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XV. Asbestos-Cement Flat Sheet

A. Product Description

Asbestos is used as a reinforcing material because of its high tensile strength, flexibility, thermal resistance, chemical inertness, and large aspect ratio (ratio of length to diameter).

Flat asbestos-cement sheet is made from a mixture of Portland cement, asbestos fiber, and silica. Sometimes, an additional fraction of finely ground inert filler and pigment may be included. Asbestos fiber is used to improve the strength, stiffness, and toughness of the material, resulting in a product that is rigid, durable, noncombustible, and resistant to heat, weather, and corrosive chemicals (Krusell and Cogley 1982). In the past, sheets usually contained between 15 and 40 percent asbestos fiber with Portland cement and silica accounting for the rest (ICF 1985). However, Nicolet, the only remaining U.S. producer of asbestos-cement flat sheet has a formulation containing 45.6 percent asbestos (ICF 1986). A significant feature of the asbestos-cement sheet is its wet strength, which enables it to be molded into complex shapes at the end of the production process (Krusell and Cogley 1982).

Asbestos-cement sheets, both flat and corrugated, are manufactured by using a dry, a wet, or a wet-mechanical process. In the dry process, asbestos, cement, and filler are mixed together; the mixture is placed on a flat conveyor belt, sprayed with water, and compressed by steel rolls; the sheet is then cut and autoclaved. The wet process is similar, except water is added to the mixture in the initial stages, forming a slurry. The slurry is then placed on a flat conveyor belt and the excess water is squeezed out by a press. The wet-mechanical process is similar in principal to some papermaking processes: a thin layer of slurry is pumped onto a fine screen from which water is removed; this layer is then transferred onto a conveyor, from which more water is removed by vacuum; more layers are then added, their water removed, and the process continues until the desired thickness is achieved (Krusell and Cogley 1982).

Flat asbestos-cement sheet is used where fire and moisture resistance are required. It is used primarily in the construction industry as wall lining in factories and agricultural buildings, fire-resistant walls, curtain walls, partitions, soffit material (covering the underside of structural components), and decorative paneling in both exterior and interior applications. It is also used in utility applications, such as electrical barrier boards, bus bar run separators, reactance coil partitions, and as a component of vaults, ovens, safes, heaters, and boilers. A second type of flat asbestos-cement sheet being produced domestically is used for laboratory work surfaces, such as table tops and fume hoods liners (Nicolet 1986a and b, Krusell and Cogley 1982). In 1985, approximately 20 percent of flat asbestos-cement sheet production was for laboratory surfaces and 80 percent for construction/utility applications[1] (Nicolet 1986b).

B. Producers and Importers of Flat Asbestos-Cement Sheet

In 1981 there were four producers of flat asbestos-cement sheet: International Building Products, Johns-Manville, Nicolet, and National Gypsum (TSCA 1982). Manville Sales Corporation (formerly Johns-Manville) stopped flat asbestos-cement sheet production in 1985. In 1986, Nicolet is the only remaining U.S. producer although they have temporarily stopped flat asbestos-cement sheet production due to a shortage of orders (ICF 1986).

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[1] Asbestos-cement flat sheet for construction/utility applications can be broken down into two categories: ebonized, or asphalt-impregnated flat asbestos-cement sheet (no longer being produced in the U.S.), once used as a mounting/insulating board for low to medium temperature, high voltage electrical apparatus; and non-ebonized (construction/utility) asbestos-cement sheet, used for low voltage applications with no moisture (Tailored Industries 1986).

There is only one known importer of flat asbestos-cement sheet into the U.S., Atlas International Building Products (AIBP) located in Montreal, Quebec, Canada (Atlas 1986a, b, and c). In 1981, there were four U.S. importers of flat asbestos-cement sheet: R.E. Hebert & Co., Rochester, NY; GII Corporation (now Eternit, Inc.), Reading, PA; Roofing Wholesale Co., Phoenix, AZ; and Tara Wholesale Co., Seattle, WA (ICF 1984). None of these companies currently import flat asbestos-cement sheet (R.E. Hebert & Co. 1986, Eternit 1986b, Roofing Wholesale Co. 1986).

C. Trends

Flat asbestos-cement sheet production volume for 1985 was converted to a 1/2" basis. Manville ceased flat asbestos-cement production in 1985.[2] However, a decline in flat asbestos-cement sheet manufacture during the past five years is very obvious from the figures for fiber consumption during this time. In 1981, 10,766 tons of asbestos fiber were consumed in the production of flat asbestos-cement sheet. This declined to 2,579 tons by 1985, a reduction of 76 percent (ICF 1985, ICF 1986). Even though the raw material mix may have changed a little, it is reasonable to conclude that production of output has decreased in a similar fashion. Nicolet claims that the market for flat asbestos-cement sheet is rapidly declining (Nicolet 1986b).

It is not known how much flat asbestos-cement sheet is imported into the U.S. According to the U.S. Bureau of the Census, imports of asbestos-cement products other than pipe, tubes, and fittings declined by 278 percent from 39,407.3630 tons in 1981 to 10,416.3785 tons in 1985. In 1985, 8,489 tons of this category, or 81.5 percent, came from Canada (U.S. Dep. Comm. 1986a and b). This number most likely includes flat and corrugated asbestos-cement

[2] 1981 production is not directly comparable with 1985 data because a majority of 1981 data was reported in 100 square feet and the remainder (Nicolet's) in tons. In addition, the thickness used as a base for the square footage data was not given in 1981.

sheet and asbestos-cement shingles (Atlas 1986a, Atlas 1986c, Eternit 1986b). It is not known precisely what part is asbestos-cement sheet, however it is believed to be very small (Eternit 1986b). AIBP, which is the only known importer of asbestos-cement flat and corrugated sheet and asbestos-cement shingles into the U.S., estimated that roughly 10 percent of their shipments to the U.S. are flat asbestos-cement sheet (Atlas 1986a). Ten percent of their shipments, or 848.9 tons, converts to about 3,396 squares[3] of 1/2" thick flat asbestos-cement sheet imported into the U.S. in 1985 (see Attachment, Item 2). This estimate is probably low because it does not include some flat asbestos-cement sheet from countries other than Canada, although that quantity is expected to be very small.

D. Substitutes

The following section presents separate discussions of substitutes for flat asbestos-cement construction/utility sheets and laboratory work surface sheets. Table 1 summarizes the product substitutes for flat asbestos-cement construction/utility sheet.

1. Construction/Utility Substitutes

a. Calcium Silicates

Manville Sales Corporation, once the largest producer of flat asbestos-cement sheet, makes a variety of calcium silicate substitutes for flat asbestos-cement sheet. These include: Transite(R) II, Marinite(R), Flexboard(R) II, Colorlith(R) II, Ebony(R) II, and six architectural panels: Stonehenge(R) II, Agean(R) II, Splitwood(R) II, Sandstone(R) II,

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[3] Square = 100 square feet.

Table 1. Product Substitutes for Flat Asbestos-Cement Sheet in Construction/Utility Applications

Product/Substitute	Manufacturer	Advantages	Disadvantages	Availability	Source
Flat asbestos-cement sheet	Nicolet Ambler, PA	Can be molded. High thermal resistance. Weather resistance. Chemical resistance. Flexibility.	May crack or bend when impacted.	National	ICF 1984a, ICF 1986
<u>Calcium Silicate Product Substitutes</u>					
Transite(R) II (calcium silicate)	Manville Sales Denver, CO	Colorfastness. Integral color. Freeze/thaw resistance. Accepts paint. Fire retardant. Rust, rot, and corrosion resistant.	Less strength than A/C sheet. Maximum operating temperature, 450°F, is less than A/C sheets. Very brittle.	National	Manville 1986c and 1985a, Coastal GFRC 1986, Western Slate 1986
Flexboard(R) II (calcium silicate)	Manville Sales Denver, CO	Colorfastness. Integral color. Freeze/thaw resistant. Water resistant Resists dents/scratches.	Much less strength than A/C sheet. Maximum operating temperature, 250°F, much less than A/C sheets. Difficult to drill without breakage. Brittle.	National	Manville 1986a, c; Western Slate 1986
Marinite(R) (calcium silicate)	Manville Sales Denver, CO	Greater heat resistance than A/C sheets, 1200-1500°F.	Higher moisture absorbance. Less dense than A/C sheet. Lower strength.	National	Manville 1987, Zircar 1986a.
Efkex(R) and Eterboard(R) (calcium silicate)	Eternit, Inc. Reading, PA	Noncombustible. Water resistant. Higher impact resistance than A/C sheet. High strength/weight ratio. Insect and rot resistant. No painting required for exterior for use.	500°F continuous maximum temperature lower than A/C sheets. Not thicker than 1/4".	National	Eternit 1986a. Eternit 1986b.
Latricrete(R) EP (epoxy primed cement board -- calcium silicate)	Laticrete Int'l Bethany, CT	Fire, weather, and impact resistant. Low moisture absorption. Durable.	Less water resistant than A/C sheet. Less strength than A/C sheet.	National	Laticrete 1986.

Table 1 (Continued)

Product/Substitute	Manufacturer	Advantages	Disadvantages	Availability	Source
<u>Non-Calcium Silicate Product Substitutes</u>					
Ultra-Board(TM) (cement, mica and fibrous glass)	Weyerhaeuser Tacoma, WA (U.S. distributor) TAC Construction Materials, UK (manufacturer, owned by Eternit)	Noncombustible. Frost resistant. Insect/vermin resistant. Flexible. Durable.	Less strength than A/C sheet. Eflex, or Eterboard. Continuous maximum temperature, generally 500°F, lower than A/C sheets.	National	Weyerhaeuser 1985, Eternit 1986a, b
Minerit(R) (cement, cellulose and	Oy Partek Ab Scandanvia (manufacturer) Sanspray Santa Clara, CA (distributor)	Less brittle than A/C sheet. Moisture, rot and corrosion resistant noncombustible.	Less strength than A/C sheet. Less fire resistant than A/C sheet. Loses strength in prolonged soaking. 300°F maximum continuous temperature, lower A/C sheet's.	National	Sanspray 1986a, b
Durock(R) Tile Backer Board (cement and fiberglass mesh)	USG Corp. Chicago, IL	Water resistant. Fire resistant.	Conductive rather than insulative. Less fire resistant than A/C sheet. Interior use only. 3'x5' not standard 4'x8' A/C sheet size.	National	U.S.G. Corporation 1986, Laticrete 1986
Wonderboard(R) (cement and fiberglass mesh)	Modulars, Inc. Hamilton, OH	Water resistant. Fire resistant.	Less fire resistant than A/C sheets. 3'x5' not standard 4'x8' A/C sheet size.	National	U.S.G. Corporation 1986, Laticrete 1986
Glass-Reinforced Cement (GRC) Sheet or Sterling Board	Tailored Industries Pittsburgh, PA and 3-4 other U.S. distributors. Tunnel Building Products Norwich, England (manufacturer)	Superior overall strength. Higher impact resistance. Higher strength/weight ratio. Water impermeable. Rot proof. Accepts paint.	Expensive. Lower service temperature than A/C sheet. If cut, edges may chip. Cement may break down in high corrosion environment.	National	Tunnel Building Products 1986, Cem-Fil Corporation 1986, Krusell and Cogley 1982
Benelex(R) (laminated wood composite)	Masonite Corp. Laurel, MS	Lightweight. Strong. Abrasion resistant surface.	Low maximum service temperature, 195°F. Low weather resistance.	National	Masonite 1986a, b, and n.d.

Table 1 (Continued)

Product/Substitute	Manufacturer	Advantages	Disadvantages	Availability	Source
Glass Polyester (GPO) Sheet	Glastic Co. Cleveland, OH Haxite Co. Erie, PA; and several others	Low moisture absorbance. Better electrical insulator. Less brittle. Continuous operating temperature, 350-550°F, higher than the old ebonized A/C's.	Very expensive.	National	Glastic 1986
Zircar(R) Refractory Sheet (75% alumina, 16% silica, 9% other metal oxides)	Zircar Products Florida, NY	Over twice maximum service temperature of A/C. Greater flexural strength. Shock resistant. Low moisture absorbance. Not brittle. Moldable or rigid form.	Very expensive. Sheets are only 2'x4' in size.	National	Zircar 1986a, b, c
Monolux(R)	Cape Boards and panels UK (producer) WB Arnold & Co. West Caldwell, NJ (U.S. distributor)	Noncombustible. Rigid and inert. Chemical resistant. Water resistant. Greater heat resistance than A/C.	Not Known.	National	ICF 1986a

Klefstone(R)II, and Rentone(R) II (Manville 1985a and b, Manville 1986a and c).[4] Transite(R) II primarily is used in high temperature areas, such as ovens, kilns, induction heaters, and furnaces, insulators, electronic high-temperature resistant plates, as well as in the metallurgy, glassforming and thermosetting industries (Manville 1986c). Other uses include fume hoods, benches, and counter tops (Manville 1985a).

Marinite(R) I, D, C, Metal Mover(R), and Metalform(R) are Manville's higher temperature calcium silicate sheets. They have various architectural uses including fireproofing and structural support protection, as well as uses in press platen insulation applications and metal processing industries (Zircar 1986b and 1986c). Their maximum temperature use ranges from 1200 to 1500°F. They are not used for electrical applications primarily because of their high moisture absorption. Marinite(R) sheets are also not used as a structural support replacements for asbestos-cement sheet because they do not have the strength of either asbestos-cement or Transite(R) II sheets (Zircar 1986b and 1986c).

Flexboard(R) II is used primarily as a building and utility board for exterior and interior walls, partitions, ceilings, and soffits in homes, warehouses, schools and commercial buildings (Manville 1986a). Colorlith(R) II is used in laboratories for table tops, fume hood bases and liners, shelves, and window sills (Manville 1985b and 1986c). Ebony(R) II is recommended for base and mounting panels for electrical equipment (Manville 1985a).

For most of the Manville products mentioned above there have been serious problems. All of Manville's new products, except Marinite(R), have much lower heat resistance than asbestos-cement. While asbestos-cement sheet is rated at

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[4] The II refers to a non-asbestos product, replacing Manville's old asbestos products.

600°F, it has been used successfully temperatures close to 1000°F. Transite II was initially rated at 600°F, but this was reduced to 450°F after customer complaints. Flexboard(R) II can not be used over 250°F (Manville 1986c, Tailored Industries 1986). The second major disadvantage of these Manville products is their brittleness. Transite(R) II and Flexboard(R) II often break during shipping (Western Slate 1986, Tailored Industries 1986).

Eflex(R) and Eterboard(R), made by Eternit, Inc., are, respectively, high and medium-high density, calcium silicate cement boards with several interior and exterior applications. They are used in construction as soffits, fire resistant paneling, ceilings, walls, partitions, and substrates for tile and stone. In industry and laboratories, they are used for fumigation chambers, welding booths, electrical arc barriers, wet areas such as cooling towers, and occasionally for laboratory table tops and fume hoods. They have also been used in agriculture as walls, partitions, and feed bins (Eternit 1986a and 1986b).

Laticrete(R) EP Cement Board is an interior/exterior calcium silicate epoxy primed cement and mineral fiber board which, like the previous two products, is used primarily for tile backing (Laticrete 1986). It is also used for partitions, soffits, balconies, decks, hearth and stove guards, and in agricultural buildings, pens and animal feeders. Though fire, impact, and weather resistant, it does not match asbestos-cement sheet's performance.

b. <u>Non-Calcium Silicates</u>

Ultra-Board(TM) is another direct competitor with Eflex(R) and Eterboard(R) and has similar uses. It comes in four varieties, each with different densities and fire resistances. In construction it is used for interior and exterior partitions, curtain walls, soffits, fascias, tile backer board, laminated paneling, doors and ventilation ducts. Other uses include laboratory furniture, fume hoods, oven linings, welding booths, foundry and molten metal applications, electrical bus bar barriers and swimming pool panels. One variety, Ultra-Board(TM) VC, is a special fire resistant board with a high maximum operating temperature of 1,650°F and is used for lining steel, concrete, and timber beams and columns (Weyerhaueser 1985, Eternit 1986b).

Minerit(R), made from Portland cement, cellulose fibers and marble fillers, was designed as a replacement for flat asbestos-cement sheet and is a competitor with products such as Eflex(R), Eterboard(R), and Ultra-Board(TM). It is used for architectural panels, decorative panels, waste plants, partitions, soffits, fume hood liners, and in agricultural areas for its rot warp and corrosion resistance (Sanspray 1986a and b).

Durock(R) Tile Backer Board and Wonderboard(R) are the primary substitute tile backer boards for use in moist areas such as in bathrooms and kitchens. Both boards are made from cement and vinyl coated fiberglass mesh, while Wonderboard also contains ceramic aggregate. In addition to moisture resistance, both boards have good fire resistance and can be used as stove and oven guards. They do not, however, have the fire or heat resistance of asbestos-cement sheet. Wonderboard(R) can be used for interior or exterior applications, while Durock(R) Tile Backer Board is for interior use only. A new product for exterior use, Durock(R) Exterior Cement Board, was released in October 1986 (U.S.G. Corporation 1986).

While Sterling Board(R) or glass-reinforced cement (GRC) sheet, imported from England, is a substitute that has many properties which are most similar to those of flat asbestos-cement sheet it has not taken the share of the market that was predicted when the board was introduced in the U.S. in the late 1970's (Cem-Fil 1986). Its primary uses are for soffit and fascia panels, fireproof partitions, storage sheds, garages, wall panels, permanent form boards, drywall finishing for steel, masonry and concrete, and even as road signs (ICF 1985). While flat GRC sheet has a very small market in the U.S. due to so many competing products, in Europe, Australia, and Scandanavia flat GRC sheet is very popular (Cem-Fil 1986). For flat GRC sheet to match asbestos-cement's properties requires very expensive alkalai-resistant glass; this cost in addition to large shipping costs (overseas from England) make the product 30 to 40 percent more expensive than flat asbestos-cement sheet (Chem-Fil 1986). Sterling Board currently has a very small share of the flat asbestos-cement sheet replacement market (Cem-Fil 1986, Tunnel Building Products 1986, National Tile Roofing Manufacturers' Association 1986).

Benelex(R), a 100 percent wood composite, is readily available and is used in a range of electrical apparatus,including bus bar barrier boards, switching plates, as well as in non-electrical applications, such as locomotive floors, high performance industrial conveyers, and laboratory surfaces. Approximately 70 percent of its uses are electrical (Masonite 1986a). It competes with GPO and flat asbestos-cement sheet, and has substituted for ebonized asbestos-cement sheet in less critical electrical applications -- those with low voltage, heat, and moisture (Masonite 1986a, Glastic 1986).

Glass polyester (GPO) sheet is used primarily in electrical applications such as switchgear mounting panels and boxes. GPO has already taken most of the replacement market in applications where ebonized asbestos was once used -- critical areas with high voltage and/or low moisture. GPO still competes with non-ebonized asbestos-cement sheet and other substitutes in non-critical areas with lower voltage and without moisture. GPO also replaces flat asbestos-cement sheet and Transite(R) II in press platen applications which require insulators to reduce heat loss from the thermosetting resin mold. According to one manufacturer, GPO is replacing Manville's Transite(R) II and Ebony(R) II because these products are too brittle. One significant disadvantage of GPO is that it is two to three times as costly as other substitutes with similar uses (Glastic 1986).

Zircar(R) Refractory Sheet 100, a ceramic alumina sheet, is abrasion resistant and exceeds asbestos-cement sheet's resistance to heat. It is used in high temperature applications to replace asbestos-cement sheet in oven construction and shelving, induction heating and coil fixtures, electrical terminal blocks, fireproof structural insulation, and molten metal transport. Zircar(R) Refractory sheets are very expensive (Zircar 1986a and b).

Monolux(R) is a noncombustible industrial insulating board used in small ovens and dryers, high temperature ducts, and as insulation in furnaces and kilns (ICF 1985). It is rigid, durable, inert, and resistant to attack by insects and vermin. The board is unaffected by dilute acids and alkalis, brine, chlorine, or volatile solvents. It will not disintegrate, warp, or swell under prolonged immersion in water. Monolux(R) is more resistant to heat than asbestos-cement sheet (Krusell and Cogley 1982).

Other materials such as brick, masonry, wood, stucco, galvanized steel, and aluminum sheet can be used in exterior architectural/building applications. However, they are not major substitutes for flat asbestos-cement sheet (ICF 1985).

In discussions with substitute producers, it appears that there is one flat asbestos-cement construction/utility sheet application for which satisfactory substitutes are not available when one considers cost and/or performance; this application is pizza oven hearths. Some substitute producers claim that the best potential substitutes, Transite(R) II and Zircar(R) Refractory Sheet, are not adequate; Transite(R) II is too brittle and does not have the high temperature capability of asbestos-cement (Western Slate 1986, Tailored Industries 1986), while Zircar(R) Refractory Sheet is very expensive (see Attachment, Item 4). In addition, one substitute sheet manufacturer claims that its largest size, 24 by 48 inches, is too small for an oven hearth (Tailored Industries 1986). According to Zircar(R) Products, however, three pizza oven manufacturers are using Zircar(R) Refractory Sheets in pizza ovens (Zircar 1986b).

i. Cost and Market Shares for Construction/Utility Sheets

The cost for 1/2" thick flat asbestos-cement construction/utility sheet is $1.81/square foot (see Attachment, Item 3). The average price for substitute flat calcium silicate construction/utility sheet is $1.82/square foot and for flat non-calcium silicate construction/utility sheet is $4.17/square foot (see Attachment, Item 4).

No substitute producers were able to estimate how the current flat asbestos-cement construction/utility sheet market is broken down among its end uses: construction, high temperature, and electrical applications. However, one industry contact estimated that 95 percent of the flat asbestos-cement construction/utility market would be taken over by calcium silicate sheets, with non-calcium silicate sheets taking over the remaining 5 percent (Eternit 1986b).

2. Laboratory Work Surface Substitutes

Substitutes for asbestos-cement laboratory work surfaces, which as previously mentioned represent 20 percent of the flat asbestos-cement sheet market (Nicolet 1986b), are compared in Table 2.

Epoxy resin is the best material for making laboratory table tops. Its market has grown partially because five companies currently produce it whereas in the past there had been only one producer (General Equipment Manufacturers 1986b). Epoxy impregnated sandstone's properties (e.g., chemical resistance and strength) make for a excellent laboratory top, however it is very heavy and must be handled carefully during installation (S. Blickman Inc. 1986). Epoxy impregnated sandstone is made by two companies, Waller Brothers Stone

Table 2. Characteristics of Laboratory Work Tops Made from Asbestos-Cement Sheet and Substitute Products

Property	Asbestos-Cement Sheet	Epoxy Resin	Epoxy Resin Impregnated Sandstone	Colorlith(R) II	Laminated Plastic (Formica)
Chemical Resistance	Very Good	Excellent	Very Good	Excellent	Fair
Heat Resistance	Excellent	Excellent	Very Good	Fair	Fair
Stain Resistance	Good	Excellent	Very Good	Excellent	Good
Moisture Resistance	Good	Excellent	Very Good	Good	Very Good

Sources: Manville 1985b, Manville 1986c, ICF 1984a.

Company and Taylor Stone Company, both in Ohio (Waller Brothers 1986). Fabrication of Colorlith(R) II, a Manville product, into a table top requires much more time and more difficult processing than is required to make flat asbestos-cement sheet into table tops (Western Slate 1986). For example, because of its moisture absorption, one must either bake Colorlith(R) II for a very long time to remove moisture and prevent the later paint coats from blistering, or if one does not bake before painting, it is necessary to resand and repaint if blistering of initial paint coats occurs. In addition, Colorlith(R) II is very brittle and may crack during shipping (Western Slate 1986, General Equipment Manufacturers 1986a). Other laboratory surface products, such as industrial grade formica, plastic laminates, Dupont's Corian(R), and Celotex's Fibertop(R) can substitute for asbestos-cement sheet in biology and general science laboratories, but not in chemistry or industrial laboratories. Furthermore, these products last half as long as other asbestos-cement laboratory table top substitutes (Waller Brothers 1986, General Equipment Manufacturers 1986a and b).

a. <u>Cost and Market Shares for Laboratory Work Surface Sheet</u>

Fabricated asbestos-cement laboratory work surface sheets are approximately $10.50/square foot. Fabricated epoxy resin sheets are the most expensive substitute at $13.50/square foot. Epoxy impregnated sandstone and Colorlith(R) II are both $12.00/square foot. Plastic laminates are about half the price of sandstone, or $6.00/square foot; however, as previously mentioned, plastic laminates cannot be used in corrosive environments and do not last as long as the other substitutes.[5]

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[5] Because the prices for laboratory work tops are for fabricated tops and include the extra costs necessary to turn a bare laboratory work sheet into a laboratory table top, they are generally much higher than those for asbestos-cement and substitute construction/utility sheets which require no additional fabrication. For the asbestos regulatory cost model it is necessary to derive a price for laboratory worksheets that is comparable to

Asbestos-cement flat sheet, which held about half of the laboratory work surface market a few years ago (S. Blickman Inc. 1986), now holds about 10 percent of this market. The remainder of this market is currently divided among epoxy resin, 50 percent; sandstone, 25 percent and Colorlith(R) II, 15 percent. It is projected that if asbestos were banned the laboratory work surface market would be broken down as follows: epoxy resin, 60 percent; sandstone, 25 percent (or more); Colorlith(R) II, 10 percent; and plastic laminates and others, 5 percent (or less)[6] (see Attachment, Item 5).

Table 3 presents the data for the asbestos regulatory cost model and summarizes the findings of this analysis (see Attachment, Items 6-8 for calculations).

E. Summary

There are two types of asbestos-cement flat sheet produced domestically; the first type, comprising 80 percent of the market, is used for construction/ utility applications and the second type, used for laboratory work surfaces, accounts for the remaining 20 percent of flat asbestos-cement sheet (Nicolet 1986a, b). Currently, Nicolet is the only remaining domestic producer of flat asbestos-cement sheet and they temporarily stopped production in 1986 due to a shortage of orders (ICF 1985, Nicolet 1986b). Nicolet claims that market is rapidly declining for this product (Nicolet 1986b). Atlas International Building products of Montreal, Quebec, Canada is the only company known to import flat asbestos-cement sheet into the U.S. (Atlas 1986a, b, c).

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the price of asbestos-cement and substitute construction/utility sheets. This weighted average price for all substitute laboratory work sheets is $2.17/square foot (see Attachment, Items 5-6).

[6] The previous breakdown of the substitute market into 95 percent calcium silicates and 5 percent non-calcium silicates for construction/utility sheet applies only to the construction/utility sheet market and not to the laboratory table top market.

Table 3. Data Inputs for Asbestos Regulatory Cost Model[a]

Product	Output (100 sq. ft.)	Product Asbestos Coefficient (tons/100 sq. ft.)	Consumption Production Ratio	Price ($/100 sq. ft.)	Useful Life[b]	Equivalent Price ($/100 sq. ft.)	Market Share	Reference
Asbestos-Cement Flat Sheet	22,621	0.114	1.15	$181.00	25 years	$181.00	N/A	See Attachment
Calcium Silicate Construction/Utility Flat Sheet	N/A	N/A	N/A	$182.00	25 years	$182.00	76%	See Attachment
Non-Calcium Silicate Construction/Utility Flat Sheet	N/A	N/A	N/A	$417.00	25 years	$417.00	4%	See Attachment
Substitute Laboratory Work Sheet	N/A	N/A	N/A	$217.00	25 years	$217.00	20%	See Attachment

N/A: Not Applicable.

[a] See Attachment, Items 1-8 for sources and calculations.

[b] ICF 1985. The useful life of substitutes varies depending on the application, but for the same application flat asbestos-cement sheet and its substitutes will have approximately the same useful life.

Although there is no single substitute that can replace flat asbestos-cement sheet in all of its applications, there are substitutes available for each specific application. One industry contact estimated that the flat asbestos-cement construction/utility market would be 95 percent calcium silicates costing just slightly more than the asbestos product and 5 percent non-calcium silicates which are more than twice the price of flat asbestos-cement sheets. The three major substitutes for laboratory work surface flat asbestos-cement sheet -- epoxy resin, sandstone, and Colorlith(R) II -- are 15-30 percent more expensive than the asbestos product.

ATTACHMENT

(1) Methodology for determining Nicolet's and Manville's production of flat asbestos-cement sheet and converting it to a 1/2" basis.

This calculation is based on confidential business information.

(2) Calculation of imports of flat asbestos-cement sheet.

10,416.3785 tons of asbestos-cement flat and corrugated sheet and asbestos-cement shingles were imported into the U.S. in 1985. 81.5 percent, or 8,489 tons, of this figure is from Canada. Atlas International Building Products (AIBP), the only importer of these products from Canada estimates that 10 percent of their imports is asbestos-cement flat sheet (Atlas 1986a). Ten percent equals 848.93 tons of 1,697,869.70 lb. of flat asbestos-cement sheet.

Using Nicolet's weight for 1/2" thick sheet of 5 lb./square foot:

> 1,697,869.70 lb. of flat asbestos-cement sheet/(170 lb./34.03 square feet or 5 lb./square foot) = 339,573.94 square feet or 3,395.74 squares of asbestos-cement flat sheet imported into the U.S. in 1985.

This estimate may be low because it does not include the 18.5 percent of asbestos-cement products other than pipe, tubes, and fittings imported from countries other than Canada. Imports from these other countries may possibly include some flat asbestos-cement sheet (U.S. Dep. Comm. 1986a and b).

(3) Calculation of cost of asbestos-cement construction/utility sheet.

This calculation is based on confidential business information.

(4) Calculation of cost of substitutes for flat asbestos-cement construction/utility sheet.

Flat Sheet Product	Thickness	F.O.B. Plant Price/ Thickness	Comments	Source
Asbestos-Cement Sheet	1/2"	$1.81		Nicolet 1986a
Calcium Silicates				
Transite(R) II	1/2"	$2.08	15% more expensive than asbestos-cement sheet	Manville 1986c
Flexboard(R) II	1/2"	$2.08	15% more expensive than asbestos-cement sheet	Manville 1986c
Marinite(R) I	1/2"	$3.00		Manville 1987
Eflex(R)	1/4"	$1.25	Thickest is 1/4"	Eternit 1986c
Eterboard(R)	1/4"	$0.90	Thickest is 1/4"	Eternit 1986c
Laticrete(R) EP	1/2"	$1.60		Laticrete 1986

Flat Sheet Product	Thickness	F.O.B. Plant Price/ Thickness	Comments	Source
Non-Calcium Silicates				
Ultra-board(TM)	1/2"	$0.90		Eternit 1986b, Weyerhaeuser 1986
Miniret(R)	1/2"	$1.65		Wiley-Baley 1986
Durock(R)	1/2"	$0.65		U.S.G. Crop. 1986
Wonderboard(R)	1/2"	$0.65		Modulars 1986
GRC	1/2"	$2.44	35% more expensive than asbestos-cement sheet	Cem-Fil 1986
Benelex(R)	1/2"	$1.65		Masonite 1986b
GPO (fiberglass reinforced polyester)	1/2"	$5.43	3 times more expensive than asbestos-cement sheet	R.E. Hebert & Co. 1986
Zircar(R) Refractory	1/2"	$20.00		Zircar 1986a

It is estimated that 95 percent of the flat asbestos-cement construction/utility market would be taken over by calcium silicates and the remaining 5 percent by non-calcium silicates (Eternit 1986). The average price for calcium silicates is $1.82/square foot while the average price for non-calcium silicates is $4.17/square foot.

(5) Sources used to determine market shares and prices for laboratory work surfaces.

	Share	Sources
	Current Market Shares	
Asbestos-Cement	10%	Waller Brothers 1986
Epoxy Resin	50%	General Equipment Manufacturers 1986b, Waller Brothers 1986, S. Blickman Inc. 1986, Laboratory Services 1986
Sandstone	25%	General Equipment Manufacturers 1986b, Waller Brothers 1986
Colorlith(R) II	15%	Waller Brothers 1986
Plastic	--	-
	Projected Market Shares	
Epoxy Resin	60%	S. Blickman Inc. 1986, General Equipment Manufacturers 1986b, Waller Brothers 1986, Laboratory Services 1986
Sandstone	25% or more	Waller Brothers
Colorlith(R) II	10%	General Equipment Manufacturers 1986b, Waller Brothers 1986
Plastic laminates and others	5% or less	Waller Brothers 1986, Laboratory Services 1986

Prices for fabricated laboratory tops are based on the following sources:

	Price (sq. ft.)	Sources
Asbestos-Cement	$10.50	Waller Brothers 1986, S. Blickman Inc. 1986
Epoxy Resin	$13.50	Waller Brothers 1986, S. Blickman Inc. 1986, General Equipment Manufacturers 1986b, Western Slate 1986
Sandstone	$12.00	Waller Brothers 1986, S. Blickman Inc. 1986, General Equipment Manufacturers 1986
Colorlith(R) II	$12.00	Waller Brothers 1986; S. Blickman Inc. 1986, Western Slate 1986
Plastic laminates and others	$ 6.00	General Equipment Manufacturers 1986b

(6) <u>Calculating to determine weighted average cost of substitutes for flat asbestos-cement laboratory work sheets to be used in asbestos regulatory cost model</u>.

Prices for asbestos-cement laboratory work sheets and its substitutes are end-product prices. Therefore, in order to determine a price for substitute work sheets that can be compared to the prices for asbestos-cement and substitute construction/utility sheets (raw product) for the asbestos regulatory cost model, the following methodology is used.

A weighted average price based on projected market share is determined by multiplying each substitute by its projected market share as shown on the previous page.

0.60 ($13.50) + 0.25 ($12.00) + 0.10 ($12.00) + 0.05 ($6.00) = $12.60. This is the average cost for substitute laboratory table tops.

Next we determine the ratio of weighted average substitute cost to the asbestos-cement laboratory table top cost.

$12.60/$10.50 = 1.2

This factor is multiplied by the cost for flat asbestos-cement construction/utility sheets ($1.81/square foot) to derive a price for fabricated laboratory top sheets that is comparable to the cost of construction/utility asbestos-cement substitute sheets, and can thus be used in the asbestos regulatory cost model.

1.2 x (cost of flat asbestos-cement construction/utility sheet)
= 1.2 x $1.81/square foot = $2.17/square foot
or $217 square.

(7) Calculations for consumption-production ratio for asbestos regulatory cost model.

Domestic production of flat asbestos-cement sheet = 22,621 squares
Imports of flat asbestos-cement sheet = 3,396 squares

As stated in the text and Attachment, Item 2, this import amount is probably low.

(Domestic production + imports)/domestic production
= 26,017 squares/22,621 squares
= 1.15.

(8) Calculation of product asbestos coefficient for flat asbestos-cement sheet.

Tons of asbestos used/squares of flat asbestos-cement sheet produced.

= 2,578.8 tons/22,621 squares
= 0.114 tons/square.

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XVI. CORRUGATED ASBESTOS-CEMENT SHEET

A. Product Description

Asbestos-cement corrugated sheet is made from a mixture of Portland cement and asbestos fiber. An additional fraction of finely ground inert filler and pigments is sometimes included (Krusell and Cogley 1982). In general, sheets contain between 15 and 40 percent asbestos fiber, although, for curing in short time periods, a general formulation of 12 to 25 percent asbestos, 45 to 54 percent cement, and 30 to 40 percent silica is used (Cogley 1980).

Asbestos-cement corrugated sheet is manufactured by using a dry, wet, or wet-mechanical process. In the dry process, asbestos, cement, and filler are mixed together. This mixture is placed on a flat conveyer, sprayed with water, and compressed by steel rolls. The sheet is then cut and autoclaved. The wet process is similar, except water is added to the mixture in the initial stages forming a slurry. The slurry is then placed on a flat conveyer and the excess water is squeezed out by a press. The wet-mechanical process is similar in principal to some papermaking processes. This process begins similarly to the wet process, however, a thin layer of slurry is pumped onto a fine screen from which water is removed. This layer is then transferred onto a conveyor, from which more water is removed by vacuum. More layers are then added, water removed, and the process continues until the desired thickness is achieved (Krusell and Cogley 1982).

Asbestos is used as a reinforcing material in cement sheet products because of its high tensile strength, flexibility, thermal resistance, chemical inertness, and large aspect ratio (ratio of length to diameter). Cement sheet becomes strong, stiff, and tough when asbestos fiber is added, resulting in a product that is stable, rigid, durable, noncombustible, and resistant to heat, weather, and corrosive chemicals (Krusell and Cogley 1982).

Corrugated asbestos-cement sheet has been used historically in industrial and agricultural applications, serving as siding and roofing in factories, warehouses, and agricultural buildings (Krusell and Cogley 1982; Atlas 1986a). It has also been used as a lining for waterways, such as water slides in amusement parks and bulkheads in canals or to keep water away from coastal homes, and for special applications in cooling towers (Krusell and Cogley 1982; Atlas International Building Products 1986 a and b). The present applications of corrugated asbestos-cement sheet are limited to the replacement market in the U.S., primarily because of the availability of good substitutes. Approximately 85 percent of the replacement market is for general construction in chemical, potash, paper, ammunition, and other industries; about 10 percent is used for replacement in waterways, and 5 percent for replacement in cooling towers (Atlas 1986a and b).

B. Producers and Importers of Corrugated Asbestos-Cement Sheet

Corrugated asbestos-cement sheet is no longer being produced in the U.S. The last company to produce corrugated asbestos-cement sheet, International Building Products, Inc. in New Orleans, Louisiana, closed in March 1986 (ICF 1985 and 1986; Atlas 1986a).

Currently, the only company known to import corrugated asbestos-cement sheet into the U.S. is Atlas International Building Products, Inc. (AIBP) of Montreal, Canada (Coastal GFRC 1986). Atlas of Canada bought International Building Products' equipment when they went out of business and created Atlas International Building Products, the U.S. sales division of Atlas. International Building Products had been one of Atlas' main competitors. AIBP has no plants in the U.S. and ships directly to its U.S. customers (Atlas 1986a and b). Their only U.S. sales representative is in Port Newark, NJ and is believed to be affiliated with the Port Newark Refrigerated Warehouse (Eternit 1986, Atlas 1986b). It is not known precisely when International Buildings

Products stopped production of corrugated asbestos-cement sheet or if any was produced in 1985.

C. Trends

It is not known how much corrugated A/C sheet was imported into the U.S. in 1985. According to the U.S. Bureau of the Census 10,416.3785 tons of A/C products other than pipe, tubes, and fittings were imported in 1985, of which 8,489 tons, or 81.5 percent came from Canada (U.S. Dep. Comm. 1986a, 1986b). This number most likely includes flat and corrugated asbestos-cement sheet and asbestos-cement shingles (Atlas 1986a, 1986c, Eternit 1986). AIBP, which is the only known importer of A/C flat and corrugated sheet and A/C shingles into the U.S., estimated that roughly 10 percent of their shipments to the U.S. are corrugated asbestos-cement sheet (Atlas 1986a). Ten percent of their shipments, 848.9 tons, converts to about 38,59[1] squares of 3/8" thick corrugated asbestos-cement sheet imported into the U.S. in 1985 (see Attachment, Item 1). This estimate is probably low because it does not include some flat asbestos-cement sheet from other countries, although that quantity is expected to be very small.

D. Substitutes

Table 1 presents a list of product substitutes for corrugated asbestos-cement sheet, as well as their advantages and disadvantages. Fiberglass reinforced plastic (FRP) corrugated sheet is a lightweight, corrosion resistant, and strong product which comes in four basic varieties: fire resistant translucent, non-fire resistant translucent, fire resistant opaque, and non-fire resistant opaque. The fire resistant varieties are the best FRP substitutes for asbestos-cement corrugated sheet (Resolite 1986a and b, Sequentia 1986). FRP corrugated panels are used primarily for industrial and

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[1] Square = 100 square feet.

Table 1. Product Substitutes for Corrugated Asbestos-Cement Sheet

Product Substitute	Manufacturer	Advantages	Disadvantages	Availability	References
Corrugated A/C Sheet	Imported from Atlas International Building Products Montreal, Canada	Can be molded. High thermal resistance. Weather resistance. Chemical resistance. Flexibility.	Brittle. Cracks or bends when impacted. Heavy. Expensive to install.	National	Krusell and Cogley 1982, ICF 1984, H&F Manufacturing 1986a
Substitutes					
FRP Corrugated Sheet	Resolite Zelionople, PA Sequentia Cleveland, OH Lasco, Inc. Anahiem, CA Filon Division Hawthorne, CA and many others	Corrosion and chemical resistance. Not as noisy as aluminum. Lightweight. Can be colored easily. Translucent or opaque. Many colors. Durable. High strength/shatterproof. Easy to install. Can be cut easily.	Not as temperature resistant as A/C sheet. Combustible at 700-900°F. Not recommended for continuous use above 200°F. More flexible than A/C sheet and thus needs more support.	National	Resolite 1986a, b; Sequentia 1984, 1986; ICF 1984
PVC Corrugated Sheet	H&F Manufacturing Feasterville, PA and many others	Not brittle. More impact resistant. Doesn't absorb moisture. Water repellant and weather resistant. Easier to handle. Lighter. Broad chemical resistance. Corrosion resistance. Available in longer lengths than A/C sheet. Several colors available. Non-combustible.	More expensive than other substitutes. Thermoplastic -- loses strength at 165°F.	National	H&F Manufacturing 1986a, b
Aluminum Corrugated Sheet	Corrugated Metals, Inc. Jersey City, NJ Reynolds Eastman, GA and several others	Lighter than A/C sheet. Available in large sheets. Doesn't crack. Less expensive than other substitutes.	Weak in corrosive environment. Can be noisy. Conducts electricity.	National	Corrugated Metals, Inc. 1986a, ICF 1984
Steel Corrugated Panel	Corrugated Metals, Inc. Jersey City, NJ Reynolds Eastman, GA and several others	Can stand more force. Available in wide range of thicknesses. Lighter than A/C, but heavier than other substitutes.	May rust. Very weak in corrosive environment. Conducts electricity.	National	Corrugated Metals, Inc. 1986a, ICF 1984

wastewater purposes. They are used in factories, chemical plants, mining operations, cooling towers, or in any area where strong corrosion resistance and/or light transmission is desired (Resolite 1986a and b, Sequentia 1986). About 95 percent of all cooling towers were once clad with corrugated asbestos-cement sheet, however, today nearly 100 percent are clad with corrugated FRP sheet. Corrugated FRP sheet is not generally used for waterways (Resolite 1986b). The Resolite division of H.H. Robertson makes a high strength FRP product called Tred-Safe(R), which is strong and rigid enough to walk on (Resolite 1986a).

A second substitute for asbestos-cement corrugated sheet is corrugated polyvinyl chloride (PVC) sheet for roofing and siding. Corrugated PVC panels are used in chemical plants, pulp and paper manufacturing plants, oil refineries, steel mills, horticulture and industrial process buildings, warehouses, enclosures, compressor houses, as cooling tower siding and louvers, and in other areas (H&F Manufacturing 1986a and b). Both PVC and FRP are available in the same 4.2" pitch corrugation as asbestos-cement corrugated sheet.

Aluminum siding and roofing is a third substitute for corrugated asbestos-cement sheet, with a relatively wide range of applications. Aluminum corrugated sheet is used in pulp and paper mills, but not in environments with sulfuric acid or phosphates (Reynolds 1986). Aluminum and other metal-based products, such as steel paneling, are not appropriate in most highly corrosive environments. However, both steel and aluminum are used for waterways and bulkheads (Alpha Marine 1986; Reynolds 1986).

Corrugated Sterling Board(R) (corrugated glass-reinforced cement (GRC) sheet, made in England) is one of the substitutes with properties most similar to those of corrugated asbestos-cement sheet, but it has not taken the share of the market that was once predicted when it was introduced in the U.S. in the early 1980's. The major reason for this lack of popularity is its high cost (about 30-40 percent higher than other corrugated products). It continues to be popular in Europe and Scandanavia, primarily because of less competition (Cem-Fil 1986).

Table 2 compares the costs of various corrugated asbestos-cement sheet substitutes. Aluminum and galvanized steel are the least expensive substitutes and are about two-thirds the cost of PVC corrugated sheet. The service life for FRP and PVC is a minimum of 20 years. They may last longer, however, they only have been on the market for about 20 years (H&F Manufacturing 1986b). Galvanized steel sheet can last from 10 to 20 years, depending on the environment in which it is used (H&F Manufacturing 1986b, Corrugated Metals, Inc. 1986b). Maintenance costs are essentially zero for all products. FRP may not be appropriate for certain heavy duty uses because it is more flexible than other substitutes and may require extra support (Resolite 1986b). Aluminum siding is the least expensive of any substitute. Steel paneling, while less expensive than PVC or FRP corrugated sheet siding, is much heavier and less corrosion resistant and therefore has restricted applications.

As previously mentioned, corrugated asbestos-cement sheet is now primarily being used in the small replacement market. Estimating the possible market share for the substitutes if corrugated asbestos-cement sheet were unavailable is difficult because each substitute has many applications. In general, these products could substitute for corrugated asbestos-cement sheet in its three major kinds of applications: (1) roofing and siding on industrial and commercial structures; (2) specialty applications in cooling towers; and (3) waterway liners and bulkheads. In general construction, the replacement market for corrugated asbestos-cement sheet will be 45 percent FRP, 35 percent aluminum, 10 percent PVC, and 10 percent galvanized steel (Reynolds 1986;

Table 2. Costs for Corrugated Sheet Siding[a]

	Asbestos-Cement	FRP	PVC	Aluminum	Galvanized Steel
F.O.B. Cost ($/100 sq. ft.)	170[b]	173[c]	230[d]	105[e]	75[e]
Installation Cost[f] ($/100 sq. ft.)	107	73	71	83	82
Total Cost ($/100 sq. ft.)	277	246	301	188	157
Operating Life (years)	30[g]	20[g]	20[g]	20[h]	15[h]
Present Value ($/100 sq. ft.)	277	303	371	232	233

[a] See Attachment, Items 2-6 for calculations.

[b] Atlas 1986a.

[c] Sequentia 1984; Resolite 1986a.

[d] H&F Manufacturing 1986a.

[e] Corrugated Metals, Inc. 1986a; Reynolds 1986.

[f] Means 1986. Installation costs are for siding on a steel frame.

[g] ICF 1984.

[h] Corrugated Metals, Inc. 1986a.

Interstate Contractors 1986). About 95 percent of new cooling tower cladding is corrugated FRP sheet, with the remaining 5 percent of this market being taken by PVC (Sequentia 1986; H&F Manufacturing 1986b). The waterways and bulkhead market will probably be evenly divided between aluminum and coated steel (Alpha Marine 1986; Reynolds 1986). Because the asbestos-cement corrugated sheet market is 85 percent general construction, 10 percent cooling tower exteriors and 5 percent waterways and bulkheads (Atlas 1986a), the overall replacement market will probably breakdown as follows (see Attachment, Item 8):

Substitute Product	Projected Market Share (Percent)
FRP	48
Aluminum	32
Steel	11
PVC	9

Table 3 presents the data for the asbestos regulatory cost model and summarizes the findings of this analysis (see Attachment, Items 7-10).

E. Summary

Currently, the applications of asbestos-cement corrugated sheet in the U.S. are limited to the replacement market, primarily due to the availability of adequate substitutes. This replacement market is approximately 85 percent general construction, 10 percent waterways and 5 percent in cooling towers. Asbestos-cement corrugated sheet is no longer produced in the U.S. The only known importer is Atlas International Building Products in Montreal, Quebec, Canada (Atlas 1986a, Atlas 1986c).

The four substitutes and their projected market shares are Fiberglass-reinforced plastic, 48 percent, aluminum, 32 percent; steel, 11 percent; and

Table 3. Data Inputs for Asbestos Regulatory Cost Model

Product	Imports (3/8" thick, 100 sq. ft.)	Product Asbestos Coefficient	Consumption Production Ratio	Price ($/100 sq. ft.)	Useful Life	Equivalent Price ($/100 sq. ft.)	Market Share	Reference
Asbestos-Cement Corrugated Sheet	3,859[a]	0.0855[b]	Infinity[c]	277.00	30 years	277.00	N/A	See Attachment
FRP	N/A	N/A	N/A	246.00	20 years	288.15	48%	See Attachment
Aluminum	N/A	N/A	N/A	188.00	20 years	220.21	32%	See Attachment
Steel	N/A	N/A	N/A	157.00	15 years	213.90	11%	See Attachment
PVC	N/A	N/A	N/A	301.00	20 years	352.57	9%	See Attachment

N/A: Not Applicable.

[a]See Attachment, Item 1.

[b]See Attachment, Item 9.

[c]See Attachment, Item 10.

polyvinyl chloride, 9 percent. Aluminum and steel are 19 percent less expensive than imported asbestos-cement corrugated sheet, while FRP is 9 percent and PVC is 34 percent more expensive than imported asbestos-cement corrugated sheet.

ATTACHMENT

(1) Calculation of corrugated asbestos-cement sheet imported into the U.S.

10,416.7785 tons of flat and corrugated asbestos-cement sheet and asbestos-cement shingles were imported into the U.S. in 1985. Of this amount, 8,489 tons, or 81.5 percent, came from Canada. AIBP, the only importer of these products from Canada roughly estimated that 10 percent of their imports were corrugated sheet (Atlas 1986a). This equals 848.9 tons, or 1,697,800 lbs. of corrugated asbestos-cement sheet. AIBP's 3/8 inch thick sheet weighs 440 lbs./square (1,697,800 lbs.)/(440 lbs./square) = 3,858.65 = 3,859 squares of imported corrugated asbestos-cement sheet.

(2) Calculations for F.O.B. plant price of aluminum corrugated sheet.

The price is an average for two major producers for 4.0 ribbed, 0.32" thick when purchased in less than 10,000 square feet quantities.

$1.20/square foot (Corrugated Metals 1986a)
$0.90/square foot (Reynolds 1986)
Average price is $1.05 square foot

(4) Calculations for F.O.B. plant of RFP sheet.

Resolite's prices for translucent and opaque fire resistant FRP corrugated sheet with 4.2" pitch corrugation are:

Translucent $1.44/square foot (Resolite 1986a)
Opaque $1.47/square foot (Resolite 1986a)
Average cost is $1.455 or $1.46/square foot

Sequentia's prices for translucent and opaque fire resistant FRP corrugated sheet with 4.2" pitch corrugation are:

Translucent $1.80/square foot (Sequentia 1986a)
Opaque $2.19/square foot (Sequentia 1986a)
Average cost is $1.995 or $2.00/square foot

The average of these two prices is $1.73/square foot.

(4) Calculations for F.O.B. plant price of corrugated PVC sheet.

The price is derived by averaging H&F Manufacturing's prices for different purchase amounts of 1/8" thick corrugated PVC sheet.

When over 5,000 square feet purchased	$2.16/square foot
When over 2,500 square feet purchased	$2.27/square foot
When up to 2,500 square feet purchased	$2.46/square foot

This gives an average price of $2.30/square foot for PVC (H&F Manufacturing 1986a).

(5) Calculations for F.O.B. plant price of steel corrugated sheet.

The price is an average for two major producers for 4.0 ribbed sheet when purchased in less than 10,000 square feet quantities.

Corrugated Metals prices for steel corrugated steel are:

22 gauge thick \$0.86/square foot (Corrugated Metals 1986b)
24 gauge thick \$0.71/square foot (Corrugated Metals 1986b)
Average price is \$0.79/square foot

22 and 24 gauge are used because they are the most popular thicknesses.

Reynolds estimated that the average cost for 4.0 ribbed steel sheet is approximately \$0.70/square foot (Reynolds 1986).

Thus, the average cost for these is:

\$0.79/square foot
\$0.70/square foot
Average price is \$0.745 or \$0.75/square foot for steel sheet.

(6) Calculations for installation costs.

Installation costs are all taken from Means 1986.

Asbestos-cement corrugated sheet.

Mineral fiber cement panels, corrugated, 3/8" thick as siding on a one story steel frame cost \$1.07/square foot to install.

Steel Corrugated Sheet.

Steel Siding.

24 gauge \$0.82 square foot
22 gauge \$0.82/square foot
Average cost is \$0.82/square foot to install.

PVC Corrugated Sheet. Corrugated vinyl sheets used as siding, 0.120" thick, cost \$0.71/square foot to install.

Aluminum Corrugated Sheet. Aluminum industrial corrugated sheet used as siding, 0.024" thick, mounted on a steel frame costs \$0.83/square foot to install.

Corrugated FRP Sheet. Corrugated fiberglass siding, all weights, costs \$0.73/square foot to install.

(7) Present value calculations (discount rate is 5 percent).

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

where:

a = (1.05)**Ns
b = (1.05)**Na
Ns = Life of substitute product
Na = Life of asbestos product
TC = Total cost of substitute product

Na = 30 years.
Ns for FRP, PVC, and aluminum = 20 years
Ns for steel = 15 years

Thus, b = (1.05)**30 = 4.3219
and for FRP, PVC, and aluminum a = (1.05)**20 = 2.6533
and for steel a = (1.05)**15 = 2.0789

FRP

PV = $246 x (2.6533/4.3219) x (4.3219-1)/(2.6533-1) = $303

PVC

PV = $301 x (2.6533/4.3219) x (4.3219-1)/(2.6533-1) = $371.29 = $371

Aluminum

PV = $188 x (2.6533/4.3219) x (4.3219-1)/(2.6533-1) = $232

Steel

PV = $157 x (2.0789/4.3219) x (4.3219-1)/(2.0789-1) = $233

(8) Calculation of market shares in the replacement market.

Because 85 percent of corrugated asbestos-cement sheet's uses in the replacement market are in general construction, 10 percent are for cooling towers, and 5 percent are for waterways overall (Atlas 1986a), substitute products market shares are derived as follows:

General construction replacement (85%)

FRP	45% x 0.85 = 38.25%
Aluminum	35% x 0.85 = 29.75%
PVC	10% x 0.85 = 8.50%
Steel	10% x 0.85 = 8.50%

Cooling tower replacement (10%)

FRP	95% x 0.10 = 9.50%
PVC	5% x 0.10 = 0.50%

Waterways and bulkhead replacement (5%)

Aluminum	50% x 0.05 = 2.50%
Steel	50% x 0.05 = 2.50%

Thus the total market share for each product is:

FRP	=	38.25%	+	9.50%	=	47.75%	=	48%
Aluminum	=	29.75%	+	2.50%	=	32.25%	=	32%
Steel	=	8.50%	+	2.50%	=	11.00%	=	11%
PVC	=	8.50%	+	0.50%	=	9.00%	=	9%

(9) Calculation of product asbestos coefficient for asbestos-cement sheet for asbestos regulatory cost model.

Because this product is not produced domestically and only imported information on the amount of asbestos used was not available and thus it was assumed to have the same product asbestos coefficient as flat asbestos-cement sheet -- 0.114 tons/square. However, this is for 1/2" thick flat sheet whereas imported corrugated sheet is 3/8" thick. Therefore, to find the coefficient for corrugated sheet: (0.114 tons/square)/(1/2 inches) = (X)/(3/8 inches).

Solving for X,

X = 0.75 (0.114 tons/square) = 0.0855 tons/square

(10) Calculation for consumption/production ratio for asbestos regulatory cost model.

Domestic production of corrugated asbestos-cement sheet = 0
Imports of corrugated asbestos-cement sheet = 3,859 squares

(Domestic production + imports)/(domestic production)

= (0 + 3,859)/0 = infinity.

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