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ANALYSIS OF FIBER RELEASE FROM CERTAIN ASBESTOS PRODUCTS

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SECTION 4

COATINGS AND SEALANTS

INTRODUCTION

Asbestos fibers are used in the manufacture of coatings and sealants because of the strength, durability, thermal and corrosion resistance, sound deadening, and waterproofing characteristics they impart. Coatings are covering products used to rejuvenate and/or protect various types of surfaces. Sealants are liquid or semiliquid fillers used to fill gaps in building construction, vehicle components, and industrial equipment. Table 9 lists the applications of several coating and sealant products and the asbestos characteristics that make them desirable.

The products within this category can be divided into two subcategories based on their composition: those which are petroleum based and those which have a water soluble latex or gypsum base.

Petroleum-Based Products

Petroleum-based products primarily include asphalt and tar-based sealants. Product formulations vary widely depending on end use application. In general, petroleum sealants are comprised of 5 to 30 percent asbestos (primarily chrysotile) and 55 to 80 percent cut asphalt.[1] Other petroleum derivatives added to achieve the proper consistency required for the intended end use are naphtha, mineral spirits, and lighter-weight solvents. Other ingredients include rust proofing chemicals, pigments, heat reflecting powdered metals such as aluminum, emulsifiers, resins, and clay fillers.[1]

Sealants are produced in batches under a controlled production cycle. Initially, the fibers are fluffed prior to being charged to a batch blending tank where they are mixed with asphalt or tar and other additives, as required, for an even dispersion. After blending, the liquid product is pumped to dispersing operations and finally shipped out to market.

The batch sizes produced vary from several hundred gallons for small manufacturers with one production line to several thousand gallons for larger manufacturers with a wide product mix and several production lines.[2] The batch sizes also vary with company size, type of product, method of containerization, type of production equipment, and size of order. Sealant manufacturing is often not a full-time operation but rather run part-time. This is due to seasonal fluctuations in demand, a greater amount of sealants may be produced in certain months of the year than in others.[1]

TABLE 9. ASBESTOS-CONTAINING COATINGS AND SEALANTS[1]

Use	Distinguishing characteristics of asbestos[a]
Roof coatings	A, E, G
Roof cements[b]	A, G
Flashing cements[b]	A, G
Chimney stack paints[b]	B, E, G
Automobile and truck undercoatings	A, B, E, F, G
Appliance insulating coatings	E, F
Corrosion-resistant coatings (resistant to salt solutions including seawater spray, organic acids, mineral acids, petroleum products)	B, G
Waterproof coatings for underground pipelines, concrete foundations, side walls, tanks, and other structures such as mobile homes and cooling towers in nuclear power plants	A, C, E, G
Anticondensation coatings for low temperature refrigeration services	B, G
Tile cements	A
Woodblock and concrete floor mastics	F, G
Spackle[b]	A, C, D
Dry wall joint compounds[b]	A, C, D
Caulking compounds	A, C, D
Texture paints[b]	A, C, D
Sprayed-on ceiling finishes[b]	A, C, D
Welding rod coatings[b]	B, E

[a]Letters correspond with the characteristics listed below. Stability, durability, and economy of asbestos are relevant to all uses listed above.

[b]No longer manufactured containing asbestos fibers.

Key: A. Strength
B. Corrosion resistance
C. Decay resistance
D. Vermin resistance
E. Thermal resistance
F. Sound deadening
G. Waterproofing

Water Soluble Latex or Gypsum-Based Products

Products under this subcategory include joint compounds, patching plaster, spackle, and drywall taping and finishing compounds. Use of this class of compounds has decreased significantly since the issuance of a Consumer Product Safety Commission (CPSC) ban of consumer patching compounds containing respirable free-form asbestos in 1977.[3] The ban applies only to 'consumer' products, i.e., products that a consumer can purchase. The ban covers uses in residences, schools, hospitals, public buildings, or other areas where consumers have customary access.[3] Patching compounds which are labeled as, marketed, and sold solely for industrial use applications are not subject to the ban.

Two principal types of water soluble compounds have been produced. One used latex as the binder, which set by evaporation of the water. The other used dehydrated gypsum as the binder (and primary dry ingredient) and set by chemical reaction as the gypsum took up waters of hydration. The first type was mainly limestone with lesser amounts of mica and 3 to 5 percent asbestos. This type was used by about 80 percent of the market, and was mostly sold in the ready-mixed, wet form. The gypsum-based material, capturing roughly 20 percent of the market, also usually contained asbestos and was sold dry, requiring wetting just before use. The worker mixed the compound with water in the field. Wet-mix products were manufactured and packaged in a can for ready use.[2]

Manufacture of both these products involved the usual handling of raw asbestos fibers where bags were stored, transferred, split, dumped, and fluffed. After dry blending, the latex-based products were wet mixed, binding the fibers in the matrix. The dry mixed gypsum-based product, which was not wetted during manufacture, maintained the potential for fiber release throughout the manufacturing process, as well as during packaging, distribution, and end use.[2]

SECONDARY PROCESSING - FABRICATION

There is no secondary processing of the products within either subcategory. Once manufactured and containerized, the products are shipped to wholesalers and retailers who sell directly to end users.

END USE ACTIVITIES

Petroleum-Based Products

Petroleum-based compounds include roof and horizontal surface coatings, roof and flashing cements, automobile and truck undercoatings, waterproofing coatings, and floor mastics.[1] These products are applied by contractors, specialty coating professionals (undercoating, roofing), and homeowners who buy the product at local retail and hardware stores and lumberyards. The products may be applied by brush, spray gun, roller or trowel, depending on their consistency and intended use. The following discussion provides examples of some of the more common applications of petroleum-based sealants and coatings.

Asphalt and tar-based coatings and sealants are used primarily by the building and construction trades to protect exposed metal surfaces, waterproof exterior building walls, and to patch existing roofing and siding. Asbestos-containing coatings are used in highly corrosive environments, such as those found in paper mills, to protect structural metal surfaces from attack by chlorine, chlorine dioxide, and moisture.[4] The coating is shipped to the site in premix form and applied using a high pressure airless atomization spray gun.

Asphaltic-based asbestos sealants are widely used in the construction industry to waterproof foundations and other subgrade structures, as well as in "back-up" walls, which are exterior walls that are ultimately covered by an architectural covering such as brick.[5] Depending upon the amount of surface area to be coated and its location, the coating is applied either using brushes or spray equipment.

For roofing applications, the asbestos sealant is used primarily for installing flashing or the perimeter of a built-up roof.[5] It goes on after the roof covering material and is applied by a trowel. Asbestos sealants are also used in repair jobs, when, for example, a leaking chimney or roof must be patched. This operation is often performed by the homeowner and takes advantage of the ability of the asbestos product to bridge a crack without subsequently drying, contracting and cracking again. A brush is most often used for this purpose.

The activities just described occur predominantly outdoors or in large open areas within buildings. Application of the compounds may last from one half hour up to a full workday depending on the method of application and the size of area to be worked.

Another use of petroleum-based asbestos-containing compounds is for protective undercoatings and sound deadening on automobiles and trucks. Application of these materials is commonly carried out inside an automotive assembly factory or service shop using spraying equipment. Depending on the production schedule, material application may last from a few hours to a full 8-hour work shift. Spraying may occur in enclosed work booths or in an area open to the workroom environment.

Although the asbestos content of petroleum-based compounds is moderately high, the potential for fiber release during application and in-service use is low. Fibers contained within these products are thoroughly wetted and remain bound by the tacky asphalt or tar matrix. The petroleum compounds of the product mix effectively cover and bind the fibers together, minimizing the potential for free-form release during application.[2]

Most of the petroleum-based products are applied as exterior surface coatings, upon which no direct physical exertion is applied. Consequently, except for weathering, which is expected to have a minor effect on fiber release, the material remains unaltered after application.

Water Soluble Latex or Gypsum-Based Products

Water soluble asbestos-containing coatings and sealants include such products as spackling compounds and drywall patching and taping compounds. The latex sealing and coating products often come in premixed containers whereas the gypsum-based materials come dry and must be mixed by the user. Substantial fiber release can occur during dry product mixing, sanding, and clean-up, which, it is believed, contributed, in large measure, to the CPSC ban.

The dry joint compound powder, where still available, is normally purchased packaged in paper bags. The bag is slit open with a knife and the powder dumped into a container. Water is then added according to the manufacturer's directions and the compound is mixed by means of a portable electric drill equipped with a mud or paint mixer bit. Some joint compound is sold as a paste (referred to as "premix") and only a small amount of water is required. The prepared mixture, in its putty-like form after wetting, is referred to as mud. The time spent mixing in a working day is short. It usually takes 5 to 10 minutes to mix a batch and in most instances one to three batches are required daily.[6]

An initial or "embedding" coat of joint compound (mud) is spread across the joint by a 2-inch putty knife. This is immediately followed by the application of a 2-inch wide perforated paper tape which adheres to the mud; the mud passes through the perforations, insuring intimate tape/mud contact. The tape/mud layer is allowed to dry until it is thick and then is followed in succession by two additional mud coats. Each of these coats is feathered using putty knives until they blend with the wallboard surface.[7] For large jobs, a joint taping machine is available which puts down the first mud coat, the tape, and the second mud coat in one continuous operation. The final coats are applied by hand. A skilled worker can put down an 8-foot joint in 2 to 5 minutes.[7] A homeowner, however, may take up to 20 minutes for the same task. Sixty-five to 70 percent of the working day, or up to 5-1/2 hours, is spent performing this operation.[6]

After the mud has dried, it is sanded, as required, to leave a smooth connection between successive wallboards. Here again, the experience of the worker is evident, for if the final mud coat is feathered skillfully, no additional sanding is required.[7] When sanding is undertaken, a hand-held abrasive paper-covered sanding block is the most common tool employed. Electric sanders are not widely used since the mud, even after drying, is too soft for the high speed sander.[7] Pole sanders, in which the sanding block is attached to the end of a long pole, may be used for hard-to-reach areas. Workers employed in the sanding operation may use face masks for dust control, regardless of whether or not the joint compound contains asbestos.[7] It is estimated that 25 to 30 percent of the total joint application time is spent in sanding,[6] or up to 2-1/2 hours of every 8-hour workday. Almost all applications of the water soluble products occur indoors.

The debris and the dust accumulated on the floor resulting from the mixing, application, and sanding operations are generally cleaned up by dry sweeping. In many instances, especially in cases of commercial building and large projects, this operation is carried out by nonskilled laborers. However, it was generally found to be part of the work responsibilities of skilled employees of small companies working on residential construction projects.[6]

AIRBORNE FIBER MONITORING DATA

Petroleum-Based Products

Airborne fiber concentrations measured during spray application and sand blasting removal of different types of asbestos-containing petroleum-based coatings are presented in Table 10. Operations monitored varied from spraying cutback asphalt containing 7.7 percent asbestos on a roof surface to sand blasting a 2.1 percent asbestos content high performance exterior resin coating from a steel tank. As shown in the table, airborne fiber concentrations did not exceed 0.6 f/cm^3. Another activity monitored involved sawing pipe coated with a polyester resin containing 2 to 3 percent asbestos. Measured fiber concentrations during this operation ranged from 0.04 to 0.1 f/cm^3.

Water Soluble Latex or Gypsum-Based Products

A summary of airborne fiber monitoring data obtained during the performance of the end use activities associated with gypsum-based drywall compounds is presented in Table 11. The table breaks down fiber concentrations into the various steps of product use and handling. Fiber concentrations measured during dry mixing ranged from 9.0 to 59 f/cm^3. During application, concentrations of 0.4 to 1.3 f/cm^3 were recorded. Fiber levels associated with sanding and sweeping operations ranged from 1.2 to 24.2 f/cm^3 and 4.0 to greater than 41.4 f/cm^3, respectively.

SUMMARY OF FINDINGS

From the discussion above, it is obvious that water soluble latex or gypsum-based coatings and sealants pose a far greater potential for fiber release during end use than petroleum-based products. Airborne fiber concentrations associated with dry mixing of such water soluble drywall patching compounds can approach 60 f/cm^3. Detection of such levels probably contributed, in part, to the 1977 decision by the Consumer Product Safety Commission to ban consumer patching compounds containing respirable free-form asbestos fibers. Because these materials are still used in industrial settings and may still be present in existing buildings, care must be taken during all phases of product handling to minimize asbestos fiber release.

Asbestos-containing petroleum-based coatings and sealants are applied in both exterior and interior settings by workers utilizing high pressure spray guns, brushes, or trowels. The asbestos fibers contained in these products are thoroughly wetted by the petroleum-based liquids, greatly reducing the potential for free-form fiber release during use. Monitoring tests conducted during product application and removal revealed airborne fiber concentrations

TABLE 10. FIBER CONCENTRATIONS ASSOCIATED WITH THE SPRAY APPLICATION OF ASBESTOS-CONTAINING PETROLEUM-BASED COATING PRODUCTS[8]

Asbestos-containing product	Activity performed	Measured fiber concentration (f/cm^3)	Date of tests	Duration of activity/ sampling time (min)	Analytical method	Comments
Spray-applied asphaltic roof coating						
Outback asphalt	Spraying	0.003 to 0.15	1974	342 to 432	Phase contrast[a] (assumed)	Percent weight of asbestos as sprayed ranged from 5.8 to 7.7, after curing 9.7 to 12.8
Asphalt-emulsion	Spraying	0.01 to 0.3	1974,1976	NR	Phase contrast (assumed)	Percent weight of asbestos as sprayed was 2.8, after curing 5.1
Built-up roofing	Tear-off	0.1 to 0.4	1974	NR	Phase contrast (assumed)	Monitoring performed in Indiana
	Tear-off and replace (spray)	0.0 to 0.3	1974,1976	NR	Phase contrast (assumed)	Monitoring performed in Pennsylvania and Indiana
	New application (spray)	0.0 to 0.6	1974,1975,1976	NR	Phase contrast (assumed)	Monitoring performed in Wisconsin, Colorado, and Indiana
Resin coatings	Ship coating by spray application	0.2	1974	8 to 33	Phase contrast (assumed)	Operator spraying outside and under a ship with asbestos-containing epoxy resin. Percent asbestos as sprayed 1.5
	Dry dock coating by spray application	0.0 to 0.2	1974	11 to 38	Phase contrast (assumed)	Operator spraying dock with an asbestos-containing epoxy and coal tar mixture. One percent asbestos as sprayed
	Coating pipe interior - spray application	0.1	1974	37	Phase contrast (assumed)	Operator spraying interior of 7.6, 15 and 30 cm diameter pipe with an asbestos-containing (1 percent) epoxy and coal tar mixture
	Fiber-glass pipe MFG (Mandrel coating)	0.1 to 0.4	1974	14 to 23	Phase contrast (assumed)	Operators monitored were involved in running automatic spray machine and wiping mandrel. A 1.4 percent asbestos chemical resistant resin was sprayed-applied
	Ship coating below waterline (spray application)	0.0 to 0.4	1974	23 to 65	Phase contrast (assumed)	Chemical resistant resin containing 0.7 percent asbestos applied
	Painting building exterior (commercial)	0.0 to 0.06	1974,1977	5 to 16	Phase contrast (assumed)	Alkyd resin containing 6 percent asbestos or vinyl-acrylic latex containing 0.6 percent asbestos applied

(continued)

TABLE 10 (continued)

Asbestos-containing product	Activity performed	Measured fiber concentration (f/cm^3)	Date of tests	Duration of activity/ sampling time (min)	Analytical method	Comments
Resin coatings (continued)	Painting building interior (commercial)	0.03 to 0.06	1977	23	Phase contrast (assumed)	Vinyl-acrylic latex containing 0.6 percent asbestos applied
	Wall and roof spraying	0.0 to 0.2	1974	12 to 15	Phase contrast (assumed)	Operator spraying 2.8 to 3.7 percent asbestos vinyl latex on vertical wall panel
	Roof spraying	0.0	1974	14 to 28	Phase contrast (assumed)	Operator spraying 0.7 percent asbestos acrylic latex
	Boat MFG - spraying surface coatings	0.0 to 0.6	1972,1974,1975	4 to 55	Phase contrast (assumed)	Operator spraying 0.5 percent asbestos general purpose polyester resin
	Sawing pipe coated with polyester resin	0.04 to 0.1	1973	19 to 49	Phase contrast (assumed)	Operator sawing reinforced fiberglass pipe coated with polyester resin containing 2 to 3 percent asbestos
	Handsanding interior building panels	0.0 to 0.3	1977	1 to 16	1.5 asbestos Phase contrast (assumed)	Operator handsanding panel surfaces covered with vinyl latex paint containing 1.1 percent asbestos
	Sand blasting high performance exterior coating	0.2 to 0.3	1978	5 to 27	Phase contrast	Operators sandblasted 12 meter diameter by 7.6 meter high steel tank spray coated in 1973 with a 2.1 percent asbestos resin coating.

[a]Fibers 5 μm long or longer with a length-to-diameter aspect ratio of 3 or greater were counted by phase contrast microscopy.

NR - Not Reported

TABLE 11. SUMMARY OF AIRBORNE FIBER CONCENTRATIONS ENCOUNTERED IN THE DRYWALL TAPING PROCESS[6,9]

Asbestos-containing product	Activity performed	Measured fiber concentration (f/cm^3)	Date of tests	Duration of activity/ sampling time (min)	Analytical method	Comments
Water soluble gypsum-based drywall compound (Study A)	Application	0.4 to 1.3	1978	39 to 65	Phase contrast[a]	Commercial operation
	Mixing (dry powder)	9.0 to 12.4	1975 to 1977	10 to 12	Phase contrast	Residential setting
	Mixing (pre-mix)	1.2 to 3.2	1978	4 to 5	Phase contrast	Commercial operation
	Hand sanding	2.1 to 24.2	1975 to 1977	10 to 80	Phase contrast	Residential setting
	Pole sanding	1.2 to 10.1	1975 to 1977	10 to 38	Phase contrast	Residential setting
	Pole sanding	1.2 to 10.0	1978	4 to 21	Phase contrast	Commercial operation
	Sweeping	4.0 to 26.5	1975 to 1977	9 to 30	Phase contrast	Residential setting
	Sweeping	14.5 to 25.4	1978	10 to 20	Phase contrast	Commercial operation
Water soluble gypsum-based drywall compound (Study B)	Dry mixing (0.9 to 1.5 m)	35.4 to 59.0	1974	NR	Phase contrast	Commercial operation. Fiber range reported is not less background levels, which for the same room ranged from 0.5 to 13.1 f/cm^3
	Hand sanding (0.9 to 1.5 m)	1.3 to 16.9	1974	NR	Phase contrast	Commercial operation. Fiber range reported is not less background levels, which for the same room ranged from 2.1 to 2.5 f/cm^3
	Pole sanding (0.9 to 1.5 m)	1.2 to 19.3	1974	NR	Phase contrast	Commercial operation. Fiber range reported is not less background levels, which for the same room ranged from 3.5 to 19.8 f/cm^3
	Sweeping (3.0 to 15 m)	41.4 (mean)	1974	NR	Phase contrast	Due to heavy loading during sweeping, sampling occurred 15 minutes after sweeping stopped. After 35 minutes, the measured fiber level was 26.4 f/cm^3

[a]Fibers 5 μm long or longer with a length-to-diameter aspect ratio of 3 or greater were counted by phase contrast microscopy.

NR - Not Reported

ranging from 0.0 to 0.6 f/cm^3. Spray-applied petroleum-based coatings and sealants containing more than 1 percent asbestos are the only products not banned from building construction use by the asbestos NESHAP regulation.[10]

Table 12 summarizes the data presented on coatings and sealants and identifies the principal activities of concern with respect to fiber release.

TABLE 12. SUMMARY OF COATINGS AND SEALANTS SECONDARY PROCESSING AND END USE ACTIVITIES

Product: Coatings and sealants	Secondary processing	End use: Petroleum-based products	End use: Water soluble products
Activity:	No secondary processing of either product line	Spray application, hand brushing and troweling, sand blasting removal	Dry mixing hand application troweling, sanding
Duration: Per Incident Daily Total		Continuous operation up to 8 hours per day	Mixing--5 to 10 minutes Application--up to 5 1/2 hours Sanding--up to 2 1/2 hours
Fiber Releasability:		Low	High
Chemical Composition		5 to 30% asbestos, 55 to 80% asphalt	3 to 5% asbestos, majority gypsum or limestone
Physical Composition		Tacky material as applied, hard resinous finish when dry	Wet paste as applied, granular finish after drying
Disruptive Energy		Moderate to high, power sanding (sand blasting) of material off surfaces	Moderate, hand sanding
Measured Fiber Concentrations (f/cm^3):		0.0 to 0.6	Mixing--1.2 to 59 Application--0.4 to 1.3 Sanding--1.2 to 24.2 Sweeping--4.0 to >41.4
Environmental Setting:		Usually applied out of doors to exterior surfaces	Applied indoors to wall surfaces

Activity of Concern

Mixing, sanding, and cleanup sweeping of water soluble products that are still available and applied to interior wall surfaces.

COATINGS AND SEALANTS
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SECTION 7

ASBESTOS PAPER PRODUCTS

OVERVIEW

Products within this category include those that contain asbestos fibers and are manufactured on a fourdrinier or cylinder papermaking machine. Several subcategories have been identified for Paper Products.[1,2] For this report, the following subcategories were investigated; roofing felt, flooring felt, millboard and rollboard, beater-add paper used for gaskets, and electrical insulating paper. Paper product subcategories not profiled include commercial paper, specialty paper, and pipeline wrap.

The manufacture of all asbestos-containing paper products is similar. Raw materials are blended together with water in a pulp beater or hollander. This base stock is then processed through a series of material build-up and dewatering steps followed by drying. Product differentiation results from the addition of a manufacturing step, such as the saturation of paper with asphalt to produce roofing felts, or from using different forming equipment, as with millboard production. Paper products are also differentiated by varying asbestos content and grades, as well as binders and fillers.[3]

ROOFING FELT

Introduction

Asbestos roofing felt is a paper product that is converted to a weather resistant roofing material by saturation of the paper with asphalt or tar. Asbestos fibers are used in the manufacture of roofing felts because they provide dimensional stability and resistance to rot, fire, and heat buildup. Rot resistance is particularly important due to roofing felt's use on flat or nearly flat surfaces having poor drainage.

Asbestos roofing felts are typically composed of 85 to 87 percent asbestos (primarily chrysotile) with differing amounts of cellulose fibers and starch binders. Sheets of roofing paper are made in either single or multilayered grades and may have fiberglass filaments or wire strands embedded between the felt layers for reinforcement.

Following formation on the papermaking machines, the paper-like product is either drawn through a bath of hot asphalt or coal tar to provide a weather resistant coating or wound into rolls for future processing. The process of saturating the felt with asphalt is a distinct operation, often performed by the felt manufacturer at a different plant from where the felt itself is made.[1]

Secondary Processing--Fabrication

There is no secondary processing of asbestos-containing roofing felts. These materials are supplied in roll form by the roofing felt manufacturer to local distributors who market roofing products to construction firms.

End Use Activities

Roofing felts are primarily used as one component of "built-up" horizontal roofing systems and less frequently as an underlay for inclined roofs covered by conventional shingles or sheet roofing materials. Both applications require cutting the asbestos felt to size prior to attaching it to the roof deck using adhesives or nails. If removal of the roofing material is required, the methods used depend largely on the materials of construction and amounts installed.

Built-up roofs are constructed by building up successive layers of roofing felt (asbestos or nonasbestos) and asphalt or an asphaltic-type coating. The felts used may be composed of asbestos fibers, fiberglass, or organic fibers, all saturated with asphalt.[4,5] With respect to asphaltic roof coatings and cements, a wide range of product types are available. These include both asbestos-containing and nonasbestos-containing materials.[6,7]

Three basic types of built-up roof systems are currently in use. They are smooth surface, gravel surface, and mineral surface. Each type includes a number of variations which allow for the use of different felt compositions, number of felt plies, and type of roofing substrate (nailable deck without insulation, insulated nailable or nonnailable deck, or light weight loosefill insulating material). The smooth-surface roof type consists of alternating layers of asphalt and roofing felt topped with a light application of heated asphalt or a cold-apply asphaltic coating. The gravel-surface roof type has a similar built-up layer configuration but the top coat is a heavy application of heated asphalt, over which a mineral aggregate is distributed and embedded. The mineral surface roof type has the same built-up layer construction as the other two but the top covering consists of a preformed inorganic "cap sheet" mat that is embedded in a layer of asphalt. The cap sheet is manufactured in different colors and is installed to add a cosmetic finish to the roof.

During installation roofing felts are cut to length using a knife whereas width cuts, when necessary, are made using a knife or a "felt slitter" cutting tool.[4,8] Felts, which are laid down with adjacent edges overlapping, are attached to the roof deck and to underlying felts using nails or asphalt, depending on the deck composition and the roof slope. Asphalt may be mopped on and the felt manually unrolled and pushed into the asphalt, or a specially designed machine can be used that automatically dispenses the asphalt and applies the felt. In order to achieve a uniform membrane (referring to the total built-up layer) thickness along the edges of the roof deck, a single felt is ordinarily cut lengthwise to obtain two felt strips of the required widths to build up the perimeter thickness. These strips are generally 30, 46, and 61 cm (12, 18, and 24 inches) wide. When the felt is used as underlayment for a shingle or sheet roof, the felt is generally nailed to the deck and no asphalt coatings are used.[5]

Asbestos roofing felts have been in use for over 100 years.[9] Built-up roofs comprised of these felts are reported to have an expected service life of at least 20 years, with some lasting up to 40 years.[9,10]

Product deterioration results principally from climatic exposure. During weathering asphalt coatings and asphaltic felts become brittle and crack.[4] Where isolated leaks occur due to excessive wear, the roof may be repaired simply by application of heated asphalt or a cold-apply roof coating to the affected area. If the deterioration is widespread, the entire roof must be recovered or replaced. Since the roof membrane derives much of its integrity from the structure of overlapping felts, a number of localized repairs is much less effective than total recovering or replacement.[7]

Industry representatives report that more than 60 percent of the asbestos roofing felt produced is applied during reroofing, with the remainder used in new construction.[1] Johns-Manville representatives report that the smooth-surface type of roof is the easiest to recover and replace, owing to the smooth surface and overall light weight.[4,8] A gravel-surface roof requires at least power-brooming to prepare the surface for recovering, and frequently the top layer of gravel/asphalt must be removed entirely to provide a smooth surface.[4,8] Additionally, the gravel-surface roof is the heaviest of the three built-up roof types, and careful attention must be paid to the structural capacity of the underlying roof deck if the existing asphalt flood coat and gravel are to be left intact. Recovering tends to be preferred over reroofing because of lower costs.[8]

Roof removal generally requires chopping or sawing the existing roof membrane into pieces which can be pried or scraped off the roof deck. Any number of roof layers may be removed depending on the scope of the roofing job, from the top layer of asphalt down to the insulation or the roof deck itself. Cutting tools commonly used are an axe or circular saw (mounted on wheels), the latter being faster and generally used on large jobs.[4,11] The circular saw is preferred for removal of top layers of a membrane because it cuts to a controlled depth. After cutting, the cut-up blocks of roof are pried off of the deck or underlying layers with a shovel or crow bar.[4,11] In large job operations, the waste material is carted to the edge of the roof in wheelbarrows and is dropped down enclosed chutes leading to a ground-level dumpster. Less sophisticated disposal methods are used for smaller jobs.

A series of several scraping routines and a final sweep of the roof area may be necessary to prepare the deck for application of a new roof.[11] A Johns-Manville representative stated that it is impossible to characterize the number of workers and time required for a reroofing job, as the work and even the tools used vary widely with the roof type.[4] Removal of a 10.5 x 18 meter (35 x 60 foot) section of fiberglass-insulated asphalt roofing membrane, which was monitored by GCA/Technology Division personnel in December 1979, required about 2 hours.[11] Built-up roof installation is estimated to take a similar length of time or longer to apply the multilayered membrane.

Airborne asbestos fiber release during roofing felt installation is expected to be low. Asbestos-containing roofing felts, which are coated with asphalt, are quite pliable and normally carefully handled during built-up roof construction to ensure the integrity of the finished membrane.[7,12] During installation, the only mechanical disruption applied to the felt is cutting with a sharp bladed tool. Liberation of asbestos fibers from such a low energy activity is expected to be minimal.

In use, asbestos-containing felt is isolated from the atmosphere by layers of asphalt and/or other roof coating materials. Although these coatings may eventually wear off, wind and water erosion is believed to be a very gradual process whereby minimal fiber release is expected. By the time the felt becomes exposed, a membrane leak is likely and repairs would be performed on the affected area. Roofing materials tend to wear nonuniformly, therefore the felt is not likely to be exposed over the whole roof at one time.

Of all the roofing felt end use activities, felt removal poses the greatest potential for fiber release. During this operation the top membrane coating and the asphalt in the felt have weathered to a hard, stiff material. During removal, when surface layers are sawed and scraped, the felt matrix is likely to be physically altered, releasing free-form asbestos fibers. The membrane top coat and asphalt coats between the felt layers, however, do tend to bind the cut felts together, minimizing felt fracture during prying and waste disposal.

Airborne Fiber Monitoring Data

Several monitoring studies have been conducted to determine airborne asbestos fiber concentrations encountered during roofing felt installation and removal. Results of these studies, conducted by the Johns-Manville Corporation and GCA/Technology Division, are presented in Table 19. Airborne fiber concentrations in and around the work sites were generally found to be equal to or less than 0.6 f/cm^3.

The Johns-Manville studies were initiated through requests by internal marketing staff or roofing representatives and spanned a period from October 1972 to August 1976. Air samples collected were analyzed in Waukegan, IL, Manville, NJ, and Denver, CO by Johns-Manville technicians using the PCM analytical method.[6] The GCA samples were obtained on December 11, 1979 and were analyzed by Eastern Analytical Laboratories of Burlington, MA using SEM (5000x) and EDXR techniques.

The data presented in Table 19 do not indicate any trends as to which roofing operation has the greatest potential for airborne asbestos fiber release. Although reported fiber concentrations for any given study

TABLE 19. FIBER MONITORING DATA FROM ASBESTOS ROOFING FELT STUDIES[11,13]

Test conditions[a]	Sample No.[b] Man	Area	Specific operation or area sampled	Tools/materials	Fiber level (f/cm^3)[c]
10-10-72 (5-10 mph) Univ. of Wisconsin (ND) by Nelson Roofing Co. (I)—Johns-Manville (Waukegan)	1		Majority of cutting felt; also spread asphalt	Centurian base, No. 15 finishing felts	0.3
	2		Assisted cutting and laying felt	Same as above	0.2
	3		Carried felts to operation; some cutting	Same as above	0.2
		1	Upwind of operation	—	0.1
		2	Along side operation	—	0.1
		3	Downwind of operation	—	0.1
		4	Six ft above operation	—	0.1
5-18-73 (ND) School at Hobart, IN (ND) by Maris Roofing Co. (I)—Johns-Manville (Waukegan)	1		Mopping hot asphalt	ND	0.1
	2		Laying and cutting felt	ND	0.1
	3		Hot asphalt tank operator	ND	0.2
		1	Downwind of operation	—	0.1
		2	Downwind of operation (near men shoveling scrap off roof to truck)	—	0.4
		3	Downwind of operation	—	0.1
3-14-74 (9-10 mph) at Racine, WI (2,000 sq ft) by unidentified contractor (I)—Johns-Manville (Denver)		1	Ground level 500 ft from school building (75 ft below roof)	—	0.4
		2	15 ft upwind of operation, 4 ft above roof	—	0.4
		3	Same as No. 2 area	—	0.2
		4	15 ft downwind of operation, 2 ft above roof	—	0.3
		5	30-15 ft downwind of operation, 2 ft above roof	—	0.3
	6		Mopping hot asphalt; some felt cutting and laying	Knife to cut felt/Centurian base, perforated finishing felts	0.6

Test conditions[a]	Sample No.[b] Man	Area	Specific operation or area sampled	Tools/materials	Fiber level (f/cm^3)[c]
4-11-74 (10 mph) School at Indianapolis, IN (1,350 sq ft) by Sink & Edwards Roofing CO. (R)—Johns-Manville (Waukegan)		1	525 ft upwind of building at ground level	—	0.3
		2	18-25 ft downwind of operation, 4-5 ft above roof	—	0.1
		3	Same as No. 2 area	—	0.2
		4	40 ft upwind of operation 4-5 ft above roof	—	0.4
	5		All phases of roof removal	Axe cutting, pry bars and shovels to remove surface; sweep clean with broom	0.1
	6		Same as No. 5 man	Same as above	0.3
5-21-74 ("slight-moderate") Dept. Store at Allentown, PA (1,500 sq ft) by Hill Metal and Roofing Co. (R,I)—Johns-Manville (Manville)	1		Power sawing and removing sections of old roofing	Power saw, pry bar	0.1
			Tacking down new felt	Nailing Centurian base felt	0.0
	2		Prying off old roofing	Pry bar	0.0
			Laying new felt (unrolling)	Centurian base felt	0.1
	3		Removing old roofing	Wheelbarrow	0.1
			Tacking down new felt	Nailing Centurian base felt	0.2
		4	Upwind corner of work area—removal	—	0.1
			- Installation	—	0.1
		5	25 ft downwind of work area—removal	—	0.1
			- Installation	—	0.1
		6	15 ft downwind of ground-level truck receiving waste roofing—removal	—	0.2
			- Installation	—	0.1
		7	150 ft downwind of work area and at ground level—removal	—	0.1
			- Installation	—	0.1

(continued)

TABLE 19 (continued)

Test conditions[a]	Sample No.[b] Man	Sample No.[b] Area	Specific operation or area sampled	Tools/materials	Fiber level (f/cm^3)[c]
5-21-74 (continued)		8	25 ft upwind of ground-level truck receiving waste roofing—removal	—	0.0
			- Installation	—	0.0
7-25-74 (0-2 mph) School at Gary, IN (3,500 sq ft) by Maris Roofing Co. (R,I)—Johns-Manville (Waukegan)	1		Roof removal by sawing, prying; installation by nailing base felt and hot mopping other layers	Power saw, shovel, wheel-barrow, broom; nailing felts, mopping hot asphalt	0.2
	2		Same as No. 1 man	Same as above	0.3
		3	15 ft downwind of work area	—	0.1
		4	15 ft upwind of work area	—	0.2
11-20-74 (18-8 mph) School at Cherry Creek, no state given (5,800 sq ft) by United Materials Roofing Co. (I)—Johns-Manville (Waukegan)		1	Upwind edge of work area	—	0.1
		2	Downwind edge of work area	—	0.1
	3		Felt laying machine operator	Machine lays felt in hot tar	0.2
	4		Broom felt into hot asphalt	Push broom	0.1
	5		Hot asphalt tank operator	Pouring hot asphalt	0.1
	6		Felt "fitting" (probable cutting)	ND	0.2
12-15-75 (variable) Industrial building no location given (7,700 sq ft) by unknown contractor (I)—Johns-Manville (Waukegan)	1		Felt laying machine operator	Machine lays felt in hot tar	<0.1
	2		Replace felt rolls on laying machine, broom felt into tar	Push broom	<0.1
		3	North edge of work area, generally upwind	—	<0.1
		4	South edge of work area, generally downwind	—	0.0
		5	East edge of work area	—	<0.1
8-76 (ND) School at Anderson, IN (1,500 sq ft) by Adams Roofing (R,I)—Johns-Manville (Waukegan)		1	2 ft downwind of work area, 5 ft above roof—removal	—	0.0
			- Installation	—	0.0
		2	Same as No. 1 area—removal	—	0.0

TABLE 19 (continued)

Test conditions[a]	Sample No.[b] Man	Area	Specific operation or area sampled	Tools/materials	Fiber level (f/cm^3)[c]
8-76 (continued)		2	- Installation (continued)	—	0.0
		3	Upwind edge of work area, 5 ft above roof—removal	—	0.0
			- Installation	—	0.0
	4		"Tear-off man" (probably cutting and prying off old roofing)	ND	0.0
	5		"Scrap removal man" (probably shoveling and wheelbarrowing old roof material)	ND	0.0
	6		"Asphalt applicator" (probably mopping hot tar)	ND	0.0
	7		"Asbestos paper application" (probably cutting and laying felt)	ND	0.0
8-76 (ND) School at Chesterfield, IN (1,500 sq ft) by Adams Roofing (I)—Johns Manville (Waukegan)		1	2 ft downwind of work area, 5 ft above roof	—	0.0
		2	Same as No. 1 area	—	0.0
		3	Upwind edge of work area, 5 ft above roof	—	0.0
	4		"Asphalt applicator" (probably mopping hot tar)	ND	0.0
	5		"Asbestos paper applicator" (probably cutting and laying felt)	ND	0.0
12-11-79 (15 mph) Office building at Bedford, MA (31,000 sq ft) by unidentified contractor (R, I)—GCA/Technology Division (Eastern Analytical)		1	Corner of roof 25 ft downwind of work area	—	0.00
		2	Edge of roof 25 ft downwind of work area	—	NA
		3	Edge of roof 25 ft downwind of work area	—	0.03
		4	100 ft upwind of work area	—	0.05

TABLE 19 (continued)

Test conditions[a]	Sample No.[b] Man	Sample No.[b] Area	Specific operation or area sampled	Tools/materials	Fiber level (f/cm^3)[c]
12-11-79 (continued)		5	Same as No. 4 area	—	0.01
	5		Cutting, scraping, and shoveling old roof off of deck; sweeping; laying fiberglass insulation and roofing felts, layered with hot asphalt	Removal: circular saw, shovels, wheelbarrows, brooms Installation : ND	0.00

[a]Test conditions include date of sampling (reported wind speed); location (area of work site); roofer (type of operation—R = removal, I = installation); sampling personnel (analysis lab).

[b]Sample No. generally corresponds to sampler's reported data, and two columns indicate whether sampling was performed on a worker (moving) or in a general area (stationary).

[c]Johns-Manville data based on PCM. GCA data based on SEM/EDXR analysis.

ND = No data

NA = Not analyzed

generally follow a logical pattern, with highest concentrations reported for cutting, scraping, and sawing operations as compared to spreading asphalt or unrolling felts, the differences in fiber levels within a given study are less than the differences between studies (generally less than 0.2 f/cm^3). The variations in reported concentrations between studies in which similar materials and operations were used seem to suggest some contribution from the work practices of individual roofers' or from background fiber concentrations. A confusing factor in 4 of the 11 studies was that upwind fiber concentrations were higher than downwind concentrations, and in 3 of the 4 studies they were higher than work site levels. No explanation is given for these unexpected results.

Summary of Findings

There is no secondary processing of asbestos-containing roofing felt. The manufactured material is sold directly or through distributors to the roofing contractor. Asbestos-containing felts are used predominantly in "built-up" roof systems which combine the felts between layers of asphalt or other coatings. These systems are rarely used for residential roofing. The flat or gently sloping "built-up" roof is widely employed on commercial and industrial buildings. Asbestos-containing felts are occasionally used as an underlay for shingle or sheet roofing materials on inclined surfaces.

Felt handling practices employed by roofing contractors tend to be fairly standardized, although a wide range of combinations with asphalt, roof deck insulation, and other felts occur. Felt installation is generally a low energy intensity process, requiring only felt unrolling, "brooming" (removal of underlying air pockets), and mopping with hot asphalt. Only a minor amount of cutting (with a sharp-bladed hand tool) is required. Removal of existing roof material requires greater energy input. Power saws or axes are used to cut the substrate into 0.6 meter (two foot) square or larger blocks, which are then pried off and scraped from the underlying deck using crow bars and shovels.

Despite the variety of cutting and scraping operations that are performed, roofing felts appear to have a low fiber release potential. This probably results from the encapsulation of the fibers during the asphalt saturation step of manufacturing. Also, during installation, as the felts are successively layered with hot asphalt and/or cold coatings, the asbestos fibers are further isolated. In addition, roof weathering is very gradual and fiber release resulting from wind or rain erosion is expected to be minimal. The greatest potential for fiber release exists during roof removal when high-energy mechanical disruption is required to remove sections of felt from the roof deck. Fiber monitoring studies indicate that asbestos roofing felt installation and removal operations result in airborne fiber concentrations that are equal to or less than 0.6 f/cm^3. Table 20 provides a summary of the data presented on asbestos roofing felts and identifies the principal activity of concern with respect to airborne asbestos fiber release.

TABLE 20. SUMMARY OF ASBESTOS ROOFING FELT SECONDARY PROCESSING AND END USE ACTIVITIES

Product: Roofing Felt	Secondary processing	End use
Activity:	No secondary processing performed	Installation; in-service use; and removal
Duration--per incident Daily total		Site-specific; Installation and removal highly variable with roof size and number of felt layers. Actual felt cutting time is estimated to last less than one hour.
Fiber releasability:		Low
Chemical composition		Before asphalt saturation: 85 to 87% asbestos fiber content, remainder filler(s) and binder(s)
Physical composition		Pliable, with a tacky surface
Disruptive energy		Knife or slitting machine during installation; axes, power saws, and hand scraping tools during removal
Control measure(s):		None
Measured fiber concentrations (f/cm^3):		0.0 to 0.6 (ranging from installation to removal)
Environmental setting:		Outdoors

Activity of Concern

Removal (power sawing and scraping) of wornout, brittle felts from roof deck.

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