# Testimony
# Committee on Environment and Public Works
# United States Senate

## "Examination of the Health Effects of Asbestos and Methods of Mitigating Such Impacts"

*Statement of*


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Madam Chair and members of the Committee, I am Dr. David Weissman, and I direct the Division of Respiratory Disease Studies in the National Institute for Occupational Safety and Health (NIOSH), a part of the Centers for Disease Control and Prevention (CDC) within the Department of Health and Human Services (HHS). NIOSH is the federal agency responsible for conducting research and making recommendations to identify and prevent work-related illness and injury. I am also a pulmonary diseases physician, and over the last 20 years have seen firsthand the human suffering caused by asbestos. Thank you for the opportunity to provide testimony on the health effects of asbestos and efforts by NIOSH to address this important problem.

My testimony today will address current scientific knowledge about the health risks posed by exposure of workers to airborne asbestos. I will also provide an update on NIOSH's recent activities in this area, including NIOSH efforts to define key areas for research as described in the draft NIOSH document released in February for public comment, *Asbestos and Other Mineral Fibers: A Roadmap for Scientific Research*.

**Background**

Asbestos is a term that is generally used to refer to a group of fibrous silicate minerals with exceptional resistance to degradation by heat, acids, bases, or solvents. The minerals are not combustible and have a high melting point and low thermal and electrical conductivity. Their fibers can be woven or incorporated into other materials. These and other useful properties resulted in their widespread commercial application during much of the 20th century. Unfortunately, widespread use of asbestos was followed by a marked increase in asbestos-related disease.

The definition of asbestos in many Federal regulations is limited to the fibrous forms of six specific commercial types of asbestiform minerals. One is from a class of minerals called serpentines, which have curved fibers: chrysotile. The other five are members of a class of minerals called amphiboles, which have straight fibers: crocidolite, amosite, tremolite asbestos, actinolite asbestos, and anthophyllite asbestos. The elemental composition of the six asbestos minerals can vary slightly, even within a single fiber, as a result of geological conditions such as pressure, temperature, or proximity of other minerals. Recognizing these variations in elemental composition, the six asbestos minerals can be defined by their "solid-solution" mineral series. For example, the mineral series tremolite-ferroactinolite contains the asbestos mineral actinolite. These mineral series are considered solid-solutions in which cations (i.e., sodium, calcium, magnesium, iron, etc.) are replaced by other cations which can affect the elemental composition of the mineral without significantly altering the structure. As another example, the Libby, Montana vermiculite ore body contains amphibole asbestos fibers of the tremolite-actinolite-richterite-winchite solid solution series. The minerals in the solution series have only minor differences in chemical content and have similar, if not identical, health effects. A third example of a mineral that produces similar diseases as asbestos is erionite, a fibrous mineral that is neither a serpentine nor an amphibole. It belongs to an entirely different class of minerals called zeolites.

**Asbestos-Related Diseases**

Exposure to asbestos significantly increases the risk of developing several types of cancer and non-cancerous diseases. Most asbestos-related diseases, particularly the cancers, have long latency periods often extending 10-40 years from initial exposure to onset of illness. These include:

1.) **Asbestosis**—a non-cancerous disease characterized by scarring of the air-exchange regions of the lungs. Progressive lung damage can cause progressive shortness of breath and inability to engage in physical activity, as well as other symptoms such as coughing and chest pain;

2.) **Lung cancer**—for which asbestos is one of the leading causes among non-smokers, and which occurs at dramatically high rates among asbestos-exposed smokers;

3.) **Malignant mesothelioma**—an almost invariably fatal cancer of the tissue covering the lungs and chest wall (called the pleura) or abdomen (called the peritoneum) for which asbestos and similar fibers are the only known cause; and

4.) **Nonmalignant pleural disease**—asbestos exposure can affect the pleura in several ways. It can cause a painful accumulation of bloody fluid surrounding the lungs. It can cause a circumscribed thickening, fibrosis, and sometimes calcification of pleural tissue – a condition called pleural plaques. Finally, it can cause a more severe condition with more extensive and sometimes constricting scarring of the tissue surrounding the lungs called diffuse pleural thickening.

In addition, asbestos exposure is associated with excess mortality due to cancer of the larynx and cancer of the gastrointestinal tract. The various types of cancers caused by asbestos are often fatal within a few years after initial diagnosis. In contrast, asbestosis deaths typically occur only after many years of suffering from impaired breathing.

The risk of developing adverse health effects from asbestos is related to the amount and duration of exposure to airborne asbestos fibers. Exposure occurs in the occupational setting when microscopic asbestos fibers become airborne during various industrial processes or from handling of asbestos-containing materials. The fibers can then be inhaled and/or swallowed. In the lungs, asbestos fibers can interact with cellular targets such as alveolar macrophages and alveolar epithelial cells, inducing a chain of events leading to scarring and/or cancer in the lungs. Fibers can also translocate through the lungs to the pleura, where they can cause malignant mesothelioma and nonmalignant pleural disease. Key factors associated with the carcinogenic potential of asbestos fibers include: particle length (longer fibers are more toxic than shorter fibers); diameter (fibers $\leq$ 3 micrometers in diameter are more likely than thicker fibers to be inhaled into the lungs, and fibers $< 0.5$ micrometers in diameter are more likely to migrate through lung tissue to the pleura); and biopersistence (fibers able to persist in the lung and not be cleared from the lung by physiological lung defense mechanisms are more likely to cause adverse health effects).

Asbestos-related diseases can be prevented by eliminating or limiting exposures to asbestos. The Occupational Safety and Health Administration (OSHA), the Mine Safety and Health Administration (MSHA), and the Environmental Protection Agency (EPA) regulate the six asbestos minerals. The OSHA permissible exposure limit (PEL) for asbestos is 0.1 fibers per cubic centimeter (cc) of air. This limit was set in part based on the limit of detection of the exposure assessment method specified in the standard (phase contrast microscopy (PCM)) and is not completely protective against asbestos-induced disease. Occupational exposure limits are generally set to reduce risk associated with exposures to a level at or below 1 per 1,000 working lifetimes.

The risk analyses upon which the OSHA PEL and MSHA's proposal to revise its PEL are based were recently detailed by MSHA in its proposed rule. It should be noted that these risk analyses make the maximally protective assumption that exposure would be at the PEL every work day over an entire 45-year working lifetime. Over such a working lifetime, exposure at the OSHA asbestos PEL is estimated to be associated with an excess risk of cancer (lung, mesothelioma, and gastrointestinal) of 3.4 cases per 1,000 exposed individuals and an excess risk of asbestosis of 2.5 cases per 1,000 exposed individuals.   In mining, the current MSHA PEL for asbestos is 20-fold higher at two fibers per cc air.  Were exposure to the current MSHA PEL to occur every day over a 45- year working lifetime, it would be associated with an excess risk of cancer of 64.1 cases per 1,000 exposed individuals and an excess risk of asbestosis of 49.7 cases per 1,000 exposed individuals.  Fortunately, the U.S. mining industry does not currently mine or produce asbestos and asbestos sampling data presented in MSHA's proposed rule showed low exposures for the mining population. MSHA has proposed to reduce its PEL to make it consistent with the OSHA PEL, and NIOSH has provided public comments in support of this proposed rule.

**Burden of Asbestos-Related Diseases**

NIOSH has tracked annual U.S. asbestosis deaths since 1968 and malignant mesothelioma deaths since 1999 using death certificate data in the National Occupational Respiratory Mortality System (NORMS).  Data from NORMS show that asbestosis deaths increased almost 20-fold from the late 1960s to the late 1990s and have apparently plateaued only since 2000 at approximately 1,500 per year (Figure 1).  By contrast, mesothelioma deaths continue to rise (Table 1).  Current asbestos and mesothelioma mortality reflect past exposures because the latency between exposure and disease onset is long, particularly for mesothelioma, and asbestosis is a chronic disease, with affected individuals typically living for many years with the disease before succumbing.

**Figure 1.** Number of asbestosis deaths, U.S. residents age 15 and over, 1968-2004. Source: National Occupational Respiratory Mortality System (NORMS), found at: http://webappa.cdc.gov/ords/norms.html.

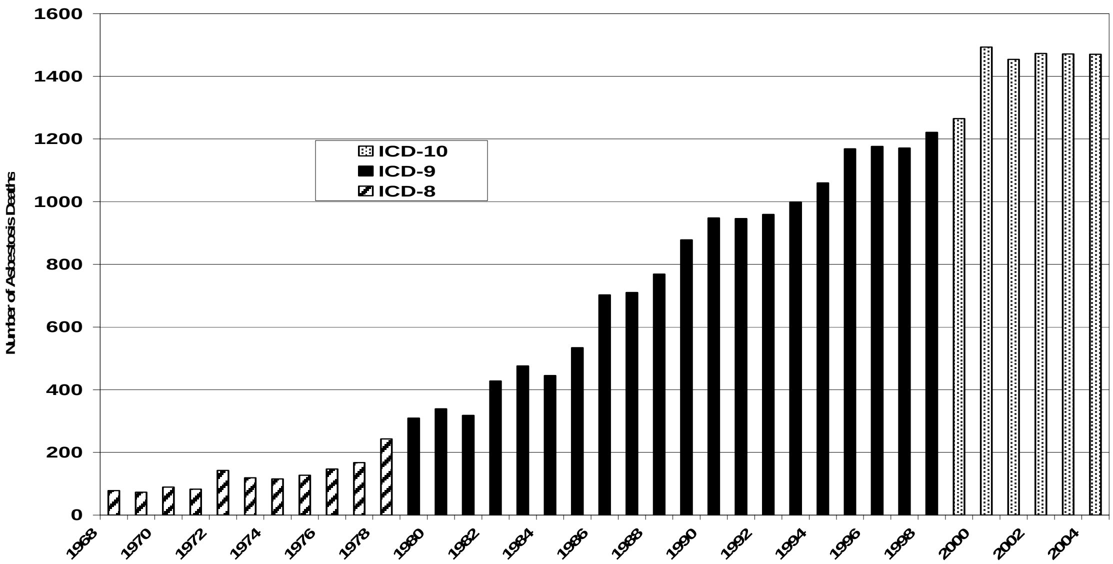


**Table 1.** Number of mesothelioma deaths, U.S. residents age 15 and over, 1999-2004.

| Year | Deaths |
|---|---|
| 1999 | 2,484 |
| 2000 | 2,531 |
| 2001 | 2,509 |
| 2002 | 2,573 |
| 2003 | 2,625 |
| 2004 | 2,657 |
| 1999-2004 (total) | 15,379 |

Source: NORMS (http://webappa.cdc.gov/ords/norms.html)

Over time, the annual number of deaths should decrease substantially as a result of reductions in exposures. However, asbestos usage has not been completely eliminated. Although domestic production of asbestos has ceased and importation of raw asbestos fibers has markedly declined, many finished asbestos-containing products continue to be imported into the United States. These include asbestos-cement sheets, panels, and tiles; corrugated sheets; and automotive friction products. In addition, a reservoir of asbestos-containing materials remains in place in older buildings and machinery. Thus, even with limitations or exclusions from new use, occupational exposures to asbestos will continue, albeit at a far lower level than in the past.

**Update on NIOSH Activities Related to Asbestos**

NIOSH continues to work actively to address issues related to asbestos-induced lung disease. We are continuing to track asbestosis deaths, mesothelioma deaths, and occupational exposures to asbestos and have plans to include updated findings in an upcoming new edition of the recurring NIOSH document, the "Work-Related Lung Disease Surveillance Report." Updates are also available on the NIOSH Web site.

NIOSH recently reported updated information on the occupational respiratory disease mortality among workers who mined, milled, and processed vermiculite contaminated with asbestiform fibers, including winchite, richterite, and tremolite from the mine near Libby, Montana. These workers had significantly increased rates of death from cancer, including lung cancer and malignant mesothelioma. They also had significantly increased rates of death from nonmalignant respiratory disease, including asbestosis and chronic obstructive pulmonary disease. Exposure-response relationships were demonstrated, with increasing fiber exposure associated with increasing mortality from lung cancer, asbestosis, and noncancerous chronic respiratory disease. This report adds to the growing body of literature documenting the adverse effects of exposure to Libby amphibole fibers.

With regard to Libby, the activities of the Agency for Toxic Substances and Disease Registry (ATSDR), an important partner of NIOSH, should be noted. A medical screening program conducted by ATSDR in Libby revealed an unusually high rate of asbestos-related disease among participants. Although many of these participants were former mine workers, others were their household contacts or community members with possible environmental exposures. Based on these findings, ATSDR established a Tremolite Asbestos Registry, which will complement NIOSH's work by tracking the health outcomes of exposed individuals over time. To date, ATSDR has enrolled more than 4,000 individuals – comprising 83% of former Libby mine workers, their household contacts and a defined set of other local residents – and will administer follow-up interviews and medical screenings on a regular basis. "Take-home" exposures—involving family members of workers who bring asbestos home on their hair, clothing, or shoes—is a well-recognized hazard addressed by NIOSH in a 1995 report to Congress (http://www.cdc.gov/niosh/contamin.html), so ATSDR's inclusion of household contacts in the registry will contribute important information to the body of research. In addition to research, ATSDR will use the registry to provide participants with information about new therapies that may become available in the future. ATSDR is also studying exposures to asbestiform fiber-contaminated vermiculite ore from Libby that was processed at sites in California, Ohio, Minnesota, New Jersey, New York and Wisconsin. ATSDR plans to use the findings of the registry and studies conducted at processing sites to develop a research agenda for Libby amphibole-related research.

NIOSH is doing research to clarify the relationships between fiber dimensions (length and diameter) and the risk for developing lung cancer or asbestosis through follow-up studies of a cohort of chrysotile-exposed South Carolina textile workers. NIOSH originally reported on this cohort in the 1980s. Exposures were originally evaluated by PCM. Since then, archived samples collected by NIOSH have been re-analyzed by transmission electron microscopy (TEM) to better evaluate fiber dimensions, including fibers too small to be seen by PCM. Also, mortality information about the cohort has been updated. Based on these data, fiber size-specific exposure estimates have been developed for the cohort. Analyses are underway to determine the influence of fiber length and width on lung disease risk. These findings will help to inform approaches to quantitative risk assessment, particularly the potential utility of risk assessment based on fiber size.

NIOSH is also doing research in the area of exposure assessment. A recently published American Society for Testing and Materials (ASTM) International Standard – “Method for Sampling and Counting Airborne Fibers, Including Asbestos Fibers, In Mines and Quarries, by Phase Contrast Microscopy” (D7200-06) – contains a proposed methodology for separating fiber-like particles other than asbestos from probable asbestos fibers. The new ASTM procedure has not yet been validated to confirm that it produces accurate, reproducible results. A current NIOSH study will address this issue by documenting the performance of the ASTM procedure. Another important issue in asbestos exposure assessment is sampling in dusty environments, such as mines. Traditional filter samplers quickly become overloaded with dust, limiting the ability to detect asbestos fibers. One approach to reducing this problem is to use a sampler that only collects particles small enough to reach the airways of the lung when inhaled, and not larger particles that mostly deposit in the mouth, nose, and throat. NIOSH is currently evaluating two such “thoracic” particulate samplers in comparison to the traditional filter sampler in two different mining environments.

NIOSH is pursuing research relevant to the detection of asbestos-related respiratory diseases. Traditionally, film-based chest radiographs have been used in epidemiological studies evaluating workers for pulmonary and pleural disease associated with asbestos exposure. This is because only film-based chest radiographs may be systematically classified for changes of dust-induced lung disease (pneumoconiosis) using the widely accepted International Labour Organization (ILO) classification system. However, in the United States, digital chest radiography has largely replaced film-based radiography. NIOSH has funded research to evaluate the impact of classifying digital, instead of film-based, chest x-rays on the detection and classification of pulmonary and pleural disease. Initial results suggest that the two methods do not differ significantly in detection of interstitial (lung tissue) processes, but do differ in detection of pleural processes, with fewer pleural changes detected in those undergoing digital chest radiography. In follow up to this finding, NIOSH is assisting ATSDR in performing a study to compare detection of pleural changes in those exposed to Libby amphibole by film-based and digital radiography, with findings of computed tomography scans of the chest serving as a “gold standard.”

In 2006, NIOSH published a Recommended Exposure Limit (REL) for another type of inorganic fiber, refractory ceramic fibers (RCF). Although RCF are man-made fibers which differ from asbestos in toxicity, many of the same issues relevant to asbestos such as fiber length, diameter, and biopersistence were considered in developing the NIOSH REL of 0.5 fibers per cc.

**Asbestos and Other Mineral Fibers: A Roadmap for Scientific Research**

A major recent NIOSH effort has been the development of a draft “Roadmap” document that details key scientific issues in asbestos and identifies research directions to address these issues. Key issues include the following:

**Which minerals should be treated as asbestos?**

As already described, most regulatory definitions of asbestos do not explicitly include minerals such as winchite, richterite, and erionite, despite the known similar health effects of their fibers to those of the explicitly listed asbestos minerals. In addition, significant controversy exists regarding other types of mineral particles that have the dimensions of fibers. For example, El Dorado, California, is a site with natural deposits of amphibole that have been disturbed by construction and crushing of rock. Analyses of air and rock samples have identified the presence of actinolite in the form of needle-like crystalline structures called “acicular/prismatic actinolite.” Although many of these amphibole particles meet the dimensional criteria of asbestos fibers, they have a different crystalline structure from fibrous actinolite asbestos. A recent report by investigators from the University of California found that residential proximity to deposits of “naturally occurring asbestos” such as those in the vicinity of El Dorado was associated with increased risk for mesothelioma, implicating these minerals as a possible health hazard. It should be noted that this report did not include actual measurement of fiber exposures associated with residence in these areas.

Asbestos minerals have analogs that are crystallized in non-asbestiform (massive) structures. A controversial type of mineral particle is the “cleavage fragment," which can be generated from massive forms of these analog minerals during their handling, crushing, or processing, as occurs in mining and construction. Using current analytical methods based on light microscopy, these “cleavage fragments” are often microscopically indistinguishable from asbestiform fibers of their asbestos mineral counterparts. The toxic potential of these mineral particles, in particular their carcinogenicity, has been an area of great controversy.

**Are the specified dimensions of asbestos fibers appropriate?**

Currently, a mineral particle is detected by PCM and counted as a fiber if it has a length to width ("aspect") ratio of 3:1 and length of at least 5 micrometers. These counting rules include particles with diameters greater than 3 microns, which are unlikely to reach the airways or the gas-exchange regions of the lungs when inhaled. Also, PCM cannot detect particles with diameters less than about 0.25 micrometers, which, although not visible by PCM, are capable of causing harm. Finally, although longer fibers have been associated with greater potential for carcinogenicity, studies of fibers deposited in human tissues suggest that fibers less than 5 micrometers in length may also contribute to human disease, including cancer.

The broad goals of the research outlined in the *Roadmap* are to: 1) provide a scientific framework for evidence-based worker protection recommendations; 2) address the broad range of mineral fibers to which workers are exposed; and 3) refine our understanding of fiber characteristics associated with toxicity. Strategic goals identified by the *Roadmap* are to: 1) develop improved sampling and analytical methods for mineral fibers; 2) develop information and knowledge on occupational exposures to the range of mineral fiber types and their health outcomes; and 3) develop a broader understanding of the important determinants of fiber toxicity. In particular, it would be useful to develop approaches that would make it possible to predict the ability of various mineral fiber types to cause human disease and apply this information for risk management.

NIOSH has solicited public comment on the draft *Roadmap* document via docket submissions and a public meeting. The draft document was first made available to the public on February 28, 2007, and public comments were accepted into the docket from the time of posting until May 31, 2007. The public meeting was held on May 4, 2007. Peer reviewers have been selected and are being provided with a copy of the public comments as well as the draft *Roadmap* document. Revision of the document will take into account both public and peer review comments. The goals expressed in the *Roadmap* are ambitious. NIOSH plans to develop a range of partnerships to address these goals, including with other Federal agencies, labor, industry, academia, and other interested parties. Although NIOSH will focus on occupational safety and health, we will pursue opportunities to ensure that the results of research arising from the *Roadmap* can be extended outside of the occupational setting.

**Conclusion**

Despite the ability to prevent asbestos-related diseases by preventing exposure, they continue to be an important problem in the United States. At least in part because of the long lag in time between exposure and mortality, deaths from asbestos-related diseases such as asbestosis and mesothelioma have not yet declined. Furthermore, asbestos exposure continues to occur due to the presence of asbestos in older buildings and continued importation of asbestos-containing products from other parts of the world. Asbestiform erionite, a non-serpentine, non-amphibole mineral fiber that is well-established as having toxicity similar to asbestos, is not included within regulatory definitions that are limited to the six commercial types of asbestos. Controversy surrounds the toxic potential of several other mineral fiber types, in particular acicular/prismatic actinolite identified in El Dorado, California; and “cleavage fragments” of non-asbestiform amphibole minerals encountered especially in mining and construction. NIOSH continues to work actively in this area and has developed a draft *Roadmap* describing current issues and research strategies to address these issues. Working with a range of partners, our ultimate goal is to develop, disseminate, and facilitate the adoption of evidence-based recommendations to better protect workers from diseases caused by asbestos and other mineral fibers.

Thank you again for the opportunity to testify before you today. I would be happy to answer any questions you may have.