologic changes, symptoms, rales, other clinical features of fibrosing lung disease, and a history of exposure to asbestos.

Asbestos exposure can cause pleural and/or other pulmonary disease. Pleural plaques are one of the markers of asbestos exposure and may develop within 10–20 years after the initial exposure. Plaques are opaque patches visible on chest X rays that consist of dense strands of collagen (connective tissue protein) lined by mesothelial cells. All commercially used types of asbestos induce plaques. Plaques can occur without fibrosis and do not seem to reflect the severity of pulmonary parenchymal disease. Pleural calcification is also commonly found in persons who have been exposed to asbestos (Craighead et al., Ex. 84–033).

The adverse effects of exposure to asbestos have been observed in workers involved in the manufacture of asbestos cement pipes and shingles (Enterline et al., Exs. 84–044, 84–122; Weill et al., Ex. 84–123, Finkelstein, Exs. 84–206, 84–240), asbestos mining and milling (Wagner et al., Ex. 2–21; Liddell et al., Ex. 84–059; McDonald et al., Ex. 84–065; Hobbs et al., Ex. 84–072; Nicholson et al. Ex. 84–086; Rubino et al., Ex. 84–086), asbestos textile manufacturing (Doll, Ex. 84–040; Peto et al., Ex. 84–169; Berry et al., Ex. 84–020; Dement et al., Ex. 84–037), insulation work (Selikoff et al., Ex. 84–109), shipbuilding (Selikoff et al., Ex. 84–091; Blot et al., ex. 84–109; Tagnon et al., Ex. 84–182), talc mining and milling (Brown et al., Ex. 84–29) and in a variety of asbestos products manufacturing industries (Jones et al., Ex. 84–138; Henderson and Enterline, Ex. 84–048; McDonald and McDonald, Ex. 84–154; Seidman et al., Exs. 84–087, 261–A; Robinson et al., Ex. 84–082; Acheson et al., Ex. 84–103).

The conclusions just expressed are widely accepted both in the U.S. and abroad. The following agencies and organizations have reviewed the health data for asbestos: International Agency for Research on Cancer (IARC) (Ex. 84–321), Organization for Economic Cooperation and Development (OECD) (Ex. 84–337), NIOSH (Exs. 84–338 and 84–320), Advisory Committee of the Health and Safety Commission of the United Kingdom (Ex. 84–216), the Chronic Hazard Advisory Panel on Asbestos (CHAP) (Ex. 84–256), and the U.S. Environmental Protection Agency (Ex. 84–180). All of these groups have concluded that there is a causal relationship between asbestos exposure and the development of cancer and non-malignant respiratory disease. NIOSH recommended reducing the permissible exposure limit (PEL) for asbestos to 0.1 fiber per cubic centimeter (0.1 f/cc) in 1976. In 1980, a joint NIOSH-OSHA Asbestos Work Group stated that there was no level of exposure to asbestos below which clinical effects did not occur and recommended a PEL of 0.1 fiber per cubic centimeter (0.1 f/cc), based on the limitations of current technologies for measuring airborne concentrations of asbestos. The 1979 report of the Advisory Committee of the Health and Safety Commission of the United Kingdom (hereafter referred to as the U.K. Committee) led to the reduction of the British standard for asbestos to 1 f/cc for chrysotile, 0.5 f/cc for amosite, and 0.2 f/cc for crocidolite.

The following sections describe the record evidence that demonstrates the causal relationship between asbestos exposure and increased risks of incurring lung cancer, mesothelioma, gastrointestinal cancer, and non-malignant respiratory diseases such as asbestosis. In addition, evidence is presented pertaining to the relationship between exposure to various types and sizes of asbestos fiber and the risks of asbestos-related disease; evidence concerning the synergistic effect of smoking and asbestos exposure on the risks of developing lung cancer is also presented. Most of the health effects evidence was previously presented in OSHA's November proposal (48 FR 51099–51122). The current publication summarizes the evidence contained in that **Federal Register** notice and presents in detail new evidence obtained during and after the public hearing.

B. Epidemiologic Evidence of Risk of Lung Cancer and Mesothelioma Mortality

1. Epidemiologic Studies

The epidemiologic studies of greatest interest are those that show a correlation between the intensity and duration of asbestos exposure and an observed excess in lung cancer and mesothelioma. In the November proposal, OSHA reviewed several studies that provided information on exposure level and incidence of lung cancer (Exs. 84–21; 84–36; 84–37; 84–48; 84–87; 84–90; 84–206; 84–240) and mesothelioma (Exs. 84–36; 84–87; 84–90; 84–206; 84–240). These studies, which provide the basis for OSHA's Quantitative Risk Assessment are briefly reviewed here, along with a number of more recent investigations (Exs. 162–C; 163–E; 168–A; 168–B; 261–A) that were submitted to the record after publication of the November proposal.

Seidman et al. (Ex. 84–087) studied cause specific mortality among 820 amosite insulation manufacturing workers employed sometime during 1941–1945 at the Patterson insulation facility, which was known to have a deficient ventilation system. Estimates of asbestos exposure at this facility were not available at the time this study was published. Workers were classified as having worked less than 1 month, 2 months, 3–5 months, 6–11 months, 1 year, or 2 or more years. Workers in all of these exposure categories had excessive mortality from lung cancer. This study demonstrates that workers with exposures of relatively short duration are at excess risk of lung cancer.

This mortality study was updated to include both a longer followup period and exposure estimates (Seidman, Ex. 261–A). The updated analysis included an additional 593 cases involving deaths occurring during the period from 5 to 40 years after onset of work. To increase the comparability of this study with others, Seidman re-analyzed the results of the earlier study by using death rates for white males from New Jersey to calculate Standardized Mortality Ratios (SMRs). Cumulative exposure to asbestos was estimated for each worker using work history records and exposure measurements taken in 1967, 1970, and 1971 from two similar amosite insulation production plants. These exposure data were collected and reported by NIOSH (Ex. 2–12). Workers were progressively assigned to the following cumulative exposure categories during the 35-year followup period: less than 6.0 f/cc-years, 6.0–11.9 f/cc-years, 12.0–24.9 f/cc-years, 25.0–49.9 f/cc-years, 50.0–99.9 f/cc-years 100.0–149.9 f/cc-years, 150.0–249.9 f/cc-years, and 250 or more f/cc-years. The use of exposure data from plants other than that from which the cohort was derived is appropriate in this study since the exposure measurements were from "plants of the same company where the same products were made utilizing the same machinery, fiber and production processes" (Ex. 261–A, p. 5). The investigators indicated that their exposure estimates may be on the high side for two reasons: (1) Dustier areas tend to be sampled more often than other areas, and (2) a concerted effort was made to have respiratory protection used by workers in the plant from which the study cohort was taken. Furthermore, Dr. Morton Corn, former Assistant Secretary for OSHA and testifying on the behalf of the Building and Construction Trades Department, commented that the Tyler, Texas plant, where some of the exposure data were obtained, was ". . . one of the most contaminated asbestos facilities I've ever been in" (Tr. 7/3, p. 67). Therefore, it is likely that the exposure estimates were overestimated, leading to an underestimate of excess risk for workers in each of the cumulative exposure categories.

Overall deaths were significantly (p less than 0.001) elevated (SMR–167), as were deaths from all cancers (SMR–287), from all "asbestos" diseases (SMR–396), from noninfectious lung disease (SMR–489), and from lung cancer (SMR–541). Colorectal cancer mortality was also significantly (p less than 0.05) increased (SMR–185). In addition, 17 deaths from mesothelioma were observed, a finding of great significance given the rarity of ths disease. A strong cumulative dose-response relationship was evident for both lung cancer mortality and mortality from all "asbestos" diseases.

Dement et al. (Exs. 84–036, 84–037) estimated individual cumulative exposures for 768 workers employed at a chrysotile textile plant during 1930–1975. Mean exposure levels were estimated for these workers on the basis of 5,952 industrial hygiene samples. The following exposure categories were defined: less than 1,000 f/cc-days, 1,000–10,000 f/cc-days and 10,000–40,000 f/cc-days. As explained in the November proposal, OSHA calculated that these categories of cumulative exposure are roughly equivalent to the following exposure categories: less than 2.7 f/cc-years; 2.7–27.4 f/cc-years, 27.4–109.6 f/cc-years, 109.6–274 f/cc-years, and greater than 274 f/cc-years. The first three of these exposure categories fall within at or below the lifetime cumulative exposure permitted by the 2-f/cc standard. Fifteen or more years after the onset of exposure, standardized mortality ratios (SMRs) for lung cancer among white males were 140, 279 (p less than 0.05), and 352 (p less than 0.05) in the first three exposure categories, respectively, demonstrating the existence of a dose-response relationship. Dement et al. (Ex. 84–037, p. 432) concluded that: "Based on data from this study, significantly elevated mortality risks are predicted for lung cancer and for asbestosis at cumulative exposures of 100 fibers/cc-years in the textile industry." OSHA considers that these observations of excess risk from low cumulative exposures are well-supported because of the careful estimation of exposure histories for members of the cohort in this study.

Henderson and Enterline (Ex. 84–048) studied the mortality of 1,075 retired asbestos production workers. Mean estimated exposures for the cumulative exposure categories were 62, 182, 352, 606, and 976 mpcf-years. Based on the recommended conversion factor of 1:1.4 for asbestos production (discussed in the November proposal), 62 mpcf-years is roughly equal to 87 f/cc-years, a cumulative exposure permitted by the 2 f/cc standard. An SMR of 197.7 for respiratory cancer was observed for workers in this cumulative exposure category. This observed excess mortality risk is not as high as that observed by Dement et al. (Exs. 84–036, 84–037); however, the authors of the Dement et al. study suggested that this difference may be the result of the fact that Henderson and Enterline studied retirees, which constitute a select group of survivors; only 8 of the 35 lung cancer deaths observed by Dement et al. (Ex. 84–37) occurred among persons 65 or older.

McDonald et al. (Ex. 84–065) studied the mortality of 11,379 workers exposed to chrysotile mining and milling. Based on a conversion factor for these operations of 1:3 for mpcf to f/cc, the exposure classifications developed by the authors would correspond to the following exposure categories: less than 90 f/cc-years, 90–899 f/cc-years, and 900 or more f/cc-years. Although they did observe an increased incidence of pneumoconiosis (SMRs 298, 1081, and 5400, respectively), McDonald et al. (Ex. 84–065) observed less lung cancer risk for these exposure categories than other investigators (SMRs were 93, 118, and 225, respectively). Regarding the different findings between the studies by McDonald et al. (Ex. 84–065) and Dement et al. (Exs. 84–036, 84–037) on lung cancer risk from low exposures, Dement et al. suggested that differences in the characteristics of airborne fibers, as well as the presence of a competing risk of pneumoconiosis among miners in the McDonald et al., study, could account for the differences in lung cancer mortality reported in these two studies.

Finkelstein (Ex. 84–240) studied the mortality of 339 men who had been employed at an Ontario asbestos cement factory for 9 or more years. Each cohort member was classified as having accumulated 8–69 f/cc-years, 70–121 f/cc-years, or 122–420 f/cc-years of asbestos exposure during the 18 years following onset of exposure. Cohort mortality was analyzed by cumulative exposure, starting 20 years after onset of exposure, and was compared to that of non-exposed Ontario men. Approximate relative risks for lung cancer mortality for the three exposure categories were 8.5, 16.3, and 7.4, respectively. Mesothelioma mortality rates per 1000 man-years were 1.9, 4.9, and 11.9, respectively, showing a clear dose-response relationship between asbestos exposure and mesothelioma. Finkelstein suggested several explanations for the unexpected decrease in excess lung cancer mortality in the highest exposure category: he argued that statistical fluctuations caused by the small size of the cohort or the possible confounding effects of smoking may have been responsible for this unexpected result. More likely, lung cancer risk may have been underestimated for the highest exposure category by Finkelstein's exclusion of any lung cancer deaths that might have occurred during the 20 years from onset of exposure to the beginning of the followup period. In addition to showing dose-response relationships between asbestos exposure and the excess risk from lung cancer and mesothelioma, OSHA notes that Finkelstein's study presents evidence that an excess risk for these diseases exists at cumulative exposures that would be permitted by lifetime exposure to the 2-fcc standard.

Rubino et al. (Ex. 84-086) studied the mortality of 952 male Italian chrysotile miners and millers. The mortality experience of the overall cohort was compared with that of nonexposed Italian males. Compared with nonexposed Italians, the overall cohort had statistically significant excesses of mortality from laryngeal cancer, nonmalignant respiratory diseases, and non-asbestos-related causes, but not from lung cancer. However, there were some trends showing increasing lung cancer risk with increasing length of followup and increasing cumulative exposure. Using the methodology presented in Ex. 84-336, OSHA determined that this study had only a 33.5 percent power to detect a 50 percent increase in lung cancer risk among workers with 20 or more years of followup. Generally, it is considered desirable for studies to have at least an 80 percent power to detect a 50 percent increase in disease.

Weill et al. (Ex. 84-206) studied mortality among 5,645 men having at least 20 years of latency since first exposure in either of two asbestos cement plants. Each worker's cumulative dust exposure during the 20 years after the onset of exposure was estimated in terms of mpcf-years. Based on the conversion factor of 1:1.4 suggested by Hammad et al. Ex. 84-277), the five cumulative exposure categories would be equivalent to 14 or fewer f/cc-years, 15-70 f/cc-years, 71-140 f/cc-years, 141-280 f/cc-years, and 281 or more f/cc-years. Neither respiratory cancer mortality nor any other cause of death was increased among workers in the three lowest exposure categories. Weill et al. noted that the relatively high proportion (25 percent) of the cohort that was lost to followup and assumed to be alive may have led to an underestimation of respiratory cancer risk. The upper limits of the 95 percent confidence intervals of the SMRs for respiratory cancer for the three lowest exposure categories ranged from approximately 115 to 150, indicating, in OSHA's opinion, that the presence of an excess risk of mortality from lung cancer could not be ruled out for the cohorts in these exposure categories.

Berry and Newhouse (Ex. 84-021) studied the mortality of a large cohort of friction material production workers whose asbestos exposures were relatively low (generally less than 1 f/cc to 5 f/cc) and of short duration. Cumulative exposures for the cohort averaged less than 50 f/cc-years. Only non-significant increases in mortality from lung cancer were observed; however, mortality from mesothelioma was significantly elevated compared with that of controls. Most of the mesothelioma victims had been exposed to asbestos levels exceeding 5 f/cc; their cumulative exposure estimates were not reported. A sizeable portion of the cohort was studied for a relatively short followup period between onset of exposure and the end of the study. For example, the followup period for 33 percent of the men was less than 20 years. Because of the short followup period used, OSHA does not believe that the non-significant increases in lung cancer mortality found by these investigators contradict the findings from other studies, which show that low-level exposure to asbestos has resulted in excessive mortality from lung cancer.

Of the few epidemiologic studies submitted to the docket after the publication of the November proposal, four provide additional information on the risk of lung cancer mortality and/or mesothelioma mortality among workers exposed to asbestos. The first (Cantor, Ex. 168-A; Cantor et al., Ex. 168-B) is only an interim report on a proportionate mortality study and has no estimates of cumulative exposure. Two other studies similarly give no estimates of cumulative exposure; one (Nicholson and Selikoff, Ex. 162-C) investigates the risks of recent exposures of limited duration, while another (Zoloth and Michaels, Ex. 163-E) investigates the effects of intermittent asbestos exposure. The fourth study (Seidman, Ex. 261-A) is an update of a previous study (Seidman et al., Ex. 84-087) and was discussed earlier in this section.

Kenneth P. Cantor, of the National Cancer Institute, submitted an interim report (Ex. 168-A; Cantor et al., Ex. 168-B) on his proportionate mortality study of 7,121 deaths identified among members and retirees of the California local of the United Association of Plumbers and Pipefitters. The interim report was based on 6,398 (89.8 percent) of the 7,121 deaths. No specific information was available on cigarette smoking habits or on asbestos exposure levels. Expected numbers of deaths were calculated from cause-specific proportionate mortality rates by 5-year age and 5-year calendar period groups among U.S. white males. For mesothelioma, the expected number of deaths was estimated on the basis of death certificate information for approximately 10 percent of the U.S. population. Further analysis conducted after the interim report confirms the interim report findings (Ex. 168-A).

The most striking finding from this report is that 15 mesothelioma deaths occurred in this group, while only 2 were expected. A significant (p less than 0.05) excess number of lung cancer deaths was also observed (587 observed, 408 expected). Other smoking-related cancer sites had PMRs at or near expected levels. The investigators concluded:

"It is likely that exposure to asbestos is responsible for at least part, if not all, of the excess number of lung cancers in this group:

1. The excessive number of deaths due to lung cancer is consistent with the elevated number of mesothelioma deaths that points to widespread asbestos exposure.

2. If cigarette smoking *had* [emphasis added] played an important role in causing excess lung cancer deaths, we would expect the PMR for bladder cancer, another smoking-related . . . [malignancy] that has not been linked to asbestos exposure, to also be elevated. There were 40 deaths due to bladder cancer whereas 40.4 were expected (PMR=.99), suggesting no increase in risk for cancers of this site." (Ex. 168-A, pp. 3-4.)

This study, although it is an interim report, is significant for two reasons. First, the excess number of deaths from mesothelioma add to the already considerable weight of evidence for a causal relationship between asbestos exposure and an increased mortality risk from this rare cancer. Second, despite the lack of data on smoking habits for the cohort, the study suggests that asbestos exposure, and not smoking, was the principal cause of the observed excess in lung cancer mortality.

Nicholson and Selikoff (Ex. 162-C) investigated mortality among 1,918 male shipyard workers who were employed on January 1, 1967 and who were first employed before January 11, 1957. More than 80 percent of the cohort was employed for less than 20 years. Although no estimates of exposure levels were given, the authors state that: "in terms of time from onset of exposure and duration of exposure, the exposures have been recent and of limited duration. The full manifestation of the effects of shipyard employment would not yet be expected to be present in this group" (Ex. 162-C, p. 1).

In comparison with the mortality observed in white males in Connecticut, the overall mortality for the cohort with 11.5 years of exposure was significantly (p less than 0.05) elevated (356 observed, 316 deaths expected). Mortality from cancer at all sites was also in excess (90 observed, 80 expected). The major sites of cancer increase were the lung (35 observed, 26 expected) and the gastrointestinal tract (19 observed, 15 expected), two cancer sites known to be related to asbestos exposure. These excesses were seen in both production and support workers, whereas office employees from the same shipyards experienced mortality similar to that of the general male population of Connecticut. Finding such excesses in a cohort that had relatively short employment and that had been followed for a relatively short period of time was, in the authors' words, "unexpected" and leads to augmented concern for the next two or three decades" (Ex. 162-C, pp. 3, 4).

The study (Ex. 162-C) provides additional qualitative evidence of the excess risk of lung cancer mortality and GI cancer mortality experienced by asbestos-exposed workers. Although these investigators were surprised to find such excesses following relatively recent asbestos exposure, other authors (Ex. 306-B, Ex. 320) have noted that significant increases in the lung cancer death rate begin to appear 10 to 14 years after the first exposure and peaks between 30 and 35 years after (Ex. 306-B, p. 57).

Zoloth and Michaels (Ex. 163-E) performed a proportionate mortality analysis of 381 deaths that occurred among white males who had been members of a local New York chapter of the Sheet Metalworkers International Association for at least 10 years. Specific estimates of asbestos exposure levels were not given; however, exposure was described as being intermittent and incidental. Half of the local union members were employed in installation of metal ducts. The expected distribution of deaths was based on U.S. white male mortality rates, with adjustments for age and date of death.

There was significant (p less than 0.05) excess mortality from all cancers (PMR-152), lung cancer (PMR-160), colorectal cancer (PMR-232), and non-Hodgkins lymphoma (PMR-236). In addition, three deaths from mesotheloma were observed. The authors calculated standardized mortality odds ratios (SMOR) using arteriosclerotic heart disease as a referent to offset some of the potential biases in PMRs. The calculated SMORs were reported to be virtually identical to the PMRs, indicating the absence of any significant biases in the PMR's for cancer. The authors concluded that this study, with an overall pattern of observed mortality consistent with that found in other populations exposed to asbestos, "strongly suggests the presence of significant asbestos-related illness is [sic] a population with 'secondary' asbestos exposure" (Ex. 163-E, p. 11).

The interpretation of these results is limited by the design of proportionate mortality studies. Although the investigators reported that half of the local union members were employed in installations of metal ducts, and thus were must likely to be exposed intermittently to asbestos, it is not known what proportion of the deceased members were so employed. Moreover, although the observed deaths occurred in a predominantly metropolitan population, the expected distribution of deaths was based on general U.S. mortality rates; the resultant comparison is not ideal because of the generally recognized differences in mortality patterns of urban populations in comparison to those of the overall U.S. population. These investigators did strengthen their study results by calculating SMORs.

2. Evidence of an Excess Risk of Lung Cancer and Mesothelioma at Low Cumulative Exposures of Asbestos

In establishing whether an existing permissible exposure limit is inadequate for protecting workers against the risk of occupational disease, the Agency relies principally on the findings of quantitative risk assessments and an evaluation of the significance of the risk presented by exposure at the existing PEL. After conducting the quantitative risk assessment for asbestos, OSHA concludes that the 2-f/cc PEL is inadequate for worker protection and that reduction of the PEL is warranted (see Section V, Quantitative Risk Assessment, and Section VI, Significance of Risk). OSHA's finding that the 2 f/cc PEL is inadequate is supported by the observations of excess cancer mortality among workers who have been exposed to cumulative levels of asbestos lower than would be permitted by lifetime exposure to 2 f/cc. These observations, first referred to in the November proposal and discussed above, were derived from the studies by Dement et al. (Exs. 84-36; 84-37), Henderson and Enterline (Ex. 84-48), Finkelstein (Ex. 84-240), and Seidman et al. (Exs. 84-87, 261-A). In addition, a number of studies have recorded cases of mesothelioma among members of the families of asbestos workers (Anderson et al., Exs. 84-16, 84-17; Vianna and Polon, Ex. 84-186); Li et al., Ex. 84-149). Mesothelioma has also been observed among community members living near asbestos mines and factors (Wagner et al., Ex. 2-21; Newhouse and Thompson, Ex-84-70). For example, in 1976, Anderson et al. (Ex. 84-16) reported that 4 cases of pleural mesothelioma had been diagnosed among 626 family contacts of amosite factory workers. Presumably, family contacts received their exposure to asbestos from dust carried home on the worker's clothing, and especially during the laundering of dusty clothes. Although exposure measurements were not taken for family contacts, OSHA considers it very likely that their cumulative exposure was less than the cumulative exposure that would result from lifetime exposure to the 2 f/cc standard. OSHA believes that these findings, as well as the observation in epidemiological studies of excess mortality resulting from low cumulative exposures to asbestos, further support the Agency's finding from the risk assessment that the 2 f/cc PEL is inadequate for protecting workers against the risk from lung cancer and mesothelioma.

3. Experimental Evidence

Several animal studies are contained in the record that show that experimental animals, when administered asbestos fiber by inhalation, injection, or implantation, develop malignant tumors at a rate higher than unexposed animals (Exs. 84-338; 84-320; 84-205; 94-96; 84-197; 84-120; 84-128; 84-240; 84-193; 84-195). No rulemaking participant questioned the causal relationship between asbestos exposure and the development of malignancies in experimental animals. OSHA believes that, while these studies in general support the findings of epidemiology studies, they are more germaine to the issues brought up during the rulemaking regarding the relationship between fiber type and dimension and the carcinogenicity of asbestos. OSHA discusses these experimental studies in a later section that deals with the issues of fiber type and size.

4. Summary of the Evidence of Lung Cancer and Mesothelioma

After reviewing the studies discussed above, OSHA finds that the evidence for establishing a dose-response relationship between asbestos exposure and an excess risk of either lung cancer or mesothelioma is exceptionally strong. The following studies have shown a positive dose-response relationship for an increased risk of lung cancer mortality and/or mesothelioma mortality: Finkelstein (Ex. 84-240), Dement et al. (Ex. 84-036, 84-037), Henderson and Enterline (Ex. 84-048), Seidman (Ex. 261-A), Berry and Newhouse (Ex. 84-021), Weill et al. (Ex. 84-206), Selikoff et al. (Ex. 84-87), and Peto (Ex. 84-169). OSHA has used these studies in its Quantitative Risk Assessment (see Section V) to show that cumulative exposure levels below that permitted by the existing PEL of 2 f/cc presents an excess risk of cancer mortality.

These studies also show that cumulative exposure levels of asbestos below that permitted by lifetime exposure to the 2 f/cc PEL results in excess mortality from lung cancer and mesothelioma. Furthermore, the Seidman update (Ex. 261-A) and the Nicholson and Selikoff study (Ex. 162-C) clearly indicate that workers exposed for a relatively short period of time experienced significant excess mortality from lung cancer and from all asbestos diseases. OSHA believes that the results of Zoloth and Michael's study (Ex. 163-E) of asbestos-exposed sheetmetal workers further suggests that excess mortality can occur from intermittent exposure conditions. In light of the findings of these three new studies (Exs. 162-C, 163-E, 261-A) and the previously considered evidence, OSHA concludes that well-conducted studies demonstrate a substantially increased rate of lung cancer and mesothelioma mortality among workers having low cumulative exposures to asbestos.

C. Carcinogenicity of Asbestos for Sites Other than the Lung and Mesothelium

1. Epidemiological Studies

In the November proposal, OSHA reviewed several epidemiological studies describing the mortality experience of asbestos-exposed occupational cohorts in regard to cancer occurring at sites other than the lung and mesothelium. Seven studies were reviewed that found statistically significant increases in deaths from gastrointestinal cancer among U.S. and Canadian insulation workers (Exs. 84-090, 84-224), Belfast insulation workers (Exs. 84-041, 84-090), asbestos factory workers (Exs. 84-048, 84-330), shipyard workers (Ex. 84-246), and tremolite and anthophyllite-exposed talc miners (Exs. 84-140, 84-141). Of these studies, the most striking is the investigation of 17,800 U.S. and Canadian insulation workers conducted by Selikoff, Hammond, and Seidman (Ex. 84-090). In this study, significant excess mortality was observed from lung cancer (SMR=406), mesothelioma (180 deaths), esophageal cancer (SMR=253), stomach cancer (SMR=126), colo-rectal cancer (SMR=152), laryngeal cancer (SMR=191), pharyngeal and buccal cavity cancer (SMR=159), kidney cancer (SMR=223), prostate cancer (SMR=137), and non-infectious respiratory diseases including asbestosis (SMR=319).

Selikoff, Hammond, and Seidman concluded:

> Asbestos insulation workers in the United States and Canada suffer an extraordinary increased risk of death of cancer and asbestosis associated with their employment. This includes increases in deaths from lung cancer, pleural mesothelioma, peritoneal mesothelioma, cancer of the esophagus, colon and rectum, cancer of the larynx, oro-pharynx, kidney, and perhaps stomach. Some increases were seen in cancer of several other sites, as well, but data are inadequate at this time to permit characterization of their significance although attention is called to such wider increase (Ex. 84-090, p. 114).

In addition to the above-mentioned studies, OSHA reviewed five studies that showed non-statistically significant increases in gastrointestinal tract cancer. The occupational cohorts examined in these studies included chrysotile textile plant workers (Ex. 84-090, p. 114), chrysotile miners and millers (Ex. 84-065), amosite insulation production workers (Ex. 84-087), and asbestos factory workers (Exs. 84-251, 84-082). The November 1983 notice also pointed out that several epidemiological studies failed to find any excess of gastrointestinal cancer among friction material production workers; chrysotile, anthrophyllite, and talc miners, chrysotile factory workers, asbestos gas mask workers, asbestos textile workers, and shipyard workers.

In summary, 12 different epidemiological studies of a variety of occupational cohorts exposed to asbestos have found excess mortality from gastrointestinal cancers; of these, 7 studies found statistically significant excesses. OSHA believes that these findings constitute substantial evidence of an association between asbestos exposure and a risk of incurring gastrointestinal cancer.

2. Experimental Studies

In the November proposal, OSHA discussed a number of toxicological studies conducted on animals to determine the carcinogenicity of ingested asbestos. A study conducted by Ward et al. (Ex. 84-200) found that 32 percent of amosite-treated Fischer 344 rats developed colon carcinoma; a fairly high incidence of colon tumors compared with the incidence among historical controls from the same laboratory.

Two studies show evidence of gastrointestinal tumors developing in chrysotile and amosite-treated animals but not in the control animals (Bolton et al. Ex. 84-214; Smith et al., Ex. 84-193). However, these results were considered questionable by the authors because, in the case of the Smith et al. study (Ex. 84-193), other investigators observed the same types of tumors in the animal strain studied and, in the case of the Bolton et al. study (Ex. 84-214), asbestos fibers were not found in the mesenteric lymphatic tissue of the amosite-treated animals that developed benign tumors.

However, several studies reported no significant increases in tumor incidence after the administration of chrysotile, amosite, tremolite, and crocidolite asbestos orally to laboratory animals; these studies included those conducted by the National Toxicology Program (NTP) (Exs. 84-225, 84-226, 84-227, and 84-228) and by Donham et al. (Ex. 84-222). In the NTP studies doses well below the maximum tolerated dose (1 percent of diet) were administered, and in some of the NTP studies, relatively short fibers were administered. Although the study by Donham et al. failed to show a significant increase in tumorigenesis, the authors believed that their results showed a trend towards increased colon lesions.

Since the November proposal OSHA has reviewed an additional lifetime feeding study of amosite-treated rats. McConnell et al. (Ex. 306) administered amosite asbestos (1 percent of diet) to a group of 250 8-week-old male and female Fischer 344 rats. When animals were examined for tumors, the incidence of gastro-intestinal tumors among treated male and female rats (7/249 and 4/250, respectively) was found to be comparable to that of untreated male and female controls (4/117 and 2/117, respectively). Treated male rats were found to have a significantly higher incidence of C-cell carcinoma (50/246), compared to male controls (11/117), but due to the lack of other significant findings, the authors did not attribute the increase in the incidence of C-cell carcinoma among treated male rats to amosite exposure.

Although OSHA finds that results from ingestion studies are equivocal and inconsistent with respect to the carcinogenic potential of exposure to asbestos via ingestion in animals, OSHA does not believe that the negative findings from these studies negate or diminish the strong evidence from epidemiological studies. OSHA believes that the study of 17,800 insulation workers conducted by Selikoff et al. (Ex. 84–090) carriers considerable weight with respect to the issue of gastrointestinal cancer and asbestos exposure. This study, which found significant excess mortality from gastrointestinal, laryngeal, kidney, and pharyngeal and buccal cavity cancer, had the highest statistical power of all the epidemiological studies reviewed by OSHA.

D. Epidemiologic Evidence of the Risk of Asbestosis From Exposure at the Existing PEL

The existing standard of 2 fibers/cc was established primarily on the basis of an excess risk of asbestosis among workers exposed to asbestos. Since 1972 when the PEL was promulgated, a number of studies with more precise exposure data suggest that a significant excess risk of asbestosis still exists at 2 fibers/cc. The purpose of this section is to review this evidence in light of the revised standard.

This section is organized into three parts. In part 1, asbestosis is described and the variability associated with its diagnosis is discussed with regard to the interpretation of epidemiologic data. In part 2, the disease burden associated with asbestosis is discussed, along with the problems related to the under-ascertainment of cases. Studies that provide data on asbestosis incidence at low exposure levels are critically reviewed in part 3.

1. Introduction

Asbestosis is characterized by diffuse interstitial fibrosis of the lung. It falls into the class of diseases called pneumoconioses and is caused solely by exposure to asbestos. Asbestosis is a progressive disease and, as such, occurs with varying degrees of severity (Berry et al., Ex. 84–20). The signs and symptoms of asbestosis are no different from those of other forms of interstitial fibrosis and, as a result, the diagnosis is subject to differences in interpretation, resulting in both false negative and false positive conclusions.

In unexposed populations, the diagnosis of asbestosis is rare or nonexistent. A history of asbestos exposure is essential to the diagnosis, which is typically made on the basis of physical examination and x-ray evidence and less often by means of accompanying pulmonary function tests. No single sign or symptom predicts the presence of or progression to asbestosis (Murphy, Ex. 84–314; Berry et al., Ex. 84–20). However, selected combinations of signs and symptoms appear to have high predictive value for the progression to asbestosis. Nonetheless, in some cases, minor fibrosis with considerable respiratory impairment and disability can be present without equivalent X-ray changes. Conversely, extensive radiographic findings may be present with little functional impairment (Exs. 84–2, 84–338).

Symptoms of early disease include a non-productive cough and fatigue. As fibrosis progresses, shortness of breath is apparent, even with minimal exertion. Rales, i.e., crackles heard on inspiration, are often present but are non-specific and thought to be no more prevalent in asbestosis than in other fibrotic diseases (Craighead et al., Ex. 84–033). However, in two studies of workers exposed to asbestos, basilar rales occurred with asbestosis in almost all cases (Murphy, Ex. 84–314; Berry et al., Ex. 84–20). Clubbing of the fingers is seen in the late stages of the disease but does not appear to be as specific as other signs or symptoms (Murphy, Ex. 84–314). Cyanosis of the tongue and mucous membranes may also occur in the later stages of the disease (Ex. 84–27).

The roentgenologic diagnosis of asbestosis is based on the presence of small irregular and round opacities distributed prominently in the lower lung fields, accompanied by evidence of pleural fibrosis, pleural calcification, or thickening. Specific details regarding the radiographic features associated with the progression and diagnosis of asbestosis are noted elsewhere (Craighead et al., Ex. 84–033). The presence of crepitations and X-ray changes does not indicate directly that health is impaired, in contrast to the presence of diminished lung function. Typical pulmonary function changes associated with asbestosis include diminished FVC and FEV_1 (Murphy, Ex. 84–314; Berry et al., Ex. 84–20), and, as shown in one study (Murphy, Ex. 84–314), reduced total lung capacity. Evidence does not support a direct relationship between obstructive airway disease, such as is caused by cigarette smoking; rather than by obstructing airways, asbestosis diminishes lung function by restricting the ability of the lung to expand and contract.

Asbestosis is a disease that is irreversible and that evolves and progresses even in the absence of continued exposure. It is not known whether removing an individual from exposure after the appearance of early signs and symptoms will reduce the risk of progression to more severe stages. The probability that asbestosis will progress in the absence of continued exposure appears to be subject to individual variation, as pointed out by Dr. Selikoff:

> What we don't know . . . is whether people who are removed from exposure have less progression than people who continue exposure. I wish we knew that.
>
> There are very few data on this. . . . You can be exposed, have an abnormal X-ray, and either continue exposure or be removed from exposure, and not progress.
>
> On the other hand, you can be removed from exposure and have progression occur. . . . This is an individual reaction (Tr. 7/2, p. 171).

At present, the only reliable means of preventing the occurrence of asbestosis is to reduce the cumulative exposure incurred by individuals during their working lifetimes to a level below which the risk of disease is very low.

2. Excess Morbidity and Mortality Attributable to Asbestosis

The morbidity and mortality of asbestosis have been studied in workers exposed to asbestos. Excess morbidity is determined from the incidence of disease, which is the rate at which new cases of disease are diagnosed for a given number of person-years of observation. It is important to establish the date at which the disease first occurs to accurately estimate the incidence of asbestosis. The mortality rate for asbestosis is the number of deaths due to asbestosis for a given number of person-years of observation. The cause and date of death are determined from death certificates. When a disease has a high case fatality rate; i.e., when the interval between diagnosis and death is short, then the mortality rate and incidence will be similar.

To estimate the incidence of asbestosis, periodic examinations of workers is essential to both identify cases and accurately determine the date of diagnosis. Cases with asbestosis will be missed if they are lost to followup, i.e., cannot be located for examination. If the rate of asbestosis among those who are lost to followup is higher than among those who are examined, a relatively high loss rate can bias the estimate of risk.

The diagnosis of asbestosis can be difficult. It is important, therefore, in epidemiological studies to use standardized methods of diagnosis such as those established by the ILOC. The diagnostic criteria used by different investigators very considerably, and this can account for some of the differences in the incidence of asbestosis seen between studies.

When a disease is well defined and the case fatality rate is high, such as occurs with lung cancer, the mortality rate will be similar to the incidence of the disease. In contrast, when the disease is not well defined or is difficult to diagnose and the case fatality rate is not high, the mortality rate will be less than the incidence. Unlike lung cancer, the onset of asbestosis is not always life threatening. As the disease progresses and health deteriorates, a subject may seek medical care. In the interim, however, the victim may die from other more easily recognizable causes and the existence of the asbestosis and its associated morbidity will not have been ascertained, even though asbestosis may have been the underlying or contributing cause of death. This is a special problem with diseases like asbestosis which are virtually absent in populations that are not exposed to asbestos.

Hammond, Selikoff, and Seidman (Ex. 84–47, p. 475) note that "what is recorded on the death certificate is not always [based on] the best available information on the cause of death. For example, in the absence of the patient's physician, the certificate may be signed by a doctor who knows less about the case; or an autopsy may indicate that the tentative diagnosis of cause of death was incorrect." In addition, a review of available evidence, such as from the medical record, may indicate that the patient died of another cause of death. Hammond et al. (84–47) reviewed all available medical information, including the death certificates for all deaths in a cohort of insulators. Two causes of death were established: one based on the death certificate (DC) only; and a second cause based on the best evidence available. Seventy-six cases of asbestosis were identified from the death certificate. On the other hand, 160 cases were identified on the basis of the best evidence. In contrast, 638 deaths due to cardiovascular disease were ascertained from DC, while only 566 were identified from the best evidence. These data are consistent with the work of Dement et al. (84–37) who found a statistically significant excess risk of cardiovascular disease among asbestos textile workers. This is unusual because the SMR for cardiovascular disease in working populations is consistently less than 100, reflecting a "healthy worker effect."

Unlike diseases such as lung cancer and mesothelioma, which have a relatively short interval between diagnosis and death, individuals with asbestosis experience a relatively long and debilitating period of morbidity. Dr. Holstein, a pulmonary physician, described a typical case:

> The main symptom of asbestosis is progressive shortness of breath. When this has its onset in its typically insidious and gradual manner, the individual thinks that he is just getting older or getting a little overweight, can't run as fast as he used to, or gets out of breath more easily than he used to; and attributes it to factors such as the ones I mentioned. A little later on, the person begins to notice that in fact, he or she can't do the things that many other people the same age can do. . . . As time goes on, the dependence on younger workers becomes greater and greater, until pretty soon, the individual is experiencing the fact that he or she really can't carry out the job without such dependence. . . . Eventually, in the very severe cases, a person's life consists of sitting in an armchair on the ground floor with an oxygen tank, and disconnecting it just long enough to get up and go to the bathroom.

Hence, there are limitations to using death certificates to determine the extent of mortality attributable to asbestosis. Cases will be underascertained and the person-years of morbidity, i.e., the period between diagnosis of asbestosis and death, are not considered. For these reasons, risk analyses of mortality caused by asbestosis will understate the true risk of disease.

3. Epidemiologic Studies

A number of studies have shown an excess risk of asbestosis in workers exposed to asbestos. Individual exposure data in units of fibers/cc-years are available from three studies, all of which show substantial excess risks below 100 fibers/cc-years (the cumulative lifetime exposure permitted by the 2-f/cc-standard) (Berry et al., Ex. 84–20; Dement et al., Ex. 84–35; Finkelstein, Ex. 84–44). These studies are critically reviewed below. Individual exposure data were also used in two other studies but were reported in units of mppcf-years (McDonald et al., Ex. 84–065; Enterline et al., Ex. 84–43). Several other studies that show an excess risk of asbestosis are not reviewed here because the exposure measure was expressed only as duration of time exposed (Weiss, Ex. 84–097; Doll, Ex. 84–40; Pearle, Ex. 84–079) rather than as exposure level.

The approach for assigning exposure levels to individuals, the method used for person-years analysis, the case definition, the completeness of case ascertainment, and the length of the followup period are directly related to the estimated risk of asbestosis at a defined exposure level. These factors are particularly relevant to the studies of Berry et al. (Ex. 84–20, Dement et al. (Ex. 84–35), and Finkelstein (Ex. 84–44).

All three of these studies, which assigned individual exposures in units of fibers/cc, used person-years analysis to estimate the risk of asbestosis in groups of workers defined by their cumulative exposure to asbestos. To derive such estimates the number of years that workers are exposed must be summed for all workers exposed at each exposure level. If an individual leaves the workplace, subsequent years of followup are assigned to the final cumulative exposure incurred by the individual. Two methods are typically used to assign person-years of observation to the cumulative exposure levels incurred during employment. The first approach assigns the number of person-years of observation before the disease is diagnosed in each successive cumulative exposure category. For example, four exposure groups are defined in terms of employment: greater than 5 years; 5–9 years; 10–14 years; and 15+ years. An individual with 20 years of employment contributes person-years of exposure to all four exposure groups. The same principle applies if asbestos exposure is defined as cumulative fibers/cc rather than duration of employment. That is, before person-years of exposure can be assigned to any cumulative exposure group, a worker must have first experienced a lower cumulative exposure; the person-years of exposure are then assigned in accordance with the length of time the worker spent at each exposure level. An alternative approach assigns the total number of person-years of observation only to the highest cumulative exposure group, i.e., in our example, to the denominator for the 15- to 20-year cumulative exposure group. Use of the latter method underestimates the disease incidence in the higest exposure groups and overestimates the incidence in the lowest exposure groups. Dement et al. (Ex..84–35) and Berry et al. (Ex. 84–20) both used the first approach, while Finkelstein (Ex. 84–44) took the second approach.

The completeness of case ascertainment is directly related to the length of the followup period. If a study's followup period is relatively short, then cases will be underascertained and the risk of disease will be underestimated. In addition, if latency is related to cumulative exposure, i.e., if the median latency is short for high-exposure groups and longer for the low-exposure groups, then the rates for each cumulative exposure group will be underestimated differentially, and most significantly for the lowest exposure group.

On the other hand, if the initial period of followup is ignored then the risk for workers with high exposure may be underestimated. In a study of lung cancer in asbestos cement factory workers Finkelstein (84–240) estimated the relative risk for workers in three exposure groups, starting 20 years after onset of exposure. The highest exposure group had the lowest risk. If a higher exposure causes a shorter disease latency, then proportionately more cases in the highest exposure group would have occurred prior to the beginning of the followup period, i.e., during the first 20 years since onset of exposure, and would have been missed.

It is often stated that cases of asbestosis are rarely seen within 15-20 years of first exposure; however, Berry et al, (Ex. 84–20) have shown that signs associated with interstitial fibrosis are seen less than 10 years from first exposure and clearly within 10–14 years of first exposure. In addition, Dement et al. (Ex. 84–35) have shown an excess mortality due to other non-malignant respiratory diseases within 10–19 years after initial employment. Selikoff et al. (Ex. 84–189) have reported on asbestosis death rates in a cohort with the longest period of followup. In this study, the mortality rate began to increase approximately 13 years after first exposure. A decline in the death rate from asbestosis occurred 45 years from first exposure. The authors suggested that competing causes of death, in part due to smoking, may have accounted for this decline. It is not possible, however, to tell whether the incidence of asbestosis, i.e., the occurrence of new cases, would also have begun to decline 45 years after first exposure.

Berry et al. (Ex. 84–20) studied textile factory workers. Two cohorts were defined: Workers first employed between January 1, 1933 and December 31, 1950 who were still employed as of June 30, 1966; and workers employed after June 30, 1966 who had completed at least 10 years of service up to December 31, 1972. The latter cohort is important because measures of dust or fiber levels were available beginning in 1951 and the exposure estimates for individuals in the study are likely to be more valid after that time. In addition, proportionately more of the latter cohort was exposed to a lower mean dust level than the former cohort. Although these dust levels are not equivalent to or below the level stipulated by the current PEL, they are closer to it than the mean fiber or dust levels incurred by the earlier cohort. The maximum number of years of followup, 24, was considerably less than the latency for late-onset cases of asbestosis. Among those first employed after 1950, Berry and his colleagues estimated a 1 percent prevalence of crepitations, "possible asbestosis," and "certified asbestosis" at 37, 46, and 63 f/cc-years, respectively, suggesting that an excess risk exists at levels below 100 f/cc-years. Since the average number of years of followup in this study was only 16 years, new cases will have accrued in the subsequent period. It is also noteworthy that when men who had left the factory prior to 1966 were included in the cohort in an effort to reduce the selection bias associated with the risk of asbestosis, the prevalence of signs associated with the disease increased. However, even in the more complete cohort studied, selection factors remained. The overall effect of these methodological problems is that the measures of prevalence in this study are underestimates.

Finkelstein (Ex. 84–44) studied the risk of asbestosis in 157 Ontario cement production workers first exposed to asbestos between 1948 and 1960 and employed for at least 15 years. Because of the nature of the cement production operation, some workers employed at this plant may not have been exposed to asbestos. Workers were followed up until death or up to October 1, 1980. The number of years since first exposure ranged from 18–33 years, with a median of 25 years, Cases were ascertained primarily through annual examinations or by means of death certificates. The author noted that "83 percent of the production workers received an examination for asbestosis within the 3 years prior to the cutoff date or within 3 years of their death" (Ex. 84–44). It is uncertain how the production workers who were lost to followup (17 percent) were handled in this analysis; OSHA assumes that only those person-years of observation up to the time of the last followup examination were included.

The Ontario criteria for certifying asbestosis, which results in an award of disability pensions, are not strictly defined but involve considerations of such factors as history of occupational exposure, dyspnea, crepitations, clubbing of fingers, radiographic signs of pulmonary fibrosis, and abnormal lung function. In general, it can be assumed that, despite the absence of definitive criteria, the certified asbestosis cases included in this study occurred at an advanced stage of the disease, in contrast to other studies that included possible cases of asbestosis in the analysis.

Only two cases in the Finkelstein study were certified before the 20th year after first exposure. A majority of the asbestosis cases were certified between 22 and 28 years of exposure; however, cases continued to accrue in the followup period, and there is no clear evidence that the incidence of asbestosis declined after more than 28 years since first exposure. Finkelstein calculated incidence as the number of new cases of certified asbestosis per 100 person-years at risk, i.e., the rate at which new cases of asbestosis develop in a given period of time, which results in a direct measure of the risk of developing of disease. The Finkelstein study found the incidence of asbestosis to be 0.5, 3.4, and 6.5 per 100 person-years of exposure for workers receiving 0–49, 50–99, and 100–149 f/cc-years of exposure, respectively, showing a positive dose-response relationship.

Using a life table method, Finkelstein also calculated the cumulative probability of developing a certified case of asbestosis after 32 years of followup and observed that men in the 0–49, 50–99, and 100–149 f/cc-years categories and 10 percent, 55 percent, and 70 percent probabilities, respectively. Although these estimates are somewhat uncertain because of the small number of subjects in each category, especially in the lowest exposure category, the data do indicate that, even for exposures below 50 f/cc-years, there is an excess risk of asbestosis morbidity. In addition, as noted above, there is no evidence to suggest that the risk of asbestosis declines after 32 years from first exposure.

Finkelstein (Ex. 84–044) notes that a selection bias may have been introduced by excluding workers with fewer than 15 years of employment from the cohort, resulting in an overestimation of risk at lower exposure levels. Typically, one assumes that the morbidity and mortality of the excluded group are the same as those of the group included in the study. Finkelstein suggests that if the excluded individuals had been considered, lower estimates of risk might have been obtained for the lower exposure category; however, this could only have occurred if the risk of asbestosis for the same cumulative exposure level among those excluded was less than that of the group studied. OSHA believes that it is not possible to determine the effect of such a selective exclusion.

Finkelstein estimated the cumulative exposure that would result in a 1 percent probability of developing asbestosis by extrapolating from his exposure-response curve. He arrived at a value of 10 f/cc-years, a figure considerably lower than that derived by Berry et al. (Ex. 84-20). One significant factor that may account for the difference in estimates between these two studies in a difference in the length of their followup period (i.e., it is considerably longer in the Finkelstein study). In addition, the workers studied by Finkelstein may have also been exposed to silica which was used in the production process. If there was an excess risk of silicosis from such exposure which was mistaken for asbestosis then the exposure level resulting in a 1 percent probability of developing asbestosis would have been overestimated. There were no data published on the silica exposure levels to determine if this was a possibility.

Dement et al. (Ex. 84-37) studied the risk of asbestosis in 1,261 males employed for one or more months in a chrysotile asbestos textile operation between January 1, 1940 and December 31, 1965. Mortality followup using data from death certificates was from January 1, 1940 to December 31, 1975 and was 98 percent complete. The method used in this study to assign exposures to individuals was described previously (48 FR 51102). There was a total of 33,141 person-years of observation, and 24 deaths were ascribed to "other respiratory diseases" (ICDA 751-527), the category that includes asbestosis. Of the 24 deaths in this category, asbestosis or pulmonary fibrosis was the underlying cause of 17 deaths. Nineteen of these 24 deaths occurred 20 or more years after initial employment. The overall Standardized Mortality Ratio (SMR) for this category was 552. There was also an increased SMR for deaths due to cardiovascular disease, which is consistent with other observations among asbestos workers. The authors note that "a review of death certificates for the 105 deaths found [that] 6 [certificates] mention asbestosis or pulmonary fibrosis as a contributing condition."

In the study by Dement et al. (Ex. 84-37), there was little difference in SMRs for the "other nonmalignant respiratory diseases" by years since initial employment. For the group observed 10-19 years after first employment, the SMR was 521; for 20-29 years it was 565; and for greater than 30 years, the SMR was 570. It is noteworthy that even in the group observed 30 or more years after first employment, the SMR remains at an elevated level and showed no decline. The authors also derived SMRs for white males with 15 or more years since first exposure. These were 362, 84, and 879 for the exposure categories less than 1,000 f/cc-days (2.7 f/cc-years), 1,000-10,000 f/cc-days (2.7-27.4 f/cc-years), and 10,000-40,000 f/cc-days (27.4-109.6 f/cc-years), respectively. The excesses were statistically significant for both the first and the third exposure categories, and both of these cumulative exposures are below the cumulative exposure that would be caused by 50 years of exposure at the existing PEL of 2 f/cc. Finally, since other investigators (Selikoff, Ex. 84-90; Elmes and Simpson, (Ex. 84-42) who have studied the mortality of asbestos workers have shown that relying only on death certificates for ascertainment of cases causes a significant number of asbestosis deaths to be missed, the risk estimates reporterd by Dement et al. (Ex. 84-37) may be understated.

4. Summary of the Evidence of Asbestosis

OSHA believes that the studies of Berry et al. (Ex. 84-20) and Finkelstein (Ex. 84-44) show a clear dose-response relationship between asbestos exposure and asbestosis, and substantial excess risks due to asbestosis close to or below 100 f/cc-years, the cumulative lifetime exposure permitted by the 2 f/cc standard. The risk of mortality due to asbestosis in the work by Dement et al. (Ex. 84-37) was also in excess in workers exposed to less than 100 f/cc-years, despite the problems of underascertainment of cases. Because asbestosis morbidity is a better indication of risk than is mortality, OSHA has included the studies of Berry et al. (Ex., 84-20) and Finkelstein (Ex. 84-44) in a quantitative risk assessment for asbestosis (see Section V).

In his testimony Dr. Weill concluded that asbestosis deaths would be rare to non-existent under a two fiber standard and a disease of the past at a revised standard of 0.5 f/cc. He stated that:

> . . . We are able to detect asbestosis with greater sensitivity. It means we are going to be seeing less severe disease. . . .
>
> The asbestosis that is being seen generally now around the country again, I think by wide agreement . . . is at a low level, even now. This is associated with the exposures of the last several decades, when we know certainly in most instances and particularly in end-product use the exposures would still have been relatively uncontrolled.

In response to questions on the same issue Dr. Lewinsohn noted:

> I think asbestosis as it was originally described is a vanishing disease, yes. I think that asbestosis is a different disease than we see now, if it still exists. It's much milder. It's less likely to be fatal. It's less likely to produce significant impairment. . . .
>
> I think the levels of exposure have diminished and the changes, the disease itself is different. You don't see the full blown picture of asbestosis with people who die from asbestosis after less than 10 years' exposure with severely damaged lungs, with heart failure. . . .
>
> What you see today is somebody who has pleural changes or somebody who has very minimal radiological features of asbestosis and who probably goes on to live a reasonably normal life span. . . .

The view that asbestosis mortality and severe asbestosis morbidity is on the decline is corroborated by the work of Berry et al. (84-20) who show that as the cumulative dose of asbestos decreases, more cases are diagnosed as having crepitations only or as being possible asbestosis, in contrast to certified asbestosis. Nonetheless, severe cases (Barry et al. Ex. 84-20), disabled cases (Finkelstein, Ex. 84-44), and deaths due to asbestosis (Ex. 84-37) have been found to occur in workers with estimated cumulative exposures well below 100 f/cc-years. Although the clinical impressions of Drs. Weill and Lewisohn regarding a shift in the severity of asbestosis as exposures have declined in the past few decades may be correct, their conclusions regarding the eventual absence of disabling asbestosis and death due to asbestosis at the current standard of 2 f/cc are contradicted by the evidence from epidemiological studies mentioned above. In addition, Dr. Selikoff, under cross examination by Ms. Nash, tesified that he is still seeing cases of severe asbestosis more than 10 years since the 2-f/cc standard became effective:

> Nash: . . . In your clinical observations, are you continuing to see cases of asbestosis?
>
> Selikoff: Oh, yes.
>
> Nash: Are you continuing to see advanced cases of asbestosis—?
>
> Selikoff: . . . We certainly do. We see deaths. But I have not had the experience of seeing what would happen at 0.1 [f/cc]. But I'm also not willing to expose a large number of people to 0.1 as guinea pigs, so that I can come along twenty years later and give you the answer.
>
> Nash: So you would then obviously believe there's a risk of exposing people at higher levels and developing asbestosis . . .?
>
> Selikoff: Oh, no question—there is no question about that. That we already know from our extrapolation. (Tr. 7/2, p. 173)

Based on this testimony and the epidemiological data discussed above, as well as the results from OSHA's risk assessment (see Section V), OSHA finds that a reduction of the current 2-f/cc PEL will result in a continued decline in asbestosis incidence.

E. Effects of Cigarette Smoking and Asbestos Exposure

This section discusses scientific evidence describing the influence of smoking on the risk from asbestos-related disease. Because several studies (Exs. 2–5; 84–190; 84–47) were cited in the November proposal as evidence of a multiplicative effect of asbestos exposure and cigarette smoking with regard to producing increased lung cancer risk, several commenters, including the Asbestos Information Association (Ex. 328), argued that OSHA overstated the risk of lung cancer in its qualitative risk assessment by failing to distinguish between the lung cancer risks for asbestos-exposed smokers and nonsmokers. While the scientific data are discussed here, Section VI (Significance of Risk) contains OSHA's response to comments dealing with how the lung cancer risk for asbestos-exposed smokers should be evaluated from a regulatory perspective.

Asbestos-Related Malignant Disease

Several studies were cited in the November proposal as evidence that asbestos-exposed workers who smoke have a higher risk of lung cancer mortality than either asbestos-exposed nonsmokers (Selikoff, Churg, and Hammond, Ex. 2–5; Selikoff, Seidman, and Hammond, Ex. 84–190; Hammond, Selikoff, and Seidman, (Ex. 84–047). The reduced ability of smokers to clear particles from their lungs, compared with the ability of non-smokers to do so, as suggested by Cohen et al. (Ex. 84–031), may help to explain the higher lung cancer risk of asbestos workers who smoke. The Agency also determined that there is no evidence of an association between cigarette smoking and an increased risk of either mesothelioma or gastrointestinal cancer.

To exemplify the multiplicative effect of asbestos exposure and cigarette smoking in producing an increased lung cancer risk, OSHA discussed two studies at length (Hammond et al. Ex. 84–047; Selikoff et al., Ex. 84–190). The Hammond et al. study (Ex. 84–047) examined the smoking histories of 8,220 of 12,051 asbestos insulation workers with a followup of 20 or more years since initial exposure. In late 1966, 6,841 of these workers were either current or past cigarette smokers, 488 had a history of pipe or cigar smoking, and 891 had never smoked regularly. The mortality of these workers was observed during the period 1967–1976. The comparison population, drawn from the American Cancer Society's long-term prospective study, consisted of 73,763 white men who had no more than a high school education, were not farmers, were alive as of January 1, 1967, and had a history of occupational exposure to dust, fumes, vapors, gases, chemicals, or radiation. The age-standardized lung cancer mortality rate for non-smoking controls (i.e., the baseline rate) was 11.3 deaths per 100,000 man-years; the rate for smoking controls was approximately 11 times higher (122.6 per 100,000 man-years). The lung cancer mortality of non-smoking asbestos workers was 5 times higher (58.4 deaths per 100,000 man-years) than that of non-smoking controls (11.3 deaths per 100,000 man-years). Hammond et al. (Ex. 84–047) found that the lung cancer mortality of asbestos workers who smoked was 601.6 per 100,000 man-years, a value that is also about five times higher than the baseline rate of lung cancer mortality for smoking controls.

Selikoff et al. (Ex. 84–190) examined the effects of cigarette smoking and asbestos exposure among 582 amosite production workers, 567 of whom had smoking histories. As in the study by Hammon et al. (Ex. 84–047), the age and cause-specific mortality rates were compared within each smoking status category defined by the American Cancer Society cohort. Selikoff et al. (Ex. 84–190) concluded as follows:

> Here asbestos exposure greatly multiplied the already high risk that would have been present with cigarette smoking alone. . . . This increased risk is very much the same as that seen among asbestos insulation workers [who smoked]. This observation indicates that the increased risk of death from lung cancer among cigarette-smoking asbestos workers is a specific interaction rather than coincidental, and not, for example, the result of other agents in the environment of the construction trades." (Ex. 84–190).

In the November proposal, OSHA presented two ways of calculating the *probability* that any single case of lung cancer in a person with known exposure to asbestos could be attributed to the asbestos exposure. The first way, proposed by Enterline (Ex. 84–126), was based only on relative risk estimates. Using data from Selikoff et al. (Ex. 84–090) on asbestos insulation workers, Enterline estimated that there was a probability of 75 percent that lung cancers were attributable to asbestos exposure; this probability applied both to smoking and non-smoking asbestos workers. However, in the case of asbestos workers who smoked, OSHA deems it inappropriate to dichotomize causation in terms of smoking *or* asbestos exposure because of the synergistic effect between cigarette smoke and asbestos. OSHA therefore presented its method of calculating the probabilities of causation in the November publication (Table 6 and Table 7, 48 FR 51110). Although OSHA's calculations differ from Enterline's calculations of attributable risk by including a factor for synergism, the two probability estimates do not differ by a great extent. According to OSHA's calculations, asbestos exposure contributes to 79.4 percent of lung cancer deaths among asbestos-exposed workers who smoke, and 77.2 percent of lung cancer deaths among nonsmoking asbestos workers.

Lung Disease and Chest X-ray Abnormalities

In the study by Hammond et al. (Ex. 84–047) discussed above, it was also reported that asbestos insulation workers who smoked one or more packs of cigarettes per day had an asbestosis mortality rate 2.4 times higher than that of asbestos insulation workers who had never smoked regularly. Selikoff et al. (Ex. 84–190), however, observed no increased risk of death from asbestosis among amosite production workers who smoked compared to their nonsmoking co-workers.

Weiss (Ex. 84–097) conducted a chest x-ray and questionnaire survey of 100 asbestos textile workers. Chest roentgenograms were examined for evidence of pulmonary fibrosis. Two asbestos exposure groups were defined: those with less than 20 years of exposure and those with 20 or more years of exposure. The age-adjusted prevalence of pulmonary fibrosis among smokers and non-smokers was 40 and 23 percent, respectively. None of the 11 non-smokers with less than 20 years of asbestos exposure had pulmonary fibrosis, in contrast to 29 percent of the smokers with less than 20 years of exposure to asbestos. The median duration of exposure to asbestos was similar for these two groups. Based on these findings, Weiss (Ex. 84–097) concluded that both asbestos exposure and cigarette smoking were associated with pulmonary fibrosis and that asbestos workers who smoked had a higher prevalence of fibrosis relative to that among nonsmoking asbestos workers. Weiss did not indicate whether the difference in the prevalence of pulmonary fibrosis between smokers and nonsmokers was statistically significant. OSHA tested the significance of the reported difference using a chi-square test of proportions and did not find a significant difference (p greater than 0.1). This study and its findings were criticized by Kilburn (Ex. 84–237) because Weiss used a definition of pulmonary fibrosis that differed from the standard International Labour Office criterion. Citing a study by Samet et al., which used a relatively large cohort, Kilburn argued that smoking neither produced the x-ray appearance of pulmonary fibrosis nor contributed to fibrosis resulting from asbestos exposure.

Pearle (Ex. 84–079) studied 141 shipyard workers who were referred for medical exams because of suspected asbestos-related lung disease. The shortest duration of exposure in this group was 7 years. Chest x-rays were taken on all subjects and pulmonary function data were collected, including FVC, FEV_1, and diffusion capacity. X-rays were examined for pleural thickening and interstitial abnormalities consistent with asbestosis. Smoking groups were defined in terms of nonsmokers, light smokers, moderate smokers, and heavy smokers. Three asbestos exposure groups were also defined as being mild, moderate, or heavy, based on the duration of exposure (0–14 years, 15–19 years, and 30+ years, respectively). Three percent of the nonsmokers had interstitial disease, all of whom were concentrated in a heavy exposure group. By contrast, 8–12 percent of the smokers had significant interstitial disease, with the highest prevalence in the mild and moderate asbestos exposure groups. These differences between nonsmokers and smokers, however, were not statistically significant. The prevalence of pleural disease in heavy smokers was 25 percent, compared with 9 percent in nonsmokers. This difference was statistically significant. The prevalence of pleural disease among the light and moderate smoking groups was similar to that in heavy smokers. The largest difference in the prevalence of pleural disease between heavy smokers and nonsmokers is found in the group with mild asbestos exposure. These prevalence measures were not adjusted for age, however, and it cannot be concluded definitively that the statistically significant difference in prevalence between heavy smokers and nonsmokers is attributable to smoking history alone.

Berry et al. (Ex. 84–020) studied 379 men employed in an asbestos textile mill. Two cohorts were defined; those first employed before 1951 and those employed on or after 1951. The mean cumulative exposure for the earlier cohort was approximately twice that of the more recent cohort. Smoking histories were available for 376 men. Five smoking groups were defined: Never smoked, 1–4 cigarettes per day, 5–14 cigarettes per day, 15+ cigarettes per day, and ex-smokers. In the most recent cohort, the prevalence of crepitations, possible asbestosis, certified asbestosis, and small radiological opacities was higher among heavy and ex-smokers compared with light smokers (1–4 cigarettes per day) and nonsmokers. For example, 15 percent of heavy smokers had certified asbestosis versus none in the nonsmoking and light smoking groups. By contrast, there were no apparent differences in the prevalence of asbestosis or other conditions among the five smoking groups from the earlier cohort, which incurred a higher mean cumulative exposure, was older, and had a longer period of followup than the more recent cohort. This study suggests that, although there may be differences in the prevalence of asbestosis among smokers and nonsmokers who have been exposed recently to asbestos, the prevalence of asbestosis among smokers and nonsmokers tends to be more similar as the latency period increases or at higher levels of exposure to asbestos.

One additional study received since the November proposal is pertinent to this issue. Nicholson and his colleagues obtained chest x-rays and administered pulmonary function tests to 916 brake line repair and maintenance workers and approximately 205 nonexposed blue collar workers (Ex. 172–B). Chest x-ray abnormalities were defined to include parenchymal changes of 1/0 or greater, pleural thickening, pleural plaques, and pleural calcification. Predicted values for spirometry were based on the revised analysis by Miller et al. (1980) of the 1971 data of Morris, Kuski and Johnson (Ex. 172–B).

The percentage of workers with any evidence of chest x-ray abnormality among those with garage employment was 24.2 percent compared with 18.8 percent among workers with no stated asbestos exposure or garage employment (Ex. 172–B). This overall difference between the two groups is accounted for by differences in the prevalence of parenchymal abnormalities (19.0 percent vs. 15.3 percent) rather than pleural abnormalities (8.4 percent vs. 8.9 percent). However, significant differences existed in the percentages of pleural abnormalities among those employed in work having direct asbestos exposure (22.2 percent) or shipyard employment (25.2 percent) and those employed only in garage work (8.4 percent) or having no asbestos exposure (8.9 percent).

These results were interpreted by the authors to mean that "pleural abnormalities often appear from relatively low asbestos exposures and can exceed parenchymal abnormalities in prevalence at long times from onset of exposure" (Ex. 172–B, p. 29). Similar results were obtained after standardizing for age and smoking history.

The pulmonary function test data, when standardized for smoking, indicated virtually identical results for the unexposed controls, the brake repair workers, and individuals exposed or possibly exposed to asbestos (Ex. 172–B). The investigators note that these findings are not surprising because "forced vital capacity is usually a less sensitive determination of asbestos-related changes than the presence of x-ray abnormalities and forced expiratory volume in 1 second relates to exposures other than asbestos" (Ex. 172–B, p. 46). Although this study (Ex. 172–B) provides evidence that asbestos causes chest x-ray abnormalities over and above those that may be caused by smoking, the data were not sufficient to show that asbestos-exposed workers who smoke suffered more lung impairment than either asbestos-exposed nonsmokers or non-exposed smokers (Ex. 172–B).

In summary, OSHA finds that there is limited though conflicting evidence that asbestos workers who smoke have a higher risk of dying from asbestosis, as well as a higher prevalence of crepitations, lung function decrements, and small radiological opacities than their nonsmoking co-workers.

F. Relationship of Fiber Size and Type of Risks from Asbestos-Related Disease

1. Evidence for a Differential Risk by Fiber Type

In the November proposal (48 FR 51110), OSHA reviewed numerous epidemiological studies concerning the toxicity and carcinogenicity of different asbestos fiber types. OSHA concluded that all fiber types, alone or in combination, have been observed in studies to induce lung cancer, mesothelioma, and asbestosis in exposed workers, with the exception of anthophyllite, which has been observed to induce lung cancer and asbestosis, but not mesothelioma (OSHA/NIOSH, Ex. 84–200; for amosite: Seidman et al., Exs. 84–87, 261–A; Anderson et al., Ex. 84–17; and Murphy et al., Ex. 84–311; for chrysotile: McDonald et al., Ex. 84–65; McDonald and Fry, Ex. 84–64; Liddell et al., Ex. 84–59; Nicholson et al., Ex. 84–72; Rubino et al., Ex. 84–86; Dement et al., Ex. 84–37; Acheson and Gardner, Ex. 84–15; and Berry and Newhouse, Ex. 84–21; for crocidolite: Jones et al., Ex. 84–138; Hobbs et al., Ex. 84–132; McDonald and Newhouse, Ex. 163; Berry and

Newhouse, Ex. 84–21; and Newhouse et al., Ex. 163; for anthophyllite: Meurman et al., Ex. 84–181; for tremolite and actinolite: Brown et al., Ex. 84–29; for mixed fiber types: Hughes and Weill, Ex. 84–135; Weill et al., Ex. 84–206; Jones et al., Ex. 84–138; Berry et al., Ex. 84–20; Elmes and Simpson, Ex. 84–42; Peto et al., Ex. 84–80; Lacquet et al., Ex. 84–144; Selikoff et al., Ex. 84–89; Robinson et al., Ex. 84–82; and Balselga-Monte and Segarra, Ex. 84–19).

Several investigators and committees have suggested that exposure to crocidolite and amosite is associated with a different carcinogenic potential than is exposure to chrysotile and anthophyllite, primarily with regard to the risk of mesothelioma (Enterline and Henderson, Ex. 84–122; McDonald and McDonald, Ex. 84–154; Weill et al., Ex. 84–206; Acheson and Gardner, Exs. 84–15, 84–216, and 84–243; Muir, Ex. 84–350; and the Advisory Committee on Asbestos, Ex. 84–216). Among the studies reviewed by OSHA, the variation in mesothelioma mortality among cohorts exposed to different fiber types, expressed as a percentage of all deaths attributed to mesothelioma, is as follows: for crocidolite, 1.26 to 16 percent (McDonald and McDonald, Ex. 84–154; Jones et al., Ex. 84–138; McDonald and Fry, Ex. 84–64; Hobbs et al., Ex. 84–132); for amosite-chrysotile mixtures containing less than 0.1 percent crocidolite, 4 to 7.7 percent (Hammond, Ex. 84–47; Peto, Ex. 84–168; Robinson et al., Ex. 84–82); for amosite, 2.7 percent (Seidman, Ex. 84–87); and for chrysotile, 0 to 0.5 percent (McDonald et al., Ex. 84–65; Nicholson et al., Ex. 84–72; Dement et al., Ex. 84–37; Rubino et al., Ex. 84–86). Mesothelioma has not been found to be a cause of death among miners exposed to anthophyllite (Meurman et al., Ex. 84–256). The Chronic Hazard Advisory Panel (CHAP) (Ex. 84–256) stated that it appeared that peritoneal mesothelioma was most commonly seen among workers exposed to amosite, less often among workers exposed to crocidolite, and rarely or never among workers exposed to chrysotile. However, as the Panel's report points out, large variations in the data describing peritoneal mesothelioma mortality from crocidolite exposure, frequent misdiagnosis of peritoneal mesothelioma, and the lack of risk data expressed in terms of unit exposure level complicate making definitive conclusions regarding the relationship between fiber type and mesothelioma risk.

For lung cancer, OSHA views the epidemiological evidence for differentials in risk by fiber types as being inconclusive and inconsistent. Some studies (Dement et al., Ex. 84–37; McDonald and Fry, Ex. 84–64) have found that workers exposed to chrysotile have approximately the same or higher risks of lung cancer compared to workers exposed to amphibole fibers, while other studies (McDonald and McDonald, Ex. 84–154; Henderson and Enterline, Ex. 84–158) have found that workers exposed to chrysotile have a lower relative risk of lung cancer. After comparing lung cancer risks per unit of cumulative exposure (also known as K_L, the lung cancer potency factor) among cohorts exposed to different fiber types, the CHAP (Ex. 84–256) reported that studies of workers exposed to chrysotile yielded both high and low values of K_L, as did studies of workers exposed to crocidolite or amosite. Therefore, a consistent pattern showing a higher lung cancer risk among workers exposed to chrysotile or amosite did not emerge. Dr. William Nicholson of the Mount Sinai School of Medicine (Ex. 94) agreed that these conflicting values for K_L demonstrate that no unique lung cancer risk could be attributed to a particular fiber type. OSHA also concluded (48 FR 51115) that some cross-cohort comparison studies failed to control for important variables such as fiber concentration, age distribution, length of followup observation period, and fiber size distribution.

In the November proposal, numerous studies were discussed that demonstrated that chrysotile, amosite, crocidolite, and anthophyllite asbestos fibers are carcinogenic when administered to laboratory animals via inhalation, injection, and implantation (NIOSH, Ex. 84–338; NIOSH/OSHA, Ex. 84–320; Wagner et al., Exs. 84–205, 94–96, 84–197; Davis et al., Ex. 84–120). In general, animal studies that used standardized asbestos samples from the Union Internationale Centre Cancer (UICC) have demonstrated that chrysotile was more fibrogenic and carcinogenic than amphibole asbestos. For example, Davis et al. (Ex. 84–120) showed that UICC reference samples of chrysotile exhibited a greater potential to produce fibrosis in rats via inhalation than the amphiboles; however, treatment of rats with factory samples of these two types of asbestos showed no difference in fibrogenic potential (Ex. 84–120). Bolton et al. (Ex. 236–C) treated SFF Wistar rats by intraperitoneal injection with UICC chrysotile and UICC crocidolite asbestos and found that chrysotile produced a higher incidence of mesothelioma than crocidolite over a dose range of 0.01 mg to 25 mg per rat. Although, in another study, UICC reference samples of chrysotile and amphiboles inhaled by rats showed similar potential to produce fibrosis and lung tumors (Ex. 84–96), the NIOSH/OHSA Asbestos Work Group commented that, based on the amount of dust deposited and retained in the lung, this study, in fact, showed that chrysotile was more fibrogenic and carcinogenic than the amphiboles (Ex. 84–320, p. 15). Both Canadian and Rhodesian chrysotile produced lower incidences of mesothelioma than crocidolite, amosite, or anthophyllite when these forms of asbestos were administered intrapleurally to laboratory animals (Ex. 84–197), but no differences in mesothelioma incidences among animals treated with these asbestos types were apparent in another study (Ex. 84–338). These latter studies (Exs. 84–197, 84–338) illustrate the conflicting findings of earlier animal experiments where UICC reference asbestos samples were not used.

At the informal hearing, Dr. John M.G. Davis of the Institute of Occupational Medicine, Edinburgh, Scotland, described recent animal experiments that he conducted to examine the relationship between fiber type and the development of asbestos-related disease (Tr. 7/9, pp. 3–79). In one rat inhalation study (Tr. 7/9, p. 16), 10 percent of the lung tissue taken from rats exposed to 10 f/cc UICC chrysotile showed evidence of scarring; only 1.5 and 2.5 percent of lung tissue taken from rats exposed to the same fiber concentration of crocidolite and amosite, respectively, were scarred. The same trend was observed for the incidence of malignant tumors found in exposed rats. Dr. Davis also discussed injection studies on rats (Tr. 7/9, p. 29) that showed, at doses ranging from 0.01 to 15 mg, that chrysotile produced the greatest number of mesothelioma tumors at every dose tested. Dr. Davis concluded from these studies that ". . . both by fiber number and by fiber mass, chrysotile appeared to be the most dangerous" (Tr. 7/9, p. 15).

The animal studies reviewed by OSHA and the work described by Dr. Davis suggest that chrysotile has a greater fibrogenic and carcinogenic potency than the amphiboles, a finding that contrasts with the findings of human epidemiological studies that suggest that the amphiboles have a greater potential for producing mesothelioma. Several explanations for these conflicting results were offered into the record. Dr. Davis testified that part of the reason for the different findings between animal and human studies is that

. . . it is much easier to generate dust clouds from amphiboles [than from chrysotile].

So, . . . people who were exposed to amphiboles in the past almost certainly were exposed to very high levels [compared to the levels of chrysotile to which people were exposed] (Tr. 7/9, p. 35).

Using a similar line of argument, Dr. Hans Weill of Tulane University suggested that epidemiologic studies show a fiber-specific risk differential because "it is likely . . . that a cloud of asbestos dust contains a higher proportion of respirable 'carcinogenic' fibers if crocidolite is present . . Crocidolite might therefore be more likely to be deposited in the deep portion of the lung and migrate more easily to the pleural surfaces" (Ex. 99, pp. 17–18).

Although the higher levels of amphiboles to which workers were exposed in the past may partly explain the different findings between epidemiologic and animal studies, physical differences between chrysotile and the amphiboles that affect the ability of the lung to clear fiber particles may also have led to these different findings. A number of studies have shown that chrysotile is more rapidly cleared from the lung than are the amphiboles (Exs. 84–171, 84–175, 84–178, 84–202, 312). For example, Glyseth et al. (Ex. 312) examined the asbestos content of lung tissue samples taken from asbestos cement workers who had died of pleural mesothelioma or lung cancer. Although more than 90 percent of the fibers used by the workers were chrysotile, 86 to 99 percent of the fibers found in the lung tissues were amosite, crocidolite, and anthophyllite. The differential lung retention of various fiber types has also been demonstrated in animals. Castleman (Ex. 121) discussed a study by Wagner (1982) that found that animals exposed to chrysotile fibers developed lung cancer even though a smaller amount of chrysotile was retained in the lung compared to similar tests with amphiboles. He suggested that "chrysotile fibers engaged in a process that led to cancer before removal and decomposition of . . . [the fibers] occurred" (Ex. 121, p. 2). Dr. Weill believed that "these differences in tissue persistence may wholly or partially explain the observations [that exposure to amphiboles are associated with a higher prevalence of mesothelioma] in human . . . populations . . . Non-confirmation of fiber type differences in animal experiments may be related to the much shorter life span . . . [of experimental animals, which would not allow] the effects of varying tissue persistence to be expressed" (Ex. 99, p. 18).

Dr. Davis also testified that the differential lung retention of chrysotile and the amphiboles may account for the conflicting results of human and animal studies, albeit by a different mechanism. He explained this view as follows:

[I suggest] that chrysotile or sufficient chrysotile is able to remain in the lung tissue for two or three years. Enough of it [to induce cancer] will stay for the [entire] life span of the rat. That means it can exert its maximum effect in the rat, and it means that the rat results showing chrysotile as being [more] hazardous are genuine.

I believe that chrysotile is largely removed from human lung tissue during the much longer 20, 30, [or] 40-year tumor induction period that you have got to have in human beings. I think that if that wasn't the case, then all the epidemiological evidence would be showing that chrysotile was the nastiest of the dusts" (Tr. 7/9, p. 36).

Several rulemaking participants (Exs. 84–256, 99, Tr. 7/9, p. 39) expressed the opinion that chrysotile fibers, which are composed of several hundred smaller fibrils, are easily broken apart in the lung as the result of magnesium leaching from the fibers. The magnesium loss reduces the structural strength and length of the fiber, facilitating removal of the fiber by phagocytosis. This process occurs to a lesser extent with the amphiboles, which contain a smaller quantity of magnesium. Although this may explain why chrysotile is more easily cleared from the lung, it also effectively increases the dose, in terms of the number of fibers, that reaches the lung. Dr. Davis explained this possibility:

"Now I believe what happens—and we have evidence of this—is that chrysotile deposited in lung tissue quite rapidly separates out into its individual fibrils. So if you think you have deposited one fiber in the lung tissue, six weeks later you have actually got 100, which potentially at least are the same length, but are very, very much thinner.

Now I think this certainly explains some of the very high harmful potential of chrysotile in our animal experiments. We are actually giving the animals . . . many more fibers even when we are trying to use equal doses [of chrysotile and amphiboles]" (Tr. 7/9.X, pp. 38–39).

To summarize the data on risk differential by asbestos fiber type, human epidemiological studies have suggested that occupational exposure to amphiboles is associated with a greater risk of mesothelioma than is exposure to chrysotile. No clear risk differential for lung cancer or other asbestos-related disease has been demonstrated by epidemiological studies. Animal experiments, however, have indicated that chrysotile is a more potent carcinogen than amphiboles when administered by inhalation or intrapleural injection, thus conflicting with the findings of human epidemiology studies. Rulemaking participants have suggested several reasons for the discrepancy: (1) Exposures to amphiboles in the past were much higher than exposures to chrysotile, (2) chrysotile fibers break up and are more easily cleared from the lung than are amphiboles, effectively reducing the residence time of chrysotile in the human lung, and (3) the break-up of chrysotile fibers into individual fibrils occurs more readily than for amphibole fibers, thus increasing the effective dose of chrysotile in animals. Dr. Davis explained at the hearing that the net effect of these biological mechanisms is unknown:

" . . . Is one fiber . . . of amphibole more dangerous than one fiber . . . of chrysotile? There, I . . . [have] to point out that our evidence cannot answer this with certainty. On the one side, you have almost certainly the greater harmful potential of chrysotile and the greater durability of the amphiboles. . . . I could imagine that one fiber of each in human beings will end up roughly the same harmfulness, or that might not be the case. It may be that the greater durability of amphiboles will still give a little bit of an edge. I have no definite data on this, and nobody else has." (Tr. 7/9, p. 65)

OSHA agrees with Dr. Davis that epidemiological and animal evidence, taken together, fail to establish a definitive risk differential for the various types of asbestos fiber. Accordingly, OSHA has, in its Quantitative Risk Assessment (see Section V) and in the establishment of a permissible exposure limit (see Section X) recognized that all types of asbestos fiber have the same fibrogenic and carcinogenic potential.

Evidence for a Differential Risk by Fiber Size and Aspect Ratio: Several studies contained in the rulemaking docket suggest that fiber dimension is an important determinant in asbestos-related disease development. Stanton et al. (Exs. 84–193, 84–195) studied the effects of various sizes of fibrous materials, including all forms of asbestos, implanted in the pleura of rats and found that some fibrous glasses and all asbestos fiber types produced malignant tumors. The most carcinogenic fibers were 0.25 um or less in diameter and greater than 8 um in length. Fibers less than 8 um in length appeared to be engulfed and digested by phagocytes. However, fibers that were 1.5 um or less in diameter and longer than 4 um (an aspect ratio of approximately 3) also showed a higher correlation with carcinogenicity. Wright and Kuschner (Ex. 84-210) injected asbestos intratracheally into guinea pigs and found fibrosis only with fibers longer than 10 um (Ex. 84-128). NIOSH (Platek et al., Ex. 84-240) conducted inhalation studies in rats with chrysotile fibers less than 5 um in length and did not find increased incidences of pulmonary fibrosis or tumors compared with incidences in controls. Since NIOSH has difficulty in generating fibers with an aspect ratio of 3:1 or greater by the ball milling method and in counting the fibers, the NIOSH results only suggest that short fibers do not induce pulmonary fibrosis or tumors. However, studies conducted by Koler (1982) and Pott et al. (1972, 1976), as discussed by the National Research Council (Ex. 321, p. 182), suggest that amorphous asbestos and fibers shorter than 5 um can induce mesothelioma in rodents, a finding that contrasts with the findings of other animal studies reviewed above.

One problem with the studies conducted by Stanton et al. (Exs. 84-193, 84-195) was the difficulty in generating asbestos samples with fibers of uniform lengths; because of this difficulty, the authors could not conclude that short asbestos fibers were safe despite the finding that exposure to shorter fibers were associated with lower tumor incidences in animals. At the hearing, Dr. Davis (Tr. 7/9, pp. 20-28) discussed some of his findings from rat inhalation and injection studies that used carefully prepared long- and short-fiber samples of amosite. For the inhalation experiment, rats were exposed for 12 months by inhalation to amosite samples of varying fiber lengths. Animals were observed for their full lifespans. Davis observed 13 tumors, as well as extensive lung scarring, in 40 animals exposed to the long-fiber dust. No tumors or scarring was found among animals exposed to the short-fiber dust (Tr. 7/9 p. 26). The amosite samples were also injected into the peritoneal cavities of groups of 25 rats. The long-fiber sample produced mesotheliomas in 95 percent of the animals treated, while the short-fiber sample produced only one mesothelioma tumor. Dr. Davis concluded from these studies that short asbestos fibers were ". . . unable to damage tissues" (Tr. 7/9, p. 28).

Researchers (Ex. 86-4) have also found that a significantly higher percentage of long fibers (greater than 5 um) are retained in the lungs of mesothelioma and asbestosis victims. Morgan (Ex. 86-3) showed that anthophyllite fibers less than 5 um in length were more easily cleared from rat lung than larger fibers. It has been well established that shorter fibers are readily engulfed by lung macrophages and transported to the mucociliary escalator or to the lymph system (Exs. 86-3, 86-4, 236-A, 321, Tr. 7/9, pp/ 5-6).

Several researchers (Exs. 86-3, 84-210, 86-4, 236-A, 321, Tr. 7/9, pp. 5-6) have theorized that the greater biological activity of longer fibers may be due to the inability of the macrophage to completely engulf the fiber. This may lead to the release of lysosomal enzymes and oxygen-free radicals from the macrophage, damaging alveolar epithelial cells and initiating fibrosis. In addition, the fibers may disrupt the normal proliferation and differentiation of lung fibroblasts either by directly interacting with the fibroblast or as a result of macrophage secretions.

Since the November proposal, OSHA has received much comment and testimony regarding the relative importance of fiber size, aspect ratio, and surface chemistry of the fiber to carcinogenic potential. Most of these commenters expressed the view that the surface chemistry of the fiber is an important determinant of disease. Dr. Dunnigan of the Universite de Sherbrooke (Ex. 91-15, p. 391, attachment) cited studies and comments of several investigators that were presented at the World Symposium on Asbestos (1982) that point to chemical factors rather than geometric or physical factors as the important determinant of asbestos fiber effects on the cell membrane. They postulated that asbestos fiber interaction with cell membrances causes cell homolysis. Mossman et al. (Ex. 321, p. 39) found asbestos-induced cell damage to be initiated by the reaction of the fiber with the plasma membrane, which causes cell lysis or phagocytosis. The National Research Council, National Academy of Sciences (Ex. 321) cites the work of Wilkinson (1976) and Stossel (1972), who found that recognition of the asbestos fiber by phagocytes and their subsequent ingestion of the fiber may be due to physicochemical affinities between the fiber and the phagocyte. A study done by Light and Wei (Ex. 91-15) stated that "fiber dimensions are important in determining whether asbestos fibers are able to reach sites where critical cellular interactions take place, and thus could govern whether the potential biological activity of fibers due to their surface charge is displayed" (Ex. 91-15, p. 391, attachment).

Dr. Dunnigan (Ex. 91-15-2, p. 393) contended that, in view of studies suggesting that modification of the fiber structure affects the biological reactivity of the fiber, the "Stanton Hypothesis" (see Exs. 84-193, 84-195) should be reassessed. He argues (Ex. 227-A, Table 4) that this hypothesis assumes that all comminution methods merely reduce the dimensions of the fibers without altering other fiber characteristics. To illustrate that this may not be the case, Dr. Dunnigan (Ex. 91-15-2) cites a 1978 study by Arthur Langer that showed that "ball milling of experimental [asbestos] samples results in important changes in the structural and surface characteristics of asbestos fibers, and reduces their effects on all membranes" (Ex. 19-15-2, p. 393). He also cites a 1980 report done by Dr. Spurny in Germany that concluded that "milling procedures change not only the size distribution, but also the shape and crystal structure of asbestos fibers" (Ex. 19-15-2, p. 393).

In a further elaboration of the evidence against the fiber size theory, Dr. Dunnigan cited a study done by Poole et al. (1983) that shows erionite fibers (in a concentration of 150 f/ug mineral) of the "pathogenic" size range are more reactive than a larger number ($1.6x10^5$ f/ug) of similarly sized crocidolite fibers (Ex. 227-A-4, p. 12). Studies by Suzuki (1980), Wagner, (1982), and Maltoni et al. (1982) were also cited by Dr. Dunnigan (Ex. 227-A-4) as evidence that fibrous erionite is the most powerful mesothelioma-producing agent, suggesting that these fibers may display disruptive or catalytic properties not shared equally by other types of fiber.

OSHA believes that the animal studies discussed above, in particular the recent work by Dr. Davis, point to a clear relationship between fiber dimension and disease potential. The finding in these studies that thin fibers (i.e., having an aspect ratio of at least 3:1) greater than 5 um in length are associated with elevated incidences of cancer and lung fibrosis is also consistent with current knowledge regarding lung clearance mechanisms, i.e., that shorter fibers are easily phagocytized and removed from lung tissue. OSHA also acknowledges recent findings that interactions between fibers and cell surfaces, in part, may also determine the course of asbestos-related disease. However, the mechanisms of fibercell interactions and their role in disease causation are not clearly understood at this time.

Some chemists have also suggested that the biochemically active sites or the electrical charge of the chemical groups on the asbestos fiber surface can be modified to reduce the hazardous potential of the fiber (Ex. 84-333). *In vitro* tests of modified asbestos fibers have shown decreased toxicity compared to the untreated asbestos fibers. Drs. Lemen and Groth of NIOSH (Tr. 6/21, pp. 189–191) testified at the public hearings that, to date, *in vitro* studies do not show with any degree of certainty that modification of asbestos fibers can prevent adverse health effects. They contend that the *in vitro* studies did not measure the fiber sizes of the modified asbestos fibers to determine whether the treatment shortened the fiber. Dr. Groth cited a study by Monchaux (Ex. 84–438) that showed that acid leaching of chrysotile decreased its mesothelioma toxicity in rats; however, the treatment also shortened the fiber. He was not certain, therefore, whether the reduced toxicity derived from the treatment or the shortening of the fiber. In addition, no evidence was presented in the record to indicate that modified fibers are incapable of causing adverse effects after administration into laboratory animals. Mr. Warren, of the SNA, in his testimony agreed with this position. When asked whether OSHA should deregulate modified chrysotile, Mr. Warren responded:

SNA's position is not that it wants [modified fibers] to be exempted from regulation. Indeed, it expects to be covered. And that is certainly true because the in vivo testing is not completed. There is no present basis available for making any biological distinction [between modified and unmodified fibers]. (Tr. 7/5, p. 49)

Based on these considerations, OSHA has decided that it is prudent from a public health viewpoint to continue to include chemically treated asbestos in the Agency's definition of asbestos (See Section IX. Summary and Explanation for General Industry).

G. Tremolite and Anthophyllite

In the November, 1984 notice, OSHA reviewed a number of epidemiological studies that suggested that the talc miners and millers are at excess risk of mortality from lung cancer, mesothelioma, and non-malignant respiratory disease (Exs. 84–025, 84–141, 84–181, 84–211), and have a high prevalence of pleural thickening and calcification, decreased pulmonary function, and lung fibrosis (Ex. 84–181). It is known that many, but not all, commercial talc deposits contain serpentine and amphibole asbestos and the minerals tremolite and anthophyllite, which may be found in amorphous, fibrous, or asbestiform habits (Ex. 84–039). At the time, based largely on epidemiological studies conducted by NIOSH (Ex. 84–029, 84–181), OSHA concluded that

"Talcs containing asbestos minerals . . . appear to pose a signficant health risk to exposed workers, and talc workers exposed to asbestos should receive the protection afforded by the asbestos standard" (48 FR 51120).

Specifically, Brown et al. (Ex. 84–029) of NIOSH conducted a historical prospective study of talc miners and millers employed at a New York State talc facility operated by the R.T. Vanderbilt Company. Although the company reported that the talc at this facility contained no asbestos, NIOSH (Exs. 84–39, 84–181) reported finding asbestiform tremolite and anthophyllite following analysis of personal and bulk samples by election microscopy and x-ray diffraction techniques. As measured by optical microscopy, average air concentrations of fibers greater than 5 um in length ranged from 1.7 f/cc to 9.8 f/cc as an 8-hour TWA in the mine. In the mill, average 8-hour TWA exposures for these fibers ranged from 1.5 f/cc to 8.4 f/cc.

The cohort studied by Brown et al. (Ex. 84–029) consisted of 398 workers employed between 1947 and 1959. Cause-specific mortality rates were compared to those of U.S. white males, adjusted for age and calendar period. Brown et al. reported signficantly elevated increases in cancer mortality (9 observed vs. 3.3 expected) and non-malignant respiratory disease mortality (8 observed vs. 2.9 expected). One death from mesothelioma was reported, but the death could not be specifically attributed to exposure to tremolite or anthopyllite. Of the 10 individuals who died of cancer, 3 worked previously for other New York State talc companies.

Gamble et al. (Ex. 84–181) of NIOSH also conducted a cross-sectional morbidity study of the same facility. Of 156 male miners, 121 participated in a survey consisting of a respiratory questionnaire, chest X-ray, and spirometric testing. The morbidity experience of this cohort was compared to that of coal miners, potash miners, chrysotile asbestos workers, and synthetic wool textile workers. Coal and potash miners were used as comparison groups because they were likely to be similar to talc miners in many non-occupational respects that affect respiratory morbidity. Gamble et al. (Ex. 84–181) found that, compared to coal and potash miners, talc miners with no previous work history at other talc mines had a signficantly elevated prevalence of pleural thickening and calcification. When all talc workers were combined, with or without prior talc exposure, the researchers found increased prevalences of cough, phlegm production, dyspnea, and x-ray abnormalities. Talc workers also had significantly decreased pulmonary function, which was associated with duration and intensity of exposure.

OSHA also reviewed a third study that presented conflicting findings in workers at the same facility (48 FR 51118). Stille and Tabershaw (Ex. 84–196) studied all male workers employed sometime between 1948 and 1977 at this facility. Vital status and information on control variables were determined for 655 men. Cause-specific mortality rates were compared to U.S. white males, adjusted for age and calendar period. Non-signficant excesses of mortality from lung cancer and non-malignant respiratory disease were observed in the cohort; these excesses were attributed to a "smoking effect," rather than to an effect from occupational exposure (Ex. 84–196).

As a further analysis, Stille and Tabershaw (Ex. 84–196) separately analyzed the mortality experience of cohort members with a history of any prior work experience and cohort members with no prior work experience. Among the subcohort of 540 males with prior work experience, significant elevatious were found for mortality from all cancers, liver cancer, lung cancer, lymphopietic cancer, and non-malignant respiratory diseases. No elevated causes of death were found for the subcohort of 115 males with no prior work experience. Stille and Tabershaw concluded that "Since the cancers and lung diseases typically have long latencies, the possibility exists that exposures prior to work at the . . . study mine and mill were responsible for at least some of . . . [the increased incidences of diseases observed]" Ex. 84–196, p. 482). They also concluded that "workers with 'exclusive' . . . . [study mine and mill] employment seem to be at no considerable risk of . . . lung cancer. . . . " (Ex. 84–196, p. 483).

OSHA also presented comments by Brown et al. on the Stille and Tabershaw study (48 FR 51119). To summarize, Brown et al. (Ex. 84–218, pp. 178–179) commented that Stille and Tabershaw failed to analyze mortality by length of followup period. The analysis of subcohort with or without prior work history was "not likely to be very informative," because of the small size and young age of the cohort that had no prior work history. Because of these and other concerns about the Stille and Tabershaw study, Brown et al. concluded as follows:

"[the Stille and Tabershaw] report fails to address adequately the question of whether or not there is an increased risk from lung cancer specifically associated with working at . . . [this particular facility]. In fact, at this time, it is not possible to answer this question based on epidemiologic data alone, because the population available for study is small, the follow up period is relatively short . . . , data on smoking are lacking, and previous exposures in other neighboring talc mines and mills represents a confounding factor" (Ex. 84–218, p. 179).

Tabershaw and Thompson (Ex. 84–219, pp. 179–180) responded to the criticism of Brown et al., and disagreed with NIOSH's conclusion that the talc from the facility contained asbestiform minerals. They cited other studies in which analysis of talc from the facility failed to find any asbestiform fibers, and took exception to NIOSH claiming that asbestos was present based on only 10 atmospheric samples taken during the grinding of a single ore sample. In addition, Tabershaw and Thompson pointed out that, of the nine individuals reported by NIOSH to have died from lung cancer, 4 were employed for less than one year at the facility making it doubtful that exposure to talc at the facility was the likely cause of lung cancer mortality for those 4 workers.

As part of their post-hearing submission, Organization Resources Counselors, Inc., submitted a publication by the R.T. Vanderbilt Company, in which Dr. Selikoff offered opinion on these epidemiology studies. In this publication, Dr. Selikoff is quoted as follows:

"[Vanderbilt] . . . employees in many cases had worked in other New York State mines. Therefore, in the analysis of studies, a question could be raised whether . . . sufficient latency had existed . . . to determine that people who worked only with Vanderbilt talc has excessive cancers. The data can be looked at in various ways. It does create a problem because the ones with the longest latency were also the one who had worked in other mines and mills by definition. . . . I wish we had enough Vanderbilt workers who had begun work 50 years ago, to be able to tell us what happens ultimately to people who inhale Vanderbilt talc. There simply aren't enough such people, if there are any." (Ex. 123–A)

OSHA agrees with Dr. Selikoff's assessment that the epidemiological data are inconclusive with respect to the asbestos-related risk associated with exposure to talc at the Vanderbilt facility. Although the NIOSH studies (Exs. 84–029, 84–181) are suggestive of an increased risk from lung cancer mortality and non-malignant respiratory morbidity among workers at this facility, they are not definitive because of the confounding factor or prior exposure to talc at other facilities. In addition, OSHA agrees with Tabershaw and Thompson (Ex 84–218) that the inclusion in the cohort of workers with less than one year of work experience at the facility further complicates the analysis. On the other hand, OSHA does not believe that the study by Stille and Tabershaw (Ex. 84–196) indicates a lack of carcinogenic risk among workers at the facility; their analysis of the subcohort with no other prior work experience is inconclusive because of the small size of the cohort and the lack of an adequate follow-up period. An assessment of the implications of these studies is further complicated by the controversy regarding the presence of asbestiform minerals at this facility. OSHA therefore does not find that these studies shed new light on the issue of the carcinogenic or fibrogenic potential of the various forms of tremolite or anthophyllite.

In addition to the epidemology studies discussed above, OSHA described an animal study conducted by Smith et al. (Ex. 84–194) in which the authors administered intrapleural injections of four different tremolitic substances into hamsters. The ore samples tested included fibrous tremolitic talc from New York, tremolite prepared from talc ore at the facility studied by NIOSH, tremolite prepared from Western U.S. talc deposits, and asbestiform tremolite. Tumors and pleural fibrosis were observed only in animals injected with tremolite from western talc or asbestiform tremolite. Smith et al. suggested that the tremolite sample from the facility studied by NIOSH yielded negative results because of the generally short length of the fibers, despite its high tremolite content. They also suggested that the fibrous tremolite sample from New York failed to elicit a carcinogenic response because of the low content of fibrous talc (tremolite constituted only 35 percent of the sample by weight; in addition, only 25 percent of the tremolite was in fibrous form). Smith et al. concluded as follows:

Since [the two samples that yielded positive results] . . . contain at least 5% of material other than tremolite, we cannot be sure that their activity is due wholly, or even in part, to tremolite. If we assume that their activity is due to tremolite, then the experiments indicate that appropriately high doses of long, thin particles of tremolite induced tumors, whereas high doses of shorter particles did not. This would, of course, be consistent with previous findings by ourselves and others with other materials, such as chrysotile and glass fibers. (Ex. 84–194, p. 338).

In a post-hearing submission (Ex. 306–A), R.T. Vanderbilt Company submitted two additional studies by Smith that contain the same results report by Smith et al. (Ex 84–194) for the tremolite from New York talc, this submission also contained a report by McConnell et al. (1983) in which F-344 rats were given a diet consisting of one percent tremolite obtained from Vanderbilt's Gouverneur mine. The tremolite had no effect on survival or tumor development compared to that of control rats. OHSA does not find this study noteworthy since, as discussed earlier in this section, several feeding studies of asbestiform minerals known to be carcinogenic by other routes of exposure have failed to show carcinogenic activity by the oral route.

The evidence presented by the R.T. Vanderbilt Company (Exs. 123–A, 306–A), namely the epidemiology study by Stille and Tabershaw and the animal studies conducted by Smith et al. (Exs. 84–194, 306A), would suggest that there was no evidence for asbestos-related disease at their facility, which they maintain contains no asbestiform fiber. Based on these data, and other evidence submitted on the mineralogy of asbestos (Exs. 123–A, 228, 229–A), they have urged OSHA to revise its definition of asbestos to exclude non-asbestiform fibrous tremolite and anthophyllite. As discussed earlier in this section, the finding of asbestos-related disease and the existence of asbestiform minerals at the Vanderbilt site were highly controversial issues during this rulemaking and, as suggested by Dr. Selikoff, cannot be completely resolved at this time. OSHA therefore finds that there is insufficient evidence upon which to state with any degree of certainty that exposure to some forms of fibrous tremolite or anthophyllite is safe. For this and other reasons discussed in Section X of this Preamble (Summary and Explanation), OSHA has not revised its definition of asbestos to exclude certain fibrous forms of these minerals. The Agency believes that this decision comports with prudent public health policy.

V. Quantitative Risk Assessment

Introduction

OSHA's determination that currently exposed workers face a significant risk of asbestos-related disease is primarily based on the results of the quantitative risk assessment performed by the Agency, as discussed in the November proposal [48 FR 51122]. OSHA has critically evaluated the scientific evidence concerning the health risk from asbestos exposure. OSHA, as well as other scientific groups, believes that asbestos exposure causes lung disease, respiratory cancer, mesothelioma, and gastrointestinal cancer. OSHA has also examined evidence that indicates that excess disease risk has been observed at cumulative exposures at or below those permitted by the existing OSHA 8-hour permissible exposure limit of 2 f/cc. In addition, OSHA has made risk estimates of the excess mortality from lung cancer, mesothelioma, gastrointestinal cancer, and the incidence of asbestosis using mathematical models that describe the data observed in epidemiologic studies conducted in various industrial populations.

In many cases, the elevated risks seen in worker populations reflect past exposures that were higher than those permitted today. OSHA's quantitative risk assessment entails using the directly observed risks from these past exposures to estimate risk at lower exposure levels. OSHA believes this is a scientifically appropriate and valid procedure. In some instances, OSHA estimated risks using studies which actually observed risks at or below cumulative exposures permitted by the existing standard. The range of studies used by OSHA covers many different work situations and exposure levels. Where possible, OSHA has quantified the ranges of uncertainties in the estimates. These numerical estimates, as well as those risks observed at low exposures, were evaluated to determine the significance of the risk and to determine whether the new standards will lead to a substantial reduction in risk.

OSHA's critical evaluation of all relevant animal and epidemiological studies resulted in the selection of eight studies that contain good data for the calculation of the dose-response relationship for lung cancer for this final rule [Selikoff et al., 1979, Ex. 84–90; Seidman, 1984, Ex. 261–A; Henderson and Enterline, 1979, Ex. 84–48; Weill et al., 1979, Ex. 84–206; Finkelstein, 1983, Ex. 84–240; Peto, 1980, Ex. 84–169; Dement et al., 1982, Ex. 84–35; Berry and Newhouse, 1983, Ex. 84–21] and six for mesothelioma [Selikoff et al., 1979, Ex. 84–90; Seidman et al., 1984, Ex 261–A; Finkelstein, 1983, Ex. 84–240; Peto, 1980, Ex. 84–169; Weill et al., 1979, Ex. 84–206; and Dement et al., 1982, Ex. 84–35]. In general, studies of human cohorts in the workplace should provide a better basis for quantitative risk assessment than studies of experimental animals because of the similarities in the populations at risk and the populations from which the risk estimates are derived. As Dr. Hans Weill, testifying on behalf of OSHA, noted:

> The greatest public confidence in decision-making to reduce an environmental or occupational risk results when the data used are the product of well designed and conducted studies of relevant human populations. . . . When an occupational hazard has been identified, useful epidemiologic study results will determine the quantitative relationship between the dose of exposure to the causative agent and the risk of the adverse health response in the exposed population. The product is the exposure-response relationship, which together with a valid estimate of the size of the exposed population, the extent of that exposure and accurate indicators of the disease outcome, give characterization of the risk [Ex. 99, p. 8].

The potency coefficients for lung cancer and mesothelioma (K_L and K_M, respectively) used to define the dose-response relationship were calculated for each study so that cancer mortality was estimated for various exposure levels and exposure durations. A number of well-conducted and high quality epidemiologic studies were available that contained sufficient information on which to base a quantitative risk assessment. Some of these studies did not contain exposure data, but could be coupled with exposure information from other sources in order to obtain an estimate of K_L and K_M.

OSHA chose not to use animal studies to predict quantitative estimates of risk from asbestos exposure because of the many high quality human studies available that were conducted in actual workplace situations. As is often the case with animal studies, laboratory conditions may not precisely parallel actual worksite exposures. In the case of asbestos, for example, is it not clear in all instances whether laboratory animals have been exposed to fiber size distributions similar to those found in workplaces. In addition, asbestos appears to multiply the underlying lung cancer risk of smoking and nonsmoking workers; laboratory animals generally do not have any underlying risk of lung cancer. Instead of relying on the animal studies to estimate risk, OSHA has supplemented the human data with results from animal studies when evaluating the health information and determining the significance of the risk; OSHA believes that the animal studies can provide valuable qualitative information on asbestos-related disease. For example, the animal studies show that all commercial asbestos types can cause cancer and pulmonary fibrosis. Animal studies also indicate that longer, thinner fibers may have greater carcinogenic potency than short, coarse fibers.

The paragraphs below provide a synopsis of OSHA's quantitative risk estimates derived from mathematical models and a discussion of the comments and testimony submitted regarding the quantitative assessment of risk for asbestos. OSHA's proposed estimates of risk may be found in Ex. 84–392, the emergency temporary standard ["the November proposal", 48 FR 51086], and in the April proposal [49 FR 14116].

I. Estimates of Risk for Lung Cancer

A. *The Model.* As discussed in the November proposal, OSHA chose a linear model to describe the relationship between the excess relative risk of lung cancer and asbestos exposure (dose). Relative risk is defined as the ratio of the mortality rate of exposed persons to the mortality rate of equivalent non-exposed persons. Relative risk is frequently approximated by the standardized mortality ratio (SMR), which is the observed number of deaths in the exposed population divided by the number of deaths that would be expected in the exposed population. The number of expected deaths is usually derived from the specific age, sex, and calendar year mortality rates in the comparison population.

Asbestos exposure is generally measured in terms of total or cumulative dose. Total dose, also referred to as cumulative exposure or cumulative dose, is a measure of the amount of asbestos inhaled; it is the product of the duration of exposure (in years [y]) and the intensity of exposure (which is workplace air concentration in millions of particles per cubic foot [mppcf] or fibers per cubic centimeter [f/cc]). Under this definition of exposure, a person exposed to airborne asbestos at 2 f/cc for 20 years (40 fiber-years/cc [f-y/cc]) has the same total dose as a person who is exposed to asbestos at 4 f/cc for 10 years (40 f-y/cc).

The relative risk model used by OSHA in assessing the risk of developing lung cancer from asbestos exposure is described by the following equation:

$$R_L = R_E[1 + (K_L \times f \times d_{t-10})] \qquad \text{(Eq. 1)}$$

where R_L is the lung cancer mortality resulting from the asbestos exposure, R_E is the expected mortality in the absence of exposure, f is the intensity of exposure in fibers/cc, d is the duration of exposure in years, t is the time from the onset of asbestos exposure in years (minus 10 years to allow for a minimum latent period) and K_L is the proportionality constant that is a measure of the carcinogenic potency of the asbestos exposure (slope of the dose-response curve).

The equation can be rewritten as

$$R_L/R_E) - 1 = K_L x\, f\, d_{t-10} \quad \text{(Eq. 2)}$$

showing, on the left-hand side, the excess relative risk (excess SMR) as a function of K_L and total dose (fibers times years). It is this form of the equation that is used to derive the individual K_L's for each of the eight studies. These eight K_L's are used to derive one overall K_L for lung cancer. Then the excess risk is computed for each five-year age interval; the overall lung cancer risk is then computed as the sum of the risks in each of the five-year intervals from age 25 to age 70. The excess risk is expressed as the number of additional lung cancer deaths per 1000 workers exposed for a specific time period.

Evidence of the linear dose-response relationship for lung cancer is found in several well-conducted epidemiologic studies that examined lung cancer mortality in relation to cumulative asbestos exposure in the workplace (for example, Henderson and Enterline, 1979, Ex. 84–48; Liddell et al., 1977 Ex. 84–59, and Dement et al., 1982, Ex. 84–35). In the three studies cited above, workplace asbestos air concentrations were available from measurements made in the worksite studied. Although the studies differ in the magnitude of the risk found (discussed later in this section), all three demonstrate a linear relationship over the entire range of observation.

As stated in the November proposal, other scientific and scientific groups who have attempted to estimate risk from asbestos exposure have used the linear model for lung cancer [Crump, Ex. 85–22, British Advisory Committee on Asbestos. Ex. 84–216, Acheson and Gardner, Ex. 84–243, Selikoff, Ex. 82–2, EPA, Ex. 84–180, CHAP, Ex. 84–256, National Research Council/National Academy of Sciences, Ex. 321]. The model is generally accepted and OSHA believes use of the linear model for predicting lung cancer due to asbestos exposure is reasonable and well-supported. Although participants in the rulemaking pointed to the uncertainty associated with the use of the linear model, no one suggested another model for computing the lung cancer risks.

Dr. Hans Weill elaborated on this point:

> * * * As regards the shape of the dose-response slope, and operational judgment is based on the conclusion that there is currently no available evidence that convincingly proves that the slope is not linear, crossing the [excess] risk axis at the origin. This assumption (as made in the OSHA risk analysis) is justified from the observations at moderate and high levels of exposure that generally indicate linearity, which when extended downward to levels of exposure below which observations are available, are not inconsistent with linear low dose extrapolation [Ex. 99, p. 13].

And, in his testimony, Dr. Weill concluded:

> Now, as far as the shape of the curve for the important malignant consequences of asbestos exposure, I think we are all in agreement so far today, that the evidence does not permit us, nor does concern of public health or prudence permit us for the conditions that we are concerned about, to develop on any basis other than linearity of exposure and response in a no threshold model [Tr. 6/19, p. 154].

Dr. William Nicholson of the Mount Sinai Environmental Sciences Laboratory elaborated on the rationale for the choice of the linear model for lung cancer:

> In three studies in which it [the linear dose-response curve] has been demonstrated [see above Exs. 84–48, 84–59, and 84–35] the range of exposures is large, over a tenfold range of exposures, that linearity has been documented over a tenfold range of dose. Further, it has biologic plausibility [Tr. 6/19, p. 75].

This biologic plausibility was also discussed by Dr. Kenny Crump, testifying on behalf of the AIA/NA:

> There is a theoretical argument (Crump *et al.*, 1976) that suggests that cancer incidence should vary approximately linearly with dose for low doses particularly when there is an appreciable background of carcinogenesis in unexposed populations. . . . If asbestos induces cancer through the same mechanism as smoking, then there is reason to believe that the response should be approximately linear at low dose . . . just as assumed in the OSHA model [Ex. 237A, pp. 8, 25].

Though Dr. Crump noted in his testimony that the linear model for lung cancer "is a hypothesis which is by no means proven" [Tr. 7/9, p. 90], he stated during cross-examination that "all of the estimates I have made in the testimony were based upon a linear model for lung cancer" and that the linear model for asbestos and lung cancer "has been widely used" [Tr. 7/9, p. 116].

Thus, OSHA feels confident in its adoption of a linear model to predict the risk of lung cancer from asbestos exposure. The model has wide support because of its scientific plausibility and reasonableness and its prudence for use in public health decision-making.

B. *Data Used in the Calculation of Individual* k_L's. In the November proposal [48 FR 51125], an estimate of lung cancer potency (K_L) was calculated for each of 11 studies using equation 1. For studies with individual exposure data, K_L was the slope of the regression equation fit to these points; for studies having only an overall risk estimate and average estimate of exposure, this single point was used in the calculation of K_L. For each study, the best estimate of K_L is indicated along with a range of uncertainty. The ranges given are the result of uncertainties in estimates of exposure, methodological uncertainties that led to alternate evaluations of risk or exposure, or, in some cases, statistical uncertainties associated with the use of small numbers.

The differences in the K_L's among the various studies result from a number of different factors. There do appear to be actual differences in risk depending upon the nature of the asbestos exposure. One potential explanation is that workplaces differ with regard to fiber size distribution (long finer fibers appear to have greater carcinogenic potential than coarse fibers). For example, as several participants in the rulemaking acknowledged, there appears to be a distinct difference in the risk from mining and milling and other processes. As Dr. Nicholson summarized:

> I think I stated this morning . . . the possibility that the mining work environment may demonstrate a different pre-unit risk. That is, there's three studies showing somewhat lower risks. At least two of them show, with fairly substantial data, lower risk, that that [lower risk] may be a function of the fiber size distribution in the mining environment.
>
> One may have a much greater number percentage, of long curly fibers, which are readily counted, but are not inspired. And, thus, the fiber counts are proportionately high in that environment relative to the amount of asbestos inspired. It seems to be consistently so for chrysotile and also for amosite. For example, one finds very few cases of mesothelioma associated with amosite mining but a considerable number associated with amosite manufacturing.
>
> And so there is perhaps a difference in the mining environment, where they are working with different type of fiber composition [Tr. 6/19, p. 127].

Thus, where airborne fibers are relatively coarse, the K_L's are lower than the K_L values found in studies of textile operations where fibers are fine.

Differences may also be explained by variations in study design and other factors influencing the ability to define the dose-response relationships. One of these is the limited knowledge of past fiber exposures of those populations whose mortality was later evaluated. Prior to 1970, few measurements were made in facilities using asbestos fibers. Further, those measurements that were done usually quantified all dust present in the workplace air and not just fibers. Current techniques, which involve use of membrane filters and phase contrast microscopy for the counting of fibers longer than five micrometers, have been utilized in Great Britain and the United States only since 1964 [Ayer et al., 1965, Ex. 84-253] and have been standardized in the United States only since 1972 [Leidel], 1979, Ex. 84-62] and even later in Great Britain. In any case, sampling has occurred only in a few of the worksites studied, and then only occasionally. In addition, variability in work activities and in sampling circumstances add considerable uncertainty to knowledge of dose.

Some of the epidemiologic studies, including those by Dement et al. [Ex. 84-35], Liddell et al. [Ex. 84-59] and Henderson and Enterline [Ex. 84-48], include measured air concentrations at the exposure site and used job histories of the study population to estimate exposure. In these cases the dose-response curve was calculated by estimating total asbestos exposure (in mppcf-years or in fiber-years/cc) according to the time that an individual spent at a job with a measured exposure. A conversion factor for converting from mppcf to f/cc was employed on a study-by-study basis, depending on the data available. Other epidemiological studies, for example those by Selikoff et al. [Ex. 84-90] and Seidman et al. [Ex. 84-87], did not have direct industrial hygiene measurements for the studied worker population. For these studies, exposure estimates were derived from industrial hygiene surveys of similar work operations and processes for which industrial hygiene data were available.

OSHA has evaluated these differences and has dealt with their implications on a study-by-study basis. Uncertainties associated with these measurements constitute much of the range of variability surrounding the K_L's. Taken as a whole , the asbestos studies contain data of unusually high quality, which has enabled OSHA to make the risk estimates with a high degree of confidence.

There was considerable discussion during the rulemaking about the individual K_L's for many of the studies that went into the estimation of the overall lung cancer risk, particularly the inclusion/exclusion of several of the studies in this calculation. The discussion below deals first with the comments on and adjustments to individual K_L's and then discusses the impact of their inclusion in the overall estimate of lung cancer risk.

The Selikoff et al. and Seidman et al. Studies. Several participants in the hearing criticized OSHA for including the results from the Selikoff et al., 1979 [Ex. 84-87] and Seidman et al., 1979 [Ex. 84-90] studies in the calculation of K_L. The major objection to the use of these studies was the lack of concurrent exposure information on the cohorts. For example, Dr. Crump noted that:

> The CPSC (1983) Panel placed these two studies in a separate category because of the weakness of the exposure estimates. The Seidman *et al.* study also involved brief exposures (less than four years) exclusively, which makes it less suitable than other studies for estimating the effect of long term exposures [Ex. 237A, p. 26].

Dr. Weill also expressed reservations about including the Selikoff et al. and Seidman et al. studies in the overall estimation of risk [Tr. 6/19, p. 184].

Though it is true that CHAP did characterize the Selikoff et al. and Seidman et al. studies as having "Level 2 exposure data" (no job histories or industrial hygiene measurements available for the cohort, exposure estimate made from best available sources), CHAP still computed K_L for these two studies with the information available. And, during cross-examination, Dr. Nicholson, a member of CHAP, indicated that CHAP did not weigh the K_L values from these two studies differently from those in other studies when deriving estimates of the final potency [Tr. 6/19, p. 148]. Dr. Weill emphatically stated that inclusion of the studies in the risk analysis was "not a fatal flaw [Tr. 6/19, p. 184].

OSHA offered a full description of the exposure data used in these two studies in Exhibit 84-392. Since that time, however, new and more complete information on exposures for the Seidman et al. cohort have come to light which strengthen the case for including the results of the K_L calculation in the overall estimates of risk. This new information is discussed below.

Although no new evidence has been brought forward on the Selikoff et al. study of insulation workers, OSHA still believes it is appropriate to include the K_L from this study in determining the overall level of risk. It is the largest of all the studies (17,800 workers) and also reports the largest number of lung cancer deaths (652) and deaths from mesothelioma (180). Excluding this study would mean excluding 45% of all the asbestos-related lung cancer deaths and 84% of all the mesothelioma deaths from the overall analysis. OSHA believes it would be a serious error to eliminate such a large portion of the available data, when appropriate estimates of the exposure levels of these workers are available.

OSHA calculated the K_L from the Selikoff et al. data based on average values (for duration of exposure, level of exposure and time since onset of exposure) derived from several sources. Although the use of average data and overall (average) levels of risk may not be as desirable as risks broken down by cumulative exposure, nevertheless, the estimates of K_L from these data are nevertheless valid and reasonable. OSHA predicted a K_L of 0.02 for the cohort, with an uncertainly band of (0.008 to 0.30). The value 0.02 is only twice the best estimate of an overall K_L of 0.01 and falls well within the range of overall uncertainlty given for the overall K_L, that is, 0.003 to 0.03. Thus, OSHA has not adjusted the original value of K_L computed for this cohort.

The Seidman et al Update. During the course of the hearing, the testimony of several witnesses strengthened OSHA's confidence in using results from the Seidman et al. study of 820 insulation manufacturing workers. As discussed in Exhibit 84-392, while no data exist on air concentrations at the time the Paterson factory operated, data do exist on air concentrations in two plants that manufactured the same products with similar fiber and machinery. One of these plants, in Tyler, Texas, opened in 1954 and operated until 1971. The other, in Port Allegheny, Pennsylvania, opened in 1964 and closed in 1972. Similar efforts to control dust in these newer plants were apparently made as were made in the Paterson, New Jersey plant. During 1967, 1970, and 1971, asbestos fiber concentrations in these plants were measured by the U.S. Public Health Service and were published by NIOSH [Ex. 2-12].

Participants in the rulemaking criticized the assumption that these exposure data were representative of the exposure conditions in the Paterson plant. Dr. Crump expressed his concern over the use of these data. He stated:

> OSHA thus derived exposure estimates from measurements made 21 to 31 years later in the other plants in Texas and Pennsylvania. The reasonableness of these estimates is open to question. It is certainly plausible that the exposure measurements in these plants made after the dangers associated with asbestos became known were less, and perhaps far less than exposures experienced 21-31 years earlier under wartime conditions [Ex. 237A, p. 13].

Dr. Morton Corn, former Assistant Secretary for OSHA, who appeared at OSHA's hearing on behalf of the Building and Construction Trades Department was hired by the companies who owned the plants to recommend and install control measures in the two plants in the late 1960's. At the hearings he was asked to comment on the reasonableness of using data from Tyler, Texas and Port Allegheny to estimate exposures in the Paterson plant. Dr. Corn responded:

I think the procedure is precisely what we're trying to do in industrial hygiene. And I would endorse trying to link similar plants where no measurements were available to other plants where measurements are available. There's no question about that.

I would classify Tyler as one of the most contaminated asbestos facilities I've ever been in. I think Tyler would be the high estimator. Port, I would consider typical of asbestos processing that I saw in those years. But Tyler was clearly a very bad facility. . . . So I don't know if averaging them, averaging might put you on the high side if you have measurements for both. I would pit you towards Tyler. . . . Tyler was a fairly startling facility [Tr. 7/3, p. 67].

Hence, given Dr. Corn's characterization of conditions in the two plants, to the extent that OSHA used data from the Tyler plant, the estimates of exposure would be *overestimated*, which would result in an *underestimate* of the potency factor, K_L.

Since the time of the OSHA proposals, the Seidman et al. study has been updated to include longer followup and an expansion of the findings in terms of the jobs of the workers and estimates of the fiber exposure accumulated by the workers during their work at the amosite asbestos factory. The updated study was presented at the hearings as Exhibit 261–A. The study extended the observation period through December 31, 1982, with a total of 593 deaths. Using the data from the Tyler Texas and Port Allegheny plants, Seidman and colleagues attempted to "assign plausible estimates of the exposures likely to have been associated with particular jobs in the Paterson plant" [Ex. 261–A, p. 6]. Seidman described the process as follows:

With the aid of the expertise of Dr. William Nicholson, I've gone back to the records that were accumulated on the Paterson workers, and in conjunction with fiber counts that were available for 1967 from Port Allegheny Plant and for 1967, 1970, and 1971 for the Tyler, Texas plant, *the same kind of fiber was used, the same kind of equipment was used, the same processes were used to make the same kinds of products*, we arrived at approximate—we estimated—looking at what the men themselves reported as to relative levels of dustiness in the jobs they worked at. We established levels of dustiness, dust index which at first was all I thought we could work with and I realized we had specific jobs that we could even modify this with, we assigned fiber counts per cc and then were able to then, with the aid of our historical data, to make an assignment which we applied to our Paterson plant. Then with the aid of the time that the men worked, we arrived at the total work time they worked at the plant, a total work experience dosage in terms of fibers [Tr. 7/12, p. 289, emphasis added].

As Mr. Seidman pointed out, when using the estimates of Tyler and Port Allegheny to determine exposures at the New Jersey plant, the estimates.

* * * may be somewhat on the high side to the extent that industrial hygienists tend to over-sample the dustier areas of factories. Also, there was a concerted effort to have the Paterson plant workers use respirator protectors which presumably might have reduced the exposure from inspired air while the protectors were being used. . . . It is important to realize that any overestimation there may be in the fiber counts we have assigned, will serve to underestimate the dose-response relationships associated with asbestos exposure at the Paterson plant [Ex. 216–A, p. 6].

Table 5 of Ex. 261–A shows the estimated exposures for over 30 job categories. During cross-examination, Mr. Seidman further explained:

Table 5 comes from two sources, one is internal and one is external. Internally, we had for about 40 percent of the men, a statement as to the dustiness of their job. We had—they said what their job was and how dusty it was[:] very dusty, somewhat dusty, or not dusty at all. . . . We had, for a number of jobs, what the counts—fiber counts—were for the jobs which, as I say, using the same kind of equipment, and same fiber and same kind of product, were in these plants of the same company. These were the general levels used to assign the jobs at UNARCO [Paterson, N.J.] and then modified them slightly depending on what the internal statement as to dustiness was [Tr. 7/12, p. 298–299].

Dr. Nicholson explained further:

The exposure-response data were generated by assigning each individual in the Paterson plant an exposure as calculated above for the period of time he would have been employed in a job with that given title. The total exposure in fiber-years/ml for each individual was then calculated summing over all jobs that the individual worked in [Ex. 303].

Table 1 gives cumulative observed and expected deaths for the workers in an amosite factory categorized by estimated fiber-year exposure. As noted in Ex. 84–392, it was believed that the average exposure for this population was approximately 35 f/ml, and this was the value used to calculate the original value of K_L for this cohort. However, in this updated analysis the average exposure was discovered to be closer to 50 f/ml [Tr. 7/12, p. 291]. Mr. Seidman indicated that the high number resulted when the estimates of fiber counts were "weighted by the kinds of jobs that the Paterson people had, [and] the number of people working at the jobs they had in the Paterson plant" [Tr. 7/12, p. 294]. Seidman went on to testify that "If you look at the historic data, there are ranges which go higher, but not on the averages. There are ranges, there are samples that go into the 200's" [Tr. 7/12, p. 295]. He noted, however, that the estimate of 50 f/cc "seems pretty reasonable and plausible to me" [Tr. 7/12, p. 295].

As was pointed out by Mr. Hardy, representing the AIA/NA, during cross-examination, the dose-response curve appears to cross the y-axis at a level above zero. However, Mr. Seidman was clear that possible underestimation errors in the measurements could not account for such differences. He commented—

To move them [the risk points at each dose level] far enough over so that the point on the straight line from this kind of material is going to come to zero [excess risk] on a straight line fit, they'd have such a cloud of dust, they wouldn't see each other at the next bench. . . . People couldn't work in such [conditions]—even the people who need a job desperately couldn't work in such an atmosphere [Tr. 7/12, p. 308].

TABLE 1.—CUMULATIVE OBSERVED AND EXPECTED DEATHS IN AN AMOSITE ASBESTOS FACTORY, 1941–45, BY ESTIMATED FIBER EXPOSURE—SEIDMAN.1984 [1]

Cumulative exposure f–y/ml	Midpoint	Lung cancer		
		Observed	Expected	SMR
<6	(3.0)	14	5.31	[2]264
6.0 to 11.9	(9.0)	12	2.89	[3]415
12.0 to 22.9	(18.5)	15	3.39	[2]442
25.0 to 49.9	(37.5)	12	2.78	[2]432
50.0 to 99.9	(75.0)	17	2.38	[2]714
100.0 to 149.9	(125.0)	9	1.49	[2]604
150 to 249.9	(200.0)	12	1.32	[2]909
250 plus	(250.0)	11	0.94	1,170
Total		102	20.51	49

[1] From Table 7, Seidman, 1984, Ex. 261–A.
[2] $p<.001$.
[3] $p<.01$.

In its original evaluation of this study, OSHA used overall averages (SMR=4.46, 35 f/cc, 1.46 years) to compute the K_L [$0.068=(4.46-1)/(35\times1.46)$]. Substituting the overall values from the updated study gives a slightly smaller value of K_L [$0.054=(4.97-1)/(50\times1.46)$]. In addition, the updated and expanded data base now provides enough data to perform a dose-response regression for the lung cancer data. The data are found in Table 1. As with other data sets, it may be speculated that there is greater uncertainty in the estimates at lower doses. This may be adjusted for by forcing the curve through the origin. Regressing excess SMR on the midpoints of dose gives an estimate of K_L of 0.045. Although this value of K_L is somewhat lower than the originally predicted value of 0.068, OSHA has greater confidence in it as an accurate predictor of the asbestos potency in this production population.

The Henderson and Enterline study. OSHA calculated the value of K_L based on the mortality experience of 1075 retirees from an asbestos products manufacturing plant [Ex. 84–48] by computing the slope of the dose-response relationship from the linear regression (K_L=0.0066). Henderson and Enterline had presented exposure data in terms of total dust measured in millions of particles per cubic foot, and hence a factor was needed to convert from particles to fiber count. OSHA employed the value 1.4 f/ml/mppcf, based on the work of Hammad in cement plants, which gives a best estimate of K_L of 0.0047.

Crump has pointed to what he believes to be "considerable uncertainty in the methods used by OSHA to convert from particles to fibers" [Ex. 237A, p. 14]. Citing the CHAP [Ex. 84–256], he recommends that a conversion factor of 2 should have been employed, giving a K_L of 0.0033. He also notes that "Enterline himself employed a conversion factor of 3.0 (Enterline 1981) [Ex. 84–127]" [Ex. 237A, p. 15]. However, when Dr. Enterline testified before the Ontario Royal Commission in June of 1981, he expressed considerable doubt about the conversion factor of 3, noting "I don't know how anybody comes up with a number like that anyhow" [Ex. 85–2, p. 53]. Enterline also noted that the conversion factor depended on the operation and that "I think, in asbestos cement, maybe that's [3's] the wrong number" [Ex. 85–2, p. 53]. In addition, in the same footnote [Ex. 84–127] cited by Dr. Crump, Dr. Enterline noted that the British Advisory Committee on Asbestos used conversion factors of 1, 2, and 5 f/cc/mppcf and that "the most conservative estimate of response at low doses in terms of protecting the public would result from assuming a low conversion factor" [p. 42]. Whereas CHAP employed a slightly higher conversion factor, it also noted that—

> * * * since follow-up of this group began at age 65, it is essentially a study of a survivor population and as such may have underestimated the maximum relative risk actually experienced by the entire cohort. If this peak relative risk provides the best basis for predicting the long-term experience of individuals exposed at lower levels, then the fitted slope should be increased perhaps by a factor of 2.0 [Ex. 84–256, II–102].

CHAP made such an adjustment in its estimate of the slope to account for these biases (Ex. 84–256, II–100]. Therefore, given the fact that CHAP recommends a value of K_L considerably higher than that put forth by OSHA in the November and April proposals and since Dr. Crump has suggested a value somewhat lower, OSHA believes that its estimate of 0.0047 for K_L represents a reasonable median estimate of the potency factor for lung cancer in this study population. As noted in Ex. 84–392, however, "A study of a retiree cohort with these characteristics would understate mortality by as much as 62% relative to the maximum observable risk" [p. 30]. Thus accounting for this possible underestimation, and with regard to the variation in possible conversion factors, the range of uncertainty around this value may extend from 0.0022 to 0.0106.

The Finkelstein Study. Finkelstein established a cohort of 241 production and maintenance employees from records of an Ontario asbestos cement factory. OSHA computed a K_L for this cohort based on an average cumulative 18-years exposure of 112.5 f-y/ml for the production workers alone. This group had an SMR of 850, based on 17 observed lung cancer deaths versus 2 expected. These data produced a summary K_L of 0.067 (Ex. 84–392, p. 33]. OSHA noted some uncertainties in this estimate, particularly because the two lowest exposure categories show risk increasing steeply with exposure, whereas the highest exposure category showed a cancer rate lower than that of the lowest exposure group. OSHA speculated in the proposal that this inconsistency may be due to the small number of deaths in each category.

Several participants raised the question of the suitability of using this value of K_L in the overall estimate of K_L. In particular, Dr. Crump pointed to the lack of a dose-response relationship for lung cancer in this cohort, quoting the CHAP conclusion that "no sensible dose-response for lung cancer can be inferred from these results" [Ex. 237A, p. 28]. CHAP noted that:

> * * * possible explanations for these results are incorrect exposure estimates and/or very high competing risks for the heavily exposed persons [Ex. 84–256, p. II–111].

It should be noted that CHAP included Finkelstein's study among those categorized in the Level 1 Exposure category, that is, having job histories and industrial hygiene measurements made at the relevant exposure site. Using the entire cohort (both production and maintenance workers), CHAP computed an SMR of 606 (20 observed versus 3.3 expected). Noting reservations about the exposure levels, CHAP gave a K_L of 0.048 of this cohort [(6.06–1)/(105)].

Given the same reservations as expressed by CHAP, OSHA believes 0.048 to be a valid expression of the potency of exposure to asbestos in this population of asbestos-cement workers, and has lowered its original estimate of K_L to reflect some reservations about the data.

The Dement et al. Study. OSHA calculated a lung cancer potency factor from the study of Dement and his colleagues, who investigated the mortality experience of 768 workers in a chrysotile textile products manufacturing plant. Data from impinger measurements of total dust in terms of mppcf were available since 1930 for exposures in a textile plant using chrysotile [Dement et al., 1982, Ex. 84–35]. Using a factor of 3 to convert from mppcf to f/ml (also used by CHAP), OSHA computed K_L as the slope of the weighted regression of excess SMR on the midpoint of dust levels in f-y/ml. As noted in the November proposal, this produced a value of K_L of 0.042. Participants in the hearing argued that this K_L was overestimated because Dement and his colleagues had overestimated the SMR's by using an inappropriate control group for the calculation of the expecteds. As OSHA explained in its preliminary risk assessment, Dement et al. employed U.S. national death rates rather than local county rates for computing expected values. The authors noted that:

> The choice of an appropriate comparison population for mortality analyses is difficult and arguments could be made for using rates for a set of counties contiguous to the county in which the plant was located. However, there are serious limitations to this approach which were considered in this study and resulted in rejecting the use of local county rate. First, the county in which the plant was located is the site of a large shipyard industry with peak employment of approx. 29,000 persons in 1943 (Blot *et al.* 1978). Employees for this industry were largely drawn from the local population. Many of these workers are thought to have been exposed to asbestos during ship construction and repair. In an ecological study Blot *et al.* (1978) demonstrated an association between county lung cancer rates and shipyard employment. In a more refined case-control study, Blot *et al.* (1979) demonstrated a summary odds ratio of 1.6 for shipyard employment and lung cancer after adjusting for smoking, other occupations, age, race, and county of residence. These data suggest that lung cancer death rates in the area in which the plant was located are likely to be elevated by local shipyard employment.
>
> A second factor to be considered in choosing local rates for comparison is the effect that the plant being studied might have had on local lung cancer death rates. Because of a lack of an employment record system prior to about 1930, it is difficult to estimate the exact number of persons ever employed at this plant; however, this is likely to exceed 10,000 prior to 1965. Thus [sic] could have a

significant impact of local lung cancer death rates, assuming an overall lung cancer SMR of 200 or more for these workers.

The effects of shipyard and asbestos plant employment make the use of local death rates inappropriate for this study [Ex. 84–35, p. 879–880].

In addition, state (South Carolina) mortality rates from lung cancer were similar to those of the United States. Moreover, "[A]vailable smoking data for this cohort suggest that the observed lung cancer and nonmalignant mortality excess among white males cannot be explained by cigarette smoking independent of asbestos exposure" [Ex. 84–37, p. 430].

Although Crump pointed to the arguments raised by Acheson and Gardner [Ex. 84–243] that local rates should have been preferred, OSHA found these arguments unconvincing. Crump recommended a K_L of 0.023, approximately half the value of K_L calculated by OSHA. Crump noted that:

* * * Not only does this modification provide a better fit to the Dement *et al.* data, the estimated background rate agrees closely with the 75% excess of local lung cancer rates over national rates (See Figure 3 of Acheson and Gardner, 1983 [Ex. 84–243]). The lower estimate of $K_L = 0.023$ also reduces the discrepancy between this and other studies which show a much smaller K_L.

OSHA believes that a reduction of the K_L to 0.023 is inconsistent with the available data: First, Dement et al. noted that:

* * * even if rates for contiguous counties had been used . . . the expected lung cancer rates for white males would have been increased by only approx. 15%, not nearly sufficient for the observed excess lung cancer risk [Ex. 84–35, p. 880].

Moreover, as Dement pointed out in 1982:

* * * rates for contiguous counties for black males were approximately 45 percent below U.S. rates; thus, the overall excess among blacks is underestimated by the present study, although the numbers were small [Ex. 84–229, p. 179].

Thus, to some extent, these overall estimates may be underestimated. Hence, OSHA concludes that its original estimate of K_L for this study, 0.042, is valid and reasonable, and thus has adopted it for the final rule.

C. *Calculation of the Overall* K_L. OSHA's best estimates of K_L from the proposed rule, and the final determination of K_L for each study are given in Table 2, along with a range of uncertainty. The ranges listed are the result of estimates of exposure uncertainties (usually a factor of two), methodological uncertainties that led to alternate evaluations of risk or exposure, or, in some cases, statistical uncertainties associated with small numbers. In addition to some controversy over the individual K_L's, there was widespread disagreement as to which studies should ultimately be included in the determination of an overall K_L for lung cancer.

TABLE 2.—ESTIMATES OF K_L FROM PROPOSED RULE AND FINAL DETERMINATION

	Proposal	Final	Range
Henderson & Enterline	0.0047	0.0047	(.0022–0.011)
Weill et al	0.0033	0.0033	(0.0016–0.0086)
Finkelstein	0.067	0.048	(0.033–0.13)
Peto	0.0076	0.0076	(0.0009–0.023)
Dement et al	0.042	0.042	(0.23–0.21)
Berry and Newhouse	0.0006	0.0006	(0–0.0008)
Seidman et al	0.068	0.045	(.023–.06)
Selikoff et al	0.020	0.020	(0.008–0.03)
Arithmetic Mean	0.027	0.019	
Geometic Mean	0.0113	0.01	
Median	0.0138	0.0138	

In its preliminary assessment, OSHA used the eight non-mining-and-milling studies to derive an overall estimate of K_L of 0.01. As noted in the November proposal:

Considering the industrial processes other than mining and milling, OSHA believes 0.01 to be a reasonable estimate of K_L. It is the geometric mean and median of the K_L's derived from studies of asbestos manufacturing and insulation application processes. The geometric mean had the advantage of minimizing the influence of outlying values and a K_L of 0.01 is approximately within one order of magnitude of all the estimates of K_L. In sum, the K_L of 0.01 is a best estimate which contains appropriate recognition of studies with higher and lower values of K_L. It should be noted however, that the uncertainties around this estimate of K_L are such that an appropriate estimate of K_L could lie between 0.003 and 0.03 [48 FR 51125].

The distinct nature of mining-milling data (and hence, the estimate of K_L from these data) has been considered earlier. There is some evidence that risks in the asbestos mining-milling operations are lower than other industrial operations due to differences in fiber size. This differential was discussed by Nicholson [Ex. 303A]. Thus, in determining the best overall value for K_L for the final rule, the data from mining and milling processes were not considered.

OSHA still believes it to be valid to employ the same eight studies it used to derive the estimates for the November and April proposals. As discussed earlier, OSHA modified some of the values of K_L for the final rule. Based upon these revised values, OSHA has determined that the best estimate of K_L is 0.01, the same value derived for the proposals. The values given under the final estimate column in Table 2 have an arithmetic mean of 0.019 and a geometric mean of 0.01. OSHA believes it has chosen reasonable estimates for the individual K_L's and has been responsive to the comments made by participants in the hearing. In some cases, OSHA has lowered its original value of the estimate of K_L in light of these comments or the addition of new data indicating such a change was warranted. The end result is that these small changes in individual values have little effect on the overall K_L value. This is most likely due to the Agency's choice of a reasonable K_L for the proposal.

Some scientists have suggested that some asbestos processes such as asbestos textile manufacturing, may pose a greater hazard than other processes. As noted earlier, while mining and milling appear to pose a lesser carcinogenic hazard than manufacturing processes, when OSHA compared the potency factors for lung cancer (K_L) among different studies of different processes, no consistent pattern of differential lung cancer risk by process emerged. Therefore, again, the choice of a midpoint unit risk for all industrial processes is a reasonable and justified choice.

In sum, the K_L of 0.01 is a best estimate which contains appropriate recognition of studies with higher and lower values of K_L. It should be noted, however, that the uncertainties around this estimate of K_L are such that an appropriate estimate of K_L could lie between 0.003 and 0.3.

As discussed earlier, Crump believed that both the Seidman et al. and Selikoff et al. studies should have been excluded from the calculation of K_L. Along with the other adjustments discussed above, Crump estimated an overall K_L of 0.0065. As Dr. Crump noted in his testimony:

OSHA has developed what I would term an upper limit assessment of asbestos risk. In dealing with uncertainty, OSHA has, in a number of instances, made assumptions that tend to minimize the possibility of underestimating the risk. In addition, the uncertainties in some of their assumptions appear to be underestimated by OSHA. The three most significant assumptions in OSHA's risk assessment that lead to upper limit estimates of risk are the assumptions of: (1) a linear dose-response relationship; (2) the same potency for all forms of asbestos; and (3) attribution of the lung cancer component of risk caused by smoking to the overall risk of asbestos [Ex. 237A, p. 4–5].

However, in addition to Dr. Crump's recommendations, several commenters noted a number of different ways for incorporating the available data into an overall estimate of risk. For example, in his written testimony, Dr. Marvin Schneiderman, who served as a member of CHAP and who was one of the reviewers of OSHA's November proposal, suggested several other reasonable methods for producing "medium estimates." In addition to approaches taken by OSHA, Dr. Schneiderman suggested that one look only at the four studies (from the proposal) which also had data on mesothelioma (Selikoff et al., Seidman et al., Peto, and Finkelstein). This selection produced an overall estimate of K_L derived from the individual K_L values of approximately 0.028. He also noted the K_L of 0.020 which results from use of the five U.S. studies only (Selikoff et al., Seidman et al., Henderson and Enterline, Weill et al., and Dement et al. proposed values of K_L, Ex. 116, p. 7). Schneiderman concluded that:

> The selection of the value of 0.01 [by OSHA] is based both on the various averages that could be computed and also on the informal or subjective weights given to each of the studies by OSHA. If this value is in error, it is possibly biased *downward* by the inclusion of the miners and millers and the foreign studies. However, any error introduced by an underestimate or K_L will be relatively small. Because of the changing patterns of cigarette smoking which should soon lead to reduced lung cancer mortality among younger (working-age) men, an underestimate of K_L is likely to compensate for possible overestimate of lung cancer mortality in the future [Ex. 116, p., 7–8].

Other possibilities for the calculation of K_L include: (1) Using studies with concurrent exposure data only (Henderson and Enterline, McDonald et al., Peto, and Dement et al.), which gives estimates of K_L of 0.014 (arithmetic mean) or 0.006 (geometric mean); (2) using only the upper limits of the uncertainlty ranges, which gives a K_L of 0.059 (arithmetic mean) or 0.02 (geometric mean).

The value of 0.01 falls well within the range of K_L's suggested by participants in the rulemaking. It is less than two times larger than the lowest value suggested for K_L (by Crump). In addition, as OSHA discussed in the proposal, there is a range of uncertainty associated with this value that more than covers all suggested values of K_L. Thus, OSHA believes the value of 0.01 to be a valid, reasonable estimate of K_L and has employed it in developing its estimates of risk to support these revised rules.

II. Estimates of Risk for Mesothelioma

A. *The Model.* For the November proposal, OSHA chose an absolute risk model to predict the risk for mesothelioma from exposure to asbestos. Absolute risk is calculated as observed deaths divided by the number of person-years at risk. It is believed that use of SMR's or relative risk is not appropriate for mesothelioma because the expected number of deaths in a cohort would be close to zero due to the rarity of the disease. The use of absolute risk to predict risk of mesothelioma was not questioned by any participant in the hearing.

In addition to using absolute risk rather that relative risk, this model is different from that used for lung cancer because both duration of time since initial exposure and duration of exposure are determinative or risk. The magnitude of the risk increases linearly with intensity of exposure, whereas the risk increases exponentially with duration of exposure and time from onset of exposure. The rationale for such a model describing mesothelioma risk has been discussed by several authors [Armitage and Doll, 1969, Ex. 84–252; Pike, 1966, Ex. 84–385]. Such a model was utilized by Newhouse and Berry [1976, Ex. 84–342] in predicting mesothelioma mortality among a cohort of factory workers in England. Limited data from three studies are also available on the dose-response relationship for mesothelioma [Seidman et al., 1979, Ex. 84–87; Hobbs et al., 1980, Ex. 132, and Jones et al., 1980, Ex. 84–138].

The model used by OSHA to assess the risk and derive the potency factor for mesothelioma, K_M, is given by the following equations:

$$AR_M = fxK_M[(t-10)^3-(t-10-d)^3] \text{ for } t>10+d$$

$$AR_M = fxK_M(t-10)^3 \text{ for } 10+d>t>10$$

$$AR_M = 0 \text{ for } 10>t$$

where AR_M is the excess mortality from mesothelioma, f is the intensity of exposure in fibers/cc, d is the duration of exposure in years, t is time after first exposure in years, and K_M is the proportionality constant that is a measure of the mesothelioma carcinogenic potency (slope of the dose-response curve) [Ex. 84–392].

Dr. Marvin Schneiderman discussed several aspects of the choice of this model for assessing mesothelioma risks. In his written testimony he stated:

> The formula for estimating mesothelioma risk has a somewhat different form [from that of lung cancer]—in keeping with the fact that the excess risk from mesothelioma is measured as an "absolute" rather than a "proportional" risk. . . .
>
> What these formulas say is, first, no disease will be seen sooner that 10 years after first exposure (induction period effect). Second, if d is relatively short (compared to t) then there will be less disease than if the duration of exposure is long. Finally, the age-at-first exposure effect is subsumed in the exponent 3.

The Consumer Product Safety Commission, in the report mentioned above [Ex. 84–256], also gives this formula. The NRC/NAS report on asbestiform fibers [Ex. 321] notes the great sensitivity of the estimate to the exponent of the (t–10) [and the (t–10–d)] term. Taking the term $(t-10)^3$ as a base, if t=40, the relative values of the term raised to different exponents are:

NRC/NAS "middle"	$:(t-10)^{3.2}$	$1.97\times(t-10)^3$
Peto, et al.	$:(t-10)^{3.5}$	$5.48\times(t-10)^3$
Nicholson	$:(t-10)^4$	$30.0\times(t-10)^3$

These values are somewhat different if the "delay" term is neglected [Ex. 116, p. 6–7].

In his written testimony, Dr. Crump raised several issues concerning the choice of this expression for the time factor. He stated:

> Most studies of mesothelioma predict that the mortality risks are a power of elapsed time since first exposure, as assumed by the OSHA model. However, we cannot be sure that this steep rate of increase extends indefinitely into old age as assumed by OSHA. In the Selikoff cohort, which contains the best information on mesothelioma mortality in old age, the number of mesotheliomas in the oldest group (55+ years since first exposure) is only about ½ the number predicted from the OSHA model. Although some of this shortfall may be due to underreporting in old age, it is also possible that the deficit is real. If so, the OSHA model will overestimate risk at oldest ages. None of the cohorts contain information on mesothelioma risk after 30 years past termination of exposure. OSHA's assumption that the risk will continue to increase represents an assumption which is not presently verifiable [Ex. 237A, p. 34].

In a post-hearing comment, Dr. Crump extended his argument. In addition to the data from the Selikoff cohort discussed above, Dr. Crump also discussed the mesothelioma data from the recently completed follow-up of the Seidman et al. study of amosite workers. He pointed out that for these data, ". . . the mesothelioma rate did not continue to raise with increasing age from first exposure, but dropped off 35–40 years from first exposure to 1.8/1000 person-years, which is about ⅓ of the rate observed for 30–35 years from first exposure" [Ex. 312a, Vol. I, Tab A, p. 7]. Dr. Crump noted that, although the OSHA model assumes "that the mesothelioma mortality rate increases indefinitely as a power of time from first exposure . . . the multistage model does predict an eventual reduction, the timing of which is determined by the number of stages affected and the rate of elimination of fibers from the body" [Ex. 312a, p. 8]. Dr. Crump went on to conclude that "if the reduction is real, then the OSHA model will provide a considerable overestimate of mesothelioma risk from exposures in early life" [Ex. 312a, p. 8].

In addition, Crump performed a statistical analysis which demonstrated that the use of a delay model (such as the one proposed by OSHA) will always result in higher estimates of mortality rates at older ages than use of a model which does not incorporate a delay. He concluded that "Thus, rather than compensating for the reduction in risk, OSHA's use of a model with a delay exacerbates the tendency to overestimate risk at older ages" [Ex. 312a, p. 9].

As pointed out by Drs. Crump and Schneiderman, most studies of mesothelioma risk demonstrate that mortality risks are a power of elapsed time since first exposure, and this formulation has received widespread support. In general, the selection of a power of 3 is a reasonable choice and has been used by other reputable bodies (e.g. CHAP, Ex. 84–256). As noted by Dr. Schneiderman, the choice of a power of 3 will tend to give lower estimates of risk other choices of exponents which are also consistent with the available data. In addition, while Crump raised some doubts about the use of a "delay" model, the model also has widespread support in the scientific community (e.g. NAS/NRC, Ex. 321, CHAP. Ex. 84–256). Moreover, Dr. Crump's multistage model also contains a form of delay.

While there is some indication that these risks are, by no means overestimates, the benzene decision gave OSHA leeway to make assumptions which err on the side of overprotection of workers. Thus, OSHA believes the model it has used in the proposal to predict mesothelioma to be a reasonable consideration of the available data and has not changed it for the final rule.

In addition to the selection of the time factor, Dr. Crump also expressed concern over OSHA's assumption that the dose-response relationship was linear. He noted that:

The second assumption, namely a linear dose response, is particularly subject to doubt for mesothelioma because there is virtually no dose response data for this cancer. Finkelstein (1983) [Ex. 84–240] contains a table showing dose-response data for mesothelioma derived from a total of only nine mesotheliomas. The Simpson Report (Health and Safety Executive, 1979 [Ex. 84–216]) contained a table (Table 31X) showing a dose response for mesothelioma derived from a case control analysis of data of McDonald *et al.*; however, the table did not appear in the published paper (McDonald *et al.*, 1980) [Ex. 237A, p. 35].

Crump plotted the Finkelstein mesothelioma data with linear, quadratic and cubic dose-response curves and observed that "The linear model appears to fit only slightly better than the quadratic, and even the cubic model falls well within the crude 90% confidence bounds" [Ex. 237A, p. 36]. Crump concluded that:

Consequently, a linear dose response for mesothelioma is an assumption which has not been verified observationally. Since it seems biologically implausible that a dose response for cancer would ever be supralinear (Crump 1984) the linear assumption appears very unlikely to lead to an underestimate of risk from exposure to low concentrations. However, it could possibly provide an overestimate. There have been two general arguments which suggest that a linear dose response is plausible for many carcinogens. One such argument applies for carcinogens that "act by directly causing a mutation in DNA" (NRC, 1977). However, this argument may not be applicable to the carcinogenic mechanism of asbestos in producing mesotheliomas because asbestos has not been shown to be particularly mutagenic. The other general argument holds for carcinogens that produce cancers by the same mechanism by which background tumors are produced (Peto, 1978). However, since the background rate of mesotheliomas is either zero or—at most—very small, this argument is not applicable either [Ex. 237A, p. 36].

In an effort to investigate the effects of the choice of the model for mesothelioma, Crump fit a multistage model to the mesothelioma data used by OSHA. He described the model thus:

The multistage model, in its most detailed and complete form (Day and Brown, 1980 and Crump and Howe, 1984), is derived from the assumptions that cancer is initiated in a single cell only after the cell passes through several stages. Cells compete independently to be the first to produce a tumor. The rate at which a cell passes through a dose-related stage is assumed to be proportional to the instantaneous dose.

The model predicts a linear response at low dose whenever either 1) cancers occur "spontaneously" without a carcinogenic insult, or 2) there is only one dose-related stage; otherwise the model predicts a nonlinear response (Crump *et al.*, 1976). The evidence for spontaneous occurrence of mesotheliomas is lacking; consequently, the only way the multistage model can predict a linear response at low dose is for there to be only one dose-related stage. Since there is essentially no dose-response data for mesothelioma, the number of dose-related stages for mesothelioma is open to question [Ex. 237A, p. 44].

At the hearing, Dr. Nicholson defended the use of the linear dose-response assumption to predict mortality from mesothelioma, stating that:

There's no indication that mesothelioma develops as a result of asbestos fibers acting separately at different stages in the cancer process, which would be required in the multi-stage model to elicit a nonlinear response.

I know of no mechanistic basis that . . . or no experimental data that indicate that that is the case at all.

The limited data what we have, and it is less than that for lung cancer, suggests that linearity is compatible with the data that exists. The data are sufficiently uncertain that one can't say that absolutely linearity is the case. The fact that it's applicable in the case of lung cancer, [a]nd has plausibility of an asbestos fiber doing something, [a]nd the probability of that something being done would be proportional to the number of fibers available to do it exists, and, thus linearity is a most reasonable choice. . . .

One could envision, for example, that mesothelioma comes from those fibers that manage to penetrate the lung wall and get to the pleura. And that in heavy exposure circumstances, the fibrosis that would be present would limit the number that would cross the wall. Thus, you would have in the heavy exposed circumstances fewer mesotheliomas because fewer fibers can penetrate to the pleura than in lower exposure circumstances, giving you a concave downward dose response relationship.

That's just a speculation, as is the speculation of a multi-fiber action at one site. And I don't think either have sufficiently substantive backing to deviate from the use of the linear dose response relationship, which has stood us in good stead in most other circumstances [Tr. 6/19, p. I–140–142]

TABLE 3.— ESTIMATES OF K_M and Goodness of Fit From Six Studies of Occupational Exposure to Asbestos[a]

–		Selikoff (180)[b]	Seidman (14)	Finkelstein (11)	Peto (7)	Dement (1)	Weill (2)
OSHA[c]	K_Md	1.0	5.7	12	0.7	0.22	0.07
	P[e]	0.07	0.74	0.39	.99	0.67	0.001
MS1[f]	K_M	110	300	7,800	40	12	3.6
	P	0.76	0.12	0.97	0.99	0.32	0.037
MS2[g]	K_M	12	100	270	1.9	4.4	0.76
	P	0.62	0.39	0.99	0.99	0.39	0.39
MS3[h]	K_M	0.59	2.4	15	0.061	3.1	0.016
	P	0.62	0.73	0.83	0.99	0.39	0.90

[a] Crump (Ex. 237A).
[b] Number of Mesothelioma Deaths.
[c] Estimates derived from OSHA model (Ex. 84-392). P values and K_M for Dement et al. and Weill et al. from Crump (Ex. 237A).
[d] K_M x10.[8]
[e] P Value associated with Chi-squared goodness-of-fit test.
[f] Estimates derived from multistage model with one dose-related stage.
[g] Estimates derived from Multistage model with two dose-related stages.
[h] Estimates derived from multistage model with three dose-related stages.

Table 3 summarizes the results of the goodness-of-fit tests for OHSA's model and the multistage model with one, two or three stages, for each of the data sets used by OSHA and for two additional sets of data. Consideration of the results in Table 3 show that, in fact, in four of the six cohorts, the best fitting model was linear with asbestos concentration (i.e., either the OSHA model or the multistage model with one stage showed the best fit. For the Finkelstein data, the multistage model with two stages fit only slightly better than the linear model, P=0.99 versus P=0.97). For three of the six data sets, the OSHA model fit as well or better than the multistage model. Although the fit of the OSHA model was adequate for the Finkelstein data, the OSHA model did not fit as well as the multistage model (P=0.39 [OSHA] versus P=0.99 [Crump]). And with regard to the Weill data, the fit of the OSHA model was inadequate (P=0.001) and the three-stage multistage model provided an excellent fit to the data (P=0.90). Similarly, as reported by Dr. Crump, the fit of the OSHA model to the Selikoff et al. data was "marginal", and the multistage model with one dose-related stage provided a very good fit to the data (P=0.76). Implications of the goodness-of-fit tests on the selection of the individual estimates of K_M will be discussed in the next section.

On the basis of these results, OSHA believes its choice of a risk model for mesothelioma is scientifically responsible. As discussed above, the model has received support from a large number of regulatory agencies, scientific bodies, and individual experts in risk assessment. Moreover, as will be seen in the next section, estimates of the individual K_M derived from this model are reasonable (and perhaps low), and represent the best estimate of the mesothelioma risk posed by exposure to asbestos.

B. *Data Used for the Calculation of Individual K_M's.* In the November proposal, OSHA used four studies judged by the Agency to have data adequate for the quantification of mesothelioma risk [Selikoff et al., Exs. 84-170, 84-90; Seidman et al., Ex. 84-87, 84-170; Peto et al., Ex. 84-170, and Finkelstein, Ex. 84-240]. As Dr. Nicholson pointed out at the hearings:

> These were the four studies that did provide sufficient information that could be utilized.
>
> What is necessary is not simply the number of deaths in a particular study, but one has to know the time of those deaths; because the (fit) that was made involves the matching of the equation that's given there, risk according to time per months of exposure, with data on mesothelioma risk at different times from onset of exposure in a defined population.
>
> We had to know the number of cases per person-years of risk [Tr. 6/19, p. I-121-122].

OSHA believed that these four studies were particularly appropriate studies for inclusion in the calculation of K_M because of the large numbers of mesothelioma deaths observed in these four studies (180, 14, 7, and 11, respectively). It should be noted that these four studies are the same four studies employed by CHAP in its analysis of mesothelioma risk from asbestos exposure [Ex. 83-256, II-119-120].

OSHA acknowledged in the preamble to the November proposal that its estimates of K_M were derived from studies with four of the five highest K_L values. OSHA noted that there may be "some bias in examining the value of K_M independent of the K_L in the same studies because it is likely that these K_M would tend to be slightly higher than those derived from other studies, due to the demonstrated high power of these studies to detect risk" [48 FR 51125]. To account for this bias in its analysis, OSHA arrived at an average K_M by examining the ratios of K_M to K_L. This gave an estimate of K_M of 1×10^{-8} rather than the higher central values of 4.98×10^{-8} rather than the higher central values of 4.98×10^{-8} (the arithmetic mean) and 2.91×10^{-8} (the geometric mean). OSHA believed this adjustment to the K_M value to be appropriate to avoid serious overestimation of the risk of mesothelioma.

Dr. Crump raised a number of issues regarding the calculation of K_M from these studies. As he had for the calculation of K_M, Dr. Crump noted that the Seidman et al. and Selikoff et al. studies are "particularly inappropriate for risk assessment because of the lack of exposure data" [Ex. 237A, p. 39]. OSHA's reasons for accepting the data from these two studies and the justification for their use in quantitative risk assessment have already been discussed in Section I. In light of the new data received from the Seidman cohort, OSHA has revised its estimates of K_M. Using the data in Table 1 [Ex. 267A] and four points of observation, the K_M from the updated study is 2.4×10^{-8}, somewhat lower than the value for K_M put forth in the proposal for the original Seidman study. This is not unexpected, particularly in light of the higher average exposure found upon reexamination of the data.

Dr. Crump's second major objection to the use of these studies relateds to the issue of differential risk by fiber type. At the hearing, Dr. Crump noted that—

> * * [T]urning to the risk specifically due to mesothelioma, I feel there is strong evidence that the risk in humans at least is less from chrysotile exposure than from amphibole exposures. OSHA estimated risks from four studies, each of which involved either exclusive or considerable exposures to amphiboles.
>
> Although these estimates were adjusted downwards somewhat by comparing them with lung cancer estimates, they still are considerably larger than estimates made from populations exposed predominantly to chrysotile which I have made [Tr. 7/9, p. 84].

In his written testimony, Dr. Crump elaborated on this position:

> * * I believe there is considerable data to indicate that chrysotile is less risky [than the amphiboles]. OSHA has already omitted from its risk calculation data from mining and milling operations, on the grounds that these exposures are not representative of those in the populations of workers OSHA has responsibility to protect. I believe this principle should also be applied to the chrysotile-amphibole question, and that risk to modern day workers, who are exposed almost exclusively to chrysotile, should be estimated from studies in which chrysotile exposures predominate [Ex. 237A, p. 47].

In an effort to expand the data from which to calculate an overall K_M, Dr. Crump calculated K_M's for two additional studies "for which exposures were predominantly to chrysotile. Theses are the Dement *et al.* study, where exposures were to only chrysotile, and the Weill *et al.* study, in which 77% of the workers were exposed exclusively to chrysotile" [Ex. 237A, p. 40]. The mesothelioma data for these two studies are found in Tables D and E. The K_M calculations for various models are found in Table 3.

For the Dement et al. data found in Table 4, the model used by OSHA provided a much better fit to the data (P=0.67) than any of the multistage models, and gave a K_M of 2.2×10^{-9}, approximately five times lower than the K_M of 1×10^{-8} K given in the proposal. Of the multistage models, all of which allowed showed good fit, the three-stage model gave a K_M of 3.1×10^{-8}, more than 10 times larger than that estimated by the OSHA model and three times larger than OSHA's expressed preferred estimate of risk. Dr. Crump calculated the ratio of K_M/K_L for the Dement et al. study ($K_M/K_L = 2.2 \times 10^{-9}/0.042 = 5.2 \times$

10^{-8}) and concluded that "this indicates that the assumption implicitly made by OSHA of a constant ratio is not universally valid" [Ex. 237A, p. 41]. Using Crump's preferred estimate of risk for K_L (0.023) gives a ratio of 9.5 x 10^{-8}, approximately 10 times smaller than the average K_M/K_L used in OSHA's determination of an overall K_M.

TABLE 4.—NUMBER OF MESOTHELIOMA DEATHS AND ABSOLUTE RISK BY YEARS FROM FIRST EXPOSURE, DEMENT ET AL. (1983)[a]

Years since first exposure (Avg)	Observed mesothel-iomas	Person-years	Absolute risk [b]
10 (5)	0	11,390	0
1020 (15)	0	10,921	0
2030 (25)	0	8,055	0
30 + (35)	1	2,775	0.3604
Total	1		

[a] From Crump (Ex. 237A, Table 4).
[b] Absolute risk=(number of deaths/person-years)x1,000.

TABLE 5.—Number of Mesothelioma Deaths and Absolute Risk by Years From First Exposure, Weill et al. (1972)[a]

Years since first exposure (Avg)	Observed mesothe-liomas	Person-years	Absolute risk [b]
10–15 (12.5)	0	31,180	0
15–20 (17.5)	2	29,473	0.0678
20–25 (22.5)	0	25,080	0
25–30 (27.5)	0	14,018	0
30–35 (32.5)	0	3,832	0
35 + (37.5)	0	1,565	0
Total	2		

[a] From Crump (Ex. 237A, Table 4).
[b] Absolute risk = (number of deaths/person-years)x1,000.

Table 5 gives the results of the calculation of K_M for the Weill et al. study. Data from the Weill et al. cohort gives, by far, the smallest values of K_M. The OSHA model shows an inadequate fit to the data (P=0.001) with a K_M of 7.0 x 10^{-10}. The three-stage multistage model showed excellent fit to the data (P=0.90) and gave a K_M of 1.6 x 10^{-10}, almost 100 times smaller than the overall K_M calculated by OSHA in the proposal.

Dr. Crump pointed to the calculation of K_M for the six studies, three with mixed exposures (Selikoff et al., Seidman et al., and Finkelstein) and three with predominantly chrysotile exposures (Peto et al., Dement et al., and Weill et al.) and observed that:

What one sees here is a large difference between the potency estimates in the upper three studies involving the mixed exposures and those in the lower three involving exposures primarily to chrysotile. . . . [I]f you look at the geometric mean, there is about a 20-fold difference in the risk. Although there is more uncertainty in the numbers in the lower group because of smaller numbers of mesotheliomas, these values are still not consistent with the ones in the upper group. I feel that, taken together, they do show a pattern of a smaller risk experienced by the workers—based upon exposure measurements—workers exposed predominantly to chrysotile.

The value of potency used by OSHA was 1, which is smaller than the estimates for the upper studies, but as you can see, it is considerably greater than the estimates made for populations exposed mainly to chrysotile [Tr. 7/9, p. 87].

However, during questioning, Dr. Crump admitted that—

* * * [T]he chrysotile estimates I was making, I was thinking about exposures which are today predominantly chrysotile. I wasn't thinking of necessarily applying those in situations where the exposures were to mixed fibers in removal operations [Tr. 7/9, p. 119].

Although the asbestos manufacturing industry may confine itself primarily to the use of chrysotile fiber in its products, OSHA believes now, as it did at the time of the proposal, that the major sources of exposure to asbestos workers in the next 20 to 40 years will be in the demolition, renovation, and removal of asbestos products (for example, insulation) which were installed 30 to 40 years ago. These products generally contain amphiboles. This was brought out by Dr. Nicholson during cross-examination, when he noted that:

I should make the point though we are concerned in much of the regulation of the future with exposures that will be to materials that have already been put in place, in the insulation materials, the sprayed on asbestos materials, all these loosely friable [sic] insulation materials that have been applied over the years.

Virtually all of the those exposures to those materials will be of a mixed fiber type. And so I think that's what we have to deal with. You can find in some circumstances, some manufacturing circumstances, pure fiber exposure. I don't know what their risk started at, as the discussion has indicated, because of the variabilities inherent in those studies.

But most of the exposures that we have in the future will be mixed fiber exposures [Tr. 6/19, p. I–144].

Hence, OSHA believes it is wholly correct in using esitmates of K_M from studies of mixed exposures as well as single-fiber type exposures in determining an overall estimate of mesothelioma risk.

Moreover, in a post-hearing submission, Dr. Nicholson gave some additional analysis of the carcinogenic response to different asbestos fiber types [Ex. 303A]. In an effort to make a broader comparison of mesothelioma according to exposure by mineral type, Dr. Nicholson compared the risk of pleural and peritoneal mesothelioma with that of lung cancer in a variety of studies. After various appropriate adjustments, the ratio of mesothelioma as a percentage of adjusted excess lung cancer was calculated for four studies of interest. This analysis showed reasonable agreement with the analysis done by OSHA. Dr. Nicholson concluded:

In comparing the different ratios of pleural mesothelioma to adjusted lung cancer for all studies in which the major exposure was to one fiber type, one can see that there are roughly comparable ratios for chrysotile, amosite and mixed exposure. Crocidolite has approximately a two-fold greater number of mesotheliomas as percent of excess adjusted lung cancer. However, as noted previously, the untraced individuals in the various crocidolite cohorts may lead to an overestimate of this ratio. Though some greater potency may be considered for crocidolite regarding mesothelioma (a factor of two perhaps), the uncertainty associated with other factors in a given exposure circumstance lead to much greater differences. For example, as was seen in the case of lung cancer, different exposure circumstances with the same fiber led to nearly 100-fold differences. Thus, the suggestion that there are dramatic differences between different asbestos varieties has no basis in fact. Much greater differences would appear to be related to process, to fiber size distribution effects within a single asbestos variety (note the difference between textiles and mining, e.g.), or to methodological differences in cohort studies (e.g., the asbestos cement studies of Weill et al. and of Finkelstein) [Ex. 303A, p. 6].

In addition to the data from occupational cohorts, Nicholson also pointed to some evidence of environmental exposures as supportive evidence. He noted that:

Mesothelioma has been documented in a variety of non-occupational circumstances, including among family contacts of asbestos-exposed individuals. . . . Notable is that family contact cases are seen with exposure to chrysotile, amosite and crocidolite. Relative to the risk at work, there appears to be little difference in the family contact risk by fiber type.

Animal studies substantiate the above analysis and suggest that all varieties of asbestos should be considered equally potent with respect to the production of either lung cancer or mesothelioma. Table 6 [of Ex. 303A] lists the data of Wagner et al. (1974) [Ex. 84–96] from inhalation studies using different forms of asbestos. Canadian chrysotile produced as many mesotheliomas as crocidolite and more than amosite or anthophyllite. Further, it produced lung cancer with a single day's exposure [Ex. 303A, p. 6–7].

The addition of the Weill et al. study and the Dement et al. study to the data base used for the overall calculation of K_M raises several points. First, the small number of mesothelioma deaths in the two studies makes the estimates of risk much less reliable. Dr. Nicholson discussed the advantage of additional information, but remarked that—

* * * [T]he total number of cases involved in those two studies is three. So it would be a very large uncertainty of any estimates made with those. And when one averaged it with the much higher levels of the four studies, would not substantially alter the lower value which was chosen in the OSHA document.

That is, we would now be using an average of six studies rather than four. . . . [I]f those additional two studies were utilized there may not have been the need to artificially lower the average that was obtained using the four studies that were cited here. . . . [i]n essence, what I'm saying is that if you take account of all the data, I don't think it would change the estimate of K_M substantially. And, in fact, the correction that was made to lower the estimate is an appropriate one. It fits most of the data that do exist [Tr. 6/19, p. I-138].

Dr. Crump also noted the added uncertainty associated with the use of studies containing small numbers of deaths [Ex. 7/9, p.87].

OSHA has computed the arithmetic and geometric means of the K_M's of the six studies for both the values of K_M from the OSHA model (including Dement et al. and Weill et al. as computed by Crump) and for the "best fit" model using the K_M from the multistage model with one, two or three stages. As Dr. Nicholson suggested, the inclusion of the Dement et al. and Weill et al. data may "eliminate the need to artificially lower the average" by looking at the ratio of K_M to K_L, since these two studies represent the lower end of the mesothelioma risk. Using the data in Table 3, the OSHA model gives an arithmetic mean of the K_M of 2.73×10^{-8}, (almost three times that proposed) and a geometric mean of 0.82×10^{-8}, approximately equal to OSHA's best estimate of K_M given in the proposal.

The mean values of the estimates of K_M from each of the six studies from the multistage model with the best fit are astonishingly high, with an arithmetic mean of 64.26×10^{-8} to 70.92×10^{-8}, (up to 70 times larger than OSHA's preferred estimate of K_M) and a geometric mean of the six K_M's of 2.45×10^{-8} to 7.2×10^{-8}. Further inspection of Table 3 demonstrates that using several values of K_M from models with only slightly poorer fit (e.g., .097 vs. 0.99) would produce estimates of risk several orders of magnitude larger. Hence, according to this analysis, OSHA's original choice of a best estimate of K_M of 1×10^{-8} is by no means an overestimate, as Dr. Crump apparently contends; indeed, his own calculations show that 1×10^{-8} in fact, greatly underestimates the mesothelioma risk which may be experienced by asbestos-exposed workers.

In addition, OSHA has examined several alternate combinations of the data, including computing the best estimate of K_M from the ratio of K_M/K_L. As in the lung cancer data, these calculations produce estimates which bracket the 1×10^{-8}.

Dr. Crump's preferred estimate of K_M of 2×10^{-9} [Ex. 237A, p. 48] was based solely on the studies of predominantly chrysotile-exposed workers and was meant to represent the mesothelioma risk of workers exposed predominantly to chrysotile; his preferred estimates was not meant to characterize the risk of mesothelioma faced by workers in a variety of workplaces—including the major exposures to mixed fibers that will occur in asbestos removal, demolition, and renovation operations [Tr. 7/9, p. 119].

OSHA has therefore determined that Dr. Crump's approach is not adequate to address the question of the total risk posed by asbestos exposure, and the Agency has chosen instead to base its best estimate of risk on the six studies with sufficient data to quantify the excess risk of mesothelioma. Hence, OSHA concludes that its best estimate of K_M remains at 1×10^{-8}, as proposed. The addition of the two studies with small numbers of deaths adds some uncertainty to this estimate but, as indicated, this estimate is likely to represent a substantial underestimate of the risk of mesothelioma actually experienced by asbestos-exposed workers.

III. Estimates of Risk for Other Cancers

As discussed in Section IV, OSHA has concluded that workers exposed to asbestos are likely to be at an increased risk of gastrointestinal cancer. Though an excess of GI cancer has not been observed consistently in every study of asbestos workers, and while the ratio of gastrointestinal cancer to lung cancer varies considerably from study to study, there appears to be sufficient evidence to roughly estimate the excess gastrointestinal cancer risk in asbestos-exposed populations. A number of submissions to the record recognized the relationship between asbestos and gastrointestinal cancer [see, e.g., Exs. 91-40, 116, 163e, 156, 261A, 277, 297, 321]. In general, the risk ranges from about 5 to 20% of the excess lung cancer risk.

The AIA/NA commented that:

Although excess GI cancers have been found in some heavily exposed worker studies, no such excesses have been found in many other studies. Of the twenty-one studies reviewed by OSHA (in each of which there was a minimum of 10 observed or expected GI cancers), only seven had statistically significant excess GI cancers (Ex. 84-392 at 13) [Ex. 328, p. 1-21].

However, Dr. Nicholson pointed out at the rulemaking hearing that:

* * * [Ex. 84-392] said 21 studies were listed. Twelve demonstrated an excess gastrointestinal cancer, and eight demonstrated a deficit. One was even.

Many of those—several of those—actually were studies in which there was also no excess lung cancers. So there were circumstances where the excess risk to be expected was a very low one. And, thus, one would be within the range of statistical fluctuations no matter what the risk was; since the GI cancer . . . risk is never expected to be equal to that of the excess lung cancer risk.

I think, of these 21 studies . . . only 13, if I'm not mistaken, would demonstrate an excess lung cancer risk.

And the ones that do not [demonstrate an excess lung cancer risk] are largely the negative ones [for GI cancer] [Tr. 6/19, p. I-117].

In addition, OSHA believes the finding of a statistically significant excess of GI cancer in seven studies of worker populations to be a substantial body of evidence. As pointed out by Dr. Nicholson, many of the studies in which GI cancer was not observed were unable to detect lung cancer as well. This points perhaps to methodological problems in the studies as well as low exposures.

It was also suggested that the observed excesses could conceivably be due to a misdiagnosis of peritoneal mesothelioma. While OSHA believes it is unreasonable to totally account for these excesses (some as large as 60% of the lung cancer risk) by misdiagnosis, to the extent that the incidence of mesothelioma has been underobserved in these studies, then OSHA's predictions of the risks of mesothelioma are also underestimated.

In an attempt to quantify the risk of gastrointestinal cancer, OSHA considered a simple risk model in which gastrointestinal cancer risk was assumed to be equal to 10% of the lung cancer excess risk. As Dr. Nicholson noted:

Based upon the rough finding and given the fact that there are different dose-response relationships, that overall, considering an increase over lung cancer of 10 percent for gastrointestinal cancer would give an underestimate of possible asbestos-related GI cancers.

One finds that the relationship that I just mentioned, comparing excess GI cancer with excess lung cancer to be such that some studies demonstrated an increase of GI cancer about 50-60 percent that of lung cancer, a very high correlation. Others show, in some cases, dificits, but showed very much lower ratios.

Considering that lung cancer is increasing in recent years, the ratio between excess GI cancer to lung cancer would decrease, a value of 10 percent excess was chosen as a reasonable value. It's a relatively small additional contribution. I think it underestimates what the actual contribution would be [Tr. 6/19, p. I-115-116].

There was some objection to OSHA's quantification of the risk of gastrointestinal cancer (e.g. Ex. 328), the major issue being a lack of an observed dose-response for this type of cancer. Again Dr. Nicholson responded to this objection:

Well, we have limited dose-response data. And it's of two natures. One in terms of increased risk with increased exposure. It would appear that it's a very flat relationship. I've looked at it specifically for insulation workers, and it turns out that within about 10 years, there appears to be an elevated risk 50 percent above that which would be expected, approximately.

And that same elevated risk continues with time among insulators who continue working. * * * There is a second dose-response relationship that is seen. . . . [I]f one takes those studies in which the number of gastrointestinal cancers either expected of observed exceeds 10, so we're looking at a study that has enough data that it could be—the results would not be simply statistical variability, and the study shows a statistically significant lung cancer risk so that we're looking at studies that have exposures that are of significance, one finds a fairly reasonable increasing relationship in the risk of, overall risk, of gastrointestinal cancer with the overall risk of access [excess] lung cancer. That is, access [excess] gastrointestinal cancer compared to access [excess] lung cancer correlates reasonable well [Tr. 6/19, p. I-113-114].

And , while Dr. Schneiderman noted "There is no adequate model of digestive cancers", he also stated that "OSHA's estimate [for gastrointestinal cancer risk] appears to be reasonable" [Ex. 116, p. 2]. Even Dr. Weill, who said he would have preferred OSHA not include quantitative estimates of GI cancer risk noted that "it doesn't make a lot of difference in my view in terms of the policy that emerges from such a risk assessment" [Tr. 6/19, p. I-193].

Thus, OSHA feels confident in including estimates of risk from gastrointestinal cancer in the final standard. Though this is still some controversy over the inclusion of these estimates in the risk assessment, OSHA believes there is sufficient evidence to support their inclusion and to suggest that their contribution to the overall estimates of risk may, in fact, be understated. The estimates of risk of gastrointestinal cancer are also given in Table 6 along with estimates of lung cancer and mesothelioma risks.

The incidence of cancers at sites other than the lung, mesothelium, and gastrointestinal tract have been shown to be elevated in some asbestos exposure studies, including laryngeal, kidney, pharyngeal and buccal cavity cancers. To OSHA, it appears that the excess risk for "other cancers" is about the same as for gastrointestinal cancers. OSHA recognizes many uncertainties in quantifying this risk, in view of the inconsistencies in findings among different epidemiologic studies. (Some studies have found excess risk from other cancers, while other studies have not). The sites showing excess risk have also varied among studies. Therefore, OSHA has not made numerical estimates of risks for these other cancers at this time. To the extent that estimates of these cancers are not included in the overall estimates of risk, OSHA has underestimated the total cancer risk posed by exposure to asbestos.

The data indicating gastrointestinal cancer excesses are stronger and more consistent than the data suggesting excesses at these other cancer sites. Thus, OSHA does not feel compelled to quantify the risk of cancer at these other sites at this time. The high quality and well-supported estimates of the excess risk of lung cancer, mesothelioma, gastrointestinal cancer, and asbestosis alone provide sufficient bases upon which to justify this regulatory action.

IV. Estimates of Cancer Mortality

The best estimates of K_L and K_M were utilized to estimate the mortality from exposures to varying concentrations of asbestos for different time periods. The calculations are age, intensity and duration specific. Table 6 shows the excess asbestos-related mortality rates from lung cancer, mesothelioma, and gastrointestinal cancer (gastrointestinal cancer excess is assumed to be 10% of the lung cancer excess). Table 6 gives the predicted excess lifetime risk of cancer for exposures of one year, 20 years, and 45 years, assuming first exposure at age 25. In these calculations, Equation 1 and Equation 3 were used with values of K_L equal to 0.01 and K_M equal to 1×10^{-8} and the 1977 U.S. male background lung cancer mortality rates. Because of age-specific increases in lung cancer rates in older men since 1977, estimates based on more recent background rates would be higher. Calculations were done for each 5-year age interval, and then summed to give a total lifetime risk. The calculations performed to give the results in Table 6 assumed that the relative risk increased following ten years after onset of exposure and continued to rise until ten years after cessation of exposure, after which it remained constant.

Table 6

Estimated Asbestos Related Cancer Mortality per 100,000 by Number of Years Exposed and Exposure Level [1]

Asbestos fiber concentration (f/ml)	Cancer mortality /100,000 exposed: Lung	Mesothelioma	Gastrointestinal [2]	Total
	1 year exposure			
0.1	7.2	6.9	0.7	14.8
0.2	14.4	13.8	1.4	29.6
0.5	36.1	34.6	3.6	74.3
2.0	144	138	14.4	296.4
4.0	288	275	28.8	591.8
5.0	360	344	36.0	740.0
10.0	715	684	71.5	1470.5
	20 year exposure			
0.1	139	73	13.9	225.9
0.2	278	146	27.8	451.8
0.5	692	362	69.2	1123.2
2.0	2713	1408	271.3	4392.3
4.0	5278	2706	527.8	8511.8
5.0	6509	3317	650.9	10476.9
10.0	12177	6024	1217.7	13996.7
	45 years exposure			
0.1	231	82	23.1	336.1
0.2	460	164	46.0	670.0
0.5	1143	407	114.3	1664.3
2.0	4416	1554	441.6	6411.6
4.0	8441	2924	844.1	12209.1
5.0	10318	3547	1031.8	14896.8
10.0	18515	6141	1851.5	26507.5

[1] Assumes exposure begins at age 25. Risks are calculated using U.S. male lung cancer background rates for 1977.

[2] Estimated as 10% of lung cancer risk rather than calculated using dose-response information.

Several comments should be made regarding the results in Table 6. Though excess relative risk in linear in dose, the excess mortality rates given in Table 6 are not strictly linear in dose. Therefore, for example, the risk at 2 f/cc is not exactly 4 times the risk at 0.5 f/cc, though there is a close approximation. It should also be noted that the risks for longer periods of exposures do not appear to be a straight forward multiplication of the risks of shorter duration. In the longer exposure categories, where exposures will affect older workers, some adjustments have been made for competing risks which are likely to affect the death rate from lung cancer. In addition, when looking at total cancer risks, it must be remembered that these include the risk of mesothelioma, which is related to time in an exponential fashion.

As can be seen from Table 6, the predicted risk from mesothelioma is approximately equal to the lung cancer risk for one year of exposure and to about half of the risk value for lung cancer in the 20-year exposure group. The excess risk of mesothelioma after a lifetime exposure (45 years) to asbestos is approximately one-third the lifetime excess lung cancer risk. These predictions comport with observations in several populations, where mortality from mesothelioma is observed to comprise approximately 50% of the excess mortality from lung cancer.

Using the equations given earlier, and based on the calculations in Table 6, OSHA predicts a lifetime excess risk of total cancer for a lifetime exposure (45 years) to 2 f/cc as 6411 excess deaths per 100,000 workers, or approximately 64 per 1000. Since risk from a 20 year exposure to asbestos may also be of interest, the models predict an excess cancer mortality of 4392 dealths per 100,000 workers exposed at 2 f/cc for 20 years.

Reducing in the PEL from 2 f/cc to 0.2 f/cc reduces the risk from lifetime exposure from 64 per 1000 to 6.7 per 1000. Similarly, for a 20 year exposure, the risk is reduced from 44 per 1000 to 4.5 per 1000, representing a 90% reduction in risk. The lifetime risk from one year of exposure follows a similar course. The risk reduces from 296 per 100,000 at 2 f/cc to 30 per 100,000 at 0.2 f/cc.

Lastly, Table 6 contains risks for levels higher than 2 f/cc because OSHA believes some industrial areas (such as construction) may still be at these higher level. This population of workers would consequently experience a much greater reduction in risk by reducing exposures to 0.2 f/cc or less. Moreover, to the extent that the controls that are installed to meet the new PEL result in exposures below 0.2 f/cc, cancer risks will be reduced to a greater extent than indicated in the table.

V. Quantifying the Excess Risk From Asbestosis

The November proposal included a quantification of the excess risk of asbestosis. Asbestosis is a type of pulmonary fibrosis diagnosed on the basis of a history of exposure to asbestos; it is characterized by radiologic changes to the lung, breathlessness, impaired lung function, and other clinical features of fibrosing lung disease. Asbestosis can be manifested in a range of degrees of severity and can result in disability and death.

An early response by the lung to asbestos exposure is formation of plaques, which are opaque patches visible on chest X-rays. The presence of plaques may indicate an increased risk of future development of asbestosis, but this is not certain. Although the significance of pleural plaques in terms of disease is not clear, the presence of plaques is not normal.

Asbestosis has been known to progress or worsen after cessation of exposure to asbestos, probably due to irreversible injury and/or the retention of asbestos fibers in the lung. In addition to lung function impairment, asbestosis contributes to increased asbestos-related mortality. Increased resistance created by the lung obstruction can lead to heart failure.

As pointed out by Dr. Weill in his written testimony, "Exposure-response relationships have been reported using as the biologic response indicator either a constellation of clinical findings to define asbestosis, or certification by a worker's compensation panel or board" [Ex. 99, p. 24], but such approaches have "varying degrees of limitation" [Ex. 99, p. 12]. Because of the many possible combinations, and therefore "definitions" of asbestosis given by different groups, the quantification of a single risk associated with asbestosis is difficult. As Dr. Weill noted during cross examination:

* * * The problem is with asbestosis, the quantification is not exactly the same as it is with malignant disease, because one is dealing with a different set of rules in the ascertainment of this health effect. And no two studies have exactly the same scheme for making a decision that this individual has asbestosis and this individual doesn't [Tr. 6/19, pp. 205–206].

In his prehearing testimony, Dr. Weill explained further:

Mortality data are not useful in quantifying the risk of asbestos-induced lung fibrosis (asbestosis). Affected workers may die with asbestosis but not of it, in which case it is not likely to appear on the death certificate as the primary cause of death. In contrast, sensitivity of detecting early evidence of asbestosis in a living exposed population has increased substantially in recent years. . . . Since much of the asbestosis being seen now is the result of lower dust levels in the past two decades, the films are likely to be classified in the lower categories of profusion of small opacities (fewer shadows meaning less severe disease). As is frequently the case with biological measurements, it is at these lower limits of disease detection that inter- and intra-observer variability is greatest. Again, it is gratifying to know that in spite of these recognized problems, excellent exposure-response relationships have resulted from the radiographic classification described [Ex. 99, 23].

Quantitative studies exist, primarily for the disabling forms of the disease; specifically, two separate studies provide information to develop a dose-response relationship between asbestos exposure and incidence of asbestosis [Ex. 84–254 and 84–44.] Details of the data were reported at 48 FR 51130. It is clear that material impairment from asbestosis occurs prior to the onset of its disabling stage.

As discussed in the November proposal, Berry et al. [1979, Ex. 84–20] studied a group of 379 men who worked at an asbestos textile factory for at least 10 years. Dust measurements were available and were correlated to each job performed for each year under study. Health effects were correlated to cumulative exposure. Using prevalence data, Berry et al. found a dose-response relationship with cumulative exposure (f-y/cc) for three endpoints, crepitations, possible asbestosis, and certified asbestosis. In addition, these data also support the hypothesis that there is a low, or possibly no, threshold for asbestosis, since there is increased risk at cumulative exposures as low as 37 fiber-years/cc.

Berry and Lewinsohn [1979, Ex. 84–254] have reported the incidence of asbestosis in this same asbestos textile factory. The population was divided into two cohorts: those first employed before 1951 and those employed after 1950. A dose-response relationship is apparent for the incidence data, though it is not quite as consistent as for the prevalence data.

In a second study, Finkelstein [1982, Ex. 84–44] looked at the development of compensable (certified) asbestosis among 201 workers at an asbestos-cement factory in Ontario. A dose-response relationship was developed using estimated cumulative exposures based on plant dust measurements and using medical information from the Ontario Workmen's Compensation Board.

As noted by Dr. Weill, "A final complicating aspect in the development of exposure-response information on asbestosis is that it is a slowly progressive disorder which may (and frequently does) continue to worsen after exposure ceases" [Ex. 99, p. 12].

OSHA's original estimates of risk were derived from a simple linear regression of the incidence of asbestosis on the midpoints of the cumulative exposure data of Berry and Lewinsohn and of Finkelstein. A linear relationship was assumed, at least for the point estimation of 0.5 fibers/cc for 45 years (or 22.5 fiber-years/cc). As Dr. Weill stated:

While the shape of the dose-response curve for asbestosis cannot be determined with certainty, it is clear that this fibrotic effect is dose-related, perhaps linearly, and whether a threshold exists may very well depend on the response indicator chosen [Ex. 99, p. 11].

The assumption of risk linearity is consistent with the fact that early stages of the disease are observed at low exposures. This point was reiterated by Howard Ayer on behalf of the Organization Resources Counselors, Inc. when he noted that:

It does appear clear that there is a simple linear relationship between the frequency and degree of asbestosis and the cumulative exposure to asbestos dust. Time is merely a factor in that it takes a certain amount of time—at least a matter of years—to develop the effect on the lung [Ex. 91–10–2, pp. 4–5].

A similar conclusion is drawn in the report of the British Advisory Committee on Asbestos, when the committee noted that: "The present authors come down in favor of a dose-response relationship [asbestosis] without a threshold for chrysotile within the range experienced in industry" [Ex. 84–216, volume 2, p. 38]. Based on this recommendation, OSHA did employ a linear model in the prediction of risk from asbestosis, but made no attempt in the proposal to extrapolate the data below the 0.5 f/cc level or above the 10 f/cc level using this model.

Based on the three cohorts discussed above, OSHA calculated estimates of the lifetime incidence of asbestosis for the Finkelstein, Berry and Lewinsohn pre-1951 cohort, and the Berry and Lewinsohn post-1950 cohorts, respectively. The estimates from the three cohorts differ by an approximate factor of three. This may be indicative of some of the methodological differences among the studies. For example, it is possible that the estimates made from Berry and Lewinsohn's data may be underestimates. The maximum duration of follow-up in that study was 23 years, with an average follow-up of 16 years. Observations from Finkelstein's data (his Table 1) demonstrate that only 41% (23/56 cases) of total incidence was experienced in the first 24 years since first exposure. That is, 59% of the asbestosis incidence was not expressed until at least 25 years from onset of exposure. Thus, it is likely that the low incidence rates in the Berry and Lewinsohn studies (and, therefore the low estimates of risk predicted from these data) are reflective of the short follow-up period for this group of workers.

On the other hand, Finkelstein's (1982) observations may overstate the incidence of asbestosis because at autopsy there was histologic evidence of silicosis as well as asbestosis in many men. Finkelstein states that "we have, nevertheless, chosen to call their disease 'asbestosis' as we believe that is the pathologic process of most significance. Most of the parenchymal radiographic abnormalities were small irregular opacities and the mortality pattern among the men was consistent with the toxic effects of asbestos" [Ex. 84–44, p. 500].

More importantly, it is indeed possible that all of these investigators may have understated asbestosis risk by examining only certified disability from asbestosis, which is an advanced stage of the disease. As noted in the November proposal, there was evidence of the early signs of asbestosis at levels as low as 37 f-y/cc (this level produced a 1% prevalence of crepitations) and is consistent with the predictions made above. During the hearings, several witnesses stressed the range of physical and mental disability/impairment which may occur long before even radiologic evidence of disease appears. Typical of these comments were those made by Dr. Irving Selikoff of the Mount Sinai School of Medicine. He stated:

> So, what you're seeing on x-ray is always very much less than is really present pathologically. So that, when you see a positive x-ray, there's a fair amount there in the lung . . . I've seen people with comparatively little on x-ray, who can't walk across a room. But by and large, all it means is that there's been scarring [TR. 7/2, p. 170].

While several participants commented in general on the risk of asbestosis, there was little direct comment on OSHA's quantitative estimates of risk. Hence, for these revised rules. OSHA has relied on the models developed for the proposal to predict the risk of asbestosis at the new PEL of 0.2 f/cc. Using OSHA's best estimate of risk, that from the Finkelstein data, OSHA predicted that exposure over a working lifetime to the 2 f/cc level will result in approximately a 5% incidence of asbestosis. Reducing the exposure to 0.2 f/cc would result in a lifetime incidence of asbestosis of 0.5%. While OSHA did not make predictions of risk at levels below 0.5 f/cc in the proposed rules, testimony received during the rulemaking increases OSHA's confidence that the Agency's estimates of risk at 0.2 f/cc are valid and reasonable. This is due primarily to the comments noting the validity of the model in the low dose region. Given the difficulties in accurately diagnosing cases of asbestosis and the fact that OSHA's estimates only take the risk of disabling asbestosis into account, OSHA believes that the Agency's estimates may be underestimates of the true risk of asbestosis to exposed workers.

VI. Significance of Risk

As discussed above in Section III (Pertinent Legal Authority), the Supreme Court in the Benzene case (*Industrial Union Department, AFL–CIO* v. *American Petroleum Institute* 448 U.S. 601 (1980)) ruled that, prior to the issuance of a new or revised standard regulating occupational exposures to toxic materials, OSHA must make a determination that a "significant" health risk exists and that the new standard will reduce or eliminate that risk. OSHA's analytical approach to making a determination that a significant risk of material impairment exists from exposure to hazardous workplace chemicals takes into consideration a number of factors that are consistent with recent court interpretations of the OSH Act and rational, objective policy formulation. As prescribed by Section 6(b)(5) of the Act, OSHA examines the body of "best available evidence" on the toxic effects of hazardous chemicals to determine the nature and extent of possible health consequences resulting from exposure to the hazardous agent in question. Quantitative risk assessments are conducted, where possible, and the results are considered along with other relevant information, such as the nature and severity of the health consequences, to determine whether a hazardous agent poses a significant risk to workers at the current permissible exposure level. The Agency also determines whether a reduction in the permissible exposure level for the hazardous agent will substantially reduce that risk.

The Court gave some general guidance to the Agency for arriving at findings of the significance of an occupational health risk. It recognized that the Agency's determination that a particular level of risk is "significant" will be based largely on policy considerations (*IUD* v. *API*, 448 U.S. 655, 656, n. 62). To illustrate how one may make a determination from quantitative information that a health risk is significant, the Court stated as follows:

> It is the Agency's responsibility to determine in the first instance what it considers to be a "significant" risk. Some risks are plainly acceptable and others are plainly unacceptable. If, for example, the odds are one in a billion that a person will die from cancer by taking a drink of chlorinated water, the risk clearly could not be considered significant. On the other hand, if the odds are one in a thousand that regular inhalation of gasoline vapors that are 2% benzene will be fatal, a reasonable person might well consider the risk significant and take appropriate steps to decrease or eliminate it (*IUD* v. *API* 448 U.S. at 655).

Although the Court's example is based on a quantitative expression of the risk, the Court indicated that the significant risk determination required of OSHA is not "a mathematical straitjacket," and that "OSHA is not required to support the finding that a significant risk exists with anything approaching scientific certainty." "A reviewing court [is] to give OSHA some leeway where its findings must be made on the frontiers of scientific knowledge [and] . . . the Agency is free to use conservative assumptions in interpreting the data with respect to carcinogens, risking error on the side of overprotection rather than underprotection" (448 U.S. at 655, 656).

OSHA has followed these guidelines in making a determination that the risk of material health impairment resulting from occupational exposure to asbestos is significant. The epidemiological and toxicological evidence and testimony presented in the November notice and in Section IV (Health Effects) of this preamble clearly show that exposure to asbestos is carcinogenic to humans and additionally causes disabling fibrotic lung disease. Lung cancer constitutes the greatest health risk to asbestos workers; in some occupational cohorts, this disease has been responsible for more than half of the excess mortality from asbestos exposure. Malignant mesotheliomas of the pleura and peritoneum, which are extremely rare among non-exposed persons, have been conclusively linked with asbestos exposure. Some studies of asbestos-exposed workers have also shown increases in mortality from gastrointestinal and other types of cancer. It has been known for years that exposure to asbestos is the only known cause of asbestosis, a progressive, fibrotic lung disease causing effects ranging from shortness of breath during exertion to complete disability, respiratory and cardiac failure, and death. OSHA's determination that the health risks from asbestos exposure is significant is based, in part, on the irreversible and ultimately fatal nature of these diseases, particularly of lung cancer and mesothelioma.

The finding that a significant risk exists is primarily supported by OSHA's quantitative risk assessment, which is based on studies of asbestos-exposed worker populations. OSHA's risk assessment (discussed in Section V of this preamble) estimates that 64 excess cancer deaths (including those from lung and gastrointestinal cancer and mesothelioma) will occur among 1,000 workers exposed at the existing permissible exposure limit of 2 f/cc for 45 years, a working lifetime. The estimates of mortality risk from mesothelioma, lung cancer, and gastro-intestinal cancer are 16, 44, and 4 excess deaths, respectively, per 1,000 workers exposed for 45 years at 2 f/cc.

OSHA also estimated the risk of lung cancer, mesothelioma, and gastrointestinal cancer for 20-year and 1-year durations of exposure to asbestos at 2 f/cc. From this analysis, OSHA estimates that the risk from all asbestos-related cancers among workers exposed from 20 years to 2 f/cc is 44 excess deaths per 1,000 workers. The estimated cancer risk from all cancers among workers exposed to 2 f/cc for one year is estimated to be 3 excess deaths per 1,000 workers.

Additionally, OSHA estimated the risk (i.e., the predicted incidence) of asbestosis morbidity at the existing permissible exposure level of 2 f/cc. OSHA's best estimate is based on the results of a high-quality study of the incidence of compensable (certified) asbestosis at an asbestos-cement factory (Ex. 84-240). Based on cumulative exposure data and assuming a linear model, OSHA estimates that the incidence of asbestosis is 50 cases per 1,000 workers exposed for 45 years to 2 f/cc.

In the April notice, OSHA characterized the basis for determining that a significant risk exists at the 2 f/cc level as being "particularly strong" (49 FR 14120). This assessment was based on the reliance on occupational epidemiological studies for the quantitative risk assessment, the high quality of the scientific data, the consistent estimates of dose-response among the various studies used, and the appropriateness of the models and methods employed in the risk assessment. Review of the record evidence submitted since publication of the April notice has served to reinforce OSHA's confidence in the data and analysis underlying the determination that a significant risk exists at the existing permissible exposure level for asbestos.

Regarding the quality of the data, several commenters stated that the health evidence for asbestos-related disease is far more convincing, due to the quality and number of human studies available, than are health effects data for any other hazardous substance. This point was emphasized at the informal hearing by Dr. Nicholson under cross-examination by Ms. Seminario of the AFL-CIO:

Seminario: Would you say that [the data for asbestos] . . . is generally better and more complete than . . . [for other toxic substances]?

Nicholson: I don't even think there's a comparison. The data for asbestos are so much more extensive than those of other toxic substances in the workplace. It's a wide divergence.

Seminario: . . . Basically, you have asbestos with a lot of studies and a lot of information, and a great number of workers included as subjects in those studies . . . compared to less complete data for other toxic substances?

Nicholson: Yes.

Seminario: . . . [I]t really is a much more complete data base for conducting risk assessment and making estimates [of risk] than you would have for any other substance?

Nicholson: Yes, it is

Seminario: . . . [I]n conducting risk assessments, in many cases, those risk assessments will be based not on epidemiologic studies, but, indeed, on animal studies. Is that correct?

Nicholson: Often, that may be our only recourse, in other studies. . . .[I]f one reviews the [International Agency for Research on Cancer Monographs] . . . volumes 1-29 that have evaluated human carcinogens, they have only deemed 18 agents or work processes to have sufficient data for which one could . . . establish carcinogenicity [in humans], let alone provide quantitative risk assessments in hypothetical circumstances. So our human data are very scanty for most agents (Tr. 6/19 pp. 134-135).

Similarly, Dr. Hans Weill commented that ". . . we know of no other occupational disease for which more complete exposure-response data are available from human population studies" (Ex. 99, p. 30). In its post-hearing submission, Organization Resources Counselors, Inc. stated that "[a]sbestos is a proven carcinogen of long standing. Volumes of scientific work attest to the fact that asbestos produces both lung cancer and mesothelioma" (Ex. 127-A, p. 2). These comments, and the evidence contained in the record on health effects from asbestos exposure (see Section IV) reaffirm OSHA's belief that the data used in the quantitative risk assessment are of unusually high quality.

A review of the rulemaking record has also strengthened OSHA's belief that it used the most appropriate models to calculate the risk. To estimate the risk for lung cancer, OSHA used a linear dose-response model based on evidence found in several epidemiologic studies that examined lung cancer mortality in relation to cumulative asbestos exposure (Exs. 84-43, 84-59, 84-35), and on the use of a linear model by several other investigators (Exs. 85-22, 84-216, 84-243, 82-2, 84-180, 84-256, 321). For mesothelioma, OSHA used an absolute risk model, which has been used or suggested by a number of other authors to estimate the risk of mesothelioma (Exs. 84-252, 84-385, 84-342, 84-87, 132, 84-138). In response to record comments submitted after publication of the April notice, OSHA revised the individual potency factors for lung cancer (K_L) and mesothelioma (K_M) for some of these epidemiological studies (see Section V of this preamble). These adjustments had little effect on the overall K_L of 0.01 and K_M of 1×10^{-8} originally proposed by OSHA for the combined data sets. OSHA believes that this finding reflects the reasonableness of the risk estimates for lung cancer and mesothelioma set forth in the April notice.

The first element established by the Supreme Court's Benzene decision (*IUD v. API* 448 U.S.) for determining the significance of risk of material impairment—that a significant risk existed at the existing permissible exposure limit of 2 f/cc—is thus clearly and decisively established by OSHA's risk assessment and by the insidious nature of asbestos-related disease. In making a determination that this risk is significant, OSHA relies, in part, upon the Supreme Court's indication of when a reasonable person might consider a risk significant and take steps to decrease that risk. OSHA finds, as indicated by the risk assessment, that the existing standard of 2 f/cc would permit an excess cancer mortality risk of 64 deaths per 1,000 employees and an estimated asbestosis incidence of 50 cases per 1,000 employees exposed for a working lifetime; this excess risk must be considered significant and unacceptable using virtually any reasonable basis for making such a determination. OSHA also finds that the excess risk of cancer mortality resulting from 20 years of exposure to asbestos (44 excess deaths/1,000 workers) is also significant. As pointed out in the April notice (49 FR 14120), the risk from asbestos exposure at the 2 f/cc level has also been acknowledged as being unacceptable by other governments (Exs. 84-378, 84-379). The level of risk estimated by OSHA at the existing permissible exposure limit is also comparable to the estimated risks for other toxic substances that OSHA has regulated or proposed to regulate in the past.

In accordance with the second element of the Supreme Court's Benzene decision on the determination of significant risk, OSHA has determined that reducing the permissible exposure limit for asbestos to 0.2 f/cc is reasonably necessary to reduce the cancer mortality risk from exposure to asbestos. OSHA's risk assessment shows that lowering the permissible exposure limit from 2 f/cc to 0.2 f/cc reduces the asbestos related cancer mortality risk from lifetime exposure from 64 deaths per 1,000 workers to 6.7 deaths per 1,000 workers; this corresponds to a 90 percent reduction in the risk. The asbestos-related cancer risk is also reduced by 90 percent, from 44 deaths to 4.5 deaths per 1,000 employees, for a 20-year exposure duration. It is estimated that the incidence of asbestosis for workers exposed for a working lifetime under the new standard will fall by 90 percent, from 50 cases to 5 cases per 1,000 employees. As these figures show, significant risks of asbestos-related cancer mortality and asbestosis morbidity are not eliminated at the exposure level that is permitted under the new standard; however, the reduction in the risk of asbestos-related death and disease brought about by promulgation of the new standard is both significant and dramatic.

The observation that significant risk is not eliminated under the new permissible exposure level of 0.2 f/cc led some rulemaking participants to urge OSHA to promulgate an even lower permissible exposure limit. For example, in its post-hearing brief, the Building and Construction Trades Department of the AFL-CIO agreed with OSHA's findings on the significance of risk:

> . . . OSHA's estimates point to two conclusions. First, lowering the PEL from its present level will significantly reduce the risk of mortality from lung cancer, mesothelioma and gastrointestinal cancer. This is especially evident at the BCTD-recommended PEL of 100,000 fibers per cubic meter (0.1 f/cc) where 61 fewer deaths per 1,000 workers will occur. Second, while under. . . [the Benzene decision] it is unnecessary to find the existence of a significant risk at intermediate levels above the *new* PEL . . ., a significant risk exists even at this lowest of potential PEL's. (Ex. 330, p. 11)

OSHA agrees with the BCTD that a signifiant risk of asbestos related disease would exist even under a standard having a permissible exposure limit of 0.1 f/cc. As OSHA explained in the April notice in the Summary and Explanation sections of the preamble to the final standards for asbestos for General Industry and Construction, OSHA's decision to promulgate a permissible exposure limit of 0.2 f/cc is not based on a determination that significant risk is eliminated at this level. Given that a significant risk of harm persists even at very low levels of lifetime exposure to asbestos, OSHA's decision to promulgate a PEL of 0.2 f/cc is based on a determination that this level is the lowest level that can feasibly be attained in operations in workplaces in both general industry and construction.

Some commenters, such as Organization Resources Counselors, Inc. (ORC) (Ex. 123-A) and the Asbestos Information Association of North America, (AIA/NA) (Ex. 328), argued that OSHA overstated the risk of disease from asbestos exposure. Specifically, they objected to the following:

- OSHA's use of past exposure levels, or the 2 f/cc PEL coupled with the assumption of lifetime exposure duration, as benchmarks for determining risk, rather than the lower exposure levels and shorter durations typically found in industry today.
- Failure to account for differential risks posed by different types of asbestos fiber.
- Failure to distinguish between the cancer mortality risk for asbestos-exposed workers who smoke and those who do not.

Regarding the use of past exposure data or the current PEL of 2 f/cc to estimate risk levels, the ORC commented as follows:

> . . . ORC recommends that estimates of risk be based on exposures . . . that are relevant to 1984 workplace conditions. It is important to know as accurately as possible what the actual risk is at today's exposure levels, but this is not possible unless we recognize the factors in the risk equation that have changed from 1944 to 1984. (Ex. 123-A, p. 12)

Similarly, the AIA/NA stated:

> OSHA further errs toward over-prediction of risk by assuming, without substantiation, that workers will experience exposures at the level of the standard for up to 45 years. In fact, the record evidence indicates [that] exposures will average significantly below any standard. . . . As would be predicted from accepted technological feasibility and industrial hygiene practice control, average workplace exposures to asbestos have been found to be one-fourth or less of a given standard (based on OSHA field monitoring results). . . . More detailed data from the United Kindom confirm that under its former 2 f/cc standard, average exposures in all but textile manufacturing were but one-tenth the PEL, and in textile generation—the most difficult to control—exposures averaged one-fourth the standard. (Ex. 328, pp. 22-23)

ORC and AIA/NA also objected to the use of a 45-year exposure duration for estimating risks. ORC commented that "[t]he majority of 1984 exposure are intermittent, and 4-5 days per month would be on the high side for an industry-wide average" (Ex. 123-A, p. 14). The AIA/NA argued as follows:

> OSHA's significant risk findings are also predicated on an assumed 45-year lifetime exposure. Although 45-year exposures are theoretically possible, the evidence in the record demonstrates that only a very small minority of workers will be exposed that long. The vast majority of asbestos-exposed workers will experience fewer then 10 years [of] exposure. As Dr. Nicholson notes at the hearing, approximately half of all workers leave an industry within six months, and the remaining half work in a given industry between eight and twelve years. (Ex. 328, p. I-24)

The AIA/NA concluded that the actual risk to workers exposed to asbestos is approximately one-sixteenth that predicted by OSHA, because ". . . average exposures over and average working life will be for one-fourth the time at one-fourth the level of OSHA's lifetime exposure predictions" (Ex. 328, p. I-25). For this reason, the AIA/NA claimed that significant risk would be eliminated at a new PEL of 0.5 f/cc.

OSHA agrees that the record indicates that the actual exposure conditions and employment patterns of many workers today do not conform to the exposure and duration characteristics underlying the lifetime exposure assumption used in the Agency's risk assessment. However, when determining whether a hazardous substances poses a significant risk and that reduction of a PEL is warranted, OSHA must consider what degree of risk would be *permitted* by the existing standard, even though many workers may in fact be at lesser risk because their employers have chosen to reduce their exposures to levels below those required by that standard. It is for this reason that OSHA bases its determinations of significant risk on exposure to a PEL and not on reported exposure conditions. However, it should be noted that OSHA does analyze current exposure conditions in workplaces when assessing the potential benefits of new regulations, as required by Executive Order 12091. For example, in this rulemaking, OSHA has quantified the benefits of the new standard, taking into account current occupational exposure conditions (see Section VII).

The use of the lifetime exposure (45-year) assumption has also been standard in determining significant risk in previous OSHA rulemakings. OSHA has several reasons for using a lifetime exposure assumption. First, the use of a 45-year lifetime exposure duration is based on guidance given in the OSH Act. As specified in Section 6(b)(5): "The Secretary in promulgating standards dealing with toxic materials or harmful physical agents under this subsection, shall set the standard which most adequately assures to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health of functional capacity *even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life*" (emphasis added). OSHA believes that it is reasonable to assume that a person begins work at age 20 and continues until the age of 65, a 45-year span of employment. Under Section 6(b)(5) of the Act, OSHA is compelled to promulgate standards that ensure that employees, even those exposed to the hazardous agent for their entire working lifetime, are at the lowest risk that can feasibly be attained. Therefore, OSHA's determinations of significant risk must take into account the fact that many workers may be exposed throughout their entire working lives, and reflects the view that OSHA is regulating workplace conditions and not specific employees.

A second reason for using an assumption of lifetime exposure is that this method permits comparison of the risks from asbestos exposure to the risks posed by other substances that OSHA has regulated or proposes to regulate. Such comparisons are useful to the Agency in ensuring that a consistent policy underlies OSHA's determinations of significant risk. Because the Agency has determined significance of risk in previous rulemakings based on the lifetime exposure assumption, the use of shorter exposure duration for calculating the risk of asbestos-induced disease would preclude the Agency from making such comparisons. As stated in the April notice (49 FR 14120), the Agency has determined that exposure to asbestos results in an excess disease risk that is many times that found for other hazardous agents that have been regulated by OSHA.

OSHA also believes that the argument made by the AIA/NA, that use of an assumption involving a shorter exposure duration would result in a reduction in risk, is invalid. OSHA's risk assessment shows that the total asbestos-related cancer risk is not linearly related to duration of exposure, and that risk is not reduced proportionally when the exposure durations used are reduced. The reasons for this effect are twofold: First, as the population of asbestos-exposed workers ages, the proportion of this population dying form asbestos decreases because many of these individuals die from other diseases that are related to aging. Second, the relationship between exposure duration and the risk of dying of mesothelioma is not linear. Both of these elements contribute to the non-linearity of the relationship between exposure duration and the risk of incurring asbestos-related cancer. The non-linearity of the relationship between risk and duration is illustrated by comparing the total asbestos-related cancer risk for a 45-year exposure duration with that for a 20-year exposure duration. Although there is a 56 percent reduction in exposure duration, there is only a 31 percent reduction in total asbestos-related cancer risk (from 64 to 44 deaths per 1,000 employees). Accordingly, assuming that employees are exposed to asbestos for shorter durations because of employee turnover would actually *increase* the absolute risk among the larger number of workers exposed for less than their working lifetimes, compared with the risk predicted for a constant number of workers exposed for a working lifetime. Such an increase in absolute risk is a result both of the larger number of workers exposed to asbestos for some period of time if turnover is taken into account and the non-linearity of the relationship between exposure duration and asbestos-related cancer risk. This is illustrated in a technical report (Ex. 84-405) submitted to the record by OSHA showing that calculating risks taking employee turnover and less-than-lifetime exposure into consideration results in a larger number of predicted asbestos-related cancer deaths than would be predicted using a model that assumes a lifetime exposure duration and no employee turnover. Therefore, OSHA finds that use of the lifetime exposure assumption does not result in an overstatement of the risk of mortality from asbestos-related cancers.

This concept is particularly relevant to the construction industry, which is characterized by higher employee turnover as compared to manufacturing industries. One commenter, the Associated General Contractors of America (AGC) argued that OSHA's risk estimates do not apply to the construction industry because of the unique exposure patterns characteristic of that industry:

> Many of the studies on the dangers of asbestos have only limited implications for the construction industry. Forty-five years of exposure to 2 f/cc of airborne asbestos may cause sixty-four excess cancer deaths per one-thousand workers, but few if any construction employees will ever experience such exposure. Very few employees will remain in the industry for forty-five years. Very few will even experience more than low level, intermittent exposure to asbestos. (Ex. 84-457, p. 1)

OSHA recognizes that many construction employees are exposed on a less frequent basis than employees in general industry. However, OSHA disagrees with AGC's contention that the health evidence for asbestos has "limited applications" for construction employees. First, there are construction employees, particularly those employed by asbestos abatement and demolition contractors, who have regular exposures to asbestos. Second, as discussed above, OSHA's determination of the significance of risk must be based on the risks that would be permitted by a standard, and not the actual risk of employees who are exposed at a level below that standard. OSHA has no basis for believing that risks posed by exposure to asbestos at the current PEL of 2 f/cc in construction would be any different than the risks to employees exposed to 2 f/cc in general industry.

Another issue raised by the AIA/NA involved the effect of fiber type on OSHA's risk estimate for asbestos-related cancer. By not accounting for the different carcinogenic potencies of the various fiber types, the AIA/NA maintained that the ". . . predicted risk from mesothelioma is likely to be substantially over-estimated" (Ex. 328, p. I-17). The AIA/NA went on to state:

> . . . OSHA's sole reliance on four studies where exposures were mixed, and were a large number of mesotheliomas were found, biases its risk assessment to the high side . . . Had OSHA relied on a more representative set of studies showing the highest potencies, their mesothelioma risk estimate would have been reduced by a least half. (Ex. 328, p. I-19)

OSHA discusses the health evidence for different fiber types in Section IV of this preamble. In that section, OSHA concluded that, although epidemiological studies indicate that exposure to amphiboles is associated with a greater mesothelioma risk than is exposure to chrysotile, animal studies show the opposite effect. Several rulemaking participants suggested a variety of reasons for this discrepancy. OSHA agrees with Dr. Davis (Tr. 7/10, p. 65) that, on a fiber-by-fiber basis, there are no data to show conclusively that amphibole fibers are more potent than chrysotile fibers. For this reason, OSHA did not distinguish among fiber types when conducting the Agency's risk assessment. Furthermore, no evidence was submitted to the record to indicate that such a fiber-type differential exists for lung cancer risk, which constitutes the largest component of the total cancer mortality risk predicted by OSHA's risk assessment. Moreover, even if OSHA agreed with the AIA/NA and used an estimate of mesothelioma risk that was reduced by 50 percent, the risk of dying of asbestos-related cancer continues to be significant even at the new PEL of 0.2 f/cc: reducing the mesothelioma risk by half results in an excess of 5.3 asbestos-related cancer deaths per 1,000 employees, a figure more than 5 times the Supreme Court's guidelines for significant risk. Therefore, OSHA does not agree with that its risk estimates are significantly overstated because they do not differentiate among fibers of different types.

A controversial issue raised during the rulemaking was whether the combined impact of smoking and asbestos exposure on the incidence of asbestos-related disease should lead OSHA to promulgate regulations prohibiting smoking in workplaces in lieu of establishing a lower PEL for asbestos. The epidemiological evidence presented in Section IV (Health Effects) of this preamble does indicate that the combined effect of asbestos exposure and smoking on lung cancer risks is greater than the sum of the individual lung cancer risks for these two hazards. The evidence for the effect of smoking and asbestos exposure on the incidence of asbestosis is equivocal, and there is no known relationship between smoking and mesothelioma risk. Based on this evidence, the AIA/NA argued that:

By failing to take the smoking factor into account, the OSHA risk assessment attributes a substantial portion of the risk, which is solely a matter of personal habit, to workplace exposure . . . . Section 5(b) of the OSHA Act requires each worker to comply with standards that apply 'to his own actions,' indicating that Congress intended to regulate employee conduct at least where the employer cannot control it . . . . [B]y failing to separate out the substantial portion of the lung cancer risk due to smoking, OSHA has again overestimated the risks of exposure to asbestos. Given that smokers are easily identifiable and that successful programs can be instituted to eliminate or substantially reduce smoking among asbestos workers . . . the risk Assessment fails to provide the necessary scientific basis for assessing risk reduction measures through a revised standards. (Ex. 328, p. I-28)

OSHA believes that the AIA/NA's belief that the Agency's risk assessment does not account for the portion of lung cancer risk caused by smoking is not accurate. OSHA's risk assessment for lung cancer is based on studies that measured the *relative* risk of lung cancer among asbestos-exposed populations, and not the *absolute* risk. In other words, all of the studies on which the Agency's risk assessment is based measured the increase in risk among asbestos-exposed workers over and above that experienced by the general population, which includes smokers. In some of these studies, smoking was a confounding factor that was controlled for. It is unlikely that most of the excess lung cancer deaths found among asbestos-exposed cohorts are attributable solely to smoking, as evidenced by the failure of these studies to observe significant excesses of other smoking-related diseases, such as bladder cancer and heart disease. Therefore, OSHA finds that the lung cancer risk estimates predicted by the quantitative risk assessment cannot be principally attributed to smoking.

This view is also held by Dr. Weill, whose written testimony states that "while it is clear that the extent and prevalence of smoking in a study population, its various exposure groups, and the comparison or control group, can have an extremely important effect on lung cancer exposure-response curves, there is insufficient information available to allow smoking to be used in quantitative risk assessment for asbestos-related lung cancer" (Ex. 99, p. 28). Moreover, OSHA's estimate of the risk of mesothelioma mortality, which is not confounded by smoking, is significant in itself (1.64 deaths per 1,000 workers) for lifetime exposure at the new PEL of 0.2 f/cc.

Methodological considerations aside, OSHA find it inappropriate, from a public health viewpoint, to determine the significance of occupational risk for different populations of workers who may have different sensitivities and different lifestyles on the basis of forces that act outside of the workplace. Section 6(b)(5) of the Act makes it clear that OSHA is to promulgate standards that ensure that ". . . no employee will suffer material impairment of health or functional capacity . . ." as a result of exposure to occupational hazards. Although it is true that smoking is associated with a considerable risk of lung cancer mortality, exposure to asbestos substantially increases that risk among workers who smoke. OSHA has consistently maintained that reducing the permissible exposure limit is the approach that "most adequately assures" that employees will not suffer material impairment of health as a result of occupational exposure to toxic substances. OSHA is continuing this policy by choosing not to attempt to make a distinction among exposed worker populations who may have different lifestyles. OSHA's authority to regulate workplace hazards and to reduce their associated risks, even in cases where exposure to the hazard may also occur outside the workplace, was recently reaffirmed by the U.S. Court of Appeals for the Fourth Circuit in its decision upholding OSHA's Hearing Conservation Amendment (*Forging Industry Association* v. *Secretary of Labor*):

[The Forging Industry Association] . . . constructs its first argument that because hearing loss may be sustained as a result of activities which take place outside the workplace . . . OSHA acted beyond its statutory authority by regulating non-occupational conditions or causes. . . . [T]he [Hearing Conservation] amendment does nothing more than ensure that a hearing-endangered worker is provided with protection *in the workplace* [emphasis in original] in order to decrease the risk of a hearing impairment. Having identified employee susceptibility to noise, '[t]he Act does not wait for an employee . . . [to] become injured, authorizes the promulgation of health and safety standards . . . in the hope that these will act to prevent . . . injuries from ever occurring.' *Whirlpool Corp.* v. *Marshall*, 445 U.S. 1, 12 (1980). . . .

[That hearing loss sustained outside the workplace may aggravate that sustained within the workplace] . . . is scant reason to characterize the primary risk factor as non-occupational. Breathing automobile exhaust and general air pollution, for example, is damaging to the lungs, whether [the lungs are] healthy or not. The presence of unhealthy lungs in the workplace, however, hardly justifies failure to regulate noxious workplace fumes. Nor would there be logic to characterizing regulation of the fumes as non-occupational because the condition inflicted is aggravated by outside irritants (*IFA* v. *Secretary*, p. 9, 13).

Therefore, OSHA is well within its statutory authority when it regulates asbestos as a workplace carcinogen and applies the revised asbestos standard to all exposed employees, despite the presence of non-occupational factors, such as smoking, that serve to compound the risk of some workers. OSHA believes that, by promulgating this revised standard, it is carrying out its Congressional mandate to reduce serious occupational risks, to the extent feasible, for all American workers exposed to asbestos.

VII. Final Economic Impact and Regulatory Flexibility Analysis

This analysis has been performed in accordance with the requirements of Executive Order 12291 and the Regulatory Flexibility Act of 1980 (5 U.S.C. 601 et seq.). The following paragraphs summarize the economic and other impacts of the final rule on those industries most likely to be affected.

Industries Affected

The industries affected by the final standard include primary manufacturing, secondary manufacturing, automotive brake and clutch repair, shipbuilding and ship repair, and construction.

Primary Manufacturing

Several industrial processes are used by primary manufacturers to create these diverse product lines, and many potential sources of airborne asbestos fibers can be identified throughout each process. Two particular operations that are common to all processes and that have a high potential for generating airborne asbestos fiber are fiber introduction and product finishing.

The fiber introduction stage includes operations that are necessary for preparing the asbestos fiber for subsequent mixing or blending. Broken bags and spills in the fiber receiving and storage areas account for the release of airborne fibers during this operation. (It should be noted, however, that such exposures may be reduced through modern packing methods.) Fibers may also become airborne when compacted asbestos fiber is removed from the supplier's sealed containers prior to mixing. Depending on the product line, the compacted fiber may be "willowed" or "fluffed" to facilitate mixing. Asbestos fiber may become airborne due to leakage or spillage during mixing, mixer unloading, or processing operations. In a dry-mix process, fibrous asbestos may become airborne as the batch is weighed and additional materials are added. Once the fiber has been wetted with water or other substances, encapsulated, or bonded with other materials, fiber release is significantly reduced.

In product finishing operations, asbestos fibers become airborne when they are torn loose from the parent product as it is cut, sawed, drilled, texturized, shaped, or otherwise modified to form a finished product. Occupational exposures may also occur after the finishing operation or in the handling and disposing of asbestos-containing wastes. The number of plants and the number of potentially exposed workers are presented in Table 7.

Secondary Manufacturing

Secondary fabricators are defined as establishments that receive products from primary manufacturers and further process or fabricate these products to produce other intermediate or finished products. Primary asbestos products that undergo significant secondary processing include flat asbestos-cement (A/C) sheet, friction products, gaskets and packings, plastics, and textiles. Secondary processing involves sawing, pressing, slitting or drilling of asbestos-containing materials and, hence, produces some relatively high exposure levels. The number of plants and workers are presented in Table 8.

Service Industries and Construction

In the service sectors two industries are affected: (1) Automotive brake and clutch repair and (2) shipbuilding repair. The number of sites and the number of potentially exposed workers in these sectors are shown in Table 9.

TABLE 7.—ANNUAL PRODUCTION AND ESTIMATED NUMBER OF ESTABLISHMENTS, WORKERS EXPOSED, AND EXPOSURE LEVELS FOR PRIMARY MANUFACTURERS OF ASBESTOS PRODUCTS

Product line	Annual production	Estimated number of workers exposed	Estimated number of establishments	Estimated 8-hour TWA exposure levels (f/cc)
A/C pipe	258,060 tons	512	5	0.01–1.21
A/C sheet	604,310 squares	203	6	N/D–2.4
Friction materials	260,000,000 pieces	5,104	51	N/D–7.9
Textiles	4,730 tons	413	3	N/D–3.79
Flooring	750 (10⁶) ft²	276	3	N/D–0.3
Gaskets	35.8 (10⁶) ft²	214	[1] 19	0.03–2.06
Packings	51.4 tons	101	[1] 19	0.03–2.06
Paper	72,324 tons	387	22	N/D–1.42
Coatings	177 (10⁶) gallons	1,327	78	N/D–3.3
Plastics	8,409 tons	324	4	N/D–1.11
Total		8,861	191	

[1] The same plants make both gaskets and packings.
N/D=Non-Detectable.
Sources: RTI 1984 Survey Data [Exhibit. 84-473]; OSHA MIS Files; OSHA Hearing; and ICF Inc., Asbestos Products and Their Substitutes, Appendix C, December 1983.

TABLE 8.—ESTIMATED NUMBER OF PLANTS, WORKERS EXPOSED, AND EXPOSURE LEVELS FOR SECONDARY FABRICATORS OF ASBESTOS PRODUCTS

Product line	Estimated number of establishments	Estimated number of workers exposed	Estimated 8-hour TWA exposure levels (f/cc)
Gaskets/packings	289	9,972	N/D–0.77
Automotive remanufacturing	181	4,750	N/D–1.6
Plastics	245	2,450	N/D–0.29
Friction materials	40	1,504	N/D–0.75
A/C sheet	23	345	N/D–3.2
Textiles	51	172	N/D–1.8
Total	829	19,193	

N/D=Non-detectable.
Sources: RTI 1984 Survey Data [Exhibit. 84-473]; OSHA MIS Files; OSHA Hearing; and ICF Inc., Asbestos Products and Their Substitutes, Appendix C, December 1983.

TABLE 9.—ESTIMATED NUMBER OF ESTABLISHMENTS, WORKERS EXPOSED AND ASBESTOS EXPOSURE LEVELS IN SERVICE AND REPAIR INDUSTRIES

Sector	Number of establishments	Number of workers exposed	8-hour TWA exposure levels (f/cc)[1]
Automotive brake and clutch repair	285,188	526,998	N/D–0.94
Shipbuilding and repair	400	15,000	[1] N/D–1.42
Total	285,588	541,998	

[1] These data do not include nuclear rip-out where wet methods are not permitted. The 8-hour TWA exposures during nuclear rip-out range from 0.2 f/cc to 7.2 f/cc.
N/D=Non-detectable.
Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis, based on RTI 1984 Survey Data, Phase 1 Report, Regulatory Analysis of the Proposed Standard on Asbestos [Exhibit No. 84-473]; Management Information Systems (MIS) Files; OSHA Hearing; ICF Inc., Asbestos Products and Their Substitutes, Appendix C, December 1983.

Asbestos exposures in the construction industry occur during various activities (see Table 10). For example, such exposures occur when installing A/C pipe and sheet, finishing drywall, sanding vinyl-asbestos floor tiles, installing build-up roofing, removing old insulation, removing or repairing drywall, demolishing buildings containing asbestos products, and removing old built-up roofing. Workers involved in the maintenance and repair of pipes, boilers, or furnaces in a wide variety of buildings are also exposed to asbestos.

Availability of Substitutes

The extensive tort litigation in the area of occupational exposure to asbestos and the awareness of the health effects associated with asbestos exposure have provided a strong incentive for producers and users of asbestos products to utilize substitutes. For example, approximately 50–75 percent of producers of phenolic molding compounds have substituted other materials such as clay or fiberglass for asbestos. Similar success has been achieved in the production of floor tile, where non-asbestos fibers and petrochemicals are being used, and in friction materials. Fiberglass has been used successfully as a substitute for asbestos fiber in many products. Roofing felts, pipeline felts, and asphalt coatings have all been produced using fiberglass in place of asbestos fibers.

In the past, the price of substitute materials has been much higher than the price of asbestos. The "full price" of using asbestos, which includes the potential cost of control methods, tort litigation, etc., however, has increased significantly in recent years. Consequently, the difference between the cost of using asbestos and the cost of using other substitute materials has diminished greatly and in many instances has disappeared entirely.

TABLE 10.—ESTIMATED NUMBER OF WORKERS EXPOSED AND ASBESTOS EXPOSURE LEVELS IN THE CONSTRUCTION INDUSTRY

Sector	Estimated No. of workers exposed	Mean 8-hour TWA exposure levels (f/cc)
New construction	29,320	0.13
Abatement	81,366	1.85
Demolition	24,455	0.61
General building renovation	133,700	2.8

TABLE 10.—ESTIMATED NUMBER OF WORKERS EXPOSED AND ASBESTOS EXPOSURE LEVELS IN THE CONSTRUCTION INDUSTRY—Continued

Sector	Estimated No. of workers exposed	Mean 8-hour TWA exposure levels (f/cc)
Routine maintenance in commercial and residential buildings	217,745	0.29
Routine maintenance in general industry	259,643	0.51
Total	746,228	

Sources: RTI [Exhibit. 473]; Building Owners Survey (Ex. 84-474); Consad Phase 1 Report (Ex. 84-474); and 1982 Census of Construction.

Technological Feasibility

Introduction

This analysis determines the extent to which it is currently feasible to reach a permissible exposure limit (PEL) of 0.2 fibers per cubic centimeter during affected work operations without the use of respirators. The information in the public record provides the basis for OSHA's determination that a PEL of 0.2 f/cc for an 8 hour time-weighed average (TWA) can be achieved, with a few exceptions, across the asbestos-products manufacturing industry. Exposure data indicate that some of the plants in this industry have combined engineering controls and prudent work practices to reach exposure levels below 0.2 f/cc. OSHA recognizes that some data show the current difficulties of reaching a 0.2 f/cc TWA, but OSHA believes compliance with the new PEL will become increasingly feasible in these operations. In the construction industry, the data show the capability of meeting the PEL in most operations by the conscientious application of engineering and work practice controls.

Based on this analysis, OSHA has determined that compliance with the 0.2 f/cc PEL is feasible in most industries most of the time through the use of wet methods, engineering controls, and good housekeeping practices. There are some operations, however, for which compliance through the use of engineering controls and work practices alone does not appear feasible at this time. These situations are usually due to the inability of the operation to use wet methods (e.g., textiles, nuclear rip-out, building repair, etc.), and the volume of dust generated (e.g., cutting operations for A/C pipe and sanding A/C sheet). During these operations, therefore, respiratory protection must also be used until employers apply current technology more effectively or apply new technology to the control of asbestos dust.

General Considerations

As stated above, OSHA based its conclusion about the technological feasibility of the 0.2 f/cc level on the record evidence and data summarized later in this section. The following discussion sets out the legal and policy framework for making these determinations.

Section 6(b)(5) of the Occupational Safety and Health (OSH) Act provides that OSHA may promulgate standards to the extent that they are economically and technologically feasible. In meeting its statutory mandatte to set "feasible" standards, OSHA is guided by judicial review of 14 years of Agency standards setting.

According to the Supreme Court, requirements may be imposed up to the limits of what is "technologically achievable." [*American Textile Mfgs. Institute et al.*, 452 U.S., fn. 34, 1981 OSHA sec. 25,457.] Accordingly, OSHA may promulgate standards which can be met most of the time by the technologically advanced plants in an industry. [See e.g., *American Iron and Steel Inst.* vs. *OSHA* ,577 F. 2d 825, 932–35 (3d Cir. 1978).] [*Ibid*, 5717 F. 2d at 835.] Current exposure levels in such technologically advanced plants may meet the PEL only one some measured days, yet that level may be considered feasible [*Ibid*; 577 F. 2d. at 835]. In addition, in cases where data show the current industry exposure levels are in excess of the new PEL, the new PEL is, nevertheless, determined to be technologically feasible if substantial evidence exists to show that companies acting in good faith can develop the necessary technology to reach the new PEL [*United Steelworkers*, 647 F. 2d at 1269, 1272].

The D.C. Circuit has explained that the purpose served by OSHA's industry-wide feasibility determination is to create "a general presumption of feasibility for an industry . . . [is] that industry can meet the PEL without relying on respirators" [647 F. 2d at 1296]. In the case of asbestos, OSHA has determined based on this rulemaking record and guided by this body of decisions that most industry sectors in most operations most of the time will be able to meet a time weighted average PEL of 0.2 f/cc primarily through the application of currently available engineering and work practice controls. Supplemental respirator use will be needed only occasionally. (Later, in this section OSHA discusses on an industry sector basis more detailed reasons and evidence supporting these feasibility determinations.)

Claims about technological feasibility made by participants in the rulemaking supported all exposure levels considered in the proposal, from 0.1 f/cc to 0.5 f/cc. Participants advanced policy arguments and evidence in support of their positions. For example, the AFL–CIO stated that the evidence showed that 0.1 f/cc was feasible for general industry to achieve primarily through engineering and work practice controls [see, for example, Exhibits 143 and 335]. However, as detailed in the specific industry sector discussions, the evidence indicates that the 0.1 f/cc level is not currently feasible in most dry operations in manufacturing and secondary processing of asbestos products. In the construction activities of renovation and major abatement, a proponent of a 0.1 f/cc level for construction agrees with OSHA that supplemental respirator use will be necessary to meet that lower level [see Exhibit 330]. Therefore, OSHA has determined that a 0.1 f/cc may not be achievable in most operations without routine respirator use.

In contrast, other participants contended that a 0.2 f/cc level was technologically infeasible in most manufacturing industries and, therefore, that a 0.5 f/cc should be designated as the PEL. Proponents of a 0.5 f/cc PEL did not dispute reports of the levels of exposure currently being achieved in such industries. In fact, the major proponent of the 0.5 f/cc level, the Asbestos Information Association of North America (AIA/NA) agreed that "OSHA's proposed PEL of 0.2 f/cc is close to the center of the best achievable exposure range for most manufacturing workplaces [see Exhibit 312 A]. Additionally, AIA projects that the incentive effect of a new reduced PEL will result in "long term average exposures to typical asbestos product manufacturing workers . . . in the neighborhood of 0.1 f/cc or below." AIA further projects that "[e]ven employees in the most difficult to control industry workplaces would not experience average exposure levels above 0.2 f/cc" [Exhibit 312 A].

AIA objected to finding the 0.2 f/cc level technologically feasible for two reasons. First, AIA defined a "feasible" exposure level as one in which an employer will have a 95 percent level of confidence that exposures on any day will not exceed the PEL. Therefore, according to AIA, because airborne asbestos exposure levels fluctuate from day to day, setting a 0.5 f/cc PEL would be necessary to assure that employers will not be subject to citation on unrepresentative "high" days. The second reason given by AIA is that because the measurement and analytical method for assessing asbestos exposures is uncertain at lower levels, imposing a 0.2 f/cc PEL will not allow employers to ascertain whether they are in compliance [Exhibit 328, p. 7].

Day-to-Day Variability of Exposure Levels

To demonstrate day-to-day variability, AIA submitted evidence of recent exposure levels at plants identified as well controlled in various industry sectors. AIA stated that these data showed that the airborne asbestos exposures varied significantly from day to day at the same work station due to factors beyond the employer's control [Exhibit 312, Table H].

OSHA believes that AIA's data in fact supports the Agency's conclusion that 0.2 f/cc is feasible. AIA's data from three asbestos-cement pipe plants show that all operations in these plants would be able to meet a 0.2 f/cc PEL more than 50 percent of the time. These data also show that most operations in the asbestos-cement pipe industry could be expected to do significantly better. Approximately 80 percent of the measurements in the fiber introduction area and approximately 90 percent of the measurements in the pipe formation and lathe finishing area could be expected to read under 0.2 f/cc [Exhibit 312A, Table III] based on AIA's own calculations. In addition, OSHA disagrees with AIA's contention that since little can be done about the sources of variability and a conscientious employer must keep his average exposures far below the PEL, so that he will not inadvertently be cited on a "high day" [Exhibit 312A, Tab H, p. 4]. AIA listed the factors that influence variability, including changes in internal airflows such as fans being turned off or blocked, inoperative or blocked ventilation systems, or changes in individual work practices.

OSHA has observed in its enforcement experience that proper inspection and maintenance of ventilation systems can greatly increase their effectiveness and reduce the variability resulting from inefficient operation of such control systems [see also Exhibit No. 335]. OSHA also believes that variation in work practices may be minimized by supervision and training programs. While OSHA agrees with AIA that there is a day-to-day variability in exposure, OSHA believes that many of the major sources of day to day variability can be moderated by diligent employer control.

OSHA also disagrees with AIA's contention that the appropriate legal test for technological feasibility would assure that all employers may be 95 percent confident that an OSHA inspector will not measure an over exposure based on one day's sampling. There is nothing in the Act that would support such a test. No court that has reviewed OSHA's feasibility determinations has suggested such a test. In fact, the District of Columbia Court of Appeals has stated in pre-enforcement review that the court would not expect OSHA to prove the standard *certainly* feasible for *all* firms at *all* times in *all* jobs. [United Steel workers supra, 647 F. 2d 1270]. However, applying AIA's definition of feasibility would require a feasibility level that would give employers virtually that level of assurance (i.e., 95 percent versus 100 percent). The Agency's experience in promulgating and enforcing the former asbestos standard and other health standards provides additional policy reasons to reject AIA's test for determining industrywide feasibility.

AIA's test for feasibility depends upon a static picture of exposure levels and patterns. But as stated above, all feasibility determinations are projections of future control results. OSHA appropriately has decided that higher levels will fall as experience in applying controls increases. OSHA also has projected that the mix of circumstances under which those measurements were derived will change under the new standard. The mere lowering of the PEL creates its own incentive effect of decreased exposures and will reduce exposure variability.

Other policy reasons argue against AIA's statistical formulation of feasibility. Most importantly, to give a 95-percent level of assurance to employers that an OSHA inspector will not find a measurement above the PEL would require OSHA to deny to *employees* the assurance that they will be protected by exposure levels that are achievable. For example, it can be calculated that a plant that exceeds the PEL 70 percent of the time has a 35 percent chance that OSHA will not sample above the PEL during a visit in which a single 8-hour TWA sample was taken. AIA's data showed that *all* operations in the asbestos cement pipe industry can achieve 0.2 f/cc more than 50 percent of the time. Setting a level above 0.2 f/cc would mean that employees would unnecessarily be allowed to be exposed to higher levels than are *now* being achieved, simply to increase the level of assurance that an OSHA inspector will not obtain a high sample on a one day inspection. Such a result would undermine employee protection and would be inconsistent with the policies of the OSH Act.

OSHA believes that employers can increase their assurance of not being unreasonably cited by implementing measures that would not expose employees to such increased risk. The employer can reduce the chances of citation by exercising diligence in applying available controls, by supervising the work habits and practices of employees, and by inspecting and maintaining systems in optimum condition. All of these measures will not only reduce employees' average exposures, but also will reduce their high exposures, and thus lower the probability of OSHA issuing a citation. Based on OSHA's experience in regulating other substances with notable day-to-day variability, such as coke oven emissions, OSHA is confident that employers can control a significant portion of such exposure changes.

Due to the nature of asbestos fibers, in some workplace operations, OSHA may measure on a day when exposures are above the PEL due to random exposure variations, even though the employers have installed and maintained engineering controls, instituted available work practices and conscientiously applied housekeeping measures that maintain exposures below the PEL most of the time. Therefore, where an employer can show, based on a series of measurements made pursuant to the sampling and analytic protocols set out in this standard, that the OSHA one-day measurement may be unrepresentatively high, OSHA may reinspect the workplace and measure the employees' exposure or may decide not to issue a citation, unless OSHA has reason to believe that there are circumstances within the employer's control to account for the high exposure measurement.

OSHA is not setting out specific "rebuttal" criteria in the standard that would bind OSHA always to reinspect and that would deny an employer the opportunity to contest citation only when certain specified criteria are met. One reason is that OSHA believes the informed judgment of the OSHA inspector is superior to a rule that would be based only on the number and result of the employer's measurements. Such a rule would not accommodate the OSHA inspector's observations about the quality of the employer's sampling and analytic program and the asbestos control, housekeeping, and training programs which OSHA believes are equally important in showing *why* fluctuations occur.

OSHA believes, however, that an employer's demonstration that an inspector's one-day sample is unrepresentative, in most cases, should consist of a series of full-shift measurements of the exposure of the employee under consideration. These measurements should consist of all valid measurements of the employee under consideration taken within the last year and should show that on only relatively rare occasions could random fluctuations result in measured TWA concentrations above the PEL.

Where the OSHA inspection or other information shows that the employer's exposure control programs and equipment are broken or are poorly maintained, where housekeeping programs have not been instituted or are inadequate, or where training programs do not exist or do not meet the standard, it is likely that OSHA's one-day measurements accurately reflect high exposure conditions that are not due to random exposure fluctuations but that are the result of the inadequacies of the employer's protective program. Consequently, citation is appropriate in such circumstances and no reinspection will be performed regardless of the employer's past measurements results.

It should be noted that the calculations of probable overexposures referred to in the above discussion are based on data from measurements taken in 1983 and earlier. Evidence in the record shows a gradual decline in asbestos levels over the last 5 years although the same technology is being used (e.g., compare data on the fiber receiving process in Exhibit 84-442 against the more recent data in Exhibit. 225). OSHA anticipates that, in general, exposure levels and the probability of overexposures will decline as employers more conscientiously apply all the available controls and adopt whatever new technology may become available. In this regard OSHA points to a new technique for reducing dust during abatement activity. The details of which were submitted to OSHA after the record was closed (see CACOSH, Exhibit. 344-18). OSHA believes that even minor refinements of existing technology will help employers achieve lower asbestos dust levels and will demonstrate that the concern for possible unfair citations due to day to day variability is illusory.

Based on all these considerations, OSHA believes that AIA's concerns about the issuance of citations due to occasional excursions above the PEL, are greatly overstated.

Sampling Error

The second contention made by AIA is that the sampling and analytic method for monitoring asbestos is so imprecise at lower levels that employers cannot with confidence evaluate whether they are in compliance. As discussed in great detail in the measurement section, OSHA has determined that the revised phase contrast method set out in this standard can reliably measure asbestos exposures below the action level of 0.1 f/cc if the procedures and protocols set out in the appendix are conscientiously followed.

OSHA acknowledges, however, that this sampling and analytic method for measuring asbestos has the potential for error. OSHA, therefore, will add a value that is equivalent to the sampling and analytical error (SAE) of the method to the exposure level measured by an OSHA inspector and will not cite for overexposure unless the measurement exceeds the PEL plus the SAE. As discussed in the section on method of measurement, OSHA believes that the record supports retaining the former SAE of 25 percent [OSHA Industrial Hygiene Technical Manual, 1984, p. A-240; see discussion in method of measurement section, *infra*]. OSHA, therefore, will not cite an employer for overexposure unless the measured one-day's overexposure exceeds 0.25 f/cc—that is, the PEL of 0.2 f/cc plus the SAE of 0.05 f/cc. Since the sampling and analytical error potential can also result in measurements that are *lower* than the actual concentrations, the application of the SAE always will give the benefit of the doubt to the employer and assume that actual concentrations are less by 25 percent of the measured results. OSHA believes this additional margin will add to the assurance an employer has about his capability for compliance and will further reduce the possibility that he will be unfairly vulnerable to an OSHA citation.

OSHA has also required a number of practices that will standardize sample analysis. These include specifications of a procedure for analysis and laboratory quality control programs.

Summary

In summary, OSHA has determined that the 0.2 f/cc PEL is technologically feasible and will not result in an unfair issuance of a citation to the conscientious employer. OSHA's analysis of each affected industry sector is presented below. In this analysis, OSHA concentrated on the revised PEL of 0.2 f/cc. As stated above, most the comments received by the Agency agree that 0.5 f/cc is feasible. Some comments, including those of the AFL-CIO [Exhibit No. 335], argued that a PEL of 0.1 f/cc is feasible, but most of the "best" plant exposure data indicate that average exposures at many stations (e.g., most dry mechanical operations) are in excess of 0.1 f/cc and cannot be reduced using current controls and practices.

Tables 11 and 12 summarize OSHA's findings concerning the feasibility of reducing worker exposures to below the 0.2 f/cc PEL. They show that over 99 percent of the affected employees in general industry are expected to be below the PEL. Exposures for over one-half of the affected employees in construction sectors could be reduced to that level. OSHA, therefore, has determined that it is feasible for most industry sectors to comply with the 0.2 f/cc PEL most of the time.

TABLE 11.—FEASIBILITY SUMMARY TABLE FOR GENERAL INDUSTRY: PROJECTION OF WORKERS EXPOSED BELOW AND ABOVE 0.2 F/CC FOLLOWING THE PROMULGATION OF THE STANDARD AND THE ADOPTION OF ENGINEERING CONTROLS AND WORK PRACTICES

Industry sector	Total No. of asbestos-exposed workers	Projected No. of workers exposed to asbestos levels below 0.2 f/cc	Projected No. of workers exposed to asbestos levels above 0.2 f/cc*
Primary manufacturing:			
A/C pipe	512	409	103
A/C sheet	203	150	53
Textiles	414	123	290
Floor tile	276	276	0
Coatings	1,327	1,327	0
Friction	5,104	4,777	327
Paper	387	387	0
Gaskets	315	315	0
Plastics	324	278	46
Subtotal	8,861	8,042	819
Secondary manufacturing:			
A/C sheet	345	230	115
Textiles	172	143	29
Friction	1,504	1,003	501
Gaskets	9,972	9,972	0
Plastics	2,450	2,450	0
Auto remanufacturing	4,750	4,750	0
Subtotal	19,193	18,548	645
Service and repair:			
Ship repair	15,000	12,434	2,566
Auto repair	526,998	526,996	0
Subtotal	541,998	539,434	2,566
Grand totals	570,052	566,022	4,030

* Estimates derived from RTI survey data presented in Appendix D of the Final Regulatory Impact and Regulatory Flexibility Analysis (RIA).

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

TABLE 12.—FEASIBILITY SUMMARY TABLE FOR CONSTRUCTION: PROJECTION OF WORKERS EXPOSED BELOW AND ABOVE 0.2 F/CC FOLLOWING THE PROMULGATION OF THE STANDARD AND THE ADOPTION OF ENGINEERING CONTROLS AND WORK PRACTICES

Industry sector	Total No. of asbestos-exposed workers [1]	Projected No. of workers exposed to asbestos levels below 0.2 f/cc	Projected No. of workers exposed to asbestos levels above 0.2 f/cc [1]
New construction	29,320	27,115	2,205
Abatement	81,365	13,560	67,805
Demolition	24,455	3,980	20,475
Renovation	133,700	51,300	82,400
Routine maintenance in commercial/residential building	217,745	124,155	93,590
Routine maintenance in general industry	259,643	175,053	84,590
Total	764,228	395,163	351,065

[1] Excludes small short duration jobs with negligible exposures.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

Primary Manufacturing

The production of the primary asbestos products can be divided into receiving (unloading, transporting, and storing the raw asbestos fiber), fiber introduction, and processing (mixing, drying, and finishing). The best available control technology consists of a combination of extensive local exhaust ventilation and a diligently enforced, comprehensive program of work practices and housekeeping. The automatic bag opening equipment, which is used in some sectors, is an example of the technology currently available to minimize asbestos exposures during fiber introduction. In several sectors, some finishing processes are completed with the use of water spray to reduce airborne levels of asbestos.

Two manufacturing steps that all primary asbestos product manufacturers have in common are the receipt of asbestos shipments and the introduction of asbestos fiber into the process. Due to the universal use of these steps throughout the industry as well as the large potential for release of asbestos fibers, a qualitative discussion of these steps is presented below.

Raw asbestos is shipped to manufacturers via railcar or truck. Manufacturers usually receive from 25 to 50 bundles of 100-pound bags of raw asbestos fibers. The packaging of the asbestos varies, but loose fibers or fibers pressed into bricks are usually wrapped in plastic or Kraft (TM) paper bags. These bags are transported on pallets that are constructed with high shear-resistant glue to prevent movement during shipping and handling. The entire bundle of asbestos bags is often shrink-wrapped with plastic to further reduce the potential for fiber release.

When trucks or railcars arrive at the plant, they are opened and examined for damaged bags. If any major damage is found, the entire shipment is returned to the supplier. Any minor damage is repaired by vacuuming the spilled fiber and sealing the broken bag with tape. The pallets are removed from the railcar or trailer by forklift and are stacked in the storage area [Exhibit 335].

Due to prudent work practices and recent improvements in the packaging of asbestos fibers, OSHA has determined that it is feasible for primary manufacturers of asbestos products to receive and store shipments of asbestos without experiencing exposures above the PEL of 0.2 f/cc. According to Marsden Hutchins of Quin-T Corporation:

> . . . fiber as now received lends itself to dust-free storage. Care in handling to avoid and/or clean up after accidental bag breaks makes this a relatively trouble-free area. [Exhibit 91-16, Section J, p. 17.]

Data provided in Dr. Gordon Bragg's feasibility report [Exhibit 235-A, Table III] indicate that an A/C pipe manufacturing plant with the best available technology and stringent work practices experienced a mean TWA of 0.03 f/cc during the reception and storage of asbestos shipments.

In addition to receiving and storing asbestos fibers, all primary manufacturers of asbestos products share the fiber introduction step. OSHA has concluded that it is feasible for this processing step to be completed with exposures below 0.2 f/cc. This conclusion is supported by data presented by the Research Triangle Institute (RTI) from its 1984 industry survey. In the RTI survey, exposures during fiber introduction ranged from 0.07 f/cc to 0.2 f/cc [see Appendix C of the Regulatory Impact Analysis].

The introduction of asbestos fibers to the manufacturing process begins with the transportation by forklift of the pallets of asbestos bags to the head of the production line. There, depending on the product line, the bags are sent either unopened to the mixing stage or are cut open and the asbestos is dumped onto a conveyor to be carried to the mixing stage. When unopened bags of asbestos enter into the process, exposure levels are not a problem in the introduction step. In written testimony, Mr. Hutchins indicated that only 5 percent of Quin-T Corporation's production of asbestos paper and gaskets required the asbestos paper bags to be opened prior to mixing [Exhibit No. 91-16, Section J, p. 5]. Asbestos bags packaged in polyethylene are not always opened in the production of asbestos/vinyl flooring or asbestos-reinforced plastics.

When the bags must be opened, either automated or manual debagging operations are used. Exposures at automated debagging stations have been measured to be less than 0.2 f/cc [Exhibit 235A, p. 101]. It has also been demonstrated that manual debagging operations have had exposures below the proposed PEL of 0.2 f/cc. Dr. Bragg reported an 8-hour exposure of 0.07 f/cc for the operator at a manual debagging station. He also cited an article by First and Love in which exposures at a manual debagging operation were measured to be 0.047 f/cc or lower for seven samples [Exhibit 235-A, p. 101]. Thus, OSHA has determined that it is feasible for both manual and automated debagging operations to reach exposures below the proposed PEL.

Asbestos-Cement Pipe

Data submitted to the record indicate the ability of most work stations at well-controlled A/C pipe plants to reach levels below the PEL of 0.2 f/cc except during the coupling cut-off operations. The basic steps in the manufacture of A/C pipe are fiber introduction, materials mixing, pipe forming, curing, and finishing. To reduce exposures throughout the A/C pipe manufacturing process, work practices and engineering controls have been applied to work stations as described below.

Following fiber introduction, the asbestos is carried through various processing steps by conveyor belt. The use of pneumatic conveying systems kept under negative pressure, along with local hood exhaust dust-control systems, has virtually eliminated the possibility of exposure at this stage of processing.

While being conveyed through the processing steps, the fiber is fluffed and blended and then thoroughly mixed with specific amounts of Portland cement, silica sand, and reprocessed scrap. The processing and dry mixing of the ingredients take place automatically in closed blending tanks which are maintained under a slight negative pressure by local exhaust ventilation to minimize worker exposure.

Following the dry mixing process, water is added and the resultant slurry is processed through a pipe making machine known as a "wet machine." The wet machine deposits a homogeneous mixture of the slurry in the form of a thin lamination onto a conveyor. The layer of wet asbestos cement is then conveyed to the press section of the wet machine where it is continuously wrapped around a long steel cylinder until the proper size of pipe is formed. This continuous wrapping process is carried out under high pressure which forces each new lamination to bind with the previously wrapped layer.

After the wrapping process is complete, the formed pipe is removed from the press section of the wet machine and processed through primary curing ovens to allow the cement to attain an initial set. Later, the semi-hardened pipe is placed in an autoclave where it is subjected to a high-pressure steam environment which forces the cement and silica in the pipe to undergo an accelerated cure. At this stage of the process, the asbestos fibers in the pipe become bound in a cement mixture [Exhibit 91-16, Section H].

After autoclaving, cured pipe sections are cut to uniform lengths, machined in a variety of ways (sawing, lathing, drilling), and outfitted with a coupling. The finished pipe is inspected and each section of pipe to be used for conveying water under pressure is tested hydrostatically.

A/C pipe coupling is also produced in these plants. The coupling is manufactured and then cut into smaller sections for use in pipe connection. The repetitious cutting of the coupling lengths causes high asbestos exposures. For this cutoff operation and other finishing processes like lathing and drilling, the use of custom-engineered hoods, local exhaust systems, wet sawing, and special single-point cutting tools has reduced exposure levels. Exhaust air is filtered into baghouses and the collected dust is typically removed in closed containers for recycling or disposal.

As a good housekeeping practice, measures are taken during the pipe formation process to clean up spills of slurry that could dry and become a source of emissions. These housekeeping practices include the use of wet vacuum machines and squeegees instead of brooms for cleaning floors.

The exposure data for A/C pipe used in OSHA's feasibility determination are summarized in Table 13. The average exposures at all of the processes are less than 0.15 f/cc. Among the highest exposures are those for dry mechanical operations; however, these also average less than 0.15 f/cc. Other data submitted show that some dry material operations may have difficulty achieving the new PEL some of the time. For example, the data presented by Dr. Bragg show that exposures at coupling cutoff operations in an A/C pipe plant are the highest, averaging 0.369 f/cc [Exhibit 312-A, Section H, Table II]. The high exposures during the coupling cutoff operation are also consistent with data submitted by the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers (AFL-CIO). These data show that out of 82 exposure readings taken at a CertainTeed Corporation plant, only 2 (both for coupling cutoff operations) exceeded 0.2 f/cc [Exhibit 225]. OSHA believes, however, that most dry mechanical operations can achieve the new PEL.

TABLE 13.—EXPOSURES FOR A/C PIPE MANUFACTURERS

Job classification/process	Mean 8-hr TWA exposure (f/cc)	Standard deviation	No. of observations	Source of data
Fiber introduction	0.136	0.089	83	OSHA MIS [1]
Wet mechanical	.097	.094	87	Do.[1]
Dry mechanical	.134	.145	124	Do.[1]
Other operations	.077	.100	240	Do.[1]

[1] Unpublished compliance data from the Management Information System data base for 1979-1984.
Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

Based on these data, OSHA concludes that the 0.2 f/cc PEL is feasible for all operations at A/C pipe plants using current technology except for coupling cutoff where respirators will have to be used to supplement engineering controls. OSHA, therefore, considers is feasible for the other operations, particularly mixing and conveying of materials within the plant, to reach exposures below 0.2 f/cc.

A/C Sheet

The manufacturing process of A/C sheet is similar in many aspects to that of A/C pipe. Unlike A/C pipe manufacturing, however, OSHA was unable to find data to indicate that exposures at even the "best controlled" A/C sheet plants are below 0.2 f/cc. The mean exposures at most stations, for which OSHA has data, are approximately 0.5 f/cc. Based on the analysis by Dr. Bragg, however, OSHA believes that A/C sheet manufacturers are not using the best available techniques to control asbestos dust.

> The data indicate that fiber is less well-controlled in the sheet manufacturing environment than the cement pipe operation. For example, we would expect that it is possible to control exposures at the fiber introduction stage to values similar to those found in asbestos cement pipe. As a result, the data . . . does not represent the best available technology in our opinion and the improved use of local exhaust ventilation, wet processing and good housekeeping should be capable of reducing exposure levels to values typical of the A/C pipe industry. However, the sanding operation is unique to sheet and there may be a serious control problem for this operation at a PEL of 0.5 "f/c.c." or lower. [Exhibit 235-A, pp. 65-69.]

In addition, the AFL-CIO attributed the higher exposure levels in the asbestos-sheet industry to the failure of this industry to use available controls to reduce exposures [Exhibit 335, p. 39]. Thus, OSHA has determined that by using the same control technology that is currently being used in the A/C pipe sector, it will be feasible for the A/C sheet sector to comply with a 0.2 f/cc PEL. However, in sanding, which is unique to A/C sheet, achieving the new PEL will require the use of respirators.

As previously described, OSHA has determined that fiber introduction for all primary manufacturing processes, including A/C sheet, can be performed with exposures below the PEL of 0.2 f/cc. The dry and wet mixing stages of A/C sheet production are virtually the same as the mixing steps of A/C pipe production. With the use of conveying systems kept under negative pressure, local exhaust systems, and fully enclosed exhaust mixers, it is possible for exposures to be kept under 0.2 f/cc during this phase of production.

The advanced processing steps of A/C sheet manufacture are also similar to those of A/C pipe. Following wet mixing, the slurry flows into vats and is deposited on rotating cylinder molds where the appropriate thickness is formed. The sheet is passed under embossing rolls or hydraulic presses and is then removed from the press for curing by heated air or steam-heated autoclaves. After curing, the A/C sheet undergoes a variety of finishing operations. The highest and most difficult exposures to control occur during these mechanical finishing operations, which is also true for A/C pipe manufacturing. It is possible to reduce worker exposures to below 0.2 f/cc in finishing operations with the use of local exhaust ventilation and tools equipped with exhaust systems or wet spray devices. OSHA, however, has found no evidence indicating it is feasible to lower exposure levels to below 0.2 f/cc during the sanding of A/C sheet without the use of respirators.

As in A/C pipe production, OSHA recognizes that it is difficult to reduce exposures during the cutting operation to below 2.0 f/cc. Technological improvements demonstrated in construction activities, however, have led to reduced exposures during cutting to below the PEL of 0.2 f/cc. OSHA believes that there is a strong likelihood that similar developments will occur in the manufacture of A/C pipe and sheet and in the production of other primary asbestos products. Other innovations, such as shrouded tools used in field cutting, might be applied on a larger scale to current cutting practices in factories. As suggested by Dr. Bragg, the local exhaust ventilation and good housekeeping used in the processing steps of A/C pipe could be successfully applied to A/C sheet processing. Mr. Alfred Netter of Supradur Manufacturing Corporation recognized in his written testimony the importance of good housekeeping when he stated the following:

Work practices—merely keeping the floors clean—reduce greatly the amount of dust in the air created by the movement of equipment. When used properly, this and other housekeeping chores can provide very effective dust control. [Exhibit 91-16, Section I, p. 9].

OSHA, therefore, concludes that with a combination of engineering controls and work practices it will be feasible for this sector to comply with the 0.2 f/cc PEL for all operations except sanding, where supplemental respiratory protection will be used to achieve the PEL.

Friction Products

Asbestos friction products include drum brake linings, disc brake pads, and clutch facings for automobiles, as well as materials for industrial and commercial applications where motion must be controlled. Although each of these products is manfactured by a unique process, the basic order is fiber introduction, wet or dry mixing of the asbestos with other ingredients, and production forming, curing, and finishing.

OSHA has determined that it is feasible to achieve exposure levels below 0.2 f/cc during all operations except grinding, by using engineering controls and work practices. For grinding, supplemental respiratory protection will be required.

Friction products are molded using a wet-mix or a dry-mix process or a combination of the two methods. Dry-mixing is generally used for disc brake pads and brake blocks, whereas wet-mixing generally is used to mold drum brake linings and clutch plates used in automatic transmissions. Compared with the slurry processing for drum brake linings, exposures tend to be higher during the processing of the more friable dry-mix used to make disc brake pads. Both dry-mix and wet-mix processes are used in the manufacture of clutch facing. These steps of fiber introduction and mixing closely resemble those of other primary manufacturing processes (e.g., A/C pipe).

Following mixing, the dry mix is fed through a compression molder and the wet mix through an extruder. Then, formed strips are cut and bent into various widths and lengths. Dry-mixed formulations are transferred to pressing molds where slabs are formed, sometimes after a pre-heating step. The slabs are hot pressed, are sawed into specific parts, and are then sent to a curing oven. Following curing, the parts undergo finishing steps to produce the final product. These steps include sawing, grinding, drilling, tapping, and boring.

In the friction products industry, finishing operations generate the greatest quantity of emissions, with as much as 30 percent of the asbestos in the products being ground away as dust. The Friction Materials Standards Institute claimed that a 0.2 f/cc TWA PEL is not feasible [Exhibit 90-180]. OSHA has determined, however, that although there are some operations for which the 0.2 f/cc PEL is not yet feasible, it is feasible for most operations to comply with the 0.2 f/cc PEL using engineering controls and work practices. This feasibility determination is based on exposure data obtained during an RTI site visit to the Raymark plant in Stratford, Connecticut [see Appendix B of RIA].

The Raymark plant is a primary producer of friction materials and sheet gasketing and is the second largest producer of friction products of the plants in the RTI survey. The exposure data reveal that most of the workers involved in the manufacturing of friction products are exposed to less than 0.2 f/cc of asbestos. Exposures for the 15 employees involved with fiber introduction for asbestos friction materials ranged from 0.03 f/cc to 0.21 f/cc, which is similar to the exposure data in A/C pipe manufacture. OSHA, therefore, believes that 0.2 f/cc PEL is feasible for fiber introduction. Exposures for the 28 workers involved in wet mechanical operations, in which the various products are prepared for curing, ranged from non-detectable to 0.3 f/cc, with most appearing to be below 0.2 f/cc. OSHA, therefore, concludes that it is also feasible for those activities to comply with a 0.2 f/cc PEL. This determination agrees with the hearing testimony by Dr. Franklin Mirer of the United Auto Workers (UAW) who ascertained that current technology has the ability to lower exposure levels for these practices to below 0.2 f/cc [Hearing Transcript of July 2, 1984, p. 94].

Exposures for the employees involved in dry mechanical operations, however, ranged from 0.07 f/cc to 1.7 f/cc. About one-third of the workers were regularly exposed to levels above 0.2 f/cc during the grinding of drum brake linings and the pressing and machining of clutch facings. The difficulty of controlling exposures for these dry mechanical operations is consistent with data presented by Dr. Bragg which show that exposures at many of the dry mechanical operations average between 0.3 f/cc and 0.7 f/cc. Dr. Bragg referred to the impracticality of using wet methods during these particular practices because of their detrimental effect on the final friction product [Exhibit 235-A, p. 79]. Dr. Mirer of UAW acknowledged the high exposures during the manufacture of friction products and suggested the use of substitute materials [July 2, 1984, Transcript, p. 92]. The AFL-CIO also has stated that the production of asbestos friction products is a problem area in terms of exposures [Exhibit 335, p. 44]. Thus, it appears that supplemental respiratory protection will be required to comply with the 0.2 f/cc PEL during grinding operations.

Textiles

Asbestos textiles are manufactured by either wet or dry processing. Not all asbestos textile products can be made by the wet process because chemicals used in the wet process alter the characteristics of the fiber making it undesirable for some applications. Likewise, although some operations of the conventional "dry" method could be run using dampened fibers, some fiber qualities required by the final textile product exclude the use of dampening techniques.

In the dry process, the asbestos fiber is debagged and dry blended. Cotton, rayon, or other natural or synthetic fibers can be added to impart strength and other characteristics. Following the standard textile processes, the carding operation, which is one of the problem areas for exposures, combs the fiber mix into a web of parallel fibers which is then divided into strips known as roving. The roving is spun and twisted to produce single or plied asbestos yarns. Due to the high velocity of the spinning operation, this processing step has been a source of high exposures.

The roving can be dampened by wet rollers or mist spray prior to spinning to lower the exposures. During the spinning and other processing steps, however, the strands often break and release asbestos dust as the ends whip around the spindles. Yarns are coated to produce thread, and are braided into cord, rope, or tubing. Depending on the characteristics of the final product, a damp or dry loom can be used during weaving operations.

In the wet process, the asbestos fibers are mixed with water and chemicals. The resulting slurry is extruded directly into strands. This method eliminates the carding operation, a major source of emissions during the conventional process. The strands are then spun and go through the subsequent processing steps which are similar to those of the conventional method. According to some of the developers of wet processing equipment, the balance of the processing steps are performed wet or with the fibers bound, thereby reducing exposures [Exhibit 323].

Local exhaust ventilation is the primary engineering control used to reduce levels of asbestos dust in plants using dry methods to produce asbestos textiles. It is normally provided at the bag opening and fiber introduction stages, and during the willowing and blending, carding, and winding operations. Dust control measures are particularly stringent in plants that blend cotton into the fabric, due to health hazards associated with exposure to cotton dust.

As none of the four post-1980 studies on wet operations at primary textile plants (2 from RTI survey and 2 from OSHA MIS files) show exposures in excess of 0.1 f/cc, OSHA has determined that it is feasible for these operations to comply with a 0.2 f/cc PEL. Other data submitted by the Amalgamated Clothing and Textile Workers Union (ACTWU) [Exhibit 260-A] and obtained by RTI during a site visit to a Raymark Corp. plant [Appendix B of the RIA] show that exposures during dry operations generally exceed 0.2 f/cc. Consequently, OSHA does not believe it is feasible for the dry operations of carding and spinning to comply with the 0.2 f/cc without the supplemental use of respirators. Data in the Bragg report [Exhibit 235-A, Tables VI and XVII] also indicate that these operations will have difficulty achieving average exposures below 0.2 f/cc without the use of respiratory protection.

The AFL-CIO also believes that using dry methods in the manufacture of asbestos textiles is a problem area and that some operations will have difficulty in achieving the PEL [Exhibit 335, p. 44]. The AFL-CIO has stated that it is feasible for the textile industry to comply by switching to wet processing. OSHA has determined, however, that this is not a viable option in most cases because wet processing changes the nature of the textile. RM Industrial Products Company, Inc., one of the suppliers of wet processing technology, acknowledges that the wet process "is not a complete substitute for conventionally prepared asbestos yarn products" [Exhibit 323, p. 3].

OSHA's experience with cotton textile operations has shown that a careful work practice and housekeeping program is effective in reducing cotton dust levels in the plant. Dry cotton textiles operations are similar to asbestos yarn manufacturing and OSHA believes the adoption of the controls developed for cotton dust, such as frequent vacuuming of floors and machine parts, can be used successfully in asbestos textile manufactures. OSHA expects that dry asbestos textile manufacturing will use the latest control strategies available, and should be able to reduce worker exposure to below current levels. For carding and spinning operations in dry mechanical asbestos textile manufacturing, respirators will be used to achieve the PEL.

Vinyl/Asbestos Floor Tile

During the manufacture of vinyl/asbestos floor tile, opened paper or unopened plastic bags of raw asbestos fibers are dumped into a mixer along with other dry ingredients. The mixer combines the ingredients into a hot plastic mass that binds the asbestos fibers, thus reducing the potential for exposure. The hot mix is dumped onto a conveyor and transported under negative pressure to a two-roll mill. The mill presses the plastic into a continuous slab which is passed through a series of calender rolls to achieve the desired thickness. The warm sheet next passes through an embosser which imparts a surface design if desired. After cooling and waxing, the sheet is cut to size, inspected, and packaged for shipment. Cutting scraps are returned to the mixer for recovery.

Local exhaust ventilation is provided at stations such as fiber introduction and cutting which potentially may have high exposures. Mottling granulation and scrap grinding may be isolated in enclosed rooms. Housekeeping is performed continuously to clean up spilled dry material.

Table 14 summarizes the exposure data that forms the basis for OSHA's feasibility determination for vinyl/asbestos floor tile. As shown in the table, the reported exposures at each of the three jobs were less than 0.2 f/cc. OSHA, therefore, has determined that it is feasible for this sector to comply with the 0.2 f/cc PEL. This determination is consistent with 1984 data submitted by Dr. Bragg, which showed that for operations other than fiber introduction, exposures range from 0.01 f/cc to 0.2 f/cc.

TABLE 14.—EXPOSURE DATA FOR THE MANUFACTURER OF VINYL ASBESTOS FLOOR TILE

Job classification/process	Mean 8-hr TWA exposure (f/cc)	Standard deviation	No. of observations
Fiber introduction [1]	[2] 0.014	0.022	14
Dry mechanical [3]	[4] .105	[4] .095	[5] 15
Other [3]	[4] .105	[4] .095	[5] 72

[1] OSHA MIS period 1979-1984.
[2] All observations were less than 0.1 f/cc.
[3] RTI site visit to Amtico Flooring, Lawrenceville, N.J.
[4] Ranges were from 0.01 f/cc to 0.2 f/cc, and the means and standard deviations were based on an assumption of a symmetrical distribution.
[5] Number of employees who were represented by the average exposures was used as data on the number of samples were not provided.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

Gasket and Packings

Asbestos-based gaskets and packings are used to prevent the leakage of fluids in process equipment. Asbestos is an effective sealant because it generally does not react with machine fluids and is heat resistant. In the manufacture of gaskets, raw asbestos fibers are either introduced by emptying bags or are added in unopened pulpable bags. The fibers are then mixed wet or dry, with fillers and bonding materials. During mixing, the raw fibers are encapsulated by binders and solvents which reduce the potential for fiber release throughout the rest of the manufacturing process. The mixture is rolled into sheets which may be further processed on-site or may be packaged for shipment to secondary fabricators or to suppliers of replacement parts for industrial equipment.

Asbestos-based packings can be manufactured by a number of processes. The most common production method involves the impregnation of dry yarn with a lubricant. The coated yarns then are braided into continuous lengths and calendered to specific sizes and shapes.

Exposure data upon which OSHA based its feasibility determination were obtained by RTI during a site visit to the Stratford, Connecticut, plant of the Raymark Corp. [see Appendix B of the RIA] and from two facilities responding to the RTI survey [see Appendix C of the RIA]. All three plants reported exposures at various work stations (e.g., wet mechanical, dry mechanical, etc.), other than those involved in fiber introduction and milling, to be at levels below 0.2 f/cc. The level of exposure during braiding and twisting of treated asbestos yarn is controlled by local exhaust ventilation and is supplemented by general control measures, including dilution ventilation and systematic cleaning. In addition to wet mixing operations, sheet and gasket cutting causes very little generation of airborne fibers. Thus, OSHA has determined that it is feasible for these operations to comply with the 0.2 f/cc PEL.

Fiber introduction levels at these plants were reported to be in excess of 0.2 f/cc, with exposures at two of the plants reported to be in excess of 0.75 f/cc. OSHA, however, believes that these plants did not utilize the best available technology and that it is feasible for fiber introduction stations to comply with the 0.2 f/cc PEL. This determination of feasibility was made because the fiber introduction process in the gasket and packing industry is similar to that in other primary manufacturing industries where exposures are currently below 0.2 f/cc (e.g., A/C pipe and floor tile).

Asbestos Paper

In the manufacture of asbestos paper, raw asbestos fiber is most often introduced in unopened pulpable bags, although for some types of paper the fiber is dumped from the bags. In order to decrease exposures in cases where the fiber is dumped from the bags, asbestos may be obtained in noncompressed pulpable paper bags so that bags may merely be slit and added directly to the mixer, where it is immediately wetted. The use of batch sizes requiring whole bags of asbestos (rather than ⅓ or ½ bags) can further minimize asbestos handling and the potential for dust generation. As in other manufacturing processes, the asbestos fiber is carried under negative pressure by conveyor to a mixer. There, the fiber is wet-mixed with paper stock, binder, and other ingredients. The stock slurry flows into the papermaking machine and forms a sheet with a solids content of less than 5 percent. Although the moisture content is reduced greatly during transit through the paper machine, the wet nature of the material largely precludes the release of airborne asbestos.

The steam-heated rolls in the drying section typically have canopy hoods and exhausts to remove water vapor and heat. This type of hooding and exhaust augments the general ventilation in the area and aids in removing asbestos particulates released during the drying operation.

Local exhausts, area hoods, and central exhaust collection systems represent the normal control measures used to minimize asbestos exposure at the slitting and calendering stages. Housekeeping is also critical here.

The rewinding step involves the bulk packaging of paper products on spools, reels, or beams from larger rolls. The operation is dry, and the hoods and local exhaust may be used as dust-control measures during these operations.

Although airborne asbestos fibers are generated throughout the entire manufacturing process, exposure levels vary widely depending on the asbestos content of the product. If comparable control systems are used, airborne fiber levels at a plant producing a gasket paper containing 90 percent asbestos are normally higher than levels at a plant producing specialty papers, or beverage or pharmaceutical filters containing 10 percent asbestos. Emissions also can vary depending on the physical process itself. Some plants perform fiber introduction and stock preparation (i.e., wet-mixing) as separate operations and others combine these into a single operation.

Housekeeping in the stock preparation area represents a crucial control measure for minimizing operator exposure to asbestos. Central vacuum-cleaning systems and mechanical floor-sweeper-vacuum units often are used during these operations.

OSHA based its feasibility determination on data provided by the Quin-T Corporation's plant in Tilton, New Hampshire. As shown in Table 15, these data are the most recent and comprehensive available for asbestos paper production. The mean exposures for all areas were less than the 0.2 f/cc PEL. OSHA concludes that it is feasible for this industry to comply with the 0.2 f/cc PEL. This position is consistent with RTI's findings for two paper firms that responded to their survey [see Appendix C of the RIA].

TABLE 15.—WORKER EXPOSURE FOR ASBESTOS PAPER MANUFACTURE

Job classification process	Mean 8-hr TWA exposure (f/cc)	Standard deviation	No. of observations
Fiber introduction[1]	0.05	0.04	6
Wet mechanical	.09	.10	22
Day mechanical[2]	.14	.12	17
Other	.08	.11	25

[1] These data omit one outlier of 0.56 f/cc. As all of other data were 0.1 f/cc or below, OSHA assumed that this observation was due to an equipment problem.

[2] These data omit one outlier of 1.3 f/cc. As all of the other observations were 0.4 f/cc or below, OSHA assumed that this observation was also due to an equipment problem.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

Coating and Sealants

Many types of coatings and sealants have asbestos added as a reinforcing agent and property modifier. In most instances, the final product is asphalt-based and is used for roof coatings and automobile undercoatings.

The production processes for surface coatings and sealants are similar. In the production of these products, the fibers must be opened, or fluffed, as much as possible. Thus, a fluffing operation to agitate the fibers follows the fiber introduction stage. Dry ingredients are then mixed with the opened fibers followed by the addition of the asphalt or coal tar and solvents. After mixing, the fiber is encapsulated and little asbestos dust is generated. The coatings and sealant blends are then packaged and prepared for shipment.

For this industry, the major potential sources of airborne fibrous exposures precede the mixing operation due to accidential spills during fiber receiving and storing, and from emissions during fiber introduction. As in the manufacture of other asbestos products, OSHA has determined that it is feasible to perform these tasks with with exposures below 0.2 f/cc. The fluffing and mixing operations are kept under negative pressure, and housekeeping around these operations is continuous.

OSHA based its feasibility determination on data provided by the Monsey Products Company for the firm's Indianapolis, Garland, and Rockhill plants. These data, which are the most comprehensive available on coating facilities that have good work practices,[1] are summarized in Table 16.

TABLE 16.—WORKER EXPOSURES DURING THE MANUFACTURE OF ASBESTOS COATINGS AND SEALANTS

Job classification process	Mean 8-hr TWA exposure (f/cc)	Standard deviation	No. of observations
Fiber introduction *	0.13	0.15	34
Other	.04	.05	13

* These data omit one outlier of 1.03 f/cc. As all of the other observations were below 0.7 f/cc, with most below 0.15 f/cc, OSHA assumed that this observation was due to an equipment problems.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

As indicated in the table, the average exposures for these work stations were less than 0.2 f/cc at both stations in the coating plants. OSHA, therefore, has determined that it is feasible for this industry sector to comply with the 0.2 f/cc PEL. This feasibility determination is

[1] Data provided indicate that the four other plants did not appear to have the same quality of control technology [Exhibit 312A, Section L].

consistent with the limited 1983 exposure data submitted by Dr. Bragg as well as with the position of the AFL-CIO [Exhibit 335, p. 41].

Asbestos-Reinforced Plastics

Due to their heat-resistant qualities, asbestos-reinforced plastics are used in the electrical, electronic, automotive, and printing industries. In the manufacture of these plastics, raw asbestos fiber is introduced and dry mixed with catalysts and other additives. The mixture is heated into a resin in the form of pellet or powder preform. The preform may be further processed onsite or packaged and sold to other manufacturers. Based on the information provided in a 1984 report prepared by Versar for EPA [Exhibit 333], primary manufacturers process only 30 percent of the preform that they produce. The remaining 70 percent is shipped to secondary manufacturers who shape and finish the asbestos-based plastic resin. In the shaping process of the final plastic product, the preform is rolled, stamped, pressed, or molded. The product is then cured in an isolated area with a ventilation system. The strength and stiffness characteristics of the final product are partially controlled by the time and temperature conditions during curing.

OSHA's feasibility determination for asbestos reinforced plastics is based in part upon data obtained from two plants surveyed by RTI and from three OSHA MIS reports. These data are summarized in Table 17.

TABLE 17.—WORKER EXPOSURES DURING THE MANUFACTURE OF ASBESTOS-REINFORCED PLASTICS

Job classification/process	Mean 8-hr TWA exposure (f/cc)	Standard deviation	No. of observations	Source of data.
Introduction	0.1	N/A	[1] 34	RTI survey.[2]
Introduction	N/D	0.001	3	OSHA MIS.
Wet mechanical	0.01	N/A	[1] 2	RTI survey.[3]
Dry mechanical	0.14–0.57	N/A	[1] 35	RTI survey.[4]
Other	0.04	0.047	13	OSHA MIS.

[1] Number of employees who were represented by average exposure was used since data on the number of samples were not given.
[2] Identified as plant "1."
[3] Identified as plant "g."
[4] Identified as plant "h."
N/A=Not available.
N/D=Not detectable.
Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

Since these data, especially the MIS data, do not represent plants using the best controls, OSHA's determination is also based upon the technologies currently available in the other primary sectors.

The data indicate that exposures at the fiber introduction and wet mechanical processes in this industry are below 0.2 f/cc and that the problem exposure areas during the manufacture of the plastics appear to be in dry finishing operations. These operations are similar to dry mechanical operations in other asbestos products manufacturing industries and include grinding and sanding, which OSHA has determined may not be feasible to achieve exposure levels below 0.2 f/cc without the use of respirators. Thus, OSHA believes it is technologically feasible for most operations to achieve a 0.2 f/cc TWA, but that respirators will be required during grinding and sanding.

Secondary Manufacturing

Secondary manufacturers modify or fabricate primary asbestos products to yield final products (e.g., impregnated roofing felt) or intermediate products (e.g., asbestos textiles made into fire-resistant clothing). Receiving and handling these primary products do not pose exposure problems. Compared with the primary processing steps of fiber introduction, mixing, and conveying loose fibers, secondary fabrication takes place in a more controllable environment. Exposures occur in this sector when stable asbestos products are altered by dry mechanical operations that release encapsulated fibers into the air. As supported by data, exposures resulting from these dry mechanical finishing operations can be controlled by shrouded tools and by wet methods in some cases. As with primary manufacturing, OSHA has determined that it is feasible for these industries to comply with the 0.2 f/cc PEL in all operations with the exception of some maintenance activities (e.g., repairing or servicing the controls that protect the other workers) and a limited number of dry mechanical operations. The basis for this determination is presented below.

A/C Sheet

The secondary manufacturing of A/C sheet prepares the product for specific installation requirements. This fabrication requires the same dry mechanical processes that were described for primary manufacturing processes, such as sawing, drilling, routing, beveling, and sanding. Some of the firms that responded to RTI's survey reported using wet spray during sawing and routing. As in other processes, tools are equipped with local exhaust systems. High exposures are likely to remain a problem during sanding, which is unique to A/C sheet production.

OSHA's determination of feasibility in this sector is based on data obtained in response to the RTI survey (see Table 18). As all of the exposures shown in the table are below 0.15 f/cc, and because the 1983 data [Exhibit 235–A, Table XXII] for a secondary user of A/C sheet are also all below 0.15 f/cc, OSHA has determined that it is feasible for this sector to comply with the 0.2 f/cc PEL, except for sanding, where respirators will be required.

TABLE 18.—WORKER EXPOSURES DURING SECONDARY MANUFACTURE OF ASBESTOS CEMENT SHEET

Plant designation	Annual production	Job classification	8-hr TWA exposure levels (f/cc)	No. of workers at operations
m	>1 million lbs	Dry mechanical	N/D 0.14	20
p	7,000 sq yds	Wet mechanical	0.10	1
l	N/A	Wet mechanical	N/D	5
q	21,000 sq yds	Other	<0.10	15

N/D=Non-detectable.
N/A=Not available.
Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis, based on RTI survey [Appendix C of the RIA].

Friction Products

In this sector, manufacturers assemble automatic transmission parts, disk and drum brakes, and automotive clutches. Asbestos products undergo a final forming process which may include grinding. The product is then assembled by means of a riveting operation. An example of this secondary fabrication of friction products is the assembly of disc brakes. The asbestos brake pad received from the primary manufacturer is prepared prior to attachment to the metal brake shoe. This preparation might involve drilling holes or grinding to fit a shoe. The pad is then riveted to the metal shoe. Despite the use of local exhaust, grinding generates high volumes of asbestos dust. Thus, grinding results in problem exposures as it does in primary manufacturing.

OSHA's determination of feasibility in this sector is also based on data obtained in response to the RTI survey. These data, which were obtained from four plants, are summarized in Table 19. As the average exposures shown were well below 0.2 f/cc, OSHA has determined that it is feasible for this sector to comply with the 0.2 f/cc PEL, except for grinding operations, where respirators will be used.

Gaskets and Packing

The report prepared by Versar [Exhibit 333] indicated that 95 percent of asbestos gaskets and packings undergo secondary manufacturing. Secondary fabrications cut the gaskets from paper sheets using metal die stamping or pressing machinery. Sawing and drilling are sometimes performed in the finishing of the gaskets.

The greatest potential for exposure in the secondary fabrication of packings occurs during slitting and braiding operations. Wet methods are sometimes used in the braiding of asbestos yarns. Local exhaust systems are used along with housekeeping practices to minimize exposures.

TABLE 19.—WORKER EXPOSURES DURING THE SECONDARY FABRICATION FRICTION PRODUCTS

Job classification/process	Mean 8-hr TWA exposure (f/cc)	Standard deviation	Number of observations
Dry mechanical [1]	0.07	0.04	[2] 66
Other [3]	0.04	0.03	[2] 152

[1] Data obtained from plants designated as "ee," "hh," "mm," and "nn."
[2] Four plants reported average values. This number presents the employment at the plants in this job category.
[3] Data obtained from plants designated as "hh," "nn," and "qq" in the RTI survey.
Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis, as derived from RTI survey.

OSHA's feasibility analysis for this sector is based on 70 observations obtained from the OSHA MIS compliance data for the years 1979 through 1984. These observations ranged from non-detectable to 0.43 f/cc, with a mean value of 0.06 f/cc and a standard deviation of 0.1 f/cc. Based on these data which do not represent the best controlled plants, OSHA has determined that it is feasible for this sector to comply with the 0.2 f/cc PEL.

Textiles

Secondary manufacturers produce fire-resistant and heat-resistant materials and electrical insulation from asbestos cloth and yarns. Data from OSHA MIS data and RTI surveys [See Appendix C of the RIA] indicate that the cutting of asbestos fibers and the sewing of these materials with asbestos thread result in exposures above 0.2 f/cc PEL. OSHA's feasiblity determination that this sector may have difficulty meeting the PEL is based on data obtained from two plants in response to the RTI survey and from an OSHA inspection report. These data are summarized in Table 20.

As it may not be feasible for these operations to be performed with exposures below 0.2 f/cc, respirators may have to achieve the PEL. This determination is consistent with the data provided by Raymark [Appendix B of the RIA] and with the position of the AFL-CIO [Exhibit 335, p. 44] that this is a problem sector. OSHA, however, expects that plants in this sector would utilize controls used by other asbestos processors (e.g., local exhaust ventilation, vacuums, etc.). These controls are currently available and their implementation should reduce exposures.

TABLE 20.—WORKER EXPOSURES DURING THE SECONDARY MANUFACTURE OF ASBESTOS TEXTILES

Job classification/process	Mean 8-hr TWA exposures (f/cc)	No. of observations	Source of data
Sewing and cutting of fabric.	0.6	3	OSHA MIS.
Sewing and cutting of fabric.	1.5-1.8	[1] 8	RTI Survey.[2]
Other	0.185	2	OSHA MIS.
Other	1	[1] 12	RTI Survey.[3]

[1] Number of samples was not reported. These data represent the number of workers represented by the readings.
[2] Plant designated as "ss" (see Appendix C of the RIA).
[3] Plant designated as "rr" (see Appendix C of the RIA).
Source: U.S. Department of Labor, OSHA Office of Regulatory Analysis.

Plastics

The secondary manufacture of asbestos-reinforced plastics involves the forming and finishing of preform plastics received from primary manufacturers. The process steps are the same as these for primary manufacturing. The preform is received and then remelted. It is then rolled, stamped, pressed, or molded as in primary manufacturing. The product is cured in an enclosed area which is furnished with local ventilation. When curing is complete, the product is finished through operations that may include grinding, drilling, or sanding. Hand and portable tools are equipped with shrouded exhaust/collection systems. Larger finishing machines use local exhaust systems near the surface being finished.

The dry mechanical operations performed in this industry are similar to the finishing steps of primary manufacturing where exposures have been shown to exceed the 0.2 f/cc PEL. There were no comments submitted to the OSHA record, however, that indicated that a 0.2 f/cc TWA would not be feasible for this sector. Consequently, although the Agency recognizes that some dry finishing operations may cause high exposures for short periods of time, OSHA believes it is technologically feasible to reach a 0.2 f/cc TWA. This determination is based on seven OSHA compliance reports which indicated an average exposure of 0.1 f/cc.

Automotive Brake and Clutch Remanufacturing

This type of remanufacturing is a salvage operation that rebuilds worn brakes and clutches. Worn brake pads and clutch facings are stripped from their metal supports and are replaced with new pads and linings. The stripping of the old asbestos pad is a potential source of high exposures. To remove the entire used pad, the operation may require abrasive action which causes dust to be generated. Once the metal back of the old pad has been cleaned, the process is identical to the assembly procedure described earlier for the fabrication of secondary friction products. OSHA based its feasibility determinations on data obtained from the OSHA MIS data base and from responses to the RTI survey. These data are summarized in Table 21. As the mean exposures for this industry are 0.12 f/cc or below, OSHA has determined that it is feasible for this sector to comply with the 0.2 f/cc PEL.

TABLE 21.—WORKER EXPOSURE DATA FOR AUTOMOTIVE BRAKE AND CLUTCH REMANUFACTURING

Job classification/process	Mean 8-hour TWA exposure (f/cc)	Standard deviation	Number of observations	Source of data
Dry mechanical	0.05	0.06	[1] 112	RTI survey[2]
Dry mechanical	.12	.11	[3] 23	OSHA MIS.
Other	.08	.10	[4] 56	Do.

[1] Data on the number of samples were not provided. This figure is the number of workers represented by the data.
[2] Plants designated as "tt," "uu," "vv," "xx," "zz," "GH," and "KL."
[3] Data on 24 observations were available for the years 1979 through 1984. One outlier was omitted (1.6 f/cc) since all of the other observations were 0.5 f/cc or below.
[4] Data on 58 observations were available. Two outliers were omitted (1.1 f/cc and 1.0 f/cc) since all of the other observations were 0.4 f/cc or below.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis, as derived from RTI survey.

Service Industries

Automotive Brake and Clutch Repair. Workers who repair brakes and clutches made with asbestos may be exposed because brakes and clutches deteriorate with wear, thereby resulting in friable asbestos. Asbestos dust present on these automotive parts is easily disturbed and becomes airborne during the repair and removal of the linings. Exposures above 0.2 f/cc are particularly prevalent when compressed air is used to clean the linings. These exposures can be significantly reduced, however, by using solvent mists on the linings and then wiping them off, or by using vacuums to remove the dust.

OSHA determined that it is feasible for this industry to meet the 0.2 f/cc. This determination is based primarily on data obtained from the OSHA MIS compliance data base and from a November 22, 1982, study by the National Institute for Occupational Safety and Health (NIOSH) [Report No. 32.4]. The OSHA data contained 47 observations from the period 1979 through 1984, with a mean 8-hour TWA exposure of 0.03 f/cc and a standard deviation of 0.14 f/cc. In addition, the NIOSH study demonstrated that average exposures were below 0.1 f/cc when using either the solvent mist or the high-efficiency particulate air (HEPA) vacuum systems. Thus, OSHA determined that the 0.2 f/cc is feasible in this sector.

Shipbuilding and Repair. Current shipbuilding activities should not generate any worker exposure to asbestos because the use of asbestos has been phased out of this type of construction. The greatest potential for asbestos exposure is during the removal, or "rip-out," of old asbestos material. Rip-out often requires sawing, tearing, cutting, and scraping to remove existing asbestos materials, and these activities frequently occur in confined spaces. Additional sources of asbestos exposure for a small number of shipyard workers occur during operations such as gasket cutting. OSHA believes that these additional exposures can be kept below the PEL of 0.2 f/cc through the use of ventilation and wet methods, which have been used successfully in other industries.

OSHA, however, anticipates problems in controlling exposures during major rip-out operations. These operations involve the removal of asbestos from large areas such as machinery rooms or engine rooms. The particular constraints of the shipbuilding/repair work environment limit the use of traditional engineering controls. Safety rules restrict the number of hoses, pipes, and other equipment that can pass through certain bulkhead openings below deck. The confined spaces in ships impede the use of even portable ventilation equipment in certain areas. In addition, wetting agents are not permitted for rip-out activity in nuclear reactor compartments because of the fear of contamination.

For example, in testimony at the formal hearings, Mr. James R. Thorton of the Newport News Shipbuilding Drydock Co. presented exposure data collected during major rip-outs of reactor compartments where the use of water and saturating agents was restricted. These data show that 41 percent of the exposures were greater than 2.0 f/cc, and another 32 percent were between 0.5 f/cc and 2.0 f/cc [Hearing Transcript of June 25, 1984, p. 79]. The Federal Employees Metal Trades Council [Exhibit 158-6] submitted to the record other monitoring results of major asbestos rip-outs in the reactor compartment of nuclear submarines. These data showed similar exposure levels, with 40 percent of the exposures greater than 2.0 f/cc and 10 percent between 0.5 f/cc and 2.0 f/cc. Thus, OSHA concludes that the 0.2 f/cc PEL is not feasible during asbestos rip-outs of nuclear components without the use of respirators.

According to Mr. Thorton, the exposure results for major asbestos rip-outs of non-nuclear components (where wetting agents can be used) show that 5 percent of the exposures are greater than 2.0 f/cc, and 28 percent are between 0.5 f/cc and 2.0 f/cc. One of the respondents ("QR") to the RTI survey reported exposures ranging from less than 0.02 f/cc to 0.5 f/cc for the wet removal of pipe wrap, wallboard, and gasket materials. The respondent stated that PEL of 0.2 f/cc can be attained during these small-scale or "minor rip-out" operations by using wet removal practices. OSHA has thus determined that the 0.2 f/cc PEL is feasible for certain minor rip-outs in non-nuclear vessels, but that respirators will be needed during major rip-outs in non-nuclear vessels.

Construction

New Construction. Although concerns about the potential health hazards of asbestos exposure have curtailed its use substantially in recent years, a number of asbestos materials are still used in new construction. These products include A/C pipe and sheet, vinyl/asbestos floor tile, and asphalt roofing felts and coatings.

A/C Pipe. In a study [Exhibit 84-279] performed in 1977 for the A/C Pipe Producers Association, Equitable Environmental Health, Inc., (EEH) collected short-term personal samples to evaluate exposure during various operations that might be performed in the field on A/C pipe, using different types of equipment. For example, while unloading pipe at the site and laying pipe in the trench, the highest TWA concentrations reported were 0.03 f/cc and 0.02 f/cc, respectively. These data suggest that there is little potential for exposure in these operations and that no specific controls are necessary to keep exposures below the 0.2 f/cc PEL.

When installing A/C pipe, however, it may be necessary to cut, machine, or tap the pipe at the work site, which may expose workers to airborne asbestos fibers. Although the current trend is for more of these activities to be performed by the manufacturer rather than in the field [Exhibit 333, Sections G,O,Q], cutting and machining are associated with potentially high exposures. Joe Jackson of the Association of A/C Pipe Producers (AACPP) noted, however, the feasibility of installing A/C pipe with exposures below the PEL of 0.2 f/cc. In pre-hearing written testimony he stated as follows:

> Workers following AACPP's recommended work practices could almost always ensure that they would avoid peak exposures in excess of 0.75 f/cc over 15 minutes, while eight-hour time-weighted average exposures would remain at 0.1 f/cc or below. [Exhibit 91-16, Section 0, p. 12.]

Based on the EEH study, OSHA has determined that these exposures can be controlled to levels under 0.1 f/cc through the use of shrouded or doty tools. Thus, the Agency has determined that it is feasible to comply with the 0.2 f/cc PEL during the installation of A/C pipe.

A/C Sheet. In new construction activities, the installation of A/C sheet may require sawing, drilling, or sanding operations, Much of this activity, however, is performed by primary and secondary manufacturers, thereby reducing the need for additional fabrication in the field.

For on-site fabrication that does occur, the use of tools fitted with local exhaust shrouds connected to a HEPA vacuum have been demonstrated to reduce concentations significantly [Exhibits 312–A and 298]. TWA exposures during the installation of A/C sheet have been reported to be below 0.2 f/cc, even for drilling and cutting [Exhibit 84–474, Appendix A]. In fact, some studies reported only from 40 percent to 50 percent of the measurements above concentrations of 0.1 f/cc [Exhibits 308 and 333, Section R]. Thus, OSHA has determined that it is feasible to meet a PEL of 0.2 f/cc through the use of engineering controls during the installation of A/C sheet.

Vinyl/Asbestos Floor Tile. In four studies [Exhibit 84–474, p. 314] performed for the Resilient Floor Covering Institute, personal breathing zone samples were collected to evaluate worker exposures during various installation and removal operations for both sheet vinyl floor covering and vinyl-asbestos floor tile. The results indicated that TWA airborne fiber concentrations ranged from below detectable (less than 0.01 f/cc) to 0.10 f/cc during the installation of sheet vinyl, and from below detectable to 0.03 f/cc during the installation of vinyl-asbestos floor tile. In another study, Dunnigan and Lebel [Exhibit 84–474, p. 3.14] reported TWA concentrations below detectable levels for the installation of vinyl-asbestos floor tile.

When installing a new floor, it is often necessary to first remove the old tile or sheet vinyl floor covering. The data obtained [Exhibit 84–474, p. 314] indicate that when the recommendations of the Resilient Floor Covering Institute (e.g., wet sweeping and handling, and prohibiting powersanding and blowing asbestos dust) were followed, average TWA airborne fiber concentrations were below the 0.2 f/cc PEL during the removal of the old floor. Thus, OSHA determined that it is feasible to comply with the 0.2. f/cc PEL during the removal and installation of vinyl/asbestos flooring.

Asphalt Roofing Felts and Coatings. Asbestos roofing felts are composed of approximately 85 percent chrysotile asbestos, saturated with tar or asphalt. During installation, the roofing felts are cut to length with knives and are attached to the roof with nails. Asphalt is then applied over the felts. The removal of roofing felts generally requires chopping (with an axe) or sawing (with a circular mounting on wheels) the existing roof membrane into pieces that can be pried or scraped from the the deck. Because the asbestos fibers are encapsulated with tar or asphalt during the production of the felt, the fiber release during installation and removal is expected to be relatively low.

In written testimony, Eric Wormser of Gibson-Homans emphasized that during the "tear-off" of an old roof, "there still is no asbestos exposure since asbestos fibers in any old coating or cement are encapsulated in the product" [Exhibit 91–16, Section K, p. 6]. Nevertheless, as the condition of the roof deteriorates due to age and exposure to the elements, the quantity of asbestos fibers released will increase. This is clearly shown in studies conducted by Johns-Manville, and reported by GCA Corporation [Exhibit 84–474, p. 3.17]. Personal breathing zone and area samples were collected at 11 separate construction sites to evaluate worker exposure to asbestos during the removal and subsequent replacement of old roofing. The results indicated TWA airborne fiber concentrations as high as 0.60 f/cc during the installation of roofing felts, with a mean concentration of 0.22 f/cc. Thus, engineering controls and work practices may not reduce exposures below the 0.2 f/cc PEL in all cases and respirators will be required during some roofing projects.

Asbestos Abatement. Because of the concerns about potential health hazards, many building owners and managers, as well as industrial firms, are performing asbestos abatement projects to prevent or reduce the potential for fiber release. Generally, these involve either removal (with or without replacement using a non-asbestos substitute), encapsulation with a polymeric coating, or enclosure. In recent years, many contracting firms have been formed that specialize in asbestos abatement.

In general, asbestos removal involves one of two categories of products: (1) Spray-on or trowel-applied fireproofing or acoustical plasters; and (2) insulation of pipes, boilers, or process equipment. In removing asbestos, a widely used practice is to wet the material to be removed, usually with water having a surfactant added to enhance penetration [Exhibit 84–474, p. 3.22]. The use of vacuums equipped with HEPA filters, or wet mopping are the preferred methods of clean up.

In written testimony, Suzanne Kossan of the International Brotherhood of Teamsters gave evidence to support the effectiveness of wet methods, when she stated the following:

> Of over 7,000 air samples gathered [in 1983] at Maryland construction sites, approximately one-half of the samples showed asbestos exposure levels less than 0.1 f/cc, 8-hour TWA. [Exhibit 223, p. 3].

The data by T. Joel Loving of the University of Virginia [Exhibit 84–474, p. 3.23] show that although wet methods are effective in reducing exposures to below the current PEL of 2.0 f/cc during asbestos removal, 47 percent of the observations exceeded 0.5 f/cc, and a total of 59 percent exceeded the 0.2 f/cc PEL. The Loving report also summarized similar data from other investigators.

The data from Clayton Environmental Consultants, Inc. [Exhibit 84–474, p. 3.27] for the removal of fireproofing and acoustical plastics using both wet methods and a HEPA vacuum, for example, show eight short-term exposures ranging from below detectable to 170 f/cc. In fact, of 255 personal samples collected, 79 percent exceeded the 0.2 f/cc PEL. Joseph Durst, Jr., of United Brotherhood of Carpenters and Joiners of America, acknowledged the difficulty of reducing exposure levels during abatement projects and stated as follows:

> Although exposures could be brought down to the level of 500,000 to one million fibers/m^3 [through the use of wet methods and engineering controls], exposures below 100,000 fibers/m^3 may be difficult to achieve in some cases. In those cases personal protective equipment will be necessary and would be the only feasible way to reduce exposures to below safe levels. [Exhibit 143, p. 4.]

Thus, on the basis of these data, OSHA has determined that engineering controls cannot routinely reduce exposures below the 0.2 f/cc PEL during major asbestos removal projects and that the supplemental use of respirators may be required.

For minor removal projects, where small amounts of asbestos are removed, OSHA has determined that the 0.2 f/cc PEL is feasible. For example, data supplied by Clayton Environmental Consultants, Inc., indicate that 8-hour TWA exposures during the removal of preformed pipe insulation from process pipe at petroleum refineries using wet methods, range from less than 0.01 f/cc to 0.57 f/cc with a geometric mean value of 0.09 f/cc [Exhibit 84–474, Table 3.10]. OSHA assumes that smaller jobs would be associated with such lower TWAs (due to the shorter duration of exposure). In addition, "glove bags" are available for certain types of jobs. In 15 area samples collected during the removal of asbestos from steam pipes while using glove bags [Exhibit 84–474, Table A–2], TWA concentrations ranged from below detectable (less than 0.1 f/cc) to 0.02 f/cc. These data demonstrate that glove bags can reduce airborne fiber concentrations to below the 0.2 f/cc PEL.

Encapsulants are still being used in many asbestos abatement projects. Encapsulants are water-soluble latex products that are sprayed on to asbestos materials to bind and prevent the release of asbestos fibers. An encapsulant may either be a bridge, which forms a film over the surface of the insulation material, or a penetrant, which soaks at least partially through the fiber matrix. By its nature, encapsulation, when applied by an experienced professional, does not normally involve high fiber release. In personal samples collected by Clayton Environmental during the application of both bridging and penetrating encapsulants, TWA concentrations, however, ranged from 0.03 f/cc to 0.28 f/cc, with a geometric mean of 0.17 f/cc. Thus, with the majority of samples below 0.2 f/cc, OSHA believes that it is generally feasible for this sector to comply with the 0.2 f/cc PEL during encapsulation work, although respirators may be needed on some projects.

Renovation/Remodeling of Existing Structures. Asbestos has been used widely in construction until the mid-1970s when certain applications were curtailed by the Environmental Protection Agency (EPA). As a result, substantial amounts of asbestos materials are present in numerous buildings that were constructed in earlier years.

In addition to the uses in new construction described above, materials containing asbestos are used for pipe and boiler insulation, fireproofing, drywall tape and spackling, and acoustical plasters. Consequently, such materials are present in office buildings, schools, hospitals, residential buildings, industrial facilities, power plants, etc. that were built in earlier years.

In renovation projects, workers indirectly involved with asbestos products may be exposed inadvertently by disturbing these materials [Exhibit 207]. For example, in multistory buildings where beams and/or decking are covered with asbestos fireproofing, electricians, pipefitters, telephone installers, or workers who repair heating ventilation and air-conditioners may be exposed to appreciable concentrations of asbestos fibers when working above suspended ceilings. This exposure may result from direct contact with the fireproofing, or from the disturbance of settled fibers from various surfaces above the ceiling (i.e., existing pipe, ductwork, or drop ceiling tiles).

In personal samples collected in office buildings and schools, [Exhibit 84–474, p. 3.31] Clayton Environmental Consultants measured TWA exposures ranging from 0.02 f/cc to 1.4 f/cc, with a geometric mean of 0.14 f/cc, while workers were removing drop ceiling tiles from the ceiling tract. The results of the samples collected in the breathing zones of electricians, pipefitters, and heating, ventilation, and air-conditioning (HVAC) workers indicated geometric mean TWA concentrations of 0.11 f/cc, 0.12 f/cc, and 0.14 f/cc, respectively [Exhibit 84–474, Table A–12]. The highest value measured was 2.8 f/cc for an HVAC worker. In each case, wet methods were employed for any direct contact with asbestos material, and HEPA vacuums were used for clean-up. These values are consistent with OSHA inspection data [Exhibit 84–474, Table A–11].

A variety of other activities may also involve the disturbance of asbestos materials and the subsequent exposure of renovation workers. For example, carpenters and drywallers may install new walls which, if attached to beams covered with fireproofing, may result in exposure. The results of samples collected by Clayton Environmental Consultants, Inc., indicate geometric mean TWA concentrations of 0.16 f/cc for carpenters and 0.41 f/cc for drywallers. Personal samples taken by the Argonne National Laboratory during similar activities showed TWA concentrations ranging from 0.35 f/cc to 0.87 f/cc using wet methods and HEPA vacuums [Exhibit 84–474].

OSHA has determined that engineering controls (such as negative-pressure enclosures and vacuums) are generally effective in limiting exposures after asbestos containing materials have been disturbed, but that workers who actively disturb these materials will probably require respiratory protection to comply with the 0.2 f/cc PEL.

Routine Facility Maintenance. Routine maintenance and repair activities may also involve the disturbance of asbestos materials and products, as described in the industry profile. Such activities include the repair of leaking steam pipes in buildings and the adjustment of HVAC equipment above suspended ceilings.

TWA exposures ranging from 0.02 f/cc to 1.4 f/cc have been measured in personal samples collected during the removal of drop ceiling tiles. In data reported by Paik and coworkers [Exhibit 207], the average concentrations during routine maintenance activities ranged from 0.9 f/cc to 1.4 f/cc.

In samples collected by Clayton Environmental during the inspection and repair of HVAC equipment near asbestos insulation materials, TWA concentrations ranged from 0.04 f/cc to 0.9 f/cc, with a geometric mean of 0.21 f/cc [Exhibit 308, Table A–14]. Results consistent with these findings were also reported by Argonne National Laboratory during maintenance activities where wet handling was used, when possible, and where HEPA vacuums were used [Exhibit 298].

These data demonstrate a potential for exposure of maintenance personnel to concentrations exceeding 0.5 f/cc. With the exception of wet handling, which is feasible in only very limited situations due to problems such as electrical wiring, and the use of HEPA vacuums for the clean-up of any debris generated during maintenance activities, OSHA believes that there does not appear to be any feasible engineering controls or work practices available to reduce these potential exposures to levels below the 0.2 f/cc PEL and that respirators will be required to comply with the 0.2 f/cc PEL.

Demolition. Demolition of all or part of a building or industrial facility that contains asbestos would also be likely to cause a disturbance of asbestos materials.

Under current EPA regulations (40 CFR Part 61, Subpart M, National Emission Standard for Asbestos), demolition is defined as the "wrecking to taking out [SIC] of any load-supporting structural member of a facility together with any related handling operations." EPA requires that friable asbestos materials be removed from buildings or industrial facilities prior to wrecking or dismantling the structures. Presuming compliance with the EPA regulation, the only potential for exposure would be during the removal of such materials before demolition. The feasibility of compliance with the 0.2 f/cc PEL for asbestos removal was discussed previously. The demolition project at the National Press Building in Washington, D.C., further illustrates this feasibility. During this project, work practices were so effective in limiting exposure levels that asbestos levels were higher outside the building than inside where the demolition was occurring. Although no personal samples were taken, areas samples in work activity zones revealed average exposure levels below 0.1 f/cc [Exhibit 268].

Conclusion

OSHA has determined that compliance with the 0.2 f/cc PEL is feasible in most industries most of the time through the use of wet methods, engineering controls, and good housekeeping practices. There are some operations, however, for which compliance through the use of engineering controls and work practices alone does not appear achievable at this time. These situations are usually due to the inability of the operation to use wet methods (e.g., some textile operations, nuclear rip-out, some building repair etc.), or due to space limitations, (e.g., maintenance and major rip-outs on ships) and the volume of dust generated (e.g., cutting coupling operations for A/C pipe and sanding A/C sheet). During these operations, therefore, respiratory protection must also be used to comply with the 0.2 f/cc PEL. Finally, engineering controls are needed even when immediate exposures exceed 0.2 f/cc, however, because they protect workers in neighboring areas from being exposed over the PEL.

Benefits

The inhalation of asbestos fiber has been clearly associated with three clinical conditions: asbestosis, mesothelioma (a cancer of the lining of the chest or abdomen), and lung cancer. Many studies have also observed increased gastrointestinal cancer risk. Risk from cancer at other sites, such as the larynx, pharynx, and kidneys, is also suspected.

Initial exposure limits for asbestos were based on efforts to reduce asbestosis which was known to be associated with asbestos exposure. The reduction in the number of cases of asbestosis, however, resulted in workers living long enough to develop cancers that are now recognized as associated with asbestos exposure. The following discussion of the benefits associated with a reduction in exposures, therefore, focuses on the number of cancer cases avoided within the exposed work force. The results are expressed in terms of deaths avoided because these cancers almost always result in death.

The benefits of a reduction in the PEL depend upon current exposure levels, the number of workers exposed, and the risk associated with each exposure level. The current ambient air levels estimated by OSHA and the estimated number of workers exposed to asbestos are presented in Tables 22 through 23. Based on the Agency's economic and feasibility analyses, OSHA estimated the new exposure and employment levels that would resut from the promulgation of the revised 0.2 f/cc PEL. These are also presented in Tables 22 and 23. The lifetime risk of three kinds of cancer (lung cancer, mesothelioma, and gastrointestinal cancer) was estimated by OSHA for 1 year of exposure and is presented in Section VI of this preamble.

TABLE 22.—ESTIMATES OF OCCUPATIONAL EXPOSURE TO ASBESTOS IN GENERAL INDUSTRY FOR 1984

Industry segment	Current 2.0 f/cc		Proposed 0.2 f/cc	
	No. of exposed workers	Level of exposure (f/cc)	No. of exposed workers	Level of exposure (f/cc)
Primary manufacturing:				
Asbestos/cement pipe	512	0.12	512	0.02
Asbestos/cement sheet	203	.69	159	.13
Friction materials	5,104	.68	4,801	.11
Textiles	413	.37	405	.03
Floor tile	276	.06	276	.06
Gaskets and packings	315	.37	306	.07
Paper	387	.13	380	.03
Coating and sealants	1,327	.31	1,327	.06
Plastics	324	.28	322	.05
Secondary manufacturing:				
Asbestos/cement sheet	345	.45	345	.07
Friction products	1,504	.27	1,458	.10
Gaskets and packings	9,972	.08	8,741	.02
Textiles	172	.59	170	.05
Plastics	2,450	.10	2,420	.04
Automotive remanufacturing	4,750	.19	4,669	.03
Services:				
Automotive repair	526,998	.06	526,998	.01
Shipbuilding and repair	15,000	.27	15,000	.02

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis. Based on the analysis precented in Appendix G of the RIA.

TABLE 23.—ESTIMATES OF EXPOSURE TO ASBESTOS IN THE CONSTRUCTION INDUSTRY: 1984 [1]

Industry segment	Current 2.0 f/cc		Proposed 0.2 f/cc	
	No. of full-time equivalent workers	Level of exposure (f/cc) [2]	No. of full-time equivalent workers	Level of exposure (f/cc)
New construction:				
Asbestos/cement pipe	1,415	0.035	1,415	0.035
Asbestos/cement sheet	1,225	.130	1,225	.10
Built-up roofing installation	1,375	.220	1,375	.022
Asbestos abatement:				
Asbestos removal	3,820	.140	3,820	.021
Asbestos encapsulation	453	.220	453	.022
Demolition	3,163	.061	3,163	.001
General building renovation:				
Drywall demolition	51,300	.340	51,300	.003
Built-up roofing	10,990	.120	10,990	.012
Routine maintenance in commercial and residential buildings:				
Repair/replace ceiling tiles	895	.450	895	.045
Repair/adjust ventilation/lighting	2,688	.310	2,688	.006
Other work above drop ceiling	385	.310	385	.006
Repair plumbing/boiler	2,854	.180	2,854	.018
Repair roofing	3,073	.120	3,073	.012
Repair drywall	4,618	.750	4,618	.075
Repair flooring	18,430	.020	18,430	.020
Routine maintenance in general industry:				
Gasket removal and installation	768	.090	768	.080
Removal of pipe and boiler insulation	653	.123	653	.025
Miscellaneous activities	612	.294	612	.029

[1] Based on the determination that there is a large group of construction workers who are exposed to asbestos infrequently throughout the year. This analysis converts the number of workers to the full-time equivalents (i.e., the number of workers that would be exposed for the full 1-year period).

[2] These exposure levels were estimated based on the assumption that the least costly respirator will be used. If supplied-air respirators are used, as is assumed in the cost analysis, then the exposures will be lower.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis. Based on the analysis presented in Appendix G of the RIA.

Based on these risk assessments, OSHA estimated the deaths resulting from these three types of cancer, given current exposures.[2] These estimates are

[2] Given the nature of the construction industry, many workers are exposed intermittently throughout year. In order to estimate the cancer deaths, full-time equivalents were used—that is, two workers exposed for one-half year each would total one full-time equivalent.

presented in Table 24. OSHA estimates that by reducing the PEL from the current 0.2 f/cc level to 0.5 f/cc, approximately 33 cancer deaths per year will be prevented, and by reducing the PEL to 0.2 f/cc, approximately 75 cancer deaths per year will be prevented. Estimates of the number of cancer deaths avoidable by reducing exposures to the 0.2 f/cc PEL in each major industry sector are presented in Table 25. These estimates were based on the revised employment and exposure estimates presented in Tables 22 and 23. The estimated 75 cancer deaths avoided by reducing the PEL from 2.0 f/cc to 0.2 f/cc understates the true benefits of the revised standard because these benefits do not include the reduced incidences of asbestosis-related disabilities nor the reduced incidence of asbestos-related diseases in groups indirecty exposed in the workplace.

Based on the analysis of existing studies, which are summarized in the Health Effects Section of this Notice, OSHA estimates that reducing the PEL to 0.2 f/cc would prevent 30 cases of disabling asbestosis. As these cases represent disabilities and not deaths, they were not included in the total estimated benefits. As such cases would result in potential costs to society (e.g., health care, lost worker productivity, and a decline in the quality of life to the affected individual), their prevention does have a positive value.

TABLE 24.—EXPECTED DEATHS ATTRIBUTABLE TO 1 YEAR OF OCCUPATIONAL ASBESTOS EXPOSURES AT 1984 LEVELS

Industry	Total cancer deaths
Primary manufacturing:	
A/C pipe	0.07
A/C sheet	.16
Textiles	4.00
Floor tile	.18
Gaskets and packings	.02
Paper	.13
Coatings and sealants	.06
Plastics	.48
Secondary manufacturing:	
A/C sheet	.18
Friction materials	.65
Gaskets and packings	.88
Textiles	.12
Plastics	.29
Automotive remanufacturing	.90
Services:	
Automotive repair	39.25
Ship repair	4.61
Construction:	
New construction	.61
Asbestos abatement	.76
Demolition	.23
Building renovation	22.49
Routine maintenance in commercial and residential buildings	11.23
Routine maintenance in general industry	.39
Total	87.80

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

TABLE 25.—EXCESS CANCER DEATHS AVOIDED DUE TO REDUCING THE PERMISSIBLE EXPOSURE LIMIT TO 0.2 F/CC FOR 1 YEAR

Industry	Total cancer deaths avoided
Primary manufacturing:	
A/C pipe	0.06
A/C sheet	3.14
Friction products	3.39
Textiles	3.16
Floor tile	.01
Gaskets and packings	.12
Paper	.04
Coatings and sealants	.39
Plastics	.09
Secondary manufacturing:	
A/C sheet	.16
Friction materials	.48
Gaskets and packings	.70
Textiles	.11
Plastics	.17
Automotive remanufacturing	.74
Services:	
Automotive repair	30.15
Ship repair	4.28
Construction:	
New construction	.36
Asbestos abatement	.66
Demolition	.23
Building renovation	22.15
Routine maintenance in commercial and residential buildings	9.80
Routine maintenance in general industry	.34
Total	74.72

Source: U.S. Department of Labor, OSHA, Office Regulatory Analysis.

Similarly, OSHA's analysis does not quantify benefits among those incidentally exposed. Many construction workers, for example, can be exposed to asbestos while present at sites where asbestos work is being done. Since OSHA's revised asbestos standard will reduce ambient asbestos levels at these sites, exposure among these workers will also be reduced. In addition, OSHA's analysis does not take into account any reductions in the exposures to the families of asbestos workers. For example, there have been reports of family members contracting asbestos-related diseases by laundering workers' clothing [Exhibit. 608X, pp. 8–10; 606X, p. 40]. These types of exposures among family members would be reduced as a result of the final rule.

Summary of Estimated Costs Associated With the Revised Standard

Introduction

The revised OSHA asbestos standard will result in increased costs to society due to a number of factors. Suppliers of asbestos products (i.e., primary and secondary manufacturers) will generally experience increased costs to comply with the new regulation and they will attempt to pass on these higher costs in the form of higher product prices. Consumers should respond to the price increases by demanding fewer asbestos-related products which, in turn, will have a negative impact on the revenues of producers. Asbestos-consuming sectors, including construction and secondary fabricators, will incur higher operating costs both because they must comply with the standard, and because they must pay higher prices to purchase inputs produced by other sectors that also must comply with the standard. Some sectors may face lower prices for certain goods (e.g., asbestos fiber), because of declines in demand that are expected to occur as a result of the standard.

OSHA estimated the costs associated with these effects in three ways. First, the compliance cost for each industry sector was estimated without considering the impact from other sectors. Second, the resultant cost increases were then entered into a multimarket economic model, which simultaneously estimated the new equilibrium price and output levels across sectors. Third, the cost increases on affected producers and consumers were identified.

Compliance Costs (Assuming No Price or Quantity Changes)

OSHA estimated that the total annual compliance costs for all affected industries will be approximately $460 million. The compliance costs for each of the major industry groups are $27.8 million for primary manufacturers; $30.8 million for secondary manufacturers; $44.7 million for automotive repair, $3.9 million for ship repair; and $352.0 million for construction.

The preponderance (i.e., over 95 percent) of the compliance costs for general industry result from engineering controls (ventilation and solvent spray). In fact, the cost of engineering controls is the major cost item for all sectors except A/C pipe manufacturing and ship repair.

Over 60 percent of the compliance costs for construction result from vacuums and respirators. The respirators will be used to protect those employees performing the work, and the vacuum will be used to clean the work area so that others are not exposed after the job is completed. The specific methodology used to calculate these estimates is presented below.

Primary Manufacturing, Secondary Manufacturing, and Service Sectors

OSHA estimated the compliance costs for general industry and service sectors using a model plant approach. The models were developed by RTI for each major product line in primary and secondary manufacturing, automotive brake and clutch repair, and shipyards. Model plant sizes were selected based on data obtained from the RTI survey [Exhibit 84–473]. After the model plants were developed for each industry segment, the total number of employees in the segment was used to compute the number of model plants needed to describe the segments (e.g., if total employment in a segment was 1,000 and average employment per plant was 100, then the estimated number of plants was 10). The distribution of sizes and all other attributes of the model plants were based on information contained in the RTI Phase I Report [Exhibit 84–473].

While none of the comments received by the Agency disputed the use of RTI's model plant approach, OSHA believes that some critical comments reflected a misunderstanding of RTI's methodology. For example, in their post-hearing comments, the Asbestos Information Association or North America criticized the estimates for the numbers of workers exposed for some model plants in the impacted sectors [Exhibit 312A, Tab N]. This misunderstanding appears to arise from the fact that the model plants do not represent typical plants in each sector. By design, the model plant approach describes the average state of the existing engineering controls and ancillary measures within a particular industry segment. Thus, in most cases, the number of model plants calculated by RTI to represent the industry does not equal the actual number of plants in the industry, and the number of workers at each model plant does not equal the typical number of workers at a typical plant. Although the number of model plants in an industry may differ from the actual number of plants, the aggregated compliance cost estimates that are based on the level of existing engineering controls present in a model plant should be accurate.

Other comments received by the Agency questioned the unit cost estimates used by RTI (see Exhibit 84–273, Table 4–1). OSHA has carefully reviewed these comments and has revised many of the unit cost estimates in the RTI model. Thus, although OSHA used a similar approach to the one presented by RTI, OSHA's industry cost estimates differ from those developed by RTI. Table 26 presents the unit cost estimates used by OSHA in its analysis.

From this information and the Agency's Technological Feasibility Analysis, OSHA developed a compliance strategy for each size and type of model plant. (Another source of differing cost estimates between OSHA and RTI are the differences in the feasibility analysis.) Finally, the costs for each type of plant were calculated based on the estimated compliance levels, and the costs to each industry sector were estimated by aggregating the per plant costs. Table 27 presents OSHA's estimates of the annual compliance costs for the individual industry sectors.

Table 28 presents OSHA's estimates of the cost to revenue ratios for the 17 primary manufacturing, secondary manufacturing, and service sectors. The compliance costs for each sector were obtained directly from Table 27 and the revenues for each sector were obtained from Table 5–5 of the RTI report [Exhibit 84–473]. As can be seen from the Table V, the cost-to-revenue ratios for 14 of the 17 sectors are below 2 percent with most below 0.5 percent. In three sectors (i.e., the manufacturing of primary and secondary asbestos friction products and the manufacturing of primary asbestos-reinforced plastics), the ratios are between 2 and 5 percent. Ratios of this magnitude indicate that these sectors may have some financial difficulty in complying with the requirements of the revised standard if the costs cannot be passed through to consumers in the form of higher prices. Nevertheless, OSHA believes these firms would avoid major disruptions by switching to the production of non-asbestos products.

TABLE 26.—ITEM COST ESTIMATES FOR CONTROL REQUIREMENTS IN PRIMARY MANUFACTURING, SECONDARY MANUFACTURING, AND SERVICE SECTORS

Item	Unit cost (1984 dollars)	Comments used to develop estimate
Local exhaust ventilation.	Related to CFM needed.	Exhibit 84-473 and 312a, Tab N, and transcript of July 9, 1984, page 204.
Lunch rooms, shower rooms and change rooms.	Related to Area needed.	Exhibit 84-473.
Caution tape	$6.00/sign	Exhibits 84-473, 84-474, and 179.
Suits of protective clothing.	$3.00/suit	Exhibits 84-473, 84-474, and 179.
Half-Mask cartridge respirator:		
Units	$14.05/unit	Exhibits 84-473, 84-474, 123A, 179 and 330.
Filters	$6.15/filter pair	
Powered-Air purifying respirator:		
Units	$415.00/unit	Exhibits 84-473, 84-474, 123A, 179 and 330.
Accessories (filter and battery).	$25.00/set	
Solvent spray	$1.75/can	OSHA telephone survey.
HEPA vacuums:		
Units	$1,000.00/unit	Exhibits 84-473, 84-474, 179 and 272.
Filter	$350.00/filter	
Exposure monitoring:		
Sampling	$300.00/technician/day.	Exhibits 84-473, 84-474, 179, 312A, 256, and 272; Hearing transcript of July 11, 1984, pages 898 and 892; hearing transcript of June 29, 1984, page 116.
Analysis	$30.00 per sample.	
Medical exams	$100.00 per exam	Exhibits 84-473, 84-474, 179, 123A, and 272; hearing transcript of July 2, 1984, pages 53 and 253, and hearing transcript of June 29, 1984, page 117.
Training	Based on wage rate and time.	Exhibits 84-473, and 84-474; transcript of June 20, 1984, page 179; transcript of June 29, 1984, page 201 and transcript of July 11, 1984, page 89.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

TABLE 27.—ANNUAL COMPLIANCE COSTS

[No price or quantity changes]

Industry sector	Annual compliance costs (in thousands of 1984 dollars)	Most expensive provision	Annual cost of the most expensive provision as a percentage of annual compliance costs
Primary manufacturing:			
A/C pipe	68.2	Vacuums	97
A/C sheet	642.8	Ventilation	91
Friction materials	22,661.3	do	91
Textiles	811.2	do	96
Floor tile	305.1	do	75
Gaskets and packings	758.8	do	83
Paper	834.8	do	81
Coatings and sealants	1,223.9	do	55
Plastics	474.6	do	86

TABLE 27.—ANNUAL COMPLIANCE COSTS—Continued

[No price or quantity changes]

Industry sector	Annual compliance costs (in thousands of 1984 dollars)	Most expensive provision	Annual cost of the most expensive provision as a percentage of annual compliance costs
Secondary manufacturing:			
A/C sheet	1,260.6	......do	71
Friction materials	12,722.3	......do	94
Gaskets and packings	5,553.3	......do	82
Textiles	696.6	......do	45
Plastics	4,675.8	......do	72
Automotive remanufacturing	5,870.6	......do	75
Service and repair:			
Automotive repair	44,654.7	Solvent spray.	100
Ship repair	3,918.8	Change rooms.	51
Construction: [1]			
New Construction	7,578.0	Tools	32
Asbestos abatement	27,870.0	Respirators	87
Demolition	13,610.5	Vacuums	36
Renovation	144,695.5	Protective clothing.	29
Routine maintenance in commercial and residential buildings	112,749.3	Vacuums	50
Routine maintenance in general industry	45,450.0	......do	74
Total	[2] 459,086.1		

[1] OSHA assumes that all construction workers exposed above the PEL in negative-pressure regulated areas will use supplied-air respirators in order to avoid the costs associated with daily monitoring.
[2] Total may not sum due to rounding error.

Source: U.S Department of Labor, OSHA, Office of Regulatory Analysis.

TABLE 28.—ECONOMIC FEASIBILITY IN THE PRIMARY MANUFACTURING, SECONDARY MANUFACTURING AND SERVICE SECTORS

Industry Sector	Compliance costs (millions) dollars in	Gross revenue (millions) dollars in	Costs/revenue (percent)
Primary Manufacturing:			
A/C pipe	0.068	69.0	0.10
A/C sheet	.643	82.8	.78
Friction materials	22.661	686.4	3.30
Textiles	.811	41.4	1.96
Floor tiles	.305	95.1	.32
Gaskets and packings	.759	84.0	.90
Paper	.835	356.4	.23
Coatings and sealants	1.224	468.0	.26
Plastics	.441	12.8	3.71
Secondary Manufacturing:			
A/C sheet	1.059	317.4	.40
Friction materials	12.382	592.8	2.15
Gaskets and packings	5.553	1,156.0	.48
Textiles	.697	703.8	.10
Plastics	4.676	784.0	.60
Automotive remanufacturing	5.871	1,225.0	.48
Service and repair			
Automotive repair	44.655	228,150.4	.02
Ship repair	3,918.5	2,667.1	.15

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

Construction

The compliance costs for the construction industry were estimated in a manner similar to that used for the manufacturing and service sectors. The initial step was to identify the required equipment and procedures. Based on the industry feasibility analysis, the construction industry was divided into six major subparts including new construction, abatement, demolition, renovation, routine maintenance in commercial and residential buildings, and routine maintenance in general industry. OSHA determined the specific controls necessary to meet the requirements of the revised standard for each of these subparts. Different construction activities require different control practices and/or combinations of these practices. The unit cost estimates for these control practices shown in Table 29 were obtained from comments in the record and from information presented in the studies by CONSAD [Exhibit 84–747] and RTI. Finally, the extent to which protective controls are currently utilized was considered when calculating the annual compliance costs. These costs are presented at the bottom of Table U.

Based on these costs, OSHA believes that only the demolition sector may experience financial difficulty in complying with the requirements of the revised standard. According to the August 1985 edition of the Construction Report "Value of Construction in Place," the net value of new construction in 1984 was $312.988 billion in 1984 dollars. Given estimated annual compliance costs of less than $10 million for new construction, the cost to revenue ratio is less than 0.1 percent. Thus, OSHA has determined that it is economically feasible for this sector to comply.

The preponderance of the compliance costs for construction (81 percent) are associated with abatement, renovation, and routine maintenance (i.e., $285.3 million). According to the April 1985 edition of Construction Reports "Residential Alterations and Repair," the total value of maintenance and repair activities in 1984 was about $23.784 billion in 1977 dollars (i.e., $38.929 billion in 1984 dollars). The estimated annual compliance cost-to-revenue ratio in these sectors combined is estimated to be approximately 0.7 percent. Thus, OSHA has determined that it is economically feasible for these sectors to comply.

TABLE 29.—ITEM COST ESTIMATES FOR CONTROL REQUIREMENTS IN CONSTRUCTION

Item	Unit cost (in 1984 dollars)	Comments used to develop estimates
Engineering controls		Exhibit 84–474.
Shrouded tools with HEPA vacuums:		
Vacuums (for one drill and one saw) & accessories.	5,475	
Filters	648	
Glove bag	10.48/bag	
HEPA vacuums:		
Unit and accessories	1,341/unit	Exhibits 84–473, 84–474, 179 and 272.
Filters	408/filter	
Regulated areas:		
Non-negative pressure:		
Signs	0.14/sign	Exhibits 84–473, 84–474 and 179
Tape	44.84/roll	
Negative pressure:		
HEPA ventilation systems:		
Unit and accessories	2,750/unit	Exhibits 84–474, 179 and 272.
Filters	178/filter	
Enclosures and signs	448/enclosure	
Decontamination areas:		
Rental of remote units	33.00/per day	Exhibits 84–474 and 330, and hearing transcript of June 29, 1984, page 204.
Assembly of adjacent unit	500.00/per unit	
Half-mask supplied-air:		
Respirators:		
Respirator and accessories.	276.25/unit	Exhibits 84–473, 84–474, 123A, 179 and 330.
Compressor (for 2 masks).	1,000.00/compressor.	
Suit of protective clothing	3.00/suit	Exhibit 84–473, 84–474 and 179.

TABLE 29.—ITEM COST ESTIMATES FOR CONTROL REQUIREMENTS IN CONSTRUCTION—Continued

Item	Unit cost (in 1984 dollars)	Comments used to develop estimates
Exposure monitoring:		
Sampling	300.00/ techinician/day	Exhibits 84-473, 84-474, 179, 312A, 256 and 272; and hearing transcript of July 11, 1984, pages 89, 92, 137 and 185-192, and June 29, 1984 page 117.
Analysis	30.00/per sample.	
Medical exams	100.00/per exam	Exhibits 84-473, 84-474, 123A, 256 and 272; and hearing transcript of July 2, 1984, pages 52 and 253, and June 29, 1984. page 117 and 204.
Training	Varies with type and duration of training.	Exhibits 84-473 and 84-474; hearing transcript of June 20, 1984, page 179; June 29, 1984, page 201 and July 11, 1984, page 89.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

OSHA's annual compliance cost estimate of $45.4 million for routine maintenance in general industry was developed based on the assumption that due to economies of scale, over 76,000 establishments would hire contract labor to perform activities such as the removal and installation of asbestos insulation and gaskets. Thus, although the total costs in this sector may appear large, the estimated average compliance cost to each establishment is less than $600 per year. Costs of this magnitude are clearly affordable.

According to the 1982 Census of Construction Industries, receipts for SIC 1795, Wrecking and Demolition, were $376.9 million (1982 dollars). Given the estimated annual compliance costs of $13.6 million (1984 dollars), the cost-to-revenue ratio in this sector is approximately 3.6 percent. Based upon this estimate, it appears that the demolition sector may have financial difficulty complying with the requirements of the revised standard. Demolition activity, however, is frequently associated with new construction and it is likely that any compliance cost increase for this segment of the construction industry will be shifted forward to the buyer.

Economic Impact and Regulatory Flexibility Analysis

Introduction

According to the RTI report, "An accurate assessment of the actual impacts depends on the supply and demand conditions facing each sector" [Exhibit 84–473, p. 52]. If an industry is characterized by inelastic demand, for example, then the industry can afford relatively high compliance costs (compared to revenues) because these costs can be passed on to consumers. Conversely, if an industry is characterized by an elastic demand and low profits, then it may not be able to afford even small increases in costs. In order to account for these factors, therefore, OSHA developed a partial equilibrium demand-supply model.

OSHA used the industry compliance cost estimates developed in the previous section, together with reasonable estimates of demand and supply elasticities, to examine the probable economic impacts of the revised standard on the affected industry groups. Impacts on the primary and secondary manufacturing sectors were derived from the Agency's demand-supply model. Impacts on the service industries and construction sectors were based on the methodology presented in the CONSAD report [Exhibit 84–474, Chapter 5] and on estimates of the economy's demand for the repair and construction services offered by these industries.

The application of this economic modeling indicates that the direct compliance costs of the standard, after accounting for new output levels, will be approximately $453.5 million per year. The compliance costs for each major industry group are estimated to be $27.3 million for primary manufacturing; $29.2 million for secondary manufacturing; $3.9 million for ship repair; $44.6 million for automotive repair; and $348.5 million for construction. Since these estimates account for the changes in output that the new standard will cause, they are technically more accurate than the estimates of total compliance costs (presented in the previous section) based on current output levels.

In order to estimate the total cost of the standard to the U.S. economy, OSHA added the excess burden (or dead weight loss) of the revised standard to the estimates presented above. The dead weight loss represents the lost value to buyers and sellers due to transactions that are currently taking place but will no longer take place after the implementation of the revised standard. For example, if the buyer formerly purchased 1,000 sheets of a product, those 1,000 sheets represent a value to the buyer at least as great as the price paid. If, as a result of a higher product price due to the revised standard, only 600 sheets are bought, then the buyer loses the benefit formerly received on 400 sheets. This is a loss to the buyers but it is a gain to no one (i.e., a dead weight loss to the U.S. economy). The sum of the direct compliance costs and the dead weight losses is the total social cost of the new standard (assuming negligible displacement costs). OSHA estimates that the dead weight loss will be approximately $1.7 million per year and the total annual social cost of the new regulation will be $455.2 million.

Primary and Secondary Manufacturing

Economic Impacts. In order to examine the effects of the regulation on producers of asbestos-containing products, OSHA calculated not only the compliance costs borne by suppliers but also the percentage change in profits of suppliers. This information is presented in Table 30. It is important to recognize that a decline in profit from manufacturing an asbestos-containing product does not translate into an identical decline in profit to the firm. Many asbestos producers also manufacture non-asbestos substitute goods, and, increased demand for these substitutes will partially offset declines presented in Table 30. For example, most automotive brake rebuilding shops can use non-asbestos parts. If a brake remanufacturing shop anticipates losses of $20,000 per year in profits as a result of the new asbestos standard, it could substitute non-asbestos brake parts. Thus, the results presented in Table 30 reflect the extent to which the manufacturing of asbestos products becomes more or less attractive to firms. It does not predict the complete effect on the profitability of firms switching to non-asbestos products.

As can be seen from Table 30, the model predicts that most of the sectors will experience only small changes in profits due to compliance with the provisions of the revised standard. In three sectors (i.e., primary A/C pipe, primary flooring, and secondary A/C sheet) profits are expected to increase due to a decline in the price of inputs, and in nine other sectors profits are expected to decline by less than 6 cents on the dollar. In only 3 out of the 15 modeled sectors (i.e., primary A/C sheet and friction products manufacturing and secondary asbestos gasket manufacturing) are profits expected to decline significantly.

TABLE 30.—PERCENTAGE CHANGE IN PROFITS OF SUPPLIERS AS A RESULT OF THE REVISED STANDARD

Industry sector	Percent change in profits
Primary manufacturing:	
A/C pipe	1.9
A/C sheet	−38.4
Friction materials	−11.5
Textiles	−3.7
Flooring	N/D
Gaskets	−5.5
Papers	−3.4
Coatings	−N/D
Plastics	−1.4
Secondary manufacturing:	
A/C sheet	2.5
Friction materials	−6.0
Gaskets	−23.2
Textiles	−2.4
Plastics	−2.5
Auto remanufacturing	−3.4

N/D=Not detectable.

Source: U.S. Department of Labor, OSHA, Office of Regulatory Analysis.

Profits are projected to decline by approximately 11.5 percent for primary friction products and by approximately 38 percent for the primary asbestos-cement sheet producers. These declines occur primarily because of a large reduction in demand for these products by consumers (i.e., these products are associated with highly elastic demand curves due to the availability of substitutes). For example, OSHA estimates that the costs to the construction industry of using A/C sheet would increase by about 40 percent as a result of the new standard. OSHA does not anticipate a major adverse impact on firms in these sectors, however, because firms can switch to the production of non-asbestos substitute products. Firms currently producing A/C sheet can shift some of their production to the manufacture of products such as glass-reinforced cement sheet, calcium silicate cement sheet, and polypropylene-layered cement sheet, and firms currently producing asbestos friction products can switch to the production of non-asbestos friction products.

A profit decline of 23 percent is also projected for secondary gasket manufacturers. This decline primarily results from the small volume of gaskets produced by most firms in this sector relative to the projected compliance costs. Most firms in the secondary asbestos gasket manufacturing sector primarily produce non-asbestos gaskets and only manufacture asbestos gaskets on an intermittent basis. In order to comply with the requirements of the revised standard, firms in this sector would have to make major capital investments in ventilation equipment. It may be unprofitable for firms to pay for this capital investment, however, given the current industry practice of only producing asbestos gaskets intermittently. Thus, OSHA anticipates that many firms in this sector will choose to forego this investment and shift production entirely to the manufacture of non-asbestos gaskets. This will concentrate the secondary manufacture of asbestos gaskets among fewer firms (289 firms currently compose this sector), each of which will have higher production levels and thus will be better able to afford the required capital expenditures.

Regulatory Flexibility. OSHA also considered the differential impacts of the revised asbestos standard on small businesses in primary and secondary manufacturing. Primary A/C pipe, sheet, textiles, floor tile, and friction products sectors, and the secondary friction products sector were omitted from this analysis because they are characterized entirely by medium and large firms. In addition, since secondary textiles and plastics are predominantly comprised of small firms, OSHA assumed that there will be no differential impacts in these sectors. Thus, OSHA's differential impact analysis focused on primary gaskets, paper, coatings and plastics, and secondary A/C sheet, gaskets, and automotive remanufacturing.

First, OSHA considered the relative magnitude of the profit declines in each sector (see Table 30). In those markets where profits do not decline significantly there will be no negative impact, and thus, OSHA assumed that there will also be no significant differential negative impact between small and large firms. Based on this analysis, OSHA determined that small firms in the primary asbestos coatings sector would assume a profit non-detectable decline, and that small firms in the secondary A/C sheet industry would assume an increase of 2.5 percent and therefore would not be at a competitive disadvantage. This leaves primary gaskets and paper, and secondary gaskets and automotive remanufacturing as markets in which significant differential impacts might occur.

Next, OSHA compared the differences in unit compliance costs between small firms and larger firms since a negative differential impact will obviously not occur in those markets in which there is no significant difference in unit compliance costs. The difference in unit compliance costs between small and medium-sized producers of primary gaskets is only $0.0023 per pound. This represents only 0.274 percent of the post-regulation price of primary gaskets. For primary paper, the difference in unit compliance costs between small and medium-sized firms is only $0.0021 per pound, a differential representing only 0.214 percent of the post-regulation price of primary paper. These are negligible differences.

In the automotive remanufacturing of asbestos-containing products, the compliance costs will increase the cost of production by less than 2 percent. Further, the difference in compliance costs per unit of output between small and medium-sized automotive remanufacturing firms will be about $0.0322 per piece, which represents 1.312 percent of the post-regulation price. This case shows an extremely small differential impact on small versus medium-sized automotive remanufacturing firms.

OSHA anticipates a significant negative differential impact on small firms in the secondary gasket manufacturing sector. The compliance costs per unit for small producers are well over twice those for the large producers, and OSHA's model predicts a large (23.2 percent) decline in profits in the secondary gasket sector. Thus, most small secondary asbestos gasket producers will probably stop manufacturing asbestos gaskets and will shift production entirely to the manufacture of non-asbestos gaskets. This will result in a concentration of production of secondary asbestos gaskets among medium and large firms which will be better able to afford the capital expenditures (for ventilation) required by the revised standard.

Service and Construction Industries

Economic Impacts. In order to analyze the economic impacts of the revised standard on the service and construction sector, OSHA employed a methodology similar to the one used in the CONSAD report [Exhibit 84–474, Chapter 5]. Using this methodology, the impacts were based on estimates of the elasticity of demand for the goods and services of the various sectors. In general, OSHA determined that the demand in these sectors is inelastic, and that firms in these sectors will be able to comply with the requirements of the revised standard by passing the compliance costs on to their customers.

The revised asbestos standard should have a negligible impact on firms in the service and construction industries because the estimated compliance costs are a minor percentage of the value of the object being produced or repaired. This will allow costs to be passed on to the consumer. For example, it is unlikely that the additional cost of a spray can for brake repair will have a significant impact on the number of brake jobs performed. Since the cost of complying with the revised asbestos standard is not significant when compared with the current differential in the out-of-pocket costs between having a professional do the job or doing the job oneself, OSHA believes that these costs will not have an impact on the behavior of consumers. The situation is similar in ship repair and new construction where the added compliance costs are a small percentage of the total cost of the job.

The impact of the additional compliance costs associated with routine construction maintenance should also be small. While in the short run, firms may decide to forego or reduce certain maintenance tasks (e.g., the cleaning of equipment containing asbestos material), in the long run the affected firms will have two options. The first would be to continue normal maintenance practices that involve asbestos materials and products and to comply with the revised requirements. The second option would be to remove asbestos materials from the building. As the cost of the second option could be high and would involve considerable disruption, most firms will probably choose the first option.

Since the demand for asbestos abatement is based primarily on public health and not on economic considerations, OSHA does not believe that the additional costs associated with the compliance requirements will diminish the demand for these specialized services. These activities frequently are conducted at schools and other public buildings, where the occupants' health and well-being are the major priorities. In fact, since the actual risk of removing asbestos is lessened through more stringent controls and regulations, the demand for asbestos abatement may be accelerated.

It also appears probable that the compliance costs associated with demolition can be passed on to the site developer. The circumstances surrounding a building demolition usually imply a favorable economic outlook (e.g., a major downtown development project, high office occupancy rates, etc.). Any incremental costs associated with compliance requirements are likely to be negligible when compared to the total costs of the project, and normally would not impose a major obstacle that would prevent the demolition of the existing structure and the eventual construction of a new building.

The only construction activity that may be affected by the revised standard is building renovation, because in some cases, compliance requirements may cause the renovation project to be postponed. Firms performing renovation activities, however, also do other construction work, and OSHA does not anticipate any significant impact on firms in the renovation industry.

Regulatory Flexibility Analysis

In accordance with the Regulatory Flexibility Act of 1980 (5 U.S.C. 601 et seq.), OSHA also assessed the economic burden of the revised standard on small businesses and has determined that the revised standard will not have a differential impact of them. The assessment for the automotive repair and construction sectors were based on the fact that these industries are dominated by small firms. In the automotive repair sector, for example, over 80 percent of the service stations are franchise owned [1983 Fact Book, National Petroleum News]. Similarly, data from the 1982 Census of Construction indicate that a typical firm in this industry averaged slightly under 10 employees in 1982. In particular, special trade contractors (SIC 17) averaged only eight workers per establishment in 1982. The assessment for ship repair was based on the fact that the compliance costs for both small and large shipyards were a negligible percentage of total revenue (i.e., less than 0.4 percent).

Conclusion

Based on this analysis, OSHA has determined that with two exceptions (i.e., secondary asbestos gasket manufacturing and renovation activities in construction), the revised asbestos standard will not have a significant economic impact nor will it impose an adverse differential impact on small firms. OSHA anticipates that most small firms in the secondary asbestos gasket manufacturing market will leave the industry and shift entirely to the production of non-asbestos gaskets. This will concentrate the production of secondary asbestos gaskets among the medium-sized and larger firms which are better able to afford the required capital expenditures. Given the high compliance costs associated with renovation activities (primarily due to the requirement to establish negative-pressure regulated areas), OSHA believes that some owners of buildings may forego or delay renovation activities. Since firms performing renovation activities currently perform other construction activities, OSHA believes that the impact of these firms will be small.

VIII. Environmental Impact Assessment

This assessment has been prepared in accordance with the provisions of the National Environmental Policy Act (NEPA) (42 U.S.C. 4325 et seq.) as well as the regulations of the Council on Environmental Quality (CEQ) (40 CFR Part 1500), and DOL-NEPA Compliance Procedures (29 CFR Part 11).

OSHA has reviewed the responses to the 1984 Notice of Proposed Rulemaking (NPRM) contained in the OSHA docket, as well as the revisions to the asbestos standard, and has concluded that no significant environmental impacts are likely to occur as a result of this action. The preceding description of the final rule and its supporting rationale, together with the discussion and arguments presented in the 1984 Notice (49 FR 70:14141-14144, April 10, 1984), constitute a finding of no significant impact. This is consistent with OSHA's earlier assessment, which provides a detailed discussion of the potential environmental effects of OSHA's regulatory action. Copies of that assessment are available from the OSHA Docket Office (Docket No. H-033C, Exhibit No. 84-477).

As indicated in OSHA's earlier environmental assessment, two environments may be affected by an OSHA regulatory action: (1) The workplace environment and (2) the general human environment external to the workplace, including impacts on air and water pollution, solid waste, and energy, and land use. Usually, OSHA regulations have their most significant impacts on the workplace environment, because this environment is under the Agency's jurisdiction. These regulations are beneficial to the workplace environment because they reduce worker exposure to toxic and carcinogenic substances. An in-depth discussion and analysis of the occupational nature of asbestos disease, the workplace environment, and the benefits to workers as a result of this rule are presented in earlier sections of this Notice.

In most cases, the effects of previous OSHA regulations on the external environment have been negligible because of their limited scope and application. Similarly, there is no evidence to indicate that there would be any significant adverse impacts to the external environment as a result of the standard on asbestos. As with other OSHA regulations in the past, however, there may be a potential benefit to the environment. The potential benefits and other impacts are briefly summarized here.

Air Pollution

As asbestos is used extensively in a variety of processes and products, the opportunity for its release into the atmosphere can occur at numerous points during mining and milling, primary and secondary manufacture, extended periods of use, construction and demolition, brake repair, and disposal.

In urban areas, particularly, airborne emissions also occur during the normal use and wear of friction materials such as brake and clutch linings. The final rule is not anticipated to impact directly on these sources of emissions outside of the workplace. To the extent that substitutes may be developed and used in these products as a result of the rule, however, there would be a potential benefit to the environment.

As the level of absestos fibers in the workplace is lowered to meet the PEL, there is a potential for more fibers to be vented outside of that environment, depending on the job performed and control method used. For example, as a result of EPA's National Emissions Standards for Hazardous Air Pollutants (NESHAPS) (49 FR 67:13659–13665, April 5, 1984) many industries choose to clean workplace air, thereby removing asbestos fibers, before it is vented to the outside environment. Where baghouses and other gas-cleaning devices are used to capture fibers, the 99.9 percent efficiency rate of these devices will remain unchanged. Because these controls are capable of capturing fibers as small as 0.5 microns in diameter and even as small as 0.1 microns (but with less efficiency), more fibers would be captured, potentially benefitting the ambient atmosphere.

In manufacturing processes, emissions result primarily from the handling and mixing of dry asbestos fibers and during operations such as blending and mixing, the weaving of asbestos fibers into textiles, and in the sanding, finishing, and culling of hard asbestos products. Emissions from the manufacturing process can be controlled by using local exhaust ventilations, dust collection and cleaning systems, and enclosures, by capturing and filtering devices such as baghouses, electrostatic precipitators and wet scrubbers, by using wet processes instead of dry when possible, by reducing the amount of asbestos added to products and by properly disposing of the waste materials.

Emissions also occur from extended periods of use of products; during grinding and fitting operations in replacing and repairing brake linings and clutch facings; during installation of asbestos-cement pipe insulation; during the cutting or sawing of asbestos-cement sheet, and other construction materials; during demolition, or rip out of spray-on insulation materials, [3] and during disposal operations.

In the construction and demolition industries, where exposures can far exceed 2 f/cc, the reduced PEL will have a beneficial impact on the workplace environment. Where regulated areas and air-tight enclosures are used in renovation and demolition operations, the amount of ambient emissions will be reduced. Similarly, the use of work practice, such as wetting down, or point source of controls, such as portable capture devices, will reduce ambient air emissions of asbestos fibers. Where respirators alone are used to achieve compliance and provide worker protection in specific environments, the level of ambient air emissions will remain constant.

In shipbuilding operations in the past, asbestos materials were used extensively in ceiling tile for overheads, and in fire-resistant sheets for bulkheads and insulation. As of 1978, the Maritime Administration's specification for government-subsidized ships required that nonasbestos materials be used in shipbuilding. As a result, asbestos insulation and cement materials have been replaced by products such as mineral wool and mineral wool cement. Ships built after 1978 are therefore assumed to be free of asbestos.

Although current shipbuilding operations do not generate exposures to asbestos, exposures are potentially high in ship repair and maintenance of already existing asbestos materials. The nature of this work frequently precludes the use of many engineering controls and extensive work practices. The combined use of work practices, protective clothing, and air-line respirators has been the means of controlling exposures to asbestos emissions. The actual physical configuration of ships also imposes constraints on some tear-out operations. For example, hatchways are narrow, space for life-support and power lines is limited, boiler and fire rooms are located in the lowest levels of the ship, hatchways and stairways must not be blocked, and in general, there is a need for egress in cases of emergency.

As many engineering controls appear to be infeasible in various ship repair operations, a PEL of 0.2 f/cc would not significantly alter the present level of ambient air emissions of asbestos, or affect the external environment. Worker protection can be afforded, however, by reducing the exposure levels with the use of air-line or, in some cases, full-mask respirators.

In the automotive aftermarket, exposures to airborne emissions occur in the remanufacturing and repairing of brakes and clutches. In the remanufacturing sector, exposures occur during refacing and finishing activities. In refacing operations, local controls, including shrouded machine tools with local exhaust systems, can be used to remove abraded material from the work area. In some cases, hoods and upgraded general ventilation systems exist, and overall, local vacuuming is believed to be practiced fairly extensively. In finishing operations, the control methods include the use of local controls, such as shrouds on grinders and the local vacuum collection systems.

In the general repair sector, until recently, it was common practice to use compressed air to remove asbestos fibers and wastes during the cleaning of the brake drums and bell housings prior to repair. This practice has been replaced with the use of compressed air-hoses to apply a solvent mist to remove asbestos residue from the brake drums before repair. In other instances, damp wiping is performed, wetting agents are used, and high-efficiency particulate air (HEPA) vacuum systems are employed. Where enclosed vacuum systems and the compressed-air solvent-mist process are employed, exposure levels below the action level can be attained. It is believed that the OSHA recommended spray can/solvent mist process will reduce exposures and emissions even further. These types of controls and work practices would benefit the workplace environment and lessen the potential for the release of fibers to the external environment.

In sum, the use of local controls, filters, collection devices and wet methods would reduce levels of airborne emissions in the workplace. Further, because of the nature of EPA's emissions standard (40 FR 199:483012, October 14, 1975), many industry operations already use engineering controls where feasible to reduce the amount of emissions to the atmosphere. Controls already in place are anticipated to continue to operate effectively in reducing emissions under the rule. As asbestos fibers are removed from the atmosphere by such controls, any fibers collected could be disposed of as solid waste or could comprise

[3] In 1973, EPA banned the use of spray-on insulation of fireproofing materials containing more than 1 percent asbestos by weight. But these, as well as decorative materials excluded from the ban, can and do exist in buildings that are renovated or demolished and, consequently, can pose significant sources of exposures [Exhibit No. 84–414]. Also, the OSHA rule would prohibit the spray-on application of asbestos materials in all affected industries.

some wastewater effluents or run-off. These possibilities are discussed in the following paragraphs.

Water Pollution

Asbestos occurs naturally in ground formations, which can cause contamination of surface waters, rivers, and ground waters through erosion. Asbestos fibers can contaminate water systems as a result of leaching from asbestiform deposits or commercial applications. Contamination can also result from the disposal of asbestos waste, such as effluents that are discharged directly into water systems, emitted to the atmosphere, or disposed of in landfills and then later enter surface or ground waters. Further, during asbestos manufacturing and mining/milling processes, fibers are often released into surface waters by wastewater discharge, particularly from improperly disposed of effluents.

Insufficient data make it difficult to assess the potential for asbestos contamination of water systems, but some studies have shown that plants manufacturing asbestos paper products have the greatest potential for contamination of surface waters. This may be due to the large amounts of asbestos raw materials used and the wet processes associated with the manufacture of asbestos paper products. The manufacture of asbestos-cement pipe also involves wet processes that discharge asbestos effluents. However, the suspended solids that are collected in clarifiers are usually coated or encased in cement and tend to solidify. Consequently, when these fibers are transported to landfills they rebound in a cement matrix, making release of the buried fibers unlikely. Similarly, it is unlikely that asbestos products in land fills would release significant fibers that could penetrate any distance through soil unless substantial cracks and fissures were present [Exhibit No. 84-417, p. 290].

To the extent that manufacturers change to wet-processing methods, however, there is the potential for an increased use of water and a resultant increased amount of wastewater containing asbestos or increased amounts of suspended solids disposed of as waste. Lack of data makes it difficult to determine to what degree this will occur and if it would significantly affect the environment. Moreover, the potential for any such occurrence may be offset depending on the types of treatment facilities the manufacturers use. For example, many plants recirculate water from wastewater treatment facilities to the process, resulting in fewer effluents discharged.

In case where wastewater is discharged into local sewer systems, the regulation would not significantly affect the amount of fibers discharged. EPA's effluent limitations guidelines (40 CFR Part 427 in 39 FR: 526-7535, February 26, 1974; 40 FR:1874-1878, January 9, 1975; 40 FR:6444, February 11, 1975; FR:18172. April 25, 1975) include (1) standards of performance for all new point sources within specified categories of asbestos manufacture and (2) pretreatment standards for new plants discharging to municipal sewer systems. These limitations would serve to prevent the discharge of effluents, specifically suspended solids, into the environment without prior treatment. Moreover, the Federal Water Pollution Control Act Amendments of 1972 require that wastewater effluents be treated by the best practicable control technology (BPT) by December 31, 1977, and that the best available technology (BAT) economically achievable be used by December 31, 1983. The EPA effluent limitations establish the degree of effluent quality necessary to meet the BPT and BAT requirements. The BAT and pretreatment standards would essentially mean no discharge of process wastewater to navigable waters and no discharge of incompatible pollutants, respectively [Exhibit No. 84-420]. These requirements will not change as a result of the rule, and where they continue to be met, effluent quality will not be altered.

In construction, demolition, ship repair and brake repair operations, asbestos-containing products are frequently wetted down in order to reduce airborne fibers during the repair or tear out of materials. In so doing, the once airborne fibers become effluents in the wastewater runoff. To the degree that wetting down practices increase as a result of the revised rule, however, there would be a potential for increased amounts of wastewater run-off at these sites. In wet abatement activities, the potential for wastewater effluents can be reduced by using portable high-volume water filtration units. Similarly, as HEPA vacuums are used to clean up the worksite, asbestos fibers in the form of slurry would be properly captured and disposed of and would not contribute significantly to wastewater effluent. In these types of operations, both the current OSHA standard and EPA regulations [Exhibit No. 84-414] require work practices for the proper handling, sealing, storing, and disposing of any associated waste, debris, or wastewater. These regulations would not change as a result of the rule, and therefore, such operations would not necessarily contribute to any increase in the amount of pollutants present in wastewater run-off. The overall net contribution to water pollution from these wetting down practices, therefore, is generally not considered to be significant.

Solid Waste Disposal

Waste dumps are considered to be major sources of emissions, which can be a potentially serious source of nonoccupational exposure. Waste dumps have been shown to emit significant numbers of fibers that can be detected at considerable distances from the source [Exhibit No. 84-421, p. iii].

A major concern is that waste materials may be disposed of without concern for their airborne emission potential, and as a result, they may be disposed of in open, municipal waste dumps and treated like nonasbestos waste, creating a long-term source of emissions and exposures to unaware workers and others. Dumps and waste piles containing asbestos materials are frequently located in densely populated urban areas. It has been suggested that the population exposure in waste disposal areas near manufacturing plants may be comparable to the exposure experienced by the occupational population. Consequently, waste disposal practices and waste sites are areas of recognized concern.

Emissions of asbestos fibers can occur when the wastes are transferred to the dump and as the surfaces of the waste piles are eroded by weather conditions. Emissions may also occur during transfer operations where asbestos materials may be dumped, crushed, and spread, causing visible dust emissions. Emissions from asbestos manufacturing waste piles can occur during the transporting and discharging of asbestos waste from manufacturing/milling processes. These emissions can be controlled by using enclosures and gas-cleaning devices along transfer points of conveyor systems that move asbestos tailings and by using wetting-agents on the tailings as they are discharged [Exhibit No. 84-421]. Once asbestos tailings are dumped at the site, they can be covered with a protective seal or covering to control further emissions.

Emissions from product disposal may be of potential concern. Generally, however, asbestos-containing products are bound in some type of matrix such as cement, plastic, or asphalt. Once these types of products have been disposed of in landfills or waste sites, they usually do not release any significant amount of free asbestos fibers, unless they are crushed or incinerated. To reduce the amount of emissions that may occur as a result of crushing asbestos materials, EPA's NESHAPS regulations have specific requirements for asbestos materials at active and inactive waste sites. These include covering such materials every 24 hours with compacted nonasbestos materials, or using resinous dust suppressants to bind dust and to control wind erosion, etc. Although there are insufficient data to determine how much asbestos is emitted from the incineration of waste products, one study suggests that incineration could be significant in causing air pollution in the U.S. and that incineration of products emits about 220 tons of free asbestos fibers annually from all municipal incinerators [Exhibit No. 84–417, p. 289]. It has not been established to what extent asbestos fibers survive incineration and still remain biologically active. It has been estimated, however, that fibers such as chrysotile would decompose at 900 degree Farenheit into other forms of minerals under the intense heat of incineration [Exhibit No. 84–417, p. 289].

Emissions occurring when asbestos-containing materials are torn or ripped out, or crushed generate potential waste products. As mentioned earlier, this would depend on the operation and control method used. In some manufacturing processes, for example, wastewater is recirculated and reused and air is filtered, cleaned and recirculated. in some secondary manufacturing industries, scrap materials may be reused or recycled (see Technological Feasibility, Section VII, above). Also, solid wastes that might be generated from various processes are not necessarily disposed of at waste sites because many such materials are incinerated.

In many instances, construction and renovation types of activities do not necessarily produce solid waste as asbestos abatement frequently involves encapsulation rather than the ripout of materials. The amount of potential friable asbestos and waste resulting from demolition and renovation operations would probably not change significantly, as these would be based largely on asbestos construction materials present in already-existing structures. It is anticipated, however, that waste and debris that may have been left at the worksite and not disposed of as current practice will now be removed promptly and will be labeled and disposed of properly.

As with the current asbestos standard, these asbestos-containing materials, waste, debris, sludge, etc., would be collected and removed from the worksite and disposed of in properly labeled, impermeable bags or closed containers, and deposited in a designated waste area. As many such activities may already comply with the disposal requirements of the current standard and with EPA guidelines for demolition, it is uncertain where disposal practices will increase measurably as a result of the rule. There are not data to indicate that as a result of the rule, wastes will be handled less efficiently than at present. Rather, as a result of the training provisions of the rule, worker awareness of asbestos materials and their hazards would be increased, thereby providing a potential for increased proper handling and use of these products which, in turn, could benefit the external environment, both at the worksite and the waste site.

In addition, the final rule provides an incentive for the use of these materials to be reduced, or to be replaced by suitable substitutes. It is highly likely that as a result of the rule, other materials will be used in place of asbestos which would result in fewer asbestos fibers being captured, dumped, or recycled. In such instances, fewer asbestos-containing products would be disposed of in landfills and would pose less of a risk as potential sources of emissions, thereby benefitting the external environment.

Energy and Land Use

The implementation of required engineering controls to comply with the PEL of 0.2 f/cc could result in an increase in total energy requirements, or costs, for general industry. This would be particularly true, of course, where controls are not in place or where the current PEL of 2 f/cc is not met. Some potential energy factors are briefly described here.

Where local exhaust ventilation (LEV) is the primary method of control, the annual operating costs would include the additional expense of heating or cooling the replacement air brought in from the outside to run the LEV system. Based on the model plant approach presented earlier in calculating costs of compliance, it was estimated that most model plants in general industry would require a 50-percent increase in the volume of air (cubic feet per minute) to run the LEV systems in order to comply with the standard. The exception would be the gasket industry, where it was estimated that a 20-percent increase would be required and the textile sector, where it was estimated that a 200-percent increase would be required. The energy costs for makeup air units for local exhaust ventilation air exchange were estimated at $8.9 million per year for general industry [Exhibit No. 345, p. VI–11].

Where vacuums are used to clean up spills, wastes, etc., it was estimated that each unit uses 1 kilowatt of electricity at $0.09384/kilowatt hour. The energy requirements for the use of vacuums for general industry was based on an increase of 2 hours for 250 days for all industries except secondary gaskets, where the use was estimated to be for 50 days. Specific cost estimates are presented in Section VII of this Notice and in the final Regulatory Impact Analysis [Exhibit No. 345].

In terms of land use, OSHA does not project any significant impact on land use plans, policies, or controls. OSHA does not anticipate any significant impact on the short-term uses of man's environment or upon the maintenance and enhancement of long-term productivity beyond those presented in this Notice.

Other Impacts

The final rule could also have other impacts that may affect the external environment. As mentioned earlier, the rule could encourage the further use, research, and development of suitable substitutes. This, in turn, would result in a positive environmental effect because less asbestos would be used, and fewer fibers would be emitted to the air or discharged as wastewater effluent or as solid waste. The magnitude, or probability, of these impacts, however, is impossible to quantify. (See the discussion of Economic Impacts in Section VII above.)

Overall, the projected impacts of the proposed standard on the external environment are expected to be insignificant, especially in view of EPA's proposed ban on asbestos (40 CFR Part 763; 51 FR 19:3738–3759, January 16, 1986) and on current EPA regulation of air emissions, water effluents, and solid waste disposal methods.

Summary

Under the revised rule, a variety of control methods and work practices would be implemented. These include enclosures or isolation of asbestos-producing processes, regulated areas, monitoring, local exhaust ventilation with HEPA filter dust collection systems, HEPA vacuums, general ventilation, wet methods, disposal of asbestos wastes in leak-tight containers, restrictions on the use of compressed air and spray-on asbestos containing materials, training, showers, and hygiene facilities, lunch rooms, showers, glove bags, etc. To the extent that these types of practices are employed as a result of the rule, there will be a decrease in the amount of ambient emissions to the environment. Although any captured fibers could take the form of solid waste or wastewater runoff, sludge, or slurry, this is not anticipated to result in a significant environmental impact.

In achieving compliance with the standard, industry will in some instances need to install engineering controls, implement work practices, provide personal protective equipment, and training. These measures are not expected to have any significant adverse environmental effects, and could be of potential benefit to the environment in terms of air and water quality and solid waste disposal.

The use of local controls, filters, collection devices and wet methods would reduce levels of airborne emissions in the workplace. The placement of proper controls and filtering devices may mean that filtered air is vented to baghouses or other capture/retention devices, thereby lessening the potential release of airborne emissions to the external environment. The use of air-tight enclosures will prevent the release of emissions to the general environment. This is also true where devices such as portable saws with local exhaust ventilation and capture devices are used for cutting asbestos products. Although such collection devices will increase the amount of disposable waste where they are implemented, it is difficult to quantify the degree to which this will occur. No significant adverse effect on air quality is expected to occur as a result of the final rule.

The use of wet methods and processes will also reduce the level of ambient emissions. The use of vacuums and other recommended work practices for cleanup and removal of fibers will reduce the likelihood of any reentrainment of fibers into the atmosphere. Potential wastewater effluents resulting from these methods and processes will also be alleviated depending on the control method (e.g., HEPA vacuums, recirculation and reuse of water) and disposal technique used (e.g., leak-tight containers).

The training of workers should provide an incentive for the proper use and handling of asbestos and asbestos-containing products. Training also has the potential to impact on the discharge and disposal of asbestos materials into the environment.

Finally, the revised rule, as well as the EPA proposed ban on asbestos, is likely to encourage the research, development and use of suitable substitutes.

IX. Standards Recommended to OSHA by Interested Parties

In the course of this rulemaking, several interested parties have developed and submitted to OSHA recommended standards for controlling occupational exposures to asbestos in various workplace settings. Among the organizations and entities submitting such standards were OSHA's Advisory Committee on Construction Safety and Health (hereafter called CACOSH or the Advisory Committee), which provided a number of relevant documents for the record, the Organization of Resource Counselors, Inc. (ORC), the Building and Construction Trades Department (BCTD) of the American Federation of Labor-Congress of Industrial Organizations (AFL-CIO), and the Asbestos Information Association of North America (AIA/NA).

OSHA has benefitted greatly from the recommendations and regulatory suggestions of these groups, and has incorporated many of their recommended approaches into the requirements of the revised standards for general industry and construction. Specific regulatory requirements recommended by these commenters are discussed in the Summary and Explanation sections of the preamble, as appropriate. Specific recommendations made to OSHA by CACOSH, the AIA/NA, and the BCTD are described in Section XI of this preamble (the Summary and Explanation for the revised rule for the construction industry), while specific requirements recommended by the ORC are described in Section X, the Summary and Explanation for maritime and general industry.

The paragraphs below briefly describe the standards recommended by these groups, concentrating on the general approach adopted by each organization in developing its recommended standard. In addition, OSHA's response to these recommendations and the Agency's rationale for accepting, modifying, or rejecting the approaches recommended are discussed.

Recommended Standard for General Industry

The ORC developed a standard that it recommended to OSHA to control occupational exposures to asbestos in the industry sectors predominantly represented by its members (i.e., general industry and maritime). The standard recommended by the ORC (Ex. 91–10) is generally similar to the revised standard being promulgated by OSHA for general industry. For example, the ORC recommended requirements for monitoring, medical surveillance, recordkeeping, protective clothing, employee training, and signs and labels that are nearly identical to those of OSHA's revised general industry rule. However, the ORC's recommended standard differs substantially from the revised rule in one major respect: the ORC recommends that OSHA adopt *two* permissible concentrations for exposure to asbestos, a permissible airborne concentration (PAC) and a permissible exposure limit (PEL) that governs actual in-lung employee exposure. The ORC recommended a PAC of 0.5 f/cc or less, and a PEL of 0.2 f/cc. ORC defines a PAC as the "ambient worksite concentration" or maximum 8-hour time-weighted average concentration in "which any employee may work;" ORC assumes that, if engineering controls and work practices are not sufficient to reduce the ambient concentration to this level, employees would be required to wear respiratory protection having a protection factor adequate to do so. Thus, ORC's definition of a PAC is consistent with OSHA's traditional definition of a permissible exposure limit (PEL). The ORC's definition of PEL, however, differs markedly from OSHA's. ORC states that:

> The eight hour time weighted average airborne concentration of asbestos fibers to which any employee may be exposed shall not exceed 0.2 fibers (inhaled into the lungs) per cubic centimeter of air (Ex. 91–10).

OSHA has not adopted ORC's two-pronged approach to exposure limits, for several reasons. First, OSHA has traditionally defined PELs and employee exposures as the airborne concentration of a contaminant measured *without regard to the use of respirators.* The Agency has consistently used this definition of exposure because airborne concentrations, in contrast to in-lung concentrations, are easy to control and measure, and limits based on such concentrations are comparatively easy to enforce. In addition, employers are able to determine, by means of established industrial hygiene procedures and controls such as employee monitoring, leak detection systems, continuous alarms, and the use of engineering controls and work practices, what the actual exposures of their employees are. OSHA does not believe that the cause of occupational safety and health would be well served by basing an exposure limit on an end-point that is as subject to individual variability, as dependent on individual and group behavior, and as difficult to enforce and administer as the in-lung concentration of a toxic substance. In addition, the use of such a concept would necessarily depend on increased reliance on respiratory protection as a line of defense against hazardous workplace exposures, which runs counter to the Agency's stated preference for the traditional hierarchy of controls: the use of engineering and work practice controls as the first line of defense, followed by respiratory protection. For these reasons, discussed further in the Summary and Explanation section for paragraph (g) of the general industry standard, OSHA has not adopted ORC's suggested PAC/PEL exposure limit approach.

Recommended Standards for the Construction Industry

Several rulemaking participants provided OSHA with recommended asbestos standards for construction, including the BCTD, the AIA/NA, and, more generally, the Advisory Committee (CACOSH). The general scope of these standards and the major differences between them and OSHA's revised construction standard are described below.

The BCTD Standard

The Building Construction Trades Department (AFL-CIO) submitted a comprehensive recommended standard to the docket (Ex. 330), along with extensive commentary. OSHA has found these recommendations and analyses useful in standards development, and many of the BCTD's recommendations have been adopted, often in modified form, in the final revised rule.

The BCTD recommended that OSHA adopt a construction standard that differed considerably in format from that traditionally associated with OSHA health standards. First, the BCTD recommended a three-tiered scheme for categorizing products and processes, depending on the airborne levels of asbestos likely to be produced during these operations or when handling these products. Category A products and processes are those that produce airborne levels of asbestos no greater than a 4-hour TWA of 30, 000 fibers per cubic meter (0.03 f/cc); Category B products and processes would produce airborne levels no greater than 8-hour TWA levels of 0.5 f/cc; and Category C products and processes would include materials and operations that produce airborne asbestos levels above the PEL (or that produce as yet unknown or untested concentrations of airborne asbestos).

The BCTD recommended that employers using Category A products be exempted from most of the standard's requirements, e.g., medical surveillance, monitoring, spill/emergency procedures, associated recordkeeping, etc. Employers whose construction activities involved the handling of Category B products or the performance of Category B processes would be required to observe less stringent requirements, for example less frequent employee monitoring, than employers involved in Category C work. For Category C workplaces, e.g., those involving the handling or performance of Category C products or processes, the BCTD recommended that employers be required to observe *all* of the provisions of its recommended standard.

The BCTD argued that adoption of such a categorization scheme would have a number of advantages:

(1) It would concentrate control resources in the highest risk situations;

(2) It would encourage the testing and categorization of as-yet-untested products and processes;

(3) It would encourage manufacturers to develop and employers to use less hazardous, i.e., Category A or B, products or processes;

(4) It would aid in the development of a substantial data base on employee exposures to asbestos in the construction industry.

The BCTD's suggested approach, which involves tiering the stringency of the standard's requirements to the degree of hazard associated with the use of various products or processes, essentially agrees with the structure adopted by OSHA in this revised standard for construction. That is, OSHA has tiered the standard in accordance with the relative hazard associated with certain work operations in construction. Accordingly, the revised standard reserves the standard's most stringent requirements, e.g., the use of daily exposure monitoring, negative-pressure regulated areas, disposable protective clothing, and required hygiene facilities, to asbestos renovation, demolition, and removal operations. The record evidence, discussed in connection with the Summary and Explanation sections for these paragraphs (see Section XI), repeatedly emphasizes that these operations, also known as "asbestos abatement" operations, are clearly the most hazardous asbestos-handling operations in construction at the present time.

In addition to the adoption of a tiered approach to cover asbestos renovation, demolition, and removal operations, the revised standard for construction incorporates several regulatory techniques that are designed to ensure that the impact of the standard is proportional to the degree of occupational hazard in affected workplaces. These techniques include the use of the action level concept, which permits employers whose employees are not exposed above the action level to be exempted from complying with many of the standard's requirements, and the use of a "30-day trigger," which allows workplaces that do not have airborne concentrations of the hazardous substance in question for as many as 30 or more days in any given year to be exempted from certain requirements, e.g., the standard's medical surveillance provisions. In addition, small-scale, short-duration maintenance and renovation operations, such as those involving the installation of electrical conduit or the changing of a gasket made of asbestos-containing material, are specifically exempted from a number of provisions, e.g., protective clothing, regulated areas, and hygiene facilities. OSHA is confident that the use of these methods will ensure an adequate degree of correspondence between the seriousness of the hazard to be controlled and the stringency of the control strategy imposed by the final standard.

Although conceptually similar in many respects to the standard recommended by the BCTD, OSHA believes that the regulatory approach adopted by the Agency has several advantages over the BCTD's strategy. First, OSHA's approach is simple and can be implemented immediately, without a delay to permit various processes and products to be tested and categorized according to the amount of airborne asbestos they generate. Second, the Agency's standard will be relatively simple and straightforward both to administer and to enforce. Third the revised standard's structure is similar to and consistent with that of other OSHA health standards, including the revised asbestos rule for general industry, which will permit employers who are already familiar with the format of OSHA regulations to comply with the standard and to understand its requirements more easily. For these reasons, OSHA has chosen to adopt the revised standard for construction that is discussed in Section XI, below.

Asbestos Information Association of North America. The AIA/NA also developed a set of recommendations that it suggested OSHA adopt to control hazardous occupational exposures to asbestos in the construction industry (Ex. 84-307). The AIA/NA's recommended standard was notable for its lack of a requirement for a revised permissible exposure limit for allowable airborne concentrations of asbestos. The AIA/NA argued that lowering OSHA's current PEL of 2 f/cc was not possible because of the inherent sampling and analytical variability inherent in the use of the OSHA method (for a discussion of the variability issue, see the Methods of Measurement section in the Summary and Explanation for General Industry (Section X, below). As discussed in detail in the Preamble section on Technological Feasibility (Section VII), OSHA has determined that achieving the new PEL of 0.2 f/cc as an 8-hour time-weighted average is feasible in the great majority of workplaces with the use of engineering and work practice controls alone, although respiratory protection may be required in some operations.

The AIA/NA's recommended standard was similar in many other respects to the standard recommended by the BCTD (Ex. 330). For example, the AIA/NA's recommendations include the adoption of a product classification scheme that would rank asbestos-containing products used in construction in accordance with their potential for releasing airborne concentrations of asbestos. Implementation of the AIA/NA approach would require manufacturer certifications and the validation of empirically determined product classifications, including the use of objective data or exposure studies conducted by fully qualified testing laboratories and empirical field testing by OSHA inspectors and others to confirm these test results.

According to the AIA/NA, examples of products qualifying for Category A status (the least hazardous grouping) include products in which asbestos fibers are bound, coated, or enclosed by other materials, such as mastics, mechanical packings, oil seals, compressed gaskets, sealants and caulks, roof coatings, and electrical insulating paper (Ex. 84-307, p. 23). Category B products would include those certified by their manufacturers as being incapable, under reasonably foreseeable conditions of processing or use, of releasing asbestos fibers in excess of the PEL "*when one or more specified Fabrication Installation or Removal Methods are used*" (Ex. 84-307, pp. 23-24). Category C products would include, under the AIA/NA's classification scheme, products presenting the greatest exposure potential. These products would consequently be subject to the most stringent regulatory controls.

As explained in detail above in connection with the BCTD's recommended standard, OSHA has chosen not to adopt a product and process categorization scheme in the final standard for asbestos. In addition to the objections to such an approach discussed earlier, OSHA notes that the AIA/NA's recommendations are intended to apply predominantly to the installation of new products in the construction environment, and would thus not address those construction operations that so many commenters pointed to as being the most hazardous: Asbestos renovation, demolition, and removal operations.

The Advisory Committee for Construction Safety and Health. At several critical junctures during the asbestos rulemaking, OSHA has had the benefit of the Advisory Committee's review of various draft versions of the asbestos construction standard. Most recently, CACOSH reviewed a draft standard at its September 26-27, 1985 meeting (see transcript of CACOSH proceedings for that date). In addition to providing specific reviews of successive drafts of the asbestos standard for construction, the Committee also developed, in 1980, a comprehensive document entitled *Report on Occupational Health Standards for the Construction Industry* (Ex. 84-233). Although this document is not directed specifically to asbestos, many of its findings apply to the revised construction standard. For example, CACOSH expressed concern about the difficulty of applying many traditional health standards requirements in the construction setting; specifically, the Committee noted that medical surveillance, the use of engineering controls, and extensive recordkeeping often pose problems in this high-turnover, out-of-doors, short-term work environment (Ex. 84-233).

In the context of OSHA's revised asbestos standard for construction, the Committe voted overwhelmingly in favor of the issuance of a separate standard for the construction industry (Ex. 84-424). CACOSH also recommended that the PEL for construction be set at "the lowest feasible level" (Ex. 84-424, pp. 11-13), as OSHA has in fact done (see the Preamble section on Technological feasibility, Section VII). At a later meeting (September 26-27, 1985), members of the Committee noted their support for many provisions of a draft final standard submitted to CACOSH for review; this draft was substantively similar to the standard published today. For example, committee member Joe Adam urged that the traditional hierarchy of controls be reflected in the revised standard, i.e., "engineering controls first, work practices, and then the final [choice of method] being personal protective equipment" (see transcript of CACOSH proceedings). On other issues raised by requirements of the draft under review, CACOSH urged OSHA to refine particular provisions. OSHA has generally incorporated CACOSH's suggestions. For example, in response to the point made by Mike Deis of Better Working Environments that respirators should be qualitatively fit tested with every wearing, OSHA has revised the final standard specifically to cross-reference 29 CFR 1910.134(e). Section 1910.134(e)(5)(i) requires employers to ensure the proper fitting of half-mask respirators by checking the facepiece fit "each time he [or she] puts on the respirator." In addition, CACOSH noted several minor errors in the draft standard being reviewed, particularly in the draft respiratory protection section, and these have subsequently been corrected in the final standard (see transcript of CACOSH proceedings). The final standard thus reflects, in a large number of provisions and in many ways, the expert advice received by the Agency from the Advisory Committee over the course of this asbestos rulemaking.

X. Summary and Explanation of the Revised Standard for General Industry

1. *Paragraph (a). Scope and application.*

Like the existing asbestos standard and other OSHA health standards such as inorganic arsenic (§ 1910.1018); lead (§ 1910.1025), DBCP (§ 1910.1044), and acrylonitrile (§ 1910.1045), this revised standard applies to all "occupational exposures to (asbestos)." OSHA has not defined the term "occupational exposure" in the regulatory text. However, because of increased public awareness of the hazards of asbestos and its ubiquitousness, inquiries have been made to OSHA concerning the applicability of the standard to exposures in buildings which may not result from manufacturing, processing or installing asbestos products. Significant areas of concern expressed were exposures to office employees in buildings where asbestos products has been installed and to employees who work in the vicinity of asbestos abatement and renovation activities.

In both situations the exposures are occupational and are covered by this standard. The employee's presence in the workplace places him at increased risk from asbestos exposure regardless of whether the employee is actually working with asbestos.

It is important to note that coverage by this standard because an employee's asbestos exposure is "occupational" will not impose unnecessary requirements. In most cases where the source of "occupational exposure" is unrelated to the employer's operations, the only applicable requirement is to initially monitor the levels of exposure, set out in paragraph (d)(2) of this secton. In most of these situations, the employer would not be required to monitor his employees exposures, rather he may estimate exposures using historical data or scientific expert opinion (d)(2)(iii). It is expected that building owners may be consulted to ascertain the identity, location and condition of asbestos products in their buildings. Although building owners, per se, do not incur any specific obligations under this standard, OSHA believes that they may be able to give reliable information concerning asbestos in some cases.

OSHA did not explore in detail the complex area of asbestos contamination in buildings because the available evidence shows that buildings containing even disturbed asbestos expose employees to levels considerably below the action level adopted in this standard (e.g. Alliance for Safe Building Brief to EPA, Ex. 311-D,E). Also other federal agencies, particularly EPA, are exploring in detail aspects of this problem (see EPA Docket Number OPTS-211012). For these reasons OSHA is not adopting specific regulatory language in this area and leaves open to evidence in enforcement proceedings whether "occupational exposure" is involved and whether the employer adequately applied the relevant provisions of this standard to protect occupationally exposed employees.

The two OSHA standards, general industry and construction concerning occupational exposure to asbestos, are intended to cover all industries covered by the Act. The general industry standard covers all activities and operations which are not covered by the construction standard. These industries and operations include ship repair and rebuilding, manufacturing, secondary processing, and brake and clutch repair. It should be noted that the applicability of the construction standard depends on the operations performed. Accordingly, if the employees of a manufacturer perform construction activities, their exposures are covered by the construction standard. As discussed in the preamble to the construction standard, construction activities are defined in 29 CFR 1910.12(b) as work for construction, alteration and/or repair, including painting and decorating. Further, construction work is specifically defined to include, "the erection of new electric transmission and distribution lines and equipment, and the alteration, conversion and improvement of the existing transmission and distribution lines and equipment." 29 CFR 1910.12(d).

As noted above, ship repair and shipbreaking activities are covered by the general industry standard. OSHA believes the provisions of the general industry asbestos standard are appropriate for the operations involving asbestos which will occur on ships.

Automotive brake and clutch repair work is also covered by the general industry standard. Based on data submitted to the record it appears highly probable that most asbestos exposures for employees repairing and removing brake linings will be less than 0.1 f/cc on a TWA basis if employees use work practices and controls detailed in Appendix F (see Section XII). These controls mainly involve using a solvent mist on the linings or using HEPA-filtered vacuums to remove the dust. Therefore, although covered by this standard, no other requirements are expected to apply to brake and clutch repair employers.

2. *Paragraph (b). Definitions.*

Asbestos

OSHA raised two issues in the April proposal concerning the definition of asbestos. One issue was the addition of the phrase "and any of these minerals that has been chemically treated and/or altered" to the definition of asbestos. The other issue was the mineralogical "correctness" of the definition.

Some investigators have hypothesized that in addition to the physical characteristics of the fiber, the surface chemical properties account for part of its biological activity (Exs. 226, 227A). This hypothesis has led to research with the goal of reducing toxicity of asbestos by modifying the surface properties of the fiber.

Societe Nationale de l'Amiante (SNA), a Canadian company that mines and manufactures asbestos products, has been actively engaged in the chemical modification of chrysotile fibers. They have examined a number of possible reagents that might "passivate" (reduce the biological activity) chrysotile and have focused on the use of phosphorus gas to modify fibers (Ex. 338). Their process is a dry treatment using phosphorus oxychloride ($POCl_3$) gas, and the treated product is a phosphated chrysotile fiber which the SNA calls "chrysophosphate" (Exs. 226). The treated chrysotile has been compared with untreated chrysotile in *in vitro* tests for hemolytic potential and the cytotoxic response of pulmonary macrophages. SNA reported that the treated chrysotile is less active in the tests than the untreated chrysotile (Ex. 226, 227). The treated chrysotile is currently being tested in longterm bioassays where animals are exposed to the material through inhalation and injection (Ex. 338).

At the hearing, Mr. Richard Lemen of NIOSH indicated that the results of the *in vitro* testing did not provide adequate data upon which to base any decision to exclude chemically treated asbestos from the standard (Tr. 6/21, p. 188). Dr. Arthur Langer, who has performed some of the *in vitro* testing on the chemically modified chrysotile, agreed that longterm bioassays are needed, and he called for additional *in vitro* testing and for tests to determine the stability of the chemically altered structure (Tr. 7/3, p. 97). Although Dr. Langer clearly stated that modified asbestos fibers should be regulated by the standard, he went on to state that "[t]he modification of asbestos should be viewed as an important factor in risk reduction in the future" (Ex. 220).

In his testimony at the hearing, Mr. Mark Lalancette of SNA acknowledged the need for continuing regulation of chemically treated asbestos (Tr. 7/5, p. 9). The SNA did not request that OSHA exclude phosphated chrysotile from the definition of asbestos, but requested that OSHA indicate that this particular modification of the definition be regarded as "only an interim measure designed to clarify the regulation's scope until full toxicological data are available to make distinctions" (Ex. 338). The SNA requested that OSHA "be receptive to reviewing such toxicology data when they are developed to determine the extent to which standard revisions are appropriate, given such new knowledge," (Ex. 338) a request echoed by the Asbestos Information Association (Ex. 328 p. I-33).

Although the reports of *in vitro* testing are encouraging, they provide only a small portion of the information necessary to evaluate chemically modified asbestos. The Agency does not wish to discourage research that may lead to a reduction in risk from occupational exposure to asbestos, and any data that support a reduction in risk can be submitted to the Agency at any time. However, there is considerable evidence that documents the carcinogenicity of asbestos and considerable evidence will be required to document any claims of reduced toxicity of chemically modified asbestos. Therefore, based on the data in the record and the testimony of expert witnesses, OSHA has concluded that chemically modified asbestos should be regulated in the same manner as unmodified asbestos. To make this intent clear, the phrase "and any of these minerals that has been chemically treated and/or altered" has been added to the definition of asbestos.

OSHA currently regulates all forms of tremolite, actinolite, and anthophyllite as asbestos. Some commenters, most notably representatives of the R.T. Vanderbilt Company, have strongly encouraged OSHA to revise its definition of asbestos to make it mineralogically correct. They have encouraged the Agency to amend the definition to make it clear that only the "asbestiform" varieties of tremolite, anthophyllite, and actinolite are considered to be asbestos (Ex. 337). The Agency raised this issue in the April proposal.

A number of commenters supported the addition of the term "asbestiform" (Ex. 90-3; 90-143; 90-180) or the term "fibrous" (Ex. 90-37; 117A) to the definition. Some urged OSHA to adopt the definition of another governmental Agency (Ex. 90-143; 90-161; 90-167) or to adopt a mineralogical definition (Ex. 90-37; 90-162; 90-179; 230 p. 13).

The modification of the definition to read tremolite asbestos, anthophyllite asbestos, and actinolite asbestos would eliminate other forms of tremolite, anthophyllite and actinolite from the definition of asbestos. OSHA has regulated all of these minerals as asbestos since 1972. The elimination of these minerals from the scope of the standard could only be justified by evidence that exposure to these minerals would not present a health hazard to exposed workers. Therefore, in its deliberations, OSHA examined the data in the record to determine whether or not there is evidence that workers exposed to these minerals are at risk for adverse health effects.

Both Dr. Mearl Stanton and Dr. William Smith have investigated the carcinogenicity of termolite in experimental animals. Dr. Stanton's experiments (Ex. 84-195) demonstrated that tremolite asbestos is highly carcinogenic when implanted in the pleurae of rats. He also tested two samples of talc that did not induce tumors. These two samples were certified by Dr. Ann Wylie (Ex. 337 Att 2) to be tremolitic talcs which "usually contain approximately 30-50% nonasbestiform tremolite by weight, and small quantities of nonasbestiform anthophyllite and fibrous talc" (Ex. 337 Att 2). Dr. William Smith also conducted a series of experimental carcinogenicity studies in hamsters (Ex. 84-194; 306). These studies examined the effect of intrapleural injections of a number of minerals including asbestiform and nonasbestiform tremolite. In these studies, samples of asbestiform tremolite and a sample of nonasbestiform tremolite induced tumor formation in hamsters while other samples of nonasbestiform tremolite did not (Ex. 84-194).

In addition to the experimental animal studies, much of the support to eliminate some forms of tremolite, actinolite, and anthophyllite from the definition of asbestos has focused on epidemiological studies of exposed workers. Particular attention has been paid to two prospective mortality studies at a New York state talc mine and mill. The November proposal discussed both studies in great detail.

Briefly, the NIOSH investigators (Brown, Dement and Wagoner Ex. 84-25) concluded that there were significant excesses of lung cancer mortality and of mortality due to nonmalignant respiratory disease. In the opinion of the investigators, this increase could not be accounted for by smoking history alone. They also reported that asbestos was present in the mine and mill. Stille and Tabershaw, studying a larger cohort employed at the same facility, concluded that the lung cancer excess observed was not statistically significant and was "consistent with a smoking effect" (Ex. 84-196). A number of reports, analyses, and letters to the editor that discussed the strengths and shortcomings of the two studies were placed in the record and were discussed in the November proposal (Exs. 84-217; 84-218; 84-231; 84-257; 84-375, 306, 337). (For a detailed discussion see 48 FR 51117-51120.)

Several other authors have investigated the mortality and morbidity associated with anthophyllite and tremolite exposures. Studies by Kleinfeld *et al* (Ex. 84-181). Kiviluoto *et al.* (Ex. 84-181). Gamble *et al.* (Ex. 84-181) and others were discussed in the November proposal. In general, these studies have found an excess mortality and/or morbidity associated with exposures to these minerals.

OSHA has examined the data in the record that addresses the relationship between the health of workers and exposure to tremolite, actinolite and anthophyllite. There is epidemiological evidence in the record that shows that tremolite exposed workers are at risk for both death and disease. The results in experimental animals indicate that under test conditions that some samples of nonasbestiform tremolite induce tumor formation while others do not. Therefore, OSHA concludes that exposure to all forms of tremolite, anthophyllite and actinolite should be regulated under this standard.

The Agency recognizes that the minerals tremolite, actinolite and anthophyllite exist in different forms. Further, the Agency has concluded that all forms of these minerals should continue to be regulated for the reasons stated above. Therefore, OSHA is amending the definition of asbestos in recognition that different mineral forms exist and adding a definition for tremolite, anthophyllite and actinolite to make it clear that all of the mineral forms come under the scope of the standard.

Action Level

In the final standard the action level has been set at 0.1 f/cc which triggers the monitoring, medical, and employee information and training requirements. This level is consistent with the trigger currently applied to the medical surveillance provision of the asbestos standard, so it represents no real change to the standard with regard to this provision, but merely clarifies OSHA's policy. This provision is also consistent with other OSHA health standards which trigger monitoring, medical, and training requirements at the action level (e.g., arsenic, 1910.1018; lead, 1910.1025; acrylonitrile, 1910.1045; and ethylene oxide 1910.1047). Regulated areas, hygiene facilities, and protective clothing are triggered at the PEL, consistent with past OSHA rulemaking. [See, for example, inorganic arsenic, 1910.1018].

Representatives of industry, labor and government endorsed the action level concept. Many participants suggested that a 0.1 f/cc action level should be maintained as an appropriate level for the implementation of medical surveillance [Exs. 86-4, 90-49, 90-163, 90-174, 90-180, 158D, 328]. Some commenters were of the opinion that the 0.1 level should trigger implementation of other provisions as well, such as training [Exs. 86-4, 90-49, 90-163, 90-174, 90-180, 158D, 328]. Some commenters were of the opinion that the 0.1 level should trigger implementation of other provisions as well, such as training [Exs. 86-4, 292, 328], regulated areas [Exs. 86-4, 90-49, 292], monitoring [86-4, 292, 328], hygiene facilities and protective clothing requirements [Exs. 86-4, 292]. Other industry spokespersons believed that the action level was overly burdensome, stating their opinion that if the permissible exposure level were a level that adequately protects workers, no action level should be required [Exs. 90-138, 90-166, 90-168].

The primary reason for adopting an action level is that OSHA believes, based on its experience, that it is appropriate to begin some protective actions prior to exceeding the permissible exposure limit to help drive exposure levels downward and to optimize the possibilities that the PEL can be met. Also, in the case of asbestos, significant health risks exist from exposures to 0.1 f/cc. Consequently, supplemental protective measures are clearly warranted, especially when they are feasibly instituted. The 0.1 f/cc action level also is consistent with OSHA's enforcement of the medical surveillance provision of the current asbestos standard, which requires examinations at *any* level, but which OSHA has interpreted to be 0.1 f/cc.

Another purpose of the action level is to provide an appropriate cut-off point for many of the required compliance activities under the standard. The standard applies to some employers whose employees are exposed to airborne asbestos levels that are below the permissible exposure limits but which are significantly above ambient levels. Such employers are required to perform initial monitoring to determine the extent of their employees' exposures to asbestos. If, on the basis of the results of the initial determination, exposure is below the action level, the employer may be excused from monitoring and most other protective measures for that employee, even though it would be feasible to continue them for all exposed employees. The action level concept thus provides an objective test for OSHA and employers to permit the discontinuance of certain activities, such as medical surveillance, training and periodic monitoring when exposures are low.

A statistical explanation of the need for an action level has been discussed in connection with other OSHA health standards. (See, for example, inorganic arsenic, 43 FR 19584; vinyl chloride, 39 FR 35890; and acrylonitrile, 43 FR 45762). In brief, although all employee exposure measurements on a given day may be below the PEL, it is possible that on days when no measurements are taken, an employee's actual exposure may unknowingly exceed the PEL. As discussed in detail in the section on technological feasibility, some industry representatives expressed concern that they may be unable to assure that levels are less than the PEL every day and stated that measurements showing 0.2 f/cc levels on any given day did not mean that levels on unmeasured days would not be higher. OSHA believes that setting an action level will help to alleviate these concerns because requiring periodic employee exposure measurement to begin at the action level will provide the employer with an increased degree of confidence that employees are not inadvertently overexposed on unmeasured days.

The level that should be designated as the action level was an issue during the rulemaking. OSHA had proposed 0.2 f/cc based on the possibility that 0.5 f/cc would be the PEL and because of the uncertainty about the lower limit of reliable measurement. The Asbestos Information Association/North America (AIA/NA) stated that an action level of 0.2 f/cc for monitoring and training is inappropriate based on interday variability and measurement uncertainty for asbestos workplaces [Ex. 328]. As discussed in the section on sampling and analysis, NIOSH has developed modifications to the existing phase contrast method for asbestos determination. By employing the critical aspects of the method (NIOSH Method 7400) and by adopting other procedures that reduce the analytical variability, OSHA believes, based on the record evidence, that reliable measurement can be made at 0.1 f/cc.

It is noted here, however, that even if the employer has controlled exposures to below the action level, paragraph (d)(5) of the final rule requires reinstitution of exposure monitoring "when there has been a change in the production process, control equipment, personnel or work practices that may result in new or additional exposures to asbestos or when the employer has any reason to suspect that a change may result in new or additional exposures."

Fiber

The current definition for "asbestos fibers" is somewhat circular because it begins, " 'Asbestos fibers' means asbestos fibers. . . ." OSHA has deleted the word "asbestos" and the amended definition now begins. " 'Fiber' means a particulate form of asbestos, tremolite, anthophyllite, or actinolite. . . ."

The current definition specifies only the minimum fiber length (5 micrometers) and does not specify any other dimensions. As methods have been developed to count these fibers, other criteria, for example, the aspect ratio (the ratio of length to diameter) have been used in order to standardize counting methods. When criteria of length, diameter, or aspect ratio differ from one method to another, the result could be widely differing counts on the same asbestos sample.

In the April proposal, OSHA raised the issue of adding an aspect ratio (a ratio of length to diameter) to the definition. The aspect ratio most commonly used throughout the world is 3 to 1 or greater. In 1975, both the American Industrial Hygiene Association and the U.S. Public Health Service were recommending the use of the 3 to 1 aspect ratio (40 FR 47658). This convention is currently in use in the NIOSH recommended method #P&CAM 239 (Ex. 84-062), and NIOSH method 7400 (counting rules A) specifies that only fibers with a length to width ratio equal to or greater than 3 to 1 are to be counted (Ex. 84-444). The NIOSH recommended definition for asbestos (Ex. 117A) and the definition for asbestos fiber recommended by the Building and Construction Trades Dept., also AFL-CIO (Ex. 330) specify an aspect ratio of 3 to 1 or greater.

Although the current definition for asbestos fiber does not contain an aspect ratio, OSHA has been using the 3 to 1 or greater aspect ratio in its laboratory determinations. This practice agrees with the recommendation made by NIOSH in its revised criteria document (H-033B, Ex. 5).

The experimental evidence in the record indicates that a number of durable fibers, including asbestos, are carcinogenic (Exs. 84-93, 84-131, 84-195). Fibers meeting certain criteria of length and diameter appear to be closely correlated to the incidence of sarcomas in experimental animals. Using implantation studies, Stanton and coworkers (Ex. 84-195) examined the relationship between the carcinogenicity of durable fibers and fiber length and diameter. They demonstrated that in female Osbourne-Mendel rats, the probability of pleural sarcomas correlated best with the number of fibers that measured 0.25 micrometer or less in diameter (and more than 8 micrometers in length). Relatively high correlations were noted with fibers having diameters up to 1.5 micrometers (and length greater than 4 micrometers).

Although these investigators were able to demonstrate that fibers of a certain size were associated with a higher incidence of sarcomas, their work did not show a size threshold for carcinogenicity. In addition, these implantation studies demonstrate the carcinogenicity of fibers that have been implanted in the lung and do not address the likelihood that inhaled fibers will actually reach the alveolar spaces.

Bertrand and Pezerat (Ex. 84-114) showed that the aspect ratio was related to the carcinogenicity of the fiber. They reanalyzed Stanton's early data using other variables and concluded that carcinogenic potency is an increasing function of the aspect ratio, with long, thin fibers being the most carcinogenic.

A few witnesses testified that the ratio should be 10 to 1 or greater, noting that particles with an aspect ratio of 3 to 1 may not be fibers but may be cleavage fragments. For instance, Dr. Ann Wylie testified that she had characterized the aspect ratios of two samples of amphibole asbestos. For amosite, she found that 84% of the particles had aspect ratios greater than 20 to 1. For crocidolite, she found that 89% of the particles had aspect ratios greater than 20 to 1. She suggested that an aspect ratio of approximately 20 to 1 should be chosen because it would eliminate amphibole cleavage fragments which have aspect ratios that may range from 5 to 1 to 10 to 1. (Tr. 7/5, p. 101)

Data in the record indicate that the presence of thin fibers can be correlated with increasing incidence of tumors. Therefore, it is appropriate for the definition to include an aspect ratio. However, the evidence does not demonstrate a threshold ratio below which there is no risk. Exposure assessments employing an aspect ratio of 3 to 1 or greater have been used to determine both the QRA and the feasibility of controls. OSHA acknowledges that some particles with an aspect ratio of less than 10 to 1 or 5 to 1 are not asbestos fibers, but OSHA does not regard this as a deficiency in using the 3 to 1 definition. As noted, the 3 to 1 aspect ratio has been successfully used for years. In addition, changing the ratio to 5 to 1 or greater as suggested by some commenters, would mean that OSHA would have to change the quantitative risk assessment and feasibility findings. Since a ratio of 5 to 1 would result in counting less fibers, adopting such a ratio would mean that the dose estimations in the OSHA QRA would have to be adjusted downwards, therefore increasing the risk associated with those longer fibers. Also, since the number of fibers counted would be lower, industry would have the ability to reach a lower PEL using engineering and work practice controls. For these reasons, therefore, OSHA has concluded that the health of workers will be better protected if the definition specifies an aspect ratio of at least 3 to 1.

3. *Paragraph (c). Permissible exposure limit (PEL).*

In this revised rule regulating asbestos exposure in general industry, OSHA has reduced the current 2 f/cc permissible exposure limit (PEL) to an 8-hour time-weighted average (TWA) PEL of 0.2 f/cc. OSHA's determination that a reduction in the PEL is necessary and appropriate is based on record evidence that shows that occupational exposure to asbestos at the 2 f/cc PEL places employees at significant risk of mortality from lung cancer, mesothelioma, gastrointestinal cancer, and possibly other types of cancer. Asbestos also is the cause of asbestosis, a progressive, fibrosing lung disease.

The record evidence demonstrating the causal relationship between asbestos exposure and these diseases consists of a number of well-designed epidemiological studies conducted within many different industry sectors, and of *in vivo* laboratory experiments in which animals exposed either by inhalation or injection developed increased incidences of cancer and scarring of the lung. (The health effects evidence summarized above is presented in Section IV of this preamble).

OSHA has based its determination that a significant risk of material impairment exists at the current PEL of 2 f/cc (TWA), and that reducing the PEL would substantially reduce the risk in large part on its quantitative risk assessment (see Section V). According to that assessment lifetime exposure to an 8-hour TWA of 2.0 f/cc would result in 64 excess deaths due to cancer per 1,000 workers, and 50 cases of asbestosis per 1,000 workers, an excess risk that is clearly significant and unacceptable. By comparison, lowering the PEL to 0.2 f/cc would reduce the risk by about 90 percent to 7 excess cancer deaths per 1,000 workers and 5 cases of asbestosis per 1,000 workers.

In the April 1984 notice, OSHA proposed reducing the PEL to one of two alternative PEL's (0.5 or 0.2 f/cc 8-hour TWA). As explained in that notice, because risk is not eliminated at either of these two alternative PEL's, OSHA's primary consideration for setting a PEL is whether the limit chosen is technically and economically feasible for the affected industries (49 FR 14122). One aspect of technological feasibility which concerned OSHA in the proposal was the feasibility of measuring asbestos levels below 0.5 f/cc (see, e.g. Ex. 90-168, 90–170). As discussed in Section VII of this preamble, a large amount of evidence has been submitted concerning this issue. OSHA has determined, based on this evidence, that airborne asbestos level can be reliably measured below 0.2 f/cc. Therefore OSHA finds the measurement and analysis of asbestos presents no technological bar to choosing the 0.2 f/cc level.

Most importantly the Agency has determined that the 0.2 f/cc limit is the lowest limit that generally can be achieved by feasible engineering and work practice controls. In addition the 0.2 f/cc PEL is economically feasible for the industry as a whole. These findings are based on evidence discussed in Section VII of this preamble concerning the technological feasibility and economic impact of this revised standard. OSHA's analysis projects that most operations in primary and secondary manufacturing industries most of the time will be able to meet the 0.2 f/cc time weighted average without the routine use of respirators. Maritime activities covered by this standard are expected to be primarily rip-out operations, since asbestos containing materials no longer are installed in ships. In these operations as in many non-maritime "rip-out" operations, because of confined spaces and high dust levels. OSHA projects that engineering and work practice controls will have to be supplemented by respirator use.

Virtually all participants in this rulemaking proceeding agreed with OSHA that the evidence linking asbestos exposure to dire health effects was compelling and required OSHA to reduce the PEL of 2.0 f/cc. Representatives of industry, labor, and public health groups supported the reduction of the PEL to at least the 0.2 f/cc level [e.g. Exs. 90–49, 90–236]. Other participants, primarily AIA/NA urged OSHA to pick the higher proposed level of 0.5 f/cc. They based their recommendations on three reasons: that 0.5 f/cc is the lowest level technologically feasible; that the risk from asbestos becomes insignificant at 0.5 f/cc; and that smoking is an important factor in the risk of asbestos-related disease and efforts to reduce smoking would make a 0.5 f/cc PEL sufficiently protective.

OSHA disagrees with each of these reasons. First, the discussion of why OSHA has determined that 0.2 f/cc is the lowest level feasible is found in Section VII of this preamble. OSHA also rejects the position of AIA/NA that establishing a 0.5 f/cc PEL "would eliminate any possibility of significant risk among asbestos workers" (Ex. 328, p. I–28). OSHA projected, based on a soundly conceived and well supported quantitative risk assessment, that a risk of 17 excess deaths per 1000 workers from lung cancer, mesothelioma and gastrointestinal cancer exists at the 0.5 f/cc proposed PEL, and that a risk of 7 excess deaths per 1000 workers exists at the 0.2 f/cc proposed PEL (see Section V of this preamble). Neither risk estimate can be regarded as "insignificant" under the guidelines suggested by the Supreme Court in the Benzene decision [IUD v.

API, 448 U.S. at 655]. Because OSHA has found the 0.2 f/cc level technologically feasible the Agency designated the lower proposed limit as the new PEL.

The next point made by proponents of a 0.5 f/cc PEL is that a sizeable portion of the excess risk of asbestos-related disease is caused by smoking and should be deducted from the projected asbestos risk. Accordingly, it is stated, a 0.5 level will more than adequately protect employees from the resulting *pure* asbestos excess risk (Ex. 328, p. I-26). OSHA does not agree. As stated more fully in the section on significant of risk (Section VI), the available evidence shows no causal relationship between mesothelioma and gastrointestinal cancer and smoking. The evidence on the relationship between asbestosis and smoking is limited. Lung cancer risk is influenced by smoking, but both non-smoking and smoking asbestos workers have the same *relative* lung cancer risk, compared to non asbestos-exposed workers. OSHA also believes that the Agency's mandate under the Act requires that OSHA protect the smoking worker as well as the non-smoking worker. Therefore OSHA believes that its risk estimates, which included excess risk for smoking workers properly are the basis for OSHA's determinations of when excess asbestos-related risk is no longer significant.

Other participants urged OSHA to choose a PEL less than 0.2 f/cc. They based their recommendations mainly on what levels are technologically feasible. For example, the AFL-CIO urged that OSHA choose 0.1 f/cc as the PEL because it is the lowest level feasible to achieve. However, as discussed in the section on technological feasibility, OSHA projected that if a 0.1 f/cc level were chosen, in a large number of operations most workers would have to wear respirators to be in compliance (See Section VII).

Although OSHA expects that a modest level of technological development for asbestos control and an improvement in the application of the effectiveness of currently available best controls will occur, OSHA does not find, on this record, evidence of a possible technological breakthrough which would render the 0.1 f/cc level technologically feasible in most operations.

Further, this rulemaking has again pointed out the inherent limitations of reliance on respirators to meet the PEL, particularly for full shift use. OSHA believes that where, as here, the marginal reduction in exposure levels would be quite small, i.e. 0.2 f/cc vs. 0.1 f/cc, employee protection will be more reliable if employer resources and efforts are concentrated on perfecting the more reliable engineering and work practice controls to control down to the PEL rather than deflecting such efforts by requiring widespread respirator use. OSHA also notes that the requirement that some protective activities be instituted below the 0.2 f/cc level at the action level of 0.1 f/cc, is expected to result in reductions in exposure for employees exposed between 0.1 and 0.2 f/cc.

Another issue discussed in the proposal was the need to promulgate different PEL's for different types of asbestos fibers. As discussed in Section IV (Health Effects), epidemiologic data suggest that exposure to amphiboles, particularly crocidolite, is associated with a higher risk of mortality from mesothelioma than is exposure to chrysotile. The United Kingdom and the Province of Ontario have both promulgated lower PEL's for crocidolite than for other types of asbestos minerals, based on these data (Exs. 84-379, 84-223).

Comments that OSHA received on this issue recommended against the promulgation of different PEL's for the different forms of asbestos. For example, NIOSH (Tr. 6/21), ORC (Ex. 123-A), and AIA/NA (Ex. 328) did not believe that the scientific evidence warranted this approach. OSHA agrees with this assessment of the evidence. Although a differential risk by fiber type for mesothelioma is suggested by the human studies, no differential risk is evident for lung cancer. In addition, animal inhalation and injection studies suggest that chrysotile, and not the amphiboles, pose the greatest hazard. As discussed in Section IV, a number of mechanisms have been proposed to explain these human and animal results. OSHA has found that these results and the scientific community's current level of understanding of the mechanisms leading to asbestos-related disease are insufficient to justify the establishment of different PEL's for the different asbestos minerals. Accordingly, in the revised rule, the Agency has retained the concept of the existing asbestos standard that one PEL be established for all types of asbestos minerals.

An additional reason to set a single PEL for all fiber types is OSHA's finding that it would be highly impractical to require employers to distinguish among fiber types in their measurement programs. Most exposures in working with new asbestos materials are to chrysotile, although crocidolite may also be present in smaller quantities (Tr. 7/9, p. 259-260). Removal, repair and abatement activities often involve mixed fiber exposures (Tr. 6/19, p. I-144]. These employers, therefore, would be required not only to measure total asbestos fiber levels, but also to measure and analyze by fiber type. The difficulties in making these distinctions in a timely manner as well as the uncertain capability of the reference sampling and analytic method to reliably distinguish fiber types would make fiber type differentials infeasible to comply with for many industries (Tr. 6/21. p. 64; Exs. 90-173, 90-181].

As stated above, the health evidence concerning fiber differential, suggests, but does not compel setting a lower PEL for crocidolite exposures. However, OSHA believes the difficulties of routinely distinguishing by fiber type, the fact that the dominant exposure potential is expected to be to chrysotile and the weakness of the evidence concerning fiber type, all support OSHA's decision to set a single PEL based primarily on feasibility considerations for all fiber types.

Ceiling Limit

This final standard does not designate a ceiling limit for exposure to asbestos. This differs from the April proposal which would have retained the previous requirement in the standard of a ceiling limit of 10 f/cc to be met through engineering and work practice controls (49 FR 14123). Although the existing standard's ceiling limit of 10 f/cc did not include a time period, OSHA had administratively interpreted this provision as prescribing 10 f/cc over a 15 minute period.

OSHA's decision not to designate a ceiling limit in the regulatory text is based on several considerations. First it is noted that the sizeable reduction in the time weighted average PEL affected by this revision i.e., from 2.0 f/cc to 0.2 f/cc, effectively reduces the *de facto* ceiling limit from the 10 f/cc level to 6.4 f/cc. This figure results from multiplying the new PEL of 0.2 f/cc by 32, the number of 15 minute periods in a workday. Therefore should an employer expose an employee above 6.4 f/cc for over 15 minutes, he will be violating the 0.2 f/cc TWA PEL, even if that employee has *no* asbestos exposure for the remainder of that day.

Similarly a 15 minute excursion over 3.2 f/cc would constitute a time weighted average exposure over the action level of 0.1 f/cc and would require the employer to institute monitoring, medical surveillance and training programs. OSHA believes therefore, that even without designating a specific ceiling level this standard effectively protects employees against short term very high exposures.

Not designating a ceiling level also corresponds to OSHA's use of cumulative dose models in deriving lung cancer risk and the model used to derive mesothelioma risk. Neither model attributes additional risk to peak ceiling exposures (see discussion in Section V, Quantitative Risk Assessment, and Tr. 6/19, p. I-109).

Although some experts have attributed elevated risk of disease to short "very high" level asbestos exposures, OSHA believes the level of peak exposures involved in the situations referred to far exceeded 6.0 f/cc, the practical ceiling imposed by this standard. Thus, at the rulemaking hearing, Dr. William Nicholson, based his assessment that "much of the hazardous exposures come from peaks" on evidence from

"two industries [where] the predominate exposure has been from air concentrations that have occurred that were very high, but for short duration. Insulation work is one for example. Repair work is the other. And as a consequence particularly in insulation work much of the exposures, much of the disease of today has been from these intermittent high peaks, . . . which we have averaged over time for the purpose of a risk assessment [Tr. 6/19, p. I-146-147].

For one of the groups, insulation work, time-weighted average exposures have been estimated as approximately 50 f/cc (Tr. 7/12, 295). At such a high TWA exposure a 15 minute ceiling exposure would necessarily be vastly higher than the levels allowed by this final standard. Therefore OSHA believes this record provides no evidence indicating that peaks permitted by this standard independently elevate risk above the cumulative dose permitted by the time-weighted average PEL. Other participants also pointed out the scarcity of toxicological and dose-response data concerning an appropriate ceiling level and the resultant difficulties of recommending a specific change to the 10 f/cc limit (see e.g., Ex. 90-236).

The April proposal specifically asked participants for recommendations for specific ceiling levels. In response, some participants recommended a 5 f/cc ceiling limit [Exs. 92-045, 90-180]; a ceiling limit equivalent to 10 times the PEL [Ex. 127] and the AFL-CIO recommended that OSHA should lower the ceiling level for the asbestos standard proportionally to the reduction in the permissible exposure limit which would be 0.5 f/cc, based on the AFL-CIO recommended 0.1 f/cc time-weighted average PEL [Ex. 335, p. 46]. The only scientific evidence cited by the AFL-CIO was the statement of Dr. Nicholson, discussed above, and Dr. Selikoff's testimony that mesotheliomas have appeared in a few workers with very short exposures and in household contact with peak exposures from laundering asbestos contaminated clothing. However the evidence relating dose to these diseases is limited, and OSHA believes it is as compatible with a cumulative dose model as with a peak exposure model. In addition, practical considerations rule out ceiling levels as low as AFL-CIO recommends. The NIOSH panel testified that using the reference method of sampling and analysis, the shortest period of time one could measure 0.5 f/cc would be 25 minutes [Tr. 6/21, p. III-139].

As to the other levels suggested by participants, OSHA believes there is little biological evidence in the record that supports a dose rate response model utilizing peak or ceiling exposures on which to base any specific ceiling limit. As explained above, OSHA believes that practical limitations are imposed on short-term exposures by the time-weighted PEL and by the provisions under housekeeping which would require immediate clean-up of any unexpected release of asbestos fibers such as spills and containers and bags breaking.

Further, the provisions on monitoring require that sampling be conducted during the periods when the highest exposures occur, which would include periods of peak exposures.

Because protective requirements are triggered by the action level of 0.1 f/cc any exposure for 15 minutes above 3 f/cc will have regulatory significance. OSHA believes that its treatment of the issue of a ceiling level reflects the evidence on this record and will protect employees against the as of yet unproven possibility that in fact very high short term exposures have independent significance in increasing risk.

4. *Paragraph (d). Exposure Monitoring.*

Section 6(b)(7) of the Act [29 U.S.C. 665] mandates that any standard promulgated under section 6(b) shall, where appropriate, "provide for monitoring or measuring of employee exposures at such locations and intervals, and in such a manner as may be necessary for the protection of employees." The primary purpose of monitoring is to determine the extent of employee exposures to asbestos.

Exposure monitoring informs the employer whether the employer meets the obligation to keep employee exposures below the 8-hour TWA exposure limit. Exposure monitoring also permits the employer to evaluate the effectiveness of engineering and work practice controls and informs the employer whether additional controls need to be installed. Furthermore, exposure monitoring is necessary in order to determine whether respiratory protection is required at all, and if so, which respirator is to be selected. In addition, Section 8(c)(3) of the Act [29 U.S.C. 657(c)(3)] requires employers to notify promptly any employee who has been or is being exposed to toxic materials or harmful physical agents at levels that exceed those prescribed by an applicable occupational safety or health standard. Finally, the results of exposure monitoring are part of the information that must be supplied to the physician, and these results may contribute information on the causes and prevention of occupational illness.

Paragraph (d) of the final rule contains the standard's requirements related to the monitoring of employee exposure. The final rule contains an 8-hour TWA permissible exposure limit and an action level that acts to alert employers of cases where existing exposures are approaching the PEL. There are two possible exposure situations that will determine the frequency of monitoring required. The table below lists these two exposure situations, along with the monitoring frequency for each.

Exposure scenario	Required monitoring activity
Below the action level	No monitoring required.
At or above the action level.	Monitor exposure at least every 6 months.

As is shown by the table above, the action level trigger determines whether employers must monitor employee exposure to asbestos; where the action level is reached or exceeded, the employer must monitor employee exposures. This is changed from the existing standard, which requires periodic monitoring when exposures are above the permissible exposure limits. It is OSHA's belief that this new requirement of monitoring when levels are at or above the action level is needed to properly assess worker exposure so as to ensure the proper operation of available controls and that respirators with the appropriate protection factors are used in each regulated area. Periodic measurement is appropriate when employee exposures are at or above the action level, because relatively minor changes in the process, materials or environmental conditions might increase the airborne concentration of asbestos to levels above the standard's PEL.

Paragraph (d)(2)(i) requires that each employer shall perform initial monitoring of employees who are, or may reasonably be expected to be exposed to airborne concentrations at or above the action level. Thus, for example, because office buildings generally have air concentrations less than the action level, an employer would not be required to perform initial monitoring unless there is reason to believe that conditions exist that may expose employees to asbestos at or above the action level. Such conditions include visible evidence of deterioration of asbestos materials and construction or maintenance activities which would disturb asbestos materials.

The final rule does not require periodic monitoring and measurement for the TWA when initial monitoring data reveal exposures below the 0.1 f/cc action level because exposures below the action level provide a margin that makes it unlikely that minor changes in processes, materials or environmental conditions will result in exposures above the PEL.

Many commenters addressed the specifications for monitoring frequency contained in the proposed standard [Exs. 84–379, 86–4, 90–140, 90–168, 90–173, 127, 263, 428]. Several commenters requested that OSHA not specify a frequency for monitoring employee exposure levels [Exs. 86–4, 90–173, 263]. For example, the American Iron and Steel Institute stated:

> Required exposure sampling should have a valid basis. An automatic preset sampling frequency is burdensome, wastes scarce industrial hygiene resources, and provides no direct benefit to exposed employees who follow proper work practices and use prescribed personal protective equipment. * * * Requiring sampling on a quarterly basis serves little purpose if the jobs performed are essentially the same and no changes have occurred in the operation [Ex. 263].

Bell Communications Research also addressed this point:

> The requirements for exposure monitoring should be written in terms of performance oriented language that will allow employers to structure their monitoring program to fit their specific work situation. * * * Overall employee protection is more dependent on training, work procedures, and in some cases personal protective equipment than a rigid workplace monitoring program [Ex. 90–173].

OSHA has maintained the monitoring frequency in the existing standard. However, OSHA believes that the monitoring frequency specified in the final standard is a minimal requirement, and that many employers will wish to conduct more frequent monitoring to ensure employee protection and compliance with the standard. Although the final standard contains a minimal sampling frequency, the final standard requires the employer to sample based on performance criteria. That is, the employer must sample with such frequency and pattern as to represent, with reasonable accuracy, the levels of exposure of the employees. This performance provision is contained in the existing standard and is maintained in the final standard. In this provision, the employer decides how often to monitor, depending upon the conditions in the employer's operation; some employers may monitor more than others providing the monitoring is at least on a semiannual basis for all. Clearly, the more frequent the measurements, the greater the reliability of the resulting employee exposure profile.

A number of submissions to the record supported a requirement for monitoring every three months if the airborne concentration of asbestos was at or above the action level [Exs. 84–379, 127]. For example, the European Economic Community, Labour and Social Affairs Council (1983), stated:

> The concentration of asbestos shall be measured as a general rule at least every three months and, in any case, whenever a technical change is introduced [Ex. 84–379].

And, Marshall H. Marcus, certified industrial hygienist, supported the change in monitoring frequency, commenting that exposure monitoring should be reduced to once every three months, with provisions for additional monitoring if necessary [Ex. 127].

The standard requires that whenever there has been a production, process, or control change that may result in new or additional exposures to asbestos above the action level, or whenever the employer has any other reason to suspect an increase in employee exposures above the action level, the employer shall again initiate the required monitoring for those employees affected by such change or increase. The final standard also provides that an employer may discontinue periodic monitoring for those employees for whom measurements statistically show exposures to be below the action level.

The final standard also differs from the existing standard in that the requirement to conduct environmental monitoring has been eliminated in the final standard, and the frequency of personal monitoring is increased. The purpose of the OSHA standard is to reduce worker exposure. Only air samples collected at the worker's breathing zone truly reflect the level of exposure of a worker to a given contaminant throughout a work day. Therefore, OSHA believes that personal air sampling is more useful than environmental sampling for determining compliance for the OSHA standard.

Environmental samples can be useful. When the purpose of a survey is to determine sources of contamination or to evaluate engineering controls, a network of area sampling (environmental monitoring) would be appropriate. The new standard permits this type of sampling. OSHA has not required, however, that the employer conduct environmental sampling in other toxic substance regulations, and has found that personal air sampling is adequate as a mandatory requirement. In addition, the elimination of environmental sampling permits the employer to make more efficient use of resources.

Methods of Measurement

In the April proposal (49 FR 14126), OSHA considered requiring a specific sampling and analytical protocol to measure and analyze airborne concentrations of asbestos fibers. Currently, the existing asbestos standard (29 CFR 1910.1001(e)) requires that all measurements of asbestos fibers be made by a membrane filter method using phase contrast illumination at 400–500 X (magnification). While acknowledging that airborne asbestos measurement procedures using phase contrast microscopy inherently contain several sources of error, OSHA stated that "phase contrast microscopy errors can be reduced if improved and standardized procedures are followed, perhaps by adding requirements to the standard" (49 FR 14126). Although the Agency did not propose mandating a specific monitoring procedure at that time, the proposal discussed the desirability of adopting, verbatim or with modification, procedures recommended by the Asbestos Information Association (AIA) (Ex. 86–002), Chatfield (Ex. 84–319), the British government, (Ex. 84–446), NIOSH (Ex. 84–444).

Need for Standardization of the Monitoring Method

Evidence submitted to the record clearly demonstrates that the use of different sampling and analytical protocols for phase contrast microscopic analysis of asbestos concentration leads to different monitoring results, and that monitoring results can vary according to the equipment used (particularly the graticule), mounting and clearing procedures, and rules for counting fibers (Exs. 101G, 101H; Tr. 6/20, p. 13; Tr. 6/20, pp. 38–39; Tr. 7/6, pp. 79–81). For example, use of the AIA's recommended counting rules generally leads to lower estimates of airborne asbestos concentrations than the use of other counting rules because fibers that appear to be attached to non-fibrous particles are not counted in the AIA method (Tr. 6/20, p. 13). OSHA believes that much of the testimony and evidence describing interlaboratory error (that is, differences in analytical results obtained by different laboratories analyzing the same sample) reflects the use of different analytical procedures by these laboratories. OSHA also believes that mandating a specific monitoring procedure will ensure a greater degree of consistency in monitoring results among different employers who use different laboratories. Furthermore, by using the same sampling and analytical procedure as that adopted by OSHA's Salt Lake City laboratory, employers will have greater confidence that their monitoring results will parallel those that would be obtained from OSHA's compliance monitoring.

Selection of a Standardized Monitoring Method

OSHA reviewed a number of asbestos sampling and analytical methods described during these rulemaking proceedings (Exs. 84-62, 84-230, 84-238, 84-444, 84-446, 86-002). As noted by OSHA in the April proposal, phase contrast microscopy has been widely adopted and used internationally as an accepted and reliable indicator of asbestos concentrations. The major disadvantage of this method is its inability to distinguish among different types of asbestos and among asbestiform fibers and other types of fibrous particles. Although electron microscopic analysis of asbestos samples can distinguish among different fiber types, OSHA noted in the proposal that, because of the costs involved and the length of time required for analysis, ". . . it is not practical or necessary to . . . require electron microscopic analysis instead of phase contrast light microscopy" (49 FR 14126). In addition, OSHA noted that standard counting methods for the electron microscope have only recently been developed and one in need of improvement, while those for phase microscopy are widely known and used.

Rulemaking participants were in agreement that OSHA should rely for routine monitoring of asbestos on a sampling and analytical method that utilizes phase contrast microscopy (Exs. 123A, 253, 328, 330; Tr. 7/5, p. 121). For example, the AIA stated:

The record does not demonstrate any significant advantages in terms of reproducibility of results or lowered practical limits of reliable detection to justify the large increase in analytical expenses that would result if an electron microscopy method were adopted. The primary advantages of electron microscopy methods are better visualization of very thin asbestos fibers and more precise fiber identification capabilities. Neither of these advantages are necessary for routine workplace analysis. Moreover, at the present time, standard electron microscopy analytical methods have not been sufficiently tested under workplace conditions for either precision or comparability to historical PCM measurements. (Ex. 328)

Similarly, the Building and Construction Trades Department (BCTD) of the AFL-CIO stated:

Electron microscopy has the advantage of counting all the fibers present, including the thin ones that cannot be seen under current optical microscopy. However, due to the additional cost and time in preparation, the BCTD is recommending it only as the method to be used in categorizing products or processes and for clearance samples to declassify regulated areas when greater accuracy is needed. (Ex. 330)

Dr. Eric Chatfield of the Department of Applied Physics, Ontario Research Foundation, stated that "in view of the number and frequency of measurements required [in the field] there is currently no fully developed alternative [to phase contrast microscopy] which could be immediately implemented" (Ex. 84-319). These similar comments reaffirm OSHA's view, as expressed in the April proposal, that requirements in the revised standard for asbestos sampling and analysis must be based on the use of phase contrast microscopy, which has proven to be adequate for most situations in the past.

The sampling and analytical method used by most laboratories in the United States has been the NIOSH P&CAM 239. This method requires the use of a 37-mm diameter filter, phthalate-oxalate clearing solution, Porton graticule, and the set "A" counting rules.

In February 1984, NIOSH issued a revision of the P&CAM 239 method (Ex. 84-444), incorporating a number of analytical changes that were being used for other methods worldwide. NIOSH (Ex. 117D) presented a concise comparison of the new method, called the NIOSH 7400 method, with other sampling and analytical methods, including the AIA-recommended method, Chatfield's method, and the method recommended by the International Standards Organization (ISO). Their findings were as follows:

- The NIOSH 7400, AIA, ISO, and Chatfield methods require the use of a 25 mm-diameter filter.
- The NIOSH 7400, AIA, and ISO methods require the use of a 3-piece filter cassette and a 50-mm-long cowl extension. The Chatfield method does not require the use of a cowl.
- The NIOSH 7400 method requires that the flow rate be greater than 0.5 liters per minute (1pm). The AIA, Chatfield, and ISO methods require a 1 1pm flow rate.
- The NIOSH 7400 method requires a minimum filter loading of 100 fibers/mm^2 The AIA, ISO, and Chatfield methods require a minimum filter loading of 50 fibers/mm^2.
- The NIOSH 7400, AIA, ISO and Chatfield methods all require the use of acetone-triacetin clearing solution for the preparation of samples for analysis, and a Walton-Beckett graticule to provide the counting area on the microscope.
- The NIOSH 7400, AIA, ISO, and Chatfield methods all require the use of a phase shift test slide to calibrate the microscope.
- The NIOSH 7400 method permits the use of the same counting rules (designated as the "A" rules) as the NIOSH P&CAM 239. The AIA, ISO, and Chatfied methods permit the use of the "A" rules except that fibers with a diameter of greater than 3 microns or fibers that appear to be attached to particles with a diameter of greater than 3 microns are not counted. The NIOSH 7400, AIA, ISO, and Chatfield methods all permit the use of the "B" counting rules as an alternative.

Several commenters agreed that the NIOSH 7400 and similar methods represent vast improvements over the currently used NIOSH P&CAM 239 (Exs. 117-A, 123-A, 328, 330; Tr. 6/20, p. 10; Tr. 6/21, p. 186; Tr. 7/8, p. 69). For example, the AIA stated that it has

. . . looked favorably in the past on a number of modifications to the existing NIOSH analytical method, P and CAM 239, that will increase standardization and quality control . . . These improvements include the specification of a standardized graticule, a reduction in the sample filter size, the required use of a test slide to maintain appropriate resolution and a change to the acetone-triacetin slide mounting method (Ex. 328).

Dr. Chatfield testified at the hearing that the NIOSH Method 7400 is an improvement over the existing NIOSH method in its provisions for standardization of counts between counters and laboratories. Its adoption of the acetone-triacetin fixing technique follows the international trend in that direction (Tr. 7/6, p. 69).

As part of the submittal from Organization Resources Counselors, Inc., Graham W. Gibbs. Ph.D., also agreed that the modification of P&CAM 239 is appropriate:

The reduction in the filter [size] to 25 mm [diameter] to improve the uniformity of the dust deposit is probably a sound move. . . . The use of acetone to collapse the filter results in a much [more thinly] mounted sample than with previous methods, which in turn helps to reduce the error if the observer fails to focus properly through the sample. . . .

The use of the Walton-Beckett graticule is a major improvement. This graticule was designed for fibre counting, the contrast to those recommended in previous NIOSH methods. (Ex. 123A, Appendix C)

Because the NIOSH 7400 method takes advantage of technological improvements that have been adopted worldwide for asbestos sample analysis but retains the same counting rules as the NIOSH P&CAM 239, OSHA has used the major features of the NIOSH 7400 method as the basis for developing a required standardized sampling and analytical method measuring airborne asbestos concentrations. The method required by the revised asbestos standards for both general industry and construction, referred to as the OSHA Reference Method (ORM), is detailed in the mandatory Appendix A of each standard.

These appendices require that the employer collect airborne asbestos samples using 25 mm diameter mixed cellulose filters and a 50 mm extension cowl. Samples must be analyzed using a phase contrast microscope calibrated using a phase shift test slide and equipped with a Walton-Beckett graticule. The ORM also requires that filter samples be prepared using acetone-triacetin clearing solution and be counted in accordance with the "A" rules contained in the NIOSH 7400 method.

The ORM differs from the NIOSH 7400 method in two important respects. The ORM mandates a flow rate for asbestos sampling of between 0.5 and 2.5 1pm, which is similar to the flow rate range permitted by the NIOSH P&CAM 239 method (1.0 to 2.5 1pm). In contrast, the NIOSH 7400 method permits the use of any flow rate greater than or equal to 0.5 1pm. Secondly, the ORM permits the use of the larger 37 mm diameter filter when the employer has written justification explaining the need to use a larger filter to obtain readable samples. Both of these departures from the NIOSH 7400 method were made in response to commenters who pointed out that the use of high flow rates (e.g., 4 1pm) combined with the use of the smaller 25 mm filter may result in samples that are too overloaded with dust to permit the counting of asbestos fibers. This is particularly true in construction where nonasbestos dust particles released to the air as a result of demolition or renovation activities may interfere with analyzing samples that were collected using high flow rates and the smaller filter. OSHA believes that, by limiting the flow rate and permitting the use of the 37 mm filter in certain circumstances, employers will be more likely to obtain readable samples in dusty environments. In addition, record evidence suggests that the use of high flow rates may increase electrostatic charges in the filter apparatus, preventing some fibers from reaching the filter and resulting in lower fiber counts (Ex. 84-478: Tr. 7/6. p. 99). The implications of including these changes to the NIOSH 7400 method in the ORM, and record comments pertaining to filter overload, are discussed in depth in the section below dealing with the limit of detection of the NIOSH 7400 method.

In order to provide flexibility for employers to use monitoring methods that are different from but equivalent to the ORM, paragraph (d)(6) allows employers to use an equivalent method. To ensure that employers gather reliable exposure data both for their own management purposes and for the protection of employees from exposure to asbestos fibers, OSHA has included criteria in the revised rule for determining equivalency with the OSHA reference method.

These criteria include a protocol for side-by-side comparative testing using the OSHA reference method and the employer's candidate alternative method. The employer's candidate alternative method would be judged acceptable if 90 percent of the samples collected over the range of 0.5 to 2.0 times the PEL have an accuracy range of plus or minus 25 percent of the results of sampling taken with the OSHA reference method at the 95 percent confidence level. Any method judged equivalent using the protocol can be used for conducting employee exposure monitoring if the employer documents the method used and maintains records of the comparability testing used to establish the method's equivalency with the OSHA reference method.

OSHA believes that providing this protocol for testing the equivalency of alternative monitoring methods will remove barriers to innovation and technological advancement while at the same time providing an equal level of protection for employees.

Precision of the NIOSH 7400 Method

NIOSH has estimated that the overall precision, expressed as the coefficient of variation (CV), of the 7400 method ranges from 0.115 to 0.13 for samples in which 80-100 fibers per 100 fields have been counted (Ex. 84-444). For optimally loaded filters (100 fibers/100 fields), the estimated CV of 0.115 yields a one-sided standard analytical error (SAE), which is used to determine the upper and lower 95 percent confidence limits of the sample results, of 18.9 percent. (The SAE is determined by multiplying the CV by 1.645; see Ex. 84-62.) The estimated SAE for optimally loaded filters analyzed by this method, 18.9 percent, is thus lower than the SAE of 25 percent currently listed for this method in OSHA's Industrial Hygiene Technical Manual.

The NIOSH estimates of the CV for the P&CAM 239 method reflect all random sources of variation in airborne asbestos measurement; specific sources of random variation that NIOSH considered to be important include intrafilter variations (which result because only a portion of a filter is examined for counting fibers), random intercounter variations (also referred to as intralaboratory variation), and random error in pump flow rate (Ex. 84-62). NIOSH's estimate of the overall precision of the 7400 method is the same as its estimate of the overall precision of the P&CAM 239 method; that is, NIOSH did not revise or adjust its precision estimates when developing the 7400 method, because NIOSH believes that the 7400 method is merely a revision of the P&CAM 239. Dr. David Taylor of NIOSH defended this position at the informal hearing:

> . . . The reason [that the 7400 method is a revision of P&CAM 239] is because its the same analytical process . . . [, the] use of phase contrast microscope . . . [and] the same counting rules, the A rules. And the sampling media are the same. . . . So its a revision of 239, not a new method. (Tr. 6/21, p. 157)

To measure the degree of random variability of asbestos samples analyzed by the P&CAM 239 method, Busch et al. (Ex. 84-62, Appendix C) used data collected by Johns-Manville, in an in-house interlaboratory study of the P&CAM 239 method. Each of 109 filters was counted by two to five counters located in five Johns-Manville laboratories. Busch et al. determined unbiased CV's for each of the samples and fitted a regression curve to the CV estimates plotted against average total fiber count for each sample. The resulting curve, which is presented in the NIOSH publication that accompanies the 7400 method (Ex. 84-444) as well as in Busch et al. (Ex. 84-62, Appendix C), clearly shows that analytical precision improves as the total number of fibers counted increases. For a fiber count of 10 fibers per 100 fields, NIOSH estimated the CV to be 0.41; if 100 fibers are counted in 100 fields, the estimated CV decreases to 0.115. This relationship between analytical precision and number of fibers counted has been recognized by several other rulemaking participants (Exs. 84-447, 84-455, 93-3, 328; Tr. 6/20, p. 8; Tr. 7/6, p. 111; Tr. 7/6, p. 161), and has led NIOSH to recommend that sampling strategies be designed to yield samples with fiber densities of at least 80 fibers per 100 fields when using the NIOSH 7400 method.

Intralaboratory Variability

NIOSH's statistical analysis of the Johns-Manville analytical data, and the resulting estimates of the precision of the P&CAM 239 method, were criticized by rulemaking participants, who believed NIOSH's estimates to be too low (Ex. 91-16, Tab D; 91-16, Tab E, 232-B, 233-B, 328; Tr. 7/6, p. 66). In summarizing the record evidence on intralaboratory variability, which was one of the three sources of variability included in NIOSH's overall estimate of precision for the method, the AIA concluded that ". . . NIOSH should . . . recognize a more reasonable CV value in the range of 0.2 to 0.3—a range which accords with the remainder of the evidence in the record on the best achievable total intralaboratory error" (Ex. 128, p. A-15). In arriving at this conclusion, the AIA relied on the following evidence:

- Testimony from Dr. Ogden stating that he had achieved intralaboratory CV's of approximately 0.2 in British laboratories.
- Analysis of the Johns-Manville data by Dr. Patrick Crockett, who projected a CV of over 0.31 for a total fiber count of 100.
- The study of the P&CAM 239 method by Chase and Rhodes (Ex. 86-002), who reported an intralaboratory CV of 0.38 for a total fiber count of 100.

OSHA has analyzed the evidence presented by the AIA and finds that these data do not necessarily refute NIOSH's estimates of the CV for samples analyzed by the P&CAM 239 or NIOSH 7400 methods. In fact, the evidence of Dr. Ogden cited by the AIA closely parallels the results obtained by Busch et al. (Ex. 84-62, Appendix C). Dr. Ogden examined intralaboratory variation among technicians analyzing 66 asbestos samples in British Health and Safety Executive (HSE) laboratories (Ex. 84-447). In this testimony about this work. Dr. Ogden stated that his investigation, as well as those from other laboratories, resulted in estimated intralaboratory CV's similar to the estimates obtained in the NIOSH study:

There is a lot of evidence from different laboratories that repeated evaluation of the same asbestos-loaded membrane filter by the same counter, or by different counters closely linked within a laboratory, can give a coefficient of variation of between 10 and 20 percent. . . .

Figure 1 [from Ex. 84-447] demonstrates results in our laboratory of a detailed study of one year's quality assurance results . . . . On the vertical axis we have the coefficient of variation of the repeated determination, and on the horizontal axis we have the mean number of fibers counted in that sample. . . .

Since coming to the United States I have plotted the results on the same axis which were published by [Busch et al.] . . . . If we superimpose those, you can see they lie in very much the same kind of area. (Tr. 6/20, pp. 6-7)

Dr. Ogden's estimate of 0.2 as an average CV representing intralaboratory variability is a consequence of his use of a minimum fiber density of 50 fibers per 100 fields, in contrast with NIOSH's recommendation in the 7400 method that a minimum fiber density of 80 fibers per 100 field be used, which yields an estimated CV of 0.15. Therefore, OSHA finds that Dr. Ogden's results actually confirm NIOSH's estimates of the intralaboratory coefficient of variation for asbestos samples analyzed by phase contrast microscopy.

The AIA also relied on the analysis performed by Dr. Crockett (Ex. 312-A, Tab P) of the Johns-Manville data to refute NIOSH's estimate of the precision of the P&CAM 239 method (Ex. 328, pp. A-12 to A-15). The AIA explains Dr. Crockett's analysis as follows:

Dr. Crockett identified and plotted . . . more than forty data points that were excluded from the NIOSH analysis. . . . In the very important range of 60 to 100 fibers counted, only six or seven of the eighteen data points [in this range] were included and the included points represented dramatically lower CV estimates than the excluded points . . . .

When Dr. Crockett applied a close reproduction of the NIOSH statistical method to the *entire* Johns-Manville data set, his projected CV for a total fiber count of 100 was over 0.31, about three times as high as NIOSH's result based on incomplete data. In any event, the published NIOSH method does not represent the original Johns-manville data base, but instead reflects only a subset of that database with much of the high variability data deleted. (Ex. 128, pp. A-13 to A-14)

When questioned as to why NIOSH eliminated some of the data points in the analysis, Ken Busch of NIOSH replied that these data were excluded because they were outside the fiber density range permitted by the "A" rules:

I'm absolutely certain that there was no intent to eliminate counts which would be the cause of high variability. The elimination of counts . . . which were based on large numbers of fibers was simply because this procedure of counting more than 100 fibers did not correspond to the standard procedure for the NIOSH method. (Tr. 6/21, p. 192)

In addition, the statistical model developed by Busch et al. (Ex. 84-62, Appendix C) was developed to estimate the relationship between CV and number of fibers counted. As such, the model can only appropriately be applied to samples that were counted using the "100 fields" stopping rule of the set A rules (i.e., for samples with a fiber density of less than 1 fiber per field, 100 fields must be counted, and for samples with a fiber density of more than 5 fibers per field, 20 fields must be counted). For samples with fiber densities between 1 and 5 fibers per field, the NIOSH "A" rules require that enough fields be counted to yield 100 fibers. According to Busch et al. (Ex. 84-62, Appendix C, p. 75), calculating the overall CV for samples counted using the "100 fibers" stopping rule rather than the "100 fields" stopping rule cannot be done unless additional statistical techniques are developed, although "indications are that the '100 fibers' stopping rule [would] yields a CV_T similar to that for the '100 fields' stopping rule when 100 fibers are counted" (Ex. 84-62, p. 75). Both because of the uncertainty surrounding the calculation of a CV for samples counted using the 100 fibers stopping rule, as reported by Busch (Ex. 84-62, p. 75), and because the Johns-Manville data were appropriately excluded from the NIOSH analysis, OSHA disagrees with Dr. Crockett's contention that NIOSH's estimated CV is unreliable.

The final study cited by the AIA to support its contention that the intralaboratory CV associated with the P&CAM 239 method is higher than that estimated by NIOSH is the round robin study by Chase and Rhodes (Ex. 86-002), which reported a random intralaboratory CV of 0.38 for a total fiber count of 100. According to the AIA:

This study included virtually all relevant error sources and of the studies in the record, is the most representative of everyday American experience with P&CAM 239 and commonly encountered workplace samples, and should be accorded significant weight by OSHA. (Ex. 328, p. A-11)

AIA did acknowledge that the study may overstate the magnitude of the "best achievable intralaboratory CV" because of the absence of quality control programs in some of the participating laboratories, and because some of the samples analyzed were difficult to count (Ex. 328, p. A-11, Footnote 17). The lack of quality control programs, as evidenced by the participation in the NIOSH PAT program of only 19 of the 46 laboratories included in the study, was one reason suggested by OSHA in the November proposal (48 FR 51136) for the Chase and Rhodes study's higher reported CV.

OSHA also believes that the design of the Chase and Rhodes study is deficient. The authors collected and analyzed a total of 1,774 full-shift samples, of which 541 were submitted for a second analysis. Thus, only 30 percent of the samples collected were analyzed by one other analyst. In contrast, each of the Johns-Mansville samples relied upon by Busch et al. (Ex. 84–62, Appendix C) were analyzed by 2 to 5 technicians, and each of the samples used by Ogden (Ex. 84–447) were analyzed by 7 to 8 technicans. Because of the larger number of sample recounts conducted to obtain the results reported in the Busch et al. and Ogden studies, and because of the more rigorous quality assurance procedures used by the laboratories whose results were reported in these studies, OSHA believes that the intralaboratory CV estimates reported by Busch et al. and by Ogden better reflect the inherent intralaboratory variability associated with the phase contrast method than the CV reported in the Chase and Rhodes study.

Interlaboratory Variability

Another significant source of sample variability addressed by the AIA was that of interlaboratory variability, defined as differences in results for a single sample analyzed by different laboratories. The AIA stated that analysis of samples by different laboratories "... produces a broader spread of results than would repetitive analysis by a single laboratory [i.e., intralaboratory variability]" Ex. 328, p. A–15). AIA estimated that the combined intra- and interlaboratory CV for the P&CAM 239 method was between 0.3 and 0.4. The AIA relies most heavily on the Chase and Rhodes study (Ex. 002) and information obtained from NIOSH's PAT program to estimate the interlaboratory CV (Exs. 118–A to 118–D). These reports estimated average interlaboratory values of 0.24 and 0.35, respectively.

As discussed earlier in this section, laboratories may achieve very different results from monitoring the same workplace if they use different sampling and analytical methods. In describing the NIOSH PAT program, Dr. Taylor pointed out that the program does not require participants to use the P&CAM 239 method:

[The NIOSH PAT program] ... is not an evaluation of 239, or any other particular procedure. It's an average of whatever procedures that the laboratories are using. (Tr. 6/21, p. 180)

Dr. Busch also explained that the large variability in results for PAT samples analyzed by different laboratories is due to the small sample size, which results in statistical imprecision in the CV calculated for each PAT sample (Tr. 6/21, p. 176).

Furthermore, differences in training and quality assurance procedures instituted by different laboratories can lead to large discrepancies in the analytical results obtained by those laboratories. When asked by Scott Schneider of the BCTD if quality assurance procedures can reduce interlaboratory variability, Dr. Taylor responded:

I think quality improvements and quality control within laboratories, and participation in round robin testing between laboratories and participation in a proficiency testing program tends to decrease the variability of the laboratories. And NIOSH has presented a paper at [The American Industrial Hygiene Association Conference] ... a year ago and is ready to publish results of analysis of the last 10 years of PAT data. And, in that, we show a decreasing variability with the laboratories with the number of years that [they have] ... been in it (Tr. 6/20, p. 182).

Dr. Ogden also testified as to the importane of quality assurance programs in reducing interlaboratory variability:

Standardization of the membrane filter method does not on its own harmonize results.... There is no doubt that participation in interlaboratory quality control schemes improves comparability of results, and it is reasonable to suppose that participation and improvement of standards will be encouraged by an OSHA requirement to achieve passing grades, as suggested in the proposed rule. (Tr. 6/20, p. 17)

It is clear from this testimony, as well as the evidence presented earlier in this section, that standardization of the monitoring method as well as laboratory quality control programs are important for minimizing interlaboratory error. OSHA does not believe that the Chase and Rhodes study (Ex. 86–002) nor the NIOSH PAT data (Exs. 118–A to 118–D) are reliable measures of the intrinsic interlaboratory variability of asbestos measurement because quality assurance procedures vary widely among the laboratories participating in these studies.

In his study of HSE laboratories in Great Britain, Dr. Ogden found that, among laboratories with comparable quality control procedures, interlaboratory and intralaboratory variability are analogous in that both are dependent on the number of fibers counted (Exs. 84–446, 84–447, 93–3). It is not surprising that, as laboratories become more similar in their analytical, training, and quality control procedures, the problem of *inter*laboratory variability becomes more a problem of *intra*laboratory variability. This is also reflected in NIOSH's statistical analysis of the Johns-Manville asbestos data (Ex. 84–62, p. 6), in which interlaboratory variability was treated as a non-random (systematic) rather than random source of sampling and analytical error; that is, a source of error that is capable of being controlled.

Since the NIOSH estimate of the CV for the P&CAM 239 and NIOSH 7400 methods included only sources of random variability, other sources of controllable error, such as interlaboratory or systematic intralaboratory variability, may decrease the precision of the method used beyond that estimated by NIOSH. In order to minimize both nonrandom intra- and interlaboratory variations for asbestos monitoring, OSHA has included quality control requirements in Appendix A of the revised asbestos standards for general industry and construction.

Specifically, OSHA requires in Appendix A of the revised rule for general industry that employers rely only on laboratories that have instituted intralaboratory and interlaboratory comparisons and requirements for the training of microscopists. The laboratory relied upon by the employer must conduct an intralaboratory quality assurance program involving blind recounts for statistical monitoring of the variability of counting by each microscopist and among microscopists in the laboratory. For companies with more than one laboratory location, intracompany evaluations of variability must also be conducted.

The laboratory that an employer relies on to analyze air samples for asbestos must also participate in round robin testing with at least 2 other laboratories. Each laboratory is required to participate in round robin testing at least once every six months, conduct a statistical analysis of the results, and post results in each laboratory. Appendix A of the revised rule for general industry also requires that all microscopists who analyze air samples for asbestos take the NIOSH course for sampling and evaluating airborne asbestos dust, or an equivalent course.

Some commenters requested that OSHA consider requiring laboratories that analyze personal air sample to be proficient participants in the NIOSH PAT Program (Exs. 92–8, 277, 328, 330, Tr. 6/26, p. 73). For example, the Building and Construction Trades Department, AFL–CIO, recommended that OSHA require that

... samples be sent for analysis at the end of each shift and [be] analyzed by certified laboratories. To be certified, a laboratory must meet OSHA and/or NIOSH quality control requirements for certified laboratories and participate in and pass NIOSH review in the "Asbestos Round Robin" for certified laboratories sponsored by the NIOSH Proficiency Analytical Testing (PAT) program. (Ex. 330)

The NIOSH PAT program has been in existence for 13 years. Recently, however, NIOSH has transferred the administration of the program to the American Industrial Hygiene Association, which will provide PAT samples to private laboratories. Since the direction and administration of the PAT program is undergoing changes, OSHA has not at this time required employers to utilize laboratories that are participating in the PAT program.

Intersample Variability

The third type of asbestos monitoring variablilty discussed by the AIA was that of intersample variability, defined as the difference in results obtained by analyzing two samples that are taken side-by-side. The AIA cited two reports that ". . . address directly the magnitude of [intersample variability] . . . for airborne asbestos monitoring" (Ex. 328, p. A-18). In one of these reports (Exs. 91-16, Tab D, 232-B). Dr. Chatfield used the data from the Chase and Rhodes study to compute a CV for intersample variability of 0.47 for a 100 fiber count. The AIA concluded that ". . . the breadth of the Chase and Rhodes Study warrants considerable weight for this evidence" (Ex. 328, p. A-19).

Yehia Hammad, D.Sc., Associate Professor at the School of Medicine, Tulane University, commented on this estimate of intersample variability under cross-examination by Tim Hardy of the AIA:

> I just could not see a measurement where I would have 47 percent variability between two points . . . If we have 47 percent variability between two points, then all the numbers that we are talking about today should fall out the window. That means that engineers cannot go and measure anything side-by-side because the variability is 47 percent. (Tr. 6/20, p. 89)

Under questioning by Mr. Schneider of the BCTD, Dr. Hammad elaborated on the cause of intersample variability:

> The variability that is present depends on the properties of the dust cloud . . . [I]f you are walking in a dust cloud . . . then there is a difference between dust concentrations at different points. And the point that I was making is that I do not see any reason, and I haven't seen during the past 15 years that I have been working in this field, that dust concentrations between two points four or five inches apart will be 47 percent. Things just don't happen that way. (Tr. 6/20, p. 121)

OSHA believes that the testimony of Dr. Hammad casts considerable doubt on the estimated CV for intersample variability derived from the Chase and Rhodes study. Furthermore, as discussed above, interpretation of the Chase and Rhodes study with regard to intrinsic error in the NIOSH P&CAM 239 method is complicated by a lack of adequate quality control procedures in many of the participating laboratories.

The AIA relied more heavily on a study conducted by Serocki et al. (Ex. 84-478), in which 15 paired asbestos samples placed in "close proximity" to each other were collected in two worksites where asbestos is present. The sample pairs were collected at 2 lpm for sampling durations of from 25 to 96 minutes. The AIA determined the CV for each sample pair and found that the average CV for intersample variability in this study was 0.62 (Ex. 328, p. A-20). The AIA asserted that electrostatic capture of asbestos fibers on the filter cassette was at least partially responsible for the intersample variability observed in the Serocki et al. report. The AIA concluded from the Chase and Rhodes and Serocki et al. studies that the CV for intersample variability for the P&CAM method lies between 0.4 and 0.5 (Ex. 328, p. A-22).

OSHA does not agree with the AIA's analysis of the Serocki et al. data, for a number of reasons. First, Serocki and his colleagues did not claim that electrostatic charge was responsible for the differences in results between paired samples collected at low (2 lpm) flow rates; in fact, these authors concluded that differences in results between paired low flow rate samples were not statistically significant. Serocki et al. did observe significant differences between members of paired samples where one sample was collected at a high flow rate (7.5 lpm), and the other was collected at a low flow rate (2 lpm), and these authors attributed these differences, in part, to excess electrostatic charge.

OSHA believes that some of the variability in the Serocki report's low flow rate paired samples can be attributed to the short sampling times used and the resultant low fiber counts. Table 31 shows OSHA's calculation of the number of fibers counted for each of the 15 paired samples used by the AIA in their analysis of the Serocki data, along with the CV obtained by the AIA for each sample pair. This table shows that, for the vast majority of samples analyzed by Serocki et al. (Ex. 84-478), total fiber counts were below the minimum of 80 fibers recommended by the NIOSH 7400 method (Ex. 84-444).

TABLE 31.—NUMBER OF FIBERS COUNTED PER 100 FIELDS AND COEFFICIENTS OF VARIATION REPORTED BY AIA FOR EACH OF 15 PAIRED ASBESTOS SAMPLES REPORTED BY SEROCKI ET AL.

[Ex. 84-478]

Sample No.	Concentration (f/cc)	No. of fibers counted (100 fields)	Concentration (f/cc)	No. of fibers counted (100 fields)	Coefficient of variation reported by AIA/NA [1]
1	0.40	17	1.1	46	0.66
2	.35	30	.51	44	.26
3	.17	19	.47	51	.66
4	1.0	29	[2] ND(DL=.34)	10	1.33
5	.76	36	.51	24	.28
6	.32	23	.42	30	.19
7	[2] ND(DL=.16)	10	.90	54	1.37
8	[2] ND(DL=.09)	10	.28	30	1.32
9	[2] ND(DL=.07)	10	.21	29	1.35
10	[2] ND(DL=.14)	10	.56	39	1.34
11	3.37	236	2.96	208	.09
12	.24	17	.36	26	.28
13	7.26	594	7.79	638	.05
14	7.90	444	9.01	506	.09
15	.15	17	.14	16	.05

[1] Ex. 328, Appendix A, p. A-20.
[2] ND=Not Detected; OSHA determined minimum detection level (DL) assuming a fiber count of 10 fibers per 100 fields and a microscopic field area of 0.005 mm².

Evidence to support OSHA's contention about the importance of fiber counts to the reliability of the results is found in an analysis of the CV's for four pairs of 8-hour TWA exposure levels reported by Serocki that were calculated from paired short-term samples taken consecutively over a working day (Ex. 84-478, pp. 11-12). (The AIA did not analyze CV's for these sample results.) When OSHA calculated CV's for each of these four 8-hour TWA pairs, CV's of 0.115, 0.86, 0.018, and 0.057 were obtained, respectively; these CV's reflect the adequate sampling times and fiber counts associated with these four samples.

OSHA therefore concludes that counting an adequate number of fibers when analyzing airborne asbestos samples is of the utmost importance. Accordingly, OSHA does not agree that the AIA's CV estimate for intersample variability necessarily reflects a random error that is intrinsic to the P&CAM 239 or NIOSH 7400 methods, finding instead that nonrandom error, caused by inadequate sampling times, low fiber counts, etc. accounts for what the AIA terms intersample variability. OSHA thus rejects the argument that intersample variability may be a more significant source of sampling and analytical error than intra- or interlaboratory errors.

Summary of Evidence on Sampling and Analytical Variability

In the preceding discussion, OSHA reviewed the rulemaking evidence describing the sources and extent of sampling and analytical error associated with measuring airborne asbestos concentrations using the NIOSH P&CAM 239 or NIOSH 7400 methods. The major sources of sampling and analytical variability described by the AIA (Ex. 328) include intralaboratory variability, interlaboratory variability, and intersample variability. Together, AIA estimated that these sources of variability result in an overall CV for the NIOSH P&CAM method ranging from 0.45 to 0.65 (Ex. 328, p. A–23). Based on this estimate for total CV, the AIA argued that

> OSHA must recognize that this unique variability limits the degree to which the asbestos PEL can be reduced, calls for more than usual enforcement flexibility, and, at the same time, assures that workplaces in compliance with a PEL will keep average exposures *much* lower than the PEL. (Ex. 328, p. A–1)

The AIA further argued that, given the high variability of the NIOSH P&CAM 239 and NIOSH 7400 methods, promulgation of a 0.2 f/cc PEL would not leave an adequate margin between the PEL and the "practical limit of detection" (Ex. 328, p. II–18), and that employers would thus not be able to reliably determine whether their employees' exposures are in excess of the PEL.

OSHA rejects these arguments for two reasons. First, OSHA does not agree with the AIA's estimate of the overall precision of the NIOSH P&CAM 239 method. As discussed in the section above, the data relied upon by the AIA do not predominantly reflect random sources of sampling and analytical error; instead, they reflect nonrandom error caused by the use of different monitoring methods and quality control programs by laboratories participating in the study. On the other hand, the study by Busch et al. (Ex. 84–62) of the precision of the NIOSH P&CAM 239 method reflects a truer estimate of the random variability of the method because of the greater degree of consistency in laboratory practices and training between the different Johns-Manville laboratories that generated the sampling data. NIOSH's estimate of the overall precision of the phase contrast method of asbestos analysis are similar to the estimates reported by Ogden (Ex. 84–448), who also studied analytical results from laboratories that implement similar training and laboratory practices. OSHA believes that, by promulgating requirements for specific monitoring procedures and quality control measures, it is possible to limit sources of sampling and analytical error to those that are random. Therefore, OSHA finds that NIOSH's estimates for the overall precision of the P&CAM 239 method, and consequently for the NIOSH 7400 and OSHA Reference methods, are the most reliable estimates in the record of the random sampling and analytical variability of these methods. As long as samples are obtained with a fiber density of 80–100 fibers per 100 fields counted. OSHA believes that the standard analytical error (SAE) of the ORM will be between 18.9 and 21.3 percent, with an upper estimate of 24.7 percent, based on the analysis of Dr. Ogden. This SAE coincides with the SAE of 25 percent currently used by OSHA for evaluating compliance samples of airborne asbestos. Therefore, OSHA will retain the SAE for asbestos at 25 percent. The Agency also finds that use of the ORM will *not* require employers to reduce their employees' exposures to levels substantially below the PEL of 0.2 f/cc to ensure that they are in compliance with the new PEL.

Reliable Limit of Detection

NIOSH has reported that the 7400 method for asbestos sampling and analysis has a reliable limit of detection of 0.02 f/cc, based on collecting a 1,920-liter sample (i.e., collecting an 8-hour sample using a flow rate of 4 lpm) and obtaining the minimum acceptable fiber density of 80 fibers per 100 fields. Using the formulas for calculating limits of detection (Exs. 84–444, 84–478), OSHA has determined that the reliable limit of detection for the ORM is 0.03 f/cc/, based on obtaining a fiber density of 80 fibers/100 fields from a 1,200-liter sample (2.5 lpm over 8 hours); the limit of detection for the ORM is thus well below the 0.1 f/cc action level included in the revised standards for general industry and construction.

The AIA argued that, because of the problem of nuisance dust obscuring asbestos fibers on a filter, the practical limit of detection for the NIOSH 7400 method is much higher:

> . . . The practical limit of reliable detection incorporates important practical factors that prevent the theoretical detection limit from being achieved such as reasonable sampling times, reasonable pumping rates and filter loading with nuisance dust. Problems with nuisance dust loading will vary from one atmosphere to another and may seriously limit the range of the method. . . .
>
> A number of measurement methods in the record have suggested that practical limits of reliable detection fall in the range of 0.1 f/cc to 0.5 f/cc. In fact, P&CAM 239 establishes 0.1 f/cc. as its lower bound even though exposure levels well below this may be obtained using the method. NIOSH's new Method 7400 does claim a lower value, 0.02 f/cc, but made clear that this is only a theoretical limit of detection by stating that it applies only in the absence of excessive nuisance dust loading. NIOSH has not explained why it chose to depart in Method 7400 from the practical limit of reliable detection employed in P&CAM 239. Considering the total absence in the record of any published testing results on Method 7400, there has never been any demonstration that it is practical to achieve the claimed value in manufacturing workplaces (Ex. 128, pp. A–24 through A–27).

Dr. Chatfield also expressed this view at the hearing, stating that the higher flow rates permitted by the NIOSH 7400 method ". . . will result in [the] capture of even larger pieces of nuisance dust than are collected currently using P&CAM 239 adding further to the filter obstruction problem" (Tr 7/6, p. 64).

In his testimony, Dr. Taylor stated that NIOSH intended the higher flow rates permitted by the 7400 method to be used for taking clearance samples and not for the routine monitoring of airborne asbestos levels in workplaces (Tr. 6/21, p. 161). OSHA agrees that the higher flow rates permitted by the 7400 method may contribute to filter overload or interference by other particles, and has therefore limited the ORM's flow rate to 2.5 lpm. Although OSHA believes that limiting flow rate will, in the great majority of cases, eliminate the filter overload problem, the ORM does permit the use of a 37-mm diameter filter in specific instances where filter overloading may be a problem. However, since the use of the 37-mm diameter filter doubles the limit of detection that can be achieved with the smaller filter, the larger filter may only be used if employers provide a written justification for its use. OSHA believes, based on testimony presented by Drs. Ogden and Taylor to the effect that nuisance dust overload is a rare occurrence when analyzing samples (Tr. 6/20, p. 35; Tr. 6/21, p. 161), that employers will not need to use the larger filter except in unusual circumstances.

As previously discussed, Section 8(c)(3) of the Act [29 U.S.C. 657 (c)(3)] requires employers to notify promptly any employee who is exposed to levels in excess of the PEL. The final asbestos standard requires the employer to notify each employee in writing of that employee's measurement within 15 working days after receipt of the results of any measurements required under paragraph (d) of the standard, whether exposure measurements were above or below the PEL.

As noted earlier, monitoring is carried out for the purpose of determining what measures are necessary to ensure employee protection in a given operation. The monitoring requirements in this standard are similar to those found in other toxic substance standards promulgated by OSHA [see vinyl chloride, acrylonitrile, coke oven emissions, arsenic] and these standards have been met without difficulty, thus indicating that compliance with the asbestos rule should also be feasible.

The exposure monitoring provisions require the employer to determine the exposure for each employee exposed to asbestos. However, this does not necessarily require separate measurements for each employee. If a number of employees perform essentially the same job under the same conditions on the same shift, it may be sufficient to monitor a fraction of such employees to obtain data that are representative of the remaining employees. Representative personal sampling for employees engaged in similar work and exposed to similar asbestos levels can be achieved by measuring that member of the exposed group who can reasonably be expected to have the highest exposure. This result would then be attributed to the remaining employees of the group.

In many specific work situations, the representative monitoring approach can be more cost-effective in identifying the exposures of affected employees. However, employers may use any monitoring strategy that correctly identifies the extent to which their employees are exposed.

Paragraph (d)(2)(ii) contains a provision designed to eliminate unnecessary and redundant exposure monitoring. It permits employers who have monitored employee exposures to asbestos within the six-month period immediately preceding publication of this final rule in the **Federal Register** to forego the initial monitoring required by paragraph (d)(2)(i) if the results of monitoring within this period have shown that their employees are not exposed to asbestos levels at or above the action level.

The (d)(2)(ii) provision simply makes clear that OSHA does not intend employers who have voluntarily performed employee monitoring to be required to repeat such monitoring if they have reliable and objective data showing that their employees are not exposed to asbestos at or above the action level, which triggers several of the standard's provisions, e.g., medical surveillance, periodic monitoring, training. Thus, OSHA believes that paragraph (d)(2)(ii) will enhance the cost effectiveness of the standard's monitoring requirements without compromising employee protection.

5. *Paragraph (e). Regulated Areas.* The final standard requires employers to identify as regulated areas any locations in their workplaces where there may be occupational exposures to airborne concentrations of asbestos above the PEL. The final standard prohibits eating, drinking, and smoking, in such regulated areas. In addition, only authorized persons may enter regulated areas, which are required to be clearly marked to ensure that employees are aware of these locations. Taken together, these provisions are intended to increase the standard's effectiveness by limiting the number of employees exposed above the PEL. The existing OSHA standard does not contain a provision for establishing regulated areas. OSHA stated in the proposal that it is considering establishing regulated areas at the proposed PEL's or at the action level (49 FR 14124).

Many commenters endorsed establishing regulated areas wherever there may be occupational exposures in excess of the PEL. Furthermore, they believed that regulated areas and limits on employee access into contaminated areas are appropriate and feasible methods of preventing unnecessary employee exposure to asbestos. [Exs. 312, 328, 90–138, 90–140, 90–147, 90–236, 91–34]. For example, the International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers, and Helpers, AFL–CIO stated:

> The International Brotherhood strongly believes that regulated areas and limits on employee access into contaminated areas are appropriate and feasible methods to preventing unnecessary employee exposure to asbestos. Regulated areas make it possible to restrict the number of persons potentially exposed to asbestos and to prevent contamination of larger areas of the job site. We believe that with regulated areas, employees in an asbestos environment can be provided with proper protective equipment, clothing, and ventilation while permitting other employees working in the non-regulated area to perform their work without risks of asbestos exposure [Ex. 91–34].

Other OSHA standards that regulate exposure to toxic substances contain such a provision, for example, vinyl chloride, 29 CFR 1910.1017; arsenic, 29 CFR 1910.1018; acrylonitrile, 29 CFR 1910.1045; ethylene oxide, 29 CFR 1910.1047. Additional purposes of regulated areas are to designate those locations in which precautionary signs are posted, to designate those employees subject to exposure monitoring and to define those areas where employees must wear respiratory protection and protective clothing. Additionally, when working in regulated areas certain activities are prohibited, such as smoking, eating, and drinking. This limitation is in accordance with good industrial hygiene practice which recognizes the potential of toxic chemicals to add to the body burden through ingestion. Furthermore as previously discussed in the health effects section of this document, smoking increases the risk of lung cancer.

Some participants, such as W.R. Grace and Company [Ex. 90–167], supported limiting regulated areas or expressed concern about establishing regulated areas where exposures do not consistently exceed the PEL. Bell Communications Research [Ex. 90–173] felt that short term tasks, lasting less than a single day or work shift, did not adapt themselves to the concept of regulated areas. A third commenter [Ex. 90–163] was of the opinion that regulated areas should not be required and that regulating employee exposures to asbestos "should be accomplished through the establishment of an appropriate exposure limit and any feasible combination of engineering controls, work practices and personal protective equipment".

For all the reasons stated above, after considering the record and based on OSHA's experience enforcing those standards which require regulated areas, OSHA believes that establishing regulated areas is necessary and appropriate to limit employee exposure to asbestos, regardless of the length of employee exposure.

The final standard gives employers a choice of whether to use, for example, ropes, markings, temporary barricades, gates, or more permanent enclosures to demarcate and limit access to these areas. Factors that employers might consider in determining the type of identification system include the configuration of the area, whether the regulated area is permanent, the airborne asbestos concentration, the number of employees in adjacent areas, and the period of time the area is expected to have exposure levels above the PEL. Permitting employers to choose how best to identify and limit access to regulated areas is consistent with OSHA's belief that employers are in the best position to make such a determination based on the specific conditions of their workplaces.

6. *Paragraph (f). Methods of Compliance.*

The final standard requires employers to institute engineering and work practice controls to reduce the exposures of employees to or below the permissible exposure limit, except to the extent that the employer establishes that such controls are not feasible. If engineering and work practice controls have been implemented but are not sufficient to reduce exposures to the permissible limit, respirators selected in accordance with paragraph (g) shall be used to supplement the engineering and work practice controls. This is changed from the proposal which would have retained the current requirement that employers use feasible engineering and work practice controls to reduce exposures to 2 f/cc, but would have allowed them to reduce exposures below 2 f/cc to the new PEL using any feasible combination of engineering controls, work practices or respiratory protection.

The final standard's provisions on preference in control strategy are consistent with those adopted by OSHA in all previously promulgated health standards. Similarly, they continue the preference contained in the generic standards addressing this issue: OSHA's Carcinogen Policy Standard 29 CFR 1990.111 (h)–(i); the Respiratory Protection Standard 29 CFR 1910.134(a)(1), which applies to all exposures to airborne toxins; and in the Air Contaminant Standard, 29 CFR 1919.1000(e), which applies to exposures to all substances listed in Tables Z–1, Z–2, and Z–3. The policy was inherent in national consensus standards which were adopted by OSHA in 1971 pursuant to the section 6(a) rulemaking provisions of the OSHA Act 1970, without public comment. In addition, the requirements are the same as those contained in the existing standard, except that the controls in the existing standard are required at 2 f/cc whereas the controls in the revised standard are required at 0.2 f/cc. The basic justification for the engineering and work practice provisions still pertain today.

OSHA's decision is based primarily on the overwhelming record support from all segments of the affected public. It is consistent with OSHA's traditional policy regarding the hierarchy of controls. This hierarchy as expressed in the preambles to most OSHA health standards specifies that engineering and work practice controls be used in preference to respiratory protection. Engineering controls are the preferred means of compliance because they reduce exposure hazards in the workplace environment by removing the airborne contaminant. Engineering controls may include the installation of local exhaust ventilation, modification of a process so as to reduce emission of the contaminant into the workplace, or substitution of another substance. Work practice controls reduce worker exposures by altering the manner in whch a task is performed and are often necessary for the effective operation of engineering controls. Therefore, work practice controls are also a preferred means of controlling exposures.

Respirators have traditionally been accorded the least preferred position in the hierarchy of controls because of the many problems inherent in their use. Respirators are capable of providing adequate protection only if they are properly selected for the concentrations of airborne contaminants present, properly fitted to the employee, properly and conscientiously worn by the employee, carefully maintained, and replaced when they have ceased to provide adequate protection. While theoretically it is possible for all of these conditions to be met, it is more often the case that they are not. From a practical approach, it is difficult to achieve and maintain the above conditions consistently in many workplace environments. As a consequence, the protection of employees by respirators is not always effective.

Most participants who addressed this issue, including industrial hygiene experts appearing on behalf of government, industry, public interest groups and unions, were opposed to OSHA's proposal to give respiratory protection the same priority as engineering and work practice controls. They affirmed the theoretical and practical superiority of engineering and work practice controls to reduce employee exposure to asbestos. For example, Organization Resources Counselors (ORC), an industry consultant, stated:

> ORC recommends that employers be required to institute engineering controls, to the extent feasible, to control employee exposures to airborne asbestos fibers to or below Permissible Airborne Concentrations (PAC). . . . The priority of control methods required by ORC's recommendation, i.e., use of respiratory protection only as a supplement to engineering controls and work practices or as an interim measure while engineering controls and work practices are being implemented, is consistent with the policy approach taken in all prior air contaminant standards promulgated by OSHA [Ex. 123A].

Representatives of the Asbestos Information Association of North America which represents 52 member companies who mine, mill, and manufacture products containing asbestos, stated:

> . . . The OSHA permissible exposure level (PIL) should be reduced to the lowest level feasible through engineering and work practice controls. Like many other participants in this rulemaking, AIA/NA does not believe OSHA should rely on respirator use when engineering and work practice controls can feasibly achieve the PEL [Ex. 231].

Dr. Morton Corn of Johns Hopkins and the former head of OSHA commented:

> . . . Engineering controls are at the top of the 'hierarchy of controls' because they fail with less frequency than other types of controls. Failure of controls are greatest when they are associated with responsibilities placed on the worker minute by minute, hour by hour and day by day. Engineering controls remove this responsibility from the worker and permit he/she to do his/her work effectively without this additional burden. There is nothing reported in either the literature or by word of mouth that suggests valid reasons for departing from using engineering controls as the primary method for controlling asbestos in the workplace [Ex. 176A].

Dr. Held, a consultant in respiratory protection, speaking on behalf of the AFL–CIO, stated with regard to the primacy of engineering controls:

> I can only endorse a position that requires engineering controls, when feasible, to reduce exposures below the established PEL. Respirators should only be used when engineering controls are not technically feasible, while engineering controls are being installed and evaluated, for non-routine jobs (i.e., maintenance work), and for emergencies. This principle has always been maintained by respirator experts and industrial hygienists, knowing that respiratory protection, is not as reliable as engineering controls. . . . I do not know of any standard, book, or article written on respiratory protection that does not endorse this basic approach [Ex. 171].

NIOSH and private organizations representing occupational health expertise also endorsed the general primacy of engineering and work practice controls over respirators (see NIOSH, Tr. 6/21; American Industrial Hygiene Section, Ex. 2-126, Docket H-160; American Conference of Government Industrial Hygienists, Ex. 2-32, Docket H-160).

Reliance on the use of respirators when engineering and work practice controls can feasibly achieve the PEL was also opposed by many unions, such as the United Auto Workers [Ex. 172A], International Brotherhood of Teamsters [Ex. 223], International Brotherhood of Electrical Workers [Ex. 313], the International Union of Electronic, Electrical, Technical, Salaried and Machine Workers [Ex. 90-135] and the Amalgamated Clothing and Textile Workers [Ex. 260A].

These general statements of policy preference were augmented by evidence and testimony concerning the reasons for preferring engineering and work practice controls. It is generally acknowledged that protection of the employee is most effectively attained by elimination or minimization of the hazard at its source, which work practices and engineering controls are both designed to do. Industrial hygiene doctrine also teaches that control methods which depend upon the vagaries of human behavior are inherently less reliable than well-maintained mechanical methods. The validity of these generalizations has been borne out by agency experience obtained throughout OSHA's existence and has been reiterated by a number of professional industrial hygienists for the asbestos rulemaking record [Exs. 171, 176A, 253].

Engineering controls in conjunction with appropriate work practices are usually the best method for effective and reliable control of employee exposures to asbestos. [Exs. 123A, 171, 176A]. Engineering controls act on the source of the emission and eliminate or reduce employee exposure without reliance on the employee to take self-protective action. These controls encompass product substitution, process or equipment redesign, process or equipment enclosure, exhaust or dilution ventilation, and employee isolation. Once implemented, engineering controls protect the employee permanently, subject only, in some cases, to periodic preventive maintenance. Work practices also act on the source of the emission, but rely upon employer and employee behavior, which in turn rely upon supervision, motivation, and education to make them effective. For this reason, work practices may not be as desirable as engineering controls, but because the two methods often must be employed together [Ex. 238A, 240A] and because they are the only methods that eliminate or reduce the hazard at its source, they have been given equal status in the compliance priorities of OSHA health standards. For asbestos in particular, there exist time-tested inexpensive work practices which are widely regarded as necessary and effective in many cases. These include the wetting down with surfactants of friable asbestos before handling, prohibiting blowing of asbestos dust with air hoses, prohibiting dry sweeping of asbestos dust, banning certain high speed abrasive cutting tools and others. Therefore, for asbestos, proper work practices are essential in the control of asbestos dust and are properly given priority as a control technique.

In addition, this rulemaking record again documents OSHA's past findings that respirators are the least reliable means of control because of difficulties inherent in their design and use (see e.g. preamble to OSHA's Carcinogen Policy, 45 FR 5003 at 5224 et seq., the preamble to the inorganic arsenic standard, 43 FR 19584 at 19617 et seq., and the preamble to the acrylonitrile standard, 43 FR 45800, etc.). Because of these inherent difficulties, the effectiveness of respiratory protection varies from worker to worker and is subject to human error of many forms [AFL-CIO, Ex. 335, p. 12; Held, Tr. 7/2, pp. 10-11; Corn, Tr. 7/3, pp. 7-8; ORC, Tr. 6/22, p. 61].

One difficulty facing respirator users is getting an adequate fit. For negative pressure respirators facepiece to face seal is the most critical barrier against contamination. Simply, the effectiveness of any filter is nullified by a bad fit. Even if an employer offers sophisticated quantitative fit testing, that test indicates the fit of a respirator under laboratory, not working conditions. For example, changes in strap tension significantly may affect fit. Tightness may well be endurable in a testing situation, but unacceptable to the employee at work who may then loosen the straps. Poor maintenance, defects, or normal deterioration will similarly affect fit. Fit problems are intrinsic for many workers, even under laboratory conditions because of unusual facial structures, glasses, wrinkles, scars, bumps, facial hair and dentures (Held, Tr. 7/2, pp. 14-15, Ex. 171).

Even if fit is not a problem, conscientious wearing of a respirator is hindered by many factors. As pointed out by AIA/NA, worker discomfort, skin irritation or heat stress, body movements, difficulties in communicating and vision limitations, leave only a nominal possibility that respirators will be properly worn at all times [Ex. 328, pp. III-14-15; see also NIOSH, Ex. 117A, pp. 24-25; Held, Ex. 171, p. 7; Corn, Ex. 176A, p. 5; Dukes-Bobos and Smith, Ex. 315]. Because of the problems and limitations listed above, experts testify that workers rarely keep on a respirator for an entire eight-hour shift [Rosenthal, Tr. 7/11, p. 68]. However, even short periods where respirators are not properly used dramatically affect the degree of protection to a worker relying on respiratory devices.

OSHA recognizes that there are certain activities, often involving certain maintenance and repair operations, as well as in emergency situations, in which the reliance on engineering and work practice controls to control exposures to the permissible exposure limit may not always be feasible. Where the employer can show that engineering and work practice controls for such operations are not feasible, respirators may be used as a primary means of control. For small scale, short duration maintenance and repair activities, the infeasibility of most types of engineering controls will generally be assumed. This is so, in particular, when the maintenance operations involve having personnel located at places not normally occupied by workers or when personnel must perform duties to fix broken machinery. In these situations, OSHA does not require that the employer design and install special ventilation systems. However, where asbestos insulation is being removed from components of machinery, OSHA would expect work practices to be used. In such situations, however, the employer must institute whatever engineering and work practice controls can feasibly be used.

Commenters who endorsed OSHA's proposal to permit employers to reduce exposure below 2f/cc to the new PEL using any feasible combination of engineering controls, work practices or respiratory protection [Exs. 90-166, 90-168, 90-170, 90-182, 90-233, 263] emphasized that flexibility will result in better protection. For example, Texaco stated:

> It has been our experience that control methods which are more cost-effective, but equally safeguarding, will be provided when the employer has the flexibility to select the means of controlling exposure. Therefore, we strongly support any feasible combination of engineering controls, work practices, and protective equipment to reduce exposure . . . [Ex. 90-170].

Similarly the Chemical Manufacturers Association commented:

CMA supports this approach.... The use of performance-oriented requirements is the key to achieving an effective standard without unnecessary costs and burdens. Performance-oriented rules allow an employer to design and implement a method of compliance which allows innovation and adaptation to the particular circumstances presented in a workplace, and permits an employer to avoid the expense of satisfying specifications that are of no value in the particular workplace.... As long as the employer meets a permissible exposure limit (PEL), controls the skin contact, or meets the appropriate biological levels that are consistent with employee health and safety, OSHA should not require any specific control strategy [Ex. 90–166].

W.R. Grace & Company stated:

Grace supports the concept of allowing any feasible combination of engineering controls, work practices, and personal protective equipment to reduce the exposures from 2f/cc to the new PEL. We believe that such a flexible approach is necessary to achieve any significant degree of compliance with a new reduced PEL [Ex. 90–167].

OSHA agrees that in the abstract, "flexibility" is a desirable compliance goal. However, this record has again convinced the Agency that respiratory protection is inherently less reliable than engineering and work practice controls, and therefore, cannot be granted the same compliance preference, when feasible engineering and work practice controls are available.

In previous sections concerning the Regulatory Impact Analysis and the permissible exposure limit, OSHA found that the 0.2 f/cc limit is generally feasible in almost all general industry workplace settings using engineering and work practice controls. Paragraph (f)(1)(iii) has been included to cover those operations that the Agency's analysis determined generally cannot currently comply with the 0.2 f/cc limit through the use of engineering controls and work practices. Three basic processes are covered by the paragraph: coupling cut off during A/C pipe manufacturing, grinding and sanding during the manufacturing of a number of asbestos products, and spinning and carding during the dry mechanical manufacturing of asbestos textiles. The determination for A/C pipe manufacturing was, in part, based on 1983 data supplied by Dr. Bragg (Exhibit 312 A, Tab H, Table II), which indicate that of the 12 processes studied, the coupling cutoff operation was associated with the highest exposure levels and was the only operation with average exposures in excess of 0.2 f/cc. The determination on grinding and sanding was based on data obtained from several sources (including site visit reports from OSHA's contractor Research Triangle Institute (RTI) and submissions by the Asbestos Information Association (AIA)), which indicate that local exhaust ventilation is inadequate to routinely control exposures to below 0.2 f/cc because of the volume of asbestos dust generated during these operations (see Section VII for summary of these industry specific data). The determination for primary asbestos textile manufacturing was based on data supplied by the Amalgamated Clothing and Textile Workers Union [Exhibit 260–A], by Dr. Bragg (Exhibit 235–A], and by the RTI site visit report [see Appendix B of the RIA], which indicate that exposures during carding and spinning are generally between 0.2 f/cc and 0.5 f/cc.

Thus, for the listed operations, the record supports OSHA's conclusion that most employers cannot currently meet the 0.2 f/cc limit without the use of respirators, but that 0.5 f/cc is feasible using engineering and work practice controls. However, under paragraph (f)(1)(i), employers utilizing the listed operations who are currently capable of meeting the 0.2 f/cc limit with engineering controls and work practices must do so. Those employers who must, for the present, use respirators in these operations must first reduce exposures to a level of 0.5 f/cc using feasible engineering controls and work practices, and must apply additional feasible controls as they become available to achieve the 0.2 f/cc limit.

OSHA anticipates that engineering and work practice controls will become generally feasible for those operations listed in (f)(1)(iii) to achieve the 0.2 f/cc PEL in the future. OSHA's experience with asbestos has shown that employers have consistently reduced worker exposure over the years. The OSHA PEL has been reduced from 12 f/cc to 5 f/cc in 1972 and to 2 f/cc in 1976. OSHA has found that most sectors currently have developed technology to meet the 0.2 f/cc PEL. OSHA expects that these technologies will be modified so that they could be applied to the listed operations. OSHA plans to carefully monitor the progress of control technology and OSHA will enforce the engineering and work practice control requirement at 0.2 f/cc when the technology is feasible. Paragraph (f)(1)(iii) thus provides a temporary solution for employers with current feasibility problems in a limited number of operations affecting a total of fewer than 1000 employees. For operations other than those listed and for which there is no evidence of general infeasibility, paragraph (f)(1)(ii) applies in what OSHA believes will be isolated instances of infeasibility on a case by case basis.

The standard also requires the development and implementation of a written compliance program where the employer has employees exposed to asbestos above the PEL, without regard to the use of respiratory protection. OSHA believes that the written plan is an essential element of the compliance program since it will encourage employers to implement the necessary controls to reduce employee exposure. It also provides the information to allow OSHA, the employer and employees to examine the control methods chosen and to evaluate the extent to which these planned controls are being implemented in the workplace. As with other OSHA health standards, the written compliance plan must be accessible to the individuals designated in paragraph (f)(2)(iii) for inspection and copying (see e.g. § 1910.1018, inorganic arsenic and § 1910.1047, ethylene oxide). This provision reflects section 8(c)(3) of the OSH Act, which provides for the employer to inform employees of corrective actions being taken to lower exposure to the PEL. In addition these plans must be reviewed and updated periodically to reflect the current status of the program.

New paragraph (f)(2)(iv) prohibits the use of employee rotation as a method for reducing exposure to asbestos, thereby changing the existing standard. However, an example of acceptable use of scheduling is performing an operation where asbestos exposure occurs on the work shift with the fewest employees present. Of course, these employees must be adequately protected.

As noted in the April 1984 proposal:

OSHA intends to revoke the requirement in the current standard that personnel rotation should be used to control exposures to asbestos. Personnel rotation merely increases the population at risk from asbestos exposure and would not reduce the absolute number of excess deaths attributable to asbestos, according to mathematical models [49 FR 14125].

In Exhibit 84–405, OSHA demonstrated that the number of excess deaths is not reduced by personnel rotation or employee turnover. Thus, OSHA deems it reasonable to prohibit employee rotation as a method of reducing employee exposures.

A number of commenters expressed their disapproval of employee rotation as a method for reducing exposure to asbestos [Exs. 90–236; Tr. 6/21, p. 68; Tr. 6/27, p. 19]. For example, the Tennessee Valley Authority stated:

TVA agrees with the revocation of the requirement which allows the rotation of employees as a means of controlling exposure. Unprotected exposures above the PEL should not be permitted [Ex. 90-236].

Similarly, Richard A. Lemen, Director, Division of Standards Development and Technology Transfer for NIOSH, commented:

Worker rotation as a compliance measure must be forbidden given the lack of a safe threshold for lung cancer and mesothelioma caused by asbestos [Tr. 6/21, p. 68].

The prohibition against worker rotation contained in the final standard for asbestos is, therefore, consistent with OSHA's view that this control strategy is not appropriate in occupational environments involving exposure to carcinogens.

7. *Paragraph (g). Respiratory Protection.*

The final standard requires that respirators be used to limit employee exposure to asbestos in the following circumstances:

(i) During the interval necessary to install or implement feasible engineering and work practice controls;

(ii) In work operations such as maintenance and repair activities or other activities for which the employer establishes that engineering and work practice controls are not feasible;

(iii) In work situations where feasible engineering and work practice controls are not yet sufficient to reduce exposure to or below the PEL; and

(iv) In emergencies.

These limitations on the required use of respirators are consistent with the requirements of the past asbestos standard, with 29 CFR 1910.1000 (e) and with good industrial hygiene practice. They reflect OSHA's determination, as detailed in the preceding section on methods of compliance, that respirators are inherently less reliable than engineering and work practice controls. OSHA believes, therefore, that relying on respirators to control exposures to the PEL must be confined to the designated situations.

The final standard requires the use of high efficiency filters when air purifying respirators are used. OSHA is particularly concerned about the penetrability of respirator filters (including single use respirators) other than the high efficiency type. At the new PEL of 0.2 f/cc, the NIOSH/MSHA certification criteria require the use of high efficiency filters [See 30 CFR 11.130 (a) and (c)]. NIOSH certification for other than high efficiency filters is not valid for toxic substances with PEL values less than 0.050 mg/M^3 or 2 mppcf. Using the conversion factor provided by CHAP [Ex. 84-246, p. II-137], a PEL of 0.2 f/cc equates to 0.006 mg/M^3, well below the cut-off for other than high efficiency filters.

Many commenters stated that non-powered air purifying respirators should be provided with high efficiency filters and that single-use and replaceable dust/mist respirators do not provide adequate protection against asbestos [Exs. 90-49, 90-234, 91-6, 91-40, 117E, 123A]. Other commenters were in favor of more stringent respiratory protection such as supplied air respirators or positive pressure respirators to assure the maximum protection possible (Exs. 223, 90-147].

In a letter to all respirator manufacturers published in the American Industrial Hygiene Association Journal, Dr. Jon R. May of NIOSH stated the following:

On the issue of asbestos, the Institute wishes to state that although asbestos can produce fibrosis, this effect pales in significance in comparison to the known human and animal carcinogenicity of this fibrous material. It is not our position that single-use dust respirators will provide adequate protection against the cancer causing potential of asbestos [Ex. 91-6].

Furthermore, in regards to dust, fume, and mist respirators, either with replaceable or reusable filters, Dr. May expressed concern about the filters effectively removing asbestos during the entire period of recommended use. This is based on the fact that the air-purifying components of these devices are not tested against asbestos but rather against a fine silica dust aerosol.

Norton Company, a respirator manufacturer, stated:

To obtain the greatest degree of protection available from non-powered air-purifying respirators, in asbestos environments where the TWA concentration is less than 20 fibers per cubic centimeter, Norton recommends the use of an elastomeric half-mask or full-facepiece respirator with high-efficiency filters [Ex. 117E].

OSHA acknowledges that respirator filter efficiency for asbestos has not been thoroughly tested (49 FR 14125). A recent study by the Los Alamos Scientific Laboratory (LASL), submitted to the OSHA docket [Ex. 93-5], has cast further doubt on the effectiveness of respirators when used specifically to protect against asbestos exposure. Five respirator filters, all of which are approved by the Mine Safety and Health Administration (MSHA) and NIOSH for the use with asbestos, where challenged with an aerosol of chrysotile asbestos under varying environmental conditions. Only one model (the high efficiency filter) functioned consistently well under all experimental conditions; (1) fresh from the package, (2) after exposure to an organic oil mist, and/or (3) after prolonged storage at high humidity. The other respirator filters yielded varying results. Thus, even under laboratory conditions, most approved respirator filters did not provide the consistent protection necessary to ensure worker health.

A number of commenters stated that air purifying non-high efficiency half mask negative pressure respirators should be permitted to be used as they reliably provide protection up to ten times the permissible exposure level [Exs. 328, 331, 339, 341]. E.I. DuPont DeNemours and Company submitted for the record [Ex. 339] a study it conducted on workplace protection factors for elastomeric half-mask and single use respirators. Results of their study showed that five of six respirators tested provided workplace protection factors of ten or greater and the remaining one provided a protection factor of five or greater. Unfortunately this study was not completed in time to present at the public hearing and could not be reviewed and commented upon by other interested parties. Also, DuPont did not submit data to indicate the magnitude of counting errors in their study.

OSHA does not believe that the DuPont data proves that negative pressure air purifying respirators provide adequate protection. The study was based on evaluating only a few manufacturers' respirators. In addition, workplace protection factors obtained appeared to be inconsistent with the types of respirators tested. For instance, the 3M-9910 disposable respirator tested yielded a protection factor almost equivalent to the Scott Air-Pak (SCBA) tested, and the 3M-9910 far exceeded the protection factor of an elastomeric/ high efficiency filter.

The expected results would be that the supplied air respirator would have a higher protection factor than the negative pressure respirator. The superiority of supplied air respirators is recognized by all respiratory selection procedures in existence and conforms to OSHA respirator selection tables in all toxic substances to date, including the existing asbestos standard, and all NIOSH criteria documents. There is no explanation for the inconsistent findings in the DuPont studies.

Another factor that must be realized when interpreting the results of the DuPont study is that the protection factors reported by DuPont were based upon data gathered after the workers were fit tested. According to industrial hygiene practice, if the fit test procedures adequately work, then no workers should be expected to have protection factors less than 10. That is, the fit test procedures are designed to reject respirators that have protection factors less than 10, so these should not be worn by the worker (47 FR 51110–51119). However, when applying statistical computations of a one-sided upper confidence limit for the true percentage of wearers who will experience protection factors less than 10, the results are that many workers do not achieve the acceptable protection. For example, for the dust, fume and mist filters, tested after passing the saccharin fit test, and while wearing the respirator for protection against asbestos under use, exposure, and wearer conditions similar to those existing in the study, one can state with 99% confidence that up to 16% (about 1 in 6) of the users may experience protection factors less than 10. Finally, but equally importantly, OSHA does not believe that the conditions in the study represent the typical respirator program found in use, even in the best situations, because the study created a carefully controlled environment of respirator use. In spite of the typical and excellent respirator program in place during the study, adequate respirator protection was not obtained from many respirator types. This fact, and the unexplained inconsistency in the data, further support OSHA belief that respirators should not be relied upon to provide primary protection to workers.

OSHA recognizes, however, that where engineering and work practice controls cannot reduce exposure below the PEL, respirators must be used. This study suggests that respirators will provide some measure of protection, but uncertainties in the study do not allow it to be used to define respiratory efficiency.

The NIOSH/MSHA respirator certification procedures, described in 30 CFR Part 11, establish classes of respirators. Each class is defined by a set of criteria for the capabilities of the respirator class. OSHA notes that the testing of respirator effectiveness for asbestos (the LASL and DuPont studies) suggest that certain respirators within a class appear to perform better than other respirators within the same class. For example, the 3M 8710 respirator appears to provide better protection than the other respirators in its class as a single-use respirator. OSHA does not believe that it is appropriate to make exceptions for certain respirators within a class of NIOSH/MSHA certified respirators at this time. As noted above, the existing data is not comprehensive and some is inconsistent with the current knowledge of protection afforded by different respirator types. The current classification system (30 CFR Part 11) has been in place for many years and has provided a degree of quality assurance that cannot be disregarded in light of the existing limited data. Finally, OSHA believes that no respirator reliably achieves the assigned protection factor in practical, routine use, and therefore, respirators are inferior to engineering and work practice controls. At best, the protection factors obtained in the studies show only relative differences between respirators (that is, some may be better than others), but do not show that any respirator provides consistently reliable protection. OSHA feels that further field testing of respirators should continue, so as to provide more definitive information regarding the adequacy of those negative pressure air-purifying respirators not equipped with high efficiency filters. Therefore, OSHA continues to believe that the respirator selection process should be based on the performance of the entire class of respirators and not based on the performance capabilities of selected respirators within a given class. In the final standard OSHA limits the selection of negative pressure half-mask respirators to high efficiency filters only.

Because of the unreliability and physiological distress associated with negative pressure respirators, OSHA has required employers to provide powered, air purifying (positive pressure) respirators (PAPR) to employees who request one, so long as it will provide adequate protection at the level of protection required. Powered air-purifying respirators operated in positive-pressure mode provide greater protection to individuals, especially those who cannot obtain a good face fit on a negative pressure respirator, and will provide greater comfort when a respirator needs to be worn for long periods of time. OSHA believes employees will have a greater incentive to wear respirators if discomfort is minimized.

The standard requires the employer to select respirators in accordance with Table 1 (in the regulatory text) from those jointly approved by NIOSH/MSHA. The respirator selection table will enable the employer to provide the type of respirator which affords the proper degree of protection based on the airborne concentration of asbestos. To comply with this requirement the employer must perform initial monitoring as described in paragraph (d)(2) to accurately determine the airborne concentration of asbestos to which employees may be exposed. While the employer must select the appropriate respirator from the table on the basis of the airborne concentration of asbestos, he may always select a respirator providing greater protection, that is, one prescribed for higher concentrations of asbestos than present in his workplace.

Recently published field studies as well as environmental chamber studies conducted by the Los Alamos National Laboratory indicated that the tight fitting powered air-purifying respirators (PAPRs) offer more protection that the loose fitting PAPRs. Since the affected employees are seldom exposed to more than 100 times the permissible exposure limit for asbestos, a single classification which covers all the PAPRs and continuous flow supplied-air respirators is used for simplification of the respirator selection table.

The above explanation on respirator selection provides the rationale for OSHA's deletion of the section on "spraying, demolition, or removal" which appears in the current standard.

This eliminates any ambiguity which existed previously regarding the kind of respirator required to protect employees engaged in spraying, demolition and removal operations. Furthermore, the final standard is consistent with current enforcement policy.

The standard further requires that the employer institute a respiratory protection program in accordance with paragraph (g)(3). This section contains basic requirements for proper selection, use, cleaning and maintenance of respirators. The standard also requires that respirators be properly cleaned and filters replaced when necessary.

The employer is also required to assure that the respirator assigned will fit properly. Proper fit of the respirator is critical. As a negative pressure is created within the facepiece when the wearer breathes, unfiltered contaminated air may enter the facepiece if gaps exist. Obtaining a proper fit on each employee may require the employer to provide two or three different mask styles. In order to help assure that respirators will provide employees with the necessary protection, the standard requires employers to periodically perform either qualitative (QLFT) or quantitative (QNFT) fit tests on all users of half-mask negative pressure respirators. Although the Agency feels that QNFT is more accurate than QLFT, it is OSHA's opinion the QLFT can provide the same assurance of employee health protection as QNFT in instances where protection factors up to 10 are required, and when specific protocols are followed for half-mask respirators. However, for full-face negative pressure respirators QNFT is required where protection factors up to 50 are required. Respirator fit testing procedures were subject to scrutiny during the public rulemaking for the lead standard, and the findings are relevant to this asbestos standard (47 FR 51110 to 51119).

From past experience, OSHA is aware of the problems of respirator use as the primary means of exposure control. Proper facial fit is essential, but variations in individual facial dimensions, as well as facial hair, scars or growths, make it difficult to maintain this facial fit. Fatigue and reduced efficiency may occur because of increased breathing resistance when negative-pressure respirators are used. Additionally, heat stress, reduced vision, and other safety problems presented by respirators should be considered by the employer. Visual impairment could pose a significant problem where physical hazards exist and the ability to see is important. Speech is also limited by respirator use. Voice transmission through a respirator can be difficult, annoying, and fatiguing, and communication may make the difference between a safe and efficient operation and a hazardous operation, especially in dangerous jobs.

OSHA does not presently believe that respirators should be considered the primary means of employee health protection against exposure to asbestos for activities where engineering controls are feasible. However, despite these problems OSHA has concluded that if the permissible exposure level for asbestos is exceeded, employers must provide respiratory protection as a supplementary means of protection. However, the goal of the standard is the control of emissions using engineering and work practice controls which will minimize the need for routine use of respirators.

The employee must be properly trained to wear the respirator, to know why the respirator is needed, and to understand the limitations of the respirator. An understanding of the hazards involved is necessary to enable the employee to take steps for his or her own protection. The respiratory protection program implemented by the employer must conform to that set forth in paragraph (g)(3). That section contains basic requirements for proper selection, fit, use, cleaning, and maintenance of respirators.

8. *Paragraph (h). Protective work clothing and equipment.*

This paragraph requires the employer to provide and ensure that employees use protective clothing where the employee is exposed above the permissible exposure limit. Specifically, the employer is to provide coveralls or other full body clothing, gloves, and foot coverings. The employer must also provide eye protection when necessary to prevent eye irritation.

The standard requires that the employer clean, launder, or dispose of the required protective clothing to eliminate any potential exposure that might result were the clothing to be laundered by the employee at home. Furthermore, the standard provides that the employer assure that all protective clothing is removed at the end of each work shift, and that the clothing that is to be laundered, cleaned, or disposed of be placed in a closable container. The standard also requires that protective clothing be maintained and replaced as needed in order to ensure effectiveness.

The requirement to provide and ensure the use of personal protective clothing when exposed to asbestos generally met with approval by all participants to the rulemaking. Many commenters endorsed triggering this requirement at the PEL [Exs. 84–387, 86–4, 90–173, 90–236, 328]. There were other commenters that were strongly in favor of requiring the use of protective clothing below the PEL [Exs. 84–244, 90–140, 127]. Other interested parties supported the requirement of furnishing and wearing of protective clothing when employee exposures exceed the ceiling limit [Exs. 90–168, 90–174, 90–180].

The final standard makes a change from the current standard to respond to the comments, and because OSHA believes a modification is appropriate in light of the evidence developed since 1971 that asbestos is a potent human carcinogen. Protective clothing is to be supplied to employees exposed above the PEL of 0.2 f/cc. It is necessary that protective clothing and foot coverings be required to prevent contamination of the employee's street clothing and shoes, so that exposure is not extended beyond the work day and workplace. Wearing contaminated clothing outside the work area where exposure controls are operating will lengthen the duration of exposure through both inhalation and ingestion routes. In addition, asbestos will accumulate in employee's cars and homes exposing other family members to the hazard. Evidence has shown that family members of asbestos workers face a substantially increased risk of cancer and other asbestos-related diseases from exposure to asbestos carried home on work clothes [Ex. 146]. At exposures lower than the PEL, OSHA believes it is less likely that clothing will become significantly contaminated with asbestos.

The proposal did not specify the frequency with which work clothing must be provided. OSHA has determined that if clean work clothing is provided at least weekly to employees whose exposure levels are above the PEL, adequate protection will be afforded and unnecessary costs minimized.

The final standard provides that the employer ensure that all protective clothing is removed at the end of each work shift only in change rooms. Furthermore, the standard emphasizes the need to assure that contaminated clothing is stored, cleaned/laundered, or disposed of in a safe manner. It requires that contaminated clothing be stored in closable containers prior to laundering or disposal so that contamination in the change room is minimized and that employees who later handle the clothing are protected. The latter group are further protected by the requirement to put warning labels on the containers. Since these containers are to be located in the change room, it is appropriate to limit the removal of contaminated clothing to that area.

The final standard clarifies that the obligation is on the employer to provide personal protective clothing at no cost to the employee. In this way the employer is in the best position to provide the correct type of clothing and keep it in repair. Also, as the employer has permitted exposures to exceed the permissible exposure limit the obligation properly rests on the employer. The cost of necessary clothing has been included in the various economic analyses performed.

Finally, the standard requires the employer to inform those who handle the contaminated protective clothing of the potentially harmful effects of exposure to asbestos. This provision is designed to make clear the need to use proper care in handling of the contaminated protective clothing.

9. *Paragraph (i). Hygiene facilities and practices.*

This provision requires employers to provide hygiene facilities and to assure employee compliance with basic hygiene practices which are recognized industrial hygiene practices for minimizing additional sources of asbestos which can accumulate on a worker's clothes or body. As discussed earlier, the employer must provide adequate shower and washing facilities, clean rooms for changing clothes, and filtered air lunchrooms for employees who have exposure above the PEL. In addition, employers must assure that employees use the facilities as required by the standard as well as observe prohibitions on tobacco and chewing products, and food in regulated areas. OSHA expects that strict compliance with these provisions will virtually eliminate several sources of asbestos exposure which substantially contribute to increased body burden.

Several of these facilities and practices are presently required under current OSHA standards for General Environmental Controls in Subpart J of 29 CFR Part 1910. For example, § 1910.141(e) requires the employer to provide change rooms with separate storage facilities for street and work clothing, and section 1910.141(g) requires the employer to prohibit the consumption of food and beverage in areas where there is exposure to toxic substances. The provisions of this standard are intended to augment Subpart J with additional requirements which are specifically applicable to asbestos exposure and to consolidate all related provisions under one standard. Many firms affected by this standard have already instituted facilities similar to those required in the final standard [Exs. 90–174, 93–7, 238A, 328; Tr. 7/9, p. 269].

The final standard like the existing standard reiterates specifications in section 1910.141 pertaining to the type of change room an employer must provide and the requirement that the employer prohibit the consumption of food and beverages in areas where there is exposure to toxic substances. OSHA believes it is essential that employees have separate lockers or storage facilities for street and work clothing to prevent cross-contamination between the two. This provision coupled with showering and the prohibition on wearing work clothing home will minimize employee exposure to asbestos after the work shift ends because it reduces the period in which work clothes coated with asbestos may be worn.

The final standard, unlike the existing standard, requires employers to assure that employees exposed to asbestos during their work shift shower before leaving the plant and do not leave wearing work clothing. Showing reduces the worker's period of exposure to asbestos and removes asbestos which accumulates on the skin and hair. Employees are not permitted to leave the plant wearing work clothes, because this practice would negate any advantage gained by showering. Work clothing that does not leave the workplace as well as showering serve as significant steps in reducing the movement of asbestos from the workplace and provides added protection to employees and their families.

The final standard requires employers to provide persons working in asbestos areas with filtered air lunchrooms which are readily accessible. Employers must also assure that employees wash their hands and face prior to eating or smoking and do not enter the lunchroom wearing protective clothing, unless cleaned beforehand. OSHA feels it is imperative that employees have a clean place to eat, free from the toxic substance with which they work all day. Filtered air lunchrooms will reduce employee exposure by limiting contamination by asbestos.

Employees are required to wash before eating to further minimize the possibility of food contamination and reduce the likelihood of additional exposure from loose asbestos dust. To further insure minimal worker exposure, protective clothing must either be removed or cleaned before entering the lunchroom. Instead of requiring a particular method, employers are given discretion to choose any method for removing surface asbestos which does not disperse the fibers into the air.

The hygiene provisions in the final standard are necessary and appropriate to protect employees within affected industries from unwanted and dangerous exposure to asbestos not necessary to job performance. Few, if any, participants in the rulemaking denied the benefits afforded by these provisions.

10. *Paragraph (j). Communication of hazards to employees.*

Signs and labels

The final rule for asbestos requires that legible caution signs be posted at each regulated area where occupational exposures could exceed the PEL. Signs must also be posted at all approaches to areas containing excessive concentrations of airborne asbestos fibers. These signs are to bear the following information:

DANGER—ASBESTOS; CANCER AND LUNG DISEASE HAZARD; AUTHORIZED PERSONNEL ONLY; RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA

OSHA intends the posting of these signs to serve as a warning to employees who may otherwise not know they are entering a regulated area and as training reinforcement, to encourage proper work practices and personal protective equipment use. Such warning signs are required to be posted whenever a regulated area exists, that is, wherever occupational exposures are likely to exceed the PEL. For some work sites, regulated areas are permanent, for example, in areas where engineering controls cannot reduce exposures to or below the PEL. In such situations, signs are necessary to warn employees not to enter the area without adequate respiratory protection and unless authorized to do so.

Warning signs are also required to designate temporary regulated areas, e.g., when maintenance or repair activities create a situation where occupational exposures could exceed the PEL. Warning signs are important in this situation because they will help to prevent the unnecessary exposure of employees who may not be aware that an area temporarily contains high levels of asbestos.

The final standard is not substantially different from the present OSHA standard. The section on sign specifications simplifies the sign requirements and eliminates unnecessary detailed specifications (i.e., letter sizes and styles, spacing between lines) in favor of a more performance-oriented approach. The new specification contains a very clear warning regarding the "cancer hazard" of asbestos, which is more strongly stated than the one presently required. This reflects the information gained since the promulgation of the existing standard on the serious cancer risk posed by exposure to asbestos.

OSHA has added the word "danger" for three reasons: (1) To attract the attention of workers; (2) to alert workers to the fact that they are in a dangerous area; i.e., an area where they are exposed to a potential carcinogen; and (3) to emphasize the importance of the message to follow. Additionally, the appearance of the phrase "cancer and lung disease hazard" on the warning sign assures that employees are actually being informed of this hazard. Lastly, it is believed that the addition of the phrase, "authorized personnel only" will serve to limit access and activities within regulated areas.

As indicated above the final standard requires the warning of "cancer and lung disease hazard." OSHA believes that it is important, and indeed section 6(b)(7) of the Act requires, that appropriate forms of warning, as necessary, be used to apprise employees of the hazards to which they are exposed in the course of their employment. OSHA believes, as a matter of policy, that employees should be given the opportunity to make informed decisions as to whether to work at a job under the particular working conditions. Furthermore, OSHA believes that when the control of potential safety and health problems involves the cooperation of employees, the success of such a program is highly dependent upon the employee's understanding of the hazards attendant to that job.

Finally, given the evidence of the carcinogenicity of asbestos, OSHA believes that these signs will not cause undue alarm. This is especially so when balanced against the positive results anticipated, as described above. For all of the reasons set forth OSHA believes that it is appropriate to use precautionary signs which warn of a cancer hazard.

The standard also requires that all raw materials, mixtures, scrap, waste, debris, and other products containing asbestos fibers, or their containers, be labeled with the appropriate information:

DANGER—CONTAINS ASBESTOS FIBERS; AVOID CREATING DUST; CANCER AND LUNG DISEASE HAZARD

The new standard allows two exceptions to the labeling and material safety data sheets (MSDS) requirements: no label or MSDS is required in those instances where: (1) Asbestos fibers have been modified by a bonding agent, coating, binder, or other material, provided that the manufacturer can demonstrate that during any reasonably foreseeable use (including handling, storage, disposal, processing, or transportation) employee exposure will remain below the action level; or (2) asbestos is present in a product in concentrations less than 0.1%. The exceptions provided in the revised standard are based, in part, on the exception given in the existing standard and are consistent with guidance provided in OSHA's Hazard Communication standard [1910.1200].

The existing asbestos standard provides that

> . . . no label is required where asbestos fibers have been modified by a bonding agent, coating, binder, or other material so that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the exposure limits provided in paragraph (b) [PEL] of this section will be released [1910.1001(g)(2)(i)].

This is changed slightly in the revised rule so that airborne concentrations must be kept below the action level rather than the PEL.

As discussed earlier, an action level has been added to this rule to trigger a number of provisions, such as medical surveillance and monitoring, in part, because OSHA feels exposures at the action level may still pose significant risk to workers, and so keeping exposures below this level is important for worker protection. Therefore, OSHA has changed the exception to the labeling requirement to be consistent with the introduction of an action level in the revised rule. It is OSHA's belief that materials that have been treated in the manner described in the exception (such as bonding or coating) would not generally release airborne concentrations of asbestos above the action level, and that the change in the regulatory language should not impose any additional obligations upon employers exempt under the existing rule.

OSHA has added another exception to labeling, for materials containing less than 0.1% asbestos. The exception was added in response to concerns expressed by a number of participants that asbestos is a trace contaminant in a number of materials and products (see, for example, Grace, Ex. 344–16) and that labeling such products would constitute an undue burden on employers. In choosing the percent exemption, OSHA has taken general guidance from its Hazard Communication rule which specifies that a mixture shall be considered hazardous if a carcinogen is present in concentrations in excess of 0.1% [1910.1200(d)(5)(iv)]. While other percentages were suggested to the record (for example, 0.25%, Ex. 344–16), OSHA found no other data to override considerations of safety given in the generic standard and, hence, in the interest of the protection of worker health, has maintained the 0.1% recommendation.

The signs and labels requirements discussed above are consistent with Section 6(b)(7) of the OSH Act, which prescribes the use of labels or other appropriate forms of warning to apprise employees of the hazards to which they are exposed. Rulemaking participants generally supported OSHA's requirement for signs and labels. [Exs. 146, 233, 236, 312, 86–4, 90–174, 92–38]. There were no significant issues raised to the contrary.

Information and Training

The final standard requires employers to provide a training program for all employees expected to be exposed to airborne asbestos at or above the action level of 0.1 f/cc. The training requirement in the standard is patterned after OSHA's Hazard Communication standard [29 CFR 1910.1200(h) (1) and (2)].

Information and training are to be provided at the time of initial assignment and at least annually to employees who are exposed to airborne concentrations of asbestos at or above the action level. The content of the training program is intended to inform employees of: (1) The hazards to which they are exposed; (2) the necessary steps to protect themselves, including those to be taken during emergency situations; (3) the proper use and limitation of respirators and protective equipment; (4) a description of medical examinations and their purpose; (5) implementation of work practices and the use of available engineering controls; (6) the contents of this standard and (7) the added risk of lung cancer due to the combination of cigarette smoking and asbestos exposure. Section 6(b)(7) of the Act makes it clear that these are appropriate goals for an employee training program, and the final standard includes such provisions.

The employer is required to make a copy of the standard available to affected employees and their representatives. This requirement, in combination with the review provided for as part of the training program, is intended to ensure that employees understand their rights and duties under this standard.

The employer is also required to provide, upon request, all materials relating to the training program to the Assistant Secretary and Director. This is intended to provide an objective check of compliance with the requirements under this paragraph.

OSHA recognizes that asbestos may be only one of a number of substances to which an employee may be exposed simultaneously in the workplace. The education and training requirements in this standard contain those elements OSHA has determined to be basic. The format and content of the required training and information program are neither rigid nor extensive. An employer may, if desired, incorporate the required information for asbestos into an existing program of training and education to be provided to employees.

The final standard requires that the training program be provided at least annually. OSHA believes that an annual training program is both necessary and sufficient to ensure that employees maintain a continuing awareness of the hazards of asbestos and their rights and duties under the standard.

To increase the effectiveness of training goals the final standard requires that the training material be made available, without cost, to all affected employees or their representatives.

The final training provision is virtually identical to that proposed, except that the requirement is triggered at the action level of 0.1 f/cc rather than the proposed 0.2 f/cc. Considerable evidence was submitted to the record demonstrating that training and information programs are essential in assuring worker protection to asbestos exposure [Exs. 158–I, 294, 296, 84–374, 90–174, 90–177, 93–6, Tr. 7/9, p. 189]. A number of participants supported training at the action level [Exs. 86–4, 123-A, 172-A, 328]. Furthermore, both the Asbestos Information Association of North America and the International Union, UAW, strongly recommended that a 0.1 f/cc action level would be an appropriate level.

A few commenters [Exs. 122; Tr. 6/22, p. 52] advocated that the training and information program be triggered at any airborne level and not be contingent upon the action level being reached or exceeded. These commenters expressed the view that all asbestos workers, not just those at highest risk, be informed of the health hazards of asbestos, the relationship between asbestos and smoking, and ways to minimize exposure.

Although the concerns expressed by these commenters are valid, OSHA takes the view that formal training is not required for employees whose exposures are below the action level. This is partly due to the lower risk involved, and also to the fact that asbestos is present in some shape or form in so many workplaces that it would be impractical to provide formal training to everyone who might at some time encounter it, for example, office workers. The spectrum of possible exposure would range downward from the action level to zero, and some clear cut-off is needed to identify those employees who stand to benefit the most from formal training.

In sum, the record evidence with regard to information and training reinforces the importance of informed employees to the successful implementation of an occupational health program, and provides strong support for the inclusion of these requirements in the final rule.

In its posthearing brief (Ex. 328), the AIA/NA urged OSHA to eliminate smoking in the workplace when asbestos is present. Citing evidence in the record and testimony by experts as to the synergistic effects of smoking and exposure to asbestos, the AIA/NA made several specific recommendations.

Specifically the AIA/NA] recommend[s] that OSHA prescribe the following requirements applicable to any work station or job classification that is likely to involve asbestos exposures above 0.1 f/cc for more than 30 days per year:

(1) All new workers hired should be non-smokers;

(2) All smoking during work hours should be banned;

(3) All sale of tobacco products on plant premises should be banned; and

(4) All employers should make smoking cessation programs available to their employees [Ex. 328].

The final standard addresses some of these concerns. Employees are prohibited from smoking under certain conditions. For example, employees who work in the regulated area are prohibited from smoking in that area. The training requirements of the standard mandate that the employee be informed of the nature of the hazard and the relationship between asbestos and smoking and lung cancer. We expect that such information will encourage workers to stop smoking. However, the Agency has made a determination, based on policy considerations, not to ban the hiring of smokers or require employers to have smoking cessation programs. The employer is free to follow recommendations such as those by the AIA/NA outlined above. However, the employer is not required by OSHA to institute such programs.

11. *Paragraph (k). Housekeeping.* The final standard imposes the general househeeping requirement to maintain all surfaces free, as is practicable, of accumulations of asbestos containing dust and waste. The standard bans the use of compressed air for cleaning and allows dry cleaning only if the employer shows that wet methods and vacuuming are not feasible. It also requires that vacuuming be done with cleaners equipped with HEPA filters [Exs. 240A, 264, 92–038, 312A] to prevent the dispersal of asbestos into the workplace. These are exceptionally important provisions because they minimize additional sources of exposure that engineering controls generally are not designed to control.

The existing provision requires that surfaces be maintained "free of accumulations of asbestos fibers if, with their dispersion, there would be an excessive concentration." A number of commenters has suggested and OSHA agrees that the language "an excessive concentration" is ambiguous. Thus, OSHA has removed the phrase from the final standard. OSHA believes that it may be difficult to objectively determine when the condition in the standard would occur. OSHA also believes that a rigorous housekeeping program is absolutely necessary to keep airborne asbestos levels below permissible limits.

This belief was supported by a number of submissions to the rulemaking record including, industry, labor and government organizations [Exs. 84–27, 84–346, 90–236, 91–27, 123A, 129, 274, 312A, and 328]. For example, several industrial hygiene manuals submitted to the record stressed the importance of a conscientious housekeeping program:

Good housekeeping plays a key role in the control of occupational health hazards. Dust on overhead ledges and on the floor should be removed before it can become airborne by traffic vibration and random air currents. Good housekeeping is always important, but where there are toxic materials, it is of paramount importance. . . . It is impossible to have an effecitve health hazard control program unless maintenance housekeeping (policing) is good and the worker has been informed of the need for those cleaning measures [Ex. 91–27.22, p. 630].

In particular for asbestos, a number of comments addressed the issue of housekeeping and the methods adopted by OSHA in the final standard.

Housekeeping is an important factor in safety to a worker. The cleaner the work area, the less chance there will be of airborne asbestos escaping a jobsite. Once again, it is important to keep asbestos fibers wet and to damp mop or wipe of[f] all surfaces. Regardless of the job, a final cleaning is required [Ex. 274, p. 4].

And,

Good housekeeping is essential to reducing levels of airborne asbestos. Waste materials such as rejects, scrap, shavings, or other debris should be picked up and placed in plastic bags. At the end of a shift, these bags should be taped shut, labeled as to the hazard contained therein, and disposed of.

Asbestos dust on floors, ledges, equipment, overheads, and other plant surfaces can become airborne when disturbed by drafts or work activity, and it should be removed. Sweeping is not the way to remove it, however, because the fine fibers are entrained into the air and deposited on remote ledges, pipes, and other inaccessible surfaces [Ex. 84–27, p. 78].

Housekeeping was also addressed in the control of asbestos exposure in shipyards:

a. Periodic cleaning of work area, especially at the end of each shift, contributes greatly to dust reduction. The longer materials lie the more widespread they become, producing considerable airborne dust.

b. Foot traffic produces considerable dust from fallen asbestos scrap, shavings, or debris. The simple procedure of placing cutting or work stations away from general foot traffic significantly reduces dust [Ex. 92–47.6, p. 8].

The AFL–CIO summarized the support for specific housekeeping requirements in its post-hearing brief:

> Over the past decade, since the asbestos standard was first issued, other work practices and controls have evolved and developed which have been demonstrated to be effective means of limiting exposures. . . . The prohibition of certain practices, including blowing asbestos dust with compressed air, dry-sweeping and dry clean-up of asbestos, and prohibition against accumulation of asbestos waste on surfaces have all been shown to be effective means for preventing the resuspension of asbestos fibers, and reducing airborne concentrations [Exs. 84-009,264].
>
> The record shows that these work practices, prohibitions and controls are widely accepted standard procedures in many asbestos industries and operations (Ex. 84-457, 126A, 222-F 225) and feasible for the asbestos industries as a whole (Ex 84-009). The revised permanent standard should therefore be updated and expanded to include the work practices prohibitions and controls to reduce airborne concentrations of asbestos in the work place [Ex. 335, p. 47].

OSHA agrees with this assessment and consequently has included the specific provisions for housekeeping to the final rule. OSHA believes, however, that the obligation incurred under these provisions should be measured by a standard of practicability. Therefore, OSHA anticipates that compliance with this provision will entail a regular housekeeping schedule based on exposure conditions at a particular plant and the capability for emergency cleanup of spills or other unexpected source of exposure.

12. *Paragraph (l). Medical surveillance.*

In the April notice (49 FR 14116-14145), OSHA solicited comments on whether the existing medical surveillance provision for asbestos-exposed employees should be modified. Specifically, comments were invited regarding the appropriateness of triggering the medical surveillance requirements of a revised standard at 0.2 f/cc; decreasing the frequency of chest X-rays for young employees or for those with short durations of exposure; clarifying the time permitted for employers to conduct the pre-placement examination after initial hiring; and the necessity of specifying additional tests or procedures for the early diagnosis of any asbestos-related disease, including the administration of a respiratory disease questionnaire. Comments were also requested on the need for additional specifications regarding the performance of pulmonary function testing, including completion of a course in spirometry for nonphysicians who administer these tests, calculation of the percentage difference from predicted values and use of standard predicted values; the appropriateness of requiring screening for colo-rectal cancer, including tests for occult blood in the feces; and further specifications for the interpretation and reading of chest X-rays.

The final standard requires each employer to institute a medical surveillance program for all employees who are or will be exposed to asbestos at or above the action level. Providing medical surveillance for employees exposed at or above the action level is consistent with other health standards which incorporate an action level and is considered by OSHA to be appropriate for monitoring the adequacy of the exposure limit specified.

The final standard requires that the medical surveillance program provide each affected employee with an opportunity for a comprehensive annual medical examination. In this regard the final standard does not change provisions of the existing standard requiring medical examinations on an annual basis. A comprehensive medical examination as defined by OSHA would encompass a medical history, a complete physical examination of all systems with emphasis on the respiratory system, the cardiovascular system and digestive tract, a chest roentgenogram (posterior-anterior 14 x 17 inches), pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second (FEV_1), and any additional tests deemed appropriate by the examining physician. One major change in the final standard reduces the frequency of x-rays for younger workers who have been exposed for a short period of time.

In the final standard, OSHA believes it appropriate to trigger the medical surveillance requirements at the action level of 0.1 f/cc as an eight-hour TWA. This level is consistent with current enforcement policy based on a past judicial ruling that upheld OSHA's medical surveillance at any level, but recommended that OSHA establish administratively a level that would trigger the medical surveillance requirement. [GAF Corp. v. OSHRC, No. *76-1028,* U.S. Court of Appeals for the District of Columbia Circuit]. However, in the proposal, OSHA raised the possibility of triggering medical surveillance at 0.2 f/cc.

Many commenters supported 0.1 f/cc as a trigger for medical surveillance [Exs. 86-4, 328, 90-166, 90-174, 90-180]. While others favored an action level of 0.2 f/cc [Exs. 90-160, 90-175]. A number of the concerns expressed about the medical surveillance trigger centered around general objections to a 0.1 f/cc action level, as discussed earlier.

In sum, OSHA's decision to trigger medical surveillance at 0.1 f/cc is based upon past administrative interpretation, comments submitted to the record, and OSHA's traditional policy of using the same action level to trigger other specific compliance activities (as discussed elsewhere in the preamble). Furthermore, in the case of asbestos, significant health risks are likely to be present at an airborne concentration of 0.1 f/cc and consequently supplemental protective measures are clearly warranted.

In the final rule for asbestos, OSHA has revised the time within which the employer must conduct preplacement examinations after hiring employees. The final standard requires that preplacement medical examinations be given prior to the assignment of an individual to a job exposed to concentrations of airborne asbestos. In the general questions contained in the preamble to the proposed rule, OSHA asked for clarification of the time issue, as the current standard permits the employer to conduct medical examinations within the first 30 days of the hire date.

In response to this issue, a number of commenters strongly favored a preplacement medical examination, assessing each worker's state of health prior to the beginning of exposure to asbestos fibers [Exs. 84-397, 90-140, 91-40, 128, 158E, 258, 328]. The American Association of Occupational Health Nurses, commented:

> Baseline data regarding the health status of workers is essential at the time of employment in determining whether changes occur over the period of employment. Delaying the gathering of this essential baseline information could be detrimental to both employee and employer because knowledge of a pre-existing condition could influence initial job placement. AAOHN therefore recommends that preplacement physical examinations be administered to employees before placing them into positions with asbestos exposure [Ex 128].

A few commenters supported the current OSHA standard, that is, requiring the medical examination to be given within 30 days of job assignment [Exs. 123A, 182]. On the other hand, a number of commenters supported the proposed latitude in the timing of preplacement examinations [Exs. 90-166, 90-181].

After thorough review of all the facts, and evidence in the record, OSHA concurs with the majority of commenters supporting the position that the preplacement medical examination be given prior to job assignment. The purpose of the preplacement examination is (1) to make an initial assessment of the health of each employee, (2) to determine the suitability of the prospective employee for the job under consideration, and (3) to establish a baseline health condition against which changes in an employee's health may be compared. OSHA believes that any problems associated with this revised rule will be minimal since some type of medical surveillance program is commonplace in most industries where asbestos is handled, even in the smallest firms.

OSHA received many comments regarding the frequency of periodic medical examinations. A number of commenters were in favor of the annual examination [Exs. 90–140, 90–158, 241–A, 248–B, 296] while other commenters were in favor of basing the frequency of the medical examination on the age of the worker with consideration given to the years that have elapsed since first exposure to asbestos [Exs. 123–A, 158–D, 182, 328].

After thorough review and analysis of the comments and testimony received in connection with this issue, OSHA reaffirms its position on the appropriateness of the annual medical examination. The annual medical examination and evaluation is an important tool in protecting the worker exposed to asbestos by, (1) establishing and maintaining rapport between the medical staff and asbestos exposed workers; (2) detecting changes in a worker's physical condition; (3) detecting biological effects of inhalation of asbestos as early as possible; (4) providing a way to re-evaluate the workplace conditions; and (5) evaluating the worker's suitability to continue doing the same job. For these reasons OSHA has retained the provision of an annual medical examination in the final standard.

The final standard provides that all examinations and procedures be performed by or under the supervision of a licensed physician and be provided without cost to the employee, Clearly, a licensed physician is the appropriate person to be supervising and evaluating the medical examination. However, certain parts of the required examination do not necessarily require the physician's expertise and may be conducted by a health care professional designated by the physician and under the supervision of the physician.

The final standard requires the employer to provide the physician with the following information: a copy of this standard and its appendices; a description of the affected employees' duties as they relate to the employee's exposure level; the employee's representative exposure level or anticipated exposure level; a description of any personal protective and respiratory equipment use or to be used; and information from the employee's previous medical examinations which is not readily available to the examining physician. Making this information available to the physician will aid in the evaluation of the employee's health in relation to assigned duties and fitness to wear personal protective equipment, when required.

The employer is required to obtain a written signed opinion from the examining physician containing the results of the medical examinations; the physician's opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of material impairment from exposure to asbestos; any recommended restrictions upon the employee's exposure to asbestos or upon the use of protective clothing or equipment such as respirators; and a statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions resulting from asbestos exposure that require further explanation or treatment. This written opinion must not reveal specific findings or diagnoses unrelated to occupational exposure to asbestos and a copy of the opinion must be provided to the affected employee.

The purpose in requiring the examining physician to supply the employer with a written opinion is to provide the employer with a medical basis to aid in the determination of initial placement of employees and to assess the employee's ability to use protective clothing and equipment. The requirement that a physician's opinion be in written form will ensure that employers have had the benefit of this information. The requirement that an employee be provided with a copy of the physician's written opinion will ensure that the employee is informed of the results of the medical examination. The purpose in requiring that specific findings or diagnoses unrelated to occupational exposure to asbestos not be included in the written opinion is to encourage employees to take the medical examination by removing the concern that the employer will obtain information about their physical condition that has no relation to present occupational exposures. The requirement that the physician sign the opinion is to ensure that what he gives to the employer has been seen and read by the physician.

A few substantive changes in the current medical surveillance requirements were made as the result of OSHA's review of extensive public comment and testimony. First, the frequency of x-rays for younger employees and employees who have only recently been exposed has been reduced. Given the potential radiation hazards posed by x-rays and given the long latency periods for most asbestos-related diseases, the requirement for annual x-rays has been changed to one that establishes frequencies based on a worker's age, duration of exposure and latency considerations.

Many commenters expressed the view that annual x-rays do not provide useful information in young persons and during the first few years of potential exposure. It was felf that annual x-rays in early exposure years is of minimal value, while exposing persons unnecessarily to potential harmful radiation. Comments received from Monsanto [Ex. 90–138], CAL/OSHA [Ex. 182], Atlantic Richfield [Ex. 90–160], 3M Co [Ex 90–163], Chemical Manufacturers Association [Ex. 90–166], U.S. Navy [Ex. 90–178] and NIOSH [Ex. 91–40] all suggested that the medical surveillance requirements be changed to allow for less frequent x-rays.

Consequently, the final standard requires that x-rays be offered at 5 year intervals during the 10 years following any employee's first exposure to asbestos. After 10 years from the employee's first exposure, the age category of an employee will determine the frequency of x-ray testing: up until age 35, x-rays will be required at 5 year intervals; between the ages of 35–45 medical exams will be required every 2 years; and above age 45, x-ray will be required on an annual basis. Such a program is currently in place in a number of asbestos surveillance programs (for example, see Lewinsohn, Ex. 258A).

A number of commenters stated that x-ray films should be interpreted and classified by qualified and/or certified individuals using standardized radiological procedures [Exs. 86–4, 131, 158–D]. For example, the AFL–CIO stated:

> X-rays are one of the most important diagnostic tools for asbestos-related lung diseases. The prevalence and seriousness of these diseases warrants the establishment of standardized procedure for the evaluation of x-rays by certified, qualified individuals [Ex. 131, p. 19].

OSHA shares the view of the above referred commenters, and in the final standard requires that, (1) chest x-rays be interpreted and classified in accordance with a professionally accepted classification system by either a B-reader, a board eligible/certified radiologist, or an experienced physician with known expertise in pneumoconioses; and (2) all interpreters whenever interpreting chest x-rays, have immediately available for reference the latest version of the ILO-U/C International Classification of Radiographs for Pneumoconioses.

The final asbestos standard also provides for the administration of a standardized respiratory disease questionnaire upon institution of the medical surveillance program. There were many commenters who were in favor of administering such a questionnaire [Exs. 90–138, 90–166, 123A, 128, 258A], and no commenters were opposed. In addition, OSHA notes the success it has had with the questionnaire in the cotton dust standard.

The questionnaire will elicit information from the employee about his of her work environment and job responsibilities; symptoms of possible respiratory illness such as coughing, chest tightness, and breathlessness; tobacco smoking habits; and occupational history, and will be used in conjunction with the results of the pulmonary function testing to detect the early stages of asbestos-induced respiratory disease. In addition, information from these questionnaires can be used to increase medical knowledge about specific work exposures, doses, and durations and their relations to the later development of asbestos-related diseases and can also be used by OSHA to revise the permissible exposure limits for asbestos if this is determined to be necessary. This questionnaire is contained in Appendix D to the standard.

The issue of whether to include mandatory or recommendatory medical tests in the revised standard was controversial. Some commenters argued that certain tests should be required [Exs. 277, 330, Tr. 6/26, Tr. 7/3], while others maintained that the tests should be chosen by the examining physician rather than by OSHA [Ex. 312A, Tr. 6/21, Tr. 7/10, Tr. 7/12].

A number of comments were received regarding the appropriateness of sputum cytology tests for the early detection of lung cancer and occult blood screening for colo-rectal cancer. For example, comments received from Dr. Kenneth B. Miller of the Oil, Chemical & Atomic Workers International Union [Ex. 292] and Dr. Greenberg of the Baylor College of Medicine [Ex. 90–239], were in favor of requiring sputum cytology as well as occult blood screening. The BCTD stated that OSHA should require ". . . a rectal exam and stool guaic test for occult blood [for asbestos-exposed workers] after the age of 40" [Exs. 277, 330], and the International Brotherhood of Boilermakers advocated annual tests for digestive tract cancer for employees over the age of 40 or with 20,000 hours or more of employment [Tr. 7/3].

However, many respondents supported permitting greater discretion on the part of the physician in determining what tests to conduct. For example, NIOSH recommended that "[the use of] routine periodic stool, sputum cytology and lavage tests . . . should be left to the discretion of the examining physician" [Tr. 6/21], and Dr. Hilton Lewinsohn, Assistant Corporate Medical Director of Union Carbide, stated that, as a physician, he doesn't want to be ". . . confined to doing certain things in a medical examination or a physical examination" [Tr. 7/12]. In addition, Monsanto [Ex. 90–138], the Chemical Manufacturers Association [Ex. 90–166], and the Asbestos Information Association [Ex. 328] were opposed to making such tests mandatory.

Based on a review of the total record, OSHA believes it inappropriate to include mandatory sputum cytology and occult blood screening in the medical surveillance protocol, recognizing the limitations of the diagnostic value of these screening procedures in massive screening programs [Ex. 117A]. For example, with regard to occult blood screening, the sensitivity and specificity of testing are both relatively low. As a result, many tumors are overlooked and/or healthy people are required to needlessly undergo colo-rectal investigations. Moreover, controlled data are not yet available to answer the central question of whether screening for colo-rectal cancer by stool occult blood testing reduces mortality from the disease.

Information currently available to OSHA does not justify the mandatory requirement of sputum cytology on a national level. As Dr. Lewinsohn pointed out, "A large scale multi-institutional program designed to evaluate periodic screening for early stage bronchogenic carcinoma among asymptomatic asbestos workers is currently in progress. Interim results do not indicate that sputum cytology is of overall benefit for screening individuals . . ." [Ex. 258A, p. 17]. No significant reduction in mortality was observed and any increase in survival is attributed to increased lead time and/or length bias. Since the non-squamous cell carcinomas (i.e., adenocarcinoma, large cell, small cell, oat cell) do not desquamate until the airspace (bronchus or bronchiole) is invaded, these neoplasms are better detected by x-ray. Thus, the value of sputum cytology alone as a routine screening method is questionable. Therefore, OSHA concludes that workers should be considered on a case by case basis and mandatory sputum cytology is not called for at this time. OSHA urges that where cytology is deemed appropriate for diagnostic purposes, that the sputum should be examined by a reference laboratory that has considerable experience in lung cytopathology.

A number of commenters were opposed to the proposal that additional tests or procedures be required for early diagnosis of any disease [Exs. 90–138, 90–166, 90–178]. However, one commenter was in favor of a simple urine exam to detect many of the kidney cancers [Ex. 173A].

In the final rule, OSHA has struck a balance between mandatory and nonmandatory medical surveillance requirements: The medical and work history and physical examination requirements are mandatory, while OSHA believes the examining physician is best qualified to judge what additional screening tests should be used and thus, the examining physician is given discretion in selecting appropriate tests for screening on an individual basis. These may include sputum cytology, colo-rectal screening or other procedures if deemed appropriate.

13. *Paragraph (m). Recordkeeping.*

Section 8(c)(3) of the Act provides for the promulgation of regulations requiring employers to maintain accurate records of employee exposures to potentially toxic or harmful physical agents which are required to be monitored or measured.

The final rule provides that records be kept to identify the employee monitored and to reflect the employee's exposure accurately. Specifically, records must include the following information: (a) The names and social security numbers of the employees monitored; (b) the number, duration, and results of each of the samples taken, including a description of the representative sampling procedure and equipment used to determine employee exposure where applicable; (c) a description of the operation involving exposure to asbestos which is being monitored and the date on which monitoring is performed; (d) the type of respiratory protective devices, if any, worn by the employee; and (e) a description of the sampling and analytical methods used, and evidence of their accuracy. OSHA does not require that all this has to be put into each person's file. The employer is free to keep records the most effective way. This could be common storage of some of these items and, perhaps, computer storage of other items.

The final standard also requires that the employer keep an accurate medical record for each employee subject to medical surveillance. Section 8(c) of the Act authorizes the promulgation of regulations requiring any employer to keep such records regarding the employer's activities relating to the Act as are necessary or appropriate for the enforcement of the Act or for developing information regarding the causes and prevention of occupational illnesses. OSHA believes that medical records, like exposure monitoring records, are necessary and appropriate both to the enforcement of the standard and the development of information regarding the causes and prevention of illness. In addition, medical records are necessary for the proper evaluation of the employee's health.

The final standard requires that all records required to be kept shall be made available upon request to the Assistant Secretary and the Director for examination and copying. Access to these records is necessary for the agencies to monitor compliance with the standard. These records may also contain essential information which is necessary for the agencies to carry out their statutory responsibilities.

The final rule provides for employees, former employees, and their designated representatives to have access to mandated records upon request. Section 8(c)(3) of the Act explicitly provides that "employees or their representatives shall be provided with an opportunity to observe monitoring and exposures to toxic substances"; and several other provisions of the Act contemplate that employees and their representatives are entitled to have an active role in the enforcement of the Act. Employees and their representatives need to know relevant information concerning employee exposures to toxic substances and their health consequences if they are to benefit fully from these requirements.

In addition, the final rule specifies that access to exposure and medical records by employees, designated representatives, and OSHA shall be provided in accordance with 29 CFR 1910.20. Section 1910.20 is OSHA's generic rule for access to employee exposure and medical records [45 FR 35212]. By its terms, it applies to records required by specific standards, such as this asbestos standard, as well as records which are voluntarily created by employers. In general, it provides for unrestricted employee and designated representative access to exposure records. Access to medical records is also provided for employees and, if the employee has given specific written consent, for the employee's designated representatives. OSHA retains unrestricted access to both kinds of records, but its access to personally identifiable records is subject to rules of Agency practice and procedure concerning OSHA access to employee medical records, which have been published at 29 CFR 1913.10. An extensive discussion of the provisions and the rationale for § 1910.20 may be found at 45 FR 35212; the discussion of § 1913.10 may be found at 45 FR 35384. It is noted that revisions to the access to records standard are being developed in an ongoing rulemaking proceeding. The asbestos standard may be affected by any changes which result from that rulemaking effort.

It is necessary to keep records for extended periods because of the long latency periods commonly observed for the induction of cancer caused by exposure to carcinogens. Cancer often cannot be detected until 20 or more years after onset of exposure. The extended record retention period is therefore needed for two purposes. First, diagnosis of disease in employees is assisted by having present and past exposure data as well as the results of the medical exams. In addition, retaining records for extended periods also makes it possible at some future date to review effectiveness and the adequacy of the standard.

The time period required for retention of exposure records is thirty years and for medical records, duration of employment plus thirty years. These retention periods are consistent with those in the OSHA records access standard.

The final standard requires employers to notify the Director in writing at least 3 months prior to the disposal of the records. Section 1910.20(h) also contains requirements regarding the transfer of records. The employer is required to comply with that provision and any other applicable requirements set forth in that standard.

14. *Paragraph (n). Observation of monitoring.*

Section 8(c)(3) of the Act requires that employers provide employees or their representatives with the opportunity to observe monitoring of employee exposures to toxic materials or harmful physical agents. In accordance with this section and consistent with the existing asbestos standard, the final standard contains provisions for such observation of monitoring of asbestos exposures. To insure that this right is meaningful, observers are entitled to an explanation of the measurement procedure, to observe all steps related to the measurement procedure, and to record the results obtained. The observer, whether an employee or designated representative, must be provided with, and is required to use, any personal protective devices required to be worn by employees working in the area that is being monitored, and must comply with all other applicable safety and health procedures.

15. *Paragraph (o). Dates.*

Effective Date

The effective date is July 21, 1986. The 30 day period between issuance of the standard and its effective date is intended to provide sufficient time for employers and employees to become informed of the existence of the standard and its requirements.

OSHA believes that 30 days is sufficient time because this regulatory action for asbestos is related to the past asbestos standard, and contains many of the same or similar provisions. In addition, OSHA has provided separate startup dates by which the various provisions must be completely implemented, as described below.

The amended provisions of § 1910.1001 take effect on July 21, 1986. On this date, employers are to commence complying with the provisions as amended. Until that date, employers are to comply with the unamended provisions of § 1910.1001 as currently published in Code of Federal Regulations (1985 edition). If the amended provisions are not in effect because of stays or judicial action, then the unamended provisions will remain in effect. It is the intention that there remain no gaps in coverage and that the existing provisions not terminate unless the new provisions are in effect.

Startup Dates

Since there was very little record evidence on this issue. OSHA is using its experience in making a determination on the startup dates for this standard. The startup dates provide the time required to set up initial monitoring, employee training programs and medical surveillance, to order and receive protective equipment and respirators, to construct changerooms, showers, lavatories, and lunchrooms, and to plan, order, receive and install engineering controls. It gives additional time to arrange for the implementation of this standard and to order necessary equipment. If there is no specific startup date set forth in the standard, then the startup date is the effective date of the standard. The immediate installation of changerooms, showers, lavatories, and lunchrooms is not required if installation of engineering controls would only make their use necessary for a few months. If the time period for meeting any of these startup dates cannot be met because of technical difficulties, any employer is entitled to petition for a temporary variance under section 6(b)(6)(A) of the Act.

These delayed startup dates, however, are only for the new provisions contained in the new standard or for the increased requirements which result from the reduction of the PEL from 2 f/cc to 0.2 f/cc. The provisions of the old standard must be maintained on a continuous basis, without any gap, until compliance with the new standard is achieved. For example, employers are given two years to complete engineering and work practice controls to meet the new 0.2 f/cc level. Their obligation to use these types of controls to meet the old 2 f/cc level, which has been in effect for many years, continues without interruption.

16. *Paragraph (p). Appendices.*

Eight appendices have been included in this final standard. Appendices A, C, D, and E are incorporated as a part of this standard and impose additional mandatory obligations on covered employers. Appendices B, F, G, and H are nonmandatory and are included primarily to provide information and guidance. None of the statements in Appendices B, F, G, and H should be construed as establishing a mandatory requirement not otherwise imposed by the standard or as detracting from an obligation which the standard does impose.

Appendix A (mandatory) specifies the OSHA reference method for analyzing air samples for asbestos. Appendix B (nonmandatory) is a detailed procedure for asbestos sampling and analysis and is based on NIOSH Method 7400. Appendix C (mandatory) specifies qualitative and quantitative fit testing procedures. Appendix D (mandatory) specifies the medical questionnaire that must be administered to all employees who are expected to be exposed to asbestos above the action level. Appendix E (mandatory) specifies the requirements for the interpretation and classification of chest roentgenograms. Appendix F (nonmandatory) provides guidelines for work practices and engineering controls for automotive brake repair operations. Appendix G provides general technical information on asbestos and Appendix H provides medical surveillance guidelines which may be supplied to the physician.

XI. Summary and Explanation for a Revised Standard for the Construction Industry

This section discusses the individual provisions of the revised standard for occupational exposure to asbestos in the construction industry. The record evidence and OSHA's reasons for adopting each requirement in the standard are presented in detail. Section X of the preamble should also be referred to for explanation of the provisons of the standard.

The revised standard contains a permissible exposure limit (PEL) of 0.2 fiber asbestos per cubic centimeter of air (0.2 f/cc) measured as an 8-hour time-weighted average (TWA). Engineering controls, work practices, and respiratory protection are required where necessary to reach the PEL. The standard becomes effective 30 days from publication in the **Federal Register**, and all provisions of the standard are in effect 180 days from the effective date. Because OSHA's existing asbestos standard will continue in effect until the revised standard published today becomes effective, employers are required to continue to comply with the existing standard until that time. For example, employers are required to maintain employee exposures to levels at or below 2 fibers/cc, the existing permissible exposure limit, until the new PEL of 0.2 f/cc becomes effective 180 days from the effective date.

In general, this revised standard is consistent both with OSHA's former asbestos standard, adopted in 1972, and with recent OSHA health standards, such as the arsenic standard (43 FR 19584) and the ethylene oxide standard (49 FR 25734). OSHA believes that a similar style and format should be followed from standard to standard to facilitate uniformity of interpretation for similar provisions. This is in accordance with Section 6(b)(5) of the Act, which states that health standards ". . . shall also be based on experience gained under this and other health and safety laws."

Paragraph (a)—Scope and Application

The final standard applies to all construction work as defined in 29 CFR 1910.12(b), which states:

> The standards prescribed in Part 1926 of this chapter are adopted as occupational safety and health standards under section 6 of the Act and shall apply, according to the provisions thereof, to every employment and place of employment of every employee engaged in construction work.

Section 1910.12 defines construction work as "work for construction, alteration, and/or repair, including painting and decorating." Paragraph (a) of the revised standard identifies many construction activities likely to involve exposure to asbestos, including: Demolition or salvage of structures where asbestos is present; removal or encapsulation of asbestos-containing products; construction, alteration, repair, maintenance, or renovation of structures, substrates, or portions thereof that contain asbestos; installation of asbestos-containing products; asbestos spill/emergency cleanup operations; and the transportation, disposal, storage, or containment of asbestos or asbestos-containing products on the site or location where construction work is being performed.

The adoption of a separate standard for occupational exposure to asbestos in the construction industry was recommended almost unanimously by participants in this rulemaking. For example, the Building and Construction Trades Department (BCTD) of the AFL-CIO presented a number of reasons for a separate standard governing asbestos exposure in the construction industry:

> . . . the variable nature of construction work activities, the lack of a regular workplace for many construction employees, the relatively short tenure or employment on most projects or for most employers, the generally high rate of employee turnover, the sequential arrangement of scheduled job activities on construction projects, the outdoor nature of much construction work, the existence of varied weather conditions including wind, rain, cold, heat, and environmental contaminants, frequently small workforces . . . the relationships between and among construction contractors and [between] contractors and owners, and the frequent change in physical arrangements during construction work due to the installation or removal of permanent systems which can cause interruption to exposure controls. (Ex. 330)

The appropriateness of promulgating a separate standard for the substantially different exposure and work conditions in construction and general industry was supported by a wide spectrum of rulemaking participants: BCTD, OSHA's Advisory Committee for Construction Safety and Health (CACOSH) the Asbestos Information Association of North America (AIA/NA), and the Associated General Contractors of America (AGC). The standard issued today responds to the need for a separate asbestos standard for construction identified by these commenters and reflects the record evidence supporting the Agency's decision to issue a standard that will be codified in Part 1926 of 29 CFR.

Although commenters were unanimous in recommending that OSHA adopt a separate standard for construction, many participants emphasized that there were significant differences in exposures, degree of hazard, work conditions, and applicable controls associated with various types of asbestos construction work (Exs. 84-307, 84-457, 328, 330, Trs. 6/20, 7/12,). As described above in Section IX, Standards Recommended to OSHA by Interested Parties, several participants suggested various methods of dealing with these differences. For example, the Asbestos Information Association of North America (AIA/NA) recommended the adoption of a certification program involving the classification of asbestos-containing materials according to their potential for releasing airborne asbestos fibers (Ex. 84-307). A similar scheme for categorizing products was suggested by the BCTD (Ex. 84-424). The AGC stressed the variability in asbestos construction tasks in a pre-hearing submittal that stated:

> . . . the vast majority of exposures are both short term and at low levels. Most exposures are incidental to other work . . . [and involve] asbestos products not readily friable. The risk of heavy exposure will continue to attend abatement, demolition, and similar kinds of construction activity. . . . OSHA should . . . [develop a standard that requires] a graduated response to the risk of exposure, one which varies with the risk. (Ex. 84-457)

OSHA finds the record evidence compelling both as regards the promulgation of a separate standard for construction and as regards the development of a standard tailored to the varying levels of risk associated with different construction activities. Accordingly, the final standard applies to all occupational exposures to asbestos in the construction industry, but is tiered to apply increasingly stringent requirements to those work operations associated with the highest exposures. As the record demonstrates, employees engaged in asbestos removal, demolition, and renovation operations generally have the highest asbestos exposures of all construction workers. The standard therefore includes specific paragraphs addressed to these operations: for example, employers conducting such abatement activities are required to establish temporary enclosures maintained under negative pressure and to ensure that their workers, where feasible, use the special hygiene facilities and decontamination procedures prescribed in paragraph (j)(2). OSHA believes that this tiering approach will simultaneously ensure maximum employee protection while scaling the burden of compliance with the standard to the degree of hazard associated with particular operations.

Depending on the nature and extent of exposure, certain provisions of the final rule may not be applicable in certain situations or may have limited applicability. The applicability of many provisions of the standard is based on the results of initial employee monitoring conducted by the employer or on the availability of other objective data concerning employee exposures or product characteristics. For example, paragraphs (k)(3)(i) and (m)(1)(i) are triggered by employee exposures above the action level, while other provisions, such as those in paragraphs (e)(1), (i)(1), and (k)(1)(i) are triggered by exposures above the PEL.

In addition, the revised standard for construction recognizes that countless maintenance operations involving the handling of asbestos-containing materials are conducted in the United States daily, and that these operations, which are small in scale and of short duration, are vastly dissimilar in degree of hazard to many other asbestos-related construction operations such as asbestos abatement projects. Exemptions from many of the final rule's provisions (e.g., paragraphs (e)(6), (i)(4), and (j)(1)(i) have accordingly been provided in the revised standard for "small scale, short-duration operations." Although OSHA finds it impossible to specify with precision the exact size of a "small-scale" maintenance job or to pinpoint the time involved in a short-duration" task, the Agency believes that providing employers with examples of the type of operations that OSHA considers to be included in this class of operations will provide employers with the guidance needed to use the final rule's exemptions for such operations appropriately. Paragraph (e)(6) enumerates several of these operations, including: Pipe repair; valve replacement; installation of telephone circuits, electrical conduits, and drywall; and other general building maintenance and renovation tasks. For some of these operations, the quantities of asbestos-containing material that will need to be handled will be small enough so as not to result in employee exposures above the action level or PEL; in these cases, the employer will not need to comply with the provisions that are triggered by these exposure levels. For many other maintenance operations, employers can choose to use exposure-control measures, such as glove bags, that effectively isolate the employee from the asbestos-containing materials being removed. Employers who use glove bags and other similar techniques will avail themselves of the requirements of provisions that are triggered by the action level or PEL, since such worker isolation techniques effectively reduce airborne concentrations of asbestos to below the revised level of 0.1 f/cc.

The operations listed in paragraph (a)(1) of the scope and application paragraph account for most of the construction jobs likely to involve the installation, handling, removal, and disposal of asbestos-containing material; however, OSHA is aware that no such list can be all-inclusive.

Paragraph (a)(1) makes clear that the revised standard applies to demolition or salvage operations where asbestos is present. Paragraph (a)(2) includes in the scope operations involving the removal or encapsulation of asbestos-containing products. Such asbestos abatement projects are typically associated with the highest asbestos exposures occurring in construction, and reflect an increasing national awareness of the hazards of exposure to asbestos. The volume of asbestos abatement work is increasing at a rapid rate, as more and more Federal agencies, local governments, and private-sector employers and building owners become aware of the hazards posed by the existence of asbestos-containing insulation materials and coatings in their facilities. The revised standard addresses the high hazard potential of work in the asbestos abatement portion of the construction industry by applying separate and stringent requirements to these operations. For example, employers engaged in such work are required to establish negative-pressure barriers enclosing the area where such work is taking place (paragraph (e)(6)) and to appoint a competent person to oversee the operation of this enclosure. These employers are also required to provide disposable work-suits for all employees working within the abatement enclosure (paragraph (i)(4)) and to ensure that these employers observe strict decontamination procedures before they leave the work-site.

The construction operations listed in paragraph (a)(3) include construction, alteration, repair, maintenance, or renovation of structures, substrates, or portions thereof that contain asbestos. These activities would involve minor operations, such as replacement of a gasket made of asbestos-containing material, repair of a section of drywall, or sanding down of old asbestos-containing floor tiles.

The installation of new asbestos-containing products, such as floor tiles and asbestos sheet and pipe, is called out in paragraph (a)(4) of the scope and application section. Although the record indicated that the exposures associated with the installation of new asbestos-containing products are typically much lower than those occurring in asbestos abatement work (Tr. 6/21, p. 5), there is evidence in the record showing that these operations can sometimes cause high employee exposures, particularly if specific work practices and engineering controls are not used.

Paragraph (a)(5) of the revised standard specifically includes asbestos spill and emergency situations within the scope of the standard, because these events clearly have the potential for serious employee and bystander exposures. Asbestos spills might occur during the handling of bags or containers of asbestos-containing materials or during the removal of a drop ceiling situated beneath badly deteriorated asbestos insulation material.

The final group of activities listed in the scope and application paragraph includes the transportation, disposal, storage, or containment of asbestos or asbestos-containing products on the worksites at which construction operations occur. These operations are included because they have considerable potential for excessive employee exposure to asbestos, and, if not closely supervised and properly conducted, may lead to serious bystander exposure as well. The Environmental Protection Agency (EPA) has specific requirements for the disposal of hazardous waste, and the revised standard's provisions for the safe disposal and handling of asbestos-containing wastes (paragraph (g)(1)(i)(F)) and of asbestos-contaminated clothing (paragraph (i)(3)) is consistent with EPA requirements.

OSHA notes that the final standard has been carefully structured by the Agency to relate the stringency of the requirements to the extent and duration of employee exposures. OSHA therefore believes that no compliance burden will be placed on construction employers who either do not use, handle, or remove asbestos-containing products or who maintain asbestos exposures in their workplaces to levels below the action level of 0.1 fiber/cc. The Agency believes that tailoring the revised standard in this manner responds to the concerns of the Advisory Committee for Construction Safety and Health and to the evidence in the record as a whole.

Paragraph (b)—Definitions

Paragraph (b) of the revised asbestos standard for the construction industry defines a number of terms used in the standard. In some instances, the definitions used are consistent with those of other OSHA standards, e.g., "Director," "Assistant Secretary," and "Authorized person." However, certain other terms require definition because they are used in accordance with their meanings in the construction industry.

"Action level" is defined in the revised standard as an airborne concentration of asbestos of 0.1 f/cc of air, calculated as an 8-hour time-weighted average. Several provisions of the standard, such as initial monitoring, employee training, and recordkeeping, are triggered whenever exposure measurements reach or exceed one-half of the revised permissible exposure limit (0.2 f/cc). If employers are engaged in asbestos work causing worksite levels of asbestos above the action level for 30 or more days per year, they must also institute a medical surveillance program for all employees. In addition, on sites where food and beverages are consumed and the airborne asbestos level exceeds the PEL, the standard requires employers to provide lunch areas that have airborne asbestos levels below the action level.

Past experience with the action level concept in other OSHA standards has demonstrated its usefulness to employers as an objective means of determining a cutoff point for some mandated compliance activities, thus relieving them of some of their compliance obligations in situations where higher exposures do not occur.

Many commenters in the rulemaking record advocated the inclusion of an action level in the revised rule. These commenters generally proposed that the action level be established at one-half the PEL recommended by that particular commenter. (Building and Construction Trades Department, AFL-CIO, Ex. 330; Advisory Committee for Construction Safety and Health, 84-424; United Brotherhood of Carpenters and Joiners of America, Tr. 6/27; International Brotherhood of Teamsters, Tr. 7/3; and the Asbestos Information Association/North America, Ex. 328). Typical of these commenters was the recommendation of the Building and Construction Trades Department, AFL-CIO, which stated:

> In accordance with the original action level concept as developed by NIOSH and recommended to OSHA for regulatory purposes, the BCTD recommends that the action level be set at one-half the BCTD-proposed PEL TWA. (Ex. 330.)

Action levels are important because their use permits employers to concentrate their resources on those employees and workplace conditions with the potential for high asbestos exposures. Thus the action level in the revised standard provides for the most cost-effective means of employee protection.

The final standard's definition of "demolition"—the wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos products—is identical to that proposed by the BCTD in its recommended standard and parallels that used by the Environmental Protection Agency in 40 CFR 61.141, the National Emission Standards for Hazardous Air Pollutants (NESHAP). The term, so defined, has been included in the construction standard for asbestos to clarify the distinction made between major asbestos abatement projects and small-scale, short-duration operations.

"Employee exposure" is defined as that exposure to airborne asbestos that would occur if the employee were not using respiratory protective equipment. This meaning of the term has a precedent in many OSHA standards, including ethylene oxide (29 CFR 1910.1047), and has been incorporated in the asbestos standard because OSHA believes it is essential to determine employee exposure levels without the use of respiratory protection in order to gauge the efficacy of mandated work practice and engineering controls.

In keeping with other OSHA standards that regulate exposure to hazardous substances (e.g., Arsenic, 29 CFR 1910.1018; Vinyl Chloride, 29 CFR 1910.1017), the revised asbestos rule contains a provision requiring the establishment of regulated areas to aid in limiting exposure to asbestos. The definition of "regulated area" in the revised asbestos standard covers two types of regulated areas; the negative-pressure enclosures mandated in paragraph (e)(6) for major asbestos abatement operations, and the restricted access required wherever airborne asbestos concentrations exceed or can reasonably be expected to exceed the PEL. The fact that the revised standard contains requirements for two types of regulated areas reflects both the wide differences in construction worksites and OSHA's approach in this standard to dealing with this wide range in exposure conditions. For example, the restricted access regulated area required in paragraph (e)(3) is an area that is demarcated in any manner that will alert employees to the existence of an area where airborne asbestos levels are likely to exceed the PEL; this provision is included in all OSHA health standards, and was a requirement in

OSHA's existing asbestos standard. The negative-pressure enclosure that constitutes the second type of regulated area defined and required by the revised rule (paragraph (e)(6)) is intended to provide employees engaged in the most hazardous asbestos operations—asbestos abatement projects—with the greatest possible amount of protection, and also to protect members of the public and other workers on site who are not directly involved in the abatement project from bystander exposure to asbestos. These two types of regulated areas thus reflect the revised standard's use of the "tiering" concept: increasing regulatory stringency with increasing hazard.

"Competent person" is a term and concept widely used and recognized in the construction field. The final rule's definition of a competent person as one who is capable of identifying existing asbestos hazards in the workplace and who has the authority to take prompt corrective measures to eliminate them is consistent with the definition in 29 CFR 1926.32(f), OSHA's safety and health standards for the construction industry. Support for the use of competent persons to oversee the detection and management of asbestos health hazards is documented amply in the record, and is discussed in the summary and explanation for paragraph (e) below.

The terms "clean room," "decontamination area," "equipment room," and "high-efficiency particulate air (HEPA) filter" are self-explanatory and refer to hygiene areas and equipment in standard use in major asbestos abatement work and in the construction industry. A more detailed discussion of HEPA filters may be found in the explanation and summary sections of this preamble that deal with engineering controls [paragraph (g)(1)] and respirators [paragraph (h)].

"Removal," "renovation," and "repair" are terms that refer to those high-exposure operations involving the taking out, modification, or overhauling of previously installed friable asbestos materials, structures, and substrates. OSHA's definitions of these terms reflect the sense and substance of procedures published by the Environmental Protection Agency as guidelines for certain renovation and "ripout" operations that rely primarily on work practices and engineering controls to reduce occupational exposures. For the purposes of this section, the meanings of these terms parallel those used in 40 CFR 61.141, EPA's NESHAP Standard.

In a post-hearing brief, the BCTD submitted a recommended standard to regulate asbestos in the construction industry. The brief contained definitions for a large group of terms that the BCTD felt were necessary to explicate the scope and purposes of their document. Ten of these terms are used in OSHA's revised rule, although they may be defined somewhat differently than in the BCTD document. For various reasons, OSHA did not find it necessary to include the remaining terms in the revised standard. For example, five of the terms recommended by the BCTD—"category A products or processes," "category B products or processes," "category C products or processes," "certified employee," and "certifying agent"—are concerned with aspects of a product categorization system based on the ambient air level of asbestos released through the handling of various products. OSHA has chosen not to incorporate such a system in the revised standard, because of its administrative complexity. In addition, maintaining OSHA's traditional health standard format to the extent possible facilitates compliance because employers are familiar with this format. Several other definitions recommended by the BCTD have not been included in the revised rule, because they are not used, e.g., "containment," "fiber-year," "friable asbestos," "phase contrast microscopy," "qualified person," and "transmission electron microscopy." The terms "qualitative fit-test" and "quantitative fit-test" are defined in the text of the revised standard (paragraph (h)(4)(ii), Respirator Fit Testing) and are therefore not separately defined in paragraph (b). Several terms recommended by the BCTD for inclusion in the definitions section of the revised rule are used within the body of the standard but have been not separately defined because OSHA deemed them self-explanatory: "installation," "initial personal samples," "respirator," "salvage," and "spill." The terms "asbestos job," "asbestos product or process," "asbestos project," and "asbestos-related work" are also not defined specifically in the revised standard, because they are not used in the regulatory text.

Paragraph (c)—Permissible Exposure Limit

In the revised rule regulating asbestos exposure in the construction industry, OSHA has amended the permissible exposure limit (PEL) by lowering the existing 2 f/cc PEL contained in 29 CFR 1910.1001(b)(2). Paragraph (c) of the revised standard sets an 8-hour time-weighted average (TWA) limit of 0.2 f./cc, which is the same PEL established in the revised standard for general industry.

The determination that a reduction in the PEL for construction is necessary is based on record evidence that shows that occupational exposure to asbestos increases the risk of mortality from lung cancer, mesothelioma, gastrointestinal cancer, and possibly other types of cancer. Asbestos is also the only known etiologic agent associated with asbestosis, a progressive, fibrosing lung disease.

The evidence demonstrating the causal relationship between asbestos exposure and these diseases consists of several well-designed epidemiological studies conducted within many different industry sectors, and of in vivo laboratory experiments in which animals exposed either by inhalation or injection developed increased incidences of cancer and scarring of the lung. (The health effects evidence summarized above is presented in Section IV of this preamble.)

The reduction in the PEL is also based on OSHA's finding that a significant risk of material impairment exists at the existing PEL of 2.0 f/cc (TWA), and that reducing the PEL would substantially reduce that risk. OSHA has determined in its quantitative risk assessment (see Section V) that lifetime exposure to an 8-hour TWA of 2.0 f/cc would result in 64 excess deaths due to cancer per 1,000 workers, and 50 cases of asbestosis per 1,000 workers, an excess risk that is clearly significant and unacceptable. By comparison, lowering the PEL to 0.2 f/cc would reduce the risk by about 90 percent to 7 excess cancer deaths per 1,000 workers and 5 cases of asbestosis per 1,000 workers.

In the April notice, OSHA proposed reducing the PEL to one of two alternative PELs (0.5 or 0.2 f/cc TWA_8). As explained in that notice, because risk is not eliminated at either of these two alternative PELs, "OSHA's primary consideration for setting a PEL is whether the limit chosen is technically and economically feasible for the affected industries" (49 FR 14122). OSHA is basing its decision to reduce the PEL to 0.2 f/cc for the construction industry on evidence that the 0.2 f/cc limit is the lowest limit that can be achieved by the use of engineering controls and work practices. This finding is based on evidence discussed in Section VII of this preamble (Technological Feasibility and Economic Impact Assessment), which indicates that many operations in construction would have difficulty in consistently meeting a lower PEL without the use of respirators. Some of these operations include the cutting and lathing of A/C pipe and sheet, the installation of asbestos roofing paper and felts, the removal of asbestos-containing building materials during repair and demolition activities, and the removal of asbestos insulation during abatement projects. OSHA believes that by promulgating a revised PEL of 0.2 f/cc, it has fulfilled its mandate to protect workers from the harmful effects of asbestos exposure within the confines of technological feasibility.

The vast majority of rulemaking participants were in favor of reducing the 2.0 f/cc PEL. Organizations that supported a reduction in the PEL included the Advisory Committee for Construction Safety and Health (Ex. 84-424), the National Institute for Occupational Safety and Health, (Tr. 6/21, pp. 59, 65), the Associated General Contractors of America (Ex. 84-457), the Building and Construction Trades Department, AFL-CIO (Exs. 277; 330; Tr. 6/27, p. 72), the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry (Tr. 6/27, p. 120), the International Association of Bridge, Structural, and Ornamental Iron Works (Tr. 6/27, p. 108), the United Brotherhood of Carpenters and Joiners of America (Tr. 6/26, p. 157), the International Union of Bricklayers and Allied Craftsmen (Tr. 6/26, p. 119), the International Brotherhood of Teamsters (Tr. 7/3, pp. 161-162), the United Steelworkers of America (Tr. 7/3, p. 132), the International Brotherhood of Boilermakers (Tr. 7/3, p. 174), the National Constructors Association (Tr. 7/12, p. 142), Organization Resources Counselors (Ex. 123-A), the Oil, Chemical, and Atomic Workers Union (Tr. 6/26, p. 9), and the Asbestos Information Association of North America (Tr. 7/6, p. 10).

Most of these organizations (Trs. 6/26, p. 9; 6/27, p. 120; 6/27, p. 108; 6/27, p. 157; 6/27, p. 119; 7/3, pp. 161-162; 7/3, p. 132; 7/3, p. 174; 7/3, p. 158) supported the standard recommended by the BCTD (Exs. 227; 330; Tr. 6/27, p. 72) that the 8-hour TWA PEL be reduced to 0.1 f/cc. This recommendation was based on the ". . . significant risk of death from cancer and other health impairments due to occupational exposures to asbestos . . ." in the construction industry (Ex. 330, p. 31). The BCTD argued that OSHA's belief, as expressed in the April notice, that the 0.5 and 0.2 f/cc alternative PEL's were the lowest that could be achieved through the use of engineering controls and work practices ". . . is no longer valid [since] it is contrary to the weight of evidence contained in the record . . ." (Ex. 330, p. 31). As discussed above and in Section VII of this Preamble, OSHA disagrees with the BCTD's contention that 0.1 f/cc is a feasible 8-hour TWA PEL and has identified a number of operations in construction where such an exposure level cannot be achieved through the use of engineering controls and work practices. By promulgating an 8-hour TWA PEL of 0.2 f/cc, OSHA is also concurring with the recommendation made by the Advisory Committee for Construction Safety and Health (CACOSH) that any reduction made in the asbestos PEL for general industry also applies to the construction industry. Specifically, CACOSH stated this view as follows:

> Because all employees deserve equal protection against the effects of a given toxic material, the same exposure limits should be applied to all industries, including construction. (Ex. 84-233, p. 5)

Another issue discussed in the April notice was the need to promulgate different PELs for different types of asbestos fiber. As discussed in Section IV (Health Effects), epidemiologic data suggest that exposure to amphiboles, particularly crocidolite, is associated with a higher risk of mortality from mesothelioma than is exposure to chrysotile. The United Kingdom and the Province of Ontario have both promulgated lower PELs for crocidolite than for other types of asbestos minerals, based on these data (Exs. 84-379, 84-223).

Comments that OSHA received on this issue recommended against the promulgation of different PELs for the different forms of asbestos. For example, NIOSH (Tr. 6/21), ORC (Ex. 123-A), and AIA (Ex. 328) did not believe that the scientific evidence warranted this approach. OSHA agrees with this assessment of the evidence. Although a differential risk by fiber type for mesothelioma is suggested by the human studies, no differential risk is evident for lung cancer. In addition, animal inhalation and injection studies suggest that chrysotile, and not the amphiboles, pose the greatest hazard. As discussed in Section IV, a number of mechanisms have been proposed to explain these human and animal results. OSHA has found that these results and the scientific community's current level of understanding of the mechanisms leading to asbestos-related disease are insufficient to justify the establishment of different PELs for the different asbestos minerals. Accordingly, in the revised rule, the Agency has retained the concept of the existing asbestos standard that one PEL be established for all types of asbestos minerals.

As with the revised standard for general industry, the revised standard for construction does not establish a ceiling or short-term exposure limit for asbestos. This differs from the existing asbestos standard, which imposes a ceiling limit of 10 f/cc, and from the April proposal, which would have retained this requirement. OSHA's decision not to promulgate a ceiling or short-term limit for either the general industry or construction standard is discussed at length in Section X of this preamble (Summary and Explanation for a Revised Standard for General Industry). To summarize, OSHA is not promulgating a short-term exposure limit for asbestos because toxicological and dose-response evidence fail to show that short-term exposure to asbestos is associated with an independent or greater adverse health effect than is exposure to the corresponding 8-hour TWA level; that is, there is no evidence that exposure to asbestos results in a "dose-rate" effect. This is reflected in OSHA's risk models for lung cancer and mesothelioma, which associate health risk with cumulative dose. The decision not to promulgate a short-term exposure limit for asbestos is consistent with OSHA's recent policy decision described in the Supplemental Statement of Reasons for the Final Rule for Ethylene Oxide (50 FR 64), in which OSHA established that short-term exposure limits for toxic substances are not warranted in the absence of health evidence demonstrating a dose-rate effect.

Paragraph (d)—Communication Among Employers

Paragraph (d) of the revised rule requires that, on multi-employer construction worksites, employers performing asbestos work requiring the establishment of a regulated area inform other employers on the site of the nature of their work with asbestos and of the existence of and requirements pertaining to regulated areas. This provision is new and has been included to minimize the exposure of employees working near the asbestos work area. For example, plumbers, electricians, carpenters, and workers from other construction trades frequently work alongside of employees installing asbestos-containing materials, and paragraph (d) intends that employers engaged in asbestos work notify the employers responsible for the safety and health of these nearby workers of the hazards of asbestos. OSHA has included this provision after reviewing the record evidence on the hazards and health effects associated with the incidental exposure of employees and bystanders who were not themselves working with asbestos (Exs. 169-A, 216, 328, 330, 335, Tr. 6/19, Tr. 6/21, Tr. 6/27, Tr. 6/29).

Joe Adam of the United Association of Journeymen and Apprentices stated that:

> Construction worker exposure is not restricted to only those employees working directly with asbestos products . . . . Operations such as spraying, cutting, upbrading, stripping, removal and demolition of asbestos products can expose all workers on the job sites. . . . This possibility of incidental exposure . . . clearly shows the danger in trying to identify . . . workers at risk of asbestos exposure [using SIC codes]. Plumbers, pipefitters, carpenters, sheetmetal workers, painters, laborers, iron workers, boilermakers, and [workers from] all the other construction trade classifications, are at one time or another in their working life directly or incidentally exposed to asbestos products on the work site. (Tr. 6/27)

Mr. Adam stated that one of the reasons the BCTD had included a requirement for a regulated area in its recommended standard was: ". . . to separate those people who are designated as asbestos workers on an asbestos job from those others on the job who are working in other activities, and also to separate people who have the training and information on how to conduct themselves inside a regulated area" (Tr. 6/27).

Other commenters also expressed concern about other worker and bystander exposures to asbestos. Dr. William Nicholson, Associate Director of the Mount Sinai School of Medicine of the City University of New York, conducted a study in the 1960s of asbestos insulation installers and determined that "those working nearby [in the vicinity of the workplace received] from one-third to one-half the intensity of the exposure of the insulator workers" since asbestos was "being used in an uncontrolled situation" (Tr. 6/19). Deborah Nagin, Associate Director of the Program in Occupational Health of Montefiore Medical Center, who testified on behalf of the BCTD, cited a 1983 study (Am. Ind. Hyg. Assoc. J. 44(6):428–432) on worker exposure to asbestos during the removal of sprayed-on asbestos-containing material and renovation activities in buildings containing sprayed-on material that showed that, on the average, bystander sheet metal workers working in such environments had the highest exposure, followed by bystander carpenters and electricians (Ex. 169–A). All bystander workers, except painters, according to Nagin, were consistently exposed to asbestos fiber concentration exceeding the action level of 0.1 fiber/cc over an 8-hour period, even though they themselves were not working directly with asbestos. (Ex. 169–A).

OSHA recognizes that several different operations involving workers from numerous trades may simultaneously take place on the same construction site and that the exposures of these workers to asbestos should be minimized to the extent possible. OSHA believes that requiring employers who are directly involved in asbestos-related activities to inform other employers working nearby on a multi-employer worksite of the existence of hazardous levels of asbestos, regulated areas, and the rules pertaining to such areas will contribute substantially to the protection of these bystander employees.

Paragraph (e)—Regulated Areas

The existing asbestos standard requires that signs be posted to alert employees to the existence of areas where the PEL is exceeded. In the April notice (49 FR 14116–14145), OSHA solicited comments on the need to include a provision in the revised standard requiring the designation of regulated areas, what the appropriate trigger for the establishment of such areas should be, and what activities should be required or prohibited in a regulated area (49 FR 14124). OSHA received several comments in response to these questions, and these are discussed below, in connection with the revised standard's requirements for regulated areas.

Paragraph (e) of the revised construction standard contains provisions requiring employers to establish regulated areas when certain types of construction work are performed or when the PEL is exceeded. Regulated areas required by the standard may take two forms; for asbestos work operations that do not involve asbestos removal, demolition, or renovation, such an area may consist simply of an area demarcated by posted signs that limit the number of employees entering the area. The regulated area requirement in paragraph (e)(6) of the revised construction standard requires employers who perform asbestos removal, demolition, or renovation operations to establish regulated areas that consist of negative-pressure enclosures that will confine the asbestos fibers being generated to the area within the enclosure and will thus protect other employees and bystanders on the site from exposure to excessive levels of asbestos. The requirements associated with each type of regulated area are discussed separately below.

Paragraphs (e)(1) through (e)(5) address regulated area requirements for projects other than asbestos removal, demolition, and renovation operations. For example, employers might establish a regulated area of the type described in paragraph (e)(1) during operations such as the cutting or lathing of asbestos sheet or pipe or the removal of asbestos-containing floor tile. Paragraphs (e)(2) and (e)(3) require that the regulated area be demarcated in a manner that restricts entry to the area to authorized persons only. Respirators must be supplied to persons entering regulated areas as specified in paragraph (e)(4), and eating, drinking, smoking, and applying cosmetics are prohibited in such areas by paragraph (e)(5). These requirements are consistent with similar provisions in previous OSHA standards (Acrylonitrile, 29 CFR 1910.1045; Inorganic Arsenic, 29 CFR 1910.1018; Ethylene Oxide, 29 CFR 1910.1047; and Vinyl Chloride, 29 CFR 1910.1047) and with the revised asbestos standard for general industry.

In addition to the provisions mentioned above, paragraph (e)(6) of the revised rule contains requirements related to the establishment of negative-pressure enclosures to be used in asbestos removal, demolition, and renovation operations. The purpose of this negative-pressure enclosure is to restrict the spread of asbestos dust that may be generated when large amounts of asbestos-containing material are handled during asbestos removal, renovation, and demolition operations. OSHA believes that such a requirement is necessary for construction sites where asbestos projects of these types are performed because such sites are likely to involve several employers (e.g., electricians, plumbers, etc.) and many workers who are not directly involved in the asbestos-related operations. The negative-pressure enclosure required by paragraph (e)(6) will prevent the exposure of these workers to concentrations of asbestos fibers that exceed the action level. OSHA has included an informational appendix (Appendix F) in the revised rule that provides detailed information on the use of negative-pressure enclosures during asbestos removal, demolition, and renovation operations.

Paragraph (e)(6)(ii) of the revised standard also requires employers to designate a competent person to: ensure the integrity of the enclosure; control entry to and exit from the enclosure; supervise employee exposure monitoring; and ensure that employees working within the enclosure wear the required personal protective clothing and respirators, use the appropriate hygiene facilities, and observe the correct decontamination procedures. The employer-designated competent person is also required by paragraph (e)(6)(iii) to have attended a comprehensive course, such as one of the EPA-sponsored courses offered by a number of universities that have been designated by EPA as Asbestos Information Centers. The universities are located throughout the country and are accessible to all emloyers who will need to send designated competent persons for training.

There was general support in the record for the inclusion of a provision requiring the establishment of regulated areas by employers who are conducting asbestos-related operations (Exs. 84-424, 84-457, 90-247, 123-A, 186, 270, 277, 330, Tr. 6/27, Tr. 7/3, Tr. 7/12). Some commenters emphasized the need for enclosures to contain asbestos and prevent incidental exposure during asbestos abatement projects (Exs. 90-247, 123-A, 186, 270, 277, 330, Tr 7/3). William K. Borwegen of the Service Employees International Union (SEIU) of the AFL-CIO expressed concern about protecting building service employees, maintenance workers, and building occupants from asbestos exposure during abatement work and recommended that when this type of work is being conducted:

> . . . work area barriers [should] be constructed of at least ¼ inch plywood or particle board, constructed on a 2 inch by 4 inch stud frame and covered with 6 mil polyethylene plastic sheets to prevent any asbestos from leaving the abatement areas. All seams and joints of the barrier should be continuously sealed with duct tape and a negative pressure should be maintained within the abatement areas at all times with a HEPA vacuum to maintain a water pressure drop of at least 0.1 inches of water. . . . (Ex. 270)

Dr. Morton Corn, describing the set up of a regulated area prior to the renovation or removal of asbestos indicated that

> . . . negative ventilation is applied, insuring that air flow is from the outside of [a] plastic barrier through the air interlock into the work space. In this manner, fibers from the work area do not . . . [migrate] outside the barrier . . . to insure that contamination [does] not spread from the work area to other employees. (Tr. 7/3)

In its March 1983 *Guidance for Controlling Asbestos Containing Materials in Buildings,* the Environmental Protection Agency (EPA) recommends work area containment for abatement techniques consisting of the use of 6-mil polyethylene plastic sheet, sealing tape, air locks, worker decontamination facilities, and negative air pressure systems on the grounds that "without adequate containment, increased exposure for building occupants is likely" (Ex. 186). OSHA agrees with these commenters and with EPA's recommendations and has therefore included a requirement that, whenever feasible, negative-pressure enclosures be constructed before beginning asbestos removal, demolition, and renovation operations.

Several comments were submitted regarding the need for a competent person to ensure the integrity of the enclosure and to ensure that employees working in the enclosure follow appropriate work practices (Exs. 84-424, 90-247, 277, 330). The BCTD, referring to OSHA's general requirement that construction employers designate a competent person to make frequent and regular inspections of job sites, materials, and equipment (29 CFR 1926.20(b)(2)), advocated, for the final standard, that

> . . . the competent person [have] the ability to recognize areas or structures which have the potential to contain asbestos products, and . . . that this person . . . [be authorized to supervise] the workers and [ensure] compliance with the other control measures [required by the standard]. . . . (Ex. 330)

AGC suggested that a competent person be required on all jobs where asbestos materials are identified or handled and that this person be defined as one who is specifically trained, experienced, and/or certified in the safe handling of asbestos (Ex. 90-247). The revised rule therefore requires the designation of a competent person to oversee asbestos removal, demolition, and renovation operations.

OSHA has included an exemption from the requirements of paragraph (e)(6) for employers who engage in small-scale, short-duration operations. Examples of these operations include pipe repair, valve replacement, or installing electrical conduit. OSHA intends this exemption to apply to those work operations where it is impractical to construct a negative-pressure enclosure because of the configuration of the work environment. For example, OSHA anticipates that the great majority of these small-scale, short-duration projects can be conducted using worker isolation techniques such as glove bags (see Appendix G). By using these techniques in lieu of a negative-pressure enclosure, employers will generally be able to achieve exposure levels that are below the action level, which will relieve them of many of their compliance obligations under the revised standard. OSHA is confident that most employers engaged in maintenance and renovation projects in environments that do not lend themselves to the construction of negative-pressure enclosures will elect to use glove bags, wet methods, and other control measures to ensure that their employees' exposures to asbestos remain below the standard's action level.

Paragraph (f)—Exposure Monitoring

The existing asbestos standard, 29 CFR 1910.1001, required that construction employers conduct monitoring to determine employee exposures to asbestos fibers. The standard required initial determinations of employee exposures and personal and environmental monitoring using frequencies and patterns of monitoring sufficient to represent with reasonable accuracy the exposures of employees. The existing standard also required that personal and environmental monitoring be conducted no less frequently than once every 6 months. The method of sampling and measurement prescribed by the existing standard involved using membrane filters and microscopy at a magnification of 400 to 450 times, with phase contrast illumination and a 4-millimeter objective.

The April notice (49 FR 14116) requested information from the public regarding any needed revisions of the revised rule's provisions for exposure monitoring. Specifically, OSHA requested information regarding alternatives to the traditional monitoring approach taken in previous health rulemakings, in recognition of the concerns of CACOSH (Exs. 84-233) and others (Exs. 84-2, 84-307) that these traditional requirements might be inappropriate for the transient, non-fixed nature of construction worksites.

Despite these characteristics of construction worksites, many commenters supported the inclusion of a requirement for employee exposure monitoring in a revised construction standard for asbestos (Exs. 123-A, 328, 330, 84-233). For example, Edward W. Warren, representing the Asbestos Information Association/North America (AIA/NA), stated:

> AIA/NA agrees that the monitoring requirements of the present [existing] standard should be revised to increase the coverage and frequency of routine exposure monitoring. Specifically, we urge OSHA to prescribe a trigger of 0.1 f/cc to broaden the scope of routine monitoring. (Ex. 328)

The Building and Construction Trades Department, AFL-CIO (Ex. 330), noted that exposure monitoring serves several purposes:

(1) Monitoring confirms compliance with the PEL;

(2) Monitoring provides warning when control measures are not working;

(3) Monitoring provides data on exposure levels that may indicate excess risk of disease;

(4) Monitoring is necessary to demonstrate when controls are required and when use of controls may be discontinued;

(5) Monitoring provides information necessary for the proper selection of respirators.

The Advisory Committee for Construction Safety and Health (CACOSH) affirmed the "need for environmental monitoring as part of effective worker protection programs" (Ex. 84–233). Moreover, Section 6(b)(7) of the Act mandates that standards promulgated shall, where appropriate, "provide for monitoring or measuring employee exposures at such locations and intervals, and in such a manner as may be necessary for the protection of employees" (29 U.S.C. 655(b)(7)).

Based on the requirements of the Act, the recommendations of CACOSH, and comments in the rulemaking record that support the inclusion of requirements for employee exposure monitoring, OSHA has determined that requirements for an effective employee monitoring program are appropriately included in the revised standard for construction. Accordingly, the revised standard for construction includes several monitoring requirements in paragraph (f). Paragraph (f)(1) requires employers to perform monitoring of their employees' breathing zones that will accurately reflect and be representative of their exposures to asbestos. In paragraph (f)(2), construction employers are required to conduct initial monitoring of employee exposures, unless: (1) The employer can demonstrate, on the basis of objective data, that the asbestos-containing product or material being handled cannot cause exposures above the standard's action level even under worst-case release conditions; or (2) the employer has historical or other data demonstrating that exposures on a subsequent job will be below the action level. Periodic monitoring is addressed in paragraph (f)(3), which stipulates that employers whose asbestos operations are being conducted within a regulated area monitor employee exposures daily; an exception to this requirement would permit employers whose employees are all wearing supplied-air respirators to forego periodic monitoring. Monitoring may be terminated when, in accordance with paragraph (f)(4), employers obtain confirmation by means of period monitoring that their employees' exposures are below the action level. Paragraph (f)(5) provides the details of OSHA's reference method (ORM) for asbestos sampling and analysis. It specifies the use of procedures outlined in Appendix A (or use of a method equivalent to the ORM), and also presents the essential elements of a quality assurance program to be followed by laboratories engaged in the paragraphs (f)(6) and (f)(7) pertain to requirements for employee notification of monitoring results and to observation of monitoring, respectively.

The principal differences in the monitoring requirements of the existing and revised standards are that the revised standard: (1) eliminates the existing standard's area monitoring requirements; (2) permits employers who can demonstrate that their employees' exposures to asbestos are below the action level to be exempt from initial monitoring; (3) allows employers to discontinue monitoring if reliable measurements indicate that employee exposures are below the action level; (4) specifically states that representative employee monitoring may be used; (5) restricts periodic monitoring to operations conducted within regulated areas; and (6) imposes the use of an OSHA Reference Method and a laboratory quality assurance program for the sampling and analysis of asbestos exposures. These changes reflect the input of the many construction experts who participated in the asbestos rulemaking, including OSHA's Advisory Committee for Construction Safety and Health. The monitoring requirements have thus been tailored specifically to the needs and characteristics of this sector. The record evidence and OSHA's reasons for including each of the requirements in the monitoring section of this revised standard are discussed in detail below.

Exposure monitoring was one of the more controversial issues raised by the April notice (49 FR 14116). Many commenters provided information and opinions on specific requirements that should or should not be included in the revised standard (Exs. 84–307; 123–A; 84–424; 84–457; 263; 277; 328; 330; 92–008; 92–025; 312–A; Trs. 6/26, pp. 71, 73, 82; 7/11, pp. 96, 107; 6/20, pp. 9, 122; 7/6, pp. 67, 74, 187, 204; 7/5, p. 121; 6/21, p. 64; 7/3, pp. 41, 81, 180; 285; 6/28, p. 252; 6/29, p. 140; 7/12, p. 315). The comments received addressed five major points:

(1) Selection of an appropriate monitoring method;

(2) Requirements for laboratory accreditation;

(3) Requirements for initial monitoring;

(4) Frequency of periodic monitoring;

(5) Choice of sampling strategy.

As in the case of general industry, the need for a standard reference method for conducting asbestos monitoring was supported by several rulemaking participants from the construction industry. OSHA has carefully evaluated these comments regarding the choice of a sampling and analytical method and has discussed this record evidence in Section X of this preamble (Summary and Explanation for General Industry). OSHA has determined, based on this evidence, that requiring employers to use a standard reference method for monitoring exposures to asbestos is necessary to eliminate variability in monitoring results that is caused by the use of different sampling and analytical methods. OSHA has also determined that the OSHA Reference Method described in Appendices A and B, which is derived from the NIOSH 7400 method, is appropriate for measuring asbestos levels on construction sites as well as in general industry workplaces. OSHA has further determined that the same quality assurance program for analytical laboratories that is required in the revised general industry standard is necessary to reduce both intra- and inter-laboratory variability in construction (see the discussion of this program in Section X, above). The record evidence pertaining to the construction standard's other monitoring requirements are discussed below.

Several commenters urged OSHA to require personal rather than area sampling, on the grounds that only personal sampling can adequately characterize employee exposures to asbestos fibers (Exs. 330; Trs. 7/3, p. 41; 7/3, p. 180). Typical of these comments was that of the Building and Construction Trades Department of the AFL–CIO, which stated:

> The BCTD recommends that all samples be personal samples except those area samples needed to determine the bounds of a regulated area, to monitor air quality from ventilation equipment completion and to determine abatement. Area samples can not accurately characterize a worker's exposure. (Ex. 330)

OSHA agrees with the comments of the BCTD and others, and has required in paragraph (f)(1)(i) that employers conduct monitoring to "determine accurately the airborne concentrations of asbestos to which employees may be exposed" and in paragraph (f)(1)(ii) that exposure determinations "be made from breathing zone air samples that are representative of the 8-hour TWA of each employee." This regulatory language has been standard in all of OSHA's prior health rulemakings, and reflects OSHA's belief that area samples, which are taken at locations outside the exposure envelope surrounding the employee as he or she works, generally cannot reflect the exposure experience of a particular worker accurately.

However, although employers are required to determine the exposure of each employee exposed to asbestos, this determination is not required to be based on separate measurements taken for each employee. Instead, the revised standard permits employers to use a "representative" measurement to characterize the exposures of more than one employee when these employees perform essentially the same job under the same conditions. For these types of situations, it may be sufficient for the employer to monitor one or a few of these employees to obtain data that are "representative" of the exposure of the remaining employees in the group. As permitted in paragraph (f)(1)(iii), representative personal sampling for employees engaged in similar work and exposed to similar concentrations of asbestos fibers can be achieved by measuring the exposure of that member of the exposed group who can reasonably be expected to have the highest exposure and then attributing this exposure level to the remaining employees in the group.

In many work situations, this representative monitoring approach may be more cost-effective than individual monitoring of all employees to determine the exposures of affected employees. However, employers are free to use any monitoring approach that will correctly identify the breathing-zone exposures of their employees to airborne asbestos.

Paragraph (f)(2)(i) of the revised rule contains requirements for initial monitoring for construction employees exposed to asbestos. In this paragraph OSHA requires employers to conduct initial monitoring at the start of each new asbestos job in order to assess the effectiveness of existing engineering controls and to provide information necessary for the proper selection of appropriate respirators.

OSHA believes that initial monitoring is essential for protecting employee health because it provides the employer with information for determining the necessity for using engineering controls, instituting or modifying work practices, and selecting appropriate respiratory protection. Recognizing the varied nature of construction projects. OSHA has required that initial monitoring for employee exposures be conducted at the start of each new construction project that involves the handling or disturbing of asbestos-containing materials.

Paragraph (f)(2)(ii) allows employers to dispense with initial monitoring if they can demonstrate by means of objective data that asbestos-containing products or material cannot release airborne fibers in concentrations exceeding the action level. OSHA believes that employers may be able to obtain data from the manufacturers of asbestos-containing products that demonstrate that these materials will not release asbestos at levels that exceed the action level, even under worst case conditions. This exemption is similar to those included in recent OSHA health standards (see for example, 29 CFR 1910.1047, ethylene oxide) and reflects the suggestion of the BCTD (Ex. 87-2) and the AIA/NA (Ex. 84-307) that employers be exempted from monitoring when employees are handling asbestos products that are not capable of releasing a significant amount of fibers.

OSHA also provides an exemption in paragraph (f)(2)(iii) for employers who have historical monitoring data. OSHA has included this exemption in recognition of the fact that many employers are currently conducting exposure monitoring on construction sites; this exemption would prevent these employers from having to repeat monitoring activity for construction jobs that are substantially similar to previous jobs for which monitoring was conducted.

However, such monitoring data must have been obtained from projects conducted by the employer that meet the following conditions:

(1) The data upon which judgments are based are scientifically sound and collected using methods that are sufficiently accurate and precise.

(2) The processes and work practices in use when the historical data were obtained are essentially the same as those to be used during the job for which initial monitoring will not be performed.

(3) The characteristics of the asbestos-containing material being handled when the historical data were obtained are the same as those on the job for which initial monitoring will not be performed.

(4) Environmental conditions prevailing when the historical data were obtained are the same as for the job for which initial monitoring will not be performed.

OSHA believes that if an employer has monitoring data that meet these conditions, he or she can be reasonably confident that these data are representative of employee exposures that will be encountered on a new construction site. The Associated General Contractors of America (AGC) suggested that OSHA permit a variant of this historical monitoring data provision (Ex. 84-457). The AGC noted that OSHA's traditional requirements for initial monitoring may not be appropriate for construction worksites because of the short duration of many construction operations. The AGC stated:

> Construction contractors have often found the benefits of monitoring to be quite limited. Their problem is that taking air samples, and getting results, takes far too long. By the time the results arrive, the contractors' employees have often already completed their work with the material containing asbestos. (Ex. 84-457)

The AGC suggested that OSHA permit contractors who begin an asbestos project such as asbestos removal, renovation, or maintenance activities to either (1) conduct initial monitoring at the beginning of each project, or (2) use exposure data from a data base of historical exposure monitoring results obtained from different employers conducting similar projects (Ex. 84-457). The AGC was of the opinion that:

> . . . a contractor choosing to consult an appropriate data base should not also have to monitor. The data base would serve the same essential purposes that monitoring would otherwise serve. It would inform the contractor of what to expect, and provide him with a sound basis for selecting respiratory protection and assessing the need for other steps. In fact, the data base would be superior to monitoring to the extent that it would eliminate the time lag in getting results from laboratories. (Ex. 84-457)

Although Joe Adam, Director of the Department of Safety and Health, United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada pointed that creating such a data base would require a considerable amount of monitoring, OSHA encourages employers to compile and use any information that will aid in the protection of workers' health. OSHA would permit the use of such data in lieu of initial monitoring if information from the data base is available and sufficiently detailed to meet the requirements of paragraph (f)(2)(iii) for historical data.

Paragraph (f)(3) requires that employers conduct daily air monitoring for asbestos in areas where the airborne concentration of asbestos exceeds the PEL. This requirement differs from the periodic monitoring requirement in the revised general industry standard for asbestos, which mandates quarterly monitoring of employees whose exposures exceed the action level.

Many commenters noted that mandating pre-set monitoring frequencies, such as those prescribed in other OSHA health standards for fixed worksites, may be inappropriate for certain work at operations construction sites, where asbestos-related activities are typically intermittent and of short duration (Exs. 84–307, 84–457, 330, Tr. 6/27, p. VII–17). The Building and Construction Trades Department, AFL-CIO, states:

> Monitoring construction jobs poses a unique problem since exposure levels are constantly changing as the job progresses, and may vary with weather conditions in outdoor operations. . . . Hence, traditional sampling strategies that work well for fixed work sites with predictable and stable exposure levels must be adapted for non-fixed construction exposures. (Ex. 330)

As an alternative to traditional periodic monitoring requirements, the BCTD recommended that employers engaged in asbestos abatement work conduct sampling each day for 5 consecutive days and reduce the frequency of monitoring to weekly if exposure levels remain below 1.0 f/cc. (Ex. 330).

Similarly, the specifications for asbestos abatement submitted by the New York City Office of Design and Construction requires that monitoring be conducted daily within a work area during asbestos removal or encapsulation work. (Ex. 92–25) In addition, one construction employer that participated in the rulemaking hearing stated that he conducted daily monitoring. Mr. Thomas J. Major, Jr., President of Major Insulators of Golden, Colorado noted that his firm conducted both personal and area monitoring on a daily basis for asbestos removal projects. (Ex. 608X. p. 199).

OSHA agrees with the BCTD that, due to the short duration of most construction projects and the frequency with which the work environment changes on construction sites, the traditional quarterly or semi-annual monitoring frequencies that OSHA has mandated in other health standards would not provide an adequate degree of protection to construction employees. This is particularly the case for employees working in regulated areas, where monitoring data are essential for ensuring that appropriate respiratory protection is selected throughout the project. Accordingly, OSHA has required that employers conduct daily monitoring in regulated areas, which are required to be established where the PEL has been exceeded. However, in regulated areas where the maximum level of respiratory protection is afforded employees through the use of Type C full-facepiece supplied-air respirators, the employer may, as stated in paragraph (f)(3), dispense with daily monitoring.

The existing standard (29 CFR 1910.1001) contained requirements for environmental monitoring in addition to requirements for employee exposure monitoring using breathing zone samples. This provision of the former standard stated that "samples shall be collected from areas of a work environment which are representative of the airborne concentrations of asbestos fibers which may reach the breathing zone of employees."

OSHA has not retained this requirement in the revised standards for asbestos because the Agency finds this provision duplicative of the requirements in paragraphs (f)(1)(i) and (f)(1)(ii). OSHA believes that the personal monitoring called for in these two provisions will permit the employer to accurately determine employee exposures and that compliance with the former standard's area monitoring provision will not add to an increase the accuracy of such determinations. Accordingly, the Agency has deleted the former area monitoring requirement from both the revised construction and the general industry standards. In doing so, OSHA is increasing the cost-effectiveness of the standard by eliminating duplication in regulatory requirements. OSHA has not retained the requirements for environmental monitoring in the final rule because the Agency believes that employees are provided adequate protection by the required breathing zone sampling. However, OSHA does not discourage employers from performing environmental monitoring during asbestos-related construction projects if they choose to do so, because the Agency recognizes that environmental monitoring can be useful for (1) determining the extent of emissions of asbestos fibers into the general environment, and (2) establishing the boundaries of regulated areas.

Like the existing standard, the revised standard requires employers to notify employees of their exposure levels and to provide employees exposed to asbestos an opportunity to observe any air sampling being performed in accordance with the standard; designated employee representatives must also be given this opportunity. The revised standard further specified that such observers be provide with and required to wear any protective clothing and equipment required by the standard.

These provisions are consistent with Section 8(c) of the Act, which requires employers to permit employees to observe any required monitoring and to notify employees of their monitoring results. No commenters addressed this provision of the existing rule, and OSHA's experience with that rule and other health standards has shown that these provisions have not presented compliance or other problems in the past. OSHA has therefore determined that inclusion of these observations of monitoring requirements in the revised standard is appropriate.

In sum, OSHA has determined that the monitoring requirements contained in paragraph (f) of the revised standard for construction will attain the goals of monitoring provisions traditionally included in OSHA health standards designed for fixed-site manufacturing facilities to suit the variable conditions on construction worksites, OSHA has tailored the monitoring requirements in the new standard to reflect the recommendation of the CACOSH and of many other commenters in this rulemaking.

Paragraph (g)—Methods of Compliance

The former standard governing occupational exposure to asbestos required that engineering controls and work practices be used to meet the exposure limits contained in the standard. The engineering control methods outlined in the standard included isolation, enclosure, exhaust ventilation, and dust collection. The former standard also provided specific requirements for the design, installation, and maintenance of local exhaust ventilation systems and for the use of local exhaust ventilation on hand and power tools that may produce or release asbestos fibers in excess of the exposure limits of the standard.

Work practices, particularly wet methods, were recognized by OSHA in the former standard as necessary for maintaining exposures at or below the PEL. The use of wet methods was required to the extent practicable to reduce the release of asbestos fibers unless the usefulness of the product would be diminished by the use of such methods.

In the revised standard at paragraph (g)(1)(i), OSHA has presented a list of engineering and work practice control methods that, based on the data collected in the rulemaking record, have been determined to be effective for reducing exposures to asbestos fibers.

The effectiveness of local exhaust ventilation systems that are equipped with HEPA-filtered dust collection systems was addressed by several commenters (Ex. 330; Tr. 7/10, p. 126). The Building and Construction Trades Department described the effectiveness of local exhaust ventilation systems (LEVs) as follows:

LEVs are designed to be easily employed with power and hand tools used in cutting asbestos-containing products such as A/C pipe and A/C sheet. LEVs focus a small vacuum directly on the cutting area and thus pump virtually all of the asbestos fibers out of the work environment. (Ex. 330)

OSHA believes that general ventilation systems may also be effective in reducing employee exposure to asbestos fibers. Such systems are useful for reducing the concentration of fibrous materials and removing potentially harmful asbestos fibers from the air through a HEPA filtration system. OSHA cautions employers, however, that the use of general dilution ventilation will tend to spread asbestos contamination unless the return air is passed through a HEPA filter.

Vacuum cleaners that are equipped with HEPA filters are effective controls for cleaning asbestos spills and collecting asbestos debris following an asbestos removal, demolition, or renovation activity. The HEPA-filtered vacuum systems collect asbestos-containing material while capturing asbestos fibers and preventing them from becoming airborne.

Isolation of asbestos-containing materials during construction activities is an effective means of preventing the disturbance of the asbestos materials and preventing potential exposures. Enclosures include building walls around pipes and other surfaces that are covered with asbestos-containing materials or wrapping pipes in metal sheeting to prevent the insulation from being damaged.

Several commenters advocated the use of wet methods and wetting agents as one of the most effective work practices for reducing the release of asbestos fibers and minimizing the resultant employee exposures (Exs. 92-8; 92-11; 92-25; 330; Tr. 7/3, p. 181). The Building and Construction Trades Department, AFL-CIO (Ex. 330), presented an analysis of the information contained in the rulemaking record on the use of wet methods. The data presented show a decrease in fiber counts of up to 90 percent when wet methods and wetting agents are used (Ex. 330). In addition, several of the asbestos removal specifications submitted to the rulemaking record specified wet methods and wetting agents as a mandatory method during asbestos removal (Exs. 92-1; 92-11; 92-25).

The prompt disposal of asbestos materials in leak-tight containers can be an effective work practice because asbestos-containing materials are sealed in disposal containers while they are still wet and less likely to release potentially hazardous asbestos fibers. Placing asbestos waste in disposal containers promptly will also reduce the risk that large pieces of asbestos will be broken into smaller pieces by activity in the work area and thus be more likely to become airborne.

OSHA believes that the use of the above-described engineering controls and work practices will greatly reduce employee exposure. The controls prescribed in paragraph (g)(l)(i) of the revised standard reflect the information available to OSHA in the rulemaking record regarding the effectiveness of engineering and work practice controls for reducing employee exposures in construction. Paragraph (g)(l)(i)(G) states that controls other than those listed may also be required, provided that the Assistant Secretary can show that they are feasible. When evaluating the feasibility of those controls, the Assistant Secretary will consider their availability in the marketplace.

In paragraph (g)(l)(ii), the revised rule requires, in situations where engineering and work practice controls are not sufficient to reduce employee exposures to or below the PEL, that the employer implement such controls to reduce employee exposure to the lowest feasible level and then supplement them by the use of respiratory protection. This requirement reflects OSHA's traditional policy that engineering and work practice controls should be the primary means by which workers are protected from exposure to harmful substances; personal protective equipment may only be used in emergencies or where other methods are not feasible, are not adequate, or have not yet been installed and tested.

The requirement maintaining the traditional hierarchy of controls in the revised standard represents a change from OSHA's proposed approach for the methods of compliance requirements for construction. In the April notice (49 FR 14124), OSHA proposed to retain the former provision in 1910.1001(c) that required employers to implement feasible engineering and work practice controls to achieve the 2 f/cc exposure limit. Under the proposal, the employer would then have been permitted to select among engineering controls, work practices, and personal protective equipment to achieve the reduced PEL. OSHA proposed this approach specifically for its asbestos rulemaking because of public response to OSHA's ANPRs for § 1910.1000(e) (Air Contaminants) and § 1910.134(a)(1) (Respiratory Protection) that endorsed a more flexible compliance strategy with regard to the use of respirators. In proposing these methods of compliance, the Agency also requested comments and information ". . . concerning the extent to which respirators may provide effective protection against asbestos exposure and may be relied upon as a substitute for engineering or work practice controls" (49 FR 4125).

Commenters responding to OSHA's proposed methods of compliance requirement for the asbestos construction standard objected to the Agency's departure from the traditional controls approach (Exs. 123-A; 277; 330; Trs. 6/27, p. 108; 6/27, p. 74; 6/29, p. 17; 7/3, p. 137; 7/3, p. 181; 7/6, p. 5). The BCTD argued that by not prescribing specific compliance methods. OSHA was being inconsistent with the intent of Section 6(b)(5) of the Act, and that ". . . OSHA cannot rely on a judgment by the employer as to how best to control occupational exposures to toxic substances, but rather must itself both establish the permissible exposure limits for such substances and set forth specific, objective measures to reduce exposures to or below those limits" (Ex. 330, p. 39). At the informal hearing, Robert Cooney of CACOSH read the following statement from Robert Georgine on behalf of the BCTD:

[Using engineering and work practice controls as the primary means of controlling asbestos exposures] must remain the governing principle of an asbestos health standard. OSHA should not allow employers to use personal protective equipment including respirators as a substitute for the former. (Tr. 6/27, p. 74)

Richard F. Boggs, Vice President of Organization Resources Counselors, explained the rationale for retraining the traditional hierarchy of controls:

The rationale behind [the use of engineering and work practice controls before respirators] is based primarily on two principles. One is that protection of the employee is usually most effectively attained by elimination or minimization of the hazard at its source, which work practices and engineering controls are both designed to do. The other is that methods which depend upon human behavior are inherently less reliable than well-maintained mechanical methods. (Ex. 123-A, p. 20)

Mr. Pigg, of the AIA/NA, testified at the hearing that the traditional hierarchy of controls should apply to asbestos standards for both general industry and construction:

AIA/NA fully supports OSHA's efforts to minimize all worker exposures to asbestos to the extent reasonable and feasible, whether such exposures be in the manufacture and installation of new products or in renovation, demolition and other activities where previously-installed products may release fibers.

As AIA/NA indicated in its opening comments, the OSHA . . . PEL should be reduced to the lowest level feasible through engineering and work practice controls.

Like many *other participants in this* rulemaking, AIA/NA does not believe OSHA should rely on respirator use when engineering and work practice controls can feasibly achieve the PEL. (Tr. 7/6, p. 5)

In addition, OSHA reviewed the testimony of a number of other commenters who supported OSHA's traditional approach to methods of compliance (see Section X, Summary and Explanation for a Revised Standard for General Industry). In response to the overwhelming body of evidence contained in the record and testimony supporting the retention of the traditional hierarchy of controls in this rulemaking, the revised rule for asbestos requires that engineering and work practice controls be implemented to reduce employee exposures to the PEL, and that personal protective equipment be used only to supplement engineering and work practice controls and in emergencies. As explained in the April proposal. OSHA is considering revising its policy on the hierarchy of controls and is soliciting comment on this policy in general (49 FR 14124). Because of the serious nature of the threat posed to construction workers exposed to asbestos; however, OSHA believes it would be imprudent to await the final outcome of the general rulemaking on hierarchy of controls before promulgating a revised rule for asbestos. Therefore, OSHA is proceeding with the revised asbestos rule for construction and is retaining its traditional requirements for appropriate methods of compliance.

Paragraph (g)(2) of the revised standard for construction prohibits the use of high-speed abrasive disk saws that are not equipped with local ventilation, the use of compressed air to remove asbestos-containing materials, and the application of asbestos by spray methods. OSHA has specifically prohibited these activities in response to concerns by rulemaking participants that worker exposure to asbestos during these operations would be consistently excessive.

OSHA's prohibition of the use of abrasive disk saws is consistent with the recommendation of the AIA (Ex. 328, p. IV-15). Banning the use of these saws without local ventilation was also supported by the Association of Asbestos Cement Pipe Producers (AACPP) (Tr. 710, p. 140) and the American Water Works Association (Tr. 710, pp. 124-125). Joseph Jackson of the AACPP testified at the hearing that the use of abrasive disk saws today is ". . . a very infrequent practice, mainly because of the penalties involved in major market areas such as California for the use of abrasive disk saws . . ." (Tr. 710. p. 124). The hazard associated with the use of unventilated abrasive saws is also evident from data obtained by CONSAD, Inc. (Ex. 92), which reported that the operator's 8-hour TWA exposure level can exceed 5 f/cc. The BCTD took a broader position and recommended that OSHA prohibit the use of any hand or power tool not equipped with local ventilation (Ex. 87-2, p. 13). Although the use of local ventilation is one of the engineering controls permitted under paragraph (g)(1) of the revised standard, OSHA did not find that the record evidence supported a prohibition against the use of all hand or power tools operated without local ventilation. Therefore, OSHA has restricted the prohibition to the use of abrasive disk saws operated without local ventilation.

In the revised standard, OSHA has also prohibited the use of compressed air to remove asbestos-containing materials, unless the compressed air is used in conjunction with an enclosed ventilation system to capture the resulting dust cloud. Using compressed air to clean asbestos dust from surfaces results in the formation of large dust clouds that lead to excessive exposures of the operator and bystanders unless local ventilation is used. Prohibitions against the use of compressed air were recommended by both the AIA (Ex. 328, p. IV-15) and the BCTD (Ex. 87-2, p. 13).

The final prohibition contained in the revised standard for construction is against the spray application of asbestos materials. This represents a change from the existing standard, which permitted the spraying of asbestos-containing materials if proper respiratory protection is used. Although workers performing the application may be adequately protected by the use of respirators and protective clothing, OSHA now believes that emissions resulting from the operation are high and can result in excessive bystander exposure to a carcinogen. It is for this reason that both EPA (40 CFR 61.148) and the State of California have banned the spraying of asbestos-containing materials in buildings and structures during construction, alteration, or repair operations. The prohibition contained in OSHA's revised standard against the application of asbestos materials by spray reflects the concern of these government agencies that the use of spray applications of asbestos poses a serious carcinogenic hazard.

Paragraph (h)—Respiratory Protection

The existing asbestos standard, 29 CFR 1910.1001 (effective July 7, 1972), required respiratory protection to be worn to reduce exposures below the 2.0 f/cc PEL under the following circumstances: (1) during the time necessary to install engineering controls and institute work practices; (2) in work situations in which engineering controls and work practices are not feasible for reducing exposures to or below the PEL; or (3) in emergencies. The existing standard also permitted single-use or reusable air-purifying respirators only be used in work situations in which the concentration of airborne asbestos fibers was less than 10 times the PEL or ceiling limit. In situtations in which the concentration of asbestos fibers was less than 100 times the PEL or ceiling limit, the existing standard allowed the use of full facepiece air-purifying respirators. Type "C" supplied-air respirators operated in the continuous-flow or pressure-demand mode were required in work situations in which the concentration of asbestos fibers exceeded 100 times the PEL or ceiling limit. The existing standard also required employees to establish a respirator program in accordance with ANSI Z88.2-1969.

In addition, the existing standard required that no employee be assigned to work where respiratory protection is necessary if an examining physician determined that the employee was unable to function normally while wearing a respirator.

Paragraph (c). *Methods of Compliance,* of the existing standard required that type "C" supplied-air respirators operated in a continuous-flow or pressure-demand mode be used in any work situation that involves the spraying of asbestos or during the removal or demolition of asbestos from pipes, structures, or equipment insulated with asbestos.

In the April notice, OSHA requested public comment on the selection of appropriate respirators for various work situations. Information was specifically requested regarding the necessity for requiring type "C" supplied-air respirators during the spraying of asbestos and during asbestos demolition, removal, and renovation operations.

Paragraph (h), *Respiratory Protection,* of the revised standard for the construction industry requires that employers provide respirators at no cost to employees:

(1) During the interval necessary to install or implement feasible engineering and work practice controls;

(2) In operations such as maintenance and repair activities for which engineering and work practice controls are not feasible:

(3) In work situations in which feasible engineering and work practice controls are not yet sufficient to reduce exposure to or below the PEL; and

(4) In emergencies.

The language of paragarph (h)(1) has been revised from that of the existing standard to conform to standard language used in more recent OSHA rulemakings. Employers are required under paragraph (h)(2) of the revised rule to select appropriate respirators based on employee exposure levels that exist in the workplace. The required respirators range from half-mask air-purifying respirators equipped with high-efficiency filters for concentrations that do not exceed 10 times the PEL to full-facepiece supplied-air respirators or SCBA when the concentration of asbestos fibers exceeds 100 times the PEL. Employers are required to select respirators from those that are approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration under the provisions of 30 CFR Part 11. In addition, employers are required to provide powered air-purifying respirators at the request of employees whenever such a respirator will provide adequate protection for the concentration existing in the workplace.

Under paragraph (h)(3), employers are required to institute a Respiratory Protection program as required under 29 CFR 1910.134. The required program is to include (1) criteria for changing filter elements for air-purifying respirators, (2) a policy permitting employees time to leave work areas to wash their faces and respirator facepieces to prevent skin irritation, and (3) a policy for reassigning employees to other jobs if a physician determines that the employee cannot function normally while wearing a respirator. Under paragraph (h)(4), the revised standard requires that employees perform qualitative or quantitative fit testing for all employees required to wear a negative-pressure respirator. The requirements for the use, selection, program elements, and fit testing of respirators are the same as those contained in the general industry standard and are substantially similar to the requirements contained in other recent OSHA health standards (see for example 29 CFR 1910.1043, Cotton Dust).

Many commenters who submitted information to OSHA during the rulemaking proceedings addressed issues regarding the appropriate use of respirators (Exs. 78; 90–113; 90–160; 90–173; 90–182; 90–236; 92–3; 90–13; 92–25; 123–A; 147; 169; 181; 195; 208; 298; 308; 311–E; 311–G; 313; 328; 330; Trs. 6/19, p. 102; 6/20; 6/25, p. 15; 6/26, p. 78; 6/29, p. 196; 7/2, p. 23; 7/3, p. 44; 7/12, p. 338). These commenters addressed four major issues:

(1) The use of disposable respirators;

(2) The selection of appropriate filter media for air-purifying respirators;

(3) The use of Type "C" supplied-air respirators; and

(4) Requirements for qualitative or quantitative fit testing.

Several commenters advocated the use of disposable respirators for protection against asbestos exposure (Exs. 84–457; 311; 328; 341; Tr. 7/10, p. 126). For example, the Asbestos Information Association/North America stated:

> The record of this proceeding shows that employers in primary and secondary manufacturing industries commonly provide negative pressure single use or reusable respirators to workers who request them. AIA/NA recommends that this practice be codified in the Revised Asbestos Standard to allow workers to achieve an additional margin of health protection if they so desire. (Ex. 328).

The Minnesota Mining and Manufacturing Company (3M) stated that "certain air-purifying negative-pressure half-mask disposable respirators should remain in the proposed asbestos respirator selection table for use [during exposures of] up to 10 times the permissible exposure level" (Ex. 341).

E.I. DuPont de Nemours and Company provided the results of a comparative study of the performance of various respirators, including disposable single-use half-mask air-purifying respirators and self-contained breathing apparatus (Ex. 339). DuPont concluded that two of the three disposable respirators tested achieved a protection factor of at least 10 during tests performed in the course of actual asbestos removal operations. DuPont's conclusion was based on comparisons of the concentration of fibrous materials inside the respirator and outside the respirator in the operator's breathing zone (Ex. 339). Based on the data presented in their report, DuPont concluded that negative-pressure single-use respirators can provide adequate protection against concentrations of asbestos fibers less than 10 times the PEL and should be allowed. The DuPont data are discussed at length in Section IX of this preamble (Summary and Explanation for a Revised Standard for General Industry). After reviewing this study, OSHA found that inconsistencies in the data and the failure of the study to show adequate protection factors for other types of respirators render the study inconclusive.

Many commenters opposed the use of reusable or disposable air-purifying respirators for any airborne asbestos exposure, because they felt that the protection provided by such respirators is inadequate (Exs. 117–A; 150; 151; 123–A; 92–8; 277; 330; Trs. 6/20, p. 196; 6/21, pp. 74–75; 6/25, pp. 17–18; 6/29, p. 106; 7/3, pp. 160–161; 7/3, p. 193; 7/3, p. 50; 7/11, pp. 98–99).

For example, The Building and Construction Trades Department, AFL-CIO, offered the following comments:

> In particular, the throw-away of disposable paper half-masks are not acceptable. In addition to providing field use protection factors too low for any serious consideration for wear in asbestos-exposed work throw-away or disposable paper half-masks offer little comfort. In one 1974 study, 97 miners wore disposable masks over a combined period of 248 person-shifts of work and rated their acceptability. Seventy-six miners rated the ubiquitous 3M 8710, which currently accounts for about 80 percent of the disposable dust mask market. . . . Sixty-seven of the 97 miners found it unacceptable. Forty-seven found it too fragile. Thirty-eight said it was too hot. Fourteen said it got wet and stuck to their faces. Eleven simply said that it was uncomfortable. . . . The researchers concluded that whether or not the respirator was comfortable to wear was of paramount importance (to the workers)—even more so than protection—and that a comfortable respirator will be put on sooner and removed later than one that is not. . . .
>
> The International Brotherhood of Painters and Allied Trades found similar patterns of dislike of disposable dust masks among its members in a respirator preference and use survey conducted in 1980. . . . While 40 percent of the 632 members responding in the survey wore the disposable dust mask most, over 50 percent liked it least. By contrast, over 70 percent liked air-lines most. Respondents rated the air-line masks highest in protection, fit and ease of breathing; the dust mask was rated lowest in each of these categories—even lower than widely despised reusable cartridge half-mask. (Ex. 330)

Jeffrey Paull, of the School of Hygiene and Public Health of Johns Hopkins University, reported:

> I am [in agreement] with the State of Maryland on their position on disposable respirators. I don't think that they can be reliably . . . fit checked on the face of the employee. . . . I don't like the fact that most of them can't be . . . fit checked to provide some sense of assurance that it is fitting the face. (Tr. 7/11, p. 98)

Agreeing with Mr. Paul, David Kirby, representing the Alabama Safe State Program, expressed the following concerns as regarding disposable respirators:

We get very upset with them in the State of Alabama. I feel that they're a false sense of security and, therefore, they're probably a higher hazard than if you were using no respirator at all.

I know that may shock some folks, especially the ones that are selling these. But we feel like . . . their usage is detrimental to the worker's safety. (Tr. 6/20, p. 196)

The Los Alamos Scientific Laboratory evaluated six models of disposable respirators for sodium chloride aerosol leakage while they were being worn by test subjects (Ex. 219). The results indicated that only two of the six models tested provided a protection factor of five for all members of the 10-member test panel. One model showed a decrease in the level of protection offered after exposure to a humid atmosphere. Two of the six models showed variations in the level of proteciton provided over a 6-hour workshift. Finally, all models appeared to fit male facial sizes better than female facial sizes.

NIOSH took the following position regarding single-use respirators at the informal hearing on asbestos:

Under Title 30, Code of Federal Regulations, Part 11, (30 CFR 11), NIOSH is required to test and certify respirators within the categories specified therein when such devices are submitted to NIOSH by applicants. Currently, 30 CFR 11, Subpart K defines a number of dust, fume, and mist respirators which may be used for protection against certain hazardous particulate atmospheres. Among the respirators defined in Subpart K are single-use dust respirators designed as respiratory protection against pneumoconiosis-producing and fibrosis-producing dusts, or dusts and mists. The Subpart goes on to list asbestos as one of the dusts against which the single-use dust respirator is designed to protect [Subpart K, sec. 11.130(h)]. Though at the time of the promulgation of Subpart K, it may have been assumed appropriate to list asbestos as a fibrosis-producing particulate against which the single use disposable respirator could be reasonably expected to provide adequate protection, NIOSH is no longer confident that such an assumption is reasonable because asbestos is also [a] potent carcinogen. The current requirements of 30 CFR 11 for approval of a single-use dust respirator or dust and mist respirator do not include any tests with a fibrous challenge. NIOSH is currently in the process of undertaking a comprehensive revision of 30 CFR 11 and intends to address the issue of appropriate respiratory protection for use against asbestos and to require that any respirator for which such approval is sought be proven to provide effective protection against asbestos. NIOSH may change the regulations included in 30 CFR 11 only in accordance with procedures set forth in the Administrative Procedures Act. In the interim, NIOSH will continue to approve single-use and replaceable dust/mist respirators for use against asbestos when such approvals are applied for only because of the legal requirement in the current approval regulations. However, NIOSH does not recommend the use of such respirators where exposures to asbestos may occur on the basis that such is not a prudent occupational health risk. (Ex. 117-A)

NIOSH submitted to the rulemaking record a copy of an internal memo, dated November 29, 1979, that addresses inquiries regarding the use of disposable respirators for protection against asbestos. This memo stated:

These approvals were probably granted when asbestos was classified as a "suspect" carcinogen and now that it is classified as a definite carcinogen I feel strongly that some changes in the approval need to be made. . . .

. . . perhaps a policy statement that the use of disposable respirators are not and will not be approved for a material that is classified as a carcinogen as soon as that classification occurs [should be issued] and no matter what for or when the original certification was issued. (Ex. 150)

OSHA has carefully weighed the evidence addressing the performance of disposable respirators and has determined that these respirators cannot be relied on to provide adequate protection from exposure to asbestos. OSHA's determination is based on the fact that (1) most disposable respirators are not equipped with high-efficiency filters and (2) there is no acceptable method for verifying the fit of disposable respirators. Therefore, OSHA has not allowed the use of disposable respirators in the revised standard for construction.

A significant amount of information was submitted to the rulemaking record that addressed the appropriate selection of filter media for air-purifying respirators (Exs. 84-256, 84-472). OSHA has used these data to determine the appropriate filter media for use in negative-pressure air-purifying respirators used by employees in both general industry and construction. The NIOSHA/MSHA certification criteria (30 CFR 11.13 (a) and (c)) dictate that high-efficiency filters for air-purifying respirators be used for substances for which a PEL of less than 0.050 mg/m^3 has been established. Conversion factors published by the Chronic Hazard Advisory Panel on Asbestos of the Consumer Product Safety Commission enable the conversion of the 0.2 f/cc PEL to an approximate concentration expressed in mg/m^3. Using these conversion factors, OSHA has determined that the 0.2 f/cc PEL equates approximately to a concentration of 0.006 mg/m^3 (Ex. 84-256). Therefore, OSHA believes that only those air-purifying respirators equipped with high efficiency filters are certified by NIOSH for protection against asbestos at the 0.2 f/cc PEL.

OSHA's decision to require high-efficiency filters for air-purifying respirators is further supported by a 1984 study conducted by the Los Alamos National Laboratory (LANL) on the performance of five models of respirator filters. The LANL study demonstrated the superior effectiveness of high-efficiency filters. The filters were challenged with a chrysotile aerosol, and the asbestos fiber penetration of the media was measured during simulation of different environmental conditions. One of the five models tested was a high-efficency (dust/mist/fume/radionuclide) respirator filter. The filters were tested under various conditions, including after exposures to organic oil mist, after prolonged storage at high humidity, and when uncontaminated (fresh from the package). The high-efficiency filter functioned consistently well under all experimental conditions and exhibited chrysotile asbestos penetrations of less than 0.1 percent during all experimental conditions. None of the other four respirator filters consistently exhibited chrysotile asbestos penetrations lower than 0.1 percent during all experimental conditions (Ex. 84-472).

Several commenters suggested that supplied-air respirators were so superior to negative-pressure respirators that supplied-air respirators should be required whenever respiratory protection is necessary to reduce employee exposure to asbestos. For example, the Building and Construction Trades Department, AFL-CIO, stated:

Respirator fitting is one of the major factors severely restricting effective use of negative pressure respirators. . . . The act of working disrupts the seal and prevents certain determination of its effectiveness. . . .

Other variations also limit negative pressure respirator protection reliability and certainty. Personal factors—including body movements, weight loss or gain, age, facial wrinkles, scars, dentures, eye glasses, lung capacity, general health, physiology and facial hair—contribute to the poor performance of negative pressure respirators. The amount of time the respirator is worn is a factor as well. Longer periods of wear tend to result in deterioration of the worker's ability to maintain the many unnatural and uncomfortable behaviors required for good fit. These factors are especially significant with negative pressure respirators, where protection is based upon the face seal, as opposed to positive pressure respirators, in which the air-flow counteracts interruptions in the face seal. The condition of the negative pressure respirator—strap adjustment, pliability and minor surface defects—will also affect protection, as will poor maintenance and conditions of temperature and humidity. . . . Insofar as comfort is likely to increase respirator wear, positive pressure respirators are superior to negative-pressure because they are more likely to be accepted by workers for regular use. (Ex. 330)

Many commenters requested that the selection of respirators be dictated by the exposure levels that exist in the workplace environment (Exs. 90–160; 90–173; 90–182; 339; Tr. 7/12, p. 338). For example, the Industrial Safety Equipment Association stated:

The type of respirators to be required for employees engaged in spraying, demolition and removal operations should depend on the airborne exposure levels measured for each exposed person and the proper type of respirator should be selected accordingly. If such measures are not possible, a supplied-air respirator should be required. . . .

Techniques have progressed so that relatively low levels of asbestos can be maintained in the workplace. Rather than required air-supplied respirators in all removal and demolition operations, the type of respiratory protection selected should correspond to the highest concentration of asbestos anticipated in the particular workplace. (Ex. 90–182)

Similarly, Richard Roll, Assistant Vice President for Bell Communications Research, stated:

The requirements of the present standard for a supplied air respirator whenever asbestos is removed are over restrictive in many work situations. Almost all maintenance activities on asbestos covered piping and equipment involve the removal of some of the asbestos insulation material. Work practices (wet methods, enclosure, vacuum systems) have been developed to minimize the potential for employee exposure in those situations. It makes no sense to require supplied air respirators in these work operations merely on the technicality that some asbestos material will be removed. Respirator selection should be a function of airborne fiber concentration rather than category of work. (Ex. 90–173)

Julia L. Phillips, an Attorney with the Environment, Materials and Logistics Division of E. I. DuPont de Nemours and Company noted that air line respirators and self-contained breathing apparatus had significant disadvantages when used in asbestos abatement projects (Ex. 339). Ms. Phillips stated:

Air line respirators or self-contained breathing apparatus (SCBA) create safety hazards in a complicated [asbestos] removal operation where workers are constantly climbing or descending ladders or scaffolding because of the increased risk of tripping and falling. (Ex. 339)

OSHA agrees that positive-pressure supplied-air respirators provide a greater level of protection than do half-mask negative-pressure respirators. OSHA believes that employers should have the flexibility to use any of the available respirators that provide sufficient protection to reduce the exposures to levels below the PEL. Furthermore, the safety problems associated with the use of supplied-air respirators cannot be ignored. OSHA believes that respirators should be selected that both provide adequate protection from exposure to airborne asbestos fibers and minimize the risk of accident and injury potentially caused by the use of cumbersome supplied-air respirators. In addition, OSHA has historically used a tiered approach to the application of respiratory protection in nearly all standards governing occupational health hazards. (See, for example, 29 CFR 1910.1047, ethylene oxide; 29 CFR 1910.1017, vinyl chloride; and 29 CFR 1910.1045, acrylonitrile).

Therefore, OSHA has developed the protocol contained in Table D–4 of the standard for the application of respirators, which:

(1) Allows the use of negative-pressure air-purifying respirators equipped with high-efficiency filters for concentrations of asbestos fibers less than 10 times the PEL.

(2) Allows the use of full-facepiece air-purifying respirators with high-efficiency filters for concentrations of asbestos fibers less than 50 times the PEL.

(3) Allows the use of powered air-purifying respirators with high-efficiency filters or half-mask supplied-air respirators operated in the positive-pressure mode for concentrations of asbestos fibers less than 100 times the PEL.

(4) Requires the use of full-facepiece supplied-air respirators operated in the positive-pressure mode or full-facepiece self-contained breathing apparatus operated in the positive-pressure mode for concentrations of asbestos fibers that exceed 100 times the PEL.

Data presented by the Building and Construction Trades Department, AFL–CIO (Ex. 330) indicated that the proper use of respirators may depend, to a large extent, on the workers comfort and preference for various types of respirators. Therefore OSHA has required that employers provide powered air-purifying respirators for employees who request them for concentrations of asbestos fibers less than 100 times the PEL. OSHA believes that this provision will increase the effectiveness of respiratory protection programs while allowing employers to select the most cost-effective respiratory protection options that will reduce exposure to below the PEL.

Many commenters presented information on fit-testing requirements for respirators (Exs. 263; 330; 123–A; 90–233; 302; 322; 328; Trs. 6/21, p. 75; 6/29, p. 232; 7/2, p. 25; 7/3, p. 48; 7/10, p. 299; 7/11, p. 119). Several commenters recommended that quantitative fit testing be required. For example, NIOSH commented, ". . . we want to reiterate our position that we recommend a quantitative respirator fit-testing program as previously stated in comments on the proposed lead standard" (Ex. 117–A).

Conversely, the Asbestos Information Association/North America (AIA/NA) stated that the record does not support that quantitative fit-testing procedures are more effective in providing good respirator fit than sound qualitative fit-testing procedures. The AIA/NA commented that there is no need for fitting protocols to be rigidly specified in the final standard, because techniques are widely published in industrial hygiene publications and because the 29 CFR 1910.134 requirement that the respirator be worn in a test atmosphere as part of the training program . . . would allow employers the flexibility to take advantage of improvements in fit-testing procedures in future years" (Ex. 328).

Many commenters favored the use of either quantitative or qualitative fit-testing procedures or both. The BCTD's recommended standard requires quantitative fit testing to be performed on an employee before he or she begins any asbestos-related work and at least annually thereafter, and whenever an employee's facial features change or other conditions of wear affect fit. The BCTD's standard requires daily qualitative fit testing, using methods that are adequate to ensure a proper fit for half-mask negative-pressure respirators. An article published in the American Industrial Hygiene Journal in February, 1983 (K. E. Hardis, C. A. Cadena, C. A. Carlson, R. A. da Roza, and B. J. Held: American Industrial Hygiene Association Journal (44) February, 1983) presented data on the effectiveness of qualitative fit-testing protocols for detecting poorly fitting facepieces with protection factors greater than 10. This article reported that for a fit factor of 10, 93 to 100 percent of poorly fitting half-mask respirators could be detected by qualitative methods. The article also reported that, when used to test for a fit factor of 100, qualitative methods were capable of detecting only 23 to 46 percent of the inadequately fitting full-facepiece respirators.

Therefore, based on these data, OSHA has allowed in paragraphs (h)(4)(ii) of the revised standard the use of qualitative fit-test methods only for half-mask negative-pressure respirators, which can only be used for concentrations of asbestos fibers that do not exceed 10 times the PEL. Since qualitative methods do not appear to be adequate for ensuring proper fit for full-facepiece negative-pressure respirators, OSHA has required that such respirators be fit tested using quantitative methods. Fit testing is not required for positive-pressure respirators because the flow of air from the inside of the respirator to the outside effectively eliminates the possibility of asbestos contamination entering the respirator facepiece through the face seal.

The provision in the existing standard requiring employers to establish a respirator program in accordance with the requirements contained in 29 CFR 1910.134 (b), (d), (e) and (f) is essentially unchanged in the revised standard.

Finally, the revised standard stipulates that respirators required for protection from exposure to asbestos fibers shall be provided at no cost to the employee. OSHA views this allocation of costs to control employee exposure to asbestos fibers as being necessary to effectuate the purpose of the Act. The requirement is consistent with other health standards issued under section 6(b) of the Act.

Paragraph (i)—Protective Clothing

The existing standard for asbestos (29 CFR 1910.1001(d)(3)) required that employers provide "special clothing" for any employees exposed to airborne asbestos fiber concentrations in excess of the ceiling level (10 fibers/cc of air). This special clothing was to include "coveralls or similar whole body clothing, head coverings, gloves, and foot coverings." In addition, the existing asbestos standard required that asbestos-contaminated clothing be laundered using means that "prevent the release of airborne asbestos fibers in excess of the exposure limits. . . ." The standard stated that any employer who had asbestos-contaminated clothing laundered by another person "shall inform such person of the requirement . . . to effectively prevent the release of airborne asbestos fibers . . . [and that] contaminated clothing shall be transported in sealed impermeable bags, or other closed, impermeable containers, and [be] labeled. . . ."

In the April notice (49 FR 14130), OSHA questioned the appropriateness of applying the existing standard's protective clothing requirements to the construction industry, and in particular asked whether these requirements were "adequate to protect" workers in this industry. Responses to this question and information about protective clothing used by construction workers who work with asbestos are discussed below, together with requirements for protective clothing mandated by the revised rule.

The revised standard for construction differs from the existing standard in that it requires, in paragraph (i)(1), that personal protective clothing be provided for employees exposed above the revised PEL of 0.2 fiber/cc, rather than restricting the use of such clothing to employees exposed above the ceiling level only. When nondisposable protective clothing is used, the employer is required by paragraph (i)(2) to launder the clothing in a manner that prevents the release of airborne asbestos fibers in excess of the PEL and to notify the person responsible for laundering. Paragraph (i)(3) requires employers to transport contaminated clothing in sealed impermeable bags or other impermeable containers. The requirements of paragraphs (i)(2) and (i)(3) are identical to the requirements of the existing standard and the revised standard for general industry.

In addition, a requirement for employees involved in asbestos removal, demolition, or renovation operations at paragraph (i)(4) requires that worksuits being worn by employees working inside negative-pressure enclosures be examined periodically by a competent person to detect rips or tears, and that when rips or tears are detected in clothing while an employee is working in a negative-pressure enclosure, they "shall be immediately mended, or the worksuit shall be immediately replaced."

Most commenters supported the inclusion of requirements in a revised standard mandating that employers provide personal protective clothing to employees exposed to asbestos. In general, commenters raised the following issues concerning personal protective clothing:

(1) When personal protective clothing is needed;

(2) What types of personal protective clothing should be used, e.g., full body coverings, head coverings, gloves, boots;

(3) What protective clothing materials are appropriate in various work situations;

(4) How asbestos-contaminated protective clothing should be cleaned or disposed of; and

(5) Concerns about heat stress and worker comfort.

Both NIOSH and Margaret Stasikowski of EPA stated that the standard should include the use of protective clothing (Tr. 6/21, p. III–210). D.M. Bradshaw, Director of Manpower Services for the Associated General Contractors of America (AGC), recommended that disposable protective clothing should be provided if a contractor foresees asbestos exposure at any level and stated that OSHA's personal protective clothing requirements should be followed when asbestos is being installed in new construction (Ex. 84–457).

However, other commenters did not feel that personal protective clothing should be required regardless of exposure level or work situation. Dr. Arthur Langer of Mt. Sinai Hospital, speaking on behalf of the AFL–CIO, recommended protective clothing "where appropriate" (Tr. 7/3, pp. 90–91). AIA-NA commented that employers should provide protective clothing to employees "exposed above 0.5 f/cc TWA [i.e., the PEL recommended by AIA/NA] because this is already a fairly common [practice] in manufacturing plants" (Ex. 328, p. III–43). AIA/NA also cited their article "Asbestos Cement Products," which emphasizes the need for personal protective clothing when working with asbestos cement products (Ex. 312.A). Commenters from AIA/NA also pointed out that the Council Directive of the European Communities, Article 11, requires that workers be issued personal protective equipment and that the equipment be worn, and that Article 12 of the Directive requires that a plan specifying the provision of personal protective equipment be drawn up prior to demolition and/or removal work (Ex. 312.A). The only work situations in which commenters felt that protective clothing might not be necessary or should not be required were one-time removal or installation operations (Ex. 341), cutting and installation of asbestos cement sheet (Tr. 7/10), and cutting of asbestos cement pipe (Tr. 7/10).

In response to these comments, OSHA's revised standard requires personal protective clothing only for employees exposed to airborne asbestos concentrations in excess of the PEL, i.e., in a regulated area. Triggering the requirement for personal protective clothing at the PEL is consistent both with the revised asbestos standard for general industry and with past OSHA rulemakings (see, for example, inorganic arsenic, 29 CFR 1910.1018).

A number of commenters recommended the use of disposable worksuits (Exs. 123–A, 330, 298, 92–26, 92–25, 92–11, 84–457, Trs. 7/3, 6/29, 6/25), particularly during major asbestos removal and renovation projects. These participants were of the opinion that this type of clothing provide sufficient protection to the worker but eliminates the problems that may be involved in laundering and storing asbestos-contaminated clothing (Ex. 123–A, 298, 330, Tr. 6/25). Several commenters stated that disposable clothing was currently required and used in asbestos operations. Dr. R. F. Boggs, Vice President of ORC, commented that International Paper requires disposable clothing for all asbestos demolition and removal operations (Ex. 123–A). M.K. O'Brien, Vice President of a local of the United Steelworkers of America, stated that Northern Indiana Public Service Company now uses full body overall-type paper disposable suits (Tr.7/3). Daniel F. Wilton of the Sheetmetal Workers International Association, Local 28, said that the World Trade Center requires all contractors to wear disposable protective suits and boots during renovation work (Tr. 6/29).

The Primary advantage that commenters cited for the use of disposable worksuits was that this type of clothing eliminated the need for laundering and storing asbestos-contaminated articles. Dr. Boggs included in the ORC response to the Notice of Proposed Rulemaking on Occupational Exposure to Asbestos (49FR 14116), the comments of T.E. Kupferer of the Standard Oil Company (Indiana). Mr. Kupferer stated that Standard Oil (Indiana) workers involved in asbestos removal wear disposable protective clothing "because of the problems involved in storing, laundering, and handling of reusable clothing contaminated with asbestos . . . (Ex. 123–A)."

Commenters from the BCTD also emphasized that disposable clothing should be required, stating that "while disposable overalls may not be as durable and comfortable as cotton work clothes, they . . . do not require laundering which would expose another workforce or the worker's family to asbestos" (Ex. 330, p. 68). The BCTD stressed that ". . . it is essential and feasible to provide personal protective equipment for construction workers who are exposed to asbestos . . . [and that] protective clothing [must] be provided whenever any person enters the regulated area" (Ex. 330, pp. 67-68). William L. Baker of the National Association of Demolition Contractors also cited a preference for paper uniforms because they can be disposed of (Tr. 6/25, p. 57). Mr. Baker did not think that durability was a problem because workers would "only wear them when they do the asbestos removal . . ." (Tr. 6/25, p. 57). One commenter from the N.Y.C. Board of Education, Office of Design Construction, cited the "Asbestos Abatement/Control Guidance Manual," which states that "no worker may use street clothes under disposable suits" (Ex. 92-26, p. 73).

Although these commenters agreed that disposable worksuits are preferable for large-scale asbestos removal operations, some rulemaking participants felt that disposable clothing was not necessary for other types of construction work. Connie Degrange of the Industrial Hygiene Group at Lawrence Livermore National Laboratory commented that ordinary work clothes may be worn by employees who remove or install small sections of asbestos-containing materials or perform operations involving one-time penetration of existing asbestos coverings, provided that asbestos dust in the work area is kept to a minimum (Ex. 341, p. 2, Attachment III). Joseph Jackson of the Association of Asbestos Cement Pipe Producers also felt that no special work clothes were needed during infrequent asbestos cement cutting operations because exposure levels are "very close to ambient background levels" (Tr. 7/10, p. 138).

OSHA finds that non-disposable work clothes similar to those required in the revised general industry standard will provide sufficient protection for employees engaged in construction activities, provided that such clothing is properly cleaned after work and then laundered.

Some respondents specified the articles that should be used by construction workers handling asbestos-containing materials: full body coveralls, head coverings, foot coverings, and gloves (Exs. 92–26, 92–11, 92–25, 123–A, Tr. 6/29). Therefore, the revised standard, like the existing rule, includes an enumeration of suitable articles of protective clothing. Although some commenters discussed particular types of disposable clothing, such as clothes made of Tyvek (trademark of DuPont) and shoe coverings made of rubber, OSHA has not specified particular materials for protective clothing required by the final rule.

William J. Nicholson of the Mt. Sinai School of Medicine felt strongly that "no work clothes should ever be taken home" (Tr. 6/19, p. I–92). He supported the final rule's laundering provision, stating that clothes "have to be laundered in specially controlled laundry facilities" (Tr. 6/19, p. I–93). Minnesota Department of Health commenters also urged that "precautions need to be taken to prevent contamination of workers' street clothes, cars, and homes" (Ex. 92–011, p. 2). They specified that body coveralls be worn, and "these coveralls must not be worn home" (Ex. 92–011, p. 2).

Several commenters discussed methods for cleaning and disposing of personal protective clothing. The Minnesota Department of Health, in "Guidelines for Developing an Effective Asbestos Removal Plan," recommended that "reusable clothing should be washed daily or weekly depending upon work conditions, with the launderer notified of their potential contamination" (Ex. 92–011, p. 2). The guidelines also specify that "proper precautions need to be followed when handling contaminated clothing" (Ex. 92–011, p. 2). Mr. Kupferer explained that employees of Standard Oil (Indiana) are warned not to take contaminated clothing home. Instead, when the job is completed or workers leave a barricaded area, all contaminated articles are removed.

> . . . coveralls and gloves are routinely discarded along with the asbestos scrap, as are disposable head and boot coverings, if used. Hard harts are cleaned, as are boots, and any cleaning items used are also discarded with the asbestos scrap. Where rain gear is worn over the disposable coveralls, it is also cleaned before removal from the site (Ex. 123–A, pp. 3–4 of Appendix D).

Based on the weight of the evidence presented in the rulemaking record, OSHA has retained the requirements of the existing standard for laundering reusable work clothes in such a manner as to prevent the release of airborne asbestos fibers in excess of the PEL. OSHA has assigned the responsibility for laundering asbestos-contaminated protective clothing to the employer in order to prevent exposure to workers' family members that may handle such clothing.

Two concerns about personal protective clothing were expressed by commenters: heat stress and worker comfort. David Kirby, Industrial Hygienist Chemist for the Alabama Safe State Program, felt that protective clothing is not necessary in all cases because it adds to the likelihood of heat stress (Tr. 6/20, p. 183). He explained that

> by the end of the four-hour shift, the guy's halfway out of the suit anyway. So unless asbestos exposure to the external area of the body is a definite threat, I feel like there may be some option involved with the use of external type protection. (Tr. 6/20, p. 183)

Dr. Boggs also included in the ORC response to the notice of rulemaking the comments of Carl D. Richardson of Brown and Rost, Inc., who felt that heat stress may be a problem in the summer and that "in winter months the colder temperatures present problems with the wearing of disposable clothing" (Ex. 123-A, p. 5 of Appendix B). Nevertheless, he stated that "we insist that all personnel working in close proximity to asbestos removal, whether directly involved or not, wear full protective clothing" (Ex. 123-A).

Scott Schneider, Industrial Hygienist for the United Brotherhood of Carpenters and Joiners, quoted an EPA research report that stated that "heat stress experienced by asbestos workers who wear full body and permeable clothing and respirators and who are engaged in moderate to heavy work in an enclosed work space is a serious and frequently encountered problem in asbestos removal" (Tr. 6/27, p. 183). He went on to discuss EPA guidance for controlling asbestos materials in buildings and the use of negative-pressure systems for asbestos abatement, and quoted the EPA report that stated that "the increased air change rate in the work area, facilitated by the use of negative pressure systems, . . . reportedly reduced the temperature and humidity in the work area, improved worker comfort and increased productivity" (Tr. 6/27, pp. 183-184).

OSHA recognizes that heat stress is a concern when disposable protective clothing is used in hot environments. However, OSHA believes that the use of protective clothing is an essential element of programs for protecting employees from asbestos exposure that may result from contaminated clothing. In situations in which heat stress is a concern, OSHA believes that employers should use appropriate work-rest regimens and provide heat stress monitoring that includes measuring employees' heart rates, body temperatures, and weight loss. If such measures are used to control heat stress, OSHA believes that disposable protective clothing can be safely worn to provide the needed protection against asbestos exposure.

Paragraph (j)—Hygiene Facilities and Practices

Paragraphs 1910.1001(d)(4) (i) and (ii) of the existing standard required that change rooms and two separate clothes lockers be provided "at any fixed place of employment." Similar requirements are contained in paragraph (i) of the revised standard for general industry. Since construction industry worksites are usually nonfixed, the application of such provisions to construction worksites is complicated. In the April proposal, OSHA solicited comments from affected parties concerning appropriate hygiene facilities and practices to protect construction industry employees.

The provisions pertaining to hygiene facilities and practices (paragraph (j) of the revised standard) reflect the comments received in response to the questions raised in the April proposal and data and testimony received in connection with the informal rulemaking hearing. By tailoring the requirements for hygiene facilities and practices to differences in worksite conditions, this paragraph also reflects the Agency's understanding of the wide variation in exposure and work conditions prevalent in the construction industry. For example, the requirements in paragraph (j)(i) pertain to work in regulated areas other than those involving asbestos removal, demolition, and renovation. The operations addressed by the requirements in paragraph (j) might include the installation of new asbestos-containing products, the cutting of asbestos sheet or pipe, or the removal of floor tile where these operations caused levels of airborne asbestos sufficient to trigger the regulated area requirement, i.e., above the PEL. Paragraph (j)(2) of the revised standard specifically addresses the hazards of asbestos removal, demolition, and renovation work by requiring that employers engaged in such work provide their employees with decontamination, clean room, and shower facilities wherever feasible. This separation of provisions for hygiene facilities into those pertaining to work operations requiring only the establishment of a traditional regulated area demarcated by signs and those relevant to major asbestos abatement projects accords with evidence in the record about the differences in exposures, work operations, and hazards in these two types of construction work. The evidence, as it relates to each provision of the hygiene facilities and practices section of the final rule, is described below.

Many commenters argued that the standard should require clean change rooms and provisions for separate facilities for work and street clothes on all construction jobs, regardless of the type of work performed (Exs. 84-424, 92-11, 277, Trs. 6/19, 6/21, 6/26). OSHA concurs with the rationale for the view expressed by these commenters, which was perhaps best summarized in the remarks of Dr. William J. Nicholson, of the Mt. Sinai School of Medicine. In responding to a question about the importance of such measures as hygiene facilities, Dr. Nicholson answered:

> I think [such measures are] enormously important . . . one has to confine the fibers immediately at their source . . . . Hygiene facilities are certainly required. (Tr. 6/19)

The hygiene facilities requirements of the revised construction standard, the revised general industry standard, and the existing standard are similar in many respects. For example, exposure to asbestos at levels above the PEL acts as the trigger for all three provisions, and each standard requires that employees working in such areas have a place to change their street clothes and to store them separately from their work clothes.

Paragraph (j)(1) contains requirements for hygiene facilities for employers engaged in construction operations other than major asbestos removal, demolition, and renovation operations. Paragraph (j)(1)(i) of the revised construction standard modifies the language of the existing standard's hygiene requirements from change "room" to change "area," in recognition of the fact that the place where employees change from street clothing to work clothing and back again to street clothing is not always a separate room but may be merely a separate area of a larger space. This change recognizes that it may not be feasible at some construction sites to provide a separate room with physical barriers. In these instances, employers may provide change areas that are distant from the immediate location where asbestos-related work is being conducted, such as on a separate floor of a building.

A second language change has been made in the revised standard: the existing standard's use of the term "separate lockers" has been changed to "separate storage facilities" in recognition of the fact the employers must use portable storage facilities that can be transported from job to job. OSHA's intent in this provision is to ensure that street clothes are sufficiently separated from work and protective clothing and equipment in order to prevent contamination of employees' street clothing, and this can be accomplished by separate lockers, baskets, or other containers.

New language has been added in the revised standard to require the provision of clean areas, i.e., areas that have airborne concentrations of asbestos below the action level, where employees may consume food or beverages on site. This addition was recommended by CACOSH in its 1980 report (Ex. 84-233). CACOSH recognized that permanent lunch rooms, such as exist on fixed worksites, were probably not feasible for the construction industry, due to the nonfixed nature of construction project worksites. The term "lunch area" was adopted by OSHA to indicate that a temporary facility, such as a separate trailer, would serve the purpose of protecting employee health. OSHA agreed with the CACOSH findings that the transient work conditions in nonfixed workplaces would make the installation of fixed lunchrooms difficult, and accordingly included a requirement for clean lunch areas in its revised standard; but unlike the provision in the revised general industry standard, the revised construction standard does not require that lunch facilities be equipped with a filtered air supply.

The principal changes to the hygiene facilities section reflected in the revised standard involve OSHA's efforts to tailor these requirements to the substantial differences in exposure, work conditions, and feasibility of controls found in different construction operations. For example, as the record makes clear, the significant features of a construction task involving the replacement of an asbestos-containing gasket are grossly different from those prevailing inside a negative-pressure enclosure during a major asbestos removal operation. The revised standard takes these differences into account in two ways: by providing, in paragraph (j)(1)(i), an exception to the requirement for a clean change area for employers whose employees are engaged in small-scale, short-duration operations of the type described above for paragraph (e); and by requiring employers performing asbestos removal, demolition, or renovation operations to observe the more comprehensive hygiene facilities requirements of paragraph (j)(2).

The exception in paragraph (j)(1)(i) permits employees working on small-scale, short-duration operations, such as pipe repair and valve replacement, to clean their protective clothing with a portable high-efficiency particulate air (HEPA) filter-equipped vacuum rather than exchanging their protective work clothing for street clothing in a change area at the completion of a job. An example of a task fitting this description might be the work performed by an electrician hanging electrical conduit on hooks attached to a beam covered with asbestos-containing insulation; this task would be likely to take fewer than 30 minutes to perform, and would typically make up only a small part of the electrician's overall duties.

Several commenters to the record reported that the use of vacuums to clean protective clothing after a small asbestos-related job reflects current industry practice on such jobs. For example, Mr. Darrell E. Anderson, of the Minnesota Department of Health, stated that ". . . protective clothing and vacuuming would minimize the concern for showers . . ." (Ex. 92-11). In a similar vein, the docket submittal of the New York City Board of Education (Ex. 92-26) made the point that, for small boiler and pipe insulation removal projects, separate clean rooms and shower facilities are not required. The exemption in paragraph (j)(1)(i) would permit workers engaged in small-scale and short-duration tasks to use a portable vacuum equipped with a HEPA filter to clean any asbestos dust from their clothes, hair, and exposed skin before leaving the work area. This procedure will ensure that asbestos is not carried from the work area to other areas of the building and is not retained on the employee's clothing.

OSHA believes that the special exemption for small-scale, short-duration jobs will provide employers in the construction industry whose employees must occasionally engage in asbestos-related work with the flexibility necessary to perform those jobs with a minimum amount of disruption and a high degree of protection, both for the employee performing the job and for other employees and bystanders in the vicinity.

Many commenters addressed the use of hygiene facilities in major asbestos removal renovation and demolition projects (Exs. 92-8; 92-11; 92-25; 92-26; 263; 277; 330; 328; Trs. 7/5, p. 181; 7/6, p. 214; 7/12, p. 73). The rulemaking record contains several specifications for the use of shower and change room facilities on asbestos removal or renovation projects (Exs. 92-8, 92-11, 92-25, 92-26). For example, the "Specifications for Asbestos Removal" of the North Carolina Division of State Construction contains provisions for a clean room, shower, and equipment room for each asbestos removal project building owned by the State of North Carolina (Ex. 92-8). Several commenters specifically requested that OSHA require hygiene facilities for major asbestos removal, renovation, and demolition projects (Exs. 277, 330, Tr. 7/3, p. 181). The Building and Construction Trades Department, AFL-CIO stated:

> The current asbestos standard only requires hygiene facilities for fixed worksites. Construction workers also need such facilities to prevent bringing dust out of the worksite and home to their families. Work clothing has been demonstrated to be a significant source of exposure for workers (Geissert, 1983). Numerous cases of family members contracting mesothelioma from exposure to a worker's work clothing [have occurred]. For these reasons the standard hygiene facilities . . . must be required on all construction asbestos projects where exposure exceeds the action level. We require separate change rooms for clean and dirty clothes separated by a shower facility . . . [and] specific procedures to be followed each time an employee passes between the regulated area and the clean room. . . . (Ex. 277)

On the other hand, some commenters opposed the inclusion in the revised rule of requirements for showers and change rooms for major asbestos removal and renovation operations (Exs. 263; Trs. 7/6, p. 214; 7/12, p. 73). The Advisory Committee for Construction Safety and Health (CACOSH) expressed concern that hygiene facilities might not be feasible for many construction operations when the availability of water is limited and cold weather interferes with workers' ability to take showers (Exs. 84-233, 84-244).

Based on a review of the record evidence, OSHA has required in paragraph (j)(2) that hygiene facilities consisting of a clean room, an equipment room, and a shower, where feasible, be provided for employees engaged in asbestos removal, demolition, or renovation projects. OSHA believes that providing such facilities is feasible for the great majority of projects.

In addition, in situations in which employers can demonstrate that it is not feasible to locate a shower between the equipment room and the clean change room, paragraph (j)(2)(iii) permits employers to use alternative methods of employee decontamination. These methods are:

(1) Employees may remove asbestos contamination from their disposable worksuits by using a HEPA vacuum before proceeding to a shower that is not contiguous with the work area; or

(2) Employees may remove their contaminated disposable worksuits, don clean disposable worksuits, and proceed to a shower that is not contiguous with the work area.

OSHA believes that these alternative decontamination methods will provide adequate protection to the worker and effectively prevent the spread of asbestos contamination from the work area in situations in which it is not feasible to provide a shower.

Paragraphs (j)(2) (v) and (vi) of the revised standard provide for specific decontamination practices that must be followed when entering and exiting an asbestos removal, demolition, or renovation work area. Similar procedures are contained in several of the asbestos removal specifications submitted to the rulemaking record (Exs. 92–8, 92–11, 92–25, 92–226). The specification for asbestos removal projects for the State of North Carolina requires that:

(1) Workers entering the work area remove street clothes, don disposable coveralls and respirator, and proceed through the shower to the equipment room and work area.

(2) Upon leaving the work area, the worker stops in the equipment room to remove contaminated clothes, and places them in plastic bags for disposal.

(3) The worker proceeds to the shower wearing only his respirator and showers to remove all traces of asbestos contamination.

(4) The worker then moves to the clean change room where he removes his respirator, cleans and inspects it, and dresses (Ex. 92–008).

Following these procedures appears to OSHA to be a reasonable method for ensuring that asbestos contamination is removed from the worker's body, thus preventing worker exposure, the exposure of family members, and the spread of asbestos contamination to areas outside the work area.

Paragraph (k)—Communication of Asbestos Hazards to Employees

In paragraph (k) of the revised standard, OSHA has included requirements to ensure that the dangers of asbestos-containing materials are communicated to employees by means of signs, labels, and employee information and training. The requirements for the signs and labels mandated in this section parallel those in OSHA's Hazard Communication standard (29 CFR 1910.1200). Although the Hazard Communication standard, as originally promulgated, applied only to the manufacturing Standard Industrial Classification (SIC) codes (SICs 20–39), OSHA has subsequently announced its intention of expanding the coverage of this standard to the construction industry, as well as to other industry sectors not initially covered. Ensuring that the content and format of the signs, labels, and employee information and training provisions of the final asbestos standard for construction are consistent with those of OSHA's Hazard Communication standard will thus provide construction employers with a consistent and comprehensive approach to alerting their employees to the hazards of asbestos exposure and facilitate the future inclusion of construction in the standard's scope.

OSHA's April proposal indicated that the evidence regarding the carcinogenicity of asbestos had prompted OSHA to consider updating the substantive requirements for signs and labels in the final rule. Specifically, the proposal considered adding a requirement that signs be posted to demarcate regulated areas. The Building and Construction Trades Department (BCTD) of the AFL–CIO urged the inclusion of similar requirements in its recommended standard for the construction industry (Ex. 330).

Signs and Labels. OSHA's final rule includes specifications for signs to be posted at all locations where regulated areas have been established to indicate that concentrations of airborne asbestos fibers exceed or may exceed the 0.2 f/cc PEL; such signs are to bear the following legend:

DANGER

ASBESTOS

CANCER AND LUNG DISEASE HAZARD

AUTHORIZED PERSONNEL ONLY

RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA

The purpose of these signs is to minimize the number of employees in a regulated area by alerting them to the fact that they must have authorization from their employer and take the appropriate protective measures before entering. Furthermore, as discussed in Section X (Summary and Explanation for a Revised Standard for General Industry), signs serve to apprise employees of the hazards to which they are exposed in the course of their employment, and foster cooperation between the employee and employer in controlling workplace hazards.

The standard also requires that all asbestos products and containers of asbestos products, including waste containers, be labeled with the following information and with a warning statement against breathing airborne asbestos fibers:

DANGER

CONTAINS ASBESTOS FIBERS

AVOID CREATING DUST

CANCER AND LUNG DISEASE HAZARD

Both employee and industry representatives generally supported the inclusion in a revised standard of requirements for posting signs to demarcate regulated areas and for informing employees of the health hazards of asbestos by means of signs and labels (Exs. 330, 270, 328, Tr. 7/10). However, the BCTD's recommended standard (Ex. 330) would have required that both signs and labels be bilingual, be written in the languages that predominate in the workplace, and include symbols to assist comprehension wherever necessary. "The need for such a provision," the BCTD maintained, "would appear to be self-evident in an industry which employs over 60,000 workers whose native tongue is not English" (Ex. 330). In addition, the BCTD's standard recommended a labeling provision requiring the label to display the test conditions in effect for determining the category of an asbestos-containing product, (the BCTD recommended a system of product and process categorization—see discussion under scope, paragraph (a)), and information on work rates, ventilation rates, and work practices appropriate to the product or process (Ex. 330).

As written, paragraph (k)(1) in the revised asbestos standard is consistent with CFR 1910.1200(f) and with Section 6(b)(7) of the OSH Act, which prescribes the use of labels or other appropriate forms of warning to apprise employees of the hazards to which they are exposed. The Hazard Communication standard specifies that "the employer shall ensure that labels or other forms of warning are legible, in English, and prominently displayed on the container, or readily available in the work area throughout each workshift. Employers having employees who speak other languages may add the information in their language to the material presented, as long as the information is presented in English as well" (29 CFR 1910.1200(f)(9)). OSHA believes that this language addresses the concern of communicating the hazards of asbestos to non-English-speaking employees without imposing an unduly stringent requirement on those construction employers whose work force is comprised solely of English-speaking persons.

The revised standard permits two exceptions to the labeling requirement: no label is required in those instances where (1) asbestos fibers have been modified by a bonding agent, coating, binder, or other material provided that the manufacturer of the product can demonstrate that during any reasonably foreseeable use (including handling, storage, disposal, processing, or transportation) employee exposures will remain below the action level; or (2) where asbestos is present in a product in concentrations less than 0.1 percent by weight. These exceptions are identical to the labeling exceptions contained in the revised standard for general industry.

The first exception is based on paragraph (g)(2)(i) of the existing standard, which does not require that products be labeled if asbestos is bonded or modified in such a way that use of the product will not result in employee exposures that exceed the PEL. In the revised standard, OSHA has modified this exception by triggering the labeling requirement in cases where the use of such products may result in employee exposures above the action level rather than above the PEL. OSHA has made this change to be consistent with the use of an action level, which was not included in the existing standard, as a trigger for the employer to institute measures to protect workers from exposure to asbestos.

The second exception to labeling, which pertains to products and materials containing less than 0.1 percent asbestos, is based on OSHA's Hazard Communications rule (29 CFR 1910.1200), which specifies that a mixture shall be considered to be carcinogenic if a carcinogen is present in concentrations exceeding 0.1 percent. Although one commenter (Ex. 344-16) suggested that OSHA consider asbestos to be a trace contaminant if it is present at a concentration of 0.25 percent or less, OSHA found no record evidence that indicated that a higher degree of worker protection could be attained by using a percent concentration other than that specified by the generic standard.

Employee information and training. OSHA proposed training requirements for abestos-exposed employees in the April notice, and these have been slightly modified in the final rule. The training requirements in the revised standard are patterned after those discussed in OSHA's Hazard Communication standard (29 CFR 1910.1200(h)(1) and (2)).

The revised asbestos standard for the construction industry requires affected employers to provide a training program for all employees exposed to airborne concentrations of asbestos in excess of the action level prior to or at the time of initial assignment (unless the employee has received equivalent training within the previous 12 months) and at least annually thereafter. Component areas to be covered in the training program include: (1) methods for recognizing asbestos; (2) the health effects associated with asbestos exposure; (3) the relationship between asbestos and smoking in producing lung cancer; (4) the nature of operations that could result in exposure to asbestos, the importance of necessary protective controls to minimize exposure including, as applicable, engineering controls, work practices, respirators, housekeeping and protective clothing, and any necessary instruction in the use of these controls; (5) the purpose, proper use, fitting instructions, and limitations of respirators, as described in 29 CFR 1910.134; (6) the appropriate work practices for performing the asbestos job; and (7) the medical surveillance program requirements. The employer may design and implement his own training program that contains these elements, or rely on third-party training programs, such as EPA-sponsored courses on asbestos abatement.

OSHA strongly believes that informing and training employees can reduce the incidence of work-related diseases caused by exposure to hazardous workplace conditions. A large number of commenters supported the inclusion of information and training provisions in the final rule (Trs. 7/10, 6/29, 6/26, 6/20, 6/28) and many employers and/or states reported having established programs in place (Trs. 6/20, 6/29, 6/27). The BCTD, however, proposed a more elaborate employee certification program modeled after the program specified in Maryland and California laws governing occupational exposure to asbestos. The BCTD felt that general training requirements would be too difficult to enforce (Ex. 330). The BCTD recommended that employees be given precertification examinations in proper respirator use and general competency with regard to job-specific work procedures and practices for working with asbestos-containing materials, and that only employees certified by their employer would be allowed to perform most asbestos tasks (Ex. 330).

After careful consideration of the evidence in the record, OSHA has determined that the training requirements in the final rule will provide construction employees with an understanding of the hazards of asbestos and the necessary protective measures to permit them to participate actively in their employer's training and hazard control programs.

Paragraph (1)—Housekeeping

In the revised standard for the construction industry, OSHA has included a housekeeping provision stipulating that (1) when vacuuming is used for asbestos cleanup, only HEPA-filtered equipment may be used, and (2) all asbestos waste, scrap, debris, bags, containers, equipment, and contaminated clothing must be collected and disposed of in sealed impermeable bags or in other closed impermeable containers. The Agency believes that these housekeeping practices reflect advances in vacuum filter technology and good hygiene practices, and are essential parts of any effective asbestos control program. OSHA believes that the use of HEPA-filtered vacuums and proper disposal practices will considerably diminish the risk of generating airborne asbestos during cleanup—a potentially high-exposure activity.

The required use of high-efficiency particulate air filters on vacuums employed for cleanup (paragraph (1)(i)) is not intended to preclude the use of other complementary cleanup methods, such as wet methods. However, this provision does preclude the use of conventional vacuums, which would simply redistribute the asbestos fibers. R. F. Boggs, Vice President of Organization Resources Counselors, stressed the importance of using HEPA-equipped vacuums for cleanup operations on construction sites: "In order to achieve good housekeeping, industrial asbestos vacuum cleaners are a necessity" (Ex. 123-A).

The waste disposal provision in paragraph (1)(2) is a restatement of a similar requirement in the asbestos standard adopted by OSHA in 1972. The objective of the requirement in the earlier standard was to impose bagging restrictions only in situations likely to produce airborne concentrations of asbestos in excess of the ceiling limit or the PEL. By requiring these precautions in the revised standard for the on-site transportation of all asbestos wastes for disposal, OSHA is seeking to prevent both the direct exposure of cleanup personnel and the incidental exposure of workers not directly involved in asbestos removal, installation, or renovation.

Support for a rigorous housekeeping program is amply provided in the record (e.g., Asbestos Information Association, Exs. 84-307 and 328; Associated General Contractors of America, Ex. 84-457; Organization Resources Counselors, Ex. 123-A; and the Building and Construction Trades Department, Ex. 330). Dr. Boggs also described the process used for disposing of asbestos-containing waste on construction sites:

> As [asbestos] insulation is removed, it is immediately bagged in poly bags, on which are preprinted warning labels. The bags are removed from the structure to the designated storage area and are not allowed to remain in various parts of the work area. . . . Housekeeping is of the utmost importance. (Ex. 123-A)

OSHA's requirements for waste disposal are designed to protect employees from exposure to asbestos fibers that may be released if asbestos-containing wastes are temporarily stored or transported on the construction worksite. The requirements contained in paragraph (1)(2) do not address the ultimate disposal of asbestos wastes, since these wastes and their disposal are regulated by EPA.

The existing asbestos standard and the revised standard for general industry contain a general provision requiring that surfaces be maintained free of accumulations of asbestos fibers. OSHA has not included a similar provision in the revised standard for the construction industry because the nature of much construction work, particularly asbestos removal, renovation, and demolition, makes it impossible to keep surfaces free of asbestos fibers at all times. OSHA does, however, expect employers in the construction industry to clean up accumulations of asbestos quickly to avoid generation of airborne concentrations of asbestos fibers that might exceed the PEL. OSHA believes that the provisions of paragraph (1) reflect the special circumstances found in the construction industry sector while providing protection for construction employees that are involved in cleanup operations.

Paragraph (m)—Medical Surveillance

Where appropriate, medical surveillance programs are required by Section 6(b)(7) of the OSH Act, to be included in OSHA health standard to aid in determining whether the health of workers is adversely affected by exposure to toxic substances. The requirements contained in this revised asbestos standard are designed to detect changes in the pulmonary and gastrointestinal systems resulting from occupational exposure to asbestos. Several changes have been made in the revised rule relative to OSHA's existing asbestos standard (29 CFR 1910.1001 (i)). These changes include requiring employers to implement the medical surveillance program only for employees wearing negative-pressure respirators and for employees exposed to levels of asbestos at or above the action level for 30 or more days per year. The existing standard required medical surveillance for all employees engaged in occupations in which they were exposed to airborne concentrations of asbestos fibers, regardless of the duration or level of their exposure. In addition, OSHA has added provisions to the revised standard addressing the administration of a respiratory disease questionnaire during the medical examination, requiring employers to provide information to the examining physician, and granting physicians greater latitude in determining the frequency of chest X rays and the necessity of providing other tests. OSHA has also deleted the existing standard's requirement for a medical examination at the time of an employee's termination of employment. In other respects, the medical surveillance requirements parallel the existing standard's provisions.

In the April notice (49 FR14116–14145). OSHA solicited comments on whether the existing medical surveillance provisions for asbestos-exposed employees should be modified in any new rulemaking undertaken to revise OSHA's existing asbestos standard. Specifically, comments were invited regarding the appropriations of triggering the medical surveillance requirements of a revised standard at 0.2 f/cc; decreasing the frequency of chest X rays for young employees or for those with short durations of exposure; clarifying the time permitted for employers to conduct the pre-placement examination after initial hiring; and the necessity of specifying additional tests or procedures for the early diagnosis of any asbestos-related disease, including the administration of a respiratory disease questionnaire. Comments were also requested on the need for additional specifications regarding the performance of pulmonary function testing, including completion of a NIOSH-approved course in spirometry for nonphysicians who administer these tests, calculation of the percentage difference from predicted values and use of standard predicted values; the appropriateness of requiring screening for colo-rectal cancer, including tests for occult blood in the feces; and further specifications for the interpretation and reading of chest X rays.

The April notice also specifically described several concerns of the construction industry regarding the inclusion of a traditional OSHA health standards approach to medical protection for construction workers (49 FR 14131). Among the concerns expressed by CACOSH were the "major economic and logistical problem" presented by medical surveillance programs in this section because of high employee turnover, and the use of medical examination to "exclude all but the most hardy human specimens [from employment]" (49 FR 14131). Member of CACOSH also stressed the importance of an integrated program of environmental controls and medical surveillance, rather than an "Overdependence on medical control systems [alone]" (49 FR 14131). Although information and responses relevant to these and other issues were solicited from interested parties representing all industry sectors, the Agency emphasized the need for information on any necessary changes to the medical surveillance requirements as they might affect the construction industry. The modifications considered in the development of the revised rule were suggested by the Advisory Committee for Construction Safety and Health (CACOSH), the Building and Construction Trades Department of the AFL-CIO (BCTD), the Asbestos Information Association (AIA), and by other affected organizations specifically concerned with the applicability of medical surveillance provisions to the construction industry.

Paragraph (m)(l)(i) of the revised standard for construction requires that each employer institute a medical surveillance program for all such employees who are exposed at levels at or above the action level of 0.1 f/cc for 30 or more days per year. In addition, employers are required to provide medical surveillance for all employees who are required to wear a negative-pressure respirator to protect against exposure to asbestos, regardless of exposure levels or duration. The employer is required by paragraph (m)(1)(ii)(A) to ensure that all medical examinations and procedures are performed by or under the supervision of a licensed physician selected and are provided without cost to the employee and at a reasonable time and place.

In accordance with paragraph (m)(2)(i) of the revised standard, the medical surveillance program must be instituted before the employee's initial assignment for those employees required to wear negative-pressure respirators to protect against exposure to asbestos, and within 10 working days of the thirtieth day of exposure, for those employees exposed at levels at or above the action level for 30 or more days per year. As in the existing standard, no initial medical examination is required if the employer can demonstrate that an employee has had an equivalent medical examination within the past year and periodic medical examinations are required to be conducted at least annually after the initial examination. If the examining physician determines that there is a need to provide any of the examinations more frequently, the employer is required to provide such examinations to affected employees at the frequencies specified by the physician.

The medical surveillance program specified by paragraph (m)(2)(ii) in the revised standard requires: (1) a work history, (2) a medical history, (3) administration of the standardized questionnaire contained in Appendix D, Part 1 during the initial examination and updating of the abbreviated standardized questionnaire contained in Part 2 of Appendix D during periodic examinations, (4) a physical examination, including a chest roentgenogram (if deemed necessary by the physician) and pulmonary function tests, and (6) any other examinations or tests deemed necessary by the examining physician.

The content of the revised standard's required physical examination is consistent with the identification of the adverse health effects that have been associated with asbestos exposure. A complete work history including information on any past occupational exposures to toxic substances is necessary for implementing an effective medical surveillance program.

Information regarding such past exposures can alert the physician as to the employee's current health status and the possible health consequences of continued exposure to asbestos. As discussed in Section IV (Health Effects) of the Preamble. OSHA has determined that asbestos can cause lung cancer, mesothelioma, asbestosis, and an increase in esophageal, stomach, colo-rectal, kidney, laryngeal, pharyngeal, and buccal cavity cancers. It is therefore important that the physical examination be directed to a determination of the condition of the pulmonary, cardiovascular, and gastrointestinal systems. In addition, a complete assessment of pulmonary status is essential for employees required to work in asbestos-containing atmospheres; this is accomplished through a pulmonary function test that measures forced vital capacity (FVC) and forced expiratory volume at one second (REV_1), and if desired by the physician a chest X ray. These tests are designed to allow physicians to diagnose the presence and extent of pulmonary fibrosis caused by the accumulation of asbestos fibers in the lungs and additionally to determine an employee's capability to wear negative-pressure respirators.

The respiratory disease questionnaires contained in Appendix D must be administered to construction employees during their medical examinations. These questionnaires will elicit information from the employee about his or her work environment and job responsibilities; symptoms of possible respiratory illness such as coughing, chest tightness, and breathlessness; tobacco smoking habits; and occupational history, and will be used in conjunction with the results of the pulmonary function testing to detect the early stages of asbestos-induced respiratory disease. In addition, information from these questionnaires can be used to increase medical knowledge about specific work exposures, doses, and durations and their relations to the later development of asbestos-related disease, and can also be used by OSHA to revise the permissible exposure limits for asbestos, if this is determined to be necessary.

OSHA has granted greater discretion to the examining physician by allowing him or her to choose whether to administer chest X rays. The Agency believes that the physician is the best judge of whether it is necessary, and at what intervals to conduct these X rays and will make this judgment based on the employee's health and the exposure conditions prevailing in the employee's work environment.

To aid in the physician's evaluation of an employee's health in relation to that employee's assigned work duties, paragraph (m)(3) requires that the employer provide the examining physician with the following information: (1) a copy of this standard and appendix I; (2) a description of the employee's duties as they relate to the employee's asbestos exposure; (3) the employee's representative or anticipated level of exposure to asbestos; (4) information regarding the employee's use of any personal protective equipment, including respiratory equipment; and (5) information from previous work-related medical examinations that is not otherwise available to the physician.

These requirements have been included in the revised standard to ensure that employers provide examining physicians with adequate data to facilitate analysis of the test results and to aid in the determination of the overall health status of the employee; they are also consistent with requirements in other recent OSHA health standards. Appendix I provides general information to the examining physician on the adverse effects of asbestos exposure and on the appropriate diagnosis for specific tests for asbestos-related diseases, such as the proper interpretation of chest X rays and spirometry readings. Inclusion of such informational appendices is standard in OSHA rulemakings, e.g., ethylene oxide (49 FR 25798, June 22, 1984) and inorganic arsenic (43 FR 19628, May 5, 1978).

The revised asbestos standard mandates at paragraph (m)(4) that the employer receive a written opinion from the physician that shall include the results of the medical examination, the physician's opinion as to whether the employee has any medical conditions that would increase his or her risk of material health impairment from asbestos exposure, any recommended limitations on employees or upon the use of personal protective equipment such as respirators, and a statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions that may result from asbestos exposure. The employer shall instruct the physician not to reveal in the written opinion specific findings or diagnoses unrelated to occupational exposure to asbestos. The employer is also required to provide a copy of the physician's written opinion to the affected employee within fifteen days of its receipt. These requirements have been added to the revised standard for construction to ensure adequate communication between the employer, the employee, and the physician, and are consistent with requirements in other OSHA health standards e.g., ethylene oxide (49 FR 25798; June 22, 1984), inorganic arsenic (43 FR 19628; May 5, 1978), and lead (43 FR 53011; Nov. 14, 1978). OSHA's analysis of the record evidence on these medical surveillance requirements is discussed below.

Section 6(b)(7) of the OSH Act mandates that

> . . . where appropriate, any such standard [promulgated under subsection (6)(b)] shall prescribe the type and frequency of medical examinations or other tests which shall be made available, by the employer or at his cost, to employees exposed to such hazards in order to most effectively determine whether the health of such employees is adversely affected by such exposure.

OSHA accordingly includes medical surveillance requirements in all of its health standards. In addition, the Agency considers these programs to be an appropriate means of monitoring the adequacy of the standard's permissible exposure limit.

Most commenters favored the inclusion of medical surveillance provisions in the revised rule for asbestos in the construction industry (Exs. 84-424, 84-457, 123-A, 277, 330, Trs. 6/20, 6/26, 6/27, 7/3, and 7/12). A few commenters, however, questioned the feasibility of requiring medical monitoring for the construction industry because of the high turnover rate and transient nature of the construction work force and because it is expensive (Exs. 84-233, Trs. 6/21, 7/6, and 7/10). For example, the Asbestos Information Association of North America (AIA/NA) stated that

> [The medical surveillance program] . . . is not a practical requirement to be implemented [in construction] . . . [and] . . . is very difficult to enforce because of the highly transitory nature of the employers as well as the employees . . .

The AIA/NA continued, ". . . medical surveillance [is also] time consuming, burdensome, [and] expensive" (Tr. 7/6). In a similar vein, Sherrel Mercer of the Mercer Construction Company maintained that ". . . medical surveillance requirements would serve no purpose and would impose great cost. It would be extremely difficult to arrange examinations at remote worksites" (Tr. 7/20X).

OSHA recognizes that the high turnover among construction employees and the non-fixed nature of construction workplaces complicates implementation of a medical surveillance program difficult in this sector, and the Agency has consequently retained some provisions and made changes to other requirements of the existing standard to accommodate this industry's characteristics. For example, the revised rule has maintained the provision from the existing standard permitting employers to use documentation showing that their employees have had a medical examination within the last 12 months that is equivalent to the one specified in the standard. This provision is particularly adapted to conditions in the construction industry, where, as CACOSH (Ex. 84-233) pointed out, employees may work for as many as 10 employers in a single year.

OSHA is also aware that there are numerous organizations that provide onsite chest x ray and spirometry testing through the use of mobile van units, and the Agency has, in past rulemakings, required that medical testing be performed even if these examinations must take place outside of a clinic or doctor's office. For example, the final rule for Occupational Noise Exposure (46 FR 4078; January 16, 1981) requires that audiometric testing be conducted and it is not uncommon for commercial specialists who evaluate employees' hearing to transport an audiometric test booth in a mobile van directly to the organization that has contracted for the testing.

A respondent from Oregon's occupational safety and health regulatory agency, the Workers Compensation Department, Accident Prevention Division (APD), submitted an Oregon program directive issued to construction firms that requires medical examinations whenever employees are "engaged in the removal or demolition of pipes, structures, or equipment covered with asbestos insulation or building materials. . . ." According to Kathryn T. Ellis, Supervisor of the Technical Section of APD, inspection of all asbestos demolition projects has indicated that "the demolition firms are complying with the current Oregon asbestos standard" (Ex. 92-013).

North Carolina also has a successful state program for asbestos removal operations; this program issued guidelines entitled *Specifications for Asbestos Removal* in 1981 (Ex. 90-254). These specifications require contractors to provide medical examinations for all employees. According to John C. Brooks, Commissioner of Labor of North Carolina, ". . . contractors [are] generally cooperative and [follow] established guidelines. Only 15 of 106 [asbestos] removal sites had received a notice of violation as of April 27, 1984."

In addition to questioning the feasibility of requiring a medical surveillance program for a construction standard for asbestos, the following issues were raised by comments regarding medical surveillance programs:

(1) The level at which the medical surveillance requirements should be triggered;

(2) Which employees should be covered by these provisions;

(3) How frequently chest roentgenograms and/or medical examinations should be administered, and the content of these examinations;

(4) The need for mandatory vs recommendatory medical tests;

(5) The necessity of administering a respiratory disease questionnaire;

(6) Whether non-physicians who administer pulmonary function testing should be required to complete a NIOSH-approved course in spirometry.

One issue raised in the November notice was at what level the medical surveillance program should be triggered. A few respondents supported triggering the medical surveillance provisions at 0.2 f/cc (Exs. 90-160, 90-166, and 90-173). Atlantic Richfield, commenting on the standard as it applies to both construction and general industry, noted that ". . . with the proposed standards of 0.2 or 0.5 f/cc, the action level of 0.2 f/cc is reasonable for [triggering] medical surveillance. . . ." (Ex. 90-160).

Some commenters, however, advocated a 0.1 f/cc trigger for medical surveillance (Exs. 90-49, 90-185, 92-015, and Tr. 6/26). For example, the Department of the Army suggested that "[f]or a PEL of 0.2 fiber/cc it is recommended that an action level of 0.1 fiber/cc be established for medical surveillance. . . ." (Ex. 90-49). Similarly, Dr. Kenneth Miller, a physician with the Oil, Chemical and Atomic Workers Union (OCAWU) indicated that . . . "[OCAWU] fully support[s] the AFL-CIO in their position that the . . . action level of . . . medical surveillance be set at one half the PEL" (Tr. 6/26). Setting the trigger for medical surveillance at 0.1 f/cc is consistent with the OSHA Program Directive issued on October 11, 1978, which instructed OSHA compliance officers to "provide uniform inspection and compliance procedures for the medical examination requirement in the asbestos standard". . . . specified that "[m]edical examinations . . . [are] required for any 7- to 8-hour time weighted average concentration of 0.1 f/cc or for a greater concentration."

The scope of the medical surveillance requirements was also an issue of concern to commenters. Several respondents agreed with certain elements of the provision regarding employee coverage (Exs. 84-457, 123.A, 263, 277). The Associated General Contractors of America (AGC), in a statement endorsed by the National Constructors Association (NCA) and the National Erectors Association (NEA), indicated that "the standard should require construction employers to provide an employee with a medical examination whenever that employee, *though fully protected,* has encountered airborne asbestos, at any level, for 30 days or more . . ." (Ex. 84-457). The Organization Resources Counselors, Inc. (ORC) recommended that employers institute a medical surveillance program for all employees exposed to asbestos in excess "of the action level" for more than a total of 30 days per year (Ex. 123.A). The Building and Construction Trades Department, AFL-CIO (BCTD) advocated a separate respirator examination for all persons required to wear negative-pressure or pressure demand respirators and recommended that all employees exposed to asbestos be provided an initial medical examination, except those workers who had received medical examinations within the past one year period. It also advocated the medical screening of almost all workers involved in the building trades for 10 years or more, under the assumption that all construction workers, including those not working directly with asbestos containing materials, have incurred some exposure to asbestos in the course of a decade of work in construction (Exs. 277, 330). The International Brotherhood of Boiler Makers supported BCTD's recommended medical examination protocol "as to both the detection of asbestos-related disease and the determination of an employee's fitness to wear and use a respirator" (Tr. 7/3).

Respondents disagreed about how frequently medical tests and chest X rays should be required. All of those who commented on pre-placement exams agreed with OSHA that employees engaged in asbestos work should receive a pre-placement medical examination (Exs. 84-424, 84-457, 123.A, 312.A, Trs. 6/21, 6/26, and 6/29). ORC indicated that "a pre-placement medical evaluation should be designed to determine the suitability of the individual for the job and vice-versa . . . it is important to establish baseline data for longitudinal prospective follow-up" (Ex. 123.A). The American Association of Occupational Health Nurses (AAOHN) concurred with ORC: "[d]elaying gathering of this essential baseline information could be detrimental to both the employee and the employer, because knowledge of a pre-existing condition could influence initial job placement" (Tr. 6/26).

However, opinions differed on the frequency of both medical examinations and chest X rays given after the initial exam. AGC stated that "[c]ontractors should not . . . have to provide more than one medical examination to an employee in any one calendar year" (Ex. 84-457). The BCTD suggested that triennial medical exams be given to workers under forty years of age or with less than 20,000 hours of work experience in the building trades and annual exams thereafter, except for chest X rays, which they recommended should be performed every three years without regard to duration of workplace exposure. However, the BCTD suggested that an examination to determine an employee's fitness to wear and use a respirator be given annually. The International Brotherhood of Boilermakers (IBB) generally concurred with BCTD's recommended medical examination protocol and recommended that "for those post-40 or with 20,000 hours or more of employment, the medical examination should be provided annually. . . ." (Tr. 7/3). However, the IBB felt that a chest X-ray should be included in this annual examination. The Asbestos Victims of America (AVA) also agreed with the BCTD that employees at least 40 years of age should be provided with medical examinations on an annual basis (Tr. 6/26). Scott Schneider, of the Carpenters Union, recommended one exam every three years after the initial exam, for those employees just beginning to work with asbestos (Ex. 84-424); William Ewing Jr., of the Georgia Institute of Technology, also suggested that medical tests be given every three years to reduce the frequency of X rays (Tr. 6/25); and Dr. Hans Weill, of Tulane University, questioning the usefulness of annual examinations, agreed that this frequency was appropriate (Tr. 6/19).

The National Institute for Occupational Safety and Health (NIOSH) recommended that a comprehensive medical examination be given every five years for the first fifteen years of occupational exposure to asbestos and "thereafter every two years using the standardized guidelines for instrumentation training and interpretation of the recognized expert authorities" (Tr. 6/21). The American Iron and Steel Institute (AISI) recommended a reduction in the frequency of chest X rays (Ex. 263). OSHA agrees that annual X rays may not always be necessary and believes that the interval between X rays is best determined by the physician, who can base his or her decision on the general health status of the employee and specific workplace conditions. In the final rule, OSHA has retained the requirement for a preplacement examination and at least an annual exam thereafter, but grants to the physician the right to determine what interval is appropriate.

Respondents disagreed on the content of medical examinations to determine respirator fitness (Exs. 90-254, Trs. 6/29, 7/3, 7/12). For example, the National Constructors Association (NCA) stated that, ". . . a pulmonary function test . . . must be performed because the employee could be at risk in using respirators" (Tr. 7/12). David Kirby, an Industrial Hygiene Chemist with the University of Alabama, felt that medical surveillance should be used to determine if the employee is capable of wearing a respirator and is physically able to do the work, but that chest X rays and pulmonary function tests are inappropriate for the asbestos abatement industry (Tr 6/20). OSHA has determined that pulmonary function tests serve a dual purpose in this Final Rule. In addition to establishing respirator fitness, spirometric measurements can detect lung fibrosis due to asbestosis. Therefore, pulmonary function tests are required in this standard.

The issue of whether to include mandatory or recommendatory medical tests in the revised standard was controversial. Some commenters argued that certain tests should be required (Exs. 277, 330, Trs. 6/26, and 7/3), while others maintained that the tests should be chosen by the examining physician rather than by OSHA (Exs. 312.A, Trs. 6/21, 7/12, 7/10). The following commenters suggested specific tests: BCTD stated that OSHA should require ". . . a rectal exam and stool guaic test for occult blood [for asbestos-exposed workers] after the age of 40" (Exs. 277, 330); the Oil, Chemical and Atomic Workers Union (OCAWU) recommended a stool test to screen for gastrointestinal malignancies and sputum cytology tests to screen for lung cancer (Tr. 6/26); and the International Brotherhood of Boilermakers advocated annual tests for digestive tract cancer for employees over the age of 40 or with 20,000 hours or more of employment (Tr. 7/3).

However, many respondents supported permitting greater discretion on the part of the physician in determining what tests to conduct. For example, NIOSH recommended that "[the use of] routine periodic stool, sputum cytology and lavage tests . . . should be left to the discretion of the examining physician" (Tr. 6/21), and Dr. Hilton C. Lewinsohn, Assistant Corporate Medical Director of Union Carbide, stated that, as a physician, he doesn't want to be ". . . confined to doing certain things in a medical examination or a physical examination" (Tr. 7/12).

In the final rule, OSHA has struck a balance between mandatory and non-mandatory medical surveillance requirements: the requirements for medical and work history, physical examination, and pulmonary function tests are mandatory, while the selection of other specific tests to be conducted has been left to the discretion of the examining physician. Choosing this cut-off point on the continuum between performance standards on the one hand and specification standards on the other reflects, in OSHA's view, the record evidence in the case of asbestos. In addition, mandating certain basic elements of the medical surveillance program and stating others in non-mandatory terms follows the precedent established in OSHA's final rule for ethylene oxide (29 CFR 1910.1047).

Some commenters supported the administration of a questionnaire during the medical examination (Exs. 84-424, 90-138 and 90-162). Monsanto felt that a respiratory disease questionnaire should be issued in conjunction with the pulmonary function tests (Ex. 90-138). James Packenham, of OSHA's Advisory Committee for Construction Safety and Health, suggested that ". . . because of the nature of construction . . . there has to be a rather thorough questionnaire in the appendices . . . which will facilitate the examining physician's understanding of the employees' past medical and work history" (Ex. 84-424). OSHA agrees with these commenters and has included requirements for the employee to complete a questionnaire contained in Appendix D during each of his or her initial and annual examination.

Comments were received regarding the type of medical practitioner who should implement sections of the medical surveillance program (Exs. 90-253, 289, 290, 312.A, and Tr. 6/26). The American Occupational Medical Association (AOMA) maintained that . . . "only occupational physicians [have] the background and training necessary to pull together the various aspects of an occupational health program . . ." (Ex. 289). The American Association of Occupational Health Nurses (AAOHN) suggested that occupational nurses be involved in the medical surveillance program, although not necessarily in performing the actual physical examination (Ex. 290 and Tr. 6/26). While OSHA recognizes the value of the occupational health nurse in assisting the physician, the Agency has determined that a licensed physician is the appropriate person to be supervising and evaluating a medical examination. However, certain parts of the required examination do not necessarily require the physician's expertise and may be conducted by another person under the supervision of the physician. This policy is consistent with previous OSHA rulemakings, e.g., ethylene oxide (49 FR 25798; June 22, 1984), and inorganic arsenic (43 FR 19627; May 5, 1978).

In the April notice, OSHA solicited comments on "[a]dditional specifications concerning the performance of pulmonary function testing, including the completion of a NIOSH-approved course in spirometry by non-physicians who administer the tests. . . ." (49 FR 14126). A few respondents recommended that the Agency require this course for persons other than licensed physicians (Exs. 90-130, 90-166, 290, Tr. 6/26). AAOHN recommended that the standard require NIOSH certification and recertification of individuals performing pulmonary function tests (Ex. 290, Tr. 6/26). The Chemical Manufacturer's Association (CMA), commenting on ". . . generic occupational health issues posed by the proposed standard . . . ," supported the requirement that techicians performing pulmonary function tests be certified through the completion of a NIOSH-approved course or its equivalent (Ex. 90-166). The Aluminum Company of America (ALCOA) also supported requiring non-physicians to complete a NIOSH-approved or equivalent course (Ex. 90-130). In response to these comments, the revised standard requires that individuals other than licensed physicians who administer pulmonary function tests complete a training course in spirometry sponsored by an appropriate academic or professional institution.

Paragraph (n)—Recordkeeping

Section 8(c)(3) of the OSH Act provides for the promulgation of regulations requiring employers to maintain accurate records of employee exposures to potentially toxic or harmful physical agents that are required to be monitored or measured. The Act also provides for regulations that permit employee access to such records, and that require employees to be notified if they are exposed to toxic substances in excess of permissible exposure limits.

Paragraphs (i) and (j)(6) of the existing rule for asbestos stated that employers must maintain records of personal and environmental monitoring and of medical examinations for 20 years. It also required that employees or their designated representatives, the Assistant Secretary, and the Director of NIOSH be permitted to have access to these environmental and health records.

Following promulgation of the existing asbestos standard in 1972, OSHA issued a standard for Access to Employee Exposure and Medical Records (the "Records Access Standard") (29 CFR 1910.20), which requires that exposure and medical records generated by employers be kept for 30 years; this rule requires employers to:

> Preserve and maintain exposure and medical records pertinent to an employee's occupational exposure to toxic substances or harmful physical agents. (29 CFR 1910.20(d).)

In general, these records must be maintained for 30 years. The Records Access standard also provides for access to these records by employees and their designated representatives and the Assistant Secretary, in order to improve, both directly and indirectly, "detection, treatment, and prevention of occupational disease" (29 CFR 1910.20(a)). In addition, the standard requires that employees be notified annually by their employers of their rights under the rule and of the requisite procedures for exercising those rights (29 CFR 1910.20(q)). The requirement to keep records and provide access to them applies "to each general industry, maritime, and construction employer who makes, maintains, contracts for, or has access to employee exposure or medical records, or analyses thereof, pertaining to employee exposed to toxic substances or harmful physical agents" (29 CFR 1910.20(b)). In 1980, OSHA revised the recordkeeping paragraphs of the existing asbestos standard to conform with the requirements of the Records Access rule.

The final construction standard for asbestos published today retains the basic requirement that employers keep an accurate record of all measurements taken to monitor employee exposure to asbestos. At a minimum, the record must include the following information:

(1) The date of measurement;

(2) The operation involving exposure to asbestos that is being monitored;

(3) The sampling and analytical methods used and evidence of their accuracy;

(4) The number, duration, and results of samples taken;

(5) The type of protective devices worn, if any; and

(6) The name, social security number, and exposure of the employee whose exposure is represented.

The final rule also requires that the employer establish and maintain accurate medical records for each employee covered under the medical surveillance requirements. These records must include the following information:

(1) The name and social security number of the employee;

(2) A copy of the employee's medical examination result, including the medical history, questionnaire responses, results of any tests, and the physician's recommendation;

(3) The physician's written opinions;

(4) Any employee medical complaints related to exposure to asbestos; and

(5) A copy of the information provided to the physician.

These exposure and medical records are required to be maintained for at least the duration of employment plus 30 years, in accordance with 29 CFR 1910.20 (m)(1)(iii) and (m)(2)(iii).

The maintenance of records for 30 years rather than 20 years as required by the existing asbestos rule is important in developing a body of data to improve the understanding of the causes of asbestos-related occupational disease, which is associated with long latency periods. In addition, paragraph (n)(4) of the final rule requires employers to keep employee training records for one (1) year beyond the last date of employment by that employer.

Paragraphs (n)(5) (i), (ii), and (iii) of the final rule are similar to requirements of the existing asbestos standard and require that the employer, upon written request, make exposure and medical records available to the Assistant Secretary, the Director, the employee, and his or her designated representative. Such access is necessary for the agency to monitor compliance with the rule and to carry out its statutory responsibilities. Access is also important for employees so that they have information relevant to their exposure to toxic substances and are aware of health consequences.

OHSA's final rule also requires that employers who go out of business without a successor employer to receive and retain their records for the prescribed period of 30 years notify the Director at least 90 days prior to disposal and then transfer the records to the Director (paragraph (n)(6)(ii)). This provision is in accord with 29 CFR 1910.20, and is an important method of ensuring the continuity and accuracy of long-term record maintenance.

There was broad general support in the record for a recordkeeping requirement in the asbestos standard for construction (Exs. 84–307, 330, 123–A, 312.A, Trs. 6/20, 6/28, 7/3, 6/26). For example, Robert Cooney, reading the statement of Robert Georgine for the Building and Construction Trades Department, AFL–CIO, stated:

> Unless appropriate methods of compliance, measurement, monitoring, reporting and documentation, and employee medical provisions are contained in the standard, the statutory mandate will not be fulfilled, and construction workers will not be adequately protected. (Tr. 6/27, p. VII–72)

However, comments varied regarding the detail of the records the length of time they should be maintained, and their accessibility. Two commenters argued against the feasibility of generating and maintaining detailed records for 30 years in the construction industry.

In a post-hearing submission (Ex. 308), David Potts, Director of Safety and Health for the National Constructors Association (NCA), argued that recordkeeping was impractical in the construction industry. In support of this position, Mr. Potts re-submitted the testimony NCA had submitted previously in response to OSHA's proposal to modify the Records Access rule. In this testimony (Ex. 308, Attachment E), NCA cited the Lead decision (*United Steelworkers of America, AFL–CIO–CLC* vs. *Donovan*) as precedent for excluding the construction industry from the monitoring activities that would lead to the generation of exposure records. In this earlier submission, NCA claimed that OSHA's requirements for records access were not reasonable for the construction industry because the industry was "unique" and "cannot be treated like general industry for the purposes of OSHA regulation" (Ex. 308, Attachment E, p. 4).

Elihu Leifer and Mary Vogel, attorneys for the BCTD, disagreed with NCA and stated that NCA had "misread" the Lead decision. The BCTD's post hearing brief stated that

> . . . OSHA essentially . . . found [in the *Lead* decision] that to apply the Lead standard to the construction industry would be infeasible because it would be impractical to conduct *environmental* monitoring. (Ex. 330, p. 132)

BCTD further maintained that OSHA's support of the exemption of the construction industry from the lead standard extended only to "lead exposures in the construction industry and not, as NCA would lead one to believe, as regards to all toxic substances." and that "OSHA's decision to exempt the construction industry from the lead standard cannot appropriately be compared with an exemption [of this industry] from the requirements in the asbestos standard" (Ex. 330, p. 132–133). OSHA agrees with the BCTD that the Lead decision provides no basis for exempting the construction industry from recordkeeping requirements for asbestos. Unlike the case for lead, conducting air monitoring and medical surveillance for construction workers exposed to asbestos is feasible and is routinely done by most construction employers today.

R.F. Boggs, Ph.D., Vice President of Organization Resources Counselors, also opposed the requirement that the construction industry be required to create and maintain detailed exposure and medical records for 30 years. He included a statement by Carl D. Richardson of Brown and Root, Inc., who said that "[the records] have no effective purpose in an industry where employment is temporary and the work location is highly variable" (Ex. 123–A, Appendix B, p. 7).

However, in support of the feasibility of recordkeeping in the construction industry, Dr. Morton Corn of the Johns Hopkins School of Hygiene and Public Health, pointed out that the IBM Corporation had as early as 1979 set up a detailed recordkeeping system for the exposure records of monitoring performed during the renovation of buildings and the removal of friable, sprayed-on asbestos (Tr. 7/3). IBM kept records of all airborne asbestos concentrations outside the barrier area as well as within and they kept records of the procedures used (Tr. 7/3, p. 17). Joe Adam of the BCTD argued that monitoring (and recordkeeping) is not only feasible but necessary because it can be used to form an acceptable data base and to assure that decisions reached on controlling asbestos in the work environment are effective (Tr. 6/28, p. 252). David Kirby, Industrial Hygiene Chemist for the Alabama Safe State Program, also supported inclusion of a requirement for the creation and maintenance of detailed records. He noted that with computers, microfiche, and other modern data storage systems, detailed recordkeeping requirements were both feasible and valid (Tr. 6/20, pp. 186–187).

The BCTD and Mr. Kirby point out that the 30-year retention period is important because of the long latency periods associated with asbestos disease (Ex. 330, pp, 128–129; Tr. 6/20, pp. 186–187). Mr. Leifer and Ms. Vogel, attorneys for the BCTD, pointed out that employees are entitled to medical examinations to determine the effects of asbestos exposure on their health. Medical examinations are also important for the prevention, early detection, and treatment of asbestos-related disease (Ex. 330, pp. 137–138). Records of these examinations must be kept for 30 years not only for medical and research reasons but also for monitoring the effectiveness of and compliance with the standard (Ex. 330, pp. 128–129).

Since OSHA does not mandate specific methods of recordkeeping, employers are free to use the services of competent organizations such as industry trade associations and employee associations to maintain the required records. To reduce the costs and facilitate recordkeeping, the BCTD described approaches used by several groups (Ex. 330). For example, the Painters Union has had a centralized medical recordkeeping system covering 3,000 workers since October 1980. It is financed through employer contributions (Tr. 6/28, pp. 32–33). Sweden has also implemented a nationwide centralized medical recordkeeping system. In addition, some contractors have already engaged in joint recordkeeping efforts for other purposes. For eample, the Texas affiliate of the ABC, a contractor's association, operates a joint recordkeeping system in the nature of a job bank for the benefit of its members (Tr. 6/28, p. 126). OSHA believes that centralizing recordkeeping will alleviate the problem of lost records associated with the transient nature of the construction workforce and the frequency of business closures in this sector (Ex. 84–233, pp. 32–33).

In conclusion, OSHA finds that the record evidence fully supports the inclusion in the revised standard of requirements for recordkeeping of employee exposure and medical records. In recognition of the unique advantages for this industry of a centralized data base to accommodate the records of employees who may work for several employers in a short period of time, paragraph (n)(2)(i) contains a note specifically emphasizing that employers may contract with organizations such as trade associations and unions to provide records maintenance services.

Paragraph (o)—Dates

Effective Date. In the final standard, all requirements will become effective 30 days from publication of the final rule in the **Federal Register**, which is consistent with OSHA policy. This 30-day period will provide sufficient time for employers and other responsible individuals in the industry to obtain a copy of the standard and to become familiar with the provisions prior to the startup date.

OSHA did not receive any submittals that specifically addressed the 30-day effective date for the standard. OSHA believes that 30 days is sufficient time because this regulatory action for asbestos is related to the past asbestos standard and contains many of the same or similar provisions. In addition, OSHA has provided a separate startup date by which the various provisions must be completely implemented, as described below.

The provisions of § 1926.58 take effect on July 21, 1986. On this date, employers are to commence complying with the provisions as amended. Until that date, employers are to comply with the unamended provisions of § 1919.1001 as currently published in the Code of Federal Regulations (1985 edition). If the amended provisions are not in effect because of stays or judicial action, then the unamended provisions will remain in effect. It is the intention that there remain no gaps in coverage and that the existing provisions not terminate unless the new provisions are in effect.

Startup Date. The final standard specifies that all requirements, including those for engineering controls, shall be complied with within 180 days after the effective date.

Although few commenters addressed the startup date provision, OSHA did receive two submittals on this topic (Exs. 84–424, 277). In addressing the question concerning whether any industry sector might need more time to comply with the requirements of the standard, Joe Adam, Director of the Department of Safety and Health of the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry (UAJAPPI), indicated that whatever the normal phase-in of a standard is, i.e., 1 year, should be used (Ex. 84–424, p. 55). He stated that he did not recommend that "there be any lengthening of the time. Whatever the time is that is accepted in the regulatory process is the one that we should agree to" (Ex. 84–424, p. 55). The BCTD did not support a delayed effective date (startup date), stating that "all technology for implementation of the standard currently exists" (Ex. 277, p. 14). There concern was that "increased asbestos removal and encapsulation work has already begun . . . [and] in many cases this work is being done without any protections to aviod the requirements that they anticipate in the near future. This trend would only accelerate if delayed implementation of the regulation is allowed" (Ex. 277, p. 14).

Based on these comments and because this final standard merely revises the existing OSHA standard for asbestos (29 CFR 1910.1001), which is already being complied with, OSHA believes that employers in the construction industry should be able to achieve compliance with the requirements within 180 days after the effective date. If the time period for meeting the startup date cannot be met because of technical difficulties, any employer is entitled to petition for a temporary variance under section 6(b)(6)(A) of the Act.

The 180-day delayed startup date, however, is only for the new provisions contained in the new standard or for the increased requirements which result from the reduction of the PEL from 2 f/cc to 0.2 f/cc. Compliance with the provisions of the standard must be maintained on a continuous basis, without any gap, until compliance with the new standard is achieved.

Paragraph (p)—Appendices

The revised standard contains nine appendices which are designed to assist employers and employees to implement the provisions of the standard. Appendices A, C, D, and E, are incorporated as a part of this standard and impose additional mandatory obligations on covered employers. Appendices B, F, G, H, and I are nonmandatory and are included primarily to provide information and guidance. None of the statements in Appendices B, F, G, H, and I should be construed as imposing a mandatory requirement on construction employers that is not otherwise imposed by the standard; in addition, these appendices are not intended to detract from any obligation that the revised standard imposes.

The appendices that are included in the standard are:

Appendix A—OSHA Reference Method—Mandatory.
Appendix B—Monitoring Method—Non-mandatory.
Appendix C—Methods for Respirator Fit Testing.
Appendix D—Mandatory Medical Questionnaire.
Appendix E—Information for X-Ray Interpretations.
Appendix F—Methods for Reducing Asbestos Exposures During Large-Scale Asbestos Removal or Renovation.
Appendix G—Methods for Reducing Asbestos Exposures During Small-Scale Asbestos Renovation Projects.
Appendix H—Substance Technical Information for Asbestos.
Appendix I—Medical Surveillance Guidelines for Asbestos.

Recordkeeping Requirements

The recordkeeping requirements in these revised standards are being considered by the Office of Management and Budget under the Paperwork Reduction Act of 1980, Pub. L. 96–511, 44 U.S.C. 3501 *et seq.* These requirements will not take effect until approved by the Office of Management and Budget.

List of Subjects

29 CFR Part 1910

Asbestos, Cancer, Health, Labeling, Occupational safety and health, Protective equipment, Respiratory protection, Signs and symbols.

29 CFR Part 1926

Asbestos, Cancer, Construction industry, Hazardous materials, Health, Labeling, Occupational safety and health. Protective equipment, Respiratory protection, Signs and symbols.

XII. Authority and Signature

This document was prepared under the direction of John A. Pendergrass, Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, 200 Constitution Ave, NW., Washington, DC 20210. Accordingly, pursuant to sections 4, 6(b), 8(c) and 8(g) of the Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657), section 107 of the Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333), the Longshoremen's and Harbor Workers' Compensation Act (33 U.S.C. 941), 29 CFR Part 1911 and Secretary of Labor's Order No. 9–83 (48 FR 35736), 29 CFR Parts 1910 and 1926 are hereby amended as set forth below.

The **Federal Register** has been requested to officially file this document at 1 p.m. E.D.T. on June 17, 1986 which shall be the time of issuance of this document as provided by 29 CFR § 1911.18. The time of issuance is the earliest moment that petitions for review may be filed with United States Courts of Appeals.

Signed at Washington, DC, this 12th day of June, 1986.

John A. Pendergrass,

Assistant Secretary for Occupational Safety and Health.

XIII. Amended Standards

PART 1910—[AMENDED]

Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended as follows:

1. The authority citation for Subpart B of Part 1910 continues to read as follows:

Authority: Secs. 4, 6, and 8 of the Occupational Safety and Health Act. 29 U.S.C. 653, 655, 657; Walsh-Healey Act, 41 U.S.C. 35 et seq.; Service Contract Act of 1965, 41 U.S.C. 351 et seq.; Pub. L. 91-54, 40 U.S.C. 333; Pub. L. 85-742, 33 U.S.C. 941; National Foundation on Arts and Humanities Act, 20 U.S.C. 951 et seq.; Secretary of Labor's Orders 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736); and 29 CFR Part 1911.

2. Paragraph (a) of § 1910.19 is hereby revised to read as follows:

§ 1910.19 Special provisions for air contaminants.

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

* * * * *

Subpart Z—[Amended]

3. The authority citation for Subpart Z of Part 1910 is revised as follows:

Authority: Secs. 6 and 8, Occupational Safety and Health Act, 29 U.S.C. 655, 657; Secretary of Labor's Orders Nos. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable; and 29 CFR Part 1911.

Section 1910.1000 Tables Z-1, Z-2, Z-3 also issued under 5 U.S.C. 553.

Section 1910.1000 not issued under 29 CFR Part 1911, except for "Arsenic" and "Cotton Dust" listings in Table Z-1.

Section 1910.1002 not issued under 29 U.S.C. 655 or 29 CFR Part 1911; also issued under 5 U.S.C. 553.

Sections 1910.1003 through 1910.1018 also issued under 29 U.S.C. 653.

Section 1910.1025 also issued under 29 U.S.C. 653 and 5 U.S.C. 556.

Section 1910.1043 also issued under 5 U.S.C. 551 et seq.

Sections 1910.1045 and 1970.1047 also issued under 29 U.S.C. 653.

Sections 1910.1499 and 1910.1500 also issued under 5 U.S.C. 553.

4. Section 1910.1001 is hereby revised to read as follows:

§ 1910.1001 Asbestos, tremolite, anthophyllite, and actinolite.

(a) *Scope and application.* (1) This section applies to all occupational exposures to asbestos, tremolite, anthophyllite, and actinolite, in all industries covered by the Occupational Safety and Health Act, except as provided in paragraph (a)(2) of this section.

(2) This section does not apply to construction work as defined in 29 CFR 1910.12(b). [Exposure to asbestos, tremolite, anthophyllite, and actinolite in construction work is covered by 29 CFR 1926.58.]

(b) *Definitions.* "Action level" means an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals, of 0.1 fiber per cubic centimeter (f/cc) of air calculated as an eight (8)—hour time-weighted average.

"Asbestos" includes chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these minerals that have been chemically treated and/or altered.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Authorized person" means any person authorized by the employer and required by work duties to be present in regulated areas.

"Director" means the Director of the National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

"Employee exposure" means that exposure to airborne asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals that would occur if the employee were not using respiratory protective equipment.

"Fiber" means a particulate form of asbestos, tremolite, anthophyllite, or actinolite, 5 micrometers or longer, with a length-to-diameter ratio of at lease 3 to 1.

"High-efficiency particulate air (HEPA) filter" means a filter capable of trapping and retaining at least 99.97 percent of 0.3 micrometer diameter mono-disperse particles.

"Regulated area" means an area established by the employer to demarcate areas where airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals exceed, or can reasonably be expected to exceed, the permissible exposure limit.

"Tremolite, anthophyllite, or actinolite" means the non-asbestos form of these minerals, and any of these minerals that have been chemically treated and/or altered.

(c) *Permissible exposure limit (PEL).* The employer shall ensure that no employee is exposed to an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of 0.2 fiber per cubic centimeter of air as an eight (8)-hour time-weighted average (TWA) as determined by the method prescribed in Appendix A of this section, or by an equivalent method.

(d) *Exposure monitoring.*—(1) *General.* (i) Determinations of employee exposure shall be made from breathing zone air samples that are representative of the 8-hour TWA of each employee.

(ii) Representative 8-hour TWA employee exposures shall be determined on the basis of one or more samples representing full-shift exposures for each shift for each employee in each job classification in each work area.

(2) *Initial monitoring.* (i) Each employer who has a workplace or work operation covered by this standard, except as provided for in paragraphs (d)(2)(ii) and (d)(2)(iii) of this section, shall perform initial monitoring of employees who are, or may reasonably be expected to be exposed to airborne concentrations at or above the action level.

(ii) Where the employer has monitored after December 20, 1985, and the monitoring satisfies all other requirements of this section, the employer may rely on such earlier monitoring results to satisfy the requirements of paragraph (d)(2)(i) of this section.

(iii) Where the employer has relied upon objective data that demonstrates that asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals is not capable of being released in airborne concentrations at or above the action level under the expected conditions of processing, use, or handling, then no initial monitoring is required.

(3) *Monitoring frequency (periodic monitoring) and patterns.* After the initial determinations required by

paragraph (d)(2)(i) of this section, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of the employees. In no case shall sampling be at intervals greater than six months for employees whose exposures may reasonably be foreseen to exceed the action level.

(4) *Changes in monitoring frequency.* If either the initial or the periodic monitoring required by paragraphs (d)(2) and (d)(3) of this section statistically indicates that employee exposures are below the action level, the employer may discontinue the monitoring for those employees whose exposures are represented by such monitoring.

(5) *Additional monitoring.* Notwithstanding the provisions of paragraphs (d)(2)(ii) and (d)(4) of this section, the employer shall institute the exposure monitoring required under paragraphs (d)(2)(i) and (d)(3) of this section whenever there has been a change in the production, process, control equipment, personnel or work practices that may result in new or additional exposures above the action level or when the employer has any reason to suspect that a change may result in new or additional exposures above the action level.

(6) *Method of monitoring.* (i) All samples taken to satisfy the monitoring requirements of paragraph (d) shall be personal samples collected following the procedures specified in Appendix A.

(ii) All samples taken to satisfy the monitoring requirements of paragraph (d) shall be evaluated using the OSHA Reference Method (ORM) specified in Appendix A of this section, or an equivalent counting method.

(iii) If an equivalent method to the ORM is used, the employer shall ensure that the method meets the following criteria:

(A) Replicate exposure data used to establish equivalency are collected in side-by-side field and laboratory comparisons; and

(B) The comparison indicates that 90% of the samples collected in the range 0.5 to 2.0 times the permissible limit have an accuracy range of plus or minus 25 percent of the ORM results with a 95% confidence level as demonstrated by a statistically valid protocol; and

(C) The equivalent method is documented and the results of the comparison testing are maintained.

(iv) To satisfy the monitoring requirements of paragraph (d) of this section, employers must use the results of monitoring analysis performed by laboratories which have instituted quality assurance programs that include the elements as prescribed in Appendix A.

(7) *Employee notification of monitoring results.* (i) The employer shall, within 15 working days after the receipt of the results of any montoring performed under the standard, notify the affected employees of these results in writing either individually or by posting of results in an appropriate location that is accessible to affected employees.

(ii) The written notification required by paragraph (d)(7)(i) of this section shall contain the corrective action being taken by the employer to reduce employee exposure to or below the PEL, wherever monitoring results indicated that the PEL had been exceeded.

(e) *Regulated Areas.*—(1) *Establishment.* The employer shall establish regulated areas wherever airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals are in excess of the permissible exposure limit prescribed in paragraph (c) of this section.

(2) *Demarcation.* Regulated areas shall be demarcated from the rest of the workplace in any manner that minimizes the number of persons who will be exposed to asbestos, tremolite, anthophyllite, or actinolite.

(3) *Access.* Access to regulated areas shall be limited to authorized persons or to persons authorized by the Act or regulations issued pursuant thereto.

(4) *Provision of respirators.* Each person entering a regulated area shall be supplied with and required to use a respirator, selected in accordance with paragraph (g)(2) of this section.

(5) *Prohibited activities.* The employer shall ensure that employees do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in the regulated areas.

(f) *Methods of compliance.*—(1) *Engineering controls and work practices.* (i) The employer shall institute engineering controls and work practices to reduce and maintain employee exposure to or below the exposure limit prescribed in paragraph (c) of this section, except to the extent that such controls are not feasible.

(ii) Wherever the feasible engineering controls and work practices that can be instituted are not sufficient to reduce employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section, the employer shall use them to reduce employee exposure to the lowest levels achievable by these controls and shall supplement them by the use of respiratory protection that complies with the requirements of paragraph (g) of this section.

(iii) For the following operations, wherever feasible engineering controls and work practices that can be instituted are not sufficient to reduce the employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section, the employer shall use them to reduce employee exposure to or below 0.5 fiber per cubic centimeter of air (as an eight-hour time-weighted average) and shall supplement them by the use of any combination of respiratory protection that complies with the requirements of paragraph (g) of this section, work practices and feasible engineering controls that will reduce employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section: Coupling cutoff in primary asbestos cement pipe manufacturing; sanding in primary and secondary asbestos cement sheet manufacturing; grinding in primary and secondary friction product manufacturing; carding and spinning in dry textile processes; and grinding and sanding in primary plastics manufacturing.

(iv) Local exhaust ventilation. Local exhaust ventilation and dust collection systems shall be designed, constructed, installed, and maintained in accordance with good practices such as those found in the American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2–1979.

(v) Particular tools. All hand-operated and power-operated tools which would produce or release fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals so as to expose employees to levels in excess of the exposure limit prescribed in paragraph (c) of this section, such as, but not limited to, saws, scorers, abrasive wheels, and drills, shall be provided with local exhaust ventilation systems which comply with paragraph (f)(1)(iv) of this section.

(vi) Wet methods. Insofar as practicable, asbestos, tremolite, anthophyllite, or actinolite shall be handled, mixed, applied, removed, cut, scored, or otherwise worked in a wet state sufficient to prevent the emission of airborne fibers so as to expose employees to levels in excess of the exposure limit prescribed in paragraph (c) of this section, unless the usefulness of the product would be diminished thereby.

(vii) Materials containing asbestos, tremolite, anthophyllite, or actinolite shall not be applied by spray methods.

(viii) Particular products and operations. No asbestos cement, mortar, coating, grout, plaster, or similar material containing asbestos, tremolite, anthophyllite, or actinolite shall be removed from bags, cartons, or other containers in which they are shipped, without being either wetted, or enclosed, or ventilated so as to prevent effectively the release of airborne fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals so as to expose employees to levels in excess of the limit prescribed in paragraph (c) of this section.

(ix) Compressed air. Compressed air shall not be used to remove asbestos, tremolite, anthophyllite, or actinolite or materials containing asbestos, tremolite, anthophyllite, or actinolite, unless the compressed air is used in conjunction with a ventilation system designed to capture the dust cloud created by the compressed air.

(2) *Compliance program.* (i) Where the PEL is exceeded, the employer shall establish and implement a written program to reduce employee exposure to or below the limit by means of engineering and work practice controls as required by paragraph (f)(1) of this section, and by the use of respiratory protection where required or permitted under this section.

(ii) Such programs shall be reviewed and updated as necessary to reflect significant changes in the status of the employer's compliance program.

(iii) Written programs shall be submitted upon request for examination and copying to the Assistant Secretary, the Director, affected employees and designated employee representatives.

(iv) The employer shall not use employee rotation as a means of compliance with the PEL.

(g) *Respiratory protection*—(1) *General.* The employer shall provide respirators, and ensure that they are used, where required by this section. Respirators shall be used in the following circumstances:

(i) During the interval necessary to install or implement feasible engineering and work practice controls;

(ii) In work operations, such as maintenance and repair activities, or other activities for which engineering and work practice controls are not feasible;

(iii) In work situations where feasible engineering and work practice controls are not yet sufficient to reduce exposure to or belcw the exposure limit; and

(iv) In emergencies.

(2) *Respirator selection.* (i) Where respirators are required under this section, the employer shall select and provide at no cost to the employee, the appropriate respirator as specified in Table 1. The employer shall select respirators from among those jointly approved as being acceptable for protection by the Mine Safety and Health Administration (MSHA) and by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 30 CFR Part 11.

(ii) The employer shall provide a powered, air-purifying respirator in lieu of any negative pressure respirator specified in Table 1 whenever:

(A) An employee chooses to use this type of respirator; and

(B) This respirator will provide adequate protection to the employee.

TABLE 1.—RESPIRATORY PROTECTION FOR ASBESTOS, TREMOLITE, ANTHOPHYLLITE, AND ACTINOLITE FIBERS

Airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals	Required respirator
Not in excess of 2 f/cc (10 X PEL).	1. Half-mask air-purifying respirator equipped with high-efficiency filters.
Not in excess of 10 f/cc (50 X PEL).	1. Full facepiece air-purifying respirator equipped with high-efficiency filters.
Not in excess of 20 f/cc (100 X PEL).	1. Any powered air-purifying respirator equipped with high-efficiency filters. 2. Any supplied-air respirator operated in continuous flow mode.
Not in excess of 200 f/cc (1000 X PEL).	1. Full facepiece supplied-air respirator operated in pressure demand mode.
Greater than 200 f/cc (> 1,000 X PEL) or unknown concentration.	1. Full facepiece supplied air respirator operated in pressure demand mode equipped with an auxiliary positive pressure self-contained breathing apparatus.

NOTE: a. Respirators assigned for higher environmental concentrations may be used at lower concentrations.
b. A high-efficiency filter means a filter that is at least 99.97 percent efficient against mono-dispersed particles of 0.3 micrometers or larger.

(3) *Respirator program.* (i) Where respiratory protection is required, the employer shall institute a respirator program in accordance with 29 CFR 1910.134(b), (d), (e), and (f).

(ii) The employer shall permit each employee who uses a filter respirator to change the filter elements whenever an increase in breathing resistance is detected and shall maintain an adequate supply of filter elements for this purpose.

(iii) Employees who wear respirators shall, be permitted to leave the regulated area to wash their faces and respirator facepieces whenever necessary to prevent skin irritation associated with respirator use.

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

(4) *Respirator fit testing.* (i) The employer shall ensure that the respirator issued to the employee exhibits the least possible facepiece leakage and that the respirator is fitted properly.

(ii) For each employee wearing negative pressure respirators, employers shall perform either quantitative or qualitative face fit tests at the time of initial fitting and at least every six months thereafter. The qualitative fit tests may be used only for testing the fit of half-mask respirators where they are permitted to be worn, and shall be conducted in accordance with Appendix C. The tests shall be used to select facepieces that provide the required protection as prescribed in Table I.

(h) *Protective work clothing and equipment*—(1) *Provision and use.* If an employee is exposed to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals above the PEL, or where the possibility of eye irritation exists, the employer shall provide at no cost to the employee and ensure that the employee uses appropriate protective work clothing and equipment such as, but not limited to:

(i) Coveralls or similar full-body work clothing;

(ii) Gloves, head coverings, and foot coverings; and

(iii) Face shields, vented goggles, or other appropriate protective equipment which complies with § 1910.133 of this Part.

(2) *Removal and storage.* (i) The employer shall ensure that employees remove work clothing contaminated with asbestos, tremolite, anthophyllite, or actinolite only in change rooms provided in accordance with paragraph (i)(1) of this section.

(ii) The employer shall ensure that no employee takes contaminated work clothing out of the change room, except those employees authorized to do so for the purpose of laundering, maintenance, or disposal.

(iii) Contaminated work clothing shall be placed and stored in closed containers which prevent dispersion of the asbestos, tremolite, anthophyllite, and actinolite outside the container.

(iv) Containers of contaminated protective devices or work clothing which are to be taken out of change rooms or the workplace for cleaning, maintenance or disposal, shall bear labels in accordance with paragraph (j)(2) of this section.

(3) *Cleaning and replacement.* (i) The employer shall clean, launder, repair, or replace protective clothing and equipment required by this paragraph to maintain their effectiveness. The employer shall provide clean protective clothing and equipment at least weekly to each affected employee.

(ii) The employer shall prohibit the removal of asbestos, tremolite, anthophyllite, and actinolite from protective clothing and equipment by blowing or shaking.

(iii) Laundering of contaminated clothing shall be done so as to prevent the release of airborne fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the permissible exposure limit prescribed in paragraph (c) of this section.

(iv) Any employer who gives contaminated clothing to another person for laundering shall inform such person of the requirement in paragraph (h)(3)(iii) of this section to effectively prevent the release of airborne fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the permissible exposure limit.

(v) The employer shall inform any person who launders or cleans protective clothing or equipment contaminated with asbestos, tremolite, anthophyllite, or actinolite, of the potentially harmful effects of exposure to asbestos, tremolite, anthophyllite, or actinolite.

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

(i) *Hygiene facilities and practices*—(1) *Change rooms.* (i) The employer shall provide clean change rooms for employees who work in areas where their airborne exposure to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals is above the permissible exposure limit.

(ii) The employer shall ensure that change rooms are in accordance with § 1910.141(e) of this part, and are equipped with two separate lockers or storage facilities, so separated as to prevent contamination of the employee's street clothes from his protective work clothing and equipment.

(2) *Showers.* (i) The employer shall ensure that employees who work in areas where their airborne exposure is above the permissible exposure limit shower at the end of the work shift.

(ii) The employer shall provide shower facilities which comply with § 1910.141(d)(3) of this part.

(iii) The employer shall ensure that employees who are required to shower pursuant to paragraph (i)(2)(i) of this section do not leave the workplace wearing any clothing or equipment worn during the work shift.

(3) *Lunchrooms.* (i) The employer shall provide lunchroom facilities for employees who work in areas where their airborne exposure is above the permissible exposure limit.

(ii) The employer shall ensure that lunchroom facilities have a positive pressure, filtered air supply, and are readily accessible to employees.

(iii) The employer shall ensure that employees who work in areas where their airborne exposure is above the permissible exposure limit wash their hands and faces prior to eating, drinking or smoking.

(iv) The employer shall ensure that employees do not enter lunchroom facilities with protective work clothing or equipment unless surface asbestos, tremolite, anthophyllite, and actinolite fibers have been removed from the clothing or equipment by vaccuming or other method that removes dust without causing the asbestos, tremolite, anthophyllite, or actinolite to become airborne.

(j) *Communication of hazards to employees*—(1) *Warning signs.* (i) Posting. Warning signs shall be provided and displayed at each regulated area. In addition, warning signs shall be posted at all approaches to regulated areas so that an employee may read the signs and take necessary protective steps before entering the area.

(ii) Sign specifications. The warning signs required by paragraph (j)(1)(i) of this section shall bear the following information:

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA

(iii) Where minerals in the regulated area are only tremolite, anthophyllite or actinolite, the employer may replace the term "asbestos" with the appropriate mineral name.

(2) *Warning labels.* (i) Labeling. Warning labels shall be affixed to all raw materials, mixtures, scrap, waste, debris, and other products containing asbestos, tremolite, anthophyllite, or actinolite fibers, or to their containers.

(ii) Label specifications. The labels shall comply with the requirements of 29 CFR 1910.1200(f) of OSHA's Hazard Communication standard, and shall include the following information:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD

(iii) Where minerals to be labeled are only tremolite, anthophyllite, or actinolite, the employer may replace the term "asbestos" with the appropriate mineral name.

(3) *Material safety data sheets.* Employers who are manufacturers or importers of asbestos, tremolite, anthophyllite, or actinolite or asbestos, tremolite, anthophyllite, or actionlite products shall comply with the requirements regarding development of material safety data sheets as specified in 29 CFR 1910.1200(g) of OSHA's Hazard Communication standard, except as provided by paragraph (j)(4) of this section.

(4) The provisions for labels required by paragraph (j)(2) or for material safety data sheets required by paragraph (j)(3) do not apply where:

(i) Asbestos, tremolite, anthophyllite, or actinolite fibers have been modified by a bonding agent, coating, binder, or other material provided that the manufacturer can demonstrate that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the action level will be released or

(ii) Asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals is present in a product in concentrations less than 0.1%.

(5) *Employee information and training.* (i) The employer shall institute a training program for all employees who are exposed to airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals at or above the action level ensure their participation in the program.

(ii) Training shall be provided prior to or at the time of initial assignment and at least annually thereafter.

(iii) The training program shall be conducted in a manner which the employee is able to understand. The employer shall ensure that each employee is informed of the following:

(A) The health effect associated with asbestos, tremolite, anthophyllite, or actinolite exposure;

(B) The relationship between smoking and exposure to asbestos, tremolite, anthophyllite, and actinolite in producing lung cancer:

(C) The quantity, location, manner of use, release, and storage of asbestos, tremolite, anthophyllite, or actinolite, and the specfic nature of operations which could result in exposure to asbestos, tremolite, anthophyllite,or actinolite;

(D) The engineering controls and work practices associated with the employee's job assignment;

(E) The specific procedures implemented to protect employees from exposure to asbestos, tremolite, anthophyllite, or actinolite, such as appropriate work practices, emergency and clean-up procedures, and personal protective equipment to be used;

(F) The purpose, proper use, and limitations of respirators and protective clothing;

(G) The purpose and a description of the medical surveillance program required by paragraph (1) of this section;

(H) A review of this standard, including appendices.

(iv) Access to information and training materials.

(A) The employer shall make a copy of this standard and its appendices readily available without cost to all affected employees.

(B) The employer shall provide, upon request, all materials relating to the employee information and training program to the Assistant Secretary and the training program to the Assistant Secretary and the Director.

(k) *Housekeeping.* (1) All surfaces shall be maintained as free as practicable of accumulations of dusts and waste containing asbestos, tremolite, anthophyllite, or actinolite.

(2) All spills and sudden releases of material containing asbestos, tremolite, anthophyllite, or actinolite shall be cleaned up as soon as possible.

(3) Surfaces contaminated with asbestos, tremolite, anthophyllite, or actinolite may not be cleaned by the use of compressed air.

(4) Vacuuming. HEPA-filtered vacuuming equipment shall be used for vacuuming. The equipment shall be used and emptied in a manner which minimizes the reentry of asbestos, tremolite, anthophyllite, or actinolite into the workplace.

(5) Shoveling, dry sweeping and dry clean-up of asbestos, tremolite, anthophyllite, or actinolite may be used only where vacuuming and/or wet cleaning are not feasible.

(6) Waste disposal. Waste, scrap, debris, bags, containers, equipment, and clothing contaminated with asbestos, tremolite, anthophyllite, or actinolite consigned for disposal, shall be collected and disposed of in sealed impermeable bags, or other closed, impermeable containers.

(l) *Medical surveillance—*(1) *General.—(i) Employees covered.* The employer shall institute a medical surveillance program for all employees who are or will be exposed to airborne concentrations of fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals at or above the action level.

(ii) *Examination by a physician.* (A) The employer shall ensure that all medical examinations and procedures are performed by or under the supervision of a licensed physician, and shall be provided without cost to the employee and at a reasonable time and place.

(B) Persons other than licensed physicians, who administer the pulmonary function testing required by this section, shall complete a training course in spirometry sponsored by an appropriate academic or professional institution.

(2) *Preplacement examinations.* (i) Before an employee is assigned to an occupation exposed to airborne concentrations of asbestos, tremolite, anthophyllite, or actinolite fibers, a preplacement medical examination shall be provided or made available by the employer.

(ii) Such examination shall include, as a minimum, a medical and work history: A complete physical examination of all systems with emphasis on the respiratory system, the cardiovascular system and digestive tract; completion of the respiratory disease standardized questionnaire in Appendix D, Part 1; a chest roentgenogram (posterior-anterior 14x17 inches); pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$); and any additional tests deemed appropriate by the examining physician. Interpretation and classification of chest roentgenograms shall be conducted in accordance with Appendix E.

(3) *Periodic examinations.* (i) Periodic medical examinations shall be made available annually.

(ii) The scope of the medical examination shall be in conformance with the protocol established in paragraph (1)(2)(ii), except that the frequency of chest roentgenograms shall be conducted in accordance with Table 2, and the abbreviated standardized questionnaire contained in Appendix D, Part 2, shall be administered to the employee.

TABLE 2.—FREQUENCY OF CHEST ROENTGENOGRAMS

Years since first exposure	Age of employee		
	15 to 35	35+ to 45	45+
0 to 10	Every 5 years	Every 5 years	Every 5 years.
10+	Every 5 years	Every 2 years	Every 1 year.

(4) *Termination of employment examinations.* (i) The employer shall provide, or make available, a termination of employment medical examination for any employee who has been exposed to airborne concentrations of fibers of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals at or above the action level.

(ii) The medical examination shall be in accordance with the requirements of the periodic examinations stipulated in paragraph (l)(3) of this section, and shall be given within 30 calendar days before or after the date of termination of employment.

(5) *Recent examinations.* No medical examination is required of any employee, if adequate records show that the employee has been examined in accordance with any of the preceding paragraphs [(l)(2)–(l)(4)] within the past 1 year period.

(6) *Information provided to the physician.* The employer shall provide the following information to the examining physician:

(i) A copy of this standard and Appendices D and E.

(ii) A description of the affected employee's duties as they relate to the employee's exposure.

(iii) The employee's representative exposure level or anticipated exposure level.

(iv) A description of any personal protective and respiratory equipment used or to be used.

(v) Information from previous medical examinations of the affected employee that is not otherwise available to the examining physician.

(7) *Physician's written opinion.* (i) The employer shall obtain a written signed opinion from the examining physician. This written opinion shall contain the results of the medical examination and shall include:

(A) The physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of material health impairment from exposure to asbestos, tremolite, anthophyllite, or actinolite;

(B) Any recommended limitations on the employee or upon the use of personal protective equipment such as clothing or respirators; and

(C) A statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions resulting from asbestos, tremolite, anthophyllite, or actinolite exposure that require further explanation or treatment.

(ii) The employer shall instruct the physician not to reveal in the written opinion given to the employer specific findings or diagnoses unrelated to occupational exposure to asbestos, tremolite, anthophyllite, or actinolite.

(iii) The employer shall provide a copy of the physician's written opinion to the affected employee within 30 days from its receipt.

(m) *Recordkeeping.*—(1) *Exposure measurements.* (i) The employer shall keep an accurate record of all measurements taken to monitor employee exposure to asbestos, tremolite, anthophyllite, or actinolite as prescribed in paragraph (d) of this section.

(ii) This record shall include at least the following information:

(A) The date of measurement;

(B) The operation involving exposure to asbestos, tremolite, anthophyllite, or actinolite which is being monitored;

(C) Sampling and analytical methods used and evidence of their accuracy;

(D) Number, duration, and results of samples taken;

(E) Type of respiratory protective devices worn, if any; and

(F) Name, social security number and exposure of the employees whose exposure are represented.

(iii) The employer shall maintain this record for at least thirty (30) years, in accordance with 29 CFR 1910.20.

(2) *Objective data for exempted operations.* (i) Where the processing, use, or handling of products made from or containing asbestos, tremolite, anthophyllite, or actinolite is exempted from other requirements of this section under paragraph (d)(2)(iii) of this section, the employer shall establish and maintain an accurate record of objective data reasonably relied upon in support of the exemption.

(ii) The record shall include at least the following:

(A) The product qualifying for exemption;

(B) The source of the objective data;

(C) The testing protocol, results of testing, and/or analysis of the material for the release of asbestos, tremolite, anthophyllite, or actinolite;

(D) A description of the operation exempted and how the data support the exemption; and

(E) Other data relevant to the operations, materials, processing, or employee exposures covered by the exemption.

(iii) The employer shall maintain this record for the duration of the employer's reliance upon such objective data.

Note.—The employer may utilize the services of competent organizations such as industry trade associations and employee associations to maintain the records required by this section.

(3) *Medical surveillance.* (i) The employer shall establish and maintain an accurate record for each employee subject to medical surveillance by paragraph (l)(1)(i) of this section, in accordance with 29 CFR 1910.20.

(ii) The record shall include at least the following information:

(A) The name and social security number of the employee;

(B) Physician's written opinions;

(C) Any employee medical complaints related to exposure to asbestos, tremolite, anthophyllite, or actinolite; and

(D) A copy of the information provided to the physician as required by paragraph (l)(6) of this section.

(iii) The employer shall ensure that this record is maintained for the duration of employment plus thirty (30) years, in accordance with 29 CFR 1910.20.

(4) *Training.* The employer shall maintain all employee training records for one (1) year beyond the last date of employment of that employee.

(5) *Availability.* (i) The employer, upon written request, shall make all records required to be maintained by this section available to the Assistant Secretary and the Director for examination and copying.

(ii) The employer, upon request shall make any exposure records required by paragraph (m)(1) of this section available for examination and copying to affected employees, former employees, designated representatives and the Assistant Secretary, in accordance with 29 CFR 1910.20 (a)–(e) and (g)–(i).

(iii) The employer, upon request, shall make employee medical records required by paragraph (m)(2) of this section available for examination and copying to the subject employee, to anyone having the specific written consent of the subject employee, and the Assistant Secretary, in accordance with 29 CFR 1910.20.

(6) *Transfer of records.* (i) The employer shall comply with the requirements concerning transfer of records set forth in 29 CFR 1910.20(h).

(ii) Whenever the employer ceases to do business and there is no successor employer to receive and retain the records for the prescribed period, the employer shall notify the Director at least 90 days prior to disposal of records and, upon request, transmit them to the Director.

(n) *Observation of monitoring*—(1) *Employee observation.* The employer shall provide affected employees or their designated representatives an opportunity to observe any monitoring of employee exposure to asbestos, tremolite, anthophyllite, or actinolite conducted in accordance with paragraph (d) of this section.

(2) *Observation procedures.* When observation of the monitoring of employee exposure to asbestos, tremolite, anthophyllite, or actinolite requires entry into an area where the use of protective clothing or equipment is required, the observer shall be provided with and be required to use such clothing and equipment and shall comply with all other applicable safety and health procedures.

(o) *Dates*—(1) *Effective date.* This standard shall become effective July 21, 1986. The requirements of the asbestos standard issued in June 1972 (37 FR 11318), as amended, and published in 29 CFR 1910.1001 (1985) remain in effect until compliance is achieved with the parallel provisions of this standard.

(2) *Start-up dates.* All obligations of this standard commence on the effective date except as follows:

(i) *Exposure monitoring.* Initial monitoring required by paragraph (d)(2) of this section shall be completed as soon as possible but no later than October 20, 1986.

(ii) *Regulated areas.* Regulated areas required to be established by paragraph (e) of this section as a result of initial monitoring shall be set up as soon as possible after the results of that monitoring are known and not later than November 17, 1986.

(iii) *Respiratory protection.* Respiratory protection required by paragraph (g) of this section shall be provided as soon as possible but no later than the following schedule:

(A) Employees whose 8-hour TWA exposure exceeds 2 fibers/cc—July 21, 1986.

(B) Employees whose 8-hour TWA exposure exceeds the PEL but is less than 2 fibers/cc—November 17, 1986.

(C) Powered air-purifying respirators provided under paragraph (g)(2)(ii)—January 16, 1987.

(iv) *Hygiene and lunchroom facilities.* Construction plans for changerooms, showers, lavatories, and lunchroom facilities shall be completed no later than January 16, 1987; and these facilities shall be constructed and in use no later than July 20, 1987. However, if as part of the compliance plan it is predicted by an independent engineering firm that engineering controls and work practices will reduce exposures below the permissible exposure limit by July 20, 1988, for affected employees, then such facilities need not be completed until 1 year after the engineering controls are completed, if such controls have not in fact succeeded in reducing exposure to below the permissible exposure limit.

(v) *Employee information and training.* Employee information and training required by paragraph (j)(5) of this section shall be provided as soon as possible but no later than October 20, 1986.

(vi) *Medical surveillance.* Medical examinations required by paragraph (1) of this section shall be provided as soon as possible but no later than November 17, 1986.

(vii) *Compliance program.* Written compliance programs required by paragraph (f)(2) of this section as a result of initial monitoring shall be completed and available for inspection and copying as soon as possible but no later than July 20, 1987.

(viii) *Methods of compliance.* The engineering and work practice controls as required by paragraph (f)(1) shall be implemented as soon as possible but no later than July 20, 1988.

(p) *Appendices.* (1) Appendices A, C, D, and E to this section are incorporated as part of this section and the contents of these Appendices are mandatory

(2) Appendices B, F, G and H to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

Appendix A to § 1910.1001—Osha Reference Method—Mandatory

This mandatory appendix specifies the procedure for analyzing air samples for asbestos, tremolite, anthophyllite, and actinolite and specifies quality control procedures that must be implemented by laboratories performing the analysis. The sampling and analytical methods described below represent the elements of the available monitoring methods (such as the NIOSH 7400 method) which OSHA considers to be essential to achieve adequate employee exposure monitoring while allowing employers to use methods that are already established within their organizations. All employers who are required to conduct air monitoring under paragraph (f) of the standard are required to utilize analytical laboratories that use this procedure, or an equivalent method, for collecting and analyzing samples.

Sampling and Analytical Procedure

1. The sampling medium for air samples shall be mixed cellulose ester filter membranes. These shall be designated by the manufacturer as suitable for asbestos, tremolite, anthophyllite, and actinolite counting. See below for rejection of blanks.

2. The preferred collection device shall be the 25-mm diameter cassette with an open-faced 50-mm extension cowl. The 37-mm cassette may be used if necessary but only if written justification for the need to use the 37-mm filter cassette accompanies the sample results in the employee's exposure monitoring record.

3. An air flow rate between 0.5 liter/min and 2.5 liters/min shall be selected for the 25-mm cassette. If the 37-mm cassette is used, an air flow rate between 1 liter/min and 2.5 liters/min shall be selected.

4. Where possible, a sufficient air volume for each air sample shall be collected to yield between 100 and 1,300 fibers per square millimeter on the membrane filter. If a filter darkens in appearance or if loose dust is seen on the filter, a second sample shall be started.

5. Ship the samples in a rigid container with sufficient packing material to prevent dislodging the collected fibers. Packing material that has a high electrostatic charge on its surface (e.g., expanded polystyrene) cannot be used because such material can cause loss of fibers to the sides of the cassette.

6. Calibrate each personal sampling pump before and after use with a representative filter cassette installed between the pump and the calibration devices.

7. Personal samples shall be taken in the "breathing zone" of the employee (i.e., attached to or near the collar or lapel near the worker's face).

8. Fiber counts shall be made by positive phase contrast using a microscope with an 8 to 10 X eyepiece and a 40 to 45 X objective for a total magnification of approximately 400 X and a numerical aperture of 0.65 to 0.75. The microscope shall also be fitted with a green or blue filter.

9. The microscope shall be fitted with a Walton-Beckett eyepiece graticule calibrated for a field diameter of 100 micrometers (+/−2 micrometers).

10. The phase-shift detection limit of the microscope shall be about 3 degrees measured using the HSE phase shift test slide as outlined below.

a. Place the test slide on the microscope stage and center it under the phase objective.

b. Bring the blocks of grooved lines into focus.

Note.—The slide consists of seven sets of grooved lines (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7, seven being the least visible. The requirements for asbestos, tremolite, anthophyllite, and actinolite counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 and 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope that fails to meet these requirements has either too low or too high a resolution to be used for asbestos, tremolite, anthophyllite, and actinolite counting.

c. If the image deteriorates, clean and adjust the microscope optics. If the problem persists, consult the microscope manufacturer.

11. Each set of samples taken will include 10 percent blanks or a minimum of 2 blanks. The blank results shall be averaged and subtracted from the analytical results before reporting. Any samples represented by a blank having a fiber count in excess of 7 fibers/100 fields shall be rejected.

12. The samples shall be mounted by the acetone/triacetin method or a method with an equivalent index of refraction and similar clarity.

13. Observe the following counting rules.

a. Count only fibers equal to or longer than 5 micrometers. Measure the length of curved fibers along the curve.

b. Count all particles as asbestos, tremolite, anthophyllite, and actinolite that have a length-to-width ratio (aspect ratio) of 3:1 or greater.

c. Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle, shall receive the count of one half (½). Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the gradicule area.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of an individual fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minmum of 20 fields; stop counting at 100 fields regardless of fiber count.

14. Blind recounts shall be conducted at the rate of 10 percent.

Quality Control Procedures

1. Intralaboratory program. Each laboratory and/or each company with more than one microscopist counting slides shall establish a statistically designed quality assurance program involving blind recounts and comparisons between microscopists to monitor the variability of counting by each microscopist and between microscopists. In a company with more than one laboratory, the program shall include all laboratories and shall also evaluate the laboratory-to-laboratory variability.

2. Interlaboratory program. Each laboratory analyzing asbestos, tremolite, anthophyllite, and actinolite samples for compliance determination shall implement an interlaboratory quality assurance program that as a minimum includes participation of at least two other independent laboratories. Each laboratory shall participate in round robin testing at least once every 6 months with at least all the other laboratories in its interlaboratory quality assurance group. Each laboratory shall submit slides typical of its own work load for use in this program. The round robin shall be designed and results analyzed using appropriate statistical methodology.

3. All individuals performing asbestos, tremolite, anthophyllite, and actinolite analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos, tremolite, anthophyllite, and actinolite dust or an equalivalent course.

4. When the use of different microscopes contributes to differences between counters and laboratories, the effect of the different microscope shall be evaluated and the microscope shall be replaced, as necessary.

5. Current results of these quality assurance programs shall be posted in each laboratory to keep the microscopists informed.

Appendix B to § 1910.1001—Detailed Procedure for Asbestos Tremolite, Anthophyllite, and Actinolite Sampling and Analysis—Non-Mandatory

This appendix contains a detailed procedure for sampling and analysis and includes those critical elements specified in Appendix A. Employers are not required to use this procedure, but they are required to use Appendix A. The purpose of Appendix B is to provide a detailed step-by-step sampling and analysis procedure that conforms to the elements specified in Appendix A. Since this procedure may also standardize the analysis and reduce variability, OSHA encourages employers to use this appendix.

Asbestos, Tremolite, Anthophyllite, and Actinolite Sampling and Analysis Method

Technique: Microscopy, Phase Contrast
Analyte: Fibers (manual count)
Sample Preparation: Acetone/triacetin method
Calibration: Phase-shift detection limit about 3 degrees
Range: 100 to 1300 fibers/mm ^{2} filter area
Estimated limit of detection: 7 fibers/mm ^{2} filter area
Sampler: Filter (0.8–1.2 um mixed cellulose ester membrane, 25-mm diameter)
Flow rate: 0.5 1/min to 2.5 1/min (25-mm cassette) 1.0 1/min to 2.5 1/min (37-mm cassette)
Sample volume: Adjust to obtain 100 to 1300 fibers/mm ^{2}
Shipment: Routine
Sample stability: Indefinite
Blanks: 10% of samples (minimum 2)
Standard analytical error: 0.25.

Applicability: The working range is 0.02 f/cc (1920–L air sample) to 1.25 f/cc (400–L air sample). The method gives an index of airborne asbestos, tremolite, anthophyllite, and actinolite fibers but may be used for other materials such as fibrous glass by inserting suitable parameters into the counting rules. The method does not differentiate between asbestos, tremolite, anthophyllite, and actinolite and other fibers. Asbestos, tremolite, anthophyllite, and actinolite fibers less than ca. 0.25 um diameter will not be detected by this method.

Interferences: Any other airborne fiber may interfere since all particles meeting the counting criteria are counted. Chainlike particles may appear fibrous. High levels of nonfibrous dust particles may obscure fibers in the field of view and raise the detection limit.

Reagents: 1. Acetone. 2. Triacetin (glycerol triacetate), reagent grade

Special precautions: Acetone is an extremely flammable liquid and precautions must be taken not to ignite it. Heating of acetone must be done in a ventilated laboratory fume hood using a flameless, spark-free heat source.

Equipment: 1. Collection device: 25-mm cassette with 50-mm extension cowl with cellulose ester filter, 0.8 to 1.2 mm pore size and backup pad.

Note: Analyze representative filters for fiber background before use and discard the filter lot if more than 5 fibers/100 fields are found.

2. Personal sampling pump, greater than or equal to 0.5 L/min. with flexible connecting tubing.

3. Microscope, phase contrast, with green or blue filter, 8 to 10X eyepiece, and 40 to 45X phase objective (total magnification ca 400X; numerical aperture = 0.65 to 0.75.

4. Slides, glass, single-frosted, pre-cleaned, 25 x 75 mm.

5. Cover slips, 25 x 25 mm, no. 1½ unless otherwise specified by microscope manufacturer.

6. Knife, No. 1 surgical steel, curved blade.

7. Tweezers.

8. Flask, Guth-type, insulated neck, 250 to 500 mL (with single-holed rubber stopper and elbow-jointed glass tubing, 16 to 22 cm long).

9. Hotplate, spark-free, stirring type; heating mantle; or infrared lamp and magnetic stirrer.

10. Syringe, hypodermic, with 22-gauge needle.

11. Graticule, Walton-Beckett type with 100 um diameter circular field at the specimen plane (area = 0.00785 mm ^{2}). (Type G–22).

Note.—the graticule is custom-made for each microscope.

12. HSE/NPL phase contrast test slide, Mark II.

13. Telescope, ocular phase-ring centering.

14. Stage micrometer (0.01 mm divisions).

Sampling

1. Calibrate each personal sampling pump with a representative sampler in line.

2. Fasten the sampler to the worker's lapel as close as possible to the worker's mouth. Remove the top cover from the end of the cowl extension (open face) and orient face down. Wrap the joint between the extender and the monitor's body with shrink tape to prevent air leaks.

3. Submit at least two blanks (or 10% of the total samples, whichever is greater) for each set of samples. Remove the caps from the field blank cassettes and store the caps and cassettes in a clean area (bag or box) during the sampling period. Replace the caps in the cassettes when sampling is completed.

4. Sample at 0.5 L/min or greater. Do not exceed 1 mg total dust loading on the filter. Adjust sampling flow rate, Q (L/min), and time to produce a fiber density, E (fibers/mm^2), of 100 to 1300 fibers/m^2 [3.85×10^4 to 5×10^5 fibers per 25-mm filter with effective collection area (A_c=385 mm^2)] for optimum counting precision (see step 21 below). Calculate the minimum sampling time, $t_{minimum}$ (min) at the action level (one-half of the current standard), L (f/cc) of the fibrous aerosol being sampled:

$$t_{min} = \frac{(Ac)(E)}{(Q)(L)10^3}$$

5. Remove the field monitor at the end of sampling, replace the plastic top cover and small end caps, and store the monitor.

6. Ship the samples in a rigid container with sufficient packing material to prevent jostling or damage.

Note.—Do not use polystyrene foam in the shipping container because of electrostatic forces which may cause fiber loss from the sampler filter.

Sample Preparation

Note.—The object is to produce samples with a smooth (non-grainy) background in a medium with a refractive index equal to or less than 1.46. The method below collapses the filter for easier focusing and produces permanent mounts which are useful for quality control and interlaboratory comparison. Other mounting techniques meeting the above criteria may also be used, e.g., the nonpermanent field mounting technique used in P & CAM 239.

7. Ensure that the glass slides and cover slips are free of dust and fibers.

8. Place 40 to 60 ml of acetone into a Guth-type flask. Stopper the flask with a single-hole rubber stopper through which a glass tube extends 5 to 8 cm into the flask. The portion of the glass tube that exits the top of the stopper (8 to 10 cm) is bent downward in an elbow that makes an angle of 20 to 30 degrees with the horizontal.

9. Place the flask in a stirring hotplate or wrap in a heating mantle. Heat the acetone gradually to its boiling temperature (ca. 58 °C).

Caution.—The acetone vapor must be generated in a ventilated fume hood away from all open flames and spark sources. Alternate heating methods can be used, providing no open flame or sparks are present.

10. Mount either the whole sample filter or a wedge cut from the sample filter on a clean glass slide.

a. Cut wedges of ca. 25 percent of the filter area with a curved-blade steel surgical knife using a rocking motion to prevent tearing.

b. Place the filter or wedge, dust side up, on the slide. Static electricity will usually keep the filter on the slide until it is cleared.

c. Hold the glass slide supporting the filter approximately 1 to 2 cm from the glass tube port where the acetone vapor is escaping from the heated flask. The acetone vapor stream should cause a condensation spot on the glass slide ca. 2 to 3 cm in diameter. Move the glass slide gently in the vapor stream. The filter should clear in 2 to 5 sec. If the filter curls, distorts, or is otherwise rendered unusable, the vapor stream is probably not strong enough. Periodically wipe the outlet port with tissue to prevent liquid acetone dripping onto the filter.

d. Using the hypodermic syringe with a 22-gauge needle, place 1 to 2 drops of triacetin on the filter. Gently lower a clean 25-mm square cover slip down onto the filter at a slight angle to reduce the possibility of forming bubbles. If too many bubbles form or the amount of triacetin is insufficient, the cover slip may become detached within a few hours.

e. Glue the edges of the cover slip to the glass slide using a lacquer or nail polish.

Note.—If clearing is slow, the slide preparation may be heated on a hotplate (surface temperature 50 °C) for 15 min to hasten clearing. Counting may proceed immediately after clearing and mounting are completed.

Calibration and Quality Control

11. Calibration of the Walton-Beckett graticule. The diameter, d_c(mm), of the circular counting area and the disc diameter must be specified when ordering the graticule.

a. Insert any available graticule into the eyepiece and focus so that the graticule lines are sharp and clear.

b. Set the appropriate interpupillary distance and, if applicable, reset the binocular head adjustment so that the magnification remains constant.

c. Install the 40 to 45 × phase objective.

d. Place a stage micrometer on the microscope object stage and focus the microscope on the graduate lines.

e. Measure the magnified grid length, L_o(mm), using the stage micrometer.

f. Remove the graticule from the microscope and measure its actual grid length, L_a(mm). This can best be accomplished by using a stage fitted with verniers.

g. Calculate the circle diameter, d_c(mm), for the Walton-Beckett graticule:

$$d_c = \frac{L_a x\, D}{L_o}$$

Example.—If L_o = 108 um, L_a = 2.93 mm and D = 100 um, then d_c = 2.71 mm.

h. Check the field diameter, D(acceptable range 100 mm ± 2 mm) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine field area (mm²).

12. Microscope adjustments. Follow the manufacturer's instructions and also the following:

a. Adjust the light source for even illumination across the field of view at the condenser iris.

Note.—Kohler illumination is preferred, where available.

b. Focus on the particulate material to be examined.

c. Make sure that the field iris is in focus, centered on the sample, and open only enough to fully illuminate the field of view.

d. Use the telescope ocular supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric.

13. Check the phase-shift detection limit of the microscope periodically.

a. Remove the HSE/NPL phase-contrast test slide from its shipping container and center it under the phase objective.

b. Bring the blocks of grooved lines into focus.

Note.—The slide consists of seven sets of grooves (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7. The requirements for counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 to 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope which fails to meet these requirements has either too low or too high a resolution to be used for asbestos, tremolite, anthophyllite, and actinolite counting.

c. If the image quality deteriorates, clean the microscope optics and, if the problem persists, consult the microscope manufacturer.

14. Quality control of fiber counts.

a. Prepare and count field blanks along with the field samples. Report the counts on each blank. Calculate the mean of the field blank counts and subtract this value from each sample count before reporting the results.

Note 1.—The identity of the blank filters should be unknown to the counter until all counts have been completed.

Note 2: If a field blank yields fiber counts greater than 7 fibers/100 fields, report possible contamination of the samples.

b. Perform blind recounts by the same counter on 10 percent of filters counted (slides relabeled by a person other than the counter).

15. Use the following test to determine whether a pair of counts on the same filter should be rejected because of possible bias. This statistic estimates the counting repeatability at the 95% confidence level. Discard the sample if the difference between the two counts exceeds $2.77(F)s_r$, where F=average of the two fiber counts and s_r=relative standard deviation, which should be derived by each laboratory based on historical in-house data.

Note.—If a pair of counts is rejected as a result of this test, recount the remaining samples in the set and test the new counts against the first counts. Discard all rejected paired counts.

16. Enroll each new counter in a training course that compares performance of counters on a variety of samples using this procedure.

Note.—To ensure good reproducibility, all laboratories engaged in asbestos, tremolite, anthophyllite, and actinolite counting are required to participate in the Proficiency Analytical Testing (PAT) Program and should routinely participate with other asbestos, tremolite, anthophyllite, and actinolite fiber counting laboratories in the exchange of field samples to compare performance of counters.

Measurement

17. Place the slide on the mechanical stage of the calibrated microscope with the center of the filter under the objective lens. Focus the microscope on the plane of the filter.

18. Regularly check phase-ring alignment and Kohler illumination.

19. The following are the counting rules:

a. Count only fibers longer than 5 um. Measure the length of curved fibers along the curve.

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

c. For fibers that cross the boundary of the graticule field, do the following:

1. Count any fiber longer tha 5 um that lies entirely within the graticule area.

2. Count as ½ fiber any fiber with only one end lying within the graticule area.

3. Do not count any fiber that crosses the graticule boundary more than once.

4. Reject and do not count all other fibers.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of a fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields. Stop at 100 fields regardless of fiber count.

20. Start counting from one end of the filter and progress along a radial line to the other end, shift either up or down on the filter, and continue in the reverse direction. Select fields randomly by looking away from the eyepiece briefly while advancing the mechanical stage. When an agglomerate covers ca. ⅙ or more of the field of view, reject the field and select another. Do not report rejected fields in the number of total fields counted.

Note.—When counting a field, continuously scan a range of focal planes by moving the fine focus knob to detect very fine fibers which have become embedded in the filter. The small-diameter fibers will be very faint but are an important contribution to the total count.

Calculations

21. Calculate and report fiber density on the filter, E (fibers/mm²); by dividing the total fiber count, F; minus the mean field blank count, B, by the number of fields, n; and the field area, A_f (0.00785 mm² for a properly calibrated Walton-Beckett graticule):

$$E = \frac{F-B,}{(n)(A_f)} \text{ fibers/mm}^2$$

22. Calculate the concentration, C (f/cc), o fibers in the air volume sampled, V (L), using the effective collection area of the filter, A_c (385 mm² for a 25-mm filter):

$$C = \frac{(E)(Ac)}{V(10^3)}$$

Note.—Periodically check and adjust the value of A_c, if necessary.

Appendix C to § 1910.1001—Qualitative and Quantitative Fit Testing Procedures—Mandatory

Qualitative Fit Test Protocols

I. Isoamyl Acetate Protocol.

A. Odor Threshold Screening

1. Three 1-liter glass jars with metal lids (e.g. Mason or Bell jars) are required.
2. Odor-free water (e.g. distilled or spring water) at approximately 25°C shall be used for the solutions.
3. The isoamyl acetate (IAA) (also known as isopentyl acetate) stock solution is prepared by adding 1 cc of pure IAA to 800 cc of odor free water in a 1-liter jar and shaking for 30 seconds. This solution shall be prepared new at least weekly.
4. The screening test shall be conducted in a room separate from the room used for actual fit testing. The two rooms shall be well ventilated but shall not be connected to the same recirculating ventilation system.
5. The odor test solution is prepared in a second jar by placing 0.4 cc of the stock solution into 500 cc of odor free water using a clean dropper or pipette. Shake for 30 seconds and allow to stand for two to three minutes so that the IAA concentration above the liquid may reach equilibrium. This solution may be used for only one day.
6. A test blank is prepared in a third jar by adding 500 cc of odor free water.
7. The odor test and test blank jars shall be labelled 1 and 2 for jar identification. If the labels are put on the lids they can be periodically peeled, dried off and switched to maintain the integrity of the test.
8. The following instructions shall be typed on a card and placed on the table in front of the two test jars (i.e. 1 and 2): "The purpose of this test is to determine if you can smell banana oil at a low concentration. The two bottles in front of you contain water. One of these bottles also contains a small amount of banana oil. Be sure the covers are on tight, then shake each bottle for two seconds. Unscrew the lid of each bottle, one at a time, and sniff at the mouth of the bottle. Indicate to the test conductor which bottle contains banana oil."
9. The mixtures used in the IAA odor detection test shall be prepared in an area separate from where the test is performed, in order to prevent olfactory fatigue in the subject.
10. If the test subject is unable to correctly identify the jar containing the odor test solution, the IAA qualitative fit test may not be used.
11. If the test subject correctly identifies the jar containing the odor test solution, the test subject may proceed to respirator selection and fit testing.

B. Respirator Selection

1. The test subject shall be allowed to pick the most comfortable respirator from a selection including respirators of various sizes from different manufacturers. The selection shall include at least five sizes of elastomeric half facepieces, from at least two manufacturers.
2. The selection process shall be conducted in a room separate from the fit-test chamber to prevent odor fatigue. Prior to the selection process, the test subject shall be shown how to put on a respirator, how it should be positioned on the face, how to set strap tension and how to determine a "comfortable" respirator. A mirror shall be available to assist the subject in evaluating the fit and positioning of the respirator. This instruction may not constitute the subject's formal training on respirator use, as it is only a review.
3. The test subject should understand that the employee is being asked to select the respirator which provides the most comfortable fit. Each respirator represents a different size and shape and, if fit properly and used properly will provide adequate protection.
4. The test subject holds each facepiece up to the face and eliminates those which obviously do not give a comfortable fit. Normally, selection will begin with a half-mask and if a good fit cannot be found, the subject will be asked to test the full facepiece respirators. (A small percentage of users will not be able to wear any half-mask.)
5. The more comfortable facepieces are noted; the most comfortable mask is donned and *worn at least five minutes* to assess comfort. All donning and adjustments of the facepiece shall be performed by the test subject without assistance from the test conductor or other person. Assistance in assessing confort can be given by discussing the points in #6 below. If the test subject is not familiar with using a particular respirator, the test subject shall be directed to don the mask several times and to adjust the straps each time to become adept at setting proper tension on the straps.
6. Assessment of comfort shall include reviewing the following points with the test subject and allowing the test subject adequate time to determine the comfort of the respirator:
   - Positioning of mask on nose.
   - Room for eye protection.
   - Room to talk.
   - Positioning mask on face and cheeks.
7. The following criteria shall be used to help determine the adequacy of the respirator fit:
   - Chin properly placed.
   - Strap tension.
   - Fit across nose bridge.
   - Distance from nose to chin.
   - Tendency to slip.
   - Self-observation in mirror.
8. The test subject shall conduct the conventional negative and positive-pressure fit checks (e.g. see ANSI Z88.2–1980). Before conducting the negative- or positive-pressure test the subject shall be told to "seat" the mask by rapidly moving the head from side-to-side and up and down, while taking a few deep breaths.
9. The test subject is now ready for fit testing.
10. After passing the fit test, the test subject shall be questioned again regarding the comfort of the respirator. If it has become uncomfortable, another model of respirator shall be tried.
11. The employee shall be given the opportunity to select a different facepiece and be retested if the chosen facepiece becomes increasingly uncomfortable at any time.

C. Fit Test

1. The fit test chamber shall be similar to a clear 55 gal drum liner suspended inverted over a 2 foot diameter frame, so that the top of the chamber is about 6 inches above the test subject's head. The inside top center of the chamber shall have a small hook attached.
2. Each respirator used for the fitting and fit testing shall be equipped with organic vapor cartridges or offer protection against organic vapors. The cartridges or masks shall be changed at least weekly.
3. After selecting, donning, and properly adjusting a respirator, the test subject shall wear it to the fit testing room. This room shall be separate from the room used for odor threshold screening and respirator selection, and shall be well ventilated, as by an exhaust fan or lab hood, to prevent general room contamination.
4. A copy of the following test exercises and rainbow passage shall be taped to the inside of the test chamber:

Test Exercises

i. Breathe normally.
ii. Breathe deeply. Be certain breaths are *deep* and *regular.*
iii. Turn head all the way from one side to the other. Inhale on each side. Be certain movement is complete. Do not bump the respirator against the shoulders.
iv. Nod head up-and-down. Inhale when head is in the full up position (looking toward ceiling). Be certain motions are complete and made about every second. Do not bump the respirator on the chest.
v. Talking. Talk aloud and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement Alternative passages which serve the same purpose may also be used.
vi. Jogging in place.
vii. Breathe normally.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

5. Each test subject shall wear the respirator for at least 10 minutes before starting the fit test.

6. Upon entering the test chamber, the test subject shall be given a 6 inch by 5 inch piece of paper towel or other porous absorbent single ply material, folded in half and wetted with three-quarters of one cc of pure IAA. The test subject shall hang the wet towel on the hook at the top of the chamber.

7. Allow two minutes for the IAA test concentration to be reached before starting the fit-test exercises. This would be an appropriate time to talk with the test subject, to explain the fit test, the importance of cooperation, the purpose for the head exercises, or to demonstrate some of the exercises.

8. Each exercise described in #4 above shall be performed for at least one minute.

9. If at any time during the test, the subject detects the banana-like odor of IAA, the test has failed. The subject shall quickly exit from the test chamber and leave the test area to avoid olfactory fatigue.

10. If the test is failed, the subject shall return to the selection room and remove the respirator, repeat the odor sensitivity test, select and put on another respirator, return to the test chamber, and again begin the procedure described in the c(4) through c(8) above. The process continues until a respirator that fits well has been found. Should the odor sensitivity test be failed, the subject shall wait about 5 minutes before retesting. Odor sensitivity will usually have returned by this time.

11. If a person cannot pass the fit test described above wearing a half-mask respirator from the available selection, full facepiece models must be used.

12. When a respirator is found that passes the test, the subject breaks the faceseal and takes a breath before exiting the chamber. This is to assure that the reason the test subject is not smelling the IAA is the good fit of the respirator facepiece seal and not olfactory fatigue.

13. When the test subject leaves the chamber, the subject shall remove the saturated towel and return it to the person conducting the test. To keep the area from becoming contaminated, the used towels shall be kept in a self-sealing bag so there is no significant IAA concentration buildup in the test chamber during subsequent tests.

14. At least two facepieces shall be selected for the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

15. Persons who have successfully passed this fit test with a half-mask respirator may be assigned the use of the test respirator in atmospheres with up to 10 times the PEL of airborne asbestos. In atmospheres greater than 10 times, and less than 100 times the PEL (up to 100 ppm), the subject must pass the IAA test using a full face negative pressure respirator. (The concentration of the IAA inside the test chamber must be increased by ten times for QLFT of the full facepiece.)

16. The test shall not be conducted if there is any hair growth between the skin the facepiece sealing surface.

17. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

18. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

19. Qualitative fit testing shall be repeated at least every six months.

20. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more,

(2) Significant facial scarring in the area of the facepiece seal,

(3) Significant dental changes; i.e., multiple extractions without prothesis, or acquiring dentures,

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

D. Recordkeeping

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of the test conductor.

(4) Respirators selected (indicate manufacturer, model, size and approval number).

(5) Testing agent.

II. Saccharin Solution Aerosol Protocol

A. Respirator Selection

Respirators shall be selected as described in section IB (respirator selection) above, except that each respirator shall be equipped with a particulate filter.

B. Taste Threshold Screening

1. An enclosure about head and shoulders shall be used for threshold screening (to determine if the individual can taste saccharin) and for fit testing. The enclosure shall be approximately 12 inches in diameter by 14 inches tall with at least the front clear to allow free movement of the head when a respirator is worn.

2. The test enclosure shall have a three-quarter inch hole in front of the test subject's nose and mouth area to accommodate the nebulizer nozzle.

3. The entire screening and testing procedure shall be explained to the test subject prior to conducting the screening test.

4. During the threshold screening test, the test subject shall don the test enclosure and breathe with open mouth with tongue extended.

5. Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the threshold check solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the fit test solution nebulizer.

6. The threshold check solution consists of 0.83 grams of sodium saccharin, USP in water. It can be prepared by putting 1 cc of the test solution (see C 7 below) in 100 cc of water.

7. To produce the aerosol, the nebulizer bulb is firmly squeezed so that it collapses completely, then is released and allowed to fully expand.

8. Ten squeezes of the nebulizer bulb are repeated rapidly and then the test subject is asked whether the saccharin can be tasted.

9. If the first response is negative, ten more squeezes of the nebulizer bulb are repeated rapidly and the test subject is again asked whether the saccharin can be tasted.

10. If the second response is negative ten more squeezes are repeated rapidly and the test subject is again asked whether the saccharin can be tasted.

11. The test conductor will take note of the number of squeezes required to elicit a taste response.

12. If the saccharin is not tasted after 30 squeezes (Step 10), the saccharin fit test cannot be performed on the test subject.

13. If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit test.

14. Correct use of the nebulizer means that approximately 1 cc of liquid is used at a time in the nebulizer body.

15. The nebulizer shall be thoroughly rinsed in water, shaken dry, and refilled at least every four hours.

C. Fit Test

1. The test subject shall don and adjust the respirator without the assistance from any person.

2. The fit test uses the same enclosure described in IIB above.

3. Each test subject shall wear the respirator for at least 10 minutes before starting the fit test.

4. The test subject shall don the enclosure while wearing the respirator selected in section 1B above. This respirator shall be properly adjusted and equipped with a particulate filter.

5. The test subject may not eat, drink (except plain water), or chew gum for 15 minutes before the test.

6. A second DeVilbiss Model 40 Inhalation Medication Nebulizer is used to spray the fit test solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the screening test solution nebulizer.

7. The fit test solution is prepared by adding 83 grams of sodium saccharin to 100 cc of warm water.

8. As before, the test subject shall breathe with mouth open and tongue extended.

9. The nebulizer is inserted into the hole in the front of the enclosure and the fit test solution is sprayed into the enclosure using the same technique as for the taste threshold screening and the same number of squeezes required to elicit a taste response in the screening. (See B8 through B10 above).

10. After generation of the aerosol read the following instructions to the test subject. The test subject shall perform the exercises for one minute each.

i. Breathe normally.

ii. Breathe deeply. Be certain breaths are *deep* and *regular*.

iii. Turn head all the way from one side *to the other.* Be certain movement is complete. Inhale on each side. Do not bump the respirator against the shoulders.

iv. Nod head up-and-down. Be certain motions are complete. Inhale when head is in the full up position (when looking toward the ceiling). Do not bump the respirator on the chest.

v. Talking. Talk loudly and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement. Alternative passages which serve the same purpose may also be used.

vi. Jogging in place.

vii. Breathe normally.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

11. At the beginning of each exercise, the aerosol concentration shall be replenished using one-half the number of squeezes as initially described in C9.

12. The test subject shall indicate to the test conductor if at any time during the fit test the taste of saccharin is detected.

13. If the saccharin is detected the fit is deemed unsatisfactory and a different respirator shall be tried.

14. At least two facepieces shall be selected by the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

15. Successful completion of the test protocol shall allow the use of the half mask tested respirator in contaminated atmospheres up to 10 times the PEL of asbestos. In other words this protocol may be used to assign protection factors no higher than ten.

16. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

17. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

18. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

19. Qualitative fit testing shall be repeated at least every six months.

20. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more,

(2) Significant facial scarring in the area of the facepiece seal,

(3) Significant dental changes; i.e.; multiple extractions without prothesis, or acquiring dentures,

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

D. Recordkeeping

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of test conductor.

(4) Respirators selected (indicate manufacturer, model, size and approval number).

(5) Testing agent.

III. Irritant Fume Protocol

A. Respirator selection

Respirators shall be selected as described in section IB above, except that each respirator shall be equipped with a combination of high-efficiency and acid-gas cartridges.

B. Fit test

1. The test subject shall be allowed to smell a weak concentration of the irritant smoke to familiarize the subject with the characteristic odor.

2. The test subject shall properly don the respirator selected as above, and wear it for at least 10 minutes before starting the fit test.

3. The test conductor shall review this protocol with the test subject before testing.

4. The test subject shall perform the conventional positive pressure and negative pressure fit checks (see ANSI Z88.2 1980). Failure of either check shall be cause to select an alternate respirator.

5. Break both ends of a ventilation smoke tube containing stannic oxychloride, such as the MSA part #5645, or equivalent. Attach a short length of tubing to one end of the smoke tube. Attach the other end of the smoke tube to a low pressure air pump set to deliver 200 milliliters per minute.

6. Advise the test subject that the smoke can be irritating to the eyes and instruct the subject to keep the eyes closed while the test is performed.

7. The test conductor shall direct the stream of irritant smoke from the tube towards the faceseal area of the test subject. The person conducting the test shall begin with the tube at least 12 inches from the facepiece and gradually move to within one inch, moving around the whole perimeter of the mask.

8. The test subject shall be instructed to do the following exercises while the respirator is being challenged by the smoke. Each exercise shall be performed for one minute.

i. Breathe normally.

ii. Breathe deeply. Be certain breaths are *deep* and *regular.*

iii. Turn head all the way from one side to the other. Be certain movement is complete. Inhale on each side. Do not bump the respirator against the shoulders.

iv. Nod head up-and-down. Be certain motions are complete and made every second. Inhale when head is in the full up position (looking toward ceiling). Do not bump the respirator against the chest.

v. Talking. Talk aloud and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement. Alternative passages which serve the same purpose may also be used.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

vi. Jogging in Place.

vii. Breathe normally.

9. The test subject shall indicate to the test conductor if the irritant smoke is detected. If smoke is detected, the test conductor shall stop the test. In this case, the tested respirator is rejected and another respirator shall be selected.

10. Each test subject passing the smoke test (i.e. without detecting the smoke) shall be given a sensitivity check of smoke from the same tube to determine if the test subject reacts to the smoke. Failure to evoke a response shall void the fit test.

11. Steps B4, B9, B10 of this fit test protocol shall be performed in a location with exhaust ventilation sufficient to prevent general contamination of the testing area by the test agents.

12. At least two facepieces shall be selected by the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

13. Respirators successfully tested by the protocol may be used in contaminated atmospheres up to ten times the PEL of asbestos.

14. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

15. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

16. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

17. Qualitative fit testing shall be repeated at least every six months.

18. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more,

(2) Significant facial scarring in the area of the facepiece seal,

(3) Significant dental changes; i.e.; multiple extractions without prothesis, or acquiring dentures,

(4) Reconstructive or cosmestic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

C. Recordkeeping

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of test conductor.

(4) Respirators selected (indicate manufacturer, model, size and approval number).

(5) Testing agent

Quantitative Fit Test Procedures

1. General.

a. The method applies to the negative-pressure nonpowered air-purifying respirators only.

b. The employer shall assign one individual who shall assume the full responsibility for implementing the respirator quantitative fit test program.

2. *Definition.*

a. "Quantitative Fit Test" means the measurement of the effectiveness of a respirator seal in excluding the ambient atmosphere. The test is performed by dividing the measured concentration of challenge agent in a test chamber by the measured concentration of the challenge agent inside the respirator facepiece when the normal air purifying element has been replaced by an essentially perfect purifying element.

b. "Challenge Agent" means the air contaminant introduced into a test chamber so that its concentration inside and outside the respirator may be compared.

c. "Test Subject" means the person wearing the respirator for quantitative fit testing.

d. "Normal Standing Position" means standing erect and straight with arms down along the sides and looking straight ahead.

e. "Fit Factor" means the ratio of challenge agent concentration outside with respect to the inside of a respirator inlet covering (facepiece or enclosure).

3. *Apparatus.*

a. *Instrumentation.* Corn oil, sodium chloride or other appropriate aerosol generation, dilution, and measurement systems shall be used for quantitative fit test.

b. *Test chamber.* The test chamber shall be large enough to permit all test subjects to freely perform all required exercises without distributing the challenge agent concentration or the measurement apparatus. The test chamber shall be equipped and constructed so that the challenge agent is effectively isolated from the ambient air yet uniform in concentration throughout the chamber.

c. When testing air-purifying respirators, the normal filter or cartridge element shall be replaced with a high-efficiency particular filter supplied by the same manufacturer.

d. The sampling instrument shall be selected so that a strip chart record may be made of the test showing the rise and fall of challenge agent concentration with each inspiration and expiration at fit factors of at least 2,000.

e. The combination of substitute air-purifying elements (if any), challenge agent, and challenge agent concentration in the test chamber shall be such that the test subject is not exposed in excess of PEL to the challenge agent at any time during the testing process.

f. The sampling port on the test specimen respirator shall be placed and constructed so that there is no detectable leak around the port, a free air flow, is allowed into the sampling line at all times and so there is no interference with the fit or performance of the respirator.

g. The test chamber and test set-up shall permit the person administering the test to observe one test subject inside the chamber during the test.

h. The equipment generating the challenge atmosphere shall maintain the concentration of challenge agent constant within a 10 percent variation for the duration of the test.

i. The time lag (interval between an event and its being recorded on the strip chart) of the instrumentation may not exceed 2 seconds.

j. The tubing for the test chamber atmosphere and for the respirator sampling port shall be the same diameter, length and material. It shall be kept as short as possible. The smallest diameter tubing recommended by the manufacturer shall be used.

k. The exhaust flow from the test chamber shall pass through a high-efficiency filter before release to the room.

l. When sodium chloride aerosol is used, the relative humidity inside the test chamber shall not exceed 50 percent.

4. *Procedural Requirements.*

a. The fitting of half-mask respirators should be started with those having multiple sizes and a variety of interchangeable cartridges and canisters such as the MSA Comfo II-M, Norton M. Survivair M, A-O M, or Scott-M. Use either of the tests outlined below to assure that the facepiece is properly adjusted.

(1) *Positive pressure test.* With the exhaust port(s) blocked, the negative pressure of slight inhalation should remain constant for several seconds.

(2) *Negative pressure test.* With the intake port(s) blocked, the negative pressure slight inhalation should remain constant for several seconds.

b. After a facepiece is adjusted, the test subject shall wear the facepiece for at least 5 minutes before conducting a qualitive test by using either of the methods described below and using the exercise regime described in 5.a., b., c., d, and e.

(1) *Isoamyl acetate test.* When using organic vapor cartridges, the test subject who can smell the odor should be unable to detect the odor of isoamyl acetate squirted into the air near the most vulnerable portions of the facepiece seal. In a location which is separated from the test area, the test subject shall be instructed to close her/his eyes during the test period. A combination cartridge or canister with organic vapor and high-efficiency filters shall be used when available for the particular mask being tested. The test subject shall be given an opportunity to smell the odor of isoamyl acetate before the test is conducted.

(2) *Irritant fume test.* When using high-efficiency filters, the test subject should be unable to detect the odor of irritant fume (stannic chloride or titanium tetrachloride ventilation smoke tubes) squirted into the air near the most vulnerable portions of the facepiece seal. The test subject shall be instructed to close her/his eyes during the test period.

c. The test subject may enter the quantitative testing chamber only if she or he has obtained a satisfactory fit as stated in 4.b. of this Appendix.

d. Before the subject enters the test chamber, a reasonably stable challenge agent concentration shall be measured in the test chamber.

e. Immediately after the subject enters the test chamber, the challenge agent concentration inside the respirator shall be measured to ensure that the peak penetration does not exceed 5 percent for a half-mask and 1 percent for a full facepiece.

f. A stable challenge agent concentration shall be obtained prior to the actual start of testing.

(1) Respirator restraining straps may not be overtightened for testing. The straps shall be adjusted by the wearer to give a reasonably comfortable fit typical of normal use.

5. *Exercise Regime.* Prior to entering the test chamber, the test subject shall be given complete instructions as to her/his part in the test procedures. The test subject shall perform the following exercises, in the order given, for each independent test.

a. *Normal Breathing (NB).* In the normal standing position, without talking, the subject shall breathe normally for at least one minute.

b. *Deep Breathing (DB).* In the normal standing position the subject shall do deep breathing for at least one minute pausing so as not to hyperventilate.

c. *Turning head side to side (SS).* Standing in place the subject shall slowly turn his/her head from side between the extreme positions to each side. The head shall be held at each extreme position for at least 5 seconds. Perform for at least three complete cycles.

d. *Moving head up and down (UD).* Standing in place, the subject shall slowly move his/her head up and down between the extreme position straight up and the extreme position straight down. The head shall be held at each extreme position for at least 5 seconds. Perform for at least three complete cycles.

e. *Reading (R).* The subject shall read out slowly and loud so as to be heard clearly by the test conductor or monitor. The test subject shall read the "rainbow passage" at the end of this section.

f. *Grimace (G).* The test subject shall grimace, smile, frown, and generally contort the face using the facial muscles. Continue for at least 15 seconds.

g. *Bend over and touch toes (B).* The test subject shall bend at the waist and touch toes and return to upright position. Repeat for at least 30 seconds.

h. *Jogging in place (J).* The test subject shall perform jog in place for at least 30 seconds.

i. *Normal Breathing (NB).* Same as exercise a.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

6. The test shall be terminated whenever any single peak penetration exceeds 5 percent for half-masks and 1 percent for full facepieces. The test subject may be refitted and retested. If two of the three required tests are terminated, the fit shall be deemed inadequate. (See paragraph 4.h.)

7. *Calculation of Fit Factors.*

a. The fit factor determined by the quantitative fit test equals the average concentration inside the respirator.

b. The average test chamber concentration is the arithmetic average of the test chamber concentration at the beginning and of the end of the test.

c. The average peak concentration of the challenge agent inside the respirator shall be the arithmetic average peak concentrations for each of the nine exercises of the test which are computed as the arithmetic average of the peak concentrations found for each breath during the exercise.

d. The average peak concentration for an exercise may be determined graphically if there is not a great variation in the peak concentrations during a single exercise.

8. *Interpretation of Test Results.* The fit factor measured by the quantitative fit testing shall be the lowest of the three protection factors resulting from three independent tests.

9. *Other Requirements.*

a. The test subject shall not be permitted to wear a half-mask or full facepiece mask if the minimum fit factor of 100 or 1,000, respectively, cannot be obtained. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

b. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

c. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

d. The test subject shall be given the opportunity to wear the assigned respirator for one week. If the respirator does not provide a satisfactory fit during actual use, the test subject may request another QNFT which shall be performed immediately.

e. A respirator fit factor card shall be issued to the test subject with the following information:

(1) Name.

(2) Date of fit test.

(3) Protection factors obtained through each manufacturer, model and approval number of respirator tested.

(4) Name and signature of the person that conducted the test.

f. Filters used for qualitative or quantitative fit testing shall be replaced weekly, whenever increased breathing resistance is encountered, or when the test agent has altered the integrity of the filter media. Organic vapor cartridges/canisters shall be replaced daily or sooner if there is any indication of breakthrough by the test agent.

10. In addition, because the sealing of the respirator may be affected, quantitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more,

(2) Significant facial scarring in the area of the facepiece seal,

(3) Significant dental changes; i.e., multiple extractions without prothesis, or acquiring dentures,

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

11. *Recordkeeping.*

A summary of all test results shall be maintained in for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of the test conductor.

(4) Fit factors obtained from every respirator tested (indicate manufacturer, model, size and approval number).

Appendix D to § 1910.1001—Medical Questionnaires; Mandatory

This mandatory appendix contains the medical questionnaires that must be administered to all employees who are exposed to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals above the action level, and who will therefore be included in their employer's medical surveillance program. Part 1 of the appendix contains the Initial Medical Questionnaire, which must be obtained for all new hires who will be covered by the medical surveillance requirements. Part 2 includes the abbreviated Periodical Medical Questionnaire, which must be administered to all employees who are provided periodic medical examinations under the medical surveillance provisions of the standard.

BILLING CODE 4510-26-M

Part 1
INITIAL MEDICAL QUESTIONNAIRE

1. NAME ____________________

2. SOCIAL SECURITY # __ __ __ __ __ __ __ __ __ (1 2 3 4 5 6 7 8 9)

3. CLOCK NUMBER __ __ __ __ __ __ (10 11 12 13 14 15)

4. PRESENT OCCUPATION ____________________

5. PLANT ____________________

6. ADDRESS ____________________

7. ____________________ (Zip Code)

8. TELEPHONE NUMBER ____________________

9. INTERVIEWER ____________________

10. DATE ____________________ __ __ __ __ __ __ (16 17 18 19 20 21)

11. Date of Birth ______ Month Day Year __ __ __ __ __ __ (22 23 24 25 26 27)

12. Place of Birth ____________________

13. Sex
1. Male __
2. Female __

14. What is your marital status?
1. Single __
2. Married __
3. Widowed __
4. Separated/ Divorced __

15. Race
1. White __
2. Black __
3. Asian __
4. Hispanic __
5. Indian __
6. Other __

16. What is the highest grade completed in school? ______
(For example 12 years is completion of high school)

OCCUPATIONAL HISTORY

17A. Have you ever worked full time (30 hours per week or more) for 6 months or more? 1. Yes __ 2. No __

IF YES TO 17A:

B. Have you ever worked for a year or more in any dusty job? 1. Yes __ 2. No __ 3. Does Not Apply __

Specify job/industry ______ Total Years Worked __

Was dust exposure: 1. Mild __ 2. Moderate __ 3. Severe __

C. Have you even been exposed to gas or chemical fumes in your work? 1. Yes __ 2. No __
Specify job/industry ______ Total Years Worked __

Was exposure: 1. Mild __ 2. Moderate __ 3. Severe __

D. What has been your usual occupation or job--the one you have worked at the longest?

1. Job occupation ____________________

2. Number of years employed in this occupation ______

3. Position/job title ____________________

4. Business, field or industry ____________________

(Record on lines the years in which you have worked in any of these industries, e.g. 1960-1969)

Have you ever worked:

		YES	NO
E.	In a mine?..............................	[ ]	[ ]
F.	In a quarry?............................	[ ]	[ ]
G.	In a foundry?...........................	[ ]	[ ]
H.	In a pottery?...........................	[ ]	[ ]
I.	In a cotton, flax or hemp mill?..........	[ ]	[ ]
J.	With asbestos?..........................	[ ]	[ ]

18. PAST MEDICAL HISTORY

		YES	NO
A.	Do you consider yourself to be in good health?	[ ]	[ ]

If "NO" state reason ____________________

		YES	NO
B.	Have you any defect of vision?..............	[ ]	[ ]

If "YES" state nature of defect ____________________

		YES	NO
C.	Have you any hearing defect?.................	[ ]	[ ]

If "YES" state nature of defect ____________________

D. Are you suffering from or have you ever suffered from:

a. Epilepsy (or fits, seizures, convulsions)?	[ ]	[ ]
b. Rheumatic fever?	[ ]	[ ]
c. Kidney disease?	[ ]	[ ]
d. Bladder disease?	[ ]	[ ]
e. Diabetes?	[ ]	[ ]
f. Jaundice?	[ ]	[ ]

19. CHEST COLDS AND CHEST ILLNESSES

19A. If you get a cold, does it usually go to your chest? (Usually means more than 1/2 the time)	1. Yes __ 2. No __ 3. Don't get colds __
20A. During the past 3 years, have you had any chest illnesses that have kept you off work, indoors at home, or in bed?	1. Yes __ 2. No __
IF YES TO 20A: B. Did you produce phlegm with any of these chest illnesses?	1. Yes __ 2. No __ 3. Does Not Apply __
C. In the last 3 years, how many such illnesses with (increased) phlegm did you have which lasted a week or more?	Number of illnesses __ No such illnesses __
21. Did you have any lung trouble before the age of 16?	1. Yes __ 2. No __
22. Have you ever had any of the following?	
1A. Attacks of bronchitis?	1. Yes __ 2. No __
IF YES TO 1A: B. Was it confirmed by a doctor?	1. Yes __ 2. No __ 3. Does Not Apply __
C. At what age was your first attack?	Age in Years __ Does Not Apply __
2A. Pneumonia (include bronchopneumonia)?	1. Yes __ 2. No __
IF YES TO 2A: B. Was it confirmed by a doctor?	1. Yes __ 2. No __ 3. Does Not Apply __
C. At what age did you first have it?	Age in Years __ Does Not Apply __
3A. Hay Fever?	1. Yes __ 2. No __
IF YES TO 3A: B. Was it confirmed by a doctor?	1. Yes __ 2. No __ 3. Does Not Apply __
C. At what age did it start?	Age in Years __ Does Not Apply __
23A. Have you ever had chronic bronchitis?	1. Yes __ 2. No __
IF YES TO 23A: B. Do you still have it?	1. Yes __ 2. No __ 3. Does Not Apply __
C. Was it confirmed by a doctor?	1. Yes __ 2. No __ 3. Does Not Apply __
D. At what age did it start?	Age in Years __ Does Not Apply __
24A. Have you ever had emphysema?	1. Yes __ 2. No __
IF YES TO 24A: B. Do you still have it?	1. Yes __ 2. No __ 3. Does Not Apply __
C. Was it confirmed by a doctor?	1. Yes __ 2. No __ 3. Does Not Apply __
D. At what age did it start?	Age in Years __ Does Not Apply __
25A. Have you ever had asthma?	1. Yes __ 2. No __
IF YES TO 25A: B. Do you still have it?	1. Yes __ 2. No __ 3. Does Not Apply __
C. Was it confirmed by a doctor?	1. Yes __ 2. No __ 3. Does Not Apply __
D. At what age did it start?	Age in Years __ Does Not Apply __
E. If you no longer have it, at what age did it stop?	Age stopped __ Does Not Apply __
26. Have you ever had:	
A. Any other chest illness?	1. Yes __ 2. No __

If yes, please specify ______________________________

B. Any chest operations? 1. Yes __ 2. No __

If yes, please specify ____

C. Any chest injuries? 1. Yes __ 2. No __

If yes, please specify ____

27A. Has a doctor ever told you that you had heart trouble? 1. Yes __ 2. No __

IF YES TO 27A:

B. Have you ever had treatment for heart trouble in the past 10 years? 1. Yes __ 2. No __ 3. Does Not Apply __

28A. Has a doctor ever told you that you had high blood pressure? 1. Yes __ 2. No __

IF YES TO 28A:

B. Have you had any treatment for high blood pressure (hypertension) in the past 10 years? 1. Yes __ 2. No __ 3. Does Not Apply __

29. When did you last have your chest X-rayed? (Year) __ __ __ __
25 26 27 28

30. Where did you last have your chest X-rayed (if known)? ____

What was the outcome? ____

FAMILY HISTORY

31. Were either of your natural parents ever told by a doctor that they had a chronic lung condition such as:

	FATHER 1. Yes	FATHER 2. No	FATHER 3. Don't Know	MOTHER 1. Yes	MOTHER 2. No	MOTHER 3. Don't Know
A. Chronic Bronchitis?	__	__	__	__	__	__
B. Emphysema?	__	__	__	__	__	__
C. Asthma?	__	__	__	__	__	__
D. Lung cancer?	__	__	__	__	__	__
E. Other chest conditions	__	__	__	__	__	__
F. Is parent currently alive?	__	__	__	__	__	__
G. Please Specify	__ Age if Living __ Age at Death __ Don't Know			__ Age if Living __ Age at Death __ Don't Know		

H. Please specify cause of death ____ ____

COUGH

32A. Do you usually have a cough? (Count a cough with first smoke or on first going out of doors. Exclude clearing of throat.) [If no, skip to question 32C.] 1. Yes __ 2. No __

B. Do you usually cough as much as 4 to 6 times a day 4 or more days out of the week? 1. Yes __ 2. No __

C. Do you usually cough at all on getting up or first thing in the morning? 1. Yes __ 2. No __

D. Do you usually cough at all during the rest of the day or at night? 1. Yes __ 2. No __

IF YES TO ANY OF ABOVE (32A, B, C, or D), ANSWER THE FOLLOWING. IF NO TO ALL, CHECK DOES NOT APPLY AND SKIP TO NEXT PAGE

E. Do you usually cough like this on most days for 3 consecutive months or more during the year? 1. Yes __ 2. No __ 3. Does not apply __

F. For how many years have you had the cough? Number of years __ Does not apply __

33A. Do you usually bring up phlegm from your chest? (Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.) (If no, skip to 33C) 1. Yes __ 2. No __

B. Do you usually bring up phlegm like this as much as twice a day 4 or more days out of the week? 1. Yes __ 2. No __

C. Do you usually bring up phlegm at all on getting up or first thing in the morning? 1. Yes __ 2. No __

D. Do you usually bring up phlegm at all during the rest of the day or at night? 1. Yes __ 2. No __

IF YES TO ANY OF THE ABOVE (33A, B, C, or D), ANSWER THE FOLLOWING: IF NO TO ALL, CHECK DOES NOT APPLY AND SKIP TO 34A.

E. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year? 1. Yes __ 2. No __ 3. Does not apply __

F. For how many years have you had trouble with phlegm? — Number of years __ Does not apply __

EPISODES OF COUGH AND PHLEGM

34A. Have you had periods or episodes of (increased*) cough and phlegm lasting for 3 weeks or more each year? — 1. Yes __ 2. No __
*(For persons who usually have cough and/or phlegm)

IF YES TO 34A
B. For how long have you had at least 1 such episode per year? — Number of years __ Does not apply __

WHEEZING

35A. Does your chest ever sound wheezy or whistling
1. When you have a cold? — 1. Yes __ 2. No __
2. Occasionally apart from colds? — 1. Yes __ 2. No __
3. Most days or nights? — 1. Yes __ 2. No __

IF YES TO 1, 2, or 3 in 35A
B. For how many years has this been present? — Number of years __ Does not apply __

36A. Have you ever had an attack of wheezing that has made you feel short of breath? — 1. Yes __ 2. No __

IF YES TO 36A
B. How old were you when you had your first such attack? — Age in years __ Does not apply __

C. Have you had 2 or more such episodes? — 1. Yes __ 2. No __ 3. Does not apply __

D. Have you ever required medicine or treatment for the(se) attack(s)? — 1. Yes __ 2. No __ 3. Does not apply __

BREATHLESSNESS

37. If disabled from walking by any condition other than heart or lung disease, please describe and proceed to question 39A.
Nature of condition(s)______________________________

38A. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill? — 1. Yes __ 2. No __

IF YES TO 38A

B. Do you have to walk slower than people of your age on the level because of breathlessness? — 1. Yes __ 2. No __ 3. Does not apply __

C. Do you ever have to stop for breath when walking at your own pace on the level? — 1. Yes __ 2. No __ 3. Does not apply __

D. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level? — 1. Yes __ 2. No __ 3. Does not apply __

E. Are you too breathless to leave the house or breathless on dressing or climbing one flight of stairs? — 1. Yes __ 2. No __ 3. Does not apply __

TOBACCO SMOKING

39A. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime or less than 1 cigarette a day for 1 year.) — 1. Yes __ 2. No __

IF YES TO 39A

B. Do you now smoke cigarettes (as of one month ago) — 1. Yes __ 2. No __ 3. Does not apply __

C. How old were you when you first started regular cigarette smoking? — Age in years __ Does not apply __

D. If you have stopped smoking cigarettes completely, how old were you when you stopped? — Age stopped __ Check if still smoking __ Does not apply __

E. How many cigarettes do you smoke per day now? — Cigarettes per day __ Does not apply __

F. On the average of the entire time you smoked, how many cigarettes did you smoke per day? — Cigarettes per day __ Does not apply __

G. Do or did you inhale the cigarette smoke?
1. Does not apply __
2. Not at all __
3. Slightly __
4. Moderately __
5. Deeply __

40A. Have you ever smoked a pipe regularly? (Yes means more than 12 oz. of tobacco in a lifetime.) — 1. Yes __ 2. No __

IF YES TO 40A:
FOR PERSONS WHO HAVE EVER SMOKED A PIPE

B. 1. How old were you when you started to smoke a pipe regularly? Age ___

2. If you have stopped smoking a pipe completely, how old were you when you stopped?
Age stopped ___
Check if still smoking pipe ___
Does not apply ___

C On the average over the entire time you smoked a pipe, how much pipe tobacco did you smoke per week?
___ oz. per week (a standard pouch of tobacco contains 1 1/2 oz.)
___ Does not apply

D. How much pipe tobacco are you smoking now?
oz. per week ___
Not currently smoking a pipe ___

E. Do you or did you inhale the pipe smoke?
1. Never smoked ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

41A. Have you ever smoked cigars regularly? (Yes means more than 1 cigar a week for a year) 1. Yes ___ 2. No ___

IF YES TO 41A
FOR PERSONS WHO HAVE EVER SMOKED CIGARS

B. 1. How old were you when you started smoking cigars regularly? Age ___

2. If you have stopped smoking cigars completely, how old were you when you stopped.
Age stopped ___
Check if still smoking cigars ___
Does not apply ___

C. On the average over the entire time you smoked cigars, how many cigars did you smoke per week?
Cigars per week ___
Does not apply ___

D. How many cigars are you smoking per week now?
Cigars per week ___
Check if not smoking cigars currently ___

E. Do or did you inhale the cigar smoke?
1. Never smoked ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

Signature ____________ Date ____________

Part 2
PERIODIC MEDICAL QUESTIONNAIRE

1. NAME ____________

2. SOCIAL SECURITY # __ __ __ __ __ __ __ __ __ (1 2 3 4 5 6 7 8 9) ___

3. CLOCK NUMBER __ __ __ __ __ __ (10 11 12 13 14 15) ___

4. PRESENT OCCUPATION ____________

5. PLANT ____________

6. ADDRESS ____________

7. ____________ (Zip Code)

8. TELEPHONE NUMBER ____________

9. INTERVIEWER ____________

10. DATE ____________ __ __ __ __ __ __ (16 17 18 19 20 21) ___

11. What is your marital status?
1. Single ___
2. Married ___
3. Widowed ___
4. Separated/ Divorced ___

12. OCCUPATIONAL HISTORY

12A. In the past year, did you work full time (30 hours per week or more) for 6 months or more? 1. Yes ___ 2. No ___

IF YES TO 12A:

12B. In the past year, did you work in a dusty job? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

12C. Was dust exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

12D. In the past year, were you exposed to gas or chemical fumes in your work? 1. Yes ___ 2. No ___

12E. Was exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

12F. In the past year, what was your:
1. Job/occupation? ____________
2. Position/job title? ____________

13. RECENT MEDICAL HISTORY

13A. Do you consider yourself to be in good health? Yes ___ No ___

If NO, state reason ______________________

13B. In the past year, have you developed:

	Yes	No
Epilepsy?	___	___
Rheumatic fever?	___	___
Kidney disease?	___	___
Bladder disease?	___	___
Diabetes?	___	___
Jaundice?	___	___
Cancer?	___	___

14. CHEST COLDS AND CHEST ILLNESSES

14A. If you get a cold, does it usually go to your chest? (Usually means more than 1/2 the time)
1. Yes ___ 2. No ___
3. Don't get colds ___

15A. During the past year, have you had any chest illnesses that have kept you off work, indoors at home, or in bed?
1. Yes ___ 2. No ___
3. Does Not Apply ___

IF YES TO 15A:

15B. Did you produce phlegm with any of these chest illnesses?
1. Yes ___ 2. No ___
3. Does Not Apply ___

15C. In the past year, how many such illnesses with (increased) phlegm did you have which lasted a week or more?
Number of illnesses ___
No such illnesses ___

16. RESPIRATORY SYSTEM

In the past year have you had:

	Yes or No	Further Comment on Positive Answers
Asthma	___	
Bronchitis	___	
Hay Fever	___	
Other Allergies	___	
Pneumonia	___	
Tuberculosis	___	
Chest Surgery	___	
Other Lung Problems	___	
Heart Disease	___	

Do you have:

	Yes or No	Further Comment on Positive Answers
Frequent colds	___	
Chronic cough	___	
Shortness of breath when walking or climbing one flight or stairs	___	

Do you:

	Yes or No	Further Comment on Positive Answers
Wheeze	___	
Cough up phlegm	___	
Smoke cigarettes	___	Packs per day ___ How many years ___

Date ______________ Signature ______________________

BILLING CODE 4510-26-C

Appendix E to § 1910.1001—Interpretation and Classification of Chest Roentgenograms—Mandatory

(a) Chest roentgenograms shall be interpreted and classified in accordance with a professionally accepted classification system and recorded on a Roentgenographic Interpretation Form. *Form CSD/NIOSH (M) 2.8.

(b) Roentgenograms shall be interpreted and classified only by a B-reader, a board eligible/certified radiologist, or an experienced physician with known expertise in pneumoconioses.

(c) All interpreters, whenever interpreting chest roentgenograms made under this section, shall have immediately available for reference a complete set of the ILO-U/C International Classification of Radiographs for Pneumoconioses, 1980.

Appendix F to § 1910.1001—Work Practices and Engineering Controls for Automotive Brake Repair Operations—Non-Mandatory

This appendix is intended as guidance for employers in the automotive brake and clutch repair industry who wish to reduce their employees' asbestos exposures during repair operations to levels below the new standard's action level (0.1 f/cc). OSHA believes that employers in this industry sector are likely to be able to reduce their employees' exposures to asbestos by employing the engineering and work practice controls described in Sections A and B of this appendix. Those employers who choose to use these controls and who achieve exposures below the action level will thus be able to avoid any burden that might be imposed by complying with such requirements as medical surveillance, recordkeeping, training, respiratory protection, and regulated areas, which are triggered when employee exposures exceed the action level or PEL.

Asbestos exposure in the automotive brake and clutch repair industry occurs primarily during the replacement of clutch plates and brake pads, shoes, and linings. Asbestos fibers may become airborne when an automotive mechanic removes the asbestos-containing residue that has been deposited as brakes and clutches wear. Employee exposures to asbestos occur during the cleaning of the brake drum or clutch housing.

Based on evidence in the rulemaking record (Exs. 84–74, 84–263, 90–148), OSHA believes that employers engaged in brake repair operations who implement any of the work practices and engineering controls described in Sections A and B of this appendix may be able to reduce their employees' exposures to levels below the action level (0.1 fiber/cc). These control methods and the relevant record evidence on these and other methods are described in the following sections.

A. Enclosed Cylinder/HEPA Vacuum System Method

The enclosed cylinder-vacuum system used in one of the facilities visited by representatives of the National Institute for Occupational Safety and Health (NIOSH) during a health hazard evaluation of brake repair facilities (Ex. 84–263) consists of three components:

(1) A wheel-shaped cylinder designed to cover and enclose the wheel assembly;

(2) A compressed-air hose and nozzle that fits into a port in the cylinder; and

(3) A HEPA-filtered vacuum used to evacuate airborne dust generated within the cylinder by the compressed air.

To operate the system, the brake assembly is enclosed in a cylinder that has viewing ports to provide visibility and cotton sleeves through which the mechanic can handle the brake assembly parts. The cylinder effectively isolates asbestos dust in the drum from the mechanic's breathing zone. The brake assembly isolation cylinder is available from the Nilfisk Company [1] and comes in two sizes to fit brake drums in the 7-to-12-inch size range common to automobiles and light trucks and the 12-to-19-inch size range common to large commercial vehicles. The cylinder is equipped with built-in compressed-air guns and a connection for a vacuum cleaner equipped with a High Efficiency Particulate Air (HEPA) filter. This type of filter is capable of removing all particles greater than 0.3 microns from the air. When the vacuum cleaner's filter is full, it must be replaced according to the manufacturer's instruction, and appropriate HEPA-filtered dual cartridge respirators should be worn during the process. The filter of the vacuum cleaner is assumed to be contaminated with asbestos fibers and should be handled carefully, wetted with a fine mist of water, placed immediately in a labelled plastic bag, and disposed of properly. When the cylinder is in place around the brake assembly and the HEPA vacuum is connected, compressed air is blown into the cylinder to loosen the residue from the brake assembly parts. The vacuum then evacuates the loosened material from within the cylinder, capturing the airborne material on the HEPA filter.

The HEPA vacuum system can be disconnected from the brake assembly isolation cylinder when the cylinder is not being used. The HEPA vacuum can then be used for clutch facing work, grinding, or other routine cleaning.

B. Compressed Air/Solvent System Method

A compressed-air hose fitted at the end with a bottle of solvent can be used to loosen the asbestos-containing residue and to capture the resulting airborne particles in the solvent mist. The mechanic should begin spraying the asbestos-contaminated parts with the solvent at a sufficient distance to ensure that the asbestos particles are not dislodged by the velocity of the solvent spray. After the asbestos particles are thoroughly wetted, the spray may be brought closer to the parts and the parts may be sprayed as necessary to remove grease and other material. The automotive parts sprayed with the mist are then wiped with a rag, which must then be disposed of appropriately. Rags should be placed in a labelled plastic bag or other container while they are still wet. This ensures that the asbestos fibers will not become airborne after the brake and clutch parts have been cleaned. (If cleanup rags are laundered rather than disposed of, they must be washed using methods appropriate for the laundering of asbestos-contaminated materials.)

[1] Mention of tradenames or commercial products does not constitute endorsement of recommendation for use.

OSHA believes that a variant of this compressed-air/solvent mist process offers advantages over the compressed-air/solvent mist technique discussed above, both in terms of costs and employee protection. The variant involves the use of spray cans filled with any of several solvent cleaners commercially available from auto supply stores. Spray cans of solvent are inexpensive, readily available, and easy to use. These cans will also save time, because no solvent delivery system has to be asembled, i.e., no compressed-air hose/mister ensemble. OSHA believes that a spray can will deliver solvent to the parts to be cleaned with considerably less force than the alternative compressed-air delivery system described above, and will thus generate fewer airborne asbestos fibers than the compressed-air method. The Agency therefore believes that the exposure levels of automotive repair mechanics using the spray can/solvent mist process will be even lower than the exposures reported by NIOSH (Ex. 84–263) for the compressed-air/solvent mist system (0.08 f/cc).

C. Information on the Effectiveness of Various Control Measures

The amount of airborne asbestos generated during brake and clutch repair operations depends on the work practices and engineering controls used during the repair or removal activity. Data in the rulemaking record document the 8-hour time-weighted average (TWA_8) asbestos exposure levels associated with various methods of brake and clutch repair and removal.

NIOSH submitted a report to the record entitled "Health Hazard Evaluation for Automotive Brake Repair" (Ex. 84–263). In addition, Exhibits 84–74 and 90–148 provided exposure data for comparing the airborne concentrations of asbestos generated by the use of various work practices during brake repair operations. These reports present exposure data for brake repair operations involving a variety of controls and work practices, including:

- Use of compressed air to blow out the brake drums;
- Use of a brush, without a wetting agent, to remove the asbestos-containing residue;
- Use of a brush dipped in water or a solvent to remove the asbestos-containing residue;
- Use of an enclosed vacuum cleaning system to capture the asbestos-containing residue; and
- Use of a solvent mixture applied with compressed air to remove the residue.

Prohibited Methods

The use of compressed air to blow the asbestos-containing residue off the surface of the brake drum removes the residue effectively but simultaneously produces an airborne cloud of asbestos fibers. According to NIOSH (Ex. 84–263), the peak exposures of mechanics using this technique were as high as 15 fibers/cc, and 8-hour TWA exposures ranged from 0.03 to 0.19 f/cc.

Dr. William J. Nicholson of the Mount Sinai School of Medicine (Ex. 84–74) cited data from Knight and Hickish (1970) that indicated that the concentration of asbestos ranged from 0.84 to 5.35 f/cc over a 60-minute sampling period when compressed air was being used to blow out the asbestos-containing residue from the brake drum. In the same study, a peak concentration of 87 f/cc was measured for a few seconds during brake cleaning performed with compressed air. Rohl et al. (1976) (Ex. 90–148) measured area concentrations (of unspecified duration) within 3–5 feet of operations involving the cleaning of brakes with compressed air and obtained readings ranging from 6.6 to 29.8 f/cc. Because of the high exposure levels that result from cleaning brake and clutch parts using compressed air, OSHA has prohibited this practice in the revised standard.

Ineffective Methods

When dry brushing was used to remove the asbestos-containing residue from the brake drums and wheel assemblies, peak exposures measured by NIOSH ranged from 0.61 to 0.81 f/cc, while 8-hour TWA levels were at the new standard's permissible exposure limit (PEL) of 0.2 f/cc (Ex. 84–263). Rohl and his colleagues (Ex. 90–148) collected area samples 1–3 feet from a brake cleaning operation being performed with a dry brush, and measured concentrations ranging from 1.3 to 3.6 f/cc; however, sampling times and TWA concentrations were not presented in the Rohl et al. study.

When a brush wetted with water, gasoline, or Stoddart solvent was used to clean the asbestos-containing residue from the affected parts, exposure levels (8-hour TWAs) measured by NIOSH also exceeded the new 0.2 f/cc PEL, and peak exposures ranged as high as 2.62 f/cc (Ex. 84–263).

Preferred Methods

Use of an engineering control system involving a cylinder that completely encloses the brake shoe assembly and a High Efficiency Particulate Air (HEPA) filter-equipped vacuum produced 8-hour TWA employee exposures of 0.01 f/cc and peak exposures ranging from nondetectable to 0.07 f/cc (Ex. 84–263). (Because this system achieved exposure levels below the standard's action level, it is described in detail below.) Data collected by the Mount Sinai Medical Center (Ex. 90–148) for Nilfisk of America, Inc., the manufacturer of the brake assembly enclosure system, showed that for two of three operations sampled, the exposure of mechanics to airborne asbestos fibers was nondetectable. For the third operator sampled by Mt. Sinai researchers, the exposure was 0.5 f/cc, which the authors attributed to asbestos that had contaminated the operator's clothing in the course of previous brake repair operations performed without the enclosed cylinder/vacuum system.

Some automotive repair facilities use a compressed-air hose to apply a solvent mist to remove the asbestos-containing residue from the brake drums before repair. The NIOSH data (Ex. 84–263) indicated that mechanics employing this method experienced exposures (8-hour TWAs) of 0.8 f/cc, with peaks of 0.25 to 0.68 f/cc. This technique, and a variant of it that OSHA believes is both less costly and more effective in reducing employee exposures, is described in greater detail above in Sections A and B.

D. Summary

In conclusion, OSHA believes that it is likely that employers in the brake and clutch repair industry will be able to avail themselves of the action level trigger built into the revised standard if they conscientiously employ one of the three control methods described above: the enclosed cylinder/HEPA vacuum system, the compressed air/solvent method, or the spray can/solvent mist system.

Appendix G to § 1910.1001—Substance Technical Information for Asbestos—Non-Mandatory

I. Substance Identification

A. Substance: "Asbestos" is the name of a class of magnesium-silicate minerals that occur in fibrous form. Minerals that are included in this group are chrysotile, crocidolite, amosite, tremolite asbestos, anthophyllite asbestos, and actinolite asbestos.

B. Asbestos, tremolite, anthophyllite, and actinolite are used in the manufacture of heat-resistant clothing, automative brake and clutch linings, and a variety of building materials including floor tiles, roofing felts, ceiling tiles, asbestos-cement pipe and sheet, and fire-resistant drywall. Asbestos is also present in pipe and boiler insulation materials, and in sprayed-on materials located on beams, in crawlspaces, and between walls.

C. The potential for a product containing asbestos, tremolite, anthophyllite, and actinolite to release breatheable fibers depends on its degree of friability. Friable means that the material can be crumbled with hand pressure and is therefore likely to emit fibers. The fibrous or fluffy sprayed-on materials used for fireproofing, insulation, or sound proofing are considered to be friable, and they readily release airborne fibers if disturbed. Materials such as vinyl-asbestos floor tile or roofing felts are considered nonfriable and generally do not emit airborne fibers unless subjected to sanding or sawing operations. Asbestos-cement pipe or sheet can emit airborne fibers if the materials are cut or sawed, or if they are broken during demolition operations.

D. Permissible exposure: Exposure to airborne asbestos, tremolite, anthophyllite, and actinolite fibers may not exceed 0.2 fibers per cubic centimeter of air (0.2 f/cc) averaged over the 8-hour workday.

II. Health Hazard Data

A. Asbestos, tremolite, anthophyllite, and actinolite can cause disabling respiratory disease and various types of cancers if the fibers are inhaled. Inhaling or ingesting fibers from contaminated clothing or skin can also result in these diseases. The symptoms of these diseases generally do not appear for 20 or more years after initial exposure.

B. Exposure to asbestos, tremolite, anthophyllite, and actinolite has been shown to cause lung cancer, mesothelioma, and cancer of the stomach and colon. Mesothelioma is a rare cancer of the thin membrane lining of the chest and abdomen. Symptoms of mesothelioma include shortness of breath, pain in the walls of the chest, and/or abdominal pain.

III. Respirators and Protective Clothing

A. Respirators: You are required to wear a respirator when performing tasks that result in asbestos, tremolite, anthophyllite, and actinolite exposure that exceeds the permissible exposure limit (PEL) of 0.2 f/cc. These conditions can occur while your employer is in the process of installing engineering controls to reduce asbestos, tremolite, anthophyllite, and actinolite exposure, or where engineering controls are not feasible to reduce asbestos, tremolite, anthophyllite, and actinolite exposure. Air-purifying respirators equipped with a high-efficiency particulate air (HEPA) filter can be used where airborne asbestos, tremolite, anthophyllite, and actinolite fiber concentrations do not exceed 2 f/cc; otherwise, air-supplied, positive-pressure, full facepiece respirators must be used. Disposable respirators or dust masks are not permitted to be used for asbestos, tremolite, anthophyllite, and actinolite work. For effective protection, respirators must fit your face and head snugly. Your employer is required to conduct fit tests when you are first assigned a respirator and every 6 months thereafter. Respirators should not be loosened or removed in work situations where their use is required.

B. Protective Clothing: You are required to wear protective clothing in work areas where asbestos, tremolite, anthophyllite, and actinolite fiber concentrations exceed the permissible exposure limit (PEL) of 0.2 f/cc to prevent contamination of the skin. Where protective clothing is required, your employer must provide you with clean garments. Unless you are working on a large asbestos, tremolite, anthophyllite, and actinolite removal or demolition project, your employer must also provide a change room and separate lockers for your street clothes and contaminated work clothes. If you are working on a large asbestos, tremolite, anthophyllite, and actinolite removal or demolition project, and where it is feasible to do so, your employer must provide a clean room, shower, and decontamination room contiguous to the work area. When leaving the work area, you must remove contaminated clothing before proceeding to the shower. If the shower is not adjacent to the work area, you must vacuum your clothing before proceeding to the change room and shower. To prevent inhaling fibers in contaminated change rooms and showers, leave your respirator on until you leave the shower and enter the clean change room.

IV. Disposal Procedures and Cleanup

A. Wastes that are generated by processes where asbestos, tremolite, anthophyllite, and actinolite is present include:

1. Empty asbestos, tremolite, anthophyllite, and actinolite shipping containers.

2. Process wastes such as cuttings, trimmings, or reject material.

3. Housekeeping waste from sweeping or vacuuming.

4. Asbestos, tremolite, anthophyllite, and actinolite fireproofing or insulating material that is removed from buildings.

5. Building products that contain asbestos, tremolite, anthophyllite, and actinolite removed during building renovation or demolition.

6. Contaminated disposable protective clothing.

B. Empty shipping bags can be flattened under exhaust hoods and packed into airtight containers for disposal. Empty shipping drums are difficult to clean and should be sealed.

C. Vacuum logs or disposable paper filters should not be cleaned, but should be sprayed with a fine water mist and placed into a labeled waste container.

D. Process waste and housekeeping waste should be wetted with water or a mixture of water and surfactant prior to packaging in disposable containers.

E. Material containing asbestos, tremolite, anthophyllite, and actinolite that is removed from buildings must be disposed of in leak-tight 6-mil thick plastic bags, plastic-lined cardboard containers, or plastic-lined metal containers. These wastes, which are removed while wet, should be sealed in containers before they dry out to minimize the release of asbestos, tremolite, anthophyllite, and actinolite fibers during handling.

V. Access to Information

A. Each year, your employer is required to inform you of the information contained in this standard and appendices for asbestos, tremolite, anthophyllite, and actinolite. In addition, your employer must instruct you in the proper work practices for handling materials containing asbestos, tremolite, anthophyllite, and actinolite, and the correct use of protective equipment.

B. Your employer is required to determine whether you are being exposed to asbestos, tremolite, anthophyllite, and actinolite. You or your representative has the right to observe employee measurements and to record the results obtained. Your employer is required to inform you of your exposure, and, if you are exposed above the permissible limit, he or she is required to inform you of the actions that are being taken to reduce your exposure to within the permissible limit.

C. Your employer is required to keep records of your exposures and medical examinations. These exposure records must be kept for at least thirty (30) years. Medical records must be kept for the period of your employment plus thirty (30) years.

D. Your employer is required to release your exposure and medical records to your physician or designated representative upon your written request.

Appendix H to § 1910.1001—Medical Surveillance Guidelines for Asbestos Tremolite, Anthophyllite, and Actinolite Non-Mandatory

I. Route of Entry Inhalation, Ingestion

II. Toxicology

Clinical evidence of the adverse effects associated with exposure to asbestos, tremolite, anthophyllite, and actinolite, is present in the form of several well-conducted epidemiological studies of occupationally exposed workers, family contacts of workers, and persons living near asbestos, tremolite, anthophyllite, and actinolite mines. These studies have shown a definite association between exposure to asbestos, tremolite, anthophyllite, and actinolite and an increased incidence of lung cancer, pleural and peritoneal mesothelioma, gastrointestinal cancer, and asbestosis. The latter is a disabling fibrotic lung disease that is caused only by exposure to asbestos. Exposure to asbestos, tremolite, anthophyllite, and actinolite has also been associated with an increased incidence of esophageal, kidney, laryngeal, pharyngeal, and buccal cavity cancers. As with other known chronic occupational diseases, disease associated with asbestos, tremolite, anthophyllite, and actinolite generally appears about 20 years following the first occurrence of exposure: There are no known acute effects associated with exposure to asbestos, tremolite, anthophyllite, and actinolite.

Epidemiological studies indicate that the risk of lung cancer among exposed workers who smoke cigarettes is greatly increased over the risk of lung cancer among non-exposed smokers or exposed nonsmokers. These studies suggest that cessation of smoking will reduce the risk of lung cancer for a person exposed to asbestos, tremolite, anthophyllite, and actinolite but will not reduce it to the same level of risk as that existing for an exposed worker who has never smoked.

III. Signs and Symptoms of Exposure-Related Disease

The signs and symptoms of lung cancer or gastrointestinal cancer induced by exposure to asbestos, tremolite, anthophyllite, and actinolite are not unique, except that a chest X-ray of an exposed patient with lung cancer may show pleural plaques, pleural calcification, or pleural fibrosis. Symptoms characteristic of mesothelioma include shortness of breath, pain in the walls of the chest, or abdominal pain. Mesothelioma has a much longer latency period compared with lung cancer (40 years versus 15–20 years), and mesothelioma is therefore more likely to be found among workers who were first exposed to asbestos at an early age. Mesothelioma is always fatal.

Asbestosis is pulmonary fibrosis caused by the accumulation of asbestos fibers in the lungs. Symptoms include shortness of breath, coughing, fatigue, and vague feelings of sickness. When the fibrosis worsens, shortness of breath occurs even at rest. The diagnosis of asbestosis is based on a history of exposure to asbestos, the presence of characteristic radiologic changes, end-inspiratory crackles (rales), and other clinical features of fibrosing lung disease. Pleural plaques and thickening are observed on X-rays taken during the early stages of the disease. Asbestosis is often a progressive disease even in the absence of continued exposure, although this appears to be a highly individualized characteristic. In severe cases, death may be caused by respiratory or cardiac failure.

IV. Surveillance and Preventive Considerations

As noted above, exposure to asbestos, tremolite, anthophyllite, and actinolite has been linked to an increased risk of lung cancer, mesothelioma, gastrointestinal cancer, and asbestosis among occupationally exposed workers. Adequate screening tests to determine an employee's potential for developing serious chronic diseases, such as cancer, from exposure to asbestos, tremolite, anthophyllite, and actinolite do not presently exist. However, some tests, particularly chest X-rays and pulmonary function tests, may indicate that an employee has been overexposed to asbestos, tremolite, anthophyllite, and actinolite, increasing his or her risk of developing exposure-related chronic diseases. It is important for the physician to become familiar with the operating conditions in which occupational exposure to asbestos, tremolite, anthophyllite, and actinolite is likely to occur. This is particularly important in evaluating medical and work histories and in conducting physical examinations. When an active employee has been identified as having been overexposed to asbestos, tremolite, anthophyllite, and actinolite, measures taken by the employer to eliminate or mitigate further exposure should also lower the risk of serious long-term consequences.

The employer is required to institute a medical surveillance program for all employees who are or will be exposed to asbestos, tremolite, anthophyllite, and actinolite at or above the action level (0.1 fiber per cubic centimeter of air) for 30 or more days per year and for all employees who are assigned to wear a negative-pressure respirator. All examinations and procedures must be performed by or under the supervision of a licensed physician, at a reasonable time and place, and at no cost to the employee.

Although broad latitude is given to the physician in prescribing specific tests to be included in the medical surveillance program, OSHA requires inclusion of the following elements in the routine examination:

(i) Medical and work histories with special emphasis directed to symptoms of the respiratory system, cardiovascular system, and digestive tract.

(ii) Completion of the respiratory disease questionnaire contained in Appendix D.

(iii) A physical examination including a chest roentgenogram and pulmonary function test that includes measurement of the employee's forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1).

(iv) Any laboratory or other test that the examining physician deems by sound medical practice to be necessary.

The employer is required to make the prescribed tests available at least annually to those employees covered; more often than specified if recommended by the examining physician; and upon termination of employment.

The employer is required to provide the physician with the following information: A copy of this standard and appendices; a description of the employee's duties as they relate to asbestos exposure; the employee's representative level of exposure to asbestos, tremolite, anthophyllite, and actinolite; a description of any personal protective and respiratory equipment used; and information from previous medical examinations of the affected employee that is not otherwise available to the physician. Making this information available to the physician will aid in the evaluation of the employee's health in relation to assigned duties and fitness to wear personal protective equipment, if required.

The employer is required to obtain a written opinion from the examining physician containing the results of the medical examination; the physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of exposure-related disease; any recommended limitations on the employee or on the use of personal protective equipment; and a statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions related to asbestos, tremolite, anthophyllite, and actinolite exposure that require further explanation or treatment. This written opinion must not reveal specific findings or diagnoses unrelated to exposure to asbestos, tremolite, anthophyllite, and actinolite, and a copy of the opinion must be provided to the affected employee.

PART 1926—[AMENDED]

5. An authority citation is added to Subpart D of Part 1926, to read as follows:

Authority: Secs. 4, 6, 8 Occupational Safety and Health Act of 1970, 29 U.S.C. 653, 655, 657; Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act), 40 U.S.C. 333, and Secretary of Labor's Orders 12–71 (36 FR 8754), 8–76 (41 FR 25059), or 9–83 (48 FR 35736), as applicable. Sections 1926.55(c) and 1926.58 also issued under 29 CFR Part 1911.

6. Paragraph (c) of § 1926.55 is hereby revised to read as follows:

§ 1926.55 Gases, vapors, fumes, dusts, and mists.

* * * * *

(c) Paragraphs (a) and (b) of this section do not apply to the exposure of employees to airborne asbestos, tremolite, anthophyllite, or actinolite dust. Whenever any employee is exposed to airborne asbestos, tremolite, anthophyllite, or actinolite dust, the requirements of § 1926.58 of this title shall apply.

7. A new § 1926.58 is added to Subpart D to read as follows:

§ 1926.58 Asbestos, tremolite, anthophyllite, and actinolite.

(a) *Scope and application.* This section applies to all construction work as defined in 29 CFR 1910.12(b), including but not limited to the following:

(1) Demolition or salvage of structures where asbestos, tremolite, anthophyllite, or actinolite is present;

(2) Removal or encapsulation of materials containing asbestos, tremolite, anthophyllite, or actinolite;

(3) Construction, alteration, repair, maintenance, or renovation of structures, substrates, or portions thereof, that contain asbestos, tremolite, anthophyllite, or actinolite;

(4) Installation of products containing asbestos, tremolite, anthophyllite, or actinolite;

(5) Asbestos, tremolite, anthophyllite, and actinolite spill/emergency cleanup; and

(6) Transportation, disposal, storage, or containment of asbestos, tremolite, anthophyllite, or actinolite or products containing asbestos, tremolite, anthophyllite, or actinolite on the site or location at which construction activities are performed.

(b) *Definitions.* "Action level" means an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals of 0.1 fiber per cubic centimeter (f/cc) of air calculated as an eight (8)-hour time-weighted average.

"Asbestos" includes chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these minerals that has been chemically treated and/or altered.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee

"Authorized person" means any person authorized by the employer and required by work duties to be present in regulated areas.

"Clean room" means an uncontaminated room having facilities for the storage of employees' street clothing and uncontaminated materials and equipment.

"Competent person" means one who is capable of identifying existing asbestos, tremolite, anthophyllite, or actinolite hazards in the workplace and who has the authority to take prompt corrective measures to eliminate them, as specified in 29 CFR 1926.32(f). The duties of the competent person include at least the following: establishing the negative-pressure enclosure, ensuring its integrity, and controlling entry to and exit from the enclosure; supervising any employee exposure monitoring required by the standard; ensuring that all employees working within such an enclosure wear the appropriate personal protective equipment, are trained in the use of appropriate methods of exposure control, and use the hygiene facilities and decontamination procedures specified in the standard; and ensuring that engineering controls in use are in proper operating condition and are functioning properly.

"Decontamination area" means an enclosed area adjacent and connected to the regulated area and consisting of an equipment room, shower area, and clean room, which is used for the decontamination of workers, materials, and equipment contaminated with asbestos, tremolite, anthophyllite, or actinolite.

"Demolition" means the wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos, tremolite, anthophyllite, or actinolite products.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

"Employee exposure" means that exposure to airborne asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals, that would occur if the employee were not using respiratory protective equipment.

"Equipment room (change room)" means a contaminated room located within the decontamination area that is supplied with impermeable bags or containers for the disposal of contaminated protective clothing and equipment.

"Fiber" means a particulate form of asbestos, tremolite, anthophyllite, or actinolite, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1.

"High-efficiency particulate air (HEPA) filter" means a filter capable of trapping and retaining at least 99.97 percent of all monodispersed particles of 0.3 micrometers in diameter or larger.

"Regulated area" means an area established by the employer to demarcate areas where airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals exceed or can reasonably be expected to exceed the permissible exposure limit. The regulated area may take the form of (1) a temporary enclosure, as required by paragraph (e)(6) of this section, or (2) an area demarcated in any manner that minimizes the number of employees exposed to asbestos, tremolite, anthophyllite, or actinolite.

"Removal" means the taking out or stripping of asbestos, tremolite, anthophyllite, or actinolite or materials containing asbestos, termolite, anthophyllite, or actinolite.

"Renovation" means the modifying of any existing structure, or portion thereof, where exposure to airborne asbestos, tremolite, anthophyllite, actinolite may result.

"Repair" means overhauling, rebuilding, reconstructing, or reconditioning of structures or substrates where asbestos, tremolite, anthophyllite,or actinolite is present.

"Tremolite, anthophyllite and actinolite" means the non-asbestos form of these minerals, and any of these minerals that have been chemically treated and/or altered.

(c) *Permissible exposure limit (PEL).* The employer shall ensure that no employee is exposed to an airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of 0.2 fiber per cubic centimeter of air as an eight (8) hour time-weighted average (TWA), as determined by the method prescribed in Appendix A of this section, or by an equivalent method.

(d) *Communication among employers.* On multi-employer worksites, an employer performing asbestos, tremolite, anthophyllite, or actinolite work requiring the establishment of a regulated area shall inform other employers on the site of the nature of the employer's work with asbestos, tremolite, anthophyllite, or actinolite and of the existence of and requirements pertaining to regulated areas.

(e) *Regulated areas*—(1) *General.* The employer shall establish a regulated area in work areas where airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals exceed or can reasonably be expected to exceed the permissible exposure limit prescribed in paragraph (c) of this section.

(2) *Demarcation.* The regulated area shall be demarcated in any manner that minimizes the number of persons within the area and protects persons outside the area from exposure to airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the permissible exposure limit.

(3) *Access.* Access to regulated areas shall be limited to authorized persons or to persons authorized by the Act or regulations issued pursuant thereto.

(4) *Respirators.* All persons entering a regulated area shall be supplied with a respirator, selected in accordance with paragraph (h)(2) of this section.

(5) *Prohibited activities.* The employer shall ensure that employees do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in the regulated area.

(6) *Requirements for asbestos removal, demolition, and renovation operations.* (i) Wherever feasible, the employer shall establish negative-pressure enclosures before commencing removal, demolition, and renovation operations.

(ii) The employer shall designate a competent person to perform or supervise the following duties:

(A) Set up the enclosure;

(B) Ensure the integrity of the enclosure;

(C) Control entry to and exit from the enclosure;

(D) Supervise all employee exposure monitoring required by this section;

(E) Ensure that employees working within the enclosure wear protective clothing and respirators as required by paragraphs (i) and (h) of this section and;

(F) Ensure that employees are trained in the use of engineering controls, work practices, and personal protective equipment;

(G) Ensure that employees use the hygiene facilities and observe the decontamination procedures specified in paragraph (j) of this section; and

(H) Ensure that engineering controls are functioning properly.

(iii) In addition to the qualifications specified in paragraph (b) of this section, the competent person shall be trained in all aspects of asbestos, tremolite, anthophyllite, or actinolite abatement, the contents of this standard, the identification of asbestos, tremolite, anthophyllite, or actinolite and their removal procedures, and other practices for reducing the hazard. Such training shall be obtained in a comprehensive course, such as a course conducted by an EPA Asbestos Training Center, or an equivalent course.

(iv) *Exception:* For small-scale, short-duration operations, such as pipe repair, valve replacement, installing electrical conduits, installing or removing drywall, roofing, and other general building maintenance or renovation, the employer is not required to comply with the requirements of paragraph (e)(6) of this section.

(f) *Exposure monitoring*—(1) *General.* (i) Each employer who has a workplace or work operation covered by this standard shall perform monitoring to determine accurately the airborne concentrations of asbestos, tremolite, anthophyllite, actinolite or a combination of these minerals to which employees may be exposed.

(ii) Determinations of employee exposure shall be made from breathing zone air samples that are representative of the 8-hour TWA of each employee.

(iii) Representative 8-hour TWA employee exposure shall be determined on the basis of one or more samples representing full-shift exposure for employees in each work area.

(2) *Initial monitoring.* (i) Each employer who has a workplace or work operation covered by this standard, except as provided for in paragraphs (f)(2)(ii) and (f)(2)(iii) of this section, shall perform initial monitoring at the initiation of each asbestos, tremolite, anthophyllite, actinolite job to accurately determine the airborne concentrations of asbestos, tremolite, anthophyllite, or actinolite to which employees may be exposed.

(ii) The employer may demonstrate that employee exposures are below the action level by means of objective data demonstrating that the product or material containing asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals cannot release airborne fibers in concentrations exceeding the action level under those work conditions having the greatest potential for releasing asbestos, tremolite, anthophyllite, or actinolite.

(iii) Where the employer has monitored each asbestos, tremolite, anthophyllite, or actinolite job, and the data were obtained during work operations conducted under workplace conditions closely resembling the processes, type of material, control methods, work practices, and environmental conditions used and prevailing in the employer's current operations, the employer may rely on such earlier monitoring results to satisfy the requirements of paragraph (f)(2)(i) of this section.

(3) *Periodic monitoring within regulated areas.* The employer shall conduct daily monitoring that is representative of the exposure of each employee who is assigned to work within a regulated area. *Exception:* When all employees within a regulated area are equipped with supplied-air respirators operated in the positive-pressure mode, the employer may dispense with the daily monitoring required by this paragraph.

(4) *Termination of monitoring.* If the periodic monitoring required by paragraph (f)(3) of this section reveals that employee exposures, as indicated by statistically reliable measurements, are below the action level, the employer may discontinue monitoring for those employees whose exposures are represented by such monitoring.

(5) *Method of monitoring.* (i) All samples taken to satisfy the monitoring requirements of paragraph (f) of this section shall be personal samples

collected following the porocedures specified in Appendix A.

(ii) All samples taken to satisfy the monitoring requirements of paragraph (f) of this section shall be evaluated using the OSHA Reference Method (ORM) specified in Appendix A, or an equivalent counting method.

(iii) If an equivalent method to the ORM is used, the employer shall ensure that the method meets the following criteria:

(A) Replicate exposure data used to establish equivalency are collected in side-by-side field and laboratory comparisons;

(B) The comparison indicates that 90 percent of the samples collected in the range 0.5 to 2.0 times the permissible limit have an accuracy range of plus or minus 25 percent of the ORM results with a 95 percent confidence level as demonstrated by a statistically valid protocol; and

(C) The equivalent method is documented and the results of the comparison testing are maintained.

(iv) To satisfy the monitoring requirements of paragraph (f), employers shall rely on the results of monitoring analysis performed by laboratories that have instituted quality assurance programs that include the elements prescribed in Appendix A:

(6) *Employee notification of monitoring results.* (i) The employer shall notify affected employees of the monitoring results that represent that employee's exposure as soon as possible following receipt of monitoring results.

(ii) The employer shall notify affected employees of the results of monitoring representing the employee's exposure in writing either individually or by posting at a centrally located place that is accessible to affected employees.

(7) *Observation of monitoring.* (i) The employer shall provide affected employees or their designated representatives an opportunity to observe any monitoring of employee exposure to asbestos, tremolite, anthophyllite, or actinolite conducted in accordance with this section.

(ii) When observation of the monitoring of employee exposure to asbestos, tremolite, anthophyllite, or actinolite requires entry into an area where the use of protective clothing or equipment is required, the observer shall be provided with and be required to use such clothing and equipment and shall comply with all other applicable safety and health procedures.

(g) *Methods of compliance.*—(1) *Engineering controls and work practices.* (i) The employer shall use one or any combination of the following control methods to achieve compliance with the permissible exposure limit prescribed by paragraph (c) of this section:

(A) Local exhaust ventilation equipped with HEPA filter dust collection systems;

(B) General ventilation systems;

(C) Vacuum cleaners equipped with HEPA filters;

(D) Enclosure or isolation of processes producing asbestos, tremolite, anthophyllite, or actinolite dust;

(E) Use of wet methods, wetting agents, or removal encapsulants to control employee exposures during asbestos, tremolite, anthophyllite, or actinolite handling, mixing, removal, cutting, application, and cleanup;

(F) Prompt disposal of wastes contaminated with asbestos, tremolite, anthophyllite, or actinolite in leak-tight containers; or

(G) Use of work practices or other engineering controls that the Assistant Secretary can show to be feasible.

(ii) Wherever the feasible engineering and work practice controls described above are not sufficient to reduce employee exposure to or below the limit prescribed in paragraph (c), the employer shall use them to reduce employee exposure to the lowest levels attainable by these controls and shall supplement them by the use of respiratory protection that complies with the requirements of paragraph (h) of this section.

(2) *Prohibitions.* (i) High-speed abrasive disc saws that are not equipped with appropriate engineering controls shall not be used for work related to asbestos, tremolite, anthophyllite, or actinolite.

(ii) Compressed air shall not be used to remove asbestos, tremolite, anthophyllite, or actinolite or materials containing asbestos, tremolite, anthophyllite, or actinolite unless the compressed air is used in conjunction with an enclosed ventilation system designed to capture the dust cloud created by the compressed air.

(iii) Materials containing asbestos, tremolite, anthophyllite, or actinolite shall not be applied by spray methods.

(3) *Employee rotation.* The employer shall not use employee rotation as a means of compliance with the exposure limit prescribed in paragraph (c) of this section.

(h) *Respiratory protection.*—(1) *General.* The employer shall provide respirators, and ensure that they are used, where required by this section. Respirators shall be used in the following circumstances:

(i) During the interval necessary to install or implement feasible engineering and work practice controls;

(ii) In work operations such as maintenance and repair activities, or other activities for which engineering and work practice controls are not feasible;

(iii) In work situations where feasible engineering and work practice controls are not yet sufficient to reduce exposure to or below the exposure limit; and

(iv) In emergencies.

(2) *Respirator selection.* (i) Where respirators are used, the employer shall select and provide, at no cost to the employee, the appropriate respirator as specified in Table D-4, and shall ensure that the employee uses the respirator provided.

(ii) The employer shall select respirators from among those jointly approved as being acceptable for protection by the Mine Safety and Health Administration (MSHA) and the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 30 CFR Part 11.

(iii) The employer shall provide a powered, air-purifying respirator in lieu of any negative-pressure respirator specified in Table D-4 whenever:

(A) An employee chooses to use this type of respirator; and

(B) This respirator will provide adequate protection to the employee.

TABLE D-4.—RESPIRATORY PROTECTION FOR ASBESTOS, TREMOLITE, ANTHOPHYLLITE, AND ACTINOLITE FIBERS

Airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals	Required respirator
Not in excess of 2 f/cc (10 X PEL).	1. Half-mask air-purifying respirator equipped with high-efficiency filters.
Not in excess of 10 f/cc (50 X PEL).	1. Full faceplace air-purifying respirator equipped with high-efficiency filters.
Not in excess of 20 f/cc (100 X PEL).	1. Any powered air purifying respirator equipped with high efficiency filters. 2. Any supplied-air respirator operated in continuous flow mode.
Not in excess of 200 f/cc (1000 X PEL).	1. Full facepiece supplied-air respirator operated in pressure demand mode.
Greater than 200 f/cc (>1,000 X PEL) or unknown concentration.	1. Full facepiece supplied air respirator operated in pressure demand mode equipped with an auxiliary positive pressure self-contained breathing apparatus.

NOTE: a. Respirators assigned for higher environmental concentrations may be used at lower concentrations.
b. A high-efficiency filter means a filter that is at least 99.97 percent efficient against mono-dispersed particles of 0.3 micrometers in diameter or larger.

(3) *Respirator program.* (i) Where respiratory protection is used, the employer shall institute a respirator program in accordance with 29 CFR 1910.134(b), (d), (e), and (f).

(ii) The employer shall permit each employee who uses a filter respirator to change the filter elements whenever an increase in breathing resistance is detected and shall maintain an adequate supply of filter elements for this purpose.

(iii) Employees who wear respirators shall be permitted to leave work areas to wash their faces and respirator facepieces whenever necessary to prevent skin irritation associated with respirator use.

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

(4) *Respirator fit testing.* (i) The employer shall ensure that the respirator issued to the employee exhibits the least possible facepiece leakage and that the respirator is fitted properly.

(ii) Employers shall perform either quantitative or qualitative face fit tests at the time of initial fitting and at least every 6 months thereafter for each employee wearing a negative-pressure respirator. The qualitative fit tests may be used only for testing the fit of half-mask respirators where they are permited to be worn, and shall be conducted in accordance with Appendix C. The tests shall be used to select facepieces that provide the required protection as prescribed in Table 1.

(i) *Protective clothing*—(1) *General:* The employer shall provide and require the use of protective clothing, such as coveralls or similar whole-body clothing, head coverings, gloves, and foot coverings for any employee exposed to airborne concentrations of asbestos, tremolite, anthophyllite, actinolite or a combination of these minerals that exceed the permissible exposure limit prescribed in paragraph (c) of this section.

(2) *Laundering.* (i) The employer shall ensure that laundering of contaminated clothing is done so as to prevent the release of airborne asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the exposure limit prescribed in paragraph (c) of this section.

(ii) Any employer who gives contaminated clothing to another person for laundering shall inform such person of the requirement in paragraph (i)(2)(i) of this section to effectively prevent the release of airborne asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the exposure limit prescribed in paragraph (c) of this section.

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

(4) *Protective clothing for removal, demolition, and renovation operations.* (i) The competent person shall periodically examine worksuits worn by employees for rips or tears that may occur during performance of work.

(ii) When rips or tears are detected while an employee is working within a negative-pressure enclosure, rips and tears shall be immediately mended, or the worksuit shall be immediately replaced.

(j) *Hygiene facilities and practices*—(1) *General.* (i) The employer shall provide clean change areas for employees required to work in regulated areas or required by paragraph (i)(1) of this section to wear protective clothing. *Exception:* In lieu of the change area requirement specified in paragraph (j)(1)(i), the employer may permit employees engaged in small scale, short duration operations, as described in paragraph (e)(6) of this section, to clean their protective clothing with a portable HEPA-equipped vacuum before such employees leave the area where maintenance was performed.

(ii) The employer shall ensure that change areas are equipped with separate storage facilities for protective clothing and street clothing, in accordance with section 1910.141(e).

(iii) Whenever food or beverages are consumed at the worksite and employees are exposed to airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the permissible exposure limit, the employer shall provide lunch areas in which the airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals are below the action level.

(2) *Requirements for removal, demolition, and renovation operations*—(i) *Decontamination area.* Except for small scale, short duration operations, as described in paragraph (e)(6) of this section, the employer shall establish a decontamination area that is adjacent and connected to the regulated area for the decontamination of employees contaminated with asbestos, tremolite, anthophyllite, or actinolite. The decontamination area shall consist of an equipment room, shower area, and clean room in series. The employer shall ensure that employees enter and exit the regulated area through the decontamination area.

(ii) *Clean room.* The clean room shall be equipped with a locker or appropriate storage container for each employee's use.

(iii) *Shower area.* Where feasible, shower facilities shall be provided which comply with 29 CFR 1910.141(d)(3). The showers shall be contiguous both to the equipment room and the clean change room, unless the employer can demonstrate that this location is not feasible. Where the employer can demonstrate that it is not feasible to locate the shower between the equipment room and the clean change room, the employer shall ensure that employees:

(A) Remove asbestos, tremolite, anthophyllite, or actinolite contamination from their worksuits using a HEPA vacuum before proceeding to a shower that is not contiguous to the work area; or

(B) Remove their contaminated worksuits, don clean worksuits, and proceed to a shower that is not contiguous to the work area.

(iv) *Equipment room.* The equipment room shall be supplied with impermeable, labeled bags and containers for the containment and disposal of contaminated protective clothing and equipment.

(v) *Decontamination area entry procedures.* (A) the employer shall ensure that employees:

(*1*) Enter the decontamination area through the clean room;

(*2*) Remove and deposit street clothing within a locker provided for their use; and

(*3*) Put on protective clothing and respiratory protection before leaving the clean room.

(B) Before entering the enclosure, the employer shall ensure that employees pass through the equipment room.

(vi) *Decontamination area exit procedures.* (A) Before leaving the regulated area, the employer shall ensure that employees remove all gross contamination and debris from their protective clothing.

(B) The employer shall ensure that employees remove their protective clothing in the equipment room and deposit the clothing in labeled impermeable bags or containers.

(C) The employer shall ensure that employees do not remove their respirators in the equipment room.

(D) The employer shall ensure that employees shower prior to entering the clean room.

(E) The employer shall ensure that, after showering, employees enter the clean room before changing into street clothes.

(k) *Communication of hazards to employees*—(1) *Signs.* (i) Warning signs that demarcate the regulated area shall be provided and displayed at each location where airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals may be in excess of the exposure limit prescribed in paragraph (c) of this section. Signs shall be posted at such a distance from such a location that an employee may read the signs and take necessary protective steps before entering the area marked by the signs.

(ii) The warning signs required by paragraph (k)(1)(i) of this section shall bear the following information:

DANGER

ASBESTOS

CANCER AND LUNG DISEASE HAZARD

AUTHORIZED PERSONNEL ONLY

RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA

(iii) Where minerals in the regulated area are only tremolite, anthophyllite or actinolite, the employer may replace the term "asbestos" with the appropriate mineral name.

(2) *Labels.* (i) Labels shall be affixed to all products containing asbestos, tremolite, anthophyllite, or actinolite and to all containers containing such products, including waste containers. Where feasible, installed asbestos, tremolite, anthophyllite, or actinolite products shall contain a visible label.

(ii) Labels shall be printed in large, bold letters on a contrasting background.

(iii) Labels shall be used in accordance with the requirements of 29 CFR 1910.1200(f) of OSHA's Hazard Communication standard, and shall contain the folowing information:

DANGER

CONTAINS ASBESTOS FIBERS

AVOID CREATING DUST

CANCER AND LUNG DISEASE HAZARD

(iv) Where minerals to be labeled are only tremolite, anthophyllite and actinolite, the employer may replace the term "asbestos" with the appropriate mineral name.

(v) Labels shall contain a warning statement against breathing airborne asbestos, tremolite, anthophyllite, or actinolite fibers.

(vi) The provisions for labels required by paragraphs (k)(2)(i)–(k)(2)(iv) do not apply where:

(A) asbestos, tremolite, anthophyllite, or actinolite fibers have been modified by a bonding agent, coating, binder, or other material, provided that the manufacturer can demonstrate that, during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these mineral fibers in excess of the action level will be released, or

(B) asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals is present in a product in concentrations less than 0.1 percent by weight.

(3) *Employee information and training.* (i) The employer shall institute a training program for all employees exposed to airborne concentrations of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals in excess of the action level and shall ensure their participation in the program.

(ii) Training shall be provided prior to or at the time of initial assignment, unless the employee has received equivalent training within the previous 12 months, and at least annually thereafter.

(iii) The training program shall be conducted in a manner that the employee is able to understand. The employer shall ensure that each such employee is informed of the following:

(A) Methods of recognizing asbestos, tremolite, anthophyllite, and actinolite;

(B) The health effects associated with asbestos, tremolite, anthophyllite, or actinolite exposure;

(C) The relationship between smoking and asbestos, tremolite, anthophyllite, and actinolite in producing lung cancer;

(D) The nature of operations that could result in exposure to asbestos, tremolite, anthophyllite, and actinolite, the importance of necessary protective controls to minimize exposure including, as applicable, engineering controls, work practices, respirators, housekeeping procedures, hygiene facilities, protective clothing, decontamination procedures, emergency procedures, and waste disposal procedures, and any necessary instruction in the use of these controls and procedures;

(E) The purpose, proper use, fitting instructions, and limitations of respirators as required by 29 CFR 1910.134;

(F) The appropriate work practices for performing the asbestos, tremolite, anthophyllite, or actinolite job; and

(G) Medical surveillance program requirements.

(H) A review of this standard, including appendices.

(4) *Access to training materials.* (i) The employer shall make readily available to all affected employees without cost all written materials relating to the employee training program, including a copy of this regulation.

(ii) The employer shall provide to the Assistant Secretary and the Director, upon request, all information and training materials relating to the employee information and training program.

(l) *Housekeeping*—(1) *Vacuuming.* Where vacuuming methods are selected, HEPA filtered vacuuming equipment must be used. The equipment shall be used and emptied in a manner that minimizes the reentry of asbestos, tremolite, anthophyllite, or actinolite into the workplace.

(2) *Waste disposal.* Asbestos waste, scrap, debris, bags, containers, equipment, and contaminated clothing consigned for disposal shall be collected and disposed of in sealed, labeled, impermeable bags or other closed, labeled, impermeable containers.

(m) *Medical surveillance*—(1) *General*—(i) *Employees covered.* The employer shall institute a medical surveillance program for all employees engaged in work involving levels of asbestos, tremolite, anthophyllite, actinolite or a combination of these minerals, at or above the action level for 30 or more days per year, or who are required by this section to wear negative pressure respirators.

(ii) *Examination by a physician.* (A) The employer shall ensure that all medical examinations and procedures are performed by or under the supervision of a licensed physician, and are provided at no cost to the employee and at a reasonable time and place.

(B) Persons other than such licensed physicians who administer the pulmonary function testing required by this section shall complete a training course in spirometry sponsored by an appropriate academic or professional institution.

(2) *Medical examinations and consultations*—(i) *Frequency.* The employer shall make available medical examinations and consultations to each employee covered under paragraph

(m)(1)(i) of this section on the following schedules:

(A) Prior to assignment of the employee to an area where negative-pressure respirators are worn;

(B) When the employee is assigned to an area where exposure to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals may be at or above the action level for 30 or more days per year, a medical examination must be given within 10 working days following the thirtieth day of exposure;

(C) And at least annually thereafter.

(D) If the examining physician determines that any of the examinations should be provided more frequently than specified, the employer shall provide such examinations to affected employees at the frequencies specified by the physician.

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

(ii) *Content.* Medical examinations made available pursuant to paragraphs (m)(2)(i)(A)–(m)(2)(i)(C) of this section shall include:

(A) A medical and work history with special emphasis directed to the pulmonary, cardiovascular, and gastrointestinal systems.

(B) On initial examination, the standardized questionnaire contained in Appendix D, Part 1, and, on annual examination, the abbreviated standardized questionnaire contained in Appendix D, Part 2.

(C) A physical examination directed to the pulmonary and gastrointestinal systems, including a chest roentgenogram to be administered at the discretion of the physician, and pulmonary function tests of forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1). Interpretation and classification of chest roentgenograms shall be conducted in accordance with Appendix E.

(D) Any other examinations or tests deemed necessary by the examining physician.

(3) *Information provided to the physician.* The employer shall provide the following information to the examining physician:

(i) A copy of this standard and Appendices D, E, and I;

(ii) A description of the affected employee's duties as they relate to the employee's exposure;

(iii) The employee's representative exposure level or anticipated exposure level;

(iv) A description of any personal protective and respiratory equipment used or to be used; and

(v) Information from previous medical examinations of the affected employee that is not otherwise available to the examining physician.

(4) *Physician's written opinion.* (i) The employer shall obtain a written opinion from the examining physician. This written opinion shall contain the results of the medical examination and shall include:

(A) The physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of material health impairment from exposure to asbestos, tremolite, anthophyllite, or actinolite;

(B) Any recommended limitations on the employee or on the use of personal protective equipment such as respirators; and

(C) A statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions that may result from asbestos, tremolite, anthophyllite, or actinolite exposure.

(ii) The employer shall instruct the physician not to reveal in the written opinion given to the employer specific findings or diagnoses unrelated to occupational exposure to asbestos, tremolite, anthophyllite, or actinolite.

(iii) The employer shall provide a copy of the physician's written opinion to the affected employee within 30 days from its receipt.

(n) *Recordkeeping*—(1) *Objective data for exempted operations.* (i) Where the employer has relied on objective data that demonstrate that products made from or containing asbestos, tremolite, anthophyllite, or actinolite are not capable of releasing fibers of asbestos, tremolite, anthophyllite, or actinolite or a combination of these minerals, in concentrations at or above the action level under the expected conditions of processing, use, or handling to exempt such operations from the initial monitoring requirements under paragraph (f)(2) of this section, the employer shall establish and maintain an accurate record of objective data reasonably relied upon in support of the exemption.

(ii) The record shall include at least the following information:

(A) The product qualifying for exemption;

(B) The source of the objective data;

(C) The testing protocol, results of testing, and/or analysis of the material for the release of asbestos, tremolite, anthophyllite, or actinolite;

(D) A description of the operation exempted and how the data support the exemption; and

(E) Other data relevant to the operations, materials, processing, or employee exposures covered by the exemption.

(iii) The employer shall maintain this record for the duration of the employer's reliance upon such objective data.

(2) *Exposure measurements.* (i) The employer shall keep an accurate record of all measurements taken to monitor employee exposure to asbestos, tremolite, anthophyllite, or actinolite as prescribed in paragraph (f) of this section.

Note: The employer may utilize the services of competent organizations such as industry trade associations and employee associations to maintain the records required by this section.

(ii) This record shall include at least the following information:

(A) The date of measurement;

(B) The operation involving exposure to asbestos, tremolite, anthophyllite, or actinolite that is being monitored;

(C) Sampling and analytical methods used and evidence of their accuracy;

(D) Number, duration, and results of samples taken;

(E) Type of protective devices worn, if any; and

(F) Name, social security number, and exposure of the employees whose exposures are represented.

(iii) The employer shall maintain this record for at least thirty (30) years, in accordance with 29 CFR 1910.20.

(3) *Medical surveillance.* (i) The employer shall establish and maintain an accurate record for each employee subject to medical surveillance by paragraph (m) of this section, in accordance with 29 CFR 1910.20.

(ii) The record shall include at least the following information:

(A) The name and social security number of the employee;

(B) A copy of the employee's medical examination results, including the medical history, questionnaire responses, results of any tests, and physician's recommendations.

(C) Physician's written opinions;

(D) Any employee medical complaints related to exposure to asbestos, tremolite, anthophyllite, or actinolite; and

(E) A copy of the information provided to the physician as required by paragraph (m) of this section.

(iii) The employer shall ensure that this record is maintained for the duration of employment plus thirty (30) years, in accordance with 29 CFR 1910.20.

(4) *Training records.* The employer shall maintain all employee training records for one 1 year beyond the last date of employment by that employer.

(5) *Availability.* (i) The employer, upon written request, shall make all records required to be maintained by this section available to the Assistant Secretary and the Director for examination and copying.

(ii) The employer, upon request, shall make any exposure records required by paragraphs (f) and (n) of this section available for examination and copying to affected employees, former employees, designated representatives, and the Assistant Secretary, in accordance with 29 CFR 1910.20(a)-(e) and (g)-(i).

(iii) The employer, upon request, shall make employee medical records required by paragraphs (m) and (n) of this section available for examination and copying to the subject employee, anyone having the specific written consent of the subject employee, and the Assistant Secretary, in accordance with 29 CFR 1910.20.

(6) *Transfer of records.* (i) The employer shall comply with the requirements concerning transfer of records set forth in 29 CFR 1910.20 (h).

(ii) Whenever the employer ceases to do business and there is no successor employer to receive and retain the records for the prescribed period, the employer shall notify the Director at least 90 days prior to disposal and, upon request, transmit them to the Director.

(o) *Dates*—(1) *Effective date.* This section shall become effective [insert date 30 days from publication in the **Federal Register**]. The requirements of the asbestos standard issued in June 1972 (37 FR 11318), as amended, and published in 29 CFR 1910.1001 (1985) remain in effect until compliance is achieved with the parallel provisions of this standard.

(2) *Start-up dates.* (i) The requirements of paragraphs (c) through (n) of this section, including the engineering controls specified in paragraph (g)(1) of this section, shall be complied with by [insert date 210 days from publication in the **Federal Register**].

(p) *Appendices.* (1) Appendices A, C, D, and E to this section are incorporated as part of this section and the contents of these appendices are mandatory.

(2) Appendices B, F, G, H, and I to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

Appendix A to § 1926.58—OSHA Reference Method—Mandatory

This mandatory appendix specifies the procedure for analyzing air samples for asbestos, tremolite, anthophyllite, and actinolite and specifies quality control procedures that must be implemented by laboratories performing the analysis. The sampling and analytical methods described below represent the elements of the available monitoring methods (such as the NIOSH 7400 method) which OSHA considers to be essential to achieve adequate employee exposure monitoring while allowing employers to use methods that are already established within their organizations. All employers who are required to conduct air monitoring under paragraph (f) of the standard are required to utilize analytical laboratories that use this procedure, or an equivalent method, for collecting and analyzing samples.

Sampling and Analytical Procedure

1. The sampling medium for air samples shall be mixed cellulose ester filter membranes. These shall be designated by the manufacturer as suitable for asbestos, tremolite, anthophyllite, and actinolite counting. See below for rejection of blanks.

2. The preferred collection device shall be the 25-mm diameter cassette with an open-faced 50-mm extension cowl. The 37-mm cassette may be used if necessary but only if written justification for the need to use the 37-mm filter cassette accompanies the sample results in the employee's exposure monitoring record.

3. An air flow rate between 0.5 liter/min and 2.5 liters/min shall be selected for the 25/mm cassette. If the 37-mm cassette is used, an air flow rate between 1 liter/min and 2.5 liters/min shall be selected.

4. Where possible, a sufficient air volume for each air sample shall be collected to yield between 100 and 1,300 fibers per square millimeter on the membrane filter. If a filter darkens in appearance or if loose dust is seen on the filter, a second sample shall be started.

5. Ship the samples in a rigid container with sufficient packing material to prevent dislodging the collected fibers. Packing material that has a high electrostatic charge on its surface (e.g., expanded polystyrene) cannot be ued because such material can cause loss of fibers to the sides of the cassette.

6. Calibrate each personal sampling pump before and after use with a representative filter cassette installed between the pump and the calibration devices.

7. Personal samples shall be taken in the "breathing zone" of the employee (i.e., attached to or near the collar or lapel near the worker's face).

8. Fiber counts shall be made by positive phase contrast using a microscope with an 8 to 10 X eyepiece and a 40 to 45 X objective for a total magnification of approximately 400 X and a numerical aperture of 0.65 to 0.75. The microscope shall also be fitted with a green or blue filter.

9. The microscope shall be fitted with a Walton-Beckett eyepiece graticule calibrated for a field diameter of 100 micrometers (+/−2 micrometers).

10. The phase-shift detection limit of the microscope shall be about 3 degrees measured using the HSE phase shift test slide as outlined below.

a. Place the test slide on the microscope stage and center it under the phase objective.

b. Bring the blocks of grooved lines into focus.

Note.—The slide consists of seven sets of grooved lines (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7, seven being the least visible. The requirements for asbestos, tremolite, anthophyllite, and actinolite counting are that the microscope optics must resolve the groooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 and 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope that fails to meet these requirements has either too low or too high a resolution to be used for asbestos, tremolite, anthophyllite, and actinolite counting.

c. If the image deteriorates, clean and adjust the microscope optics. If the problem persists, cosult the microscope manufacturer.

11. Each set of samples taken will include 10 percent blanks or a minimum of 2 blanks. The blank results shall be averaged and subtracted from the analytical results before reporting. Any samples represented by a blank having a fiber count in excess of 7 fibers/100 fields shall be rejected.

12. The samples shall be mounted by the acetone/triacetin method or a method with an equivalent index of refraction and similar clarity.

13. Observe the following counting rules.

a. Count only fibers equal to or longer than 5 micrometers. Measure the length of curved fibers along the curve.

b. Count all particles as asbestos, tremolite, anthophyllite, and actinolite that have a length-to-width ratio (aspect ratio) of 3:1 or greater.

c. Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle, shall receive the count of one half (½). Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of an individual fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields; stop counting at 100 fields regardless of fiber count.

14. Blind recounts shall be conducted at the rate of 10 percent.

Quality Control Procedures

1. Intralaboratory program. Each laboratory and/or each company with more than one microscopist counting slides shall establish a statistically designed quality assurance program involving blind recounts and

comparisons between microscopists to monitor the variability of counting by each microscopist and between microscopists. In a company with more than one laboratory, the program shall include all laboratories, and shall also evaluate the laboratory-to-laboratory variability.

2. Interlaboratory program. Each laboratory analyzing asbestos, tremolite, anthophyllite, and actinolite samples for compliance determination shall implement an interlaboratory quality assurance program that as a minimum includes participation of at least two other independent laboratories. Each laboratory shall participate in round robin testing at least once every 6 months with at least all the other laboratories in its interlaboratory quality assurance group. Each laboratory shall submit slides typical of its own workload for use in this program. The round robin shall be designed and results analyzed using appropriate statistical methodology.

3. All individuals performing asbestos, tremolite, anthophyllite, and actinolite analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos, tremolite, anthophyllite, and actinolite dust or an equivalent course.

4. When the use of different microscopes contributes to differences between counters and laboratories, the effect of the different microscope shall be evaluated and the microscope shall be replaced, as necessary.

5. Current results of these quality assurance programs shall be posted in each laboratory to keep the microscopists informed.

Appendix B to § 1926.58—Detailed Procedure for Asbestos Tremolite, Anthophyllite, and Actinolite Sampling and Analysis—Non-Mandatory

This appendix contains a detailed procedure for sampling and analysis and includes those critical elements specified in Appendix A. Employers are not required to use this procedure, but they are required to use Appendix A. The purpose of Appendix B is to provide a detailed step-by-step sampling and analysis procedure that conforms to the elements specified in Appendix A. Since this procedure may also standardize the analysis and reduce variability, OSHA encourages employers to use this appendix.

Asbestos, Tremolite, Anthophyllite, and Actinolite Sampling and Analysis Method

Technique: Microscopy, Phase Contrast.
Analyte: Fibers (Manual count).
Sample Preparation: Acetone/triacetin method.
Calibration: Phase-shift detection limit about 3 degrees.
Range: 100 to 1300 fibers/mm² filter area.
Estimated Limit of Detection: 7 fibers/mm² filter area.
Sampler: Filter (0.8–1.2 um mixed cellulose ester membrane, 25-mm diameter).
Flow Rate: 0.5 l/min to 2.5 l/min (25-mm cassette); 1.0 l/min to 2.5 l/min (37-mm cassette).
Sample Volume: Adjust to obtain 100 to 1300 fibers/mm².
Shipment: Routine.
Sample Stability: Indefinite.
Blanks: 10% of samples (minimum 2).
Standard Analytical Error: 0.25.
Applicability: The working range is 0.02 f/cc (1920–L air sample) to 1.25 f/cc (400–L air sample). The method gives an index of airborne asbestos, tremolite, anthophyllite, and actinolite fibers but may be used for other materials such as fibrous glass by inserting suitable parameters into the counting rules. The method does not differentiate between asbestos, tremolite, anthophyllite, and actinolite and other fibers. Asbestos, tremolite, anthophyllite, and actinolite fibers less than ca. 0.25 um diameter will not be detected by this method.
Interferences: Any other airborne fiber may interfere since all particles meeting the counting criteria are counted. Chain-like particles may appear fibrous. High levels of nonfibrous dust particles may obscure fibers in the field of view and raise the detection limit.

Reagents

1. Acetone.
2. Triacetin (glycerol triacetate), reagent grade.

Special Precautions

Acetone is an extremely flammable liquid and precautions must be taken not to ignite it. Heating of acetone must be done in a ventilated laboratory fume hood using a flameless, spark-free heat source.

Equipment

1. Collection device: 25-mm cassette with 50-mm extension cowl with cellulose ester filter, 0.8 to 1.2 mm pore size and backup pad.

Note.—Analyze representative filters for fiber background before use and discard the filter lot if more than 5 fibers/100 fields are found.

2. Personal sampling pump, greater than or equal to 0.5 L/min, with flexible connecting tubing.
3. Microscope, phase contrast, with green or blue filter, 8 to 10X eyepiece, and 40 to 45X phase objective (total magnification ca 400X); numerical aperture=0.65 to 0.75.
4. Slides, glass, single-frosted, pre-cleaned, 25×75 mm.
5. Cover slips, 25×25 mm, no. 1½ unless otherwise specified by microscope manufacturer.
6. Knife, #1 surgical steel, curved blade.
7. Tweezers.
8. Flask, Guth-type, insulated neck, 250 to 500 mL (with single-holed rubber stopper and elbow-jointed glass tubing, 16 to 22 cm long).
9. Hotplate, spark-free, stirring type; heating mantle; or infrared lamp and magnetic stirrer.
10. Syringe, hypodermic, with 22-gauge needle.
11. Graticule, Walton-Beckett type with 100 um diameter circular field at the specimen plane (area=0.00785 mm²), (Type G–22).

Note.—The graticule is custom-made for each microscope.

12. HSE/NPL phase contrast test slide, Mark II.
13. Telescope, ocular phase-ring centering.
14. Stage micrometer (0.01 mm divisions).

Sampling

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Fasten the sampler to the worker's lapel as close as possible to the worker's mouth. Remove the top cover from the end of the cowl extension (open face) and orient face down. Wrap the joint between the extender and the monitor's body with shrink tape to prevent air leaks.
3. Submit at least two blanks (or 10% of the total samples, whichever is greater) for each set of samples. Remove the caps from the field blank cassettes and store the caps and cassettes in a clean area (bag or box) during the sampling period. Replace the caps in the cassettes when sampling is completed.
4. Sample at 0.5 L/min or greater. Do not exceed 1 mg total dust loading on the filter. Adjust sampling flow rate, Q (L/min), and time to produce a fiber density, E (fibers/mm²), of 100 to 1300 fibers/m² [3.85×10^4 to 5×10^5 fibers per 25-mm filter with effective collection area (A_c=385 mm²)] for optimum counting precision (see step 21 below). Calculate the minimum sampling time, $t_{minimum}$ (min) at the action level (one-half of the current standard), L (f/cc) of the fibrous aerosol being sampled:

$$t_{min} = \frac{(Ac)(E)}{(Q)(L)10^3}$$

5. Remove the field monitor at the end of sampling, replace the plastic top cover and small end caps, and store the monitor.
6. Ship the samples in a rigid container with sufficient packing material to prevent jostling or damage. NOTE: Do not use polystyrene foam in the shipping container because of electrostatic forces which may cause fiber loss from the sampler filter.

Sample Preparation

Note.—The object is to produce samples with a smooth (non-grainy) background in a medium with a refractive index equal to or less than 1.46. The method below collapses the filter for easier focusing and produces permanent mounts which are useful for quality control and interlaboratory comparison. Other mounting techniques meeting the above criteria may also be used, e.g., the nonpermanent field mounting technique used in P & CAM 239.

7. Ensure that the glass slides and cover slips are free of dust and fibers.
8. Place 40 to 60 ml of acetone into a Guth-type flask. Stopper the flask with a single-hole rubber stopper through which a glass tube extends 5 to 8 cm into the flask. The portion of the glass tube that exits the top of the stopper (8 to 10 cm) is bent downward in an elbow that makes an angle of 20 to 30 degrees with the horizontal.
9. Place the flask in a stirring hotplate or wrap in a heating mantle. Heat the acetone gradually to its boiling temperature (ca. 58°C).

Caution.—The acetone vapor must be generated in a ventilated fume hood away from all open flames and spark sources. Alternate heating methods can be used, providing no open flame or sparks are present.

10. Mount either the whole sample filter or a wedge cut from the sample filter on a clean glass slide.

a. Cut wedges of ca. 25 percent of the filter area with a curved-blade steel surgical knife using a rocking motion to prevent tearing.

b. Place the filter or wedge, dust slide up, on the slide. Static electricity will usually keep the filter on the slide until it is cleared.

c. Hold the glass slide supporting the filter approximately 1 to 2 cm from the glass tube port where the acetone vapor is escaping from the heated flask. The acetone vapor stream should cause a condensation spot on the glass slide ca. 2 to 3 cm in diameter. Move the glass slide gently in the vapor stream. The filter should clear in 2 to 5 sec. If the filter curls, distorts, or is otherwise rendered unusable, the vapor stream is probably not strong enough. Periodically wipe the outlet port with tissue to prevent liquid acetone dripping onto the filter.

d. Using the hypodermic syringe with a 22-gauge needle, place 1 to 2 drops of triacetin on the filter. Gently lower a clean 25-mm square cover slip down onto the filter at a slight angle to reduce the possibility of forming bubbles. If too many bubbles form or the amount of triacetin in unsufficient, the cover slip may become detached within a few hours.

e. Glue the edges of the cover slip to the glass slide using a lacquer or nail polish.

Note.—If clearing is slow, the slide preparation may be heated on a hotplate (surface temperature 50°C) for 15 min to hasten clearing. Counting may proceed immediately after clearing and mounting are completed.

Calibration and Quality Control

11. Calibration of the Walton-Beckett graticule. The diameter, d_c (mm), of the circular counting area and the disc diameter must be specified when ordering the graticule.

a. Insert any available graticule into the eyepiece and focus so that the graticule lines are sharp and clear.

b. Set the appropriate interpupillary distance and, if applicable, reset the binocular head adjustment so that the magnification remains constant.

c. Install the 40 to 45 X phase objective.

d. Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.

e. Measure the magnified grid length, L_o (um), using the stage micrometer.

f. Remove the graticule from the microscope and measure its actual grid length, L_a (mm). This can best be accomplished by using a stage fitted with verniers.

g. Calculate the circle diameter, d_c (mm), for the Walton-Beckett graticule:

$$d_c = \frac{L_a \times D}{L_o}$$

Example: If $L_o = 108$ um, $L_a = 2.93$ mm and $D = 100$ um, then $d_c = 2.71$ mm.

h. Check the field diameter, D(acceptable range 100 mm±2 mm) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine field area (mm^2).

12. Microscope adjustments. Follow the manufacturer's instructions and also the following:

a. Adjust the light source for even illumination across the field of view at the condenser iris.

Note.—Kohler illumination is preferred, where available.

b. Focus on the particulate material to be examined.

c. Make sure that the field iris is in focus, centered on the sample, and open only enough to fully illuminate the field of view.

d. Use the telescope ocular supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric.

13. Check the phase-shift detection limit of the microscope periodically.

a. Remove the HSE/NPL phase-contrast test slide from its shipping container and center it under the phase objective.

b. Bring the blocks of grooved lines into focus.

Note.—The slide consists of seven sets of grooves (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7. The requirements for counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 to 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope which fails to meet these requirements has either too low or too high a resolution to be used for asbestos, tremolite, anthophyllite, and actinolite counting.

c. If the image quality deteriorates, clean the microscope optics and, if the problem persists, consult the microscope manufacturer.

14. Quality control of fiber counts.

a. Prepare and count field blanks along with the field samples. Report the counts on each blank. Calculate the mean of the field blank counts and subtract this value from each sample count before reporting the results.

Note 1.—The identity of the blank filters should be unknown to the counter until all counts have been completed.

Note 2.—If a field blank yields fiber counts greater than 7 fibers/100 fields, report possible contamination of the samples.

b. Perform blind recounts by the same counter on 10 percent of filters counted (slides relabeled by a person other than the counter).

15. Use the following test to determine whether a pair of counts on the same filter should be rejected because of possible bias. This statistic estimates the counting repeatability at the 95% confidence level. Discard the sample if the difference between the two counts exceeds 2.77 (F)s_r, where F=average of the two fiber counts and S_r=relative standard deviation, which should be derived by each laboratory based on historical in-house data.

Note.—If a pair of counts is rejected as a result of this test, recount the remaining samples in the set and test the new counts against the first counts. Discard all rejected paired counts.

16. Enroll each new counter in a training course that compares performance of counters on a variety of samples using this procedure.

Note.—To ensure good reproducibility, all laboratories engaged in asbestos, tremolite, anthophyllite, and actinolite counting are required to participate in the Proficiency Analytical Testing (PAT) Program and should routinely participate with other asbestos, tremolite, anthophyllite, and actinolite fiber counting laboratories in the exchange of field samples to compare performance of counters.

Measurement

17. Place the slide on the mechanical stage of the calibrated microscope with the center of the filter under the objective lens. Focus the microscope on the plane of the filter.

18. Regularly check phase-ring alignment and Kohler illumination.

19. The following are the counting rules:

a. Count only fibers longer than 5 um. Measure the length of curved fibers along the curve.

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

c. For fibers that cross the boundary of the graticule field, do the following:

1. Count any fiber longer than 5 um that lies entirely within the graticule area.

2. Count as ½ fiber any fiber with only one end lying within the graticule area.

3. Do not count any fiber that crosses the graticule boundary more than once.

4. Reject and do not count all other fibers.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of a fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields. Stop at 100 fields regardless of fiber count.

20. Start counting from one end of the filter and progress along a radial line to the other end, shift either up or down on the filter, and continue in the reverse direction. Select fields randomly by looking away from the eyepiece briefly while advancing the mechanical stage. When an agglomerate covers ca. ⅙ or more of the field of view, reject the field and select another. Do not report rejected fields in the number of total fields counted.

Note.—When counting a field, continuously scan a range of focal planes by moving the fine focus knob to detect very fine fibers which have become embedded in the filter. The small-diameter fibers will be very faint but are an important contribution to the total count.

Calculations

21. Calculate and report fiber density on the filter, E (fibers/mm²); by dividing the total fiber count, F; minus the mean field blank count, B, by the number of fields, n; and the field area, A_f (0.00785mm² for a properly calibrated Walton-Beckett graticule):

$$E = \frac{F-B}{(n)(A_f)} \text{ fibers/mm}^2$$

22. Calculate the concentration, C (f/cc), of fibers in the air volume sampled, V (L), using the effective collection area of the filter, A_c (385 mm² for a 25-mm filter):

$$C = \frac{(E)(Ac)}{V(10^3)}$$

Note.—Periodically check and adjust the value of A_c, if necessary.

Appendix C to § 1926.58—Qualitative and Quantitative Fit Testing Procedures—Mandatory

Qualitative Fit Test Protocols

I. Isoamyl Acetate Protocol

A. Odor threshold screening.

1. Three 1-liter glass jars with metal lids (e.g. Mason or Bell jars) are required.

2. Odor-free water (e.g. distilled or spring water) at approximately 25 °C shall be used for the solutions.

3. The isoamyl acetate (IAA) (also known as isopentyl acetate) stock solution is prepared by adding 1 cc of pure IAA to 800 cc of odor free water in a 1-liter jar and shaking for 30 seconds. This solution shall be prepared new at least weekly.

4. The screening test shall be conducted in a room separate from the room used for actual fit testing. The two rooms shall be well ventilated but shall not be connected to the same recirculating ventilation system.

5. The odor test solution is prepared in a second jar by placing 0.4 cc of the stock solution into 500 cc of odor free water using a clean dropper or pipette. Shake for 30 seconds and allow to stand for two to three minutes so that the IAA concentration above the liquid may reach equilibrium. This solution may be used for only one day.

6. A test blank is prepared in a third jar by adding 500 cc of odor free water.

7. The odor test and test blank jars shall be labelled 1 and 2 for jar identification. If the labels are put on the lids they can be periodically peeled, dried off and switched to maintain the integrity of the test.

8. The following instructions shall be typed on a card and placed on the table in front of the two test jars (i.e. 1 and 2): "The purpose of this test is to determine if you can smell banana oil at a low concentration. The two bottles in front of you contain water. One of these bottles also contains a small amount of banana oil. Be sure the covers are on tight, then shake each bottle for two seconds. Unscrew the lid of each bottle, one at a time, and sniff at the mouth of the bottle. Indicate to the test conductor which bottle contains banana oil."

9. The mixtures used in the IAA odor detection test shall be prepared in an area separate from where the test is performed, in order to prevent olfactory fatigue in the subject.

10. If the test subject is unable to correctly identify the jar containing the odor test solution, the IAA qualitative fit test may not be used.

11. If the test subject correctly identifies the jar containing the odor test solution, the test subject may proceed to respirator selection and fit testing.

B. Respirator Selection.

1. The test subject shall be allowed to pick the most comfortable respirator from a selection including respirators of various sizes from different manufacturers. The selection shall include at least five sizes of elastomeric half facepieces, from at least two manufacturers.

2. The selection process shall be conducted in a room separate from the fit-test chamber to prevent odor fatigue. Prior to the selection process, the test subject shall be shown how to put on a respirator, how it should be positioned on the face, how to set strap tension and how to determine a "comfortable" respirator. A mirror shall be available to assist the subject in evaluating the fit and positioning of the respirator. This instruction may not constitute the subject's formal training on respirator use, as it is only a review.

3. The test subject should understand that the employee is being asked to select the respirator which provides the most comfortable fit. Each respirator represents a different size and shape and, if fit properly and used properly will provide adequate protection.

4. The test subject holds each facepiece up to the face and eliminates those which obviously do not give a comfortable fit. Normally, selection will begin with a half-mask and if a good fit cannot be found, the subject will be asked to test the full facepiece respirators. (A small percentage of users will not be able to wear any half-mask.)

5. The more comfortable facepieces are noted; the most comfortable mask is donned and *worn at least five minutes* to assess comfort. All donning and adjustments of the facepiece shall be performed by the test subject without assistance from the test conductor or other person. Assistance in assessing comfort can be given by discussing the points in #6 below. If the test subject is not familiar with using a particular respirator, the test subject shall be directed to don the mask several times and to adjust the straps each time to become adept at setting proper tension on the straps.

6. Assessment of comfort shall include reviewing the following points with the test subject and allowing the test subject adequate time to determine the comfort of the respirator:

- Positioning of mask on nose.
- Room for eye protection.
- Room to talk.
- Positioning mask on face and cheeks.

7. The following criteria shall be used to help determine the adequacy of the respirator fit:

- Chin properly placed.
- Strap tension.
- Fit across nose bridge.
- Distance from nose to chin.
- Tendency to slip.
- Self-observation in mirror.

8. The test subject shall conduct the conventional negative and positive-pressure fit checks before conducting the negative- or positive-pressure test the subject shall be told to "seat" the mask by rapidly moving the head from side-to-side and up and down, while taking a few deep breaths.

9. The test subject is now ready for fit testing.

10. After passing the fit test, the test subject shall be questioned again regarding the comfort of the respirator. If it has become uncomfortable, another model of respirator shall be tried.

11. The employee shall be given the opportunity to select a different facepiece and be retested if the chosen facepiece becomes increasingly uncomfortable at any time.

C. Fit test.

1. The fit test chamber shall be similar to a clear 55 gal drum liner suspended inverted over a 2 foot diameter frame, so that the top of the chamber is about 6 inches above the test subject's head. The inside top center of the chamber shall have a small hook attached.

2. Each respirator used for the fitting and fit testing shall be equipped with organic vapor cartridges or offer protection against organic vapors. The cartridges or masks shall be changed at least weekly.

3. After selecting, donning, and properly adjusting a respirator, the test subject shall wear it to the fit testing room. This room shall be separate from the room used for odor threshold screening and respirator selection, and shall be well ventilated, as by an exhaust fan or lab hood, to prevent general room contamination.

4. A copy of the following test exercises and rainbow passage shall be taped to the inside of the test chamber:

Test Exercises

i. Breathe normally.

ii. Breathe deeply. Be certain breaths are *deep* and *regular*.

iii. Turn head all the way from one side to the other. Inhale on each side. Be certain movement is complete. Do not bump the respirator against the shoulders.

iv. Nod head up-and-down. Inhale when head is in the full up position (looking toward ceiling). Be certain motions are complete and made about every second. Do not bump the respirator on the chest.

v. Talking. Talk aloud and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement.

Alternative passages which serve the same purpose may also be used.

vi. Jogging in place.

vii. Breathe normally.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

5. Each test subject shall wear the respirator for at least 10 minutes before starting the fit test.

6. Upon entering the test chamber, the test subject shall be given a 6 inch by 5 inch piece of paper towel or other porous absorbent single ply material, folded in half and wetted with three-quarters of one cc of pure IAA. The test subject shall hang the wet towel on the hook at the top of the chamber.

7. Allow two minutes for the IAA test concentration to be reached before starting the fit-test exercises. This would be an appropriate time to talk with the test subject, to explain the fit test, the importance of cooperation, the purpose for the head exercises, or to demonstrate some of the exercises.

8. Each exercise described in #4 above shall be performed for at least one minute.

9. If at any time during the test, the subject detects the banana-like odor of IAA, the test has failed. The subject shall quickly exit from the test chamber and leave the test area to avoid olfactory fatigue.

10. If the test is failed, the subject shall return to the selection room and remove the respirator, repeat the odor sensitivity test, select and put on another respirator, return to the test chamber, and again begin the procedure described in the c(4) through c(8) above. The process continues until a respirator that fits well has been found. Should the odor sensitivity test be failed, the subject shall wait about 5 minutes before retesting. Odor sensitivity will usually have returned by this time.

11. If a person cannot pass the fit test described above wearing a half-mask respirator from the available selection, full facepiece models must be used.

12. When a respirator is found that passes the test, the subject breaks the faceseal and takes a breath before exiting the chamber. This is to assure that the reason the test subject is not smelling the IAA is the good fit of the respirator facepiece seal and not olfactory fatigue.

13. When the test subject leaves the chamber, the subject shall remove the saturated towel and return it to the person conducting the test. To keep the area from becoming contaminated, the used towels shall be kept in a self-sealing bag so there is no significant IAA concentration buildup in the test chamber during subsequent tests.

14. At least two facepieces shall be selected for the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

15. Persons who have successfully passed this fit test with a half-mask respirator may be assigned the use of the test respirator in atmospheres with up to 10 times the PEL of airborne asbestos. In atmospheres greater than 10 times, and less than 100 times the PEL (up to 100 ppm), the subject must pass the IAA test using a full face negative pressure respirator. (The concentration of the IAA inside the test chamber must be increased by ten times for QLFT of the full facepiece.)

16. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

17. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

18. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

19. Qualitative fit testing shall be repeated at least every six months.

20. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more,

(2) Significant facial scarring in the area of the facepiece seal,

(3) Significant dental changes; i.e.; multiple extractions without prothesis, or acquiring dentures,

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

D. Recordkeeping.

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of the test conductor.

(4) Respirators selected (indicate manufacturer, model, size and approval number).

(5) Testing agent.

II. Saccharin Solution Aerosol Protocol

A. Respirator Selection.

Respirators shall be selected as described in section IB (respirator selection) above, except that each respirator shall be equipped with a particulate filter.

B. Taste Threshold Screening.

1. An enclosure about head and shoulders shall be used for threshold screening (to determine if the individual can taste saccharin) and for fit testing. The enclosure shall be approximately 12 inches in diameter by 14 inches tall with at least the front clear to allow free movement of the head when a respirator is worn.

2. The test enclosure shall have a three-quarter inch hole in front of the test subject's nose and mouth area to accommodate the nebulizer nozzle.

3. The entire screening and testing procedure shall be explained to the test subject prior to conducting the screening test.

4. During the threshold screening test, the test subject shall don the test enclosure and breathe with open mouth with tongue extended.

5. Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the threshold check solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the fit test solution nebulizer.

6. The threshold check solution consists of 0.83 grams of sodium saccharin, USP in water. It can be prepared by putting 1 cc of the test solution (see C 7 below) in 100 cc of water.

7. To produce the aerosol, the nebulizer bulb is firmly squeezed so that it collapses completely, then is released and allowed to fully expand.

8. Ten squeezes of the nebulizer bulb are repeated rapidly and then the test subject is asked whether the saccharin can be tasted.

9. If the first response is negative, ten more squeezes of the nebulizer bulb are repeated rapidly and the test subject is again asked whether the saccharin can be tasted.

10. If the second response is negative ten more squeezes are repeated rapidly and the test subject is again asked whether the saccharin can be tasted.

11. The test conductor will take note of the number of squeezes required to elicit a taste response.

12. If the saccharin is not tasted after 30 squeezes (Step 10), the saccharin fit test cannot be performed on the test subject.

13. If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit test.

14. Correct use of the nebulizer means that approximately 1 cc of liquid is used at a time in the nebulizer body.

15. The nebulizer shall be thoroughly rinsed in water, shaken dry, and refilled at least every four hours.

C. Fit test.

1. The test subject shall don and adjust the respirator without the assistance from any person.

2. The fit test uses the same enclosure described in IIB above.

3. Each test subject shall wear the respirator for at least 10 minutes before starting the fit test.

4. The test subject shall don the enclosure while wearing the respirator selected in section IB above. This respirator shall be properly adjusted and equipped with a particulate filter.

5. The test subject may not eat, drink (except plain water), or chew gum for 15 minutes before the test.

6. A second DeVilbiss Model 40 Inhalation Medication Nebulizer is used to spray the fit test solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the screening test solution nebulizer.

7. The fit test solution is prepared by adding 83 grams of sodium saccharin to 100 cc of warm water.

8. As before, the test subject shall breathe with mouth open and tongue extended.

9. The nebulizer is inserted into the hole in the front of the enclosure and the fit test solution is sprayed into the enclosure using the same technique as for the taste threshold screening and the same number of squeezes required to elicit a taste response in the screening. (See B8 through B10 above.)

10. After generation of the aerosol read the following instructions to the test subject. The test subject shall perform the exercises for one minute each.

i. Breathe normally.

ii. Breathe deeply. Be certain breaths are *deep* and *regular*.

iii. Turn head all the way from one side to the other. Be certain movement is complete. Inhale on each side. Do not bump the respirator against the shoulders.

iv. Nod head up-and-down. Be certain motions are complete. Inhale when head is in the full up position (when looking toward the ceiling). Do not bump the respirator on the chest.

v. Talking. Talk aloud and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement. Alternative passages which serve the same purpose may also be used.

vi. Jogging in place.

vii. Breathe normally.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

11. At the beginning of each exercise, the aerosol concentration shall be replenished using one-half the number of squeezes as initially described in C9.

12. The test subject shall indicate to the test conductor if at any time during the fit test the taste of saccharin is detected.

13. If the saccharin is detected the fit is deemed unsatisfactory and a different respirator shall be tried.

14. At least two facepieces shall be selected by the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

15. Successful completion of the test protocol shall allow the use of the half mask tested respirator in contaminated atmospheres up to 10 times the PEL of asbestos. In other words this protocol may be used to assign protection factors no higher than ten.

16. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

17. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

18. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

19. Qualitative fit testing shall be repeated at least every six months.

20. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more,

(2) Significant facial scarring in the area of the facepiece seal,

(3) Significant dental changes; i.e.; multiple extractions without prothesis, or acquiring dentures,

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

D. Recordkeeping.

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of test conductor.

(4) Respirators selected (indicate manufacturer, model, size and approval number).

(5) Testing agent.

III. Irritant Fume Protocol

A. Respirator selection.

Respirators shall be selected as described in section IB above, except that each respirator shall be equipped with a combination of high-efficiency and acid-gas cartridges.

B. Fit test.

1. The test subject shall be allowed to smell a weak concentration of the irritant smoke to familiarize the subject with the characteristic odor.

2. The test subject shall properly don the respirator selected as above, and wear it for at least 10 minutes before starting the fit test.

3. The test conductor shall review this protocol with the test subject before testing.

4. The test subject shall perform the conventional positive pressure and negative pressure fit checks (see ANSI Z88.2 1980). Failure of either check shall be cause to select an alternate respirator.

5. Break both ends of a ventilation smoke tube containing stannic oxychloride, such as the MSA part #5645, or equivalent. Attach a short length of tubing to one end of the smoke tude. Attach the other end of the smoke tube to a low pressure air pump set to deliver 200 milliliters per minute.

6. Advise the test subject that the smoke can be irritating to the eyes and instruct the subject to keep the eyes closed while the test is performed.

7. The test conductor shall direct the stream of irritant smoke from the tube towards the faceseal area of the test subject. The person conducting the test shall begin with the tube at least 12 inches from the facepiece and gradually move to within one inch, moving around the whole perimeter of the mask.

8. The test subject shall be instructed to do the following exercises while the respirator is being challenged by the smoke. Each exercise shall be performed for one minute.

i. Breathe normally.

ii. Breathe deeply. Be certain breaths are *deep* and *regular*.

iii. Turn head all the way from one side to the other. Be certain movement is complete. Inhale on each side. Do not bump the respirator against the shoulders.

iv. Nod head up-and-down. Be certain motions are complete and made every second. Inhale when head is in the full up position (looking toward ceiling). Do not bump the respirator against the chest.

v. Talking. Talk aloud and slowly for several minutes. The following paragraph is called the Rainbow Passage. Reading it will result in a wide range of facial movements, and thus be useful to satisfy this requirement. Alternative passages which serve the same purpose may also be used.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two end apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

vi. Jogging in Place.

vii. Breathe normally.

9. The test subject shall indicate to the test conductor if the irritant smoke is detected. If smoke is detected, the test conductor shall stop the test. In this case, the tested respirator is rejected and another respirator shall be selected.

10. Each test subject passing the smoke test (i.e., without detecting the smoke) shall be given a sensitivity check of smoke from the same tube to determine if the test subject reacts to the smoke. Failure to evoke a response shall void the fit test.

11. Steps B4, B9, B10 of this fit test protocol shall be performed in a location with exhaust ventilation sufficient to prevent general contamination of the testing area by the test agents.

12. At least two facepieces shall be selected by the IAA test protocol. The test subject shall be given the opportunity to wear them for one week to choose the one which is more comfortable to wear.

13. Respirators successfully tested by the protocol may be used in contaminated atmospheres up to ten times the PEL of asbestos.

14. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

15. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

16. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

17. Qualitative fit testing shall be repeated at least every six months.

18. In addition, because the sealing of the respirator may be affected, qualitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more.

(2) Significant facial scarring in the area of the facepiece seal.

(3) Significant dental changes: i.e., multiple extractions without prothesis, or acquiring dentures.

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

C. Recordkeeping.

A summary of all test results shall be maintained in each office for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of test conductor.

(4) Respirators selected (indicate manufacturer, model, size and approval number).

(5) Testing agent.

Quantitative Fit Test Procedures

1. *General.*

a. The method applies to the negative-pressure nonpowered air-purifying respirators only.

b. The employer shall assign one individual who shall assume the full responsibility for implementing the respirator quantitative fit test program.

2. *Definition.*

a. "Quantitative Fit Test" means the measurement of the effectiveness of a respirator seal in excluding the ambient atmosphere. The test is performed by dividing the measured concentration of challenge agent in a test chamber by the measured concentration of the challenge agent inside the respirator facepiece when the normal air purifying element has been replaced by an essentially perfect purifying element.

b. "Challenge Agent" means the air contaminant introduced into a test chamber so that its concentration inside and outside the respirator may be compared.

c. "Test Subject" means the person wearing the respirator for quantitative fit testing.

d. "Normal Standing Position" means standing erect and straight with arms down along the sides and looking straight ahead.

e. "Fit Factor" means the ratio of challenge agent concentration outside with respect to the inside of a respirator inlet covering (facepiece or enclosure).

3. *Apparatus.*

a. *Instrumentation.* Corn oil, sodium chloride or other appropriate aerosol generation, dilution, and measurement systems shall be used for quantitative fit test.

b. *Test chamber.* The test chamber shall be large enough to permit all test subjects to freely perform all required exercises without distributing the challenge agent concentration or the measurement apparatus. The test chamber shall be equipped and constructed so that the challenge agent is effectively isolated from the ambient air yet uniform in concentration throughout the chamber.

c. When testing air-purifying respirators, the normal filter or cartridge element shall be replaced with a high-efficiency particular filter supplied by the same manufacturer.

d. The sampling instrument shall be selected so that a strip chart record may be made of the test showing the rise and fall of challenge agent concentration with each inspiration and expiration at fit factors of at least 2,000.

e. The combination of substitute air-purifying elements (if any), challenge agent, and challenge agent concentration in the test chamber shall be such that the test subject is not exposed in excess of PEL to the challenge agent at any time during the testing process.

f. The sampling port on the test specimen respirator shall be placed and constructed so that there is no detectable leak around the port, a free air flow is allowed into the sampling line at all times and so there is no interference with the fit or performance of the respirator.

g. The test chamber and test set-up shall permit the person administering the test to observe one test subject inside the chamber during the test.

h. The equipment generating the challenge atmosphere shall maintain the concentration of challenge agent constant within a 10 percent variation for the duration of the test.

i. The time lag (interval between an event and its being recorded on the strip chart) of the instrumentation may not exceed 2 seconds.

j. The tubing for the test chamber atmosphere and for the respirator sampling port shall be the same diameter, length and material. It shall be kept as short as possible. The smallest diameter tubing recommended by the manufacturer shall be used.

k. The exhaust flow from the test chamber shall pass through a high-efficiency filter before release to the room.

l. When sodium chloride aerosol is used, the relative humidity inside the test chamber shall not exceed 50 percent.

4. *Procedural Requirements*

a. The fitting of half-mask respirators should be started with those having multiple sizes and a variety of interchangeable cartridges and canisters such as the MSA Comfo II-M, Norton M, Survivair M, A–O M, or Scott–M. Use either of the tests outlined below to assure that the facepiece is properly adjusted.

(1) *Positive pressure test.* With the exhaust port(s) blocked, the negative pressure of slight inhalation should remain constant for several seconds.

(2) *Negative pressure test.* With the intake port(s) blocked, the negative pressure slight inhalation should remain constant for several seconds.

b. After a facepiece is adjusted, the test subject shall wear the facepiece for at least 5 minutes before conducting a qualitative test by using either of the methods described below and using the exercise regime described in 5.a., b., c., d. and e.

(1) *Isoamyl acetate test.* When using organic vapor cartridges, the test subject who can smell the odor should be unable to detect the odor of isoamyl acetate squirted into the air near the most vulnerable portions of the facepiece seal. In a location which is separated from the test area, the test subject shall be instructed to close her/his eyes during the test period. A combination cartridge or canister with organic vapor and high-efficiency filters shall be used when available for the particular mask being tested. The test subject shall be given an opportunity to smell the odor of isoamyl acetate before the test is conducted.

(2) *Irritant fume test.* When using high-efficiency filters, the test subject should be unable to detect the odor of irritant fume (stannic chloride or titanium tetrachloride ventilation smoke tubes) squirted into the air near the most vulnerable portions of the facepiece seal. The test subject shall be instructed to close her/his eyes during the test period.

c. The test subject may enter the quantitative testing chamber only if she or he has obtained a satisfactory fit as stated in 4.b. of this Appendix.

d. Before the subject enters the test chamber, a reasonably stable challenge agent concentration shall be measured in the test chamber.

e. Immediately after the subject enters the test chamber, the challenge agent concentration inside the respirator shall be measured to ensure that the peak penetration does not exceed 5 percent for a half-mask and 1 percent for a full facepiece.

f. A stable challenge agent concentration shall be obtained prior to the actual start of testing.

(1) Respirator restraining straps may not be overtightened for testing. The straps shall be adjusted by the wearer to give a reasonably comfortable fit typical of normal use.

5. *Exercise Regime.* Prior to entering the test chamber, the test subject shall be given complete instructions as to her/his part in the test procedures. The test subject shall perform the following exercises, in the order given, for each independent test.

a. *Normal Breathing (NB).* In the normal standing position, without talking, the subject shall breathe normally for at least one minute.

b. *Deep Breathing (DB).* In the normal standing position the subject shall do deep breathing for at least one minute pausing so as not to hyperventilate.

c. *Turning head side to side. (SS).* Standing in place the subject shall slowly turn his/her head from side between the extreme positions to each side. The head shall be held at each extreme position for at least 5 seconds. Perform for at least three complete cycles.

d. *Moving head up and down (UD).* Standing in place, the subject shall slowly move his/her head up and down between the extreme position straight up and the extreme position straight down. The head shall be held at each extreme position for at least 5 seconds. Perform for at least three complete cycles.

e. *Reading (R).* The subject shall read out slowly and loud so as to be heard clearly by the test conductor or monitor. The test subject shall read the "rainbow passage" at the end of this section.

f. *Grimace (G).* The test subject shall grimace, smile, frown, and generally contort the face using the facial muscles. Continue for at least 15 seconds.

g. *Bend over and touch toes (B).* The test subject shall bend at the waist and touch toes and return to upright position. Repeat for at least 30 seconds.

h. *Jogging in place (J).* The test subject shall perform jog in place for at least 30 seconds.

i. *Normal Breathing (NB).* Same as exercise a.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

6. The test shall be terminated whenever any single peak penetration exceeds 5 percent for half-masks and 1 percent for full facepieces. The test subject may be refitted and retested. If two of the three required tests are terminated, the fit shall be deemed inadequate. (See paragraph 4.h.).

7. *Calculation of Fit Factors.*

a. The fit factor determined by the quantitative fit test equals the average concentration inside the respirator.

b. The average test chamber concentration is the arithmetic average of the test chamber concentration at the beginning and of the end of the test.

c. The average peak concentration of the challenge agent inside the respirator shall be the arithmetic average peak concentrations for each of the nine exercises of the test which are computed as the arithmetic average of the peak concentrations found for each breath during the exercise.

d. The average peak concentration for an exercise may be determined graphically if there is not a great variation in the peak concentrations during a single exercise.

8. *Interpretation of Test Results.* The fit factor measured by the quantitative fit testing shall be the lowest of the three protection factors resulting from three independent tests.

9. *Other Requirements.*

a. The test subject shall not be permitted to wear a half-mask or full facepiece mask if the minimum fit factor of 100 or 1,000, respectively, cannot be obtained. If hair growth or apparel interfere with a satisfactory fit, then they shall be altered or removed so as to eliminate interference and allow a satisfactory fit. If a satisfactory fit is still not attained, the test subject must use a positive-pressure respirator such as powered air-purifying respirators, supplied air respirator, or self-contained breathing apparatus.

b. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface.

c. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician trained in respirator diseases or pulmonary medicine to determine whether the test subject can wear a respirator while performing her or his duties.

d. The test subject shall be given the opportunity to wear the assigned respirator for one week. If the respirator does not provide a satisfactory fit during actual use, the test subject may request another QNFT which shall be performed immediately.

e. A respirator fit factor card shall be issued to the test subject with the following information:

(1) Name.

(2) Date of fit test.

(3) Protection factors obtained through each manufacturer, model and approval number of respirator tested.

(4) Name and signature of the person that conducted the test.

f. Filters used for qualitative or quantitative fit testing shall be replaced weekly, whenever increased breathing resistance is encountered, or when the test agent has altered the integrity of the filter media. Organic vapor cartridges/canisters shall be replaced daily or sooner if there is any indication of breakthrough by the test agent.

10. In addition, because the sealing of the respirator may be affected, quantitative fit testing shall be repeated immediately when the test subject has a:

(1) Weight change of 20 pounds or more,

(2) Significant facial scarring in the area of the facepiece seal,

(3) Significant dental changes; i.e.; multiple extractions without prothesis, or acquiring dentures,

(4) Reconstructive or cosmetic surgery, or

(5) Any other condition that may interfere with facepiece sealing.

11. *Recordkeeping.*

A summary of all test results shall be maintained for 3 years. The summary shall include:

(1) Name of test subject.

(2) Date of testing.

(3) Name of the test conductor.

(4) Fit factors obtained from every respirator tested (indicate manufacturer, model, size and approval number).

Appendix D to § 1926.58—Medical Questionnaires; Mandatory

This mandatory appendix contains the medical questionnaires that must be administered to all employees who are exposed to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals above the action level, and who will therefore be included in their employer's medical surveillance program. Part 1 of the appendix contains the Initial Medical Questionnaire, which must be obained for all new hires who will be covered by the medical surveillance requirements. Part 2 includes the abbreviated Periodical Medical Questionnaire, which must be administered to all employees who are provided periodic medical examinations under the medical surveillance provisions of the standard.

BILLING CODE 4510-26-M

Part 1
INITIAL MEDICAL QUESTIONNAIRE

1. NAME ______________________

2. SOCIAL SECURITY # ___ 1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6 ___ 7 ___ 8 ___ 9

3. CLOCK NUMBER ___ 10 ___ 11 ___ 12 ___ 13 ___ 14 ___ 15

4. PRESENT OCCUPATION ______________________

5. PLANT ______________________

6. ADDRESS ______________________

7. ______________________ (Zip Code)

8. TELEPHONE NUMBER ______________________

9. INTERVIEWER ______________________

10. DATE ______________________ ___ 16 ___ 17 ___ 18 ___ 19 ___ 20 ___ 21

11. Date of Birth ______________________ Month Day Year ___ 22 ___ 23 ___ 24 ___ 25 ___ 26 ___ 27

12. Place of Birth ______________________

13. Sex
1. Male ___
2. Female ___

14. What is your marital status?
1. Single ___
2. Married ___
3. Widowed ___
4. Separated/ Divorced ___

15. Race
1. White ___
2. Black ___
3. Asian ___
4. Hispanic ___
5. Indian ___
6. Other ___

16. What is the highest grade completed in school? ___________
(For example 12 years is completion of high school)

OCCUPATIONAL HISTORY

17A. Have you ever worked full time (30 hours per week or more) for 6 months or more? 1. Yes ___ 2. No ___

IF YES TO 17A:

B. Have you ever worked for a year or more in any dusty job? 1. Yes ___ 2. No ___ 3. Does Not Apply ___

Specify job/industry ______________ Total Years Worked ___

Was dust exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

C. Have you even been exposed to gas or chemical fumes in your work? 1. Yes ___ 2. No ___
Specify job/industry ______________ Total Years Worked ___

Was exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

D. What has been your usual occupation or job--the one you have worked at the longest?

1. Job occupation ______________________

2. Number of years employed in this occupation ___________

3. Position/job title ______________________

4. Business, field or industry ______________________

(Record on lines the years in which you have worked in any of these industries, e.g. 1960-1969)

Have you ever worked:

		YES	NO
E.	In a mine?	[ ]	[ ]
F.	In a quarry?	[ ]	[ ]
G.	In a foundry?	[ ]	[ ]
H.	In a pottery?	[ ]	[ ]
I.	In a cotton, flax or hemp mill?	[ ]	[ ]
J.	With asbestos?	[ ]	[ ]

18. PAST MEDICAL HISTORY

		YES	NO
A.	Do you consider yourself to be in good health?	[ ]	[ ]
	If "NO" state reason ______________		
B.	Have you any defect of vision?	[ ]	[ ]
	If "YES" state nature of defect ______________		
C.	Have you any hearing defect?	[ ]	[ ]
	If "YES" state nature of defect ______________		

D. Are you suffering from or have you ever suffered from:

a. Epilepsy (or fits, seizures, convulsions)?	[__]	[__]
b. Rheumatic fever?	[__]	[__]
c. Kidney disease?	[__]	[__]
d. Bladder disease?	[__]	[__]
e. Diabetes?	[__]	[__]
f. Jaundice?	[__]	[__]

19. CHEST COLDS AND CHEST ILLNESSES

19A. If you get a cold, does it usually go to your chest? (Usually means more than 1/2 the time) — 1. Yes __ 2. No __ 3. Don't get colds __

20A. During the past 3 years, have you had any chest illnesses that have kept you off work, indoors at home, or in bed? — 1. Yes __ 2. No __

IF YES TO 20A:

B. Did you produce phlegm with any of these chest illnesses? — 1. Yes __ 2. No __ 3. Does Not Apply __

C. In the last 3 years, how many such illnesses with (increased) phlegm did you have which lasted a week or more? — Number of illnesses __ No such illnesses __

21. Did you have any lung trouble before the age of 16? — 1. Yes __ 2. No __

22. Have you ever had any of the following?

1A. Attacks of bronchitis? — 1. Yes __ 2. No __

IF YES TO 1A:

B. Was it confirmed by a doctor? — 1. Yes __ 2. No __ 3. Does Not Apply __

C. At what age was your first attack? — Age in Years __ Does Not Apply __

2A. Pneumonia (include bronchopneumonia)? — 1. Yes __ 2. No __

IF YES TO 2A:

B. Was it confirmed by a doctor? — 1. Yes __ 2. No __ 3. Does Not Apply __

C. At what age did you first have it? — Age in Years __ Does Not Apply __

3A. Hay Fever? — 1. Yes __ 2. No __

IF YES TO 3A:

B. Was it confirmed by a doctor? — 1. Yes __ 2. No __ 3. Does Not Apply __

C. At what age did it start? — Age in Years __ Does Not Apply __

23A. Have you ever had chronic bronchitis? — 1. Yes __ 2. No __

IF YES TO 23A:

B. Do you still have it? — 1. Yes __ 2. No __ 3. Does Not Apply __

C. Was it confirmed by a doctor? — 1. Yes __ 2. No __ 3. Does Not Apply __

D. At what age did it start? — Age in Years __ Does Not Apply __

24A. Have you ever had emphysema? — 1. Yes __ 2. No __

IF YES TO 24A:

B. Do you still have it? — 1. Yes __ 2. No __ 3. Does Not Apply __

C. Was it confirmed by a doctor? — 1. Yes __ 2. No __ 3. Does Not Apply __

D. At what age did it start? — Age in Years __ Does Not Apply __

25A. Have you ever had asthma? — 1. Yes __ 2. No __

IF YES TO 25A:

B. Do you still have it? — 1. Yes __ 2. No __ 3. Does Not Apply __

C. Was it confirmed by a doctor? — 1. Yes __ 2. No __ 3. Does Not Apply __

D. At what age did it start? — Age in Years __ Does Not Apply __

E. If you no longer have it, at what age did it stop? — Age stopped __ Does Not Apply __

26. Have you ever had:

A. Any other chest illness? — 1. Yes __ 2. No __

If yes, please specify ________________________

B. Any chest operations? 1. Yes __ 2. No __

If yes, please specify ______

C. Any chest injuries? 1. Yes __ 2. No __

If yes, please specify ______

27A. Has a doctor ever told you that you had heart trouble? 1. Yes __ 2. No __

IF YES TO 27A:

B. Have you ever had treatment for heart trouble in the past 10 years? 1. Yes __ 2. No __ 3. Does Not Apply __

28A. Has a doctor ever told you that you had high blood pressure? 1. Yes __ 2. No __

IF YES TO 28A:

B. Have you had any treatment for high blood pressure (hypertension) in the past 10 years? 1. Yes __ 2. No __ 3. Does Not Apply __

29. When did you last have your chest X-rayed? (Year) __ __ __ __
25 26 27 28

30. Where did you last have your chest X-rayed (if known)? ______

What was the outcome? ______

FAMILY HISTORY

31. Were either of your natural parents ever told by a doctor that they had a chronic lung condition such as:

	FATHER			MOTHER		
	1. Yes	2. No	3. Don't Know	1. Yes	2. No	3. Don't Know
A. Chronic Bronchitis?	__	__	__	__	__	__
B. Emphysema?	__	__	__	__	__	__
C. Asthma?	__	__	__	__	__	__
D. Lung cancer?	__	__	__	__	__	__
E. Other chest conditions	__	__	__	__	__	__
F. Is parent currently alive?	__	__	__	__	__	__
G. Please Specify	__ Age if Living __ Age at Death __ Don't Know			__ Age if Living __ Age at Death __ Don't Know		

H. Please specify cause of death ______ ______

COUGH

32A. Do you usually have a cough? (Count a cough with first smoke or on first going out of doors. Exclude clearing of throat.) [If no, skip to question 32C.] 1. Yes __ 2. No __

B. Do you usually cough as much as 4 to 6 times a day 4 or more days out of the week? 1. Yes __ 2. No __

C. Do you usually cough at all on getting up or first thing in the morning? 1. Yes __ 2. No __

D. Do you usually cough at all during the rest of the day or at night? 1. Yes __ 2. No __

IF YES TO ANY OF ABOVE (32A, B, C, or D), ANSWER THE FOLLOWING. IF NO TO ALL, CHECK DOES NOT APPLY AND SKIP TO NEXT PAGE

E. Do you usually cough like this on most days for 3 consecutive months or more during the year? 1. Yes __ 2. No __ 3. Does not apply __

F. For how many years have you had the cough? Number of years __ Does not apply __

33A. Do you usually bring up phlegm from your chest? (Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.) (If no, skip to 33C) 1. Yes __ 2. No __

B. Do you usually bring up phlegm like this as much as twice a day 4 or more days out of the week? 1. Yes __ 2. No __

C. Do you usually bring up phlegm at all on getting up or first thing in the morning? 1. Yes __ 2. No __

D. Do you usually bring up phlegm at all during the rest of the day or at night? 1. Yes __ 2. No __

IF YES TO ANY OF THE ABOVE (33A, B, C, or D), ANSWER THE FOLLOWING: IF NO TO ALL, CHECK DOES NOT APPLY AND SKIP TO 34A.

E. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year? 1. Yes __ 2. No __ 3. Does not apply __

F. For how many years have you had trouble with phlegm? — Number of years ___ Does not apply ___

EPISODES OF COUGH AND PHLEGM

34A. Have you had periods or episodes of (increased*) cough and phlegm lasting for 3 weeks or more each year? — 1. Yes ___ 2. No ___
*(For persons who usually have cough and/or phlegm)

IF YES TO 34A
B. For how long have you had at least 1 such episode per year? — Number of years ___ Does not apply ___

WHEEZING

35A. Does your chest ever sound wheezy or whistling
1. When you have a cold? — 1. Yes ___ 2. No ___
2. Occasionally apart from colds? — 1. Yes ___ 2. No ___
3. Most days or nights? — 1. Yes ___ 2. No ___

IF YES TO 1, 2, or 3 in 35A
B. For how many years has this been present? — Number of years ___ Does not apply ___

36A. Have you ever had an attack of wheezing that has made you feel short of breath? — 1. Yes ___ 2. No ___

IF YES TO 36A
B. How old were you when you had your first such attack? — Age in years ___ Does not apply ___

C. Have you had 2 or more such episodes? — 1. Yes ___ 2. No ___ 3. Does not apply ___

D. Have you ever required medicine or treatment for the(se) attack(s)? — 1. Yes ___ 2. No ___ 3. Does not apply ___

BREATHLESSNESS

37. If disabled from walking by any condition other than heart or lung disease, please describe and proceed to question 39A.
Nature of condition(s) ______________________________

38A. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill? — 1. Yes ___ 2. No ___

IF YES TO 38A

B. Do you have to walk slower than people of your age on the level because of breathlessness? — 1. Yes ___ 2. No ___ 3. Does not apply ___

C. Do you ever have to stop for breath when walking at your own pace on the level? — 1. Yes ___ 2. No ___ 3. Does not apply ___

D. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level? — 1. Yes ___ 2. No ___ 3. Does not apply ___

E. Are you too breathless to leave the house or breathless on dressing or climbing one flight of stairs? — 1. Yes ___ 2. No ___ 3. Does not apply ___

TOBACCO SMOKING

39A. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime or less than 1 cigarette a day for 1 year.) — 1. Yes ___ 2. No ___

IF YES TO 39A

B. Do you now smoke cigarettes (as of one month ago) — 1. Yes ___ 2. No ___ 3. Does not apply ___

C. How old were you when you first started regular cigarette smoking? — Age in years ___ Does not apply ___

D. If you have stopped smoking cigarettes completely, how old were you when you stopped? — Age stopped ___ Check if still smoking ___ Does not apply ___

E. How many cigarettes do you smoke per day now? — Cigarettes per day ___ Does not apply ___

F. On the average of the entire time you smoked, how many cigarettes did you smoke per day? — Cigarettes per day ___ Does not apply ___

G. Do or did you inhale the cigarette smoke?
1. Does not apply ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

40A. Have you ever smoked a pipe regularly? (Yes means more than 12 oz. of tobacco in a lifetime.) — 1. Yes ___ 2. No ___

IF YES TO 40A:
<u>FOR PERSONS WHO HAVE EVER SMOKED A PIPE</u>

B. 1. How old were you when you started to smoke a pipe regularly? — Age ___

2. If you have stopped smoking a pipe completely, how old were you when you stopped?
- Age stopped ___
- Check if still smoking pipe ___
- Does not apply ___

C. On the average over the entire time you smoked a pipe, how much pipe tobacco did you smoke per week?
- ___ oz. per week (a standard pouch of tobacco contains 1 1/2 oz.)
- ___ Does not apply

D. How much pipe tobacco are you smoking now?
- oz. per week ___
- Not currently smoking a pipe ___

E. Do you or did you inhale the pipe smoke?
1. Never smoked ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

41A. Have you ever smoked cigars regularly? (Yes means more than 1 cigar a week for a year) — 1. Yes ___ 2. No ___

IF YES TO 41A
<u>FOR PERSONS WHO HAVE EVER SMOKED CIGARS</u>

B. 1. How old were you when you started smoking cigars regularly? — Age ___

2. If you have stopped smoking cigars completely, how old were you when you stopped.
- Age stopped ___
- Check if still smoking cigars ___
- Does not apply ___

C. On the average over the entire time you smoked cigars, how many cigars did you smoke per week?
- Cigars per week ___
- Does not apply ___

D. How many cigars are you smoking per week now?
- Cigars per week ___
- Check if not smoking cigars currently ___

E. Do or did you inhale the cigar smoke?
1. Never smoked ___
2. Not at all ___
3. Slightly ___
4. Moderately ___
5. Deeply ___

Signature ______________________ Date ____________________

Part 2
PERIODIC MEDICAL QUESTIONNAIRE

1. NAME ______________________________

2. SOCIAL SECURITY # ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(1 2 3 4 5 6 7 8 9)

3. CLOCK NUMBER ___ ___ ___ ___ ___ ___ ___
(10 11 12 13 14 15)

4. PRESENT OCCUPATION ______________________

5. PLANT ______________________

6. ADDRESS ______________________

7. ______________________ (Zip Code)

8. *TELEPHONE NUMBER* ______________________

9. INTERVIEWER ______________________

10. DATE ______________________ ___ ___ ___ ___ ___ ___ ___
(16 17 18 19 20 21)

11. What is your marital status?
1. Single ___
2. Married ___
3. Widowed ___
4. Separated/Divorced ___

12. <u>OCCUPATIONAL HISTORY</u>

12A. In the past year, did you work full time (30 hours per week or more) for 6 months or more? — 1. Yes ___ 2. No ___

IF YES TO 12A:

12B. In the past year, did you work in a dusty job? — 1. Yes ___ 2. No ___ 3. Does Not Apply ___

12C. Was dust exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

12D. In the past year, were you exposed to gas or chemical fumes in your work? — 1. Yes ___ 2. No ___

12E. Was exposure: 1. Mild ___ 2. Moderate ___ 3. Severe ___

12F. In the past year, what was your:
1. Job/occupation? ______________________
2. Position/job title? ______________________

13. RECENT MEDICAL HISTORY

13A. Do you consider yourself to be in good health? Yes ___ No ___

If NO, state reason ______________________

13B. In the past year, have you developed:

	Yes	No
Epilepsy?	___	___
Rheumatic fever?	___	___
Kidney disease?	___	___
Bladder disease?	___	___
Diabetes?	___	___
Jaundice?	___	___
Cancer?	___	___

14. CHEST COLDS AND CHEST ILLNESSES

14A. If you get a cold, does it usually go to your chest? (Usually means more than 1/2 the time)
1. Yes ___ 2. No ___
3. Don't get colds ___

15A. During the past year, have you had any chest illnesses that have kept you off work, indoors at home, or in bed?
1. Yes ___ 2. No ___
3. Does Not Apply ___

IF YES TO 15A:

15B. Did you produce phlegm with any of these chest illnesses?
1. Yes ___ 2. No ___
3. Does Not Apply ___

15C. In the past year, how many such illnesses with (increased) phlegm did you have which lasted a week or more?
Number of illnesses ___
No such illnesses ___

16. RESPIRATORY SYSTEM

In the past year have you had:

	Yes or No	Further Comment on Positive Answers
Asthma	___	
Bronchitis	___	
Hay Fever	___	
Other Allergies	___	
Pneumonia	___	
Tuberculosis	___	
Chest Surgery	___	
Other Lung Problems	___	
Heart Disease	___	

Do you have:

	Yes or No	Further Comment on Positive Answers
Frequent colds	___	
Chronic cough	___	
Shortness of breath when walking or climbing one flight or stairs	___	

Do you:

	Yes or No	Further Comment on Positive Answers
Wheeze	___	
Cough up phlegm	___	
Smoke cigarettes	___	Packs per day ___ How many years ___

Date ______________ Signature ______________________

BILLING CODE 4510-26-C

Appendix E to § 1926.58—Interpretation and Classification of Chest Roentgenograms—Mandatory

(a) Chest roentgenograms shall be interpreted and classified in accordance with a professionally accepted classification system and recorded on a Roentgenographic Interpretation Form. *Form CSD/NIOSH (M) 2.8.

(b) Roentgenograms shall be interpreted and classified only by a B-reader, a board eligible/certified radiologist, or an experienced physician with known expertise in pneumoconioses.

(c) All interpreters, whenever interpreting chest roentgenograms made under this section, shall have immediately available for reference a complete set of the ILO-U/C International Classification of Radiographs for Pneumoconioses, 1980.

Appendix F to 1926.58—Work Practices and Engineering Controls for Major Asbestos Removal, Renovation, and Demolition Operations—Non-Mandatory

This is a non-mandatory appendix designed to provide guidelines to assist employers in complying with the requirements of 29 CFR 1926.58. Specifically, this appendix describes the equipment, methods, and procedures that should be used in major asbestos removal projects conducted to abate a recognized asbestos hazard or in preparation for building renovation or demolition. These projects require the construction of negative-pressure temporary enclosures to contain the asbestos material and to prevent the exposure of bystanders and other employees at the worksite. Paragraph (e)(6) of the standard requires that "... [W]henever feasible, the employer shall establish negative-pressure enclosures before commencing asbestos removal, demolition, or renovation operations." Employers should also be aware that, when conducting asbestos removal projects, they may be required under the National Emissions Standards for Hazardous Air Pollutants (NESHAPS), 40 CFR Part 61, Subpart M, or EPA regulations under the Clear Water Act.

Construction of a negative-pressure enclosure is a simple but time-consuming process that requires careful preparation and execution; however, if the procedures below are followed, contractors should be assured of achieving a temporary barricade that will protect employees and others outside the enclosure from exposure to asbestos and minimize to the extent possible the exposure of asbestos workers inside the barrier as well.

The equipment and materials required to construct these barriers are readily available and easily installed and used. In addition to an enclosure around the removal site, the standard requires employers to provide hygiene facilities that ensure that their asbestos contaminated employees do not leave the work site with asbestos on their persons or clothing: the construction of these facilities is also described below. The steps in the process of preparing the asbestos removal site, building the enclosure, constructing hygiene facilities, removing the asbestos-containing material, and restoring the site include:

(1) Planning the removal project;

(2) Procuring the necessary materials and equipment;

(3) Preparing the work area;

(4) Removing the asbestos-containing material;

(5) Cleaning the work area; and

(6) Disposing of the asbestos-containing waste.

Planning the Removal Project

The planning of an asbestos removal project is critical to completing the project safely and cost-effectively. A written asbestos removal plan should be prepared that describes the equipment and procedures that will be used throughout the project. The asbestos abatement plan will aid not only in executing the project but also in complying with the reporting requirements of the USEPA asbestos regulations (40 CFR 61, Subpart M), which call for specific information such as a description of control methods and control equipment to be used and the disposal sites the contractor proposes to use to dispose of the asbestos containing materials.

The asbestos abatement plan should contain the following information:

- A physical description of the work area;
- A description of the approximate amount of material to be removed;
- A schedule for turning off and sealing existing ventilation systems;
- Personnel hygiene procedures;
- Labeling procedures;
- A description of personal protective equipment and clothing to be worn by employees;
- A description of the local exhaust ventilation systems to be used;
- A description of work practices to be observed by employees;
- A description of the methods to be used to remove the asbestos-containing material;
- The wetting agent to be used;
- A description of the sealant to be used at the end of the project;
- An air monitoring plan;
- A description of the method to be used to transport waste material; and
- The location of the dump site.

Materials and Equipment Necessary for Asbestos Removal

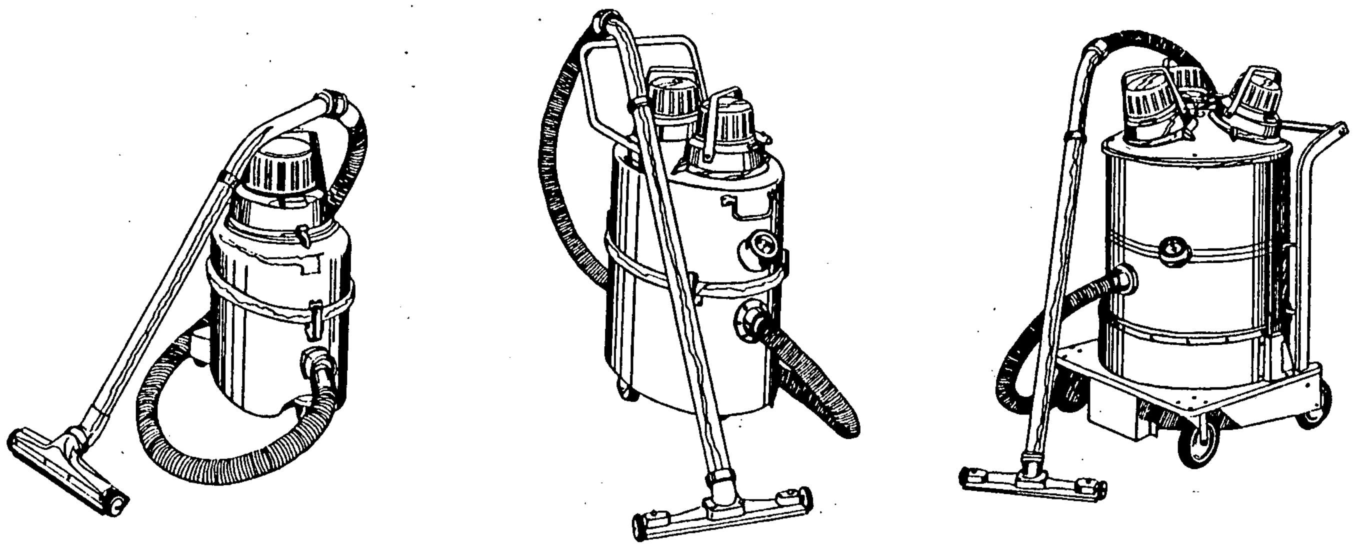
Although individual asbestos removal projects vary in terms of the equipment required to accomplish the removal of the material, some equipment and materials are common to most asbestos removal operations. Equipment and materials that should be available at the beginning of each project are: (1) rolls of polyethylene sheeting; (2) rolls of gray duct tape or clear plastic tape; (3) HEPA filtered vacuum(s); (4) HEPA-filtered portable ventilation system(s); (5) a wetting agent; (6) an airless sprayer; (7) a portable shower unit; (8) appropriate respirators; (9) disposable coveralls; (10) signs and labels; (11) pre-printed disposal bags; and (12) a manometer or pressure gauge.

Rolls of Polyethylene Plastic and Tape. Rolls of polyethylene plastic (6 mil in thickness) should be available to construct the asbestos removal enclosure and to seal windows, doors, ventilation systems, wall penetrations, and ceilings and floors in the work area. Gray duct tape or clear plastic tape should be used to seal the edges of the plastic and to seal any holes in the plastic enclosure. Polyethylene plastic sheeting can be purchased in rolls up to 12–20 feet in width and up to 100 feet in length.

HEPA-Filtered Vacuum. A HEPA-filtered vacuum is essential for cleaning the work area after the asbestos has been removed. Such vacuums are designed to be used with a HEPA (High Efficiency Particulate Air) filter, which is capable of removing 99.97 percent of the asbestos particles from the air. Various sizes and capacities of HEPA vacuums are available. One manufacturer, Nilfisk of America, Inc.*, produces three models that range in capacity from 5.25 gallons to 17 gallons (see Figure F–1). All of these models are portable, and all have long hoses capable of reaching out-of-the-way places, such as areas above ceiling tiles, behind pipes, etc.

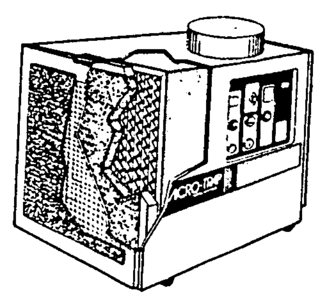
Exhaust Air Filtration System. A portable ventilation system is necessary to create a negative pressure within the asbestos removal enclosure. Such units are equipped with a HEPA filter and are designed to exhaust and clean the air inside the enclosure before exhausting it to the outside of the enclosure (See Figure F–2). Systems are available from several manufacturers. One supplier, Micro-Trap, Inc., * has two ventilation units that range in capacity from 600 cubic feet per minute (CFM) to 1,700 CFM. According to the manufacturer's literature, Micro-Trap * units filter particles of 0.3 micron in size with an efficiency of 99.99 percent. The number and capacity of units required to ventilate an enclosure depend on the size of the area to be ventilated.

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.



Source: Product Catalog, Asbestos Control Technologies, Inc., Maple Shade, N.J., 1985.

Figure F-1. HEPA Filtered Vacuums



Source: Product Catalog, Asbestos Control Technologies, Inc., Maple Shade, N.J., 1985.

Figure F-2. Portable Exhaust Ventilation System with HEPA Filter

Wetting Agents. Wetting agents (surfactants) are added to water (which is then called amended water) and used to soak asbestos-containing materials; amended water penetrates more effectively than plain water and permits more thorough soaking of the asbestos-containing materials. Wetting the asbestos-containing material reduces the number of fibers that will break free and become airborne when the asbestos-containing material is handled or otherwise disturbed. Asbestos-containing materials should be thoroughly soaked before removal is attempted; the dislodged material should feel spongy to the touch. Wetting agents are generally prepared by mixing 1 to 3 ounces of wetting agent to 5 gallons of water.

One type of asbestos, amosite, is relatively resistant to soaking, either with plain or amended water. The work practices of choice when working with amosite containing material are to soak the material as much as possible and then to bag it for disposal immediately after removal, so that the material has no time to dry and be ground into smaller particles that are more likely to liberate airborne asbestos.

In a very limited number of situations, it may not be possible to wet the asbestos-containing material before removing it. Examples of such rare situations are: (1) Removal of asbestos material from a "live" electrical box that was oversprayed with the material when the rest of the area was sprayed with asbestos-containing coating; and (2) removing asbestos-containing insulation from a live steam pipe. In both of these situations, the preferred approach would be to turn off the electricity or steam, respectively, to permit wet removal methods to be used. However, where removal work must be performed during working hours, i.e., when normal operations cannot be disrupted, the asbestos-containing material must be removed dry. Immediate bagging is then the only method of minimizing the amount of airborne asbestos generated.

Airless Sprayer. Airless sprayers are used to apply amended water to asbestos-containing materials. Airless sprayers allow the amended water to be applied in a fine spray that minimizes the release of asbestos fibers by reducing the impact of the spray on the material to be removed. Airless sprayers are inexpensive and readily available.

Portable Shower. Unless the site has available a permanent shower facility that is contiguous to the removal area, a portable shower system is necesssary to permit employees to clean themselves after exposure to asbestos and to remove any asbestos contamination from their hair and bodies. Taking a shower prevents employees from leaving the work area with asbestos on their clothes and thus prevents the spread of asbestos contamination to areas outside the asbestos removal area. This measure also protects members of the families of asbestos workers from possible exposure to asbestos. Showers should be supplied with warm water and a drain. A shower water filtration system to filter asbestos fibers from the shower water is recommended. Portable shower units are readily available, inexpensive, and easy to install and transport.

Respirators. Employees involved in asbestos removal projects should be provided with appropriate NIOSH-approved respirators. Selection of the appropriate respirator should be based on the concentration of asbestos fibers in the work area. If the concentration of asbestos fibers is unknown, employees should be provided with respirators that will provide protection against the highest concentration of asbestos fibers that can reasonably be expected to exist in the work area. For most work within an enclosure, employees should wear half-mask dual-filter cartridge respirators. Disposable face mask respirators (single-use) should not be used to protect employers from exposure to asbestos fibers.

Disposable Coveralls. Employees involved in asbestos removal operations should be provided with disposable impervious coveralls that are equipped with head and foot covers. Such coveralls are typically made of Tyvek.[1] The coverall has a zipper front and elastic wrists and ankles.

Signs and Labels. Before work begins, a supply of signs to demarcate the entrance to the work area should be obtained. Signs are available that have the wording required by the final OSHA standard. The required labels are also commercially available as press-on labels and pre-printed on the 6-mil polyethylene plastic bags used to dispose of asbestos-containing waste material.

Preparing the Work Area

Preparation for constructing negative-pressure enclosures should begin with the removal of all movable objects from the work area, e.g., desks, chairs, rugs, and light fixtures, to ensure that these objects do not become contaminated with asbestos. When movable objects are contaminated or are suspected of being contaminated, they should be vacuumed with a HEPA vacuum and cleaned with amended water, unless they are made of material that will be damaged by the wetting agent; wiping with plain water is recommend in those cases where amended water will damage the object. Before the asbestos removal work begins, objects that

[1] Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

cannot be removed from the work area should be covered with a 6-mil-thick polyethylene plastic sheeting that is securely taped with duct tape or plastic tape to achieve an air-tight seal around the object.

Constructing the Enclosure

When all objects have either been removed from the work area or covered with plastic, all penetrations of the floor, walls, and ceiling should be sealed with 6-mil polyethylene plastic and tape to prevent airborne asbestos from escaping into areas outside the work area of from lodging in cracks around the penetrations. Penetrations that require sealing are typically found around electrical conduits, telephone wires, and water supply and drain pipes. A single entrance to be used for access and egress to the work area should be selected, and all other doors and windows should be sealed with tape or be covered with 6-mil polyethylene plastic sheeting and securely taped. Covering windows and unnecessary doors with a layer of polyethylene before covering the walls provides a second layer of protection and saves time in installation because it reduces the number of edges that must be cut and taped. All other surfaces such as support columns, ledges, pipes, and other surfaces should also be covered with polyethylene plastic sheeting and taped before the walls themselves are completely covered with sheeting.

Next a thin layer of spray adhesive should be sprayed along the top of all walls surrounding the enclosed work area, close to the wall-ceiling interface, and a layer of polyethylene plastic sheeting should be stuck to this adhesive and taped. The entire inside surfaces of all wall areas are covered in this manner, and the sheeting over the walls is extended across the floor area until it meets in the center of the area, where it is taped to form a single layer of material encasing the entire room except for the ceiling. A final layer of plastic sheeting is then laid across the plastic-covered floor area and up the walls to a level of 2 feet or so; this layer provides a second protective layer of plastic sheeting over the floor, which can then be removed and disposed of easily after the asbestos-containing material that has dropped to the floor has been bagged and removed.

Building Hygiene Facilities

Paragraph (j) of the final standard mandates that employers involved in asbestos removal, demolition, or renovation operations provide their employees with hygiene facilities to be used to decontaminate asbestos-exposed workers, equipment, and clothing before such employees leave the work area. These decontamination facilities consist of:

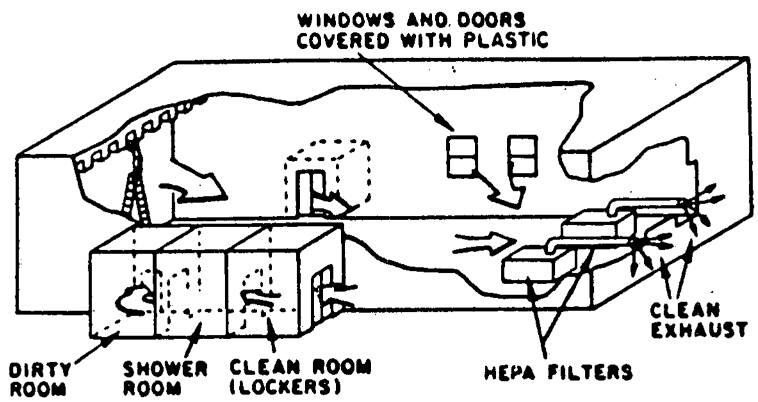
(1) A clean change room:

(2) A shower; and

(3) An equipment room.

The clean change room is an area in which employees remove their street clothes and don their respirators and disposable protective clothing. The clean room should have hooks on the wall or be equipped with lockers for the storage of workers' clothing and personal articles. Extra disposable coveralls and towels can also be stored in the clean change room.

The shower should be contiguous with both the clean and dirty change room (see Figure F-3) and should be used by all workers leaving the work area. The shower should also be used to clean asbestos-contaminated equipment and materials, such as the outsides of asbestos waste bags and hand tools used in the removal process.



Source: EPA 1985. Asbestos Waste Management Guidance (EPA/530-SW-85-007).

Figure F-3. Cutaway View of Enclosure and Hygiene Facilities

The equipment room (also called the dirty change room) is the area where workers remove their protective coveralls and where equipment that is to be used in the work area can be stored. The equipment room should be lined with 6-mil-thick polyethylene plastic sheeting in the same way as was done in the work area enclosure. Two layers of 6-mil polyethylene plastic sheeting that are not taped together from a double flap or barrier between the equipment room and the work area and between the shower and the clean change room (see Figure F-4).

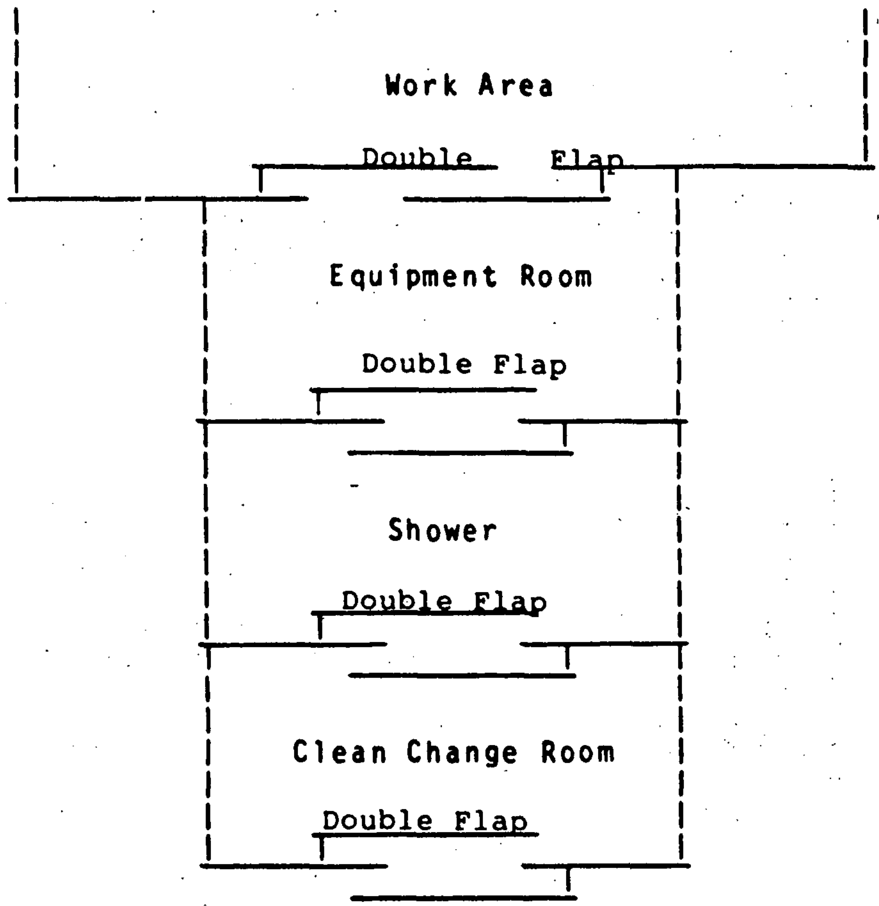


Figure F-4. Typical Hygiene Facility Layout

When feasible, the clean change room, shower, and equipment room should be contiguous and adjacent to the negative-pressure enclosure surrounding the removal area. In the overwhelming number of cases, hygiene facilities can be built contiguous to the negative-pressure enclosure. In some cases, however, hygiene facilities may have to be located on another floor of the building where removal of asbestos-containing materials is taking place. In these instances, the hygiene facilities can in effect be made to be contiguous to the work area by constructing a polythylene plastic "tunnel" from the work area to the hygiene facilities. Such a tunnel can be made even in cases where the hygiene facilities are located several floors above or below the work area; the tunnel begins with a double flap door at the enclosure, extends through the exit from the floor, continues down the necessary number of flights of stairs and goes through a double-flap entrance to the hygiene facilities, which have been prepared as described above. The tunnel is constrûcted of 2-inch by 4-inch lumber or aluminum struts and covered with 6-mil-thick polyethylene plastic sheeting.

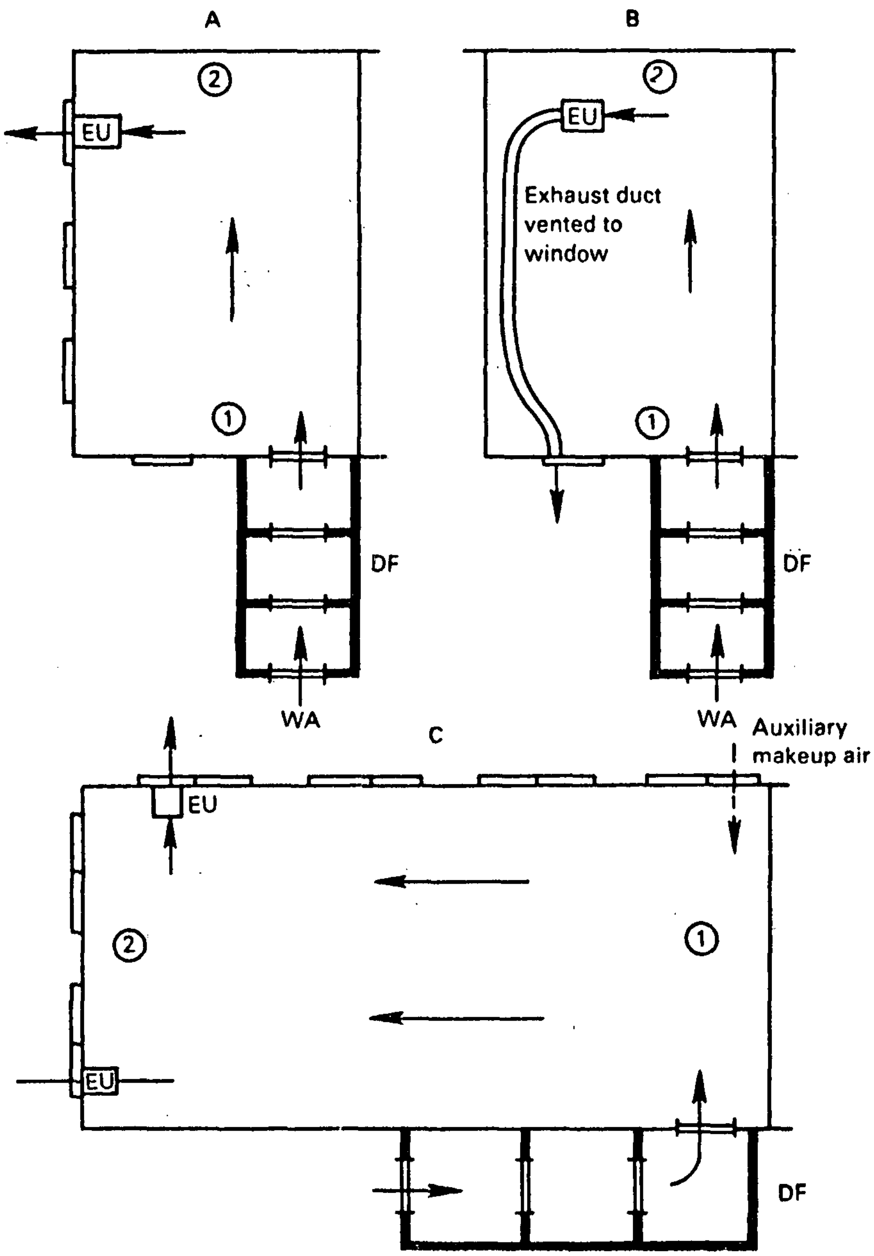
In the rare instances when there is not enough space to permit any hygiene facilities to be built at the work site, employees should be directed to change into a clean disposable worksuit immediately after exiting the enclosure (without removing their respirators) and to proceed immediately to the shower. Alternatively, employees could be directed to vacuum their disposable coveralls with a HEPA-filtered vacuum before proceeding to a shower located a distance from the enclosure.

The clean room, shower, and equipment room must be sealed completely to ensure that the sole source of air flow through these areas originates from uncontaminated areas outside the asbestos removal, demolition, or renovation enclosure. The shower must be drained properly after each use to ensure that contaminated water is not released to uncontaminated areas. If waste water is inadvertently released, it should be cleaned up as soon as possible to prevent any asbestos in the water from drying and becoming airborne in areas outside the work area.

Establishing Negative Pressure Within the Enclosure

After construction of the enclosure is completed, a ventilation system(s) should be installed to create a negative pressure within the enclosure with respect to the area outside the enclosure. Such ventilation systems must be equipped with HEPA filters to prevent the release of asbestos fibers to the environment outside the enclosure and should be operated 24 hours per day during the entire project until the final cleanup is completed and the results of final air samples are received from the laboratory. A sufficient amount of air should be exhausted to create a pressure of −0.02 inches of water within the enclosure with respect to the area outside the enclosure.

These ventilation systems should exhaust the HEPA-filtered clean air outside the building in which the asbestos removal, demolition, or renovation is taking place (see Figure F-5). If access to the outside is not available, the ventilation system can exhaust the HEPA-filtered asbestos-free air to an area within the building that is as far away as possible from the enclosure. Care should be taken to ensure that the clean air is released either to an asbestos-free area or in such a way as not to disturb any asbestos-containing materials.



Source: EPA 1985. Guidance for Controlling Asbestos-Containing materials in Buildings (EPA 560/5–85–024).

Figure F–5. Examples of Negative Pressure Systems. DF, Decontamination Facility; EU, Exhaust Unit; WA, Worker Access; A, Single-room work area with multiple windows; B, Single-room work area with single window near entrance; C, Large single-room work area with windows and auxiliary makeup air source (dotted arrow). Arrows denote direction of air flow. Circled numbers indicate progression of removal sequence.

A manometer or pressure gauge for measuring the negative pressure within the enclosure should be installed and should be monitored frequently throughout all work shifts during which asbestos removal, demolition, or renovation takes place. Several types of manometers and pressure gauges are available for this purpose.

All asbestos removal, renovation, and demolition operations should have a program for monitoring the concentration of airborne asbestos and employee exposures to asbestos. Area samples should be collected inside the enclosure (approximately four samples for 5000 square feet of enclosure area). At least two samples should be collected outside the work area, one at the entrance to the clean change room and one at the exhaust of the portable ventilation system. In addition, several breathing zone samples should be collected from those workers who can reasonably be expected to have the highest potential exposure to asbestos.

Removing Asbestos Materials

Paragraph (e)(6)(ii) requires that employers involved in asbestos removal, demolition, or renovation operations designate a competent person to:

(1) Set up the enclosure;
(2) Ensure the integrity of the enclosure;
(3) Control entry to and exit from the enclosure;
(4) Supervise all employee exposure monitoring required by this section;
(5) Ensure the use of protective clothing and equipment;
(6) Ensure that employees are trained in the use of engineering controls, work practices, and personal protective equipment;
(7) Ensure the use of hygiene facilities and the observance of proper decontamination procedures; and
(8) Ensure that engineering controls are functioning properly.

The competent person will generally be a Certified Industrial Hygienist, an industrial hygienist with training and experience in the handling of asbestos, or a person who has such training and experience as a result of on-the-job training and experience.

Ensuring the integrity of the enclosure is accomplished by inspecting the enclosure before asbestos removal work begins and prior to each work shift throughout the entire period work is being conducted in the enclosure. The inspection should be conducted by locating all areas where air might escape from the enclosure; this is best accomplished by running a hand over all seams in the plastic enclosure to ensure that no seams are ripped and the tape is securely in place.

The competent person should also ensure that all unauthorized personnel do not enter the enclosure and that all employees and other personnel who enter the enclosure have the proper protective clothing and equipment. He or she should also ensure that all employees and other personnel who enter the enclosure use the hygiene facilities and observe the proper decontamination procedures (described below).

Proper work practices are necessary during asbestos removal, demolition, and renovation to ensure that the concentration of asbestos fibers inside the enclosure remains as low as possible. One of the most important work practices is to wet the asbestos-containing material before it is disturbed. After the asbestos-containing material is thoroughly wetted, it should be removed by scraping (as in the case of sprayed-on or troweled-on ceiling material) or removed by cutting the metal bands or wire mesh that support the asbestos-containing material on boilers or pipes. Any residue that remains on the surface of the object from which asbestos is being removed should be wire brushed and wet wiped.

Bagging asbestos waste material promptly after its removal is another work practice control that is effective in reducing the airborne concentration of asbestos within the enclosure. Whenever possible, the asbestos should be removed and placed directly into bags for disposal rather than dropping the material to the floor and picking up all of the material when the removal is complete. If a significant amount of time elapses between the time that the material is removed and the time it is bagged, the asbestos material is likely to dry out and generate asbestos-laden dust when it is disturbed by people working within the enclosure. Any asbestos-contaminated supplies and equipment that cannot be decontaminated should be disposed of in pre-labeled bags; items in this category include plastic sheeting, disposable work clothing, respirator cartridges, and contaminated wash water.

A checklist is one of the most effective methods of ensuring adequate surveillance of the integrity of the asbestos removal enclosure. Such a checklist is shown in Figure F–6. Filling out the checklist at the beginning of each shift in which asbestos removal is being performed will serve to document that all the necessary precautions will be taken during the asbestos removal work. The checklist contains entries for ensuring that:

- The work area enclosure is complete;
- The negative-pressure system is in operation;
- Necessary signs and labels are used;

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Asbestos Removal, Renovation, and Demolition Checklist

Date: ______________________ Location: ______________________

Supervisor ______________________ Project # ______________________

Work Area (sq. ft.) __________

	Yes	No
I. Work site barrier		
Floor covered	____	____
Walls covered	____	____
Area ventilation off	____	____
All edges sealed	____	____
Penetrations sealed	____	____
Entry curtains	____	____
II. Negative Air Pressure		
HEPA Vac ______ Ventilation system ______		
Constant operation	____	____
Negative pressure achieved	____	____
III. Signs		
Work area entrance	____	____
Bags labeled	____	____
IV. Work Practices		
Removed material promptly bagged	____	____
Material worked wet	____	____
HEPA vacuum used	____	____
No smoking	____	____
No eating, drinking	____	____
Work area cleaned after completion	____	____
Personnel decontaminated each departure	____	____
V. Protective Equipment		
Disposable clothing used one time	____	____
Proper NIOSH-approved respirators	____	____
VII. Showers		
On site	____	____
Functioning	____	____
Soap and towels	____	____
Used by all personnel	____	____

Figure F-6. Checklist

BILLING CODE 4510-26-C

- Appropriate work practices are used;
- Necessary protective clothing and equipment are used; and
- Appropriate decontamination procedures are being followed.

Cleaning the Work Area

After all of the asbestos-containing material is removed and bagged, the entire work area should be cleaned until it is free of all visible asbestos dust. All surfaces from which asbestos has been removed should be cleaned by wire brushing the surfaces, HEPA vacuuming these surfaces, and wiping them with amended water. The inside of the plastic enclosure should be vacuumed with a HEPA vacuum and wet wiped until there is no visible dust in the enclosure. Particular attention should be given to small horizontal surfaces such as pipes, electrical conduits, lights, and support tracks for drop ceilings. All such surfaces should be free of visible dust before the final air samples are collected.

Additional sampling should be conducted inside the enclosure after the cleanup of the work area has been completed. Approximately four area samples should be collected for each 5000 square feet of enclosure area. The enclosure should not be dismantled unless the final samples show asbestos concentrations of less than the final standard's action level. EPA recommends that a clearance level of 0.01 f/cc be achieved before cleanup is considered complete.

A clearance checklist is an effective method of ensuring that all surfaces are adequately cleaned and the enclosure is ready to be dismantled. Figure F-7 shows a checklist that can be used during the final inspection phase of asbestos abatement, removal, or renovation operations.

BILLING CODE 4510-26-M

Final Inspection of Asbestos Removal, Renovation, and Demolition Projects

Date: ______________________

Project: ______________________

Location: ______________________

Building: ______________________

CHECKLIST:

Residual dust on:	Yes	No		Yes	No
a. Floor	____	____	e. Horizontal surfaces	____	____
b. Horizontal surfaces	____	____	f. Pipes	____	____
c. Pipes	____	____	g. Ducts	____	____
d. Ventilation equipment	____	____	h. Register	____	____
			i. Lights	____	____

FIELD NOTES:

Record any problems encountered here.

FINAL AIR SAMPLE RESULTS: ______________________

Figure F-7. Clearance Checklist

BILLING CODE 4510-26-C

Appendix G to § 1926.58—Work Practices and Engineering Controls for Small-Scale, Short-Duration Asbestos Renovation and Maintenance Activities—Non-Mandatory

This appendix is not mandatory, in that construction industry employers may choose to comply with all of the requirements of OSHA's final rule for occupational exposure to asbestos in the construction industry, § 1926.58. However, employers wishing to be exempted from the requirements of paragraphs (e)(6) and (f)(2)(ii)(*B*) of § 1926.58 shall comply with the provisions of this appendix when performing small-scale, short-duration renovation or maintenance activities. OSHA anticipates that employers in the electrical, carpentry, utility, plumbing, and interior construction trades may wish to avail themselves of the final standard's exemptions for small-scale, short-duration renovation and maintenance operations.

Definition of Small-Scale, Short-Duration Activities

For the purposes of this appendix, small-scale, short-duration renovation and maintenance activities are tasks such as, but not limited to:

• Removal of asbestos-containing insulation on pipes;

• Removal of small quantities of asbestos-containing insulation on beams or above ceilings;

• Replacement of an asbestos-containing gasket on a valve;

• Installation or removal of a small section of drywall;

• Installation of electrical conduits through or proximate to asbestos-containing materials.

Evidence in the record (see the Summary and Explanation section of the preamble for paragraph (g), Methods of Compliance, for specific citations) suggests that the use of certain engineering and work practice controls is capable of reducing employee exposures to asbestos to levels below the final standard's action level (0.1 f/cc). Several controls and work practices, used either singly or in combination, can be employed effectively to reduce asbestos exposures during small maintenance and renovation operations. These include:

• Wet methods;

• Removal methods

—Use of Glove bags

—Removal of entire asbestos insulated pipes or structures

—Use of mini-enclosures

• Enclosure of asbestos materials; and

• Maintenance programs.

This appendix describes these controls and work practices in detail.

Preparation of the Area Before Renovation or Maintenance Activities

The first step in preparing to perform a small-scale, short-duration asbestos renovation or maintenance task, regardless of the abatement method that will be used, is the removal from the work area of all objects that are movable to protect them from asbestos contamination. Objects that cannot be removed must be covered completely with a 6-mil-thick polyethylene plastic sheeting before the task begins. If objects have already been contaminated, they should be thoroughly cleaned with a High Efficiency Particulate Air (HEPA) filtered vacuum or be wet wiped before they are removed from the work area or completely encased in the plastic.

Wet Methods

Whenever feasible, and regardless of the abatement method to be used (e.g., removal, enclosure, use of glove bags), wet methods must be used during small-scale, short duration maintenance and renovation activities that involve disturbing asbestos-containing materials. Handling asbestos materials wet is one of the most reliable methods of ensuring that asbestos fibers do not become airborne, and this practice should therefore be used whenever feasible. As discussed in the Summary and Explanation section of the preamble for paragraph (g), Methods of Compliance, wet methods can be used in the great majority of workplace situations. Only in cases where asbestos work must be performed on live electrical equipment, on live steam lines, or in other areas where water will seriously damage materials or equipment may dry removal be performed. Amended water or another wetting agent should be applied by means of an airless sprayer to minimize the extent to which the asbestos-containing material is disturbed.

Asbestos-containing materials should be wetted from the initiation of the maintenance or renovation operation and wetting agents should be used continually throughout the work period to ensure that any dry asbestos-containing material exposed in the course of the work is wet and remains wet until final disposal.

Removal of Small Amount of Asbestos-Containing Materials

Several methods can be used to remove small amounts of asbestos-containing materials during small-scale, short-duration renovation or maintenance tasks. These include the use of glove bags, the removal of an entire asbestos-covered pipe or structure, and the construction of mini-enclosures. The procedures that employers must use for each of these operations if they wish to avail themselves of the final rule's exemptions are described in the following sections.

Glove Bags

As discussed in the Summary and Explanation section of the preamble for paragraph (g), Methods of Compliance, evidence in the record indicate that the use of glove bags to enclose the work area during small-scale, short-duration maintenance or renovation activities will result in employee exposures to asbestos that are below the final standard's action level of 0.1 f/cc. This appendix provides requirements for glove-bag procedures to be followed by employers wishing to avail themselves of the standard's exemptions for each activities. OSHA has determined that the use of these procedures will reduce the 8 hour time weighted average (TWA) exposures of employees involved in these work operations to levels below the action level and will thus provide a degree of employee protection equivalent to that provided by compliance with all provisions of the final rule.

Glove Bag Installation. Glove bags are approximately 40-inch-wide times 64-inch-long bags fitted with arms through which the work can be performed (see Figure G–1(A)). When properly installed and used, they permit workers to remain completely isolated from the asbestos material removed or replaced inside the bag. Glove bags can thus provide a flexibile, easily installed, and quickly dismantled temporary small work area enclosure that is ideal for small-scale asbestos renovation or maintenance jobs.

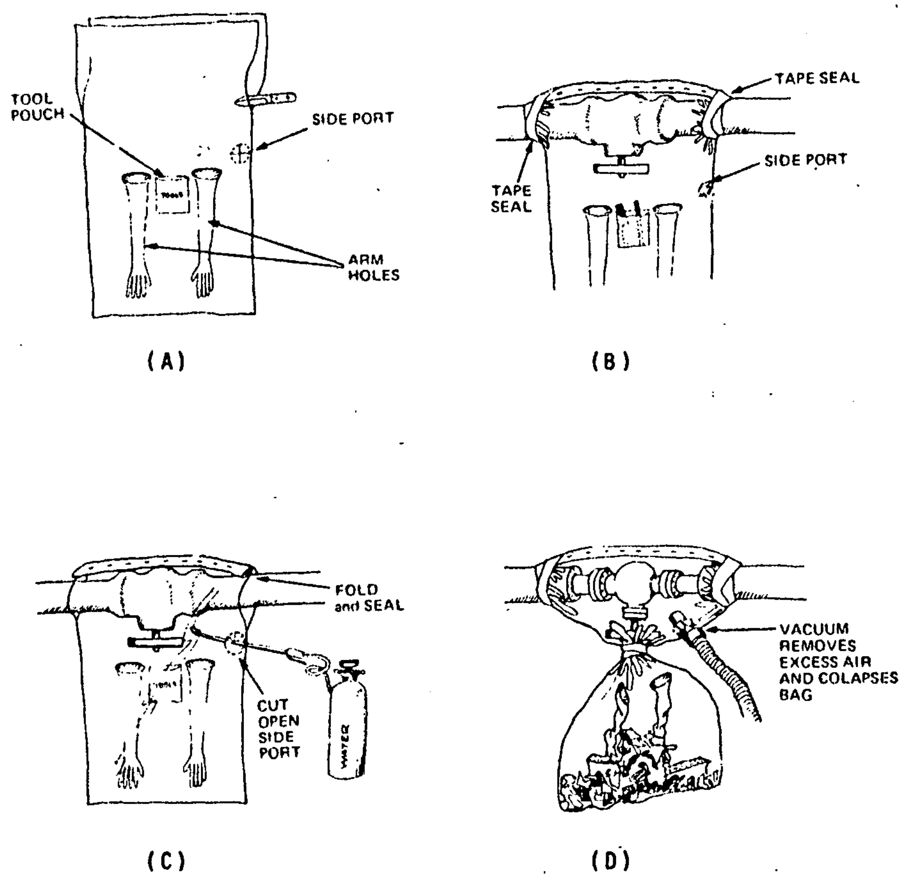

Figure G–1. Diagrams Showing Proper Use of Glove Bags in Small-Scale, Short-Duration Maintenance and Renovation Operations.

These bags are single use control devices that are disposed of at the end of each job. The bags are made of transparent 6-mil-thick polyethylene plastic with arms of Tyvek * material (the same material used to make the disposable protective suits used in major asbestos removal, renovation, and demolition operations and in protective gloves). Glove bags are readily available from safety supply stores or specialty asbestos removal supply houses. Glove bags come pre-labeled with the asbestos warning label prescribed by OSHA and EPA for bags used to dispose of asbestos waste.

Glove Bag Equipment and Supplies. Supplies and materials that are necessary to use glove bags effectively include:

(1) Tape to seal the glove bag to the area from which absbestos is to be removed;

(2) Amended water or other wetting agents;

(3) An airless sprayer for the application of the wetting agent;

(4) Bridging encapsulant (a paste-like substance for coating asbestos) to seal the rough edges of any asbestos-containing materials that remain within the glove bag at the points of attachment after the rest of the asbestos has be removed;

(5) Tools such as razor knives, nips, and wire brushes (or other tools suitable for cutting wire, etc.);

(6) A HEPA filter-equipped vacuum for evacuating the glove bag (to minimize the release of asbestos fibers) during removal of the bag from the work area and for cleaning any material that may have escaped during the installation of the glove bag; and

(7) HEPA-equipped dust cartridge respirators for use by the employees involved in the removal of asbestos with the glove bag.

Glove Bag Work Practices. The proper use of glove bags requires the following steps:

(1) Glove bags must be installed so that they completely cover the pipe or other structure where asbestos work is to be done. Glove bags are installed by cutting the sides of the glove bag to fit the size of the pipe from which asbestos is to be removed. The glove bag is attached to the pipe by folding the open edges together and securely sealing them with tape. All openings in the glove bag must be sealed with duct tape or equivalent material. The bottom seam of the glove bag must also be sealed with duct tape or equivalent to prevent any leakage from the bag that may result from a defect in the bottom seam (Figure G–1(B)).

(2) The employee who is performing the asbestos removal with the glove bag must don a half mask dual-cartridge HEPA-equipped respirator; respirators should be worn by employees who are in close contact with the glove bag and who may thus be exposed as a result of small gaps in the seams of the bag or holes punched through the bag by a razor knife or a piece of wire mesh.

(3) The removed asbestos material from the pipe or other surface that has fallen into the enclosed bag must be thoroughly wetted with a wetting agent (applied with an airless sprayer through the pre-cut port provided in most gloves bags or applied through a small hole cut in the bag) (Figure G–1(C)).

(4) Once the asbestos material has been thoroughly wetted, it can be removed from the pipe, beam or other surface. The choice of tool to use to remove the asbestos-containing material depends on the type of material to be removed. Asbestos-containing materials are generally covered with painted canvas and/or wire mesh. Painted canvas can be cut with a razor knife and peeled away from the asbestos-containing material underneath. Once the canvas has been peeled away, the asbestos-containing material underneath may be dry, in which case it should be re-sprayed with a wetting agent to ensure that it generates as little dust as possible when removed. If the asbestos-containing material is covered with wire mesh, the mesh should be cut with nips, tin snips, or other appropriate tool and removed.

A wetting agent must then be used to spray any layer of dry material that is exposed beneath the mesh, the surface of the stripped underlying structure, and the inside of the glove bag.

(5) After removal of the layer of asbestos-containing material, the pipe or surface from which asbestos has been removed must be thoroughly cleaned with a wire brush and wet wiped with a wetting agent until no traces of the asbestos containing material can be seen.

(6) Any asbestos containing insulation edges that have been exposed as a result of the removal or maintenance activity must be encapsulated with bridging encapsulant to ensure that the edges do not release asbestos fibers to the atmosphere after the glove bag has been removed.

(7) When the asbestos removal and encapsulation have been completed, a vacuum hose from a HEPA filtered vacuum must be inserted into the glove bag through the port to remove any air in the bag that may contain asbestos fibers. When the air has been removed from the bag, the bag should be squeezed tightly (as close to the top as possible), twisted, and sealed with tape, to keep the asbestos materials safely in the bottom of the bag. The HEPA vacuum can

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

then be removed from the bag and the glove bag itself can be removed from the work area to be disposed of properly (Figure G–1(D)).

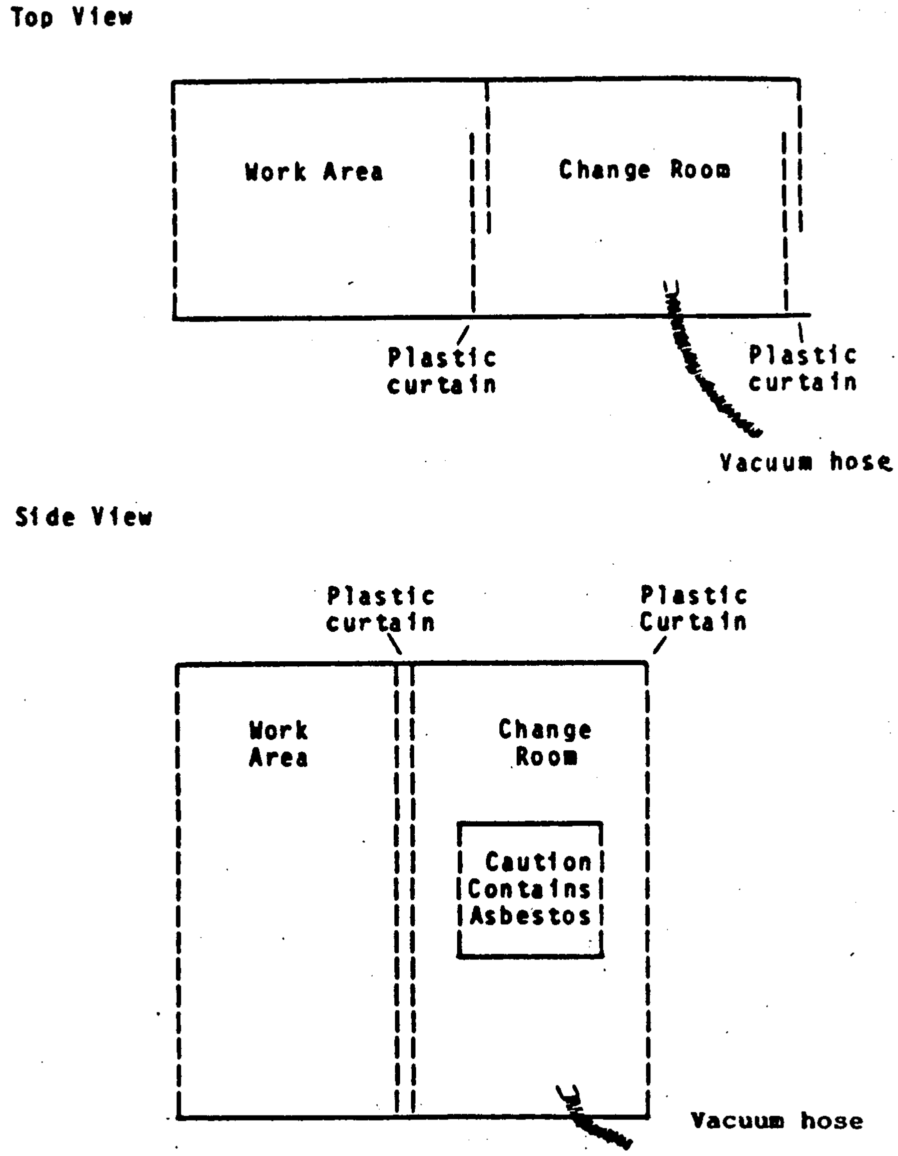

Figure G–2. Schematic of Mini-enclosure

Mini-Enclosures

In some instances, such as removal of asbestos from a small ventilation system or from a short length of duct, a glove bag may not be either large enough or of the proper shape to enclose the work area. In such cases, a mini-enclosure can be built around the area where small-scale, short-duration asbestos maintenance or renovation work is to be performed (Figure G–2). Such an enclosure should be constructed of 6-mil-thick polyethylene plastic sheeting and can be small enough to restrict entry to the asbestos work area to one worker.

For example, a mini-enclosure can be built in a small utility closet when asbestos-containing duct covering is to be removed. The enclosure is constructed by:

(1) Affixing plastic sheeting to the walls with spray adhesive and tape;

(2) Covering the floor with plastic and sealing the plastic covering the floor to the plastic on the walls,

(3) Sealing any penetrations such as pipes or electrical conduits with tape; and

(4) Constructing a small change room (approximately 3 feet square) made of 6-mil-thick polyethylene plastic supported by 2-inch by 4-inch lumber (the plastic should be attached to the lumber supports with staples or spray adhesive and tape).

The change room should be contiguous to the mini enclosure, and is necessary to allow the worker to vacuum off his protective coveralls and remove them before leaving the work area. While inside the enclosure, the worker should wear Tyvek[1] disposable coveralls and use the appropriate HEPA filtered dual cartridge respiratory protection.

The advantages of mini-enclosures are that they limit the spread of asbestos contamination, reduce the potential exposure of bystanders and other workers who may be working in adjacent areas, and are quick and easy to install. The disadvantage of mini-enclosures is that they may be too small to contain the equipment necessary to create a negative pressure within the enclosure; however, the double layer of plastic sheeting will serve to restrict the release of asbestos fibers to the area outside the enclosure.

Removal of Entire Structures

When pipes are insulated with asbestos-containing materials, removal of the entire pipe may be more protective, easier, and more cost-effective than stripping the asbestos insulation from the pipe. Before such a pipe is cut, the asbestos-containing insulation must be wrapped with 6-mil polyethylene plastic and securely sealed with duct tape or equivalent. This plastic covering will prevent asbestos fibers from becoming airborne as a result of the vibration created by the power saws used to cut the pipe. If possible, the pipes should be cut at locations that are not insulated to avoid disturbing the asbestos. If a pipe is completely insulated with asbestos-containing materials, small sections should be stripped using the glove-bag method described above before the pipe is cut at the stripped sections.

Enclosure

The decision to enclose rather than remove asbestos-containing material from an area depends on the building owner's preference, i.e., for removal or containment. Owners consider such factors as cost effectiveness, the physical configuration of the work area, and the amount of traffic in the area when determining which abatement method to use.

If the owner chooses to enclose the structure rather than to remove the asbestos-containing material insulating it, a solid structure (airtight walls and ceilings) must be built around the asbestos covered pipe or structure to prevent the release of asbestos-containing materials into the area beyond the enclosure and to prevent disturbing these

[1] Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

materials by casual contact during future maintenance operations.

Such a permanent (i.e., for the life of the building) enclosure should be built of new construction materials and should be impact resistant and airtight. Enclosure walls should be made of tongue-and-groove boards, boards with spine joints, or gypsum boards having taped seams. The underlying structure must be able to support the weight of the enclosure. (Suspended ceilings with laid in panels do not provide airtight enclosures and should not be used to enclose structures covered with asbestos-containing materials.) All joints between the walls and ceiling of the enclosure should be caulked to prevent the escape of asbestos fibers. During the installation of enclosures, tools that are used (such as drills or rivet tools) should be equipped with HEPA-filtered vacuums. Before constructing the enclosure, all electrical conduits, telephone lines, recessed lights, and pipes in the area to be enclosed should be moved to ensure that the enclosure will not have to be re-opened later for routine or emergency maintenance. If such lights or other equipment cannot be moved to a new location for logistic reasons, or if moving them will disturb the asbestos-containing materials, removal rather than enclosure of the asbestos-containing materials is the appropriate control method to use.

Maintenance Program

An asbestos maintenance program must be initiated in all facilities that have asbestos-containing materials. Such a program should include:

- Development of an inventory of all asbestos-containing materials in the facility;
- Periodic examination of all asbestos-containing materials to detect deterioration;
- Written procedures for handling asbestos materials during the performance of small-scale, short-duration maintenance and renovation activities;
- Written procedures for asbestos disposal; and
- Written procedures for dealing with asbestos-related emergencies.

Members of the building's maintenance engineering staff (electricians, heating/air conditioning engineers, plumbers, etc.) who may be required to handle asbestos-containing materials should be trained in safe procedures. Such training should include at a minimum:

- Information regarding types of asbestos and its various uses and forms;
- Information on the health effects associated with asbestos exposure;
- Descriptions of the proper methods of handling asbestos-containing materials; and
- Information on the use of HEPA-equipped dual cartridge respiratory and other personal protection during maintenance activities.

Prohibited Activities

The training program for the maintenance engineering staff should describe methods of handling asbestos-containing materials as well as routine maintenance activities that are prohibited when asbestos-containing materials are involved. For example, maintenance staff employees should be instructed:

- *Not* to drill holes in asbestos-containing materials;
- *Not* to hang plants or pictures on structures covered with asbestos-containing materials;
- *Not* to sand asbestos-containing floor tile;
- *Not* to damage asbestos-containing materials while moving furniture or other objects;
- *Not* to install curtains, drapes, or dividers in such a way that they damage asbestos-containing materials;
- *Not* to dust floors, ceilings, moldings or other surfaces in asbestos-contaminated environments with a dry brush or sweep with a dry broom;
- *Not* to use an ordinary vacuum to clean up asbestos-containing debris;
- *Not* to remove ceiling tiles below asbestos-containing materials without wearing the proper respiratory protection, clearing the area of other people, and observing asbestos removal waste disposal procedures;
- *Not* to remove ventilation system filters dry; and
- *Not* to shake ventilation system filters.

Appendix H to § 1926.58—Substance Technical Information for Asbestos, Non-Mandatory

I. Substance Identification

A. Substance: "Asbestos" is the name of a class of magnesium-silicate minerals that occur in fibrous form. Minerals that are included in this group are chrysotile, crocidolite, amosite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos.

B. Asbestos, tremolite, anthophyllite, and actinolite are used in the manufacture of heat-resistant clothing, automotive brake and clutch linings, and a variety of building materials including floor tiles, roofing felts, ceiling tiles, asbestos-cement pipe and sheet, and fire-resistant drywall. Asbestos, tremolite, anthophyllite and actinolite are also present in pipe and boiler insulation materials, and in sprayed-on materials located on beams, in crawlspaces, and between walls.

C. The potential for an asbestos-containing product to release breathable fibers depends on its degree of friability. Friable means that the material can be crumbled with hand pressure and is therefore likely to emit fibers. The fibrous or fluffy sprayed-on materials used for fireproofing, insulation, or sound proofing are considered to be friable, and they readily release airborne fibers if disturbed. Materials such as vinyl-asbestos floor tile or roofing felts are considered nonfriable and generally do not emit airborne fibers unless subjected to sanding or sawing operations. Asbestos-cement pipe or sheet can emit airborne fibers if the materials are cut or sawed, or if they are broken during demolition operations.

D. Permissible exposure: Exposure to airborne asbestos, tremolite, anthophyllite, and actinolite fibers may not exceed 0.2 fibers per cubic centimeter of air (0.2 f/cc) averaged over the 8-hour workday.

II. Health Hazard Data

A. Asbestos, tremolite, anthophyllite, and actinolite can cause disabling respiratory disease and various types of cancers if the fibers are inhaled. Inhaling or ingesting fibers from contaminated clothing or skin can also result in these diseases. The symptoms of these diseases generally do not appear for 20 or more years after initial exposure.

B. Exposure to asbestos, tremolite, anthophyllite and actinolite has been shown to cause lung cancer, mesothelioma, and cancer of the stomach and colon. Mesothelioma is a rare cancer of the thin membrane lining of the chest and abdomen. Symptoms of mesothelioma include shortness of breath, pain in the walls of the chest, and/or abdominal pain.

III. Respirators and Protective Clothing

A. Respirators: You are required to wear a respirator when performing tasks that result in asbestos, tremolite, anthophyllite and actinolite exposure that exceeds the permissible exposure limit (PEL) of 0.2 f/cc. These conditions can occur while your employer is in the process of installing engineering controls to reduce asbestos, tremolite, anthophyllite and actinolite exposure, or where engineering controls are not feasible to reduce asbestos, tremolite, anthophyllite and actinolite exposure. Air-purifying respirators equipped with a high-efficiency particulate air (HEPA) filter can be used where airborne asbestos, tremolite, anthophyllite and actinolite fiber concentrations do not exceed 2 f/cc; otherwise, air-supplied, positive-pressure, full facepiece respirators must be used. Disposable respirators or dust masks are not permitted to be used for asbestos, tremolite, anthophyllite and actinolite work. For effective protection, respirators must fit your face and head snugly. Your employer is required to conduct fit tests when you are first assigned a respirator and every 6 months thereafter. Respirators should not be loosened or removed in work situations where their use is required.

B. Protective Clothing: You are required to wear protective clothing in work areas where asbestos, tremolite, anthophyllite, and actinolite fiber concentrations exceed the permissible exposure limit (PEL) of 0.2 f/cc to prevent contamination of the skin. Where protective clothing is required, your employer must provide you with clean garments. Unless you are working on a large asbestos, tremolite, anthophyllite, and actinolite removal or demolition project, your employer must also provide a change room and separate lockers for your street clothes and contaminated work clothes. If you are working on a large asbestos, tremolite, anthophyllite, and actinolite removal or demolition project, and where it is feasible to do so, your employer must provide a clean room, shower, and decontamination room contiguous to the work area. When leaving the work area, you must remove contaminated clothing before proceeding to the shower. If the shower is not adjacent to the work area, you must vacuum your clothing before proceeding to change the room and shower. To prevent inhaling fibers in contaminated change rooms and showers, leave your respirator on until you leave the shower and enter the clean change room.

IV. Disposal Procedures and Cleanup

A. Wastes that are generated by processes where asbestos, tremolite, anthophyllite, and actinolite is present include:

1. Empty asbestos, tremolite, anthophyllite, and actinolite shipping containers.

2. Process wastes such as cuttings, trimmings, or reject materials.

3. Housekeeping waste from sweeping or vacuuming.

4. Asbestos fireproofing or insulating material that is removed from buildings.

5. Asbestos-containing building products removed during building renovation or demolition.

6. Contaminated disposable protective clothing.

B. Empty shipping bags can be flattened under exhaust hoods and packed into airtight containers for disposal. Empty shipping drums are difficult to clean and should be sealed.

C. Vacuum logs or disposable paper filters should not be cleaned, but should be sprayed with a fine water mist and placed into a labeled waste container.

D. Process waste and housekeeping waste should be wetted with water or a mixture of water and surfactant prior to packaging in disposable containers.

E. Asbestos-containing material that is removed from buildings must be disposed of in leak-tight 6-mil thick plastic bags, plastic-lined cardboard containers, or plastic-lined metal containers. These wastes, which are removed while wet, should be sealed in containers before they dry out to minimize the release of asbestos, tremolite, anthophyllite, and actinolite fibers during handling.

V. Access to Information

A. Each year, your employer is required to inform you of the information contained in this standard and appendices for asbestos. In addition, your employer must instruct you in the proper work practices for handling asbestos-containing materials, and the correct use of protective equipment.

B. Your employer is required to determine whether you are being exposed to asbestos. You or your representative has the right to observe employee measurements and to record the results obtained. Your employer is required to inform you of your exposure, and, if you are exposed above the permissible limit, he or she is required to inform you of the actions that are being taken to reduce your exposure to within the permissible limit.

C. Your employer is required to keep records of your exposures and medical examinations. These exposure records must be kept for at least thirty (30) years. Medical records must be kept for the period of your employment plus thirty (30) years.

D. Your employer is required to release your exposure and medical records to your physician or designated representative upon your written request.

Appendix I to § 1926.58—Medical Surveillance Guidelines for Asbestos, Tremolite, Anthophyllite, and Actinolite, Non-Mandatory

I. Route of Entry

Inhalation ingestion.

II. Toxicology

Clinical evidence of the adverse effects associated with exposure to asbestos, tremolite, anthophyllite, and actinolite, is present in the form of several well-conducted epidemiological studies of occupationally exposed workers, family contacts of workers, and persons living near asbestos, tremolite, anthophyllite, and actinolite mines. These studies have shown a definite association between exposure to asbestos, tremolite, anthophyllite, and actinolite and an increased incidence of lung cancer, pleural and peritoneal mesothelioma, gastrointestinal cancer, and asbestosis. The latter is a disabling fibrotic lung disease that is caused only by exposure to asbestos. Exposure to asbestos, tremolite, anthophyllite, and actinolite has also been associated with an increased incidence of esophageal, kidney, laryngeal, pharyngeal, and buccal cavity cancers. As with other known chronic occupational diseases, disease associated with asbestos, tremolite, anthophyllite, and actinolite generally appears about 20 years following the first occurrence of exposure: There are no known acute effects associated with exposure to asbestos, tremolite, anthophyllite, and actinolite.

Epidemiological studies indicate that the risk of lung cancer among exposed workers who smoke cigarettes is greatly increased over the risk of lung cancer among non-exposed smokers or exposed nonsmokers. These studies suggest that cessation of smoking will reduce the risk of lung cancer for a person exposed to asbestos, tremolite, anthophyllite, and actinolite but will not reduce it to the same level of risk as that existing for an exposed worker who has never smoked.

III. Signs and Symptoms of Exposure-Related Disease

The signs and symptoms of lung cancer or gastrointestinal cancer induced by exposure to asbestos, tremolite, anthophyllite, and actinolite are not unique, except that a chest X-ray of an exposed patient with lung cancer may show pleural plaques, pleural calcification, or pleural fibrosis. Symptoms characteristic of mesothelioma include shortness of breath, pain in the walls of the chest, or abdominal pain. Mesothelioma has a much longer latency period compared with lung cancer (40 years versus 15–20 years), and mesothelioma is therefore more likely to be found among workers who were first exposed to asbestos at an early age. Mesothelioma is always fatal.

Asbestosis is pulmonary tibrosis caused by the accumulation of asbestos fibers in the lungs. Symptoms include shortness of breath, coughing, fatigue, and vague feelings of sickness. When the fibrosis worsens, shortness of breath occurs even at rest. The diagnosis of asbestosis is based on a history of exposure to asbestos, the presence of characteristics radiologic changes, end-inspiratory crackles (rales), and other clinical features of fibrosing lung disease. Pleural plaques and thickening are observed on X-rays taken during the early stages of the disease. Asbestosis is often a progressive disease even in the absence of continued exposure, although this appears to be a highly individualized characteristic. In severe cases, death may be caused by respiratory or cardiac failure.

IV. Surveillance and Preventive Considerations

As noted above, exposure to asbestos, tremolite, anthophyllite, and actinolite has been linked to an increased risk of lung cancer, mesothelioma, gastrointestinal cancer, and asbestosis among occupationally exposed workers. Adequate screening tests to determine an employee's potential for developing serious chronic diseases, such as a cancer, from exposure to asbestos, tremolite, anthophyllite, and actinolite do not presently exist. However, some tests, particularly chest X-rays and pulmonary function tests, may indicate that an employee has been overexposed to asbestos, tremolite, anthophyllite, and actinolite, increasing his or her risk of developing exposure related chronic diseases. It is important for the physician to become familiar with the operating conditions in which occupational exposure to asbestos, tremolite, anthophyllite, and actinolite is likely to occur. This is particularly important in evaluating medical and work histories and in conducting physical examinations. When an active employee has been identified as having been overexposed to asbestos, tremolite, anthophyllite, and actinolite, measures taken by the employer to eliminate or mitigate further exposure should also lower the risk of serious long-term consequences.

The employer is required to institute a medical surveillance program for all employees who are or will be exposed to asbestos, tremolite, anthophyllite, and actinolite at or above the action level (0.1 fiber per cubic centimeter of air) for 30 or more days per year and for all employees who are assigned to wear a negative-pressure respirator. All examinations and procedures must be performed by or under the supervision of a licensed physician, at a reasonable time and place, and at no cost to the employee.

Although broad latitude is given to the physician in prescribing specific tests to be included in the medical surveillance program, OSHA requires inclusion of the following elements in the routine examination:

(i) Medical and work histories with special emphasis directed to symptoms of the respiratory system, cardiovascular system, and digestive tract.

(ii) Completion of the respiratory disease questionnaire contained in Appendix D.

(iii) A physical examination including a chest roentgenogram and pulmonary function test that includes measurement of the employee's forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1).

(iv) Any laboratory or other test that the examining physician deems by sound medical practice to be necessary.

The employer is required to make the prescribed tests available at least annually to those employees covered; more often than specified if recommended by the examining physician; and upon termination of employment.

The employer is required to provide the physician with the following information: A copy of this standard and appendices; a description of the employee's duties as they relate to asbestos exposure; the employee's representative level of exposure to asbestos, tremolite, anthophyllite, and actinolite; a description of any personal protective and respiratory equipment used; and information from previous medical examinations of the affected employee that is not otherwise available to the physician. Making this information available to the physician will aid in the evaluation of the employee's health in relation to assigned duties and fitness to wear personal protective equipment, if required.

The employer is required to obtain a written opinion from the examining physician containing the results of the medical examination; the physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of exposure-related disease; any recommended limitations on the employee or on the use of personal protective equipment; and a statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions related to asbestos, tremolite, anthophyllite, and actinolite exposure that require further explanation or treatment. This written opinion must not reveal specific findings or diagnoses unrelated to exposure to asbestos, tremolite, anthophyllite, and actinolite, and a copy of the opinion must be provided to the affected employee.

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