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ANALYSIS OF FIBER RELEASE FROM CERTAIN ASBESTOS PRODUCTS

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SECTION 3

FLOORING PRODUCTS

INTRODUCTION

Asbestos-containing floor products are classified as resilient floor coverings and include vinyl-asbestos floor tile, asphalt-asbestos floor tile, and sheet vinyl flooring backed with asbestos-containing felt. A discussion of the felt backing used for sheet vinyl flooring is presented in Section 7 under Paper Products.

Asbestos-containing floor tiles and sheet vinyl flooring backed with asbestos felt are installed in industrial, commercial, institutional, and residential buildings.[1,2] They may be installed on concrete or prepared wood floors, or over old tile floors, and are often specified for heavily trafficked areas such as kitchens, entry ways, restrooms, supermarkets, commercial plants, and offices.

Asbestos Floor Tiles

The production techniques for the two floor tile products, vinyl-asbestos and asphalt-asbestos, are similar. They differ only in product composition, with asphalt-based tiles serving some special applications and uses when darker shades are permissible.[3] Because vinyl-asbestos floor tile production accounts for most of the asbestos consumed by the floor tile industry[3], the following discussion relating to floor tiles will address only the vinyl product. This discussion, however, will apply directly to asphalt-asbestos floor tiles, as well.

Vinyl-asbestos floor tiles are composed of asbestos, binders, fillers, pigments, and chemical stabilizers.[1,2] The asbestos content of the tile usually ranges from 8 to 30 percent by weight, or up to 635 grams of asbestos per square meter (0.13 pounds per square foot) of tile.[1] Grades 5 and 7 chrysotile asbestos fibers are normally used. Polyvinyl chloride (PVC) resin serves as the binder and accounts for 15 to 25 percent of the tile composition. Limestone and other fillers represent 43 to 73 percent of the product weight. The pigment content usually averages about 5 percent, but may vary widely depending upon the materials required to produce the desired color.[1,2] Chemical stabilizers added to the product mix typically represent 1 percent of the total product formulation.

Floor tile production begins with dry mixing of the ingredients in a Banbury mixer to thoroughly blend all constituents. The mixture is then heated to 149°C (300°F) to flux the PVC resin and create a coherent plastic

mass. This material is fed to a mill where the tile is shaped, decorated, and cooled. Asbestos fibers contained in the floor tile product are tightly bound within the vinyl plastic matrix, thereby isolating them from the external environment during use.

Once cooled, the tile product is waxed, cut to size, inspected and packaged. Tiles are produced in sizes 23 cm (9 inches) square or 30 cm (12 inches) square, with thicknesses varying from 0.08 to 0.24 cm (1/32 to 3/32 inches). Asbestos floor tiles are very durable and may last for up to 30 years even in heavily trafficked areas.[1]

Sheet Vinyl Flooring

Asbestos felt-backed sheet vinyl flooring is a resilient floor covering that is applied to subfloor surfaces in roll or sheet form. The sheet backing or flooring felt is an asbestos-containing paper product that is manufactured separately and forms the underlayment of sheet vinyl flooring. Asbestos-containing flooring felts, which are produced on a conventional papermaking machine, are composed of approximately 85 percent asbestos (chrysotile) and 15 percent latex binder.[4] Once manufactured, flooring felt may be sold without further processing or may be used to produce sheet vinyl flooring.[5,6]

Asbestos flooring felt is manufactured into sheet vinyl flooring products by applying a resilient polyvinyl chloride coating to one side of the asbestos felt using various extrusion coating and laminating and spread-coating methods.[4] Once the coatings are applied, the sheet is passed through an oven where these layers are dried and gelled. The coated sheet is then decorated to enhance its appearance by passing it over one or more engraved cylinders and/or several printing stations. The printed sheet then goes to a fusion step where the sheet is coated with a "wearlayer." The wearlayer is a homogeneous polymer application that provides an impervious surface for the finished product.[2] The coated and printed sheet is next fed through an oven where the felt backing, the layers of latex and plastisol, and the wearlayer are fused into a single product. During fusion, the layer of plastisol foam may expand 2 to 6 times its original thickness, giving the sheet vinyl flooring its thickness and resilience. After fusion, these layers remain distinct, but are no longer chemically or mechanically separable.[2] The vinyl sheet is then cooled, cut to size, packaged and shipped.[1,5,6]

SECONDARY PROCESSING--FABRICATION

There is no secondary processing of the products within this category. Asbestos floor tiles and asbestos felt-backed sheet vinyl flooring are shipped directly from the factory to wholesalers and retailers who, in turn, sell directly to end users.[5,6]

END USE ACTIVITIES

As indicated above, vinyl-asbestos floor tiles and sheet vinyl flooring are used in industrial, commercial, institutional, and residential applications. Floor tiles can be installed either by professional floor

installers or home owners, while the sheet vinyl flooring is usually laid down only by professionals due to the difficulty involved in creating a perfect fit with the one-piece sheet.[7,8]

The installation of asbestos flooring products, like most floor coverings, requires preparation of a subfloor that is smooth and free of surface irregularities. Subfloor preparation may involve minor alteration of the existing floor covering or partial or total removal.

Subfloor Preparation and Removal

Subfloor preparation is considered by many installers to be the most difficult and time consuming as well as the most important part of the installation job if one is to get a smooth, long lasting new floor.[7,8] This activity also involves the greatest potential for asbestos fiber release if the existing subfloor is covered with an asbestos-containing floor product and the manufacturer's warnings against sanding are not heeded. Interviews with several flooring installers revealed that common subfloor preparation practices run the gamut from sanding or dry scraping without any personal protective equipment, to explicitly not sanding, to sanding while using a respirator.[7,8-13]

The majority of installers interviewed avoid sanding whenever it is economically or practicably possible. If the existing floor is not or cannot be sanded, it is either removed using flat-bladed putty knives or covered with plywood, fiberboard, or masonite. Sanding or removal of the subfloor covering takes approximately 4 to 8 hours for a standard 2.7 by 3.6 meter (9 foot by 12 foot) room, although this figure varies considerably depending on the size of the room and difficulties encountered in removing old tile.[8,11,12] Sanding and stripping machines, as well as flat-bladed putty knives, hammers, chisels, and scrapers are utilized in subfloor preparation.[8-13]

If the existing subfloor is covered with asbestos felt-backed sheet vinyl flooring, then the standard procedure is to "strip" the floor. This process involves removing the top two (wear and foam) layers of sheeting and splitting the bottom asbestos felt layer in half, along the horizontal plane. If the subfloor covering was glued over its entire area, then this procedure is relatively easy, since the felt has little vertical tensile strength and will split when pulled. During this process, the existing floor covering is cut into strips approximately 0.46 meters (1.5 feet) wide and each strip is pulled up and away from the subfloor.[6] This separation process, which may have a high fiber release potential, leaves half of the felt in place and offers a uniform subfloor for the new flooring product. Tarkett, Inc.* of Whitehall, PA,[6] a manufacturer of sheet vinyl flooring, recommends that the exposed felt be vacuumed immediately after each strip is removed to collect loose dirt that may contain asbestos fibers.

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*Tarkett Inc. recently purchased the Whitehall, PA facility from GAF Corporation's Consumer Product Group.

If, instead of total surface gluing, the existing sheet vinyl flooring had only been pasted along its perimeter, then stripping will remove the entire covering, leaving only split asbestos felt around the perimeter. This felt is either scraped up after it has been wetted (recommended practice) or it is feathered to provide a smooth subfloor/felt interface. The former technique is favored since feathering involves sanding the felt, which can release asbestos fibers.[14-16] If (a third scenario) the existing sheet vinyl flooring is intact and relatively smooth, then its top layer will be used as the subfloor and be rough sanded to provide a better contacting surface for the adhesive. Sanding will disturb only the wear layer of the sheet flooring and not the asbestos felt.[14] The time it takes to remove or prepare a sheet vinyl flooring is similar to that for an asbestos tile floor, approximately 4 to 8 hours for the standard size room.

Installation

Vinyl-Asbestos Floor Tile--

The installation of vinyl-asbestos floor tile in a standard 2.7 by 3.6 meter (9 by 12 foot) room will take a professional installer from 2 to 4 hours.[8-13] Installation is typically begun in the center of the room and proceeds toward the walls. Tile adhesive is applied over one section of the floor at a time and full tiles are applied. If the floor tiles are prebacked with adhesive, the protective cover layer is removed and the tiles are pressed in place. Once all full tiles are in place, the perimeter and partial pieces are measured and cut out. This requires proportionately more time than laying full tiles; up to one half of the total installation time is devoted to this detailed work.[8,10-12] After partial pieces are marked, they are hand cut either by scoring the tile (cutting partially through) and snapping it or by simply cutting entirely through the tile in one operation. Whichever technique is used, the time spent in making each cut amounts to only 5 to 10 seconds. Total cutting time for an average 2.7 by 3.6 meter (9 by 12 foot) room is approximately 10 minutes. All cutting occurs in the room being tiled. Cutting tools include commercial tile cutters, utility knives, scissors, and razor knives.[7-13,17] The low energy input associated with the use of these hand tools and the binding properties of the tile matrix minimize fiber release during installation.

Sheet Vinyl Flooring--

The installation of asbestos felt-backed sheet vinyl flooring in a standard 2.7 by 3.6 meter (9 by 12 foot) room will take from 1 1/2 to 6 hours depending on the width of the vinyl roll (1.8, 2.7, 3.6 or 4.5 meters), the way in which it is glued, and whether or not a pattern has been used.[8,14-16] The narrower the flooring width, the greater the installation time since the patterns of adjoining sections must be matched. Gluing techniques, which were briefly described above, vary in three basic ways: fully pasted, whereby the entire felt backing is glued to the subfloor; perimeter pasted, in which only the perimeter of the flooring is glued; and the "Put Down Quick" (PDQ) technique, in which the flooring is layed without any glue.[16] A fully pasted floor will take the most time to install, but will last the longest. Perimeter pasting is used most often when the subfloor is concrete. This technique is quicker and saves time and money. A PDQ installation is more common to flooring which is solely vinyl than it is to the more expensive asbestos felt-backed product.

The use of a template for cutting sheet vinyl flooring is a widespread practice. The template is cut to match the exact perimeter details of the room. These details are then transferred onto the sheet vinyl product. Narrow strips of asbestos-containing flooring felt are often used as the template in sheet vinyl installations since it is readily available and is relatively inexpensive.[14,15]

Template preparation involves laying the template sheet along the perimeter of the room and transcribing onto it the perimeter outline. Each section of the template is cut on the spot and immediately refitted to the room perimeter to insure a perfect fit. Utility and razor knives are used for cutting the template, and this operation takes approximately 10 to 20 minutes of the total 1 1/2 to 6 hour sheet vinyl flooring installation time for a standard 2.7 by 3.6 meter (9 by 12 foot) room.[8,14-16] Installation time varies depending on the complexity of the perimeter details and the skill of the installer.

Once completed, the template pattern is transferred to the sheet vinyl flooring and the flooring is cut to shape and size. Razor knives and utility knives are also used for this purpose and the total cutting time is a fraction of the total installation time, usually lasting from 5 to 20 minutes, again for the standard size room.[8,14-16] Interviews with flooring retailers and professional installers alike indicated that preparation and installation of sheet vinyl flooring involves minor mechanical disturbance to the product, minimizing the potential for airborne asbestos fiber release. The only action during installation that disturbs the asbestos felt layer of the flooring is cutting, and this is short in duration and not energy intensive. During use, the asbestos felt layer is never directly exposed.

AIRBORNE FIBER MONITORING DATA

Monitoring of asbestos fiber release during floor tile installation and removal was performed by SRI International.[18,19] Results of this study are presented in Table 6. The results of a similar SRI study, done on the installation and removal of sheet vinyl flooring, are presented in Table 7. The reported fiber concentrations for both studies were determined by phase contrast microscopy. Fiber concentrations associated with the two asbestos floor tile end use activities ranged from 0.0 to 0.58 f/cm^3. The high end value was recorded when recommended practices were not followed during removal. Concentrations for the two sheet vinyl flooring activities were somewhat higher, especially those obtained during removal of the asbestos felt layer, up to 2.17 f/cm^3 for dry scraping of the felt layer. According to the Resilient Floor Covering Institute, dry scraping is not a recommended work practice. The higher fiber concentrations recorded for the asbestos felt-backed sheet vinyl flooring product is expected because the felt backing contains a much higher percentage of asbestos (85 percent) than the tile product (8 to 30 percent) and is not as structurally cohesive as the tile.

Monitoring of fiber release during floor tile use and maintenance has been performed by SRI and Sebastien et al.[18,22] SRI's results, presented in Table 6, show that fiber concentrations ranged from 0.00 to 0.195 f/cm^3 during in-service use, wet mopping, and machine buffing vinyl-asbestos floor tiles located in an office building's copy center and snack shop.

TABLE 6. FIBER RELEASE FROM VINYL-ASBESTOS FLOOR TILE INSTALLATION, USE, MAINTENANCE, AND REMOVAL[18,19]

Site description	Age of tile (years)	Operation	Sampling time (minutes)	Fiber concentration[a] range (f/cm^3)
Residential home	6	Old tile preparation for new installation	10	0.000
Residential home	New	Installation	113 to 114	0.092 to 0.184
Residential home	New	Installation	220 to 232	0.081 to 0.267
Residential home	New	Installation	65	0.048 to 0.189
Office building copy center	5	In-service use	411 to 419	0.002 to 0.011
Office building snack shop	5	In-service use	130 to 133	0.008 to 0.062
Office building copy center	5	Maintenance - mopping	15	0.135
Office building snack shop	5	Maintenance - mopping	21	0.195
Office building copy center	5	Maintenance - buffing	11 to 30	0.000 to 0.092
Office building snack shop	5	Maintenance - buffing	21	0.000
Residential home	NR	Removal	123 to 134	0.062 to 0.147
Residential home	6	Removal[b]	80	0.153 to 0.583

[a]Phase contrast microscopy analysis performed. Samples were taken at breathing zone of operators except for those taken in the office building copy center and snack shop, these were taken from 0.3 to 1.5 meters (1 to 5 feet) above the floor surface.

[b]Removal deviated from recommended procedures that include removal without sanding, use of a flat-bladed wall scraper instead of equipment that would unduly shatter the tile, and not breaking the tile by hand before placing in a disposal bag.

NR = Not reported.

TABLE 7. FIBER CONCENTRATIONS ASSOCIATED WITH THE INSTALLATION AND REMOVAL OF SHEET VINYL FLOORING BACKED WITH ASBESTOS FLOORING FELT[20,21]

Site description	Age of vinyl sheeting and method of attachment (years)	Operation	Sampling time (minutes)	Fiber concentration[a] range (f/cm^3)
Residential home - kitchen	New adhered	Installation	175 to 177	0.246 to 0.310
Residential home - kitchen	6-adhered	Installation	100	0.000
Residential home - kitchen	13-adhered	Installation	58 to 60	0.633 to 0.655
Residential home - foyer	2-adhered	Installation	177 to 179	0.075 to 0.554
Residential home - kitchen	8-adhered	Installation	44 to 45	0.325 to 1.016
Residential home - kitchen	13-adhered	Partial removal[b]	44 to 62	0.190 to 0.408
Residential home - foyer	2-adhered	Total removal[b]	121 to 123	0.368 to 0.402
Residential home - kitchen	8-unadhered	Total removal[b]	74 to 76	0.069 to 0.100
Residential home - kitchen	6-adhered	Wear layer removal	70 to 75	0.084 to 0.218
Residential home - kitchen	6-adhered	Wet scrape felt layer	55	0.484
Residential home - kitchen	6-adhered	Dry scrape felt layer	63	1.267 to 2.168
Residential home - kitchen	6-adhered	Dry scrape felt layer	40 to 45	1.004 to 1.126

[a]Phase contrast microscopy analysis performed. Samples were taken at breathing zone of operators.

[b]Operations were performed according to Resilient Floor Covering Institute practices that do not include sanding, sweeping, or dry-scraping.

Because the air samples obtained by SRI were analyzed by PCM, actual asbestos fiber concentrations were not determined. However, monitoring results obtained by Sebastien et al. indicate that asbestos fibers are released from vinyl-asbestos floor tiles during everyday use. Sebastien et al. performed air sampling at four locations within an office building containing 5,400 m^2 of vinyl-asbestos floor tile. Transmission electron microscopic analysis of air samples taken during periods of active building use revealed airborne asbestos concentrations of 8, 21, 25 and 170 ng/m^3* at the four locations, respectively. The locations sampled included three corridor sites and a fourth site located in a workshop where electronic machines are tested and part of a corridor. The highest concentration was recorded in the workshop, an area of greatest worker activity. No fibers longer than 3 μm were observed on the membrane filters analyzed.[22]

Fiber concentrations measured during the removal of old asbestos floor tile are presented in Table 6. As evident in the table, concentrations resulting from removal are significantly higher than those associated with the installation, use, and maintenance of this flooring product. This is consistent with the amount of energy expended in removing the tile. When an existing tile floor is removed, pieces of tile may remain affixed to the floor. To remove these pieces, a worker may use a hammer and a chisel to free the individual bits of tile from the adhesive binder. Alternatively, the worker may elect to use an electric sander to sand the tile down to the existing subfloor deck. In either case, substantial amounts of mechanical energy are applied to the floor tile to effect its removal. This action, particularly sanding, may expel asbestos fibers from the vinyl matrix, resulting in elevated (higher than background) airborne fiber concentrations.

Two monitoring studies on the release of asbestos fibers from vinyl-asbestos floor tile have also been conducted by GCA/Technology Division. One revealed asbestos fiber concentrations of 0.02 to 0.10 f/cm^3 during vinyl-asbestos floor tile removal.[24] Sampling occurred approximately 4.5 to 6.0 meters (15 to 20 feet) from an area where workers manually ripped up an asbestos tile floor. The ripping activity was monitored for 165 minutes. Air samples obtained were analyzed by SEM/EDXR. The other GCA study[25] involved measuring fiber concentrations during the reenactment of various end use activities on vinyl-asbestos tiles. The activities, which were performed in a laboratory glove box, included cutting, grinding, breaking, and drilling. Sampling periods ranged from 1 to 5 minutes. Initial analysis by phase contrast microscopy indicated no fiber release. When duplicate samples were analyzed by SEM (5000X) and EDXR, a fiber concentration of 0.5 f/cm^3 was recorded for the tile grinding operation only. No fibers were detected by SEM/EDXR analysis for the other activities monitored. It is noted that even though SEM/EDXR analysis was performed, only fibers $\geq$5 μm in length and having a length-to-diameter ratio of 3-to-1 or greater were counted.

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*EPA's factor for converting nanograms to fibers is 1 nanogram equals 30 fibers.[23]

Murphy et al. monitored fiber release during sanding of vinyl-asbestos floor tile.[26] The experiment was performed under laboratory conditions in a 3 x 3.7 x 2.1 meter (10 x 12 x 7 foot) walkin chamber. A belt sander was used to remove a section of old floor tile. The data indicate that sanding can result in airborne fiber concentrations of 1.2 to 1.3 f/cm.^{3} Air samples were analyzed by PCM.

SUMMARY OF FINDINGS

Airborne fiber concentrations measured during the installation of vinyl-asbestos floor tile and sheet vinyl flooring backed with asbestos flooring felt approach 1.0 f/cm^3, as determined by PCM. During product installation, the product matrix containing asbestos fibers is disturbed by a limited number of manual cuts, each of which lasts only 5 to 10 seconds. Total cutting time amounts to 10 to 20 minutes of the total 1 1/2 to 6 hour flooring installation time. The rooms in which this cutting activity occurs are typically well-ventilated.

Discarding sanding and dry scraping operations, fiber concentrations associated with floor tile removal (0.15 f/cm^3) are approximately the same as those associated with tile installation, (0.05 to 0.27 f/cm^3) while asbestos concentrations attributable to sheet vinyl flooring removal (up to 0.48 f/cm^3) are approximately half those recorded during installation (1.0 f/cm^3). When sanding or dry scraping are employed to remove vinyl-asbestos floor tile or sheet vinyl flooring during subfloor preparation, airborne fiber concentrations of 1.0 to 2.0 f/cm^3, as determined by PCM, can occur.

Table 8 summarizes the data presented on flooring products and identifies the activities of concern with respect to airborne asbestos fiber release.

TABLE 8. SUMMARY OF ASBESTOS FLOORING PRODUCTS SECONDARY PROCESSING AND END USE ACTIVITIES

Product: Flooring products: asbestos floor tile, sheet vinyl backed with asbestos felt	Secondary processing		End use: Floor tile	End use: Sheet vinyl flooring
Activity:	No secondary processing for either product line		Subfloor preparation/ removal, installation	Subfloor preparation/ removal, installation
Duration of Activity:				
Per Incident		Subfloor preparation/ removal	NA	NA
Daily Total			4 to 8 hours	4 to 8 hours
Per Incident		Installation (cutting)	5 to 10 seconds	Somewhat continuous
Daily Total			10 minutes	10 to 20 minutes
Fiber Releasability:			Low	Moderate
Chemical Composition			8 to 30% asbestos, tightly bound in polymer resin	85% asbestos, bound by latex binder
Physical Composition			Moderately pliable, stiff, hard, very cohesive	Very pliable, not rigid
Disruptive Energy		Subfloor preparation/ removal	Hand chiseling and scraping, may use power tools (sander)	Hand scraping, may use power tools (sander)
		Installation (cutting)	Hand held scoring knife, tile cutter, scissors	Razor knives, scissors
Control Measure:		Subfloor preparation/ removal	Wetting, following recommended work practices	Wetting, following recommended work practices
		Installation	Following recommended work practices, no engineering controls	Following recommended work practices, no engineering controls

(continued)

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