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CHEMICAL MARKET INPUT/OUTPUT ANALYSIS OF SELECTED CHEMICAL SUBSTANCES TO ASSESS SOURCES OF ENVIRONMENTAL CONTAMINATION: TASK III. ASBESTOS

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11.0 ASBESTOS FLOORING

Asbestos floor tiles are produced in the United States for use in commercial applications, offices, and homes. The shortest grades of asbestos fibers are used in vinyl and asphalt floor tile manufacture. The asbestos fibers are used to impart strength, dimensional stability, and resistance to the cold. At present, vinyl asbestos floor tile (VAT) accounts for most of the asbestos used in this category, with asphalt tile serving some special applications and applications where darker shades are permissible.

11.1 Use Quantity, Shipment Values, and Industrial Firms

U.S. demand for asbestos in flooring products has ranged from 113 to 218 thousand short tons annually during the 1967 to 1976 period; in 1976, 113 thousand short tons of asbestos were used in flooring products (Clifton, 1977). Only the chrysotile variety of asbestos is used. According to the 1976 figures, about 15.6% of the total U.S. market for asbestos was consumed in the products of flooring. This is the third largest use of asbestos fiber, ranking behind roofing and A-C pipe.

Table 11.1 lists the shipment values and quantities of asbestos floor tile as given by the Census Bureau. In 1967, asphalt-asbestos floor tile made up about 15% of the asbestos floor tile market compared to vinyl-asbestos tile's 85%; however, by 1972 the market for asphalt-asbestos tile had fallen to comprise only 5% of the asbestos floor tile values. Competitive pressures from alternate flooring products is the primary reason for the decline of the asphalt-asbestos market.

In fact, in recent years the vinyl-asbestos floor tile market has been less than spectacular as a result of strong competition from carpeting and

Table 11.1. Shipment Values and Quantities of Asbestos Floor Products
(U.S. Bureau of the Census, 1972)

SIC Product Code	Product	Total Product Shipments, including interplant transfer			
		1972		1967	
		Quantity (million sq yd)	Value (million $)	Quantity (million sq yd)	Value (million $)
32925 11	Asphalt Floor Tile	9.8	9.1	28.0	25.0
32926 --	Vinyl Asbestos Floor Tile	--	199.3	143.5	153.5
32926 13	Plain backed	129.4	151.3		
32926 15	Adhesive backed	--	48.0	143.5	153.5
32926 00	Vinyl asbestos, n.s.k.	--	--		

linoleum (Igwe, 1974). The market for all types of vinyl (PVC) flooring, which includes vinyl-asbestos and all other kinds of vinyl floorings, declined from about 50% of all basic floor coverings in 1961 to only 30% in 1971. As a point of reference, about 67% of all vinyl flooring in 1969 was of the vinyl-asbestos type (Frey, 1976). The phenomenal growth in the use of tufted carpets in both residential and commercial buildings is the main reason for the decline. However, vinyl flooring is now believed to have firmly established its market share according to 1971 figures (Frey, 1976). This implies that significant increases in the use of asbestos for flooring are not likely to occur in the foreseeable future.

Table 11.2 lists the major manufacturers of asbestos-flooring products along with their respective locations and estimated 1975 sales.

The 1976 floor tile consumption of 113 thousand tons of asbestos would produce roughly 105 million sq. yds. of asbestos flooring.

11.2 Manufacturing Process Technology

Floor tile manufacture involves proprietary production line processes highly developed by the individual manufacturers. Equipment layout, process description and compound formulations are held very confidential because the industry is highly competitive (Daly et al., 1976).

The asbestos content of the tile ranges from 8-30% by weight (Carton, 1974) and usually comprises very short fibers, grades 5 and 7 (Table 4.10, p. 46). Each square foot of tile may contain upwards of 0.13 pounds asbestos fibers (Daly et al., 1976). PVC resin serves as the binder and makes up 15-25% of the tile; chemical stabilizers usually represent about 1%. Limestone and other fillers make up 55-70% of the weight. Pigment content usually averages about 5%, but may vary widely depending upon the materials required to produce the desired color (Carton, 1974).

Table 11.2. Major U.S. Manufacturers of Asbestos Flooring

Manufacturer	Plant Location	Estimated 1975 Sales* of Asbestos Flooring (millions of dollars)
American Biltrite Rubber	LaMirada, Cal.	5.7
Armstrong Cork Co.	South Gate, Cal. Kankakee, Ill. Jackson, Miss. Lancaster, Pa.	36.5
Flinkote	Los Angeles, Cal. Chicago, Ill. New Orleans, La.	20.3 14.4 6.6
GAF Corp.	Long Beach, Cal. Joliet, Ill. Vails Gate, N.Y. Houston, Tex.	14.4 15.0 17.4 8.7
Mentile Floors	Brooklyn, N.Y.	29.5
	TOTAL	168.5

* Economic Information Systems, Inc.; SRC Estimates
Monetary values are in 1975 dollars.

Most floor tile manufactured today uses a vinyl resin, although some asphalt tile is still being produced. The manufacturing processes are very similar and the water pollution control aspects are almost identical for the two forms of tile (Carton, 1974). Figure 11.1 shows the general manufacturing process.

The ingredients are weighed and mixed dry. Liquid constituents, if required, are then added and thoroughly blended into the batch. After mixing, the batch is heated to about 150 degrees C and fed into a mill where it is joined with the remainder of a previous batch for continuous processing through the rest of the manufacturing operation. The mill consists of a series of hot rollers that squeeze the mass of raw tile material down to the desired thickness. During the milling operation, surface decoration in the form of small colored chips of tile (mottle) are sprinkled onto the surface of the raw tile sheet and pressed in to become a part of the sheet. Some tile has a surface decoration embossed and inked into the tile surface during the rolling operation. This may be done before or after cooling. After milling, the tile passes through calenders until it reaches the required thickness and is ready for cooling. Tile cooling is accomplished in many ways and a given tile plant may use one or several methods. Water contact cooling in which the tile passes through a water bath or is sprayed with water is used by some plants. Others use non-contact cooling in which the rollers are filled with water. In some plants, the sheet of tile passes through a refrigeration unit where cold air is blown onto the tile surface. After cooling, the tile is waxed, stamped into squares, inspected, and packaged. Trimmings and rejected tile squares are chopped up and reused (Carton, 1974).

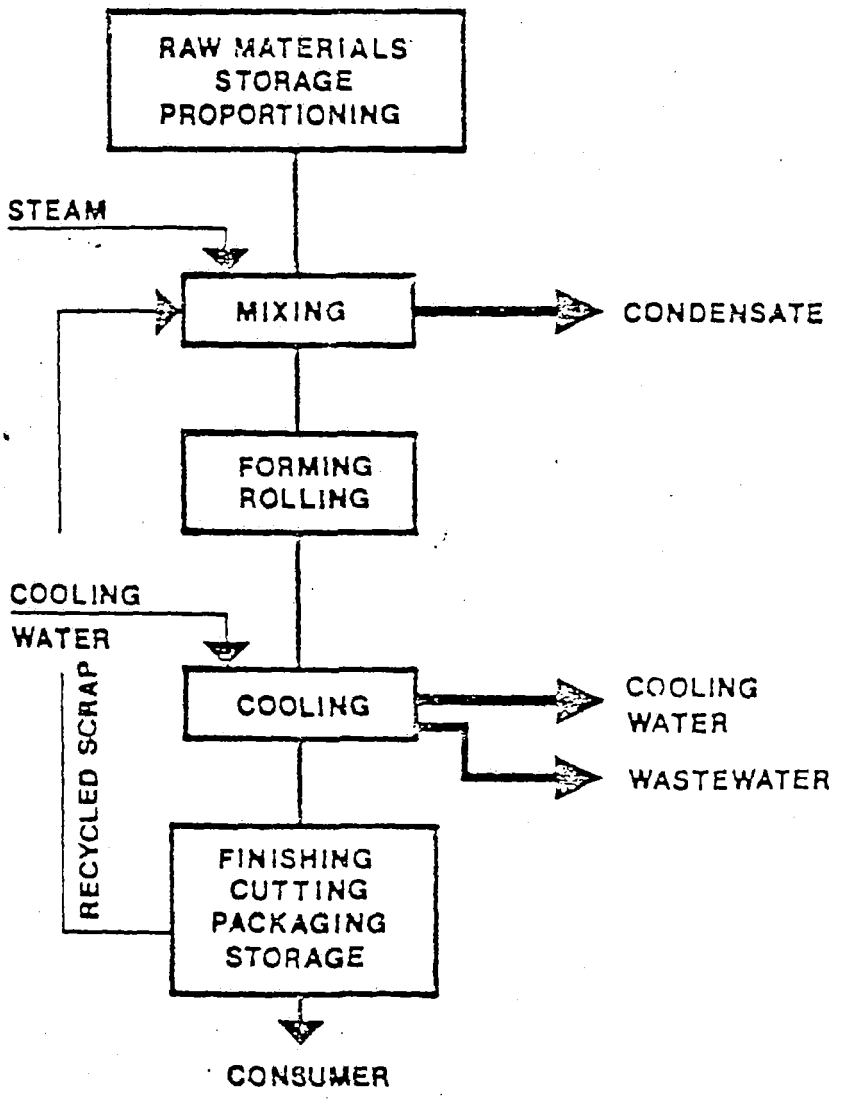


Figure 11.1. Asbestos Floor Tile Manufacturing Operations (Carton, 1974)

11.3 Quantities of Asbestos Released to the Environment from Manufacture

In the manufacture of asbestos vinyl tile, water is used only for cooling purposes. Both contact and non-contact cooling are usually employed. Water does not come into contact with the tile until it has been heated and rolled into its final form. In this stage it is completely inert to water (Carton, 1974). Therefore, wastewaters will contain little, if any, asbestos fibers. Stewart et al. (1976) found asbestos concentrations of less than 10^6-10^7 fibers per liter in wastewaters from Armstrong's Kankakee, Ill. floor tile plant.

Additionally, trimmings and rejected tile squares are chopped up and reused. Therefore, there are only minor amounts of manufacturing scraps disposed to landfills.

The only major source of asbestos release to the environment from floor tile manufacture is from baghouses, both air emissions and collection dumpings. There are no direct data available by which to make direct estimations of these baghouse collections and emissions; however, the manufacturing process, in this regard, is similar to that of the mastic asphalt mix for roofing. As developed in section 9.3.4, it was estimated that perhaps 0.2% of production volumes, for the mastic roofing mix, were collected by baghouses. Applying this figure to floor tiles, about 227 tons of asbestos fibers are annually collected in baghouses. The Siebert et al. (1976) baghouse efficiency of 99.99% indicates that 0.0227 tons of fibers are emitted into the atmosphere annually. The alternate method for predicting baghouse emissions given in section 7.3.1 would estimate emissions to be on the order of one ton.

11.4 Release of Asbestos from Asbestos Flooring Use

By far, the major release of asbestos to the environment from flooring use occurs at replacement time when old flooring is removed and disposed to landfills. Service time for asbestos floorings depends upon the severity of use; accordingly, service life may vary from 10 to 30 years. Therefore, a healthy percentage of production is intended as flooring replacements. This percentage may be in the neighborhood of 40-60%.

During the service life of an asbestos floor various forces act upon it and the result may be a release of free asbestos fibers. Forces such as walking, scrapping, cleaning, and machine scrubbing may be sufficient to break-down the vinyl matrix and allow asbestos to escape. However, there has been no study conducted to determine if, or how much, asbestos may be released during use or cleaning. Such a study may be desirable.

The following hypothetical example of asbestos fiber release from flooring use is intended to illustrate a potential magnitude of emissions which can be theoretically calculated from various assumptions. Daly et al. (1976) have reported that each sq. ft. of tile may contain up to 0.13 lb asbestos; therefore, it is assumed that each sq. ft. of tile contains 0.13 lb asbestos. Additionally, the following assumptions are made: (1) the average service-life of an asbestos floor is 20 years; (2) approximately 10% of the flooring is worn away during the service-life by use and cleaning; and (3) about 1% of the "worn-away-flooring" becomes airborne. It is visualized that wear on the floor will not be even over the entire surface because sections may be covered may be covered by equipment, desks, etc.; however, it is assumed that sections of the floor which are worn away disperse airborne fibers uniformly throughout the

entire room. Therefore, the following computation can be made which gives the amount of asbestos emitted per day, on average, from each square foot of asbestos tile:

$$0.13 \frac{\text{lb asbestos}}{\text{ft}^2} \times \frac{0.10 \text{ wear}}{20 \text{ yrs}} \times 0.01 \text{ airborne} \times 453.6 \frac{\text{grams}}{\text{lb}} =$$

$$0.003 \frac{\text{grams emitted}}{\text{yr/ft}^2} = 3.6 \times 10^6 \frac{\text{ng}}{\text{yr/ft}^2} = 8.2 \times 10^3 \frac{\text{ng emitted}}{\text{day/ft}^2}$$

It is now assumed that each square foot of tile is installed 10 feet below the ceiling; therefore, each square foot is topped by 10 ft^3 of air. Assuming ventilation design requires 15 air changes per hour, then 1 ft^2 of tile will be topped by approximately 3600 ft^3 of air each day, which is equivalent to 102 m^3 of air each day. Therefore, assuming uniform mixing of air and airborne asbestos fibers, the average asbestos concentration of the air is raised daily by:

$$\frac{8.2 \times 10^3 \text{ ng emitted}}{102 \text{ m}^3} = 80 \frac{\text{ng}}{\text{m}^3} = 8 \times 10^{-5} \frac{\text{ng}}{\text{cm}^3}$$

Using the conversion factor of 10^3 asbestos fibers per nanogram, the air concentration of 80 ng/m^3 is equivalent to 0.08 fibers/cm^3. The above assumptions predict that the average asbestos concentration of the air above an asbestos floor can theoretically be raised by daily use of the floor by 0.08 fibers/cm^3. This 0.08 fiber figure is based upon the estimation that 1 nanogram equals 10^3 fibers which is, in turn, based upon electron microscopy count. Rohl et al.

1975) have indicated that the number of fibers visible by electron microscopy is perhaps one hundred fold as compared to an optical microscopy method which counts only fibers of 5 μm in length or longer. The optical microscopy method for counting fibers 5 μm or longer is used for determining compliance with OSHA regulations. On this basis, the concentration of fibers emitted by asbestos flooring, if measured by the OSHA optical microscopy method, in the above example would be 0.0008 fibers/cm^3.

It should be noted that the example given above is only supposition. Monitoring is required to determine actual concentrations, if any. Under practical conditions, it would be unlikely that all fibers released by use would become airborne. A large percentage would probably be incorporated into water used for cleaning purposes which would then be released into wastewaters. This is the reason for assuming that only 1% of worn material would become airborne.

11.5 Alternative Products to Asbestos Flooring

Asbestos flooring competes principally with carpeting, linoleum, and solid vinyl flooring. At present, about 95% of all asbestos flooring is vinyl-asbestos. As indicated earlier, in section 10.1, all types of vinyl floor coverings make up about 30% of the flooring market; and, in 1969, about two-thirds of the vinyl market was asbestos-vinyl. Therefore, in the late 1960's and perhaps, early 1970's, vinyl-asbestos flooring covered about 20% of the total flooring market. However, this 20% figure has decreased and is decreasing somewhat due to the popularity of various types of non-asbestos vinyl flooring. In recent years, coated types of vinyl flooring (plastisol-coated felts) have moved strongly into flooring markets of all cost levels at the expense of vinyl-asbestos tile (Frey, 1976).