XXX. NON-ROOFING ADHESIVES, SEALANTS, AND COATINGS

A. Product Description

Asbestos containing non-roofing[1] adhesives, sealants, and coatings are used primarily in the building construction, automobile, and aerospace industries. These products are in most cases specialty products that are manufactured for specific applications.

The construction industry is one of the largest consumers of asbestos containing adhesives, sealants, and coatings. These include:

- Adhesives and cements, generally containing 1 to 5 percent asbestos, manufactured to bond a variety of surfaces such as brick, lumber, mirror, and glass.
- Liquid sealants, containing 1 to 5 percent asbestos, used for waterproofing and sound deadening interior walls.
- Semi-liquid glazing, caulking, and patching compounds, containing 5 to 25 percent asbestos, applied with a caulking gun or putty knife, to seal around glass in windows, joints in metal ducts, and bricks adjacent to other surfaces.
- Asphalt based coatings, containing 5 to 10 percent asbestos, produced to prevent the decay of underground pipes, and corrosion of structural steel in high humidity environments, such as paper mills.

Asbestos is used as a filler because it has a low price, high strength characteristics, fibrous network that prevents sagging in application, and excellent viscosity control (ICF 1986a; Krusell and Cogley 1982).

The automobile industry historically used asbestos in a wide variety of adhesive, sealant, and coating applications. However, the industry has been able to find effective substitutes for most of the general uses, and the remaining uses of asbestos are limited to specialized products such as:

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[1] Since roof coatings and cements account for 90 percent of all asbestos containing adhesives, sealants and coatings compounds in 1985 (ICF 1986a), these products are discussed separately under the Roof Coatings and Cements category in Chapter XXIX (ICF 1986a).

- Epoxy adhesives, containing 5 percent asbestos, used for specialized bonding, such as hood braces.
- Butyl rubber and vinyl sealants containing 2 to 5 percent asbestos, applied over welds for corrosion protection and aesthetic purposes.
- Vehicle undercoatings to prevent corrosion and excessive road noise.

Asbestos content in these compounds provides the necessary viscosity control, corrosion resistance, and sound deadening characteristics (ICF 1986a).

The aerospace industry uses asbestos in extremely specialized applications such as firewall sealants and epoxy adhesives. Asbestos content varies between 5 and 20 percent depending upon use and military specification. The excellent heat resistant characteristics of the fiber make it a useful filler in these high temperature adhesives, sealants, and coatings (ICF 1986a).

Traditional asbestos-containing products such as texture paints[2] and block filler paints[3] no longer contain the fiber. In many cases this is the result of the 1977 Consumer Product Safety Commission ban[4] on consumer patching compounds containing respirable freeform asbestos. Many of the same companies that were manufacturing patching compounds were also producing asbestos containing paints. Faced with the prospect of removing asbestos from one product line, they decided to remove asbestos from all products, as far as feasible, because of the potential liability involved in placing an asbestos containing product in the consumer marketplace (NPCA 1986; ICF 1986a; Krusell and Cogley 1982).

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[2] Texture paints are heavily bodied paints which can be patterned or textured to simulate a stucco surface on interior ceilings and walls for aesthetic design.

[3] Block filler paints are used to coat masonry and other stone surfaces.

[4] Consumer Product Safety Commission. Title 16, Chapter IV, Part 1304. Ban of Consumer Patching Compounds Containing Respirable Freeform Asbestos.

Adhesives, sealants, and coatings are all manufactured by essentially similar processes. There may be one or more production lines, each dedicated to a specific product for the length of time necessary to produce the required inventory of that product. Production is normally a batch process. Bagged asbestos is moved from storage and dumped into a fluffing machine that is used to separate the fibers that may be compressed together. The fibers are then generally transferred to a batch mixing tank and combined with other dry ingredients such as pigments, fillers, and stabilizers. Solvents or resins are added and all the ingredients are mixed until even dispersion is obtained. The batch is then sent to a packaging operation where the mixture may be placed in 5 or 55 gallon metal pails with lids, or in smaller containers and tubes. Batch sizes vary from a few gallons to several thousand gallons depending on the size and number of production lines, the order or inventory size necessary to satisfy projected sales, the type of the product, and the packaging method (ICF 1986a; Krusell and Cogley 1982).

B. Manufacturers of Non-Roofing Adhesives, Sealants, and Coatings

In 1985, 51 companies operating 66 plants nationwide produced approximately 9.6 million gallons[5] of asbestos containing non-roofing adhesives, sealants and coatings. These companies consumed 2,951 tons of fiber (less than 2 percent of the 145,300 tons of total asbestos consumed in 1985 for all product applications).

The percentage of fiber consumed per unit output varied considerably because almost every company manufactured a different product. Table 1

[5] Four of the 51 companies producing asbestos containing non-roofing adhesives, sealants, and coatings in 1985 refused to provide production and fiber consumption data for their 13 plants in operation. Their production volume and fiber consumption have been estimated using the method described in Appendix A and are included in the totals listed above.

Table 1. Production of Asbestos Non-Roofing Compounds

	Tons Fiber Consumed (1985)	Gallons Produced (1985)
Total	2,951.4	9,612,655

Source: ICF 1986a.

lists the tons of fiber consumed and the total gallons produced in 1985 (ICF 1986a).

Non-roofing asbestos containing adhesives, sealants, and coatings production was estimated to be 9.6 million gallons. At an average price of $13.90/gallon, this market is estimated to be worth $133.6 million. While actual prices varied greatly from a low of $1.90 to a high of $3,824, 80 percent of the products were priced at less than $30 per gallon (ICF 1986a).

C. Trends

The number of asbestos-based non-roofing adhesives, sealants, and coatings manufacturers declined steadily from 1981 until 1985. During those four years 28 companies (35 percent), formerly producing asbestos containing compounds, either substituted asbestos with other materials or discontinued their operation. By the end of 1986, 21 of the 51 companies that processed asbestos in 1985 had ceased processing asbestos because of rising insurance premiums, customer pressure to remove asbestos, and the possibility of regulatory action. These companies, while only accounting for 15 percent of output, were some of the largest consumers of asbestos (accounting for 29 percent of fiber consumption in 1985) (ICF 1986a).

D. Substitutes

Asbestos is unique among known raw minerals because it is a chemically inert, durable mineral that can be processed into a fiber. The fibrous quality of this mineral delivers both strength and viscosity control to a liquid or semi-liquid medium. The strong fibrous network and adsorption ability of asbestos binds the mixture together preventing a compound from running or sagging in application. Asbestos also imparts thixotropic[6] properties causing a mixture to gel. No one substitute has been found to simultaneously duplicate the unique characteristics of asbestos. Hence, manufacturers attempting substitution have been forced to replace asbestos with a combination of substitute fibers and fillers. Fibers such as polyolefin, aramid, cellulose, processed mineral, glass, carbon, and phosphate have been used to provide reinforcement and sag resistance. Fillers, such as clay, talc, wollastonite, mica, calcium carbonate (limestone), and silica gels have been used to provide viscosity control.

Since non-roofing mixtures containing asbestos are produced for numerous specialty applications, the current market share of non-asbestos substitutes is unknown. Our attempt to project the market shares in the event of an asbestos ban relies more on informed judgement of industry experts rather than hard numbers. Nevertheless, it is evident from the survey, that the market share of asbestos-free formulations is increasing rapidly as more and more companies replace asbestos in their formulations.

Manufacturers use a trial and error procedure to arrive at an adequate substitute formulation for their product. Hence, it is impossible to project the possible substitute formulations at this stage when industry is still struggling to find adequate substitutes. This analysis attempts to classify the likely substitute formulations by separating them into two categories according to the dominant type of non-asbestos material used:

- fiber mixtures, and
- non-fiber mixtures (ICF 1986a).

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[6] Thixotropy is the property exhibited by certain gels which causes mixture to liquefy when stirred and reharden when left stationary. Asbestos, as a thixotrope, imparts high viscosity at low shear rates helping to maintain mix uniformity during processing, packaging and storage; and low viscosity at high shear rates making application easier.

The description of each substitute mixture is divided into two parts: a description of the substitute fiber(s) or material(s) replacing asbestos (section a), and a description of the actual formulations (and manufacturers) of non-asbestos adhesives, sealants and coatings (section b).

1. Fiber Mixtures

a. Synthetic, Cellulose, and Other Fibers

Synthetic fibers, such as polypropylene and polyethylene, aramid, and polyester fibers have all been used to increase viscosity and lend strength and sag resistance to sealant and coating compounds so that they remain stationary on vertical surfaces and do not melt or run as a result of heat. They are frequently used in conjunction with fillers such as talc and clay in amounts one-tenth that of asbestos (Hercules 1983; DuPont 1986). Hercules and DuPont of Wilmington, Delaware and Minifibers of Johnson City, Tennessee are three of the largest manufacturers of synthetic fibers used by manufacturers of asbestos-free non-roofing adhesives, sealants, and coatings.

Hercules' Pulpex (R) polyolefin pulps are high surface area, short length fibrils that increase viscosity and improve crack and slump resistance in many types of applications (Hercules 1983). Minifibers' Short Stuff (R) fibers are similar high density, highly branched polyethylene fibers that increase viscosity and impart significant crack resistance. Used at levels between 1 and 2 percent, by weight, in conjunction with talc and thickening clays, these fibers are frequently used substitutes for asbestos in various adhesives, sealants, and coatings formulations (Minifibers 1986). DuPont's Kevlar (R) aramid pulp is finding increased usage as an effective replacement for asbestos in a number of different applications. In tire sealants and oil well seals, Kevlar provides the necessary viscosity control at concentrations of about 1 percent. DuPont also indicates that Kevlar(R) pulp has been specified for use in 5 rocket programs with others currently under review (Dupont, 1986).

Cellulose fibers are another popular substitute fiber. These high liquid absorbing fibers, milled from recycled and unused newsprint provide viscosity control, sag resistance, and fiber reinforcement. Cellulose fibers are often used at concentrations of about 3 to 5 percent, in conjunction with thickening clays and talcs (American Fillers & Abrasives 1986). American Fillers & Abrasives of Bangor, Michigan, Custom Fibers International of Los Angeles, and James River Corporation of Hackensack, New Jersey all produce cellulose fibers for asbestos replacement in non-roofing adhesives, sealants, and coatings.

Other fibers such as fiberglass, ceramic, carbon, phosphate and processed mineral have also been used to replace asbestos in products where strength, sag, heat, and fire resistance are needed.

b. <u>Substitute Fibrous Adhesives, Sealants, and Coatings</u>

More than 23 companies currently produce non-asbestos substitutes for their currently or previously produced asbestos containing products using polyolefin, polyester, aramid, cellulose, processed mineral, glass, ceramic, carbon or phosphate fibers.

The major manufacturers of non-roofing compounds that substitute some or all of their asbestos with these fibers are Mameco International, Palmer Products, Pecora, Gibson-Homans, and Flamemaster. Table 2 identifies additional manufacturers of non-asbestos fibered compounds (ICF 1986a).

Mameco International, a manufacturer of specialty caulking compounds, indicated that substituting asbestos has been extremely difficult. None of the substitute fibers both adsorb and absorb the semi-liquid medium used in their formulations. As a result, sagging has occurred after a period of time on hot surfaces. Polyethylene fibers are currently being used in substitute

Table 2. Manufacturers of Substitute Fibered Non-Roofing Compounds

Manufacturer	Location
Bacon Industries Inc. of California	Irvine, California
Chemseco Incorporated	Kansas City, Missouri
Cobitco Incorporated	Denver, Colorado
Dolphin Paint & Chemical Company	Toledo, Ohio
Flamemaster Corporation	Sun Valley, California
Frost Paint & Oil Corporation	Minneapolis, Minnesota
The Garland Company	Cleveland, Ohio
Gibson-Homans Corporation	Ennis, Texas
H.B. Egan Manufacturing Company	Muskogee, Oklahoma
Hercules Incorporated	McGregor, Texas
Industrial Gasket & Shim Company	Meadowlands, Pennsylvania
Intercostal Division	Union City, California
J.C. Dolph Company	Monmouth Junction, NJ
Kent Industries	Fort Worth, Texas
Maintenance Incorporated	Wooster, Massachusetts
Mameco International	Cleveland, Ohio
Palmer Products Corporation	Louisville, Kentucky
Pecora Corporation	Harleysville, PA
Pfizer Incorporated	Easton, Pennsylvania
Products Research & Chemicals Corp.	Glendale, California
Protective Treatments Incorporated	Dayton, Ohio
Russel Standard Corporation	Atlanta, Georgia
Sterling-Clark-Lurton Corp.	Malden, Massachusetts

Source: ICF 1986a.

products which are clearly inferior, according to company officials, but which cost only fractionally more to produce (Mameco International 1986).

Palmer Products hopes to discontinue asbestos processing in 1987. Currently, they produce an asbestos-free formulation of their popular mirror and structural glass adhesive using a combination of Kevlar (R) and cellulose fibers. Company officials report that the asbestos-free formulation costs no more to produce and that consumers could switch completely to the substitute formulation with no loss in performance if the asbestos product were made unavailable (Palmer Products 1986).

Pecora Corporation produces both asbestos and cellulose fibered industrial glazing putties. Currently, the cellulose putties are priced above the asbestos containing products. Pecora indicated that since their substitute product has been on the market for only one year, they are unsure, at this time, whether consumers could completely switch to the asbestos-free formulations if the asbestos product were made unavailable. However, they expect accelerated testing results to reveal a comparable service life for the non-asbestos compounds (Pecora 1986).

Gibson-Homans recently replaced asbestos in their sewer joint compound with a combination of cellulose fibers, kaolin clay, crushed limestone, sodium silicates and water. Company officials indicated that the reformulated compound had no shortcomings in performance and that its introduction did not result in any lost sales. However, company officials indicated that the new formulation costs more to produce. As a result, profit margins have been trimmed to retain the same price charged for the previously produced mixtures containing asbestos (Gibson-Homans 1986).

Flamemaster has replaced 70 percent of their asbestos containing high temperature military coatings in 1985. The coatings are applied to ground support vehicles to shield heat from missile firings. Asbestos has so far been substituted with carbon fibers. The remaining asbestos is expected to be replaced with phosphate fiber pending military specification testing, and clearance (Flamemaster 1986).

Although non-asbestos fibered compounds are rapidly replacing the remaining specialty formulations that still contain asbestos, manufacturers have encountered several difficulties:

- The formulations are difficult to mix and require additional ingredients such as clays and talc.
- The formulations may sag or run in application.
- The formulations lack corrosion and fire resistance requiring additional chemical additives.
- The formulations may dry too quickly because the synthetic fibers do not absorb water.
- The formulations cost from 1 to 42 percent more to product (ICF 1986a).

Regardless of these problems, manufacturers of asbestos containing non-roofing compounds recommend these fibered formulations more than any other substitute material for asbestos containing adhesives, sealants, and coatings (ICF 1986a).

Formulations containing synthetic, cellulose, and other various fibers, in combination with thickening clays and talcs, are estimated to capture 70 percent of the non-roofing adhesives, sealants, and coatings market as a result of an asbestos ban (see Attachment A). Prices would be expected to be 8.9 percent (see Attachment B) higher than the existing price of asbestos containing products. This increase, reflecting added material and production costs, would result in an estimated average price of $15.14 per gallon for the substitutes (ICF 1986a).

2. Clay and Mineral Filler Mixtures

a. Clays, Silica Gels and Other Fillers

While clay, talc, and calcium carbonate are being used in combination with various non-asbestos fibers by manufacturers of asbestos-free non-roofing adhesives, sealants, and coatings, they are also frequently being used on their own. Other similar fillers such as mica, wollastonite, and silica gel are also being used as substitutes for asbestos. Although fillers do not have the strong reinforcing characteristics of the substitute fibers, they can provide adequate viscosity control (ICF 1986a). Clay thickeners, in combination with surfactants,[7] are able to gel formulations when used at levels ranging from 2 to 8 percent by weight (Engelhard n.d.). Engelhard's Attagel (R), and Floridin's Min-U-Gel (R) are two of the most popular attapulgite-derived thickeners used by manufacturers of asbestos-free compounds. Southern Clay Products' Claytone (R) and NL Chemicals' Bentone (R) are derived from bentonite clay and possess similar characteristics to attapulgite-derived thickeners, but cost more. Silica gels, such as Cab-o-Sil (R) fumed silica by Cabot Corporation, are also used by a small number of non-roofing compounds manufacturers. The fumed silica, in concentrations of between 1 and 3 percent, acts predominantly as a thixotropic thickener, although it may be used to provide mild reinforcement to rubber sealants when used at levels greater than 5 percent (Cabot, 1986).

Other mineral thickeners, such as talc, wollastonite, calcium carbonate, and mica, provide adequate bulk and increase viscosity at a low cost to manufacturers of asbestos-free compounds. However, these fillers do not

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[7] Surfactants, such as cationic quarternarium salts, are required to modify the surface charge of a clay thickener, aiding optimal wetting and dispersion of the clay in the medium (Engelhard n.d.).

posses the thixotropic properties of either asbestos, clays, or silica gels, and are consequently unable to gel a formulation.

b. Substitute Non-Fibrous Adhesives, Sealants, and Coatings

At least 18 companies currently produce asbestos-free, non-fibered substitutes to their currently or previously produced asbestos-containing products. The major manufacturers that substitute some or all of their asbestos with clays, silica gels, and mineral thickeners are Contech, Pecora, and Widger Chemical. Table 3 identifies some additional manufacturers using these products to replace asbestos in non-roofing compounds (ICF 1986a).

Contech plans to completely discontinue the use of the fiber in 1986. Asbestos will be replaced with a washed clay that is not yet commercially available. According to Contech, the clay adhesive exhibits slightly better tensile strength for dry lumber applications, but poorer strength for wet lumber. The new formulation only costs a fraction more to produce and will be priced the same as the asbestos-based adhesive (Contech 1986).

Pecora Corporation uses bentonite clay and wollastonite in their asbestos-free caulking and patching compounds. The substitute products, which have been on the market for only one year, cost more than their asbestos-containing counterparts. Company officials indicated that these substitute products, like the substitute fibered putties, are likely to have comparable service lives to asbestos containing products (Pecora 1986).

Companies such as Riverain, Dayton Chemicals, and Hysol Aerospace have used silica gel formulations to replace some or all of their previous asbestos containing specialty compounds. Riverain Corporation currently produces some asbestos-free automotive seam sealants using fumed silica in combination with bentonite clay (Riverain 1986). Dayton Chemicals has completely replaced asbestos in their metal coating with silica in 1986, although the company officials indicated that the product does not perform as well and costs 8

Table 3. Manufacturers of Non-Fibered Substitute Non-Roofing Compounds

Manufacturer	Location
American Abrasive Metals Company	Irvington, New Jersey
Amicon Division, W.R. Grace Inc.	Danvers, Massachusetts
Contech Incorporated	Mattawan, Michigan
Dayton Chemicals Div., Whittaker Corp.	West Alexandria,
Franklin Chemical Industries	Columbus, Ohio
Futura Coatings Incorporated	Hazelwood, Missouri
Hardman Incorporated	Belleview, New Jersey
Hysol Aerospace & Industrial Adhesive Co.	Pittsburgh, California
Parr Incorporated	Cleveland, Ohio
Pecora Corporation	Harleysville, PA
PPG Industries	Adrian, Michigan
Products Research & Chemicals Corp.	Dayton, Ohio
Republic Powdered Metals Inc.	Medina, Ohio
Riverain Corporation	Dayton, Ohio
Rockwell International	Pittsburgh, Pennsylvania
Smooth-On Incorporated	Gillette, New Jersey
S.W. Petro-Chem Incorporated	Olathe, Kansas
Thiem Corporation	Dayton, Ohio
Widger Chemical Corporation	Warren, Michigan

Source: ICF 1986a.

percent more than the previous asbestos formulation (Dayton Chemicals 1986). Hysol Aerospace and Industrial Adhesives Division has substituted asbestos with a proprietary silica formulation in 80 percent of their products. Full substitution is expected in 1987 (Hysol 1986).

Widger Chemical Corporation of Warren, Michigan indicates that customer pressure from General Motors, Ford, and Chrysler has forced substitution of asbestos in all their adhesives, sealants and coatings. They have replaced asbestos with ground mica, ground talc, and dolamitic limestone. Although the final products cost more to produce, the company officials indicated that the switch to the mineral filler formulations did not result in any loss in performance (Widger Chemical 1986).

Non-fibered mixtures containing clays, silica gels, or mineral fillers are estimated to account for 30 percent of the non-roofing compounds market as a result of a ban on asbestos (see Attachment A). The price of these formulations would be expected to be 4.1 percent (see Attachment B) more than the current price of an asbestos containing counterpart. This price increase results in an estimated average price of $14.47 per gallon for non-fibered substitute adhesives, sealants and coatings (ICF 1986a).

E. Summary

Asbestos is unique among known raw minerals because of its strength, fire and heat resistance, viscosity control, and price. Since no across the board substitute fiber can duplicate the many properties of the mineral, the range of different substitute formulations appears endless. Companies use a myriad of substitute materials such as polyethylene, polypropylene, aramid, polyester, glass, ceramic, carbon, and phosphate fibers, and clay, silica gel, talc, wollastonite, mica, and calcium carbonate fillers (ICF 1986a).

The asbestos containing specialty adhesive, sealant, and coating market is extremely diverse. The large number of different applications for these products makes the task of deriving projected market shares for substitute mixtures, resulting from an asbestos ban, almost impossible. Consequently, the estimation of market shares and prices of the substitute formulations relies to a large degree upon educated judgments of industry experts. Table 4 summarizes the findings of this analysis, and presents the data for the Asbestos Regulatory Cost Model.

If asbestos were made unavailable, perhaps 70 percent of the non-roofing adhesives, sealants, and coatings market would be taken by formulations containing substitute fibers (see Attachment A). The average price of these formulations is estimated to be $15.14 per gallon, reflecting an 8.9 percent increase (see Attachment B) above the current average price of asbestos containing products (ICF 1986a). Non-fibered formulations, containing clays, silica gels, and various fillers are estimated to account for the remaining 30 percent of the substitute market (see Attachment A). The average price of these products is estimated to be $14.47, reflecting a 4.1 percent increase (see Attachment B) over the current average price for asbestos containing adhesives, sealants, and coatings (ICF 1986a).

Table 4. Data Inputs for Asbestos Regulatory Cost Model

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life*	Equivalent Price	Market Share	Reference
Asbestos Mixture	9,612,655	0.00031 gals/ton	1.0	$13.90/gal	10 yrs	$13.90/gal	N/A	ICF (1986a)**
Fiber Mixture	N/A	N/A	N/A	$13.10/gal	10 yrs	$15.10/gal	70%	ICF (1986a)**
Non-Fiber Mixture	N/A	N/A	N/A	$14.42/gal	10 yrs	$14.42/gal	30%	ICF (1986a)**

N/A: Not applicable.

* The useful life was estimated to be ten years. However, due to the extreme diversity in products actual values varied greatly.

** See Appendices A and B.

ATTACHMENT A

PROJECTED MARKET SHARES ANALYSIS BASED ON 1985 PRODUCTION OF NON-ROOFING ADHESIVES, SEALANTS, AND COATINGS[a]

Substitute Material	Manufacturer(s)	Production Which Would Likely Switch to Substitute	Projected Market Share (Subtotal/Grant Total x 100)
Synthetic, Cellulose, and Other Fibers	Bacon		
	Bitucote		
	Dolphin		
	Flamemaster		
	Gibson-Homans		
	Hercules		
	Industrial Gasket and Shim		
	Kent		
	Mameco		
	Palmer		
	Pecora[b]		
	Products Research[b]		
	Protective Treatments		
	Royston		
	Sterling Clarke		
	Subtotal 1	2,552,057	70.31%
Clay and Mineral Fillers	American Abrasives		
	Contech		
	Dayton		
	Franklin		
	Futura		
	Hysol		
	Pecora[b]		
	Products Research[b]		
	Riverain		
	Widger		
	Subtotal 2	1,077,783	29.69%
	Grand Total	3,629,840	100.00%

[a]This analysis is based on firms which were willing or able to provide us with information on how they would react to an asbestos ban. It is assumed that all remaining firms (in aggregate) will substitute for asbestos in the same relative proportions.

[b]These companies indicated they use both fibers and fillers as the primary substitute material depending upon the product. For the purpose of this analysis, we have divided their production equally between the two substitutes.

ATTACHMENT B

PROJECTED PRICES ANALYSIS BASED ON AVAILABLE PRICE DIFFERENTIALS BETWEEN ASBESTOS CONTAINING AND NON-ASBESTOS NON-ROOFING ADHESIVES, SEALANTS AND COATINGS

Substitute Material	Manufacturer(s)	Production (1985)	Current or Probable Price Increase[a] (%)	Average Price Increase[b] (%)
Synthetic, Cellulose, and Other Fibers	Cobitco	c		
	Dolphin			
	Gibson-Homans			
	Hercules			
	J.C. Dolph	c		
	Mameco			
	Palmer			
	Sterling-Clarke		—	
	Subtotal 1	1,487,429		8.9%
Clay and Mineral Fillers	American Abrasives			
	Contech			
	Dayton			
	Franklin			
	Futura			
	Republic Powdered Metals	c		
	Widger		—	
	Subtotal 2	930,687		4.1%

[a]Many manufacturers currently price non-asbestos formulations the same as asbestos containing mixtures. For the purpose of this analysis, we have inserted the increased cost of production when necessary.

[b]The average price increase was determined by calculating a weighted average of individual price increases of non-asbestos over asbestos containing roof coatings and cements using 1985 asbestos containing production levels.

[c]When 1985 production quantities were unknown, a value corresponding to the average production of a 1985 plant (according to survey data) was inserted.

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XXXI. ASBESTOS-REINFORCED PLASTICS

A. Product Description

Asbestos-reinforced plastic is typically a mixture of some type of plastic resin (usually phenolic or epoxy), a general filler (often chalk or limestone), and raw asbestos fiber. In general, the raw asbestos fiber is 17 percent of the weight of the plastic.[1] Asbestos-reinforced plastics are used for electro-mechanical parts in the automotive and appliance industries and as high-performance plastics for the aerospace industry. The use of asbestos enhances the thermal and mechanical properties of plastic by improving heat resistance, stiffness, strength, dielectric strength, and processability (ICF 1986a).

In the past asbestos had been used in plastics not only for its unique combination of chemical properties, but also as a general filler or extender of the plastic resin because of its low cost. As the severity of asbestos-related health hazards became known, asbestos was gradually replaced with other fillers such as talc and clay (ICF 1985). Asbestos is now only used in plastics when the presence of the asbestos-imparted reinforcing properties is critical to the performance of the plastic. Such applications include:

- Electro-mechanical parts for the automotive and appliance industries; i.e., commutators, switches, circuit breaker and motor starter casings, terminal boards, thermoplugs, and arc chutes.
- Parts for the aerospace industry; i.e., heat shields and missile casings.

B. Producers and Importers of Asbestos-Reinforced Plastics

Table 1 lists the total production and fiber consumption in this market.

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[1] See Attachment, Item 1.

Table 1. Primary Production of Asbestos-Reinforced Plastic -- 1985

Primary Processors	1985 Production (short tons)	1985 Fiber Consumption (short tons)	Reference
Total	4,835	812.1	ICF 1986a

Six of the eight 1985 primary processors used asbestos to manufacture electro-mechanical plastics and only two processors (Narmco Materials Incorporated and the Raymark Corporation), manufactured asbestos-containing plastics for the aerospace industry (ICF 1986a).

In 1985 there were four secondary processors of asbestos-reinforced plastics, two of which (Ametek and the West Bend Company) imported almost all their plastic from Japan. The secondary processors buy finished asbestos-reinforced plastic parts for assembly, and do not manufacture any asbestos-reinforced plastic themselves. Ametek and the Hoover Company purchase commutators made of asbestos-reinforced plastic that they place in electric motors (Ametek 1986, Hoover 1986). The West Bend Company purchases an asbestos-reinforced plastic thermoplug that is then attached to its kitchen appliances (West Bend 1986). United Technologies purchases an asbestos-reinforced plastic sheet and then places the sheet in missiles to serve as a heat shield (United Technologies 1986). Consumption of fiber and total 1985 imports of product for secondary processors are listed in Table 2 (ICF 1986b).

C. Trends

Asbestos use in plastics is declining as manufacturers move towards non-asbestos compounds. Even though the U.S. production of reinforced plastic has been rising since 1981, the production of asbestos-reinforced plastic has been declining (Table 3). The production of asbestos-reinforced plastic has fallen from 12,187 short tons in 1981, to 4,835 short tons in 1985. This represents a 60 percent decline in four years.[2]

[2] See Attachment, Item 2.

Table 2. Secondary Production of Asbestos-Reinforced Plastic -- 1985

Secondary Processors	Consumption of Asbestos-Reinforced Plastic (short tons)	Quantity of Asbestos-Reinforced Plastic Imported (short tons)	Reference
Total	156.8	127.5	ICF 1986b

Table 3. U.S. Production of Reinforced Plastics and Asbestos-Reinforced Plastics (short tons)

	1981	1985	References
Production of Reinforced Plastic	920,000	1,105,000	Automotive News 1985
Production of Asbestos-Reinforced Plastic	12,187[a]	4,835[b]	ICF 1985, ICF 1986a
Asbestos-Reinforced Plastic as a Percentage of Total Reinforced Plastic	1.3%	0.4%	See Attachment Item 3

[a]1981 production from ICF 1985.

[b]1985 production from ICF 1986a.

Since 1985, three asbestos-reinforced plastic producers, (Meriden Molded Plastics, Inc., Resinoid Engineering Corp., and Rostone Division Allan-Bradley Co.), have stopped using asbestos (Table 1). Celanese Engineering Resins, the largest producer in 1985, plans to stop using asbestos by the second quarter of 1987 (Celanese 1986). The replacement of asbestos in plastics is likely to continue at an increasing rate.

D. Substitutes

While there are many potential substitutes for asbestos in the manufacture of reinforced plastic, the discussion of the substitutes will focus on the six substitutes that would be expected to replace the remaining asbestos-reinforced plastics market in the event of a ban. The six substitutes, listed in order of importance, are fibrous glass, teflon, Product X, porcelain, silica, and carbon. Manufacturers of these substitutes are listed in Table 4. Table 5 lists the advantages, disadvantages and some general remarks about each of the substitutes. The following discussion of each of the substitutes will include the justification of the predicted market shares of the substitutes in the event that asbestos use is banned.

1. Fibrous Glass

Fibrous glass, which is essentially chopped glass, is currently the leading reinforcer of plastic in the United States and industry experts agree that glass-reinforced plastic would capture the largest share of the asbestos-reinforced plastic market in the event that asbestos use is banned. The majority of the asbestos-reinforced plastics produced in the U.S. is used in electro-mechanical applications and fibrous glass has proven to be a good replacement for asbestos in such applications (commutators, circuit breakers, electric motor casings, thermoplugs, and arc chutes.) The glass-reinforced plastics are strong enough to be molded into thin-walled parts and have the required heat resistance and dielectric strength for these products. The main

Table 4. Producers of Substitute Materials

Glass Fibers[a]	Porcelain[b]
Advance Coatings	Relmech Manufacturing (Canada)
Armco Steel Corp.	
Certainteed Corp, Fiber Glass Reinforcements Division	**Cab-O-Sil[b]**
Compounding Technology Inc.	
Durkin Chemicals, Inc.	Cabot Corporation
Fiber Glass Industries, Inc.	
Fibre Glass Development	
GLS Fiberglass Div., Great Lakes Terminal & Transport	**Teflon Fiber[b]**
Kristal Kraft, Inc.	Celanese Engineering Resins
LNP Corp.	
Manville, Filtration and Minerals Div.	
Mead Paper, Specialty Paper Div.	**Product X**
Miles, A.L. Company	
Nicofibers, Inc.	Raymark Corporation
Owens-Corning Fiberglas Corp.	
PPG Industries, Inc., Fiber Glass Div.	
Reichold Chemicals, Inc.	
Techni-Glas, Inc.	
Trevarno Div., Hexcel Corp.	
United Merchants & Mfrs., Inc.	
Wilson-Fiberfil International	
Carbon Fibers[a]	
Avco Specialty	
Compounding Technology Inc.	
Fibre Glass Development	
Great Lakes Carbon Corp.	
Hercules, Inc., Aerospace Div.	
Hi-Tech Composites, Inc.	
Hysol Grafil Co.	
LNP Corp.	
Mead Paper	
Stackpole Corp.	
Trevarno Div., Hexcel Corp	
Union Carbide Corp.	
Wilson-Fiberfil International	

[a]From World Plastics Directory 1986.

[b]From ICF 1986a.

Table 5. Substitutes for Asbestos in Reinforced Plastics
(Listed in Order of Importance)

Substitute	Advantages	Disadvantages	Remarks
Asbestos	Good impact resistance. Fire and heat resistance. Low shrinkage and warpage. Ease of handling during processing.	Environmental and occupational problems.	Specialty uses only. Phased out in general purpose uses.
Fibrous Glass	Light weight. Can be used in thin-walled parts. Good heat resistance.	May require some processing changes. Processing equipment wears more quickly.	Has been used for many years. Well-suited for use in commutators, flat-iron skirts, motor housings, transmission components.
Teflon Fiber	Good dielectric strength. Good impact resistance.	Poor wear resistance. High price. Can only be used in low temperature ranges (below 500°F).	Celanese plans to use in electro-mechanical applications.
Porcelain	Temperature use to 1800°F.	Brittle. High price.	This is the only non-plastic substitute cited for asbestos-reinforced plastic. Used to make high temperature (1500-1800°F) arc chutes.
Fumed Silica Powder	Good dielectric strength.	Poor processing characteristics. More expensive.	Used with epoxy resins. Trade name Cab-O-Sil.
Carbon Fiber	Light weight. High strength. High chemical resistance. Good heat resistance.	Very high price. Conducts electricity.	Used in aircraft parts, sporting goods, textile machine parts. Used in molding compounds.

Source: ICF 1986a.

disadvantages of fibrous glass as an asbestos substitute are that it is not as heat resistant as asbestos and it is more difficult to process because of its abrasive characteristics. Because of its lower heat resistance, fibrous glass is unable to replace asbestos in any of the aerospace applications still using asbestos reinforced-plastics (missile casings and heat shields) or in the switchgears of power plants that require high temperature (1500-1800°F) electro-mechanical plastics (ICF 1986a).

Resinoid Engineering Corporation and the Rostone Division of the Allan-Bradley Company now use fibrous glass in the manufacture of electro-mechanical plastics for the automotive and appliance industries (Resinoid 1986, Rostone 1986). Meriden Molded Plastics Incorporated stated that 70 percent of its 1985 asbestos- reinforced plastics have been replaced with glass-reinforced plastics. Rogers Corporation, the second largest asbestos-reinforced plastic processor, plans to eventually replace all asbestos with fibrous glass in electro-mechanical plastics (Rogers 1986). Based on these substitutions, the predicted share that glass-reinforced plastic will gain of the 1985 asbestos-reinforced plastic market is over 40 percent.[3]

2. Teflon

The second most important substitute is teflon. Teflon's chemical resistance, dielectric strength, heat resistance, and impact resistance make it an adequate replacement for asbestos in relatively low temperature (below 500°F) electro-mechanical applications. The largest asbestos-reinforced plastic processor, Celanese Engineering Resins, plans to use Teflon K-10 (teflon powder) to reinforce its electro-mechanical plastics. Celanese has cited the high cost of the teflon powder ($8.00/lb.) as a disadvantage,

[3] See Attachment, Item 4.

although the planned sale price of the teflon-based plastic ($2.25/lb) is the same as the company's asbestos- reinforced plastic. Celanese has stated that it plans to replace all its asbestos with teflon by 1987 (Celanese 1986).

3. Porcelain

Porcelain, the only non-plastic substitute for asbestos-reinforced plastics, is an effective substitute for extremely high temperature electro-mechanical applications. Porcelain, which is a high-quality ceramic, can withstand temperatures up to 1800°F and also has high dielectric strength. These characteristics enable it to be used in the extremely high temperature arc chutes (high-temperature arc chutes guide the electric current in large electric motors or generators used in power plants). The main disadvantages of porcelain are that it is difficult to mold and it costs about 50-60 percent more than asbestos-reinforced plastics (Relmech 1986).

High-temperature arc chutes accounted for about 30 percent of Meriden Molded Plastics' asbestos product market and the company was unable to find an effective substitute for that portion of its market. However, Meriden Molded Plastic sold its plastics operations to Relmech Manufacturing in 1986 and Relmech Manufacturing has stated that porcelain has already replaced some of Meriden's high-temperature arc chute market and could replace all asbestos in these arc chutes (Relmech 1986). Porcelain is expected to capture less than 5 percent of the market in the event of a ban. (Meriden 1986).

4. Fumed Silica Powder

The fourth substitute to be discussed is Cab-O-Sil(R), a fumed silica powder. One processor, Magnolia Plastics Incorporated, cited the product as a substitute for asbestos in reinforced plastic used in electro-mechanical applications. While Magnolia Plastics Incorporated stated that the Cab-O-Sil(R) could replace 100 percent of their asbestos-reinforced plastic, the company cited some disadvantages of the substitute, such as its high cost and poor processing characteristics. The silica-containing plastic exhibits lower viscosity during manufacturing than the asbestos mixture.[4] The only advantage Magnolia cited was that the Cab-O-Sil(R) is not a health hazard. Total replacement of Magnolia's market gives Cab-O-Sil(R) less than 5 percent of the market (ICF 1986a).

5. Carbon

Carbon (usually a graphite fiber) is very strong, extremely heat resistant, and chemically inert. These properties make carbon-reinforced plastics well-suited for use as missile casings and heat shields, the only remaining asbestos-reinforced plastic products in the aerospace industry. The two major disadvantages of carbon are its cost and its low dielectric strength. Carbon fibers can cost more than 100 times as much as asbestos fiber, effectively restricting the use of carbon-reinforced plastic to high performance applications (Narmco 1986). In addition, because of carbon's low dielectric strength, carbon-reinforced plastics are generally not used to make electro-mechanical parts (ICF 1986a). One 1985 processor, Narmco Materials Inc., has substituted carbon for asbestos in some of its plastic.

The substitute plastic is used to make missile casings and costs only 25 percent more than the asbestos-reinforced plastic that it is replacing (Narmco 1986). Even though carbon fibers are much more expensive than asbestos fibers, the cost difference is mitigated by the fact that reinforcing fibers are usually a small part of the cost of aerospace plastics and they are required in smaller amounts for providing the same kind of reinforcement as asbestos fibers. The company has stated that the only reason that it has not switched completely to carbon-reinforced plastic is that the DOD

[4] Viscosity is a measure of the fluidity of a substance. Reinforced plastics are manufactured by injecting fluid plastic into a pressure mold. The lower viscosity imparted by Cab-O-Sil(R) makes the setting of the mold more difficult.

specifications for the missile casing require the use of asbestos. Replacement of Narmco's market would give carbon-reinforced plastic less than 5 percent of the market (Narmco 1986).

Raymark Corporation, the other producer of asbestos-reinforced plastics used in aerospace, did not specify which substitute could replace asbestos in its plastics. The company did, however, state that it has a potential substitute (Product X) under development and estimated that the cost of plastic made with this substitute would be 100 percent higher than the cost of Raymark's asbestos-reinforced plastic. The Raymark Corporation's asbestos-reinforced plastic product is a heat-shield used in aerospace applications and the company would not release further information about substitutes or product applications because Product X is part of a military contract (Raymark 1986).

Table 6 lists the data inputs to the asbestos regulatory cost model, including substitute prices and projected market shares as well as information concerning the asbestos-reinforced plastic.

E. Summary

Asbestos has been replaced as a general filler of plastic, but asbestos is still used in plastic when the presence of the asbestos imparted reinforcing properties is critical to the performance of the plastic. Asbestos-reinforced plastics are now only used for electro-mechanical parts in the automotive and appliance industries and as high-performance plastics for the aerospace industry. In 1985 there were eight primary processors, four secondary processors and two importers of asbestos-reinforced plastic in the United States. Since 1985, three of the primary processors and one of the secondary processors have stopped processing asbestos. The replacement of asbestos in plastics is likely to continue at an increasing rate. The six substitutes expected to replace the remaining asbestos-reinforced plastics market in the event of a ban (listed in order of importance) are: fibrous glass, teflon, Product X, porcelain, silica and carbon.

Table 6. Data Inputs for Asbestos Regulatory Cost Model
(031) Asbestos-Reinforced Plastic

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life[g]	Equivalent Price	Market Share	Reference
Asbestos-Reinforced Plastic	4,835 tons	0.17 lbs./ton[a]	1.03[b]	$2.63/lb.[c]	1 year	$2.63/lb.	N/A	ICF 1986a
Glass-Reinforced Plastic	N/A	N/A	N/A	$1.40/lb.[d]	1 year	$1.40/lb.	47.9%	ICF 1986a
Teflon-Reinforced Plastic	N/A	N/A	N/A	$2.25/lb.	1 year	$2.25/lb.	42.5%	Celanese 1986
Product X	N/A	N/A	N/A	$11.22/lb.[e]	1 year	$11.22/lb.	7.4%	Raymark 1986
Porcelain	N/A	N/A	N/A	$4.08/lb.[f]	1 year	$4.08/lb.	1.4%	Relmech 1986
Silica-Reinforced Plastic	N/A	N/A	N/A	$3.00/lb.	1 year	$3.00/lb.	0.5%	Magnolia 1986
Carbon-Reinforced Plastic	N/A	N/A	N/A	$47.25/lb.	1 year	$47.25/lb.	0.3%	Narmco 1986

N/A: Not Applicable.

[a]See Attachment, Item 1.

[b]See Attachment, Item 8.

[c]See Attachment, Item 5.

[d]See Attachment, Item 6.

[e]See Attachment, Item 10.

[f]See Attachment, Item 7.

[g]See Attachment, Item 9.

ATTACHMENT

1. Calculation of Product Asbestos Coefficient. A weighted average (using market shares as weight) of the product coefficient by company yielded an average of 0.1678 lbs./lb. or about 0.17 lbs./lb.

Company	(A) Product Asbestos Coefficient, by Company (lbs. of Asbestos/lbs. of Plastic)[a]	(B) Market Share 1985	Weighted Product Coefficient, (A) x (B)/100
Celanese Engineering Resins	0.027		
Magnolia Plastics Inc.	0.030		
Meriden Molded Plastics Inc.	0.390		
Narmco Materials Inc.	0.020		
Raymark Corporation	0.600		
Resinoid Engineering Corp.	0.350		
Rogers Corporation	0.185		
Rostone Division Allan-Bradley	0.150		
		Total:	0.1678 lbs./lb.

[a]From ICF 1986a.

2. Percentage Decrease in Asbestos-Reinforced Plastics Production from 1981 to 1985.

(/1985 Production - 1981 Production//1981 Production) x 100
= Percentage Change '81-'85.
(/4,835 - 12,187//12,187) x 100 = -60%.

3. Asbestos-Reinforced Plastic Production as a Percentage of Total Reinforced Plastic Production. (From Table 3.)

1981. (12,187/920,000) x 100 = 1.3
1985. (4,835/1,105,000) x 100 = .4

4. Projected Market Share of Fibrous Glass.

Combined market shares of Resinoid Engineering Corp., Rogers Corporation, Rostone and 70 percent of Meriden's share:

5. Price of Asbestos-Reinforced Plastic.

Company	(A) Price of Asbestos-Reinforced Plastic[a]	(B) Market Share 1985	Weighted Price (A) x (B)/100
Celanese			
Magnolia			
Meriden			
Narmco			
Raymark			
Resinoid			
Rogers			
Rostone			
	Weighted Average Price		2.630/lb.

[a]From ICF 1986a.

6. Price of Glass-Reinforced Plastic.

The largest primary processor that is using glass-reinforced plastic as a substitute for asbestos-reinforced plastic is the Rogers Corporation. The average price of their most important substitute glass-reinforced plastic is was used in the analysis.

7. Price of Porcelain.

Relmech Manufacturing stated that, on average, porcelain cost about 50-60 percent more than asbestos-reinforced plastic.

8. Consumption/Production Ratio.

Domestic production of asbestos-reinforced plastic in 1985 was 4,835 short tons (see Table 1). 1985 imports of asbestos-reinforced plastic totaled 127.5 tons (see Table 3).

Consumption = Production + Imports
4,962.5 = 4,835 + 127.5

Consumption/Production = 4,962.5/4,835 = 1.03

9. Useful Life of Products.

Useful life of asbestos-reinforced plastic from ICF (1984a). Respondents to survey stated that substitute products had the same expected service life as asbestos-reinforced plastic.

10. Price of Product X.

Raymark Corporation reported that it has a potential substitute under development as part of a defense contract. Raymark did not release the name of this product and ICF has referred to the substitute as Product X. Raymark provided ICF with the relative price of Product X and their asbestos product.

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XXXII. MISSILE LINER

A. Product Description

Missile liner is a rubber compound which is used to coat the interior of "rocket motors". Because a rocket is propelled purely by the burning of rocket fuel, it has no observable engine. Therefore, the term rocket motor refers to the entire chamber which the fuel occupies as it is being burned. Rockets and rocket boosters are used to propel a number of objects including military weapons and the space shuttle (ICF 1986).

The missile liner's main function is to insulate the outer casing of the rocket from the intense heat being generated in the rocket motor while the rocket fuel is being burned. This is where the need for asbestos arises. Asbestos is mixed into the rubber liner because of its excellent heat and fire resistance properties. In addition, the excellent thixotropic[1] characteristics of asbestos fiber facilitate the processing of the liner (ICF 1986).

B. Producers and Importers of Missile Liner

There are currently five companies which process asbestos for use in missile liner. A complete list of the six plants these companies operate is presented in Table 1.

These companies consumed approximately 700 tons of asbestos in 1985 in producing 4,667 tons of missile liner (ICF 1986).[2] The cost of this liner was not revealed by any of the companies either because it was considered proprietary or because it was considered classified military information.

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[1] Thixotropic characteristics refer to a gel's ability to liquefy when stirred or shaken and to harden when left stationary.

[2] See Attachment for explanation of calculations. These totals include estimated values for the Koch Asphalt Company because they refused to respond to our survey. In 1981, this plant (which was owned by Allied Corporation) produced insulation material. It is not clear whether that insulation material was missile liner or some other type of insulation, but we have decided to include it here because all other types of insulation are no longer made using asbestos.

Table 1. Producers of Asbestos Missile Liner

Company	Location
Aerojet Liquid Rocket Company	Sacramento, CA
Hercules, Incorporated	McGregor, TX
Kirkhill Rubber Company	Brea, CA
Koch Asphalt Company	Stroud, OK
Morton Thiokol Corporation	Elkton, MD Brigham City, UT

Furthermore, it is not clear that prices would have any meaning in this context because they would likely be arbitrary internal transfer prices rather than market generated prices. A company which now produces only a substitute liner revealed that its price of asbestos liner was $7.00/lb. in 1985 (Uniroyal 1986).

No importers of this asbestos product were identified (ICF 1984, ICF 1986). Because this product is used extensively in military applications it is likely that it is all produced domestically.

C. Trends

1981 production of asbestos missile liner was 4,006 tons (TSCA 1982), and 1985 production is estimated to have been 4,667 tons. This suggests that missile liner production increased by approximately 16 percent. However, there is considerable uncertainty associated with the 1985 figure. First of all, the largest processor, accounting for approximately 75 percent of 1981 production, refused to respond to our survey. Thus, we were forced to estimate this company's production. Second, most respondents did not tell us how much liner they produced. They only told us how much asbestos they consumed. Hence, production is estimated based on product coefficients that range from 5 percent to 30 percent. Nonetheless, it seems fair to say that production of missile liner probably remained constant or increased slightly, but it probably did not decline appreciably.

D. Substitutes

There are currently two substitutes for asbestos in missile liner. They are Kevlar(R) and ceramic fibers. The Kevlar(R) liner is produced by Uniroyal, Inc. and by Hercules, Inc., while the ceramic fiber liner is produced by Olin Corp. Although these substitute liners are more expensive than asbestos liner, industry experts believe that they can completely replace asbestos use in this product if EPA decides to ban asbestos. They also note that the cost of the liner will be an extremely small portion of the total cost of the final product.

The projected market shares for the substitute liners were computed by looking at past production of liner and taking prices into consideration. The data inputs for the Regulatory Cost Model are presented in Table 2.

Substitution away from asbestos has been limited because government specifications stipulate that missile liners must be made with asbestos. Exemptions can be obtained by having the substitute pass a series of tests which guarantee that it will perform as well as the asbestos product. The process of developing a substitute mixture and having it pass these tests is very expensive. As a result, some companies have decided to continue producing the asbestos product even though substitutes are available.

The substitution that has occurred has taken place for one of two reasons. First, the company may have decided that it wished to avoid any potential future liabilities associated with asbestos usage. As a result, it would incur the costs of switching to a substitute. Alternatively, if a company is developing a new missile, it is free to design the liner in any way it sees fit as long as it functions properly and passes all the appropriate tests. In this case, substituting for asbestos is not very costly.

E. Summary

Asbestos is used to produce a rubber product which lines the interior of "rocket motors". There are currently five producers of asbestos missile liner, and their output is estimated to be 4,667 tons. This estimate is, however, subject to uncertainty because some producers were unable to provide us with all the necessary data because they felt the information may have been classified. No importers of this product were identified.

Companies that have already formulated asbestos-free mixtures believe that complete substitution can take place. They note that the primary obstacle to

Table 2. Data Inputs for Asbestos Regulatory Cost Model

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price[a]	Useful Life	Equivalent Price	Market Share	Reference
Asbestos Liner	4,667 tons	0.15 tons/ton[b]	1.0	$14,000/ton	1 use	$14,000/ton	N/A	ICF 1986
Kevlar(R) Liner	N/A	N/A	N/A	$29,000/ton[b]	1 use	$29,000/ton[b]	60%	ICF 1986
Ceramic Fiber Liner	N/A	N/A	N/A	$140,000/ton	1 use	$140,000/ton	20%	Olin 1986

N/A: Not Applicable.

[a]Prices in the text are given on a per pound basis, but they have been converted to prices per ton for use in the ARCM.

[b]See Attachment for explanations.

eliminating asbestos is government contracts that mandate the use of asbestos. Based on the opinions of industry experts, liners containing Kevlar(R) fiber are projected to capture 80 percent of the market at a price of $14.50/lb., while liners containing ceramic fiber are projected to capture 20 percent of the market at a price of $70.00/lb.

ATTACHMENT

The four companies that responded to our survey indicated that they consumed 151.2 tons of asbestos fiber in 1985, but three of them did not tell us how much missile liner they produced. The only company still producing missile liner that also reported its missile liner production was Morton Thiokol Corp. However, two companies which are no longer producing asbestos missile liner, B.F. Goodrich, Inc. and Uniroyal Corp., did supply us with their past ratios of fiber consumption to missile liner output. We found these values to be considerably different than Morton Thiokol's value. As a result, we computed a simple average of the three available ratios for use in our analysis. The information is summarized in Table A-1.

Once we had the value of the consumption-output ratio (0.15) and the amount of asbestos fiber consumed by the respondents, we were able to compute 1985 asbestos missile liner output for these four companies. As noted earlier, Koch Asphalt refused to respond to our survey. Because insulation material is a separate Bureau of Mines (BOM) asbestos fiber consumption category, we decided to use the total for the four companies to estimate Koch Asphalt's consumption by subtracting the consumption of the four respondents from 700 (the BOM estimate for total consumption in this category). This results in an estimate of fiber consumption for Koch Asphalt. If we then divide fiber consumption by the consumption-output ratio, we compute an estimate of output.

The price of the Kevlar(R) linear was computed by averaging the prices of the two liners. The average of Hercules, Inc.'s liner and Uniroyal, Inc.'s liner is $14.50/lb. A weighted average could not be computed because we did not have production data for either company.

Table A-1. Consumption-Output Ratio in Asbestos Missile Liner

	Ratio	Reference
Average	15%	ICF 1986

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XXXIII. EXTRUDED SEALANT TAPE

A. Product Description

Sealant tape is made from a semi-liquid mixture of butyl rubber and asbestos (usually 80 percent butyl rubber and 20 percent asbestos by weight) that is contained in 55-gallon metal drums (Tremco 1986). On exposure to air, the sealant solidifies forming a rubber tape, that is typically about an inch wide and about an eighth of an inch thick. The product usually is sold to customers in linear feet. The tape acts as a gasket for sealing building windows, automotive windshields, and mobile home windows. It is also used in the manufacture of parts for the aerospace industry and in the manufacture of insulated glass. Asbestos is used in the tape for its strength, heat resistance, and dimensional stability (ICF 1986a).

B. Producers and Importers of Extruded Sealant Tape

In 1985 there were four processors with five plants nationwide that manufactured the tape. The four primary processors consumed 1,660.2 tons of asbestos fiber in 1985, which is 1.1 percent of total domestic asbestos fiber consumption for all product categories.[1] Table 1 shows the total fiber consumption and output for this product in 1985. There are no known importers of the tape (ICF 1986a, ICF 1986b).

C. Trends

Despite a drop in the number of processors from seven to four, the production of sealant tape increased 22.5 percent between 1981 and 1985, while fiber consumption in sealant tape increased only about 9.5 percent.[2] The

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[1] See Attachment, Item 1.

[2] 1981 figures from Parr Inc., one of the two firms (the other is Concrete Sealants Inc.) that have ceased production of asbestos sealant tapes, are not available, resulting in the percentage increase in production volumes and fiber consumption for 1985 to be slightly overstated. See Attachment, Item 2, for calculations.

Table 1. Primary Production of Extruded Sealant Tape -- 1985

Primary Production	Production (feet)	Fiber Consumed (short tons)	Reference
Total	423,048,539	1,660.2	ICF 1986a

difference in the growth rates between production volumes and fiber consumption can be explained by the fact that one of the processors that stopped using asbestos, Concrete Sealants Inc., manufactured a relatively high asbestos content tape in 1981 (Concrete 1986).

Industry experts expect a significant decline in the asbestos extruded sealant tape market over the next several years due to the development of cost effective substitutes, particulary in the area of automotive applications. (MB Associates 1986, Essex 1986). Table 2 illustrates the market trends of extruded sealant tape.

D. Substitutes

Effective non-asbestos substitutes for almost all the applications of asbestos sealant tape are available. The substitutes include cellulose-tape (butyl rubber containing cellulose fibers), structural urethane, carbon-based tape (butyl rubber containing carbon black), and non-curing tape (butyl rubber with calcium carbonate filler). The four substitutes, their manufacturers, relative advantages and disadvantages, and their potential market shares are listed in Table 3. The following discussion of the substitutes will include a justification of the predicted market shares for each of the substitutes in the event that asbestos use is banned.

1. Cellulose Tape

The most important substitute is cellulose tape. It would capture the largest share of the asbestos sealant tape market if asbestos were to be banned. Cellulose tapes are used to seal building windows, automobile windshields in the after-market (cellulose tapes are usually unable to meet the Original Equipment Market (OEM) safety specifications), and to seal windows in mobile homes and recreational vehicles. Cellulose tapes are not as strong or as heat resistant as asbestos sealant tapes and as a result they generally have shorter service life (15 yrs.) than an asbestos tape (20 yrs.)

Table 2. Market Trends of Extruded Sealant Tape, 1981-1985

	Production of Tape (feet)	Consumption of Fiber (short tons)	Reference
1981	345,480,853	1,516.0	ICF 1986a[a]
1985	423,048,539	1,660.2	ICF 1986a

[a]See Attachment, Item 1.

Table 3. Substitutes for Asbestos Sealant Tape

Product	Manufacturer(s)	Price (f.o.b.)	Potential Market Share	Advantages	Disadvantages	Remarks	Reference
Asbestos-Sealant Tape	See Table 1	a	N/A	Strength (sheer strength 50 psi). Dielectric strength. Heat resistance.	Health hazards. Liability costs.	Market expected to decline.	ICF 1986a
Structural Urethane	Essex Specialty Products			Less expensive. No health hazard. Stronger than asbestos tapes (sheer strength 700-800 psi).		Essex is only producer of structural urethane. This product has captured 90 percent of OEM market of automobile windshields; PTI confirmed product as potential substitute.	Essex 1986, PTI 1986
Cellulose-Fiber Tape	Concrete Sealants Inc. Parr Inc. Tremco Inc.			Less expensive. No health hazard.	Not as strong. Not as heat resistant. Shorter service life.	Parr markets product for sealing windows on mobile homes and RVS. Tremco and concrete market product to seal windows.	Parr 1986 Tremco 1986
Carbon-Based Tape (Non-Asbestos Swiggle Tape(R))	Tremco Inc.			No health hazard.	Increased cost.	Product under development. Asbestos is replaced with carbon black (soot).	Tremco 1986
Non-Curing Tape	Fiber-Resin Corp.			No health hazard. Longer shelf life.	Not as heat resistant. Unable to replace 20 percent of fiber-resin's asbestos-tape applications.	Tape is composed of butyl rubber with calcium carbonate filler. Tape is used to manufacture aerospace parts.	Fiber-Resin 1986

(Tremco 1986). However, they are generally cost-competitive with asbestos tapes and have an added advantage in not being considered hazardous (ICF 1986a).

Three producers of cellulose tapes have been identified in the survey, two former processors of asbestos, Concrete Sealants Inc. and Parr Inc., and one current processor, Tremco Inc. Concrete Sealants and Tremco market cellulose tapes that are used to seal glass in the large metal frames of building windows. Tremco's cellulose tape is also used to seal automobile windshields (after-market only). Parr Inc., which has stopped processing asbestos, produces a cellulose-tape that is used to seal windows on mobile homes and recreational vehicles (ICF 1986a).

Two current processors of asbestos have cited cellulose tape as a potential substitute for their asbestos sealant tape markets. Tremco has stated that its cellulose tape could replace the entire market of the asbestos sealant tape produced at Tremco's Kentucky plant for the sealing of windows and windshields (Tremco 1986). Elixir Industries, which produces an asbestos tape for sealing windows on mobile homes and recreational vehicles, stated that cellulose tape could replace its entire asbestos tape market, although Elixir cited the poorer performance of the cellulose tapes as a disadvantage (Elixir 1986). If the expected substitutions were to occur at Elixir and Tremco, cellulose tapes would gain a majority market share of the existing asbestos sealant tape market.

2. Structural Urethane

Structural urethane, produced by Essex Specialty Products, would capture the second largest share of the asbestos sealant tape market if asbestos was banned. Structural urethane is mainly used to seal automobile windshields and has the largest share of the market for windshield sealers (90 percent of the domestic OEM market and 60 percent of the after-market of windshield sealers.) (Essex 1986). Essex expects the market share of the structural urethane to increase and considers structural urethane as capable of replacing 100 percent of the windshield sealer market. In terms of service life, structural urethane's expected 20 years of service is the same as the expected service life of an asbestos tape. Structural urethane's main advantages over the other sealers are its strength (sheer strength is 700-800 psi, compared to about 50 psi for asbestos tapes), and lower costs (Essex 1986, Protective Treatments Inc. 1986).

Protective Treatments Inc. markets the most popular asbestos sealant tape and has confirmed that its entire market could be replaced by the structural urethane. Even without an asbestos ban, Protective Treatments Inc. anticipates a decline in the demand for their sealant tape in both the OEM and after-market of windshield sealers. If structural urethane were to replace asbestos, 100 percent of Protective Treatment's market would be captured by the structural urethane (Protective Treatments Inc. 1986).

3. Carbon-based Tape

At its Columbus, Ohio plant, Tremco Incorporated manufactures an asbestos containing tape called Swiggle Tape(R), a product that has revolutionized the manufacture of insulated glass.[3] The asbestos in Swiggle Tape(R) provides thermal stability and Tremco is developing a substitute Swiggle Tape(R) that contains carbon black in place of asbestos. The anticipated cost of the carbon-based Swiggle Tape(R) is 39 percent higher than the current price of the asbestos Swiggle Tape(R), however, Tremco does not foresee any major obstacles to complete replacement of asbestos in its Swiggle

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[3] Swiggle Tape(R) allows the production of insulated glass to be a one-step process of inserting the tape between two sheets of glass. The older method was a multi-stepped, labor intensive process of lining each side of glass with separate pieces of aluminum and then applying several layers of adhesives before adding a second glass sheet.

Tape(R). Total substitution of Tremco's asbestos Swiggle Tape(R) market would give the carbon-based tape a market share of less than 10 percent (Tremco 1986).

4. Non-Curing Tape

The fourth substitute, the non-curing tape, which is butyl rubber with calcium carbonate as a filler, is manufactured by the smallest asbestos sealant tape processor, Fiber-Resin Corp. The non-curing tape is used in the manufacture of plastic parts for the aerospace industry. When setting a plastic mold, a vacuum is created to force the plastic around the mold and the non-curing tape is used to seal the mold and maintain a vacuum. As the name implies, the non-curing tape is not used when the molds have to be heated. The potential market share of the non-curing tape is less than 5 percent of the market (Fiber-Resin 1986).

The salient features of the available substitutes for asbestos sealant tapes and their potential market shares in the event of an asbestos ban are presented below. Cellulose tapes would gain a 56.3 percent market share, replacing the asbestos sealant tapes produced by Elixir Industries and the asbestos tape produced at Tremco's Kentucky plant. Structural urethane would replace Protective Treatment's entire market. Tremco Incorporated is developing a carbon-containing version of its Swiggle Tape (R) that would capture less than 10 percent of the market if asbestos is banned. The non-curing tape would replace 80 percent of Fiber-Resin's market. The market substitutions are presented in Table 3. The data inputs for the model are presented in Table 4.

E. Summary

Sealant tape is made from a semi-liquid mixture of butyl-rubber and asbestos and is used for sealing building windows, automotive windshields, and mobile home windows. The tape is also used in the manufacture of parts for

Table 4. Data Inputs for Asbestos Regulatory Cost Model
(033) Sealant Tape

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	References
Asbestos Tape	423,048,539 ft.[a]	0.0000039 tons/ft.[b]	1	$0.07/ft.[c]	20 years	$0.07/ft.	N/A	ICF 1986a
Cellulose Tape	N/A	N/A	N/A	$0.05/ft.[d]	15 years	$0.06/ft.[f]	56.4%	ICF 1986a, Parr 1986
Structural Urethane	N/A	N/A	N/A	$0.07/ft.	20 years	$0.07/ft.	36.8%	ICF 1986a, Essex 1986
Carbon-Based Tape	N/A	N/A	N/A	$0.32/ft.	20 years	$0.32/ft.	6.6%	Tremco 1986
Non-Curing Tape	N/A	N/A	N/A	$0.10/ft.	N/A[e]	$0.10/ft.	0.2%	Fiber-Resin 1986

N/A: Not Applicable.

[a]See Attachment Item 7.

[b]See Attachment Item 4.

[c]See Attachment Item 3.

[d]See Attachment Item 5.

[e]Fiber-Resin's asbestos tape is used in a manufacturing process that takes minutes to complete and once complete the tape is discarded.

[f]See Attachment Item 6.

[g]Due to rounding error, the actual total of the market shares was 99.9 percent. To adjust for the rounding error, 0.1 percent was added to the cellulose tape market share.

the aerospace industry and in the manufacture of insulated glass. In 1985 there were four processors with five plants nationwide that manufactured the tape. There are no known importers of the tape. Although the production of the asbestos sealant tape increased 22.5 percent between 1981 and 1985, industry experts expect a significant erosion of the asbestos extruded sealant tape market over the next several years due to the development of cost-effective substitutes, particularly in the area of automotive applications. Effective non-asbestos substitutes for almost all the applications of asbestos sealant tape are available. The substitutes include cellulose-tape, structural urethane, carbon-based tape and non-curing tape.

ATTACHMENT

1. Fiber Consumption In Production of Asbestos Sealant Tapes as Percentage of Total Asbestos Fiber Consumed.

   According to ICF survey data, 145,123.3 short tons of asbestos fiber were consumed in the United States in 1985. A total of 1,660.2 tons were consumed in the production of sealant tapes in 1985. The percentage of sealant fiber consumption in 1985 is (1,660.2/145,123.3) x 100 = 1.1 percent.

2. 1981 Fiber Consumption and Sealant Tape Production.

1981	Fiber Consumption (short tons)	Production (feet)	Reference
Total	1,516	345,480,853	ICF 1986a

From the above 1981 data, two calculations were performed:

(a) Percentage change in production volume between 1981 and 1985 = (/1985 production - 1981 production//1981 production) x 100 = (/423,048,539 - 345,480,853//345,480,853) x 100 = 22.5 percent

(b) Percentage change in fiber consumption between 1981 and 1985 = (/1985 consumption - 1981 consumption//1981 consumption) x 100 = (/1660-1516//1516) x 100 = 9.5 percent

3. Calculation Of Average Price Of Asbestos Sealant Tape.

Company	Price of Asbestos Tape[a]
Average Price	$0.07/ft.

[a]From ICF 1986a.

The average price was calculated as a weighted average using the market share of each separately priced asbestos tape as the weight:

4. Calculation of the Product Asbestos Coefficient.

Company	Product Asbestos Coefficient[a]
Coefficient	0.009 lbs./ft.

[a]From ICF 1986a.

The product asbestos coefficient was calculated as a weighted average using the market share of each asbestos tape as the weight.

5. Calculation of Price of Cellulose Tape.

Two processors identified cellulose tape as a potential substitute. Tremco stated that the cellulose tape that it produces could replace 100 percent of the market of its Kentucky plant. Elixir Industries stated that a cellulose tape could replace their entire asbestos sealant tape market and it is assumed that the cellulose tape produced by Parr (used for the same applications as Elixir's tape) is a good estimate of the price of any potential replacement at Elixir.

The combined output of Elixir's plant and Tremco's Kentucky plant represents 100 percent of the expected share cellulose tapes would gain of the existing asbestos tape market. The total production replaced by cellulose tapes is the sum of Elixir's and Tremco's 1985 production. The average price of the cellulose tape can be calculated by taking a weighted average (using cellulose tape market shares as a weight) of the prices of the two substitute tapes.

6. Calculation of Equivalent Price of Cellulose Tape.

The equivalent prices were calculated using a present value formula assuming a 5 percent real interest rate. The equivalent price of cellulose tape was calculated to be $0.06/ft.

Let:

TC = total cost of cellulose tape = $0.05/ft.
PV = present value price of substitute product calculated for the life of the asbestos product.
Na = Useful life of asbestos sealant tape = 20 yrs.
Ns = Useful life of cellulose tape = 15 yrs.

In the following present value formula:

$$PV = TC \times (a/b) \times (b-1)/(a-1)$$

where

$$a = (1.05)^{Ns} \text{ and } b = (1.05)^{Na}$$
$$a = 1.05^{15} = 2.08 \text{ and } b = (1.05)^{20} = 2.65$$
$$PV = 0.05 \times (2.08/2.65) \times (2.65 - 1)/(2.08 - 1)$$
$$PV = 0.06$$

7. Fiber-Resin Corp. reported that one liquid gallon of the butyl rubber asbestos mixture is equivalent to 275-300 feet of sealant tape and this works out to an average of 287.5 feet per gallon. This information may be desirable for conversion purposes.

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XXXIV. ASBESTOS SEPARATORS IN FUEL CELLS AND BATTERIES

A. Product Description

In very specialized aerospace applications, asbestos functions as an insulator and separator between the negative and positive terminals of a fuel cell/battery. The porous nature of the 100 percent woven-asbestos material allows it to adsorb the liquids used in fuel cells and batteries. The liquids used in these fuel cells/batteries are highly corrosive and reach very high temperatures. The properties of asbestos that are desirable in this function are its porosity, heat resistance, anti-corrosiveness, strength and dielectric strength (ICF 1986).

B. Producers and Importers of Asbestos Separators

Currently, two companies in the country use asbestos in fuel cells and batteries. Eagle-Pitcher Industries sells its batteries to the Defense Department for use on ICBMs and Power Systems Division sells its fuel cells to NASA for use on the Space Shuttle (Eagle-Pitcher 1986, Power 1986). Table 1 lists the total fiber consumed in 1981 and 1985 in this market. Neither Eagle-Pitcher nor Power Systems were able to state with certainty the number of asbestos-containing fuel cells/ batteries they produced, however, given that the separators are 100 percent asbestos, the record of fiber consumption gives a good indicator of the market (ICF 1986). There are no known importers of asbestos containing batteries/fuel cells (ICF 1986, ICF 1984).

C. Trends

Since 1981, asbestos use in this function has declined slightly from 2,150 lbs. to 2,046 lbs. Neither company anticipates a change in the government specifications that require the use of asbestos in their batteries/fuel cells and thus do not expect any drastic changes in the asbestos separator market (ICF 1986).

Table 1. Asbestos Fiber Consumption in Batteries/Fuel Cells

	1981 Fiber Consumed (pounds)	1985 Fiber Consumed (pounds)	Reference
Total	2,150	2,046	ICF 1986

D. Substitutes

Eagle-Pitcher Industries has developed a substitute for asbestos that could replace about two-thirds of its asbestos battery market. The substitute material is aluminum silicate. The aluminum silicate batteries cost the same as the asbestos batteries and show no performance differences for two-thirds of the asbestos battery market. Eagle-Pitcher would not elaborate on why the remaining one-third of their asbestos batteries could not be replaced with non-asbestos substitutes. Power Systems Division claims that asbestos is required for the unique conditions encountered in outer space and reports that there are no available substitutes (ICF 1986).

This product category, a part of the miscellaneous asbestos mixture category, was deemed too small to be included in the asbestos regulatory cost model. The 1 ton of asbestos fiber consumed in this category accounted for an extremely small percentage of the total domestic consumption (145,123.3 tons) in 1985 (ICF 1986).

E. Summary

In very specialized aerospace applications, asbestos functions as an insulator and separator between the negative and positive terminals of a fuel cell/battery. Currently, two companies in the country use asbestos separators in fuel cells and batteries. Since 1981, the market for asbestos separators has been stable and no dramatic changes in the market are expected in the near future. One of the processors, Eagle-Pitcher Industries, has developed a substitute battery containing aluminum silicate that could replace two-thirds of its asbestos containing batteries.

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XXXV. ASBESTOS ARC CHUTES

A. Product Description

Ceramic arc chutes containing asbestos are produced by General Electric and are used to guide electric arcs in motor starter units in electric generating plants. Asbestos is used in the arc chutes for its strength, heat resistance, and dielectric strength (General Electric 1986).

B. Producers and Importers of Asbestos Arc Chutes

General Electric Company is the only processor of asbestos-containing ceramic arc chutes. There are, however, other processors of asbestos arc chutes, but they manufacture plastic arc chutes that have been classified in the asbestos-reinforced plastic category (031). Generally, the plastic arc chutes are smaller and are not able to withstand as high a temperature (above 1500°F) as the ceramic arc chutes. The plastic arc chutes are used in smaller electric motors, often in the automotive and appliance industries (ICF 1986).

C. Trends

Production of asbestos arc chutes has fallen dramatically from 9,400 arc chutes in 1981 to 900 in 1985. Fiber consumption has fallen correspondingly from 141 tons in 1981 to 13.5 tons in 1985. (General Electric 1986). Table 1 shows production of asbestos arc chutes and consumption of asbestos fiber in 1981 and 1985.

D. Substitutes

General Electric is converting their ceramic blast breaker, which contains the asbestos arc chutes, to a vacuum breaker which does not require any arc chutes. General Electric expects to be asbestos-free within a few years and total replacement of this asbestos product market is predicted. General Electric did not cite any cost or performance differences of the vacuum breaker versus the ceramic blast breaker (General Electric 1986).

Table 1. Asbestos-Containing Ceramic Arc Chutes, Production and Fiber Consumption 1981-85

Year	Production of Arc Chutes	Fiber Consumption (short tons)	Reference
1981	9,400	141.0	ICF 1986
1985	900	13.5	ICF 1986

This product category, a part of the miscellaneous asbestos mixture category, was deemed too small to be included in the asbestos regulatory cost model. The 13.5 tons of asbestos fiber consumed in this category accounted for an extremely small percentage of the total domestic consumption (145,123.3 tons) in 1985 (ICF 1986).

E. Summary

One company, General Electric in Philadelphia, produces a ceramic arc chute containing asbestos. The arc chutes are used to guide electric arcs in motor starter units in electric generating plants. Production of asbestos arc chutes has fallen dramatically since 1981. General Electric is converting from using a blast breaker to using a vacuum breaker that does not require any asbestos. Total replacement of this asbestos product is expected within a few years.

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