Glass Wool (Respirable Size)*

Reasonably anticipated to be a human carcinogen
First Listed in the *Seventh Annual Report on Carcinogens* (1994)

Carcinogenicity

Glass wool (respirable size) is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity in experimental animals (IARC 1988). Rats and hamsters receiving glass wool (length of <3.2 to <7 μm; diameter of <0.18 to <1 μm) by intratracheal instillation developed adenocarcinomas, squamous cell carcinomas, bronchoalveolar tumors, lung carcinomas, mesotheliomas, and sarcomas. When administered by intraperitoneal injection (length of <2.4 to <30 μm; diameter of <0.18 to <1 μm), glass wool-induced mesotheliomas and sarcomas were observed. In another study in which female rats received coarse glass wool by intraperitoneal injection, abdominal tumors (mesotheliomas, sarcomas and, rarely, carcinomas) were induced. In another study, rats received glass wool, treated with an acid or an alkali, by intraperitoneal injection. The acid-treated glass wool induced mesotheliomas, sarcomas and, rarely, carcinomas. Alkali-treated glass wool also induced the formation of tumors in rats (IARC 1988).

The IARC Working Group on Man-Made Mineral Fibers and Radon also reviewed five inhalation studies in rats. Although a few respiratory-tract tumors were observed in these studies, there was no statistically significant increase in tumor incidence. The IARC Working Group expressed concerns about the adequacy of many of these studies, noting factors such as short exposure period, small number of animals, lack of survival data, and failure to report fiber dimensions. The National Toxicology Program (NTP) scientific committees reviewed, in addition to the IARC Working Group's monograph, a more recent rat inhalation study (Hesterberg *et al.* 1993). The authors of this study also reported no statistically significant increase in lung tumor incidence. NTP reviewers of this study noted the high tumor incidence in the control group and expressed concern that the doses administered may have been too low to elicit a response.

Debate continues in the scientific community regarding the use of implantation studies as indicators of carcinogenic potential of fibers. Some investigators maintain that only inhalation exposure is relevant to the manner in which humans are typically exposed (McClellan *et al.* 1992). The IARC Working Group noted that

> "Inhalation is the major route of exposure to mineral fibers that have been shown to cause cancer in humans (e.g., asbestos). Therefore, it is desirable to use the inhalation route, if possible, when testing such fibers for their carcinogenicity in animals; however, the qualitative and quantitative aspects of particle deposition and retention in rodents are considerably different from those in humans. As a result, particles that may be important in the induction of disease in humans may never reach the target tissues in sufficient quantities in rodents. This problem cannot be overcome by generating higher concentrations of particulate aerosols because of technical complications, e.g., particle aggregation. The consequence is that inhalation tests may be less sensitive than tests by other routes for evaluating the carcinogenicity of particulate and fibrous materials. In addition, the high cost of and the shortage of adequate facilities for such studies severely limit the number that can be performed.
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> It is thus often necessary that other routes of administration be used for testing the carcinogenic potential of mineral fibers. The methods that have been most frequently employed are intratracheal instillation and intrapleural and intraperitoneal administration. With the first, various lung tissues as well as the pleural mesothelium are the major targets for the administered test fibers; in the latter two, the pleural and the peritoneal mesothelium, respectively, are the target tissues. These routes of administration can be used to test the carcinogenicity of mineral fibers to laboratory animals because they bring the test fibers into intimate contact with the same target tissues as in humans" (IARC 1988).

There is inadequate evidence for the carcinogenicity of glass wool in humans (IARC 1988). A number of studies have been conducted of workers involved in the production of glass wool. Most of the studies identified the association of workers exposed to glass wool and lung cancer. In a Canadian study, there was a statistically significant excess of lung cancer among glass wool workers; however, there was no relationship between the length of employment and lung cancer mortality (IARC 1988). In a U.S. study, Enterline *et al.* (1987) reported a small statistically significant excess in all malignant neoplasms and in respiratory cancer 20 years or more after first employment using local death rates to estimate expected deaths. In an update of this study, Marsh *et al.* (1990) reported that "overall the evidence of a relationship between exposure to man-made mineral fibers and respiratory cancer appears to be somewhat weaker than in the previous update".

Properties

Fibrous glass is the name for a manufactured fiber in which the fiber-forming substance is glass. Silicon dioxide is the primary chemical component in all glass types; however, many other metal oxides are present (IARC 1988). These other metal oxides (glass modifiers or fluxes) and intermediate oxides (stabilizers) alter the composition of the various glass types and provide the specific chemical and physical characteristics required by the end-use product. These characteristics include strength, durability, electrical resistivity, resistance to chemical attack, and resistance to temperature. Glass wool is resistant to chemical corrosion by mineral acids.

A fiber is considered to be a particle with a length-to-diameter aspect ratio of 3 to 1 or greater. Respirable fibers have mass median aerodynamic diameter approximately 3.5 μm or less. Fibers less than 1 μm in diameter have the highest probability for deposition in the alveolar regions of the lung, where gas exchange occurs (WHO 1988).

Use

The major uses of glass wool are in thermal, electrical, and acoustical insulation, weatherproofing, and filtration media. In 1980, approximately 80% of the glass wool produced for structural insulation was used in houses. Glass wool, in the form of loose-bagged wool, is pneumatically blown or hand poured into structural spaces, such as between joists and in attics. Plumbing and air-handling systems also require insulation. Glass wool and glass fibers are used to insulate against heat flow with prefabricated sleeves. Sheet-metal ducts and plenums of air-handling systems are often insulated with flexible blankets and semirigid boards usually made of glass fibers. Small-diameter glass fibers (0.05 to 3.8 μm) have been used in air and liquid filtration, and glass fiber air filters have been used in furnaces and air conditioning systems. Glass fiber filters have been used in the manufacture of beverages, pharmaceuticals, paper, swimming pool filters, and many other applications (IARC 1988).

Production

The mineral fiber industry began to grow in the United States and Europe after World War I and includes products made from rock, clay, slag, or glass. Glass wool is composed of relatively short cylindrical glass fibers that are produced by drawing, centrifuging, or blowing molten glass. Improvements in glass fiber manufacturing technology and new markets in textiles fueled much of the growth. In the 1950s and 1960s, glass wool began to replace rock wool and slag wool products used in thermal insulation. Consequently, the number of rock wool and slag wool plants in the United States peaked at 80 to 90 in the 1950s. By 1985, there were 58 plants in the United States that produced glass wool, rock wool, slag wool, or ceramic fibers. The total quantities of glass wool, rock wool, and slag wool products produced in the United States were approximately 1.5 million metric tons in 1977 and 1.6 million metric tons in 1982 (IARC 1988). Currently, at least nine companies supply glass wool products in the United States (Chem Sources 2001). U.S. imports and exports of glass fiber rovings and glass fiber yarns (including glass wool) were approximately 51,200 and 80,000 metric tons, respectively, in 2000 (ITA 2001).

Exposure

Exposures to glass wool and other man-made mineral fibers are reported as total dust concentrations or respirable fiber concentrations in air. The primary routes of potential human exposure to glass wool are inhalation and dermal and/or eye contact. Generally, the upper diameter limit for respirable fibers ranges from 3 to 3.5 µm; however, some studies used 5 µm as the upper limit (IARC 1988).

Glass wool is released as airborne respirable particles during their production and use. As the diameter of the glass wool decreases, both the concentration of respirable fibers and ratio of respirable to total fibers increases. The highest levels of occupational exposure to glass wool occur when it is used in confined spaces. Concentrations of man-made mineral fibers in outdoor air and nonoccupational indoor settings are much lower than those associated with occupational settings (IARC 1988). NIOSH estimated that 200,000 workers were potentially exposed to fibrous glass in the mid 1980s (Sittig 1985).

Measurements taken in facilities producing fibrous glass insulation or fibrous glass textile products in the 1960s reported airborne concentrations of total (0.06 to 12.29 mg/m^3) and respirable dust (0.03 to 0.55 mg/m^3) and total fibers (0.09 to 3.64 fibers/cm^3). These levels were approximately 20-fold lower than fiber concentrations reported in the asbestos textile industry and indicated negligible exposure to workers. In a study of 16 mineral-fiber production plants conducted in the 1970s, mean concentrations of total suspended particulate matter and fibers were 0.21 to 4.73 mg/m^3 and 0.01 to 0.78 fibers/cm^3, respectively. Generally, concentrations of respirable fibers in glass wool production plants have been approximately 0.1 fibers/cm^3 or less (IARC 1988).

Studies have indicated that exposure of users may exceed those of production workers. Airborne concentrations from various operations using fibrous glass insulation (duct wrapping, wall and plenum insulation, pipe insulation, and fan housing insulation) ranged from 0.51 to 8.08 fibers/cm^3 with mean fiber diameters ranging from 2.3 to 8.4 µm. Swedish and Danish surveys conducted in the early 1980s reported a geometric mean respirable fiber concentration of 0.046 fibers/cm^3 in open and ventilated spaces and 0.05 fibers/cm^3 in confined and poorly ventilated spaces (IARC 1988).

Regulations

OSHA

Permissible Exposure Limit (PEL) = 15 mg/m^3 (total); 5 mg/m^3 (respirable) (PEL based on the standard for Particulates Not Otherwise Regulated)

Guidelines

ACGIH

Threshold Limit Value - Time-Weighted Average Limit (TLV-TWA) = 1 respirable fiber/cc

NIOSH

Recommended Exposure Limit (REL) = 3 fibers/cm^3 (fibers with diameter < or = 3.5 µm & length > or = 10 µm); 5 mg/m^3 (total)

*No separate CAS registry number is assigned to glass wool.

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