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CHARACTERIZATION OF ASBESTOS CONSTRUCTION PRODUCTS AT NAVAL SHO--ETC(U)

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INTRODUCTION

The Civil Engineering Laboratory (CEL) has been tasked by the Naval Facilities Engineering Command (NAVFAC) to characterize the present and past asbestos-containing construction products used at Navy installations in order to assess the potential for asbestos fiber release into Navy work spaces.

A number of factors influenced the formulation of this objective. New Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) regulations reinforced by court decisions have placed new burdens on facility managers to inventory and maintain permanent records of hazardous conditions and potentially hazardous working areas. Decisions on expensive mitigation measures and alternatives will be essential to maintain appropriate working conditions within available resources.

Many types of asbestos products have been used in Navy construction in a variety of applications, ranging from spray-applied asbestos insulation to asbestos cement sheeting. Because of the difficulties in field identification of products and estimation of potential fiber release of products, these problems have led to confusion in identifying possibly hazardous products.

The objective of the work described in this document is to characterize the present and past asbestos-containing construction products used at Navy installations. The task is to assemble information developed through a search of pertinent asbestos literature and contact with asbestos product manufacturers. The characterization of asbestos-containing construction products will be used to establish categories of these products according to their potential for asbestos fiber release. This type of information is essential to the managers of facilities with a potential for adverse impact on personnel and the local environment. Building managers will need to maintain permanent records of control and mitigation measures that have been implemented to prevent long-term effects on employee health involved with asbestos-containing construction products. Such records will support the Navy's interest if litigation should occur in the future. This information will also provide a basis for decisions regarding the direction of further development of Navy-related asbestos data and technology.

Whether or not asbestos fibers enter a workspace depends upon construction product type, structural form, work practices, and state of deterioration. Fiber dissemination is a function of (1) the frequency and amount of energy delivered to the asbestos-containing product, normally through the generation of air currents and mechanical agitation and (2) the bonding matrix characteristics of the product.

Asbestos is classified as a hydrated silicate mineral, characterized by high tensile strength, high flexibility, and good heat resistance. These and other unique properties allow most types of asbestos to be spun, woven, pressed into sheets, or used for reinforcement of composite materials such as cement or plastic.

POLICY

In the past few years, the Navy has attempted to minimize the use of asbestos. In January 1972, NAVFAC ceased the use of asbestos-containing products in spray-applied ceiling surfaces and insulation projects. Asbestos insulation was eliminated from NAVFAC's specification "Insulation of Mechanical Systems" in March 1973. In May 1973, NAVFAC issued heating and ventilating criteria to be used in designing systems where asbestos-containing materials is to be cut, sawed, or mixed (Ref 1). Current policy on asbestos-containing products is to substitute durable and economical asbestos-free material that meets the physical and technical qualities of the asbestos-containing products, whenever feasible. The use of substitutes for asbestos-containing products will be judged case-by-case, based on certification or other acceptable procedures. Testing to determine asbestos-free substitute materials will be the responsibility of industry.

ASBESTOS-RELATED HEALTH CONCERNS

Only certain types of asbestos-containing products have been found to be hazardous (Ref 2). The hazard potential depends on fiber release from the product and entrance into an environment where people are present. This, in turn, is related to the bonding matrix characteristics or the lack of bonding agents of the product containing the asbestos fibers.

The health hazard from asbestos exposure was first thought to be a simple dose-disease response relationship. As more medical and air pollution data become available, it is likely to be found that even some of the nonoccupational workers exposed to low concentrations of asbestos have developed an asbestos disease (Ref 2).

The onset of asbestos diseases is usually caused by inhalation of airborne asbestos fibers. These asbestos diseases appear predisposed to evolve into a carcinogenic type (malignancies of the lung, the abdomen, and other sites). However, an asbestos-related disease may develop slowly (a latency period of 20 to 40 years or more after first exposure) before a tumor can be detected. A hypothesis is being developed that states, "an inverse relationship exists between dose rates and the latency period; as the dose rate becomes progressively lower, the latency period may approach the life span of exposed individuals" (Ref 3).

ASBESTOS CHARACTERISTICS

Asbestos, a generic term, is applied to a number of hydrated silicates that, when crushed or processed, separate into flexible fibers made up of fibrils. A mineral fiber, on the other hand, is described as at least three times as long as it is wide. Because these two definitions are very general and do not conform to classical mineralogical terminology, the terms "asbestiform" and "asbestos-like" are being used in current literature in reference to asbestos fibers. Asbestos fibers are divided into two groups: chrysotile and amphiboles, depending upon their crystalline structure.

Chrysotile fibers are very small in diameter, tubular, and very soft and flexible. Individual fibrils measure 100 to 250 angstroms in diameter. Although finely fibrous, chrysotile belongs to a class of sheeted crystal structures. The sheets are composed of alternating layers of silica tetrahedrally bonded together by hydroxyl groups and magnesium ions. The fibrous form results from the growth pattern of the chrysotile sheet structure, giving rise to spirally wound tubes. Fibrous growth pattern has significant implications regarding mineralogical identification and analyses because, obvious as the fibers may appear to the eye, mineralogical identification and measurement based on the usual indirect analytical methods alone is practically impossible. Identification problem arises because the chrysotile sheet structure (and chemical composition) is nearly identical to that of other platy serpentine minerals with which it is associated. Thus, identification and quantification require both visual and indirect techniques for accurate identification.

Amphiboles, on the other hand, have a fibrous nature derived from a chain-like crystalline structure. Amosite, crocidolite, anthophyllite, actimolite and tremolite fibers are classified as amphiboles. The fibers are larger in diameter, straight and solid in nature, and hard and springy. Because of structural and chemical differences within the amphibole groups, identification and measurement of amphibole asbestos minerals are somewhat easier to make than those of chrysotile. The fibrous nature, however, presents special problems for most indirect analytical techniques, and visual assessment or control is usually carried out in conjunction with indirect techniques of analysis.

APPLICATION OF ASBESTOS FIBERS

It is interesting to note that although the existence and properties of asbestos have been known for centuries, widespread construction applications were not developed until the latter portion of the 19th century. The extent of the use of asbestos in construction since its introduction is difficult to estimate, but indications are that applications have been escalating in recent years.

The utilization of asbestos-containing construction products aboard Navy installations has resulted from both contract construction and federal supply purchases. Although a ban on the use of friable asbestos construction material was instituted in 1973, the only previous criteria for the use of this material stemmed from construction specifications.

Chrysotile asbestos, or "white asbestos," accounts for approximately 97% of all asbestos used in this country. The use of this mineral came about because of its natural fineness of fiber, high flexibility, good heat resistance and overall workability. Chrysotile asbestos is used in various textile products and in various high-strength cement products.

Amosite asbestos, or "silver-gray asbestos," has the longest naturally occurring mineral fibers and, in this case, exhibits good acid resistance and a coarse texture. It is less flexible and less workable than chrysotile and is used principally in high-temperature products. Amosite asbestos can be found abundantly in insulation products, plastics, textiles, and various construction products.

Crocidolite, or "blue asbestos," is very resistant to acid and is resistant to the effects of outdoor exposure. Crocidolite is spun or woven into fabrics and used in various high strength cement products.

Anthophyllite, actinolite, and tremolite fibers are too brittle to be spun or used as fibrous reinforcements but are used as fibers in various adhesives and cements.

REGULATIONS APPLICABLE TO ASBESTOS-RELATED WORK

Federal

Government personnel and contractors engaged in asbestos-related projects must comply with Occupational Safety and Health Administration (Ref 4) (OSHA) Standard 29CFR 1910.1001 which was prepared to guide the limits on heavy exposure of individuals to asbestos fibers. This standard prescribes workplace exposure limits to which asbestos workers can be exposed and describes some of the engineering controls available to limit exposure, such as air monitoring to determine fiber concentrations. Some state and local governments also impose regulations for asbestos demolition.

According to OSHA regulation 29CFR 1910.1001(b)(2) (Ref 4), effective July 1, 1976, National Institute of Occupational Safety and Health (NIOSH) promulgated: ".....occupational exposure to airborne asbestos dust shall be controlled so that no worker shall be exposed to more than 2.0 asbestos fibers/cm^3 of air based on a count of fibers greater than 5 μm in length..., determined as a time-weighted average (TWA) exposure for an 8-hour work day, and no peak concentration of asbestos to which workers are exposed shall exceed 10.0 fibers/cm^3 of a size greater than 5 μm as determined by a minimum sampling time of 15 minutes."

EPA regulations require that removed asbestos material be properly contained and disposed of without release of asbestos fibers into the environment and that the operation involving asbestos products does not produce visible emissions. EPA regulations were issued under the National Emissions Standards for Hazardous Air Pollutants Title 40CFR, Part 61 (Ref 5).

Navy

OSHA standards imposed on the Navy by Executive Order 11807 (Ref 6), followed by OPNAVINST 5100.8E (Ref 7) require implementation of health and safety methods for Navy personnel. References 4 and 8 are concerned with the control of asbestos emissions for the protection of personnel and the environment.

According to Reference 8 "medical surveillance action level" for asbestos is defined to include any individual who, because of employment, is required to enter or work on a regular basis in areas containing an airborne concentration of asbestos at or above 0.5 fibers/cm^3 that are >5 μm in length, as determined by phase contrast microscopy. "On a regular basis" is defined as 15 separate days in any quarter during a calendar year or 45 days/yr. Additionally, those personnel exposed at any time, for any length of time, to airborne concentrations in excess of the "ceiling limit" shall be included under the medical surveillance action level.

OSHA and EPA regulations and OPNAVINST 5100.8E must be adhered to by all Naval activities.

PRODUCTS CONTAINING ASBESTOS

Asbestos-containing construction products may be grossly divided into two categories:

Category I - Friable insulating products and woven asbestos products

Category II - Nonfriable matrix-bonded composite products

Friable insulating products are ones that can be crumbled, pulverized, or reduced to powder in the hand, thus readily releasing fibers with minimal mechanical disturbance. In woven products, raw asbestos fibers and fibers of numerous other materials, of both organic and inorganic origin, are worked into rovings, yarns, and cords. Hence, these can be woven, braided, or knitted into textile products. Usually, binding agents are not used in these textile products.

Nonfriable matrix-bonded composite products are prepared by mixing fibers with various bonding agents (e.g., starch, glue, sodium silicate, plastics, cements, asphalt). The degree of asbestos fiber immobilization covers a wide range; also, the mobilization varies according to the use and environmental conditions to which the product is subjected.

Friable-Insulating Products and Woven Products

The friable insulating products and woven products (Category I) are divided into three types of uses:

1. Applied friable insulating products
2. Preformed thermal insulation products
3. Textile products

Table 1 presents information on the Category I types of products, including generic name, percentage of asbestos, dates of use, and binder or sizing.

Applied Friable Insulating Products. Spray-applied or trowelled-on friable insulating products containing asbestos have four major insulation uses in construction: (1) fireproofing, (2) acoustical and decorative purposes, (3) thermal insulation, and (4) condensation control. Fireproofing accounts for the largest use of sprayed mineral fiber in buildings, although acoustical control accounts for a significant portion of the material. The products used in building construction usually are a blend of 5% to 95% asbestos fibers combined with vermiculite, sand, mineral fibers, bentonite clay binders, or cellulose fibers.

Applied friable insulating products are divided into three groups according to appearance: (1) fibrous, (2) granular/cementitious, and (3) insulating/fireproofing concrete. Fibrous insulating products have a typical fibrous appearance (cottony, wooly) or may have a textured appearance due to being tamped during application. Granular/cementitious products have a coarse sand appearance. The insulating/fireproofing concrete has a foamy appearance and probably contains vermiculite or mica.

Preformed Thermal Insulation. Preformed thermal insulation products include the batts and blocks for boilers and pipe coverings. The principal fiber used for these purposes has been chrysotile. From 1926 to 1949, 15% of fiber and 85% magnesium carbonate were combined (commonly called 85 mag); from 1949 to 1971, the chrysotile fibers were combined with calcium silicate. Asbestos content of the latter varied from as high as 15% to a low of 6 to 8%.

Textile Products. Asbestos textile products have electrical insulating properties, thermal resistance, acid resistance, and durability. Common asbestos textile products include cloth, cord, rope, yarn, tubing, tape, strips, felts, and blankets. The chrysotile asbestos content of these products can vary from 80% to 100%, and these products are normally blended with wool, cotton, wire, crocidolite, or amosite fiber.

The asbestos yarns produced by spinning serve as the basic component in the construction of rope, tubing, tape, and strips. Asbestos cord is generally defined as a multi-ply yarn used for electrical element insulation and tying cord for asbestos cloth.

Asbestos tape, strip, and tubing are used for insulating electrical conductors and for wrapping high temperature pipe joints. Asbestos cloth is woven in a wide variety of styles, textures, grades, weights, and thicknesses. The weight of asbestos cloth ranges from a few ounces to several pounds per square yard. Some of the more important previous uses for asbestos cloth include jackets or covering for pipe insulation, theatre curtains, and electrical insulation.

Nonfriable Matrix-Bonded Products

The nonfriable matrix-bonded composite products (Category II) are divided into eight subdivisions:

1. Cementitious products
2. Paper products
3. Roofing felts
4. Asbestos compounds
5. Asbestos ebony
6. Flooring tile and sheet goods
7. Wallcovering
8. Paints and coatings

Table 2 presents the information on the Category II types of products including generic name, percentage of asbestos, dates of use, and binder or sizing.

Cementitious Products. Asbestos-cement products are primarily composed of portland cement reinforced with medium length chrysotile asbestos fibers. The percent by weight of cement varies over a range of approximately 10% to 75% and depends upon the physical characteristics desired. Cement pipe is generally made with proportions (by weight) of three chrysotile to one crocidolite. The strong asbestos fibers behave similarly to the steel rebars used for reinforcing concrete.

Asbestos-cement panels* involve a wide range of construction products: siding shingles, flat sheets, roofing shingles, corrugated sheets, facings of acoustical products, laboratory table tops, electrical conduits, and laminated panels. Asbestos-cement products are used primarily in the construction of supply buildings, maintenance shops, production offices, assembly spaces, research development areas, and testing facilities. In a number of cases, asbestos-cement panels are exposed to the interior work environment. The panels have been used for interior partitions and ceilings, and, in certain industrial buildings, are used for smoke baffles in high ceilings.

Clapboard, a thin asbestos-cement sheet, has been used extensively on wood frame buildings under siding product. This product had a short production period (about 2 to 3 years), and probably was never used in Navy construction. However, asbestos siding shingles have been used extensively on wood frame buildings. Asbestos roofing shingles are available but were probably not used extensively in Navy construction, except for "blowaway" buildings for ammunition demilling. Asbestos-cement pipe has been used extensively at Navy installations for water mains, sewage and industrial liquid-waste disposal lines, conduits, vent pipes, flues, and chimneys for heaters.

Paper Products. A great variety of paper products are made from chrysotile, including corrugated, indented, reinforced board and millboard. Asbestos paper fills the need for a paper that has the inorganic properties of asbestos: good heat resistance, chemical inertness, and good electrical and insulating properties. The asbestos content in most papers is 75% to 99%, with sodium silicate as the primary binder for corrugated and indented papers. Millboard, made of 80% to 85% chrysotile fiber bound with starch, lime, and clay, has been used for a wide variety of thermal insulation requirements, such as lining in firedoors, pipe insulation, electric heaters, and firewalls (laminated with wood).

Roofing Felts. Asbestos felt impregnated with asphalt is used on the roofs of buildings. The roofing sheets can be made up of single layers, plied layers saturated or coated with asphalt, or may be both saturated and coated with asphaltic compositions. The asbestos roofing felts are manufactured with a fiber content varying between 10% to 15% asbestos. Asbestos roofing shingles with an asbestos content of about 1% are manufactured with asbestos felt saturated with asphalt. Asbestos felt saturated with asphalt is used to cover hot steam lines outside of buildings. Because of the higher cost of asbestos felt, rag felt (which does not contain asbestos fiber) has normally been used in most Naval roofing construction applications.

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*A number of asbestos-cement panel products are commonly referred to as Transite products even though Transite is a Johns-Manville tradename.

Asbestos Compounds. Asbestos-containing compounds encompass a wide variety of products. Examples are roofing asphalt, tile cement, grout, plaster, stucco, and insulation cements. In all these uses, 3% to 85% asbestos fibers serve as a filler/reinforcement lubricant and enhance workability. The asbestos-containing compounds for exterior and interior construction uses are classified by their organic and inorganic binders. Examples of organic binders are linseed oil and asphalt; examples of inorganic binders are portland cement and magnesia.

Asbestos Ebony Products. Asbestos ebony is a cement product that contains about 50% asbestos fibers. Its principal use in the construction industry is in electrical panels and circuitry.

Floor Tile and Sheet Goods. Asphalt floor tile was developed during attempts to produce slate shingles and has been expanded into vinyl-asbestos tile and sheet goods. Asphalt tile contains 25% to 35% asbestos fibers, whereas vinyl-asbestos tile contains about 20% asbestos fibers. The vinyl tiles are made of a vinyl chloride-vinyl acetate copolymer resin mixed with plasticizers, limestone, color pigments, and asbestos. Vinyl-asbestos floor tiles are commonly found in Naval shore construction. In sheet goods and resilient sheet, asbestos is found only in the back reinforcing sheet.

Wallcovering. Better quality vinyl wallcovering has an asbestos content between 6% and 8%. Due to cost, this material would not normally be used in Navy building construction.

Paints and Coatings. Many exterior asphaltic paints contain between 4% and 7% asbestos fibers. The textured wall paints contain between 8% and 10% asbestos fibers. The "airtight" coating used for sealing cracks and joints normally contains 15% asbestos fibers.

ANALYSIS FOR ASBESTOS CONTENT

Many products are mixtures of asbestos and other components, such as fibrous glass, rockwool, slagwool, woodpulp, and paper fibers. Qualitative analytical techniques used for asbestos identification are concerned with determining the presence and type of asbestos within a bulk sample of the asbestos-containing construction product. Techniques for examination of bulk samples are relatively straightforward and give an unambiguous result in most cases.

Three reliable methods of asbestos fiber identification* are commonly used for bulk sample analysis:

1. Petrographic microscopy, as performed by a laboratory of recognized competence in optical crystallography
2. X-ray diffraction, as necessary, as a supplement to petrographic microscopy
3. Electron microscopy, as a further supplement if ambiguity exists following analysis by the other methods

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*Nondestructive tests do not presently exist for asbestos fiber identification in the field.

Petrographic Microscopy

The petrographic microscope, a transmitted polarized light instrument with dispersion staining, is widely used in the geological and chemical sciences for identification and characterization of crystalline substances based upon their optical and crystallographic properties. Techniques are well-established, and equipment is relatively low in cost. Petrographic microscopy is an effective method for identification of particular mineral species. However, petrographic microscopy requires a highly skilled and experienced microscopist, who must be able to adequately search a bulk sample optically and successfully recognize and identify component material. An experienced microscopist should be able to locate and identify even small amounts of asbestos in bulk samples. Content below 5%, however, is questionable.

X-Ray Diffraction

When this technique is utilized, x-rays are diffracted by a small sample of suspect material, and a pattern fingerprinting uniquely characteristic of any crystalline materials present is produced. In routine examination procedures, x-ray diffraction of bulk samples may fail to detect small concentrations of asbestos (<2% to 4%) if fibers are not concentrated during laboratory preparation; other silicates or crystalline phases may significantly interfere with accurate identification. However, the x-ray diffraction technique usually yields information with a high degree of diagnostic reliability as well as a printed record. It is usually used as a confirmation of petrographic microscopy impressions and not as a screening procedure.

Electron Microscopy

Specific and accurate fiber identification can be achieved by examination of the structure of individual fibers or fibrils, especially if used in conjunction with electron diffraction or energy dispersive x-ray analysis. The extrapolation of precise electron microscopy data, however, to significant bulk sample information is inefficient and costly. Its use in identification is usually confined to resolving ambiguities raised by petrographic microscopy and x-ray diffraction.

SUBSTITUTES FOR ASBESTOS MATERIALS

Asbestos fibers have several unique characteristics unmatched by other fibrous or nonfibrous minerals. Attempts to minimize asbestos fiber content have been made by manufacturers of asbestos products. Many of the major manufacturers of asbestos thermal insulation are changing product lines to asbestos-free products. Over the last few years, many construction products have had the asbestos fiber content reduced from their original formulations. A few of the generalized decreases in asbestos fiber content are shown, indicated with an arrow, in Tables 1 and 2.

In general, the basic materials substituted for asbestos in thermal insulation systems thus far are:

1. Synthetic fibers, such as fibrous glass cloth and felt
2. Alumina and silica refractory felt
3. Calcium silicate with a nonasbestos fiber filler
4. Mica

In addition, spray-applied mixtures of vermiculite and gypsum have been used in place of asbestos products for fire protection and acoustical control.

RECOMMENDATIONS

Further investigation into possible fiber release from asbestos-containing products will clarify the extent of fiber release, conditions under which it occurs, and procedures for controlling its release. Methods for controlling fiber release are available today for new construction and remodeling projects; however, problems of controlling fiber release occur during normal product use or during demolition of facilities. Possible fiber erosion from normal use can affect a significant number of Navy personnel over an extended period of time.

With the vast diversity of existing asbestos building products and the difficulties of assessment in the field, a device for rapid detection and assessment should be developed as stricter regulations are implemented by OSHA. A standardized asbestos-containing product or asbestos-free product coding system should be considered for shore activities, as well as a flagging system for Public Works Department maintenance files.

Alternative asbestos-free substitute products should be the subject of further investigations to ensure that asbestos-free substitutes recommended (such as fibrous glass) have no potential for causing carcinogenic effects. Products recommended should be cost-effective, aid energy conservation, reduce life-cycle cost, and possess engineering compatibility with existing materials and products.

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Table 1. Description of Category I Asbestos Products

Typical Use	Generic Name	Asbestos (%)	Dates of Use	Binder/Sizing
Applied Friable Insulating Products	spray-applied insulation	5-95	1940-1970	sodium silicate, portland cement, organic material
Preformed Thermal Insulating Products	Batts, blocks and pipe coverings			
	85% magnesia	15	1926-1949	magnesium carbonate
	calcium silicate	6-8	1949-1971	calcium silicate
Textiles	cloth			
	blue stripe	>80	1920-present	cotton
	red stripe	>90	1920-present	cotton
	green stripe	>95	1920-present	cotton
	sheet	95→50[a]	1920-present	cotton/wool
	cord/rope/yarn	80-100	1920-present	cotton/wool
	tubing	80-85	1920-present	cotton/wool
	tape/strip	90	1920-present	cotton/wool
	curtains (theatre)	60-65	1945-present	cotton
	blankets	100	1910-present	none
	felts	90-95	1920-present	cotton/wool

[a]Arrow indicates a reduction of asbestos content from the original to present formulations.

Table 2. Description of Category II of Nonfriable Matrix-Bonded Composite Products

Typical Use	Generic Name	Asbestos (%)	Dates of Use	Binder/Sizing
Cementitious Products	extrusions	8	1965-1977	portland cement
	panels			
	corrugated	20-45	1930-present	portland cement
	flat	40-50	1930-present	portland cement
	flexible	30-50	1930-present	portland cement
	flexible perforated	30-50	1930-present	portland cement
	laminated (outer surface)	35-50	1930-present	portland cement
	roof tiles	30→20[a]	1930-present	portland cement
	clapboard and shingles			
	clapboard	12-25	1944-1945	portland cement
	siding shingles	12-14	-present	portland cement
	roofing shingles	32→20[a]	-present	portland cement
	pipe	20→15[a]	1935-present	portland cement
Paper Products	corrugated			
	high temperature	>90	1935-present	sodium silicate
	moderate temperature	>70→35[a]	1910-present	starch
	indented	>98	1935-present	cotton & organic binder
	millboard	80-85	1925-present	starch, lime, clay
Roofing Felts	smooth surface	10-15	1910-present	asphalt
	mineral surface	10-15	1910-present	asphalt
	shingles	1	1971-1974	asphalt
	pipeline	10	1920-present	asphalt

(continued)

Table 2. Continued

Typical Use	Generic Name	Asbestos (%)	Dates of Use	Binder/Sizing
Asbestos-Containing Compounds	caulking putties	30	1930-present	linseed oil
	adhesive (cold applied)	5-25	1945-present	asphalt
	joint compound		1945-1975	asphalt
	roofing asphalt	<5	1920-present	asphalt
	mastics	5-25	1920-present	asphalt
	asphalt tile cement	13-25	1959-present	asphalt
	roof putty	10-25	-present	asphalt
	plaster/stucco	2-10	-present	portland cement
	spackles	3-5	1930-1975	starch, casein, synthetic resins
	sealants fire/water	50-55	1935-present	castor oil or polyisobutylene
	cement insulation	20-100	1900-1973	clay
	cement finishing	55	1920-1973	clay
	cement magnesia	15	1926-1950	magnesium carbonate
Asbestos Ebony Products		50	1930-present	portland cement
Flooring Tile and Sheet Goods	vinyl/asbestos tile	21	1950-present	poly(vinylchloride)
	asphalt/asbestos tile	26-33	1920-present	asphalt
	sheet goods/resilient sheet	30	1950-present	dry oils
Wallcovering	vinyl wallpaper	6-8	-present	
Paints and Coatings	roof coating	4-7	1900-present	asphalt
	air tight	15	1940-present	asphalt

[a]Arrow indicates a reduction of asbestos content from the original to present formulations.

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