NIOSH Testimony to DOL

TESTIMONY OF THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH ON THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION'S NOTICE OF PROPOSED RULEMAKING ON OCCUPATIONAL EXPOSURE TO ASBESTOS, TREMOLITE, ANTHOPHYLLITE, AND ACTINOLITE

29 CFR Parts 1910 and 1926
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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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I am Richard A. Lemen, Assistant Director of the National Institute for Occupational Safety and Health (NIOSH). With me today are senior staff from NIOSH. Our purpose for appearing at this hearing is to provide testimony to OSHA regarding the proposed rulemaking to remove nonasbestiform tremolite, anthophyllite, and actinolite from the asbestos standard.

NIOSH is concerned that deleting cleavage fragments of nonasbestiform tremolite, anthophyllite, and actinolite from the asbestos standard poses a potentially serious health risk for exposed workers. On June 21, 1984, NIOSH testified at the OSHA public hearings on occupational exposure to asbestos and presented supporting evidence that there is no safe airborne fiber concentration for any of the asbestos minerals [NIOSH 1984]. NIOSH stated that not even the lowest fiber exposure limit could assure all workers of absolute protection from exposure-related cancer. This conclusion was consistent with previous positions taken by NIOSH in the 1976 criteria document on asbestos and the joint NIOSH/OSHA report of 1980 [NIOSH 1976; NIOSH/OSHA 1980]. In the NIOSH/OSHA report, NIOSH also reaffirmed its position that there is no scientific basis for differentiating health risks between types of asbestos fibers for regulatory purposes. In its 1984 testimony, NIOSH urged that the goal be to eliminate asbestos fiber exposures [NIOSH 1984]. Where fiber exposures cannot be eliminated, exposures should be limited to the lowest concentration possible.

When recommending an occupational exposure limit in its 1984 testimony, NIOSH acknowledged the limitations imposed by currently accepted methods of sampling and analysis. NIOSH concluded that for regulatory purposes, phase contrast microscopy (PCM) was still the most practical technique for assessing asbestos fiber exposures when using the criteria given in NIOSH Analytical Method 7400 [NIOSH 1989a]. NIOSH also recognized that phase contrast microscopy (1) lacked specificity when asbestos and other fibers occurred in the same environment, and (2) was not capable of detecting fibers with diameters less than approximately 0.25 micrometers. NIOSH further stated that it might be necessary to analyze air samples by electron microscopy where both electron diffraction and microchemical analysis can be used to help identify the type of mineral and assist in ascertaining asbestos fiber concentrations.

REVIEW OF THE LITERATURE BY OSHA

In its review of the health literature, OSHA has acknowledged the difficulties in interpreting the health effects data gathered from epidemiologic studies or animal bioassays where exposure to nonasbestiform tremolite, anthophyllite, or actinolite were reported. These difficulties result partly from the confusion over mineralogic definitions and the ways in which these definitions have been applied to characterize mineral particles (e.g., cleavage fragments, fibers) when viewed microscopically. OSHA concluded from their review of the mineralogic data that the amphibole minerals form in a continuum of habits ranging from massive to fibrous to the extremely fibrous and thin asbestiform habit. OSHA further noted that often, no exact line can be drawn between the nonasbestiform acicular habits and the asbestiform habit. They also stated that, at the microscopic level, cleavage fragments from the nonasbestiform habits are frequently indistinguishable from asbestos fibers.

Exposure to Nonasbestiform Minerals

OSHA has evaluated various reports that reviewed the health effects of exposure to nonasbestiform minerals [Bailey 1988; Environmental Health Associates, Inc. 1988; Boehlecke 1988; Cooper 1988; Balmes and Rempel 1989; Nicholson 1989] and has determined that the evidence suggests the existence of a possible carcinogenic hazard and other impairing noncarcinogenic adverse health effects from exposure to these minerals. OSHA stated further that evidence indicates mixed exposures of the asbestiform and nonasbestiform minerals have caused lung cancer and other asbestos-related diseases in workers employed in the mining and milling of talc [Kleinfeld et al. 1974; Kleinfeld et al. 1967; Brown et al. 1979] and vermiculite [McDonald et al. 1986; Amandus and Wheeler 1987].

Fiber Characteristics

Several studies submitted to the docket and reviewed by OSHA [Stanton et al. 1981; Stanton et al. 1977; Wagner et al. 1986] provide evidence that fiber dimension is an important factor in the etiology of asbestos-related disease. In the experimental animal study reported by Stanton et al. [1977] the carcinogenicity of fibers was found to be dependent on dimension and durability rather than physiochemical properties; they emphasized that all respirable fibers should be viewed with caution. Other reports of experimental animal studies submitted to OSHA supported this conclusion [Harington 1981; Pott 1980; Wagner et al. 1980; Wright and Kuschner 1977; Bertrand and Pezerat 1980]. An analysis of Stanton's data by others [Bertrand and Pezerat 1980; Bonneau et al. 1986] indicated a high correlation between aspect ratio and tumor incidence with an increase in tumor development observed beginning with exposure to fibers having aspect ratios of about 3 to 5.

In the proposed rule, OSHA concluded the following from their review of the epidemiologic and animal data:

> "There is insufficient evidence to conclude that nonasbestiform tremolite, anthophyllite, and actinolite cleavage fragments present a health risk similar in magnitude or type to fibers of their asbestiform counterparts. However, the positive evidence of carcinogenicity of their asbestiform counterparts and other durable nonasbestos minerals, in conjunction with evidence that the carcinogenic process is associated with fiber characteristics (i.e., size, shape, durability) possessed by nonasbestiform tremolite, anthophyllite, and actinolite particles, do raise questions as to the toxic potential of cleavage fragments of nonasbestiform minerals."

NIOSH ASSESSMENT OF THE SCIENTIFIC LITERATURE

NIOSH concurs with OSHA's review and assessment of the epidemiologic and animal data submitted to the docket. Reviews of epidemiologic studies submitted to OSHA on workers exposed to nonasbestiform cleavage fragments have found equivocal evidence of a health risk [Nicholson 1989; Balmes and Rempel 1989]. Other epidemiologic studies [Brown et al. 1979; Kleinfeld et al. 1974; Kleinfeld et al. 1967, McDonald et al. 1986; Amandus and Wheeler 1987] cited by OSHA have provided clear evidence of an increase in lung cancer and other asbestos-related diseases in talc and vermiculite workers with mixed airborne exposures to asbestos fibers and nonasbestiform cleavage fragments.

As stated by OSHA, most of the experimental animal carcinogenicity studies with mineral fibers have been conducted by intrapleural or intraperitoneal administration. These studies [Stanton et al. 1977; Stanton et al. 1981; Wagner et al. 1982; Muhle et al. 1987; Pott et al. 1974; Pott et al. 1987] have provided the strongest evidence that the carcinogenic potential depends on the size of the mineral particle length and diameter. The consistency in tumorigenic responses observed for various mineral particles of the same size suggests that the chemical composition of these particles may not be a critical factor in carcinogenic potential. Published reviews of these data by others [Lippmann 1988; Pott et al. 1987] support the hypothesis that any mineral particle can induce cancer and mesothelioma if it is sufficiently durable to be retained in the lung and if it has the appropriate aspect ratio and dimensions.

On the basis of these data, and the lack of sufficient data to the contrary, NIOSH concludes for regulatory purposes that cleavage fragments of the appropriate aspect ratio and length from the nonasbestiform minerals should be considered as hazardous as fibers from the asbestiform minerals. Furthermore, NIOSH is concerned about the potentially serious health hazard that could be posed to exposed workers if users of crushed stone, aggregate rock, or any other mineral commodity that may contain nonasbestiform or asbestiform minerals are exempted from initial monitoring and labeling requirements of the asbestos standard. Many of the crushed stone, aggregate rock, talc, and vermiculite mines and quarries in the United States are located in areas containing igneous or metamorphic rocks where exposures to asbestiform and nonasbestiform tremolite, anthophyllite, and actinolite can occur [Bartlett 1988; Campbell 1988]. The asbestiform and nonasbestiform minerals are formed together as a result of regional metamorphism of large bodies of rock that are chemically changed by intense heat and pressure associated with folding and faulting of the rock. These minerals may also be formed during contact metamorphism, by which a body of rock is changed because of its proximity to an intrusion of molten rock. Because all metamorphic processes are incomplete, asbestiform tremolite, actinolite, and anthophyllite can be formed in distinct veins or widely disseminated within deposits of the same nonasbestiform minerals. The same metamorphic conditions often occur during the formation of talc where small amounts of asbestiform and nonasbestiform tremolite and anthophyllite, and chrysotile develop during the metamorphism of dolomite and quartzose rocks, or by the hydrothermal alteration of iron/magnesium igneous intrusive rocks [Clifton 1984]. The presence of mixed exposures to asbestiform and nonasbestiform tremolite and anthophyllite has been documented by Dement et al. [1979] and others [Kleinfeld et al. 1973] during the mining and milling of talc. Airborne fiber exposures of workers to tremolite and anthophyllite, as determined by optical microscopy, were found to range from 0.8 to 9.8 fibers/cc in the mine, and 0.2 to 16.0 fibers/cc in the mill at a talc operation in upper New York State [Dement et al. 1979]. Similar occurrences of mixed fiber exposures have been reported by the Mine Safety and Health Administration (MSHA) at selected stone and sand/gravel mine sites [Consad Research Corporation 1989]. Exposure data collected at these sites indicated airborne fiber concentrations (total of 60 samples) that ranged from 0.18 to 15.60 fibers/cc when analyzed by optical microscopy. Asbestos fibers were identified in 2 of 60 samples, and nonasbestiform tremolite, anthophyllite, and actinolite cleavage fragments were found in 7 of 60 samples when analyzed by electron microscopy. When exposure concentrations were determined by electron microscopy for these 9 samples, concentrations of 0.01 to 1.2 fibers/cc were found when all fibers and cleavage fragments with aspect ratios ≥ 3:1 and lengths greater than 5 μm were analyzed. Similar exposure concentrations (0.02 to 0.9 fibers/cc) have been reported by the Fairfax County Health Department [Dusek and Yetman 1990] for workers exposed to asbestiform and nonasbestiform tremolite and actinolite during earth and rock removal operations in Fairfax County, Virginia.

Because many of the crushed stone and aggregate rock mines and quarries are located in areas of the country where the asbestiform and nonasbestiform serpentine and amphibole minerals occur, NIOSH is concerned about the inadvertent contamination of these minerals in mined commodities. In the absence of appropriate labeling as required in the asbestos standard, users of these commodities could be subjected to a serious health risk as a result of airborne exposure to fibers or cleavage fragments when minimal or no engineering controls are used. NIOSH has identified from the National Occupational Exposure Survey (NOES) data the potential for exposure to talc/tremolite/anthophyllite in forty-one 2-digit Standard Industrial Classification (SIC) codes in which over 1 million workers in 67,678 industrial facilities could be potentially exposed [NIOSH 1983]. Of these forty-one 2-digit SIC codes, 25 were identified as sources of potential exposure to tremolite (4,517 industrial facilities and 46,980 workers). An analysis of the various talcs reported in the NOES tradename data base as of January 1, 1990, indicated that the talc observed in these industries could contain up to 50% tremolite and 10% anthophyllite.

NIOSH is unaware of any geologic evaluation that can be performed at a mine or quarry where nonasbestiform serpentine or amphibole minerals occur, including the analysis of bulk samples, that can provide an adequate assurance of the absence of asbestiform minerals since these minerals can occur sporadically at the mine and quarry site. Also, NIOSH is unaware of any routine analytical methods that can be used to differentiate between airborne exposures to asbestos fibers and nonasbestiform cleavage fragments that meet the microscopic definition of a fiber. The inability to microscopically distinguish between fibers and cleavage fragments of similar morphologic dimensions raises serious concerns about excluding nonasbestiform tremolite, anthophyllite, and actinolite from the asbestos standard. Because of these uncertainties, exclusion of these minerals from the asbestos standard will present enforcement difficulties when the source of the airborne exposure is unknown or when the exposure involves mixed mineral types.

CONCLUSIONS AND RECOMMENDATIONS

NIOSH finds no scientifically valid health evidence for removing from the asbestos standard cleavage fragments that (1) become airborne when nonasbestiform tremolite, anthophyllite, and actinolite are mined, milled and used and (2) meet the microscopic definition of a fiber. Deletion of these nonasbestiform cleavage fragments from the standard would pose a potentially serious health risk to exposed workers and would compromise the protection afforded to workers with mixed airborne exposures to the asbestiform and nonasbestiform minerals. The risk of cancer from exposure to asbestos fibers and the potential risk of cancer from exposure to cleavage fragments from nonasbestiform tremolite, anthophyllite, and actinolite warrant limiting exposures to these minerals to the lowest feasible concentration.

NIOSH has attempted to incorporate the appropriate mineralogic nomenclature in its recommended standard for asbestos and recommends the following to be adopted for regulating exposures to asbestos:

> The current NIOSH asbestos recommended exposure limit is 100,000 fibers greater than 5 micrometers in length per cubic meter of air, as determined in a sample collected over any 100-minute period at a flow rate of 4L/min. This airborne fiber count can be determined using NIOSH Method 7400, or equivalent. In those cases when mixed fiber types occur in the same environment, then Method 7400 can be supplemented with electron microscopy, using electron diffraction and microchemical analyses to improve specificity of the fiber determination. NIOSH Method 7402 [NIOSH 1989b] provides a qualitative technique for assisting in the asbestos fiber determinations. Using these NIOSH microscopic methods, or equivalent, airborne asbestos fibers are defined, by reference, as those particles having (1) an aspect ratio of 3 to 1 or greater; and (2) the mineralogic characteristics (that is, the crystal structure and elemental composition) of the asbestos minerals and their nonasbestiform analogs. The asbestos minerals are defined as chrysotile, crocidolite, amosite (cummingtonite-grunerite), anthophyllite, tremolite, and actinolite. In addition, airborne cleavage fragments from the nonasbestiform habits of the serpentine minerals antigorite and lizardite, and the amphibole minerals contained in the series cummingtonite-grunerite, tremolite-ferroactinolite, and glaucophane-riebeckite shall also be counted as fibers provided they meet the criteria for a fiber when viewed microscopically.

A glossary of terms has been attached to our testimony and provides the basis for the mineral terminology used in the NIOSH recommended regulatory definition for asbestos.

NIOSH maintains that prudent public health practice dictates the use of appropriate labeling and exposure monitoring when workers are potentially exposed to asbestos fibers or cleavage fragments from the nonasbestiform analogs. NIOSH is particularly concerned about mined commodities which originate from mines and quarries located in igneous or metamorphic rock formations in which secondary users may unknowingly be exposed to asbestos fibers or nonasbestiform cleavage fragments. OSHA should require these mine operators to label their mined commodities as required under the current asbestos standard and notify users of these commodities as to the potential for fiber exposure during their handling. NIOSH acknowledges that many mined commodities (such as limestone, sandstone, shale) originate from mines and quarries located exclusively in sedimentary rock formations in which the occurrence of serpentine and amphibole minerals are unlikely and may require separate treatment for granting exemption.

SUMMARY

NIOSH has identified several issues that form the basis for our recommendation that no regulatory distinction be made between airborne asbestos fibers and airborne nonasbestiform cleavage fragments. These issues are as follows:

1. Experimental animal carcinogenicity studies conducted by intrapleural or intraperitoneal administration with various minerals have provided strong evidence that the carcinogenic potential depends on the particle length and diameter. The consistency in tumorigenic responses observed for various mineral particles of the same size provides reasonable evidence that neither chemical composition nor origin of the particle is a critical factor in carcinogenic potential.

2. Epidemiologic studies of workers exposed to nonasbestiform cleavage fragments provide equivocal evidence of an excess in lung cancer risk [Gillam et al. 1976; McDonald et al. 1978; Brown et al. 1986; Higgins et al. 1983; Cooper et al. 1988]. The results of other epidemiologic studies of workers exposed to mixed exposures of asbestos fibers and nonasbestiform cleavage fragments have demonstrated an excess in lung cancer risk [Brown et al. 1979; Kleinfeld et al. 1967; Kleinfeld et al. 1974; McDonald et al. 1986; Amandus and Wheeler 1987].

3. Asbestiform and nonasbestiform minerals can occur separately or in the same geologic area where crushed stone, aggregate rock, talc, and vermiculite mines and quarries are found. The location and identification of asbestiform tremolite, actinolite, and anthophyllite within deposits of the same nonasbestiform minerals are often difficult since the asbestiform minerals can occur sporadically at the mine or quarry site. The occurrence of these minerals within the mine or quarry often inadvertently contaminate the mined commodity.

4. No analytical methods are available that can be used routinely to differentiate between airborne exposures to asbestos fibers and nonasbestiform cleavage fragments that meet the microscopic definition of a fiber.

Based on this body of evidence, NIOSH finds no compelling reason to delete airborne nonasbestiform tremolite, actinolite, and anthophyllite cleavage fragments from the asbestos standard until sufficient health and exposure data are collected to demonstrate the absence of risk from exposures to these nonasbestiform minerals.

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Attachment A

GLOSSARY OF TERMS

ASBESTOS

Asbestos is a generic term for a number of silicate minerals with a fibrous crystalline structure.

The quality of commercially used asbestos depends on the mineralogy of the asbestiform variety, the degree of fiber development, the ratio of fibers to acicular crystals or other impurities, and the length and flexibility of the fibers. The asbestiform varieties of these minerals can be found in both the amphibole and serpentine mineral groups. The asbestiform varieties occur in veins or small veinlets within rock containing or composed of the massive (nonasbestiform) variety of the same mineral. The major asbestiform varieties of minerals used commercially are chrysotile, tremolite-actinolite asbestos, cummingtonite-grunerite asbestos, anthophyllite asbestos, and crocidolite. Asbestos is marketed by its mineral name (e.g., anthophyllite asbestos), its variety name (e.g., chrysotile or crocidolite), or its trade name (e.g., Amosite).

SERPENTINE MINERALS

The serpentine minerals belong to the phyllosilicate group of minerals. The commercially important variety is chrysotile, which originates in the asbestiform habit. Antigorite and lizardite are two other types of serpentine minerals that are structurally distinct in mineral habit. The fibrous form of antigorite is called picrolite.

Chrysotile: Chrysotile generally occurs segregated as parallel fibers in veins or veinlets and can easily separate into individual fibers or bundles. Often referred to as "white asbestos," it is used commercially for its good spinnability in the making of textile products, and as an additive in cement or friction products.

AMPHIBOLE MINERALS

Minerals in the amphibole group are widely distributed in the earth's crust in many igneous or metamorphic rocks. In some instances, the mineral deposits contain sufficient quantities of the asbestiform minerals to be economically minable for commercial use. The minerals and mineral series of the amphibole group have variable compositions with extensive elemental substitutions. They are found in forms ranging from massive to fibrous. The most common commercially exploited asbestiform varieties of this mineralogical group include crocidolite, amosite, anthophyllite, tremolite, and actinolite. Crocidolite, amosite, and anthophyllite are selectively mined for commercial use, whereas tremolite and actinolite are most often found as a contaminant in other mined commodities such as talc and vermiculite. The amphiboles have good thermal and electrical insulation properties, and they have moderate to good resistance to acids.

Crocidolite: Crocidolite is a varietal name for the fibrous habit of the mineral riebeckite and is in the mineral series glaucophane-riebeckite, in which both asbestiform and nonasbestiform habits can occur. This mineral type is commonly referred to as "blue asbestos."

Amosite: Amosite is the commercial term derived from the acronym "Asbestos Mines of South Africa." Amosite is in the mineral series cummingtonite-grunerite*, in which both asbestiform and nonasbestiform habits of the mineral can occur. This mineral type is commonly referred to as "brown asbestos."

Anthophyllite: Anthophyllite can occur in both the asbestiform and nonasbestiform mineral habits. The asbestiform variety is often referred to as anthophyllite asbestos.

Tremolite: Tremolite can occur in both the asbestiform and nonasbestiform mineral habits and is in the mineral series tremolite-ferroactinolite*. The asbestiform variety is often referred to as tremolite asbestos.

Actinolite: Actinolite can occur in both the asbestiform and nonasbestiform mineral habits and is in the mineral series tremolite-ferroactinolite*. The asbestiform variety is often referred to as actinolite asbestos.

Asbestiform habit: A specific type of mineral fibrosity in which the growth is primarily in one dimension and the crystals form naturally as long, flexible fibers. Fibers can be found in bundles that can be easily separated into smaller bundles or ultimately into fibrils.

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*Mineral series such as cummingtonite-grunerite and tremolite-ferroactinolite are created when one cation is replaced by another in a crystal structure without significantly altering the structure. There may be a gradation in the structure in some series, and minor changes in physical characteristics may occur with elemental substitution. Usually a series has two end members with an intermediate substitutional compound being separately named, or just qualified by being referred to as members of the series. Members of the tremolite-ferroactinolite series are hydroxylated calcium-magnesium, magnesium-iron, and iron silicates, with the intermediate member of this series being named actinolite.

__Cleavage fragments__: Mineral particles produced by the breaking of crystals in directions that are related to the crystal structure and are always parallel to possible crystal faces. Minerals with perfect cleavage can produce perfect regular fragments. Amphiboles with prismatic cleavage will produce prismatic fragments.

> __Note__: These particles can be elongated and may meet the NIOSH definition of a fiber upon microscopic examination.

__Fiber__: An acicular single crystal or similarly elongated polycrystalline aggregate particle. Such particles have macroscopic properties such as flexibility, high tensile strength and aspect ratio, and silky luster, and axial lineation. These particles have attained their shape primarily because of manifold dislocation planes that are randomly oriented in two axes but parallel in the third.

> __Note__: Upon microscopic examination, particles that have a 3:1 or greater aspect ratio are defined as fibers by NIOSH. Other macroscopic properties (e.g., flexibility, tensile strength) used to mineralogically define fibers cannot be ascertained for individual fibers examined microscopically.

__Nonasbestiform habit__: Each of the six commercially exploited asbestiform minerals also occurs in a nonasbestiform mineral habit. These minerals have the same chemical formula as the asbestiform variety, but have crystal habits where growth proceeds in two or three dimensions instead of one dimension. When milled, these minerals do not break into fibrils but rather into fragments resulting from cleavage along the two or three growth planes.

> __Note__: Particles formed by the comminution of these minerals are referred to as cleavage fragments and can meet the NIOSH definition of a fiber for regulatory purposes when viewed microscopically.

__Mineral__: A homogeneous, naturally occurring, inorganic crystalline substance. Minerals have distinct crystal structures and variation in chemical composition, and are given individual names.

__Mineral series__: A mineral series includes two or more members of a mineral group in which the cations in secondary structural position are similar in chemical properties and can be present in variable but frequently limited ratios (e.g., cummingtonite-actinolite). The current trend in referring to a mineral series is to simplify long series names by using the mineral name of only one (end or intermediate) member (e.g., tremolite for tremolite-actinolite-ferroactinolite).

> __Note__: The microscopic analysis of individual particles or fibers from the asbestiform and nonasbestiform habits often exhibit chemical ratios within a mineral series rather than that of a particular end member.

BIBLIOGRAPHY FOR ATTACHMENT A

Mineral terms and definitions were taken or adapted from the following sources:

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