REGULATORY IMPACT ANALYSIS OF CONTROLS ON ASBESTOS AND ASBESTOS PRODUCTS

FINAL REPORT

VOLUME III
APPENDIX F

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I. COMMERCIAL PAPER

A. Product Description

Asbestos commercial paper can be classified into two categories -- general insulation paper and muffler paper. Commercial papers are used to provide insulation against fire, heat, and corrosion at a minimum thickness. These papers are used in a variety of specialized applications and are, therefore, produced in many different weights and thicknesses. They usually consist of approximately 95 to 98 percent asbestos fiber by weight; the balance 2 to 5 percent is typically starch binder (Krusell and Cogley 1982).

Commercial papers are produced on conventional papermaking machines. The ingredients are combined with water to produce a mixture that is fed through a series of rollers. These rollers apply pressure and heat to produce a paper of uniform and desired thickness. The paper is then allowed to cool before it is cut, rolled, and packaged.

Muffler paper is used by the automotive industry for exhaust emission control systems. The paper is applied between the inner and outer skins of the muffler or converter to maintain the high temperature necessary for pollution control within the catalytic converter reaction chamber and to protect the outer layer from the heat (Krusell and Cogley 1982).

General asbestos insulation paper is used in a variety of industries. The steel and aluminum industries use it as insulation in furnaces, in trough linings, in the smelting process, and against hot metal and drippings of molten metal. Asbestos paper is also used in the glass and ceramic industry for kiln insulation, in foundries as mold liners, and in the electrical parts and appliance industry for electrical insulation.

B. Producers and Importers of Asbestos Commercial Paper

There were two primary processors of asbestos commercial paper in 1981: Johns-Manville Corporation (now Manville Sales Corporation) and Celotex

Corporation (TSCA 1982a). There were also three secondary processors of asbestos commercial paper in 1981: Metallic Gasket Division, Sepco Corporation (now Fluorocarbon Metallic Gasket Division), Parker Hannifan Corporation, and Lamons Metal Gasket Company (TSCA 1982b). All of these companies have stopped processing asbestos commercial paper, and there are currently no primary or secondary processors of this product (ICF 1986). However, a representative of Quin-T Corporation's Erie, PA plant stated that it is selling small amounts of commercial paper out of inventory. The official could not quantify the amount sold in 1985, but did state that production had been discontinued (ICF 1986). Because none of the other respondents to our survey indicated that they had begun the production of asbestos commercial paper in the period since the previous survey, or that they were aware of any other distributors or importer of this product, we have concluded that there are currently no domestic producers of asbestos commercial paper. In addition, a 1984 survey of importers failed to identify any importers of asbestos commercial paper (ICF 1984).

C. Trends

1981 production of asbestos commercial paper was 936 tons (TSCA 1982a). As described above, there was no production of this product in 1985.

D. Substitutes

Asbestos fiber has been used in commercial paper because of its corrosion resistance, fire resistance, chemical resistance, strength, and durability. Information on the advantages and disadvantages of asbestos commercial paper and its substitutes is summarized in Table 1.

The major substitute for asbestos commercial paper is ceramic paper (ICF 1985). Ceramic paper is manufactured by Carborundum Corporation, Cotronics Corporation, Babcock & Wilcox, and Lydall Corporation. This product shares many of the advantages of asbestos commercial paper such as corrosion, fire,

Table 1. Substitutes for Asbestos Commercial Paper

Product	Manufacturer	Advantages	Disadvantages	References
Asbestos Commercial Paper	None	Fire, heat, rot, and corrosion resistant. Low cost. Long service life.	Environmental and occupational health problems.	Krusell and Cogley (1982) ICF (1986)
Ceramic Paper	Carborundum Corp., NY Cotronics Corp., NY Babcock & Wilcox, GA Lydall Corp., NH	Heat, corrosion, and chemical resistant. High temperature use limit (2300°F).	Not as strong or resilient as asbestos. More expensive.	Carborundum (1986) Cotronics (1986) Babcock & Wilcox (1986)
Cellulose Paper	Hollingsworth & Vose, MA	Good electrical properties. Inexpensive	Not heat resistant. Low temperature use limit.	Hollingsworth & Vose (1983)
Fiberglass Paper	Lydall Corp., NH	Heat resistant. Temperature use limit of 1100°F.	Not as strong or dimensionally stable as asbestos.	Lydall (1983)

and chemical resistance. However, at extremely high temperatures the binders in the paper begin to burn and all that is left is the fiber. The strength differential becomes more important as the binder burns away because ceramic fibers are not as strong as asbestos fibers. In addition, ceramic paper is more expensive than commercial paper.

Despite these drawbacks, ceramic papers can substitute for asbestos commercial papers in any of the following applications: insulation for the aluminum and steel industries, foundry insulation, glass making, fire protecting barriers, mufflers, catalytic converters, kiln and furnace construction, and other high temperature uses.

Hollingsworth & Vose Company produces a cellulose electrical insulation paper. This product is a good substitute for asbestos commercial paper in the electrical parts and appliance industry. It is less expensive than the other substitutes, but it cannot be used in high temperature applications (Hollingsworth & Vose 1983).

Lydall Corporation also manufactures fiberglass commercial paper. This product is considered an inferior substitute because it can only operate at temperatures up to 1100°F and is not as strong or dimensionally stable as asbestos commercial paper (Lydall 1983).

E. Summary

Domestic production of asbestos commercial paper did not take place in 1985. A small amount was sold out of inventory, but there is currently no more consumption of this product. As a result, complete substitution of asbestos in commercial paper has taken place. The substitutes are more expensive than the asbestos product, but they have generally been able to match its performance along the critical dimensions.

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II. ROLLBOARD

A. Product Description

Rollboard is a paper product that is used to protect against fire, heat, corrosion, and moisture. It is a thin and flexible material composed basically of two sheets of paper laminated together with sodium silicate. Rollboard can be cut, folded, wrapped, and rolled. In addition, it can be molded around sharp corners (Krusell and Cogley 1982).

The primary constituent of asbestos rollboard is asbestos fiber. The balance consists of binders and fillers. The asbestos content can range from 60 to 95 percent by weight, but 70 to 80 percent is considered typical. Frequently used binders include starches, elastomers, silicates, and cement; common fillers are mineral wool, clay, and lime (Krusell and Cogley 1982).

Rollboard is manufactured in a process similar to that used for millboard production, but it is produced in a continuous sheet. The ingredients are mixed together and combined with water. This mixture is then fed into a conventional cylinder paper machine where heat and heavy rollers are applied to produce a uniform board. The material is then dried. The final steps are to laminate two of these sheets together, allow them to set, and to package the finished rollboard product.

Rollboard can be used in many industrial applications -- it can be used as a gasket and as a fire-proofing agent for security boxes, safes, and files. Its commercial uses include office partitioning and garage paneling, while its residential uss include linings for stoves and electric switch boxes.

B. Producers and Importers of Asbestos Rollboard

There were no domestic primary or secondary processors of asbestos rollboard in 1981, although a Johns-Manville Corp. (now Manville Sales Corp.) plant in Waukegan, IL was still selling the product out of inventory (TSCA 1982a, TSCA 1982b). In addition, a 1984 survey of importers failed to identify any importers of asbestos rollboard (ICF 1984). The Waukegan, IL plant no longer produces or sells asbestos rollboard (ICF 1986). Because none of the other respondents to our survey indicated either that they had begun the production of asbestos rollboard in the period since the previous survey, or that they were aware of any other distributors or importers of this product, we have concluded that there are currently no domestic producers or consumers of asbestos rollboard.

C. Trends

There was no production of asbestos rollboard in 1981 and there was still no production of asbestos rollboard in 1985. Small amounts of asbestos rollboard were being sold out of inventory in 1981, but this had ceased by 1985.

D. Substitutes

Most non-asbestos rollboards in the market today are made of ceramic fibers. Information on asbestos rollboard and its substitutes is summarized in Table 1.

Cotronics Corporation manufactures ceramic paper which is the primary substitute for asbestos rollboard (ICF 1985). It is made from high purity asbestos-free refractory fibers. Even though the product is sold in paper rolls, it can be made into free standing shapes such as rollboards. The continuous service temperature is 2300°F and applications include insulation materials and high temperature gaskets for furnaces, electrical wire insulation, kiln construction, and cushioning in furnace construction. Ceramic paper has low specific heat, low thermal conductivity, and has resistance to thermal shock and corrosion (Cotronics 1986).

Carborundum Corporation manufactures two asbestos rollboard substitutes. The first is Fiberfrax 550(R). It is a paper product made of alumina-silicate (ceramic) fiber and contains approximately 8 percent organic binder. It is

Table 1. Substitutes for Asbestos Rollboard

Product	Manufacturer	Advantages	Disadvantages	References
Asbestos Rollboard	None	Fire, heat, rot, and corrosion resistant. Long service life. Low cost.	Environmental and occupational health problems.	Krusell and Cogley (1982) ICF (1986)
Fiberfrax 550(R)	Carborundum Corp. Niagara Falls, NY	High temperature use limit (2300°F). Resistant to chemical attack. Good handling strength.	Poor resistance to acids and alkalies.	Carborundum (1986)
Fiberfrax 970(R)	Carborundum Corp. Niagara Falls, NY	High temperature use limit (2300°F). Resistant to chemical attack. Good handling strength.	Poor resistance to acids and alkalies. Lacks strength and rigidity.	Carborundum (1986)
Kaowool(R) Rollboard	Babcock & Wilcox, Inc. Augusta, GA	High temperature use limit (2300°F). Resistant to chemical attack. Good chemical stability.	Poor resistance to hydrofluoric and phosphoric acid and alkalies.	Babcock & Wilcox (1986)
Ceramic Paper	Cotronics Corp. Brooklyn, NY	High temperature use limit (2300°F). Thermal shock resistance. Corrosion resistance.		Cotronics (1986)

resistant to most chemical attacks with the exception of acids and alkalies. It also possesses good handling strength and has a continuous use temperature of 2300°F.* Fiberfrax 550(R) is designed specifically for applications where high temperature protection is more critical than heat retention. Typical applications of Fiberfrax 550(R) are industrial gasketing, liquid metal back-up insulation, brazing furnace insulation, and as an investment casting parting agent (Carborundum 1986).

The second asbestos rollboard substitute produced by Carborundum Corporation is Fiberfrax 970(R). It is also a ceramic paper product, and it contains approximately 6 percent organic binder. Fiberfrax 970(R) is noted for its exceptionally low thermal conductivity and good handling properties. Fiberfrax 970(R) is less suitable as an asbestos rollboard substitute because it lacks strength and rigidity; however, it does possess some of the favorable characteristics found in Fiberfrax 550(R) such as high temperature stability, resiliency, and excellent corrosion resistance. Typical applications of Fiberfrax 970(R) include high temperature gaskets, combustion chamber linings, thermal and electrical insulation, and glass furnace blow pipe insulation (Carborundum 1986).

Babcock & Wilcox produces non-asbestos ceramic rollboard made of Kaowool(R) which consists either of Kaolin, a natural occurring alumina-silica fireclay, or a blend of high purity alumina and silica. Kaowool(R) rollboard has a maximum temperature use limit of 2300°F, and it possesses good chemical stability with resistance to most chemicals. Kaowool rollboard is designed to replace asbestos rollboard in many non-furnace applications such as laundry and trough linings, gasketing between trough sections, glass conveyer rolls,

* The continuous use temperature of asbestos rollboard could not be determined because the product is no longer produced. However, it is likely to have been approximately 1000°F, the continuous use temperature of standard asbestos millboard, a product with a very similar composition.

boiler jacket insulation, electrical appliance insulation, and radiator covers (Babcock & Wilcox 1986).

The use of asbestos rollboard was very limited and the substitutes are generally able to match or exceed the performance of the asbestos product. The price of asbestos rollboard in 1981 was approximately $1.00/lb. (ICF 1985). The current prices for the various substitutes are presented in Table 2. It is clear that the complete substitution away from asbestos rollboard has resulted in a higher price.

E. Summary

Domestic production or consumption of asbestos rollboard did not take place in 1985. This has resulted in complete substitution of asbestos rollboard with other substitute products. The substitute products are more expensive, but they have generally been able to match or exceed the performance of asbestos rollboard.

Table 2. Prices of Asbestos Rollboard and Its Substitutes
(in $/lb.)

Product	Manufacturer	Price	Reference
Asbestos Rollboard	None	N/A	ICF (1986)
Ceramic Paper	Cotronics Corp. Brooklyn, NY	$8.27-$12.40	Cotronics (1986)
Fiberfrax 550(R)	Carborundum Corp. Niagara Falls, NY	$5.92	Carborundum (1986)
Fiberfrax 970(R)	Carborundum Corp. Niagara Falls, NY	$10.24	Carborundum (1986)
Kaowool(R)	Babcock & Wilcox Augusta, GA	$5.70	Babcock & Wilcox (1986)

N/A: Not Applicable.

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III. MILLBOARD

A. Product Description

Asbestos millboard is essentially a heavy cardboard product that can be used for gasketing, insulation, fireproofing, and resistance against corrosion and rot. The primary constituent of this product is asbestos fiber, with the balance consisting of binders and fillers. The asbestos content ranges from 60 to 95 percent, but 70 to 80 percent is considered typical. Frequently used binders are starches, elastomers, silicates, and cement; common fillers include mineral wool, clay, and lime (Krusell and Cogley 1982).

Millboard is manufactured in essentially the same way as paper. The ingredients are mixed together and combined with water. This mixture is then fed into a conventional cylinder paper machine where heat and heavy rollers are applied to produce a uniform board. The material is cut lengthwise and then removed for final drying. Standard size millboards are 42 x 48 inches and 1/4 to 3/4 inches thick. The most popular millboards are 1/4 and 1/2 inch thick. Asbestos millboards are very similar to asbestos commercial paper and are differentiated primarily by their thickness and lower fiber composition than commercial paper.

Millboard is also sold in different grades. Differences between millboard grades reflect their ability to withstand elevated temperatures. Standard asbestos millboard is able to withstand temperatures of 1000°F, while premium millboard can withstand temperatures well above 2000°F (Quin-T 1986a).

The uses of asbestos millboard are numerous. Specific industrial applications include linings in boilers, kilns, and foundries; insulation in glass tank crowns, melters, refiners, and sidewalls in the glass industry; linings for troughs and covers in the aluminum, marine, and aircraft industries; and thermal protection in circuit breakers in the electrical industry. In addition, thin millboard is inserted between metal to produce gaskets. Commercial applications for millboard include fireproof linings for safes, dry-cleaning machines, and incinerators. Asbestos millboard had been used in residential applications, but this application has ceased (Quin-T 1986b).

B. Producers and Importers of Millboard

There were five primary processors of asbestos millboard in 1981: Celotex Corporation, GAF Corporation, Johns-Manville Corporation, Nicolet, Inc., and Quin-T Corporation (TSCA 1982a). Celotex Corporation, Johns-Manville Corporation (now Manville Sales Corporation), and Nicolet, Inc. have since stopped producing asbestos millboard. However, Nicolet, Inc. continues to sell the product out of inventory. GAF Corporation sold their plant in Erie, PA to Quin-T Corporation, and that plant is still producing asbestos millboard. The other Quin-T Corporation plant in Tilton, NH still produces an asbestos product, but they have decided to reclassify it as electrical paper. Therefore, there is currently only one domestic primary processor of asbestos millboard. That plant consumed 436 tons of asbestos fiber in producing 581 tons of asbestos millboard in 1985 (ICF 1986).

There were eight secondary processors of asbestos millboard in 1981 (TSCA 1982b). Since that time, four companies have stopped processing asbestos millboard. The four companies which still process asbestos millboard are: Capital Rubber & Specialty Company, Fluorocarbon Metallic Gasket Division of Sepco Company, Lamons Metal Gasket Company, and Parker Hannafin Corporation. All four companies process millboard for producing gaskets. Capital Rubber and Specialty Company imported millboard in 1985; no other importers of asbestos millboard were identified (ICF 1984; ICF 1986). The other three companies purchased approximately 120 tons of asbestos millboard (ICF 1986).

C. Trends

Total annual production of asbestos millboard has declined dramatically from 2,767 tons in 1981 to 581 tons in 1985. This decline may be somewhat overstated because Quin-T Corporation's plant in Tilton, NH believes that their 1981 millboard production should have been classified as electrical paper. Nonetheless, this decline is expected to continue, and Quin-T Corporation's plant in Erie, PA plans to stop producing asbestos millboard in 1988 (Quin-T 1986a).

D. Substitutes

The major advantages of asbestos millboard are its resistance to heat, fire, rot, and corrosion; its tensile strength, and its low price. In general, the substitutes can match or exceed the heat and fire resistance of asbestos millboard, but they do not offer as much rot or corrosion resistance or as much tensile strength. In addition, all the substitutes are more expensive. Despite these drawbacks, the substitutes are expected to perform adequately enough to replace asbestos millboard in all its current uses.

For the purposes of this analysis, the substitutes have been grouped into two categories -- standard boards and premium boards. This has been done because the performance characteristics of the boards within each category are similar, even though their exact chemical compositions are different. The performance characteristics across categories are, however, different. The advantages, disadvantages, and prices of asbestos millboard and its substitutes are presented in Table 1.

The major substitutes for asbestos millboard fall into the standard board category. The Quin-T Corporation produces a standard board known as mineral board which can replace asbestos millboard. This product is composed of a proprietary combination of inorganic fillers. It can withstand temperatures up to 1000°F and can replace millboard in many of its applications, even

Table 1. Substitutes for Asbestos Millboard

Product	Manufacturer	Advantages	Disadvantages	References
Asbestos Millboard	Quin-T Corp. Erie, PA	Fire, heat, and rot resistant. Corrosion resistant. Low cost.	Potential environmental and occupational health problems.	Krusell and Cogley (1982)
Standard Board	Quin-T Corp. Erie, PA; Nicolet, Inc. Ambler, PA	Temperature use limit of 850-1000°F. Not combustible.	Low tensile strength. High cost.	Quin-T (1986a) Nicolet (n.d.)
Premium Board	Babcock & Wilcox Co. Augusta, GA; Carborundum Corp. Niagara Falls, NY; Cotronics Corp. Brooklyn, NY; Janos Corp. Moonachie, NJ; Nicolet, IN. Ambler, PA	Temperature use limit of 1500-2300°F. Not combustible. Heat resistant.	Low tensile strength. High cost.	Babcock & Wilcox (1986) Carborundum (1986) Cotronics (n.d.) Janos (1986) Nicolet (n.d.

though it has a lower tensile strength. It costs over $1.23/lb. (Quin-T 1986a).

Nicolet, Inc. produces a non-asbestos standard board known as Nampro 901(R). This product is a cement-bound millboard and can be used in gaskets, electric ovens, strong-box liners, and welding pads. It has a temperature use limit of 850°F (1200°F if strength loss is not detrimental) (Nicolet n.d.). It costs $1.33/lb. (Nicolet 1986). It has been estimated that these two standard boards will combine to take 80 percent of the asbestos millboard market if asbestos is banned (Quin-T 1986a).

The remaining substitutes for asbestos millboard fall into the premium board category. They are more expensive, but they have much higher temperature resistance. Janos Industrial Insulation Corporation purchases a premium board called Nuboard 1800(R) from a British manufacturer and distributes it in the U.S. This board consists primarily of mineral fibers and silica. Nuboard 1800(R) can withstand temperatures up to 1800°F. This product can replace asbestos in many of its premium uses, even though it has a lower tensile strength. It costs $2.92/lb. (Janos 1986).

Nicolet, Inc. produces a premium non-asbestos board known as Nampro 911(R). This product is an inorganic-bound millboard and can be used in kiln liners, incinerator liners, induction-furnace liners, and ingot-mold liners. It has a temperature use limit of 1500°F (2100°F if strength loss is not detrimental (Nicolet n.d.). It costs $2.46/lb. (Nicolet 1986).

Babcock & Wilcox Company produces a premium non-asbestos board made of Kaowool(R). Kaowool(R) consists either of Kaolin, a naturally occurring alumina-silica fireclay or a blend of high purity alumina and silica. Kaowool board has a maximum temperature use limit of 2300°F and possesses good chemical stability with resistance to most chemicals. Kaowool can replace asbestos millboard in almost all its premium applications, and it costs $4.70/lb. (Babcock & Wilcox 1986).

Cotronics Corporation produces a premium non-asbestos board called Ceramic Board 360(R). This product is made from high purity refractory fibers which are interlaced and bonded with an inorganic binder. It is resistant to oxidizing and reducing atmospheres, molten non-ferrous metals, steam, and most chemicals and solvents. It also has a continuous use temperature of 2300°F. it can be used in rigid high temperature gaskets, heat shields, chemical reactor insulation, and brazing fixture supports; it costs $1.88/lb. (Cotronics n.d.).

Carborundum Corporation produces a premium non-asbestos board called GH Board made of Fiberfrax(R). Fiberfrax(R) consists mainly of ceramic fibers and has a temperature use limit of 2300°F. In addition, Fiberfrax(R) will work well in electrical insulating applications because it has a low dielectric constant and does not conduct electricity. GH board can substitute for asbestos in all applications where tensile strength is not important, and it costs $5.05/lb. (Carborundum 1986). The premium boards are estimated to take the remaining 20 percent of the asbestos millboard market if asbestos is banned (Quin-T 1986a). All the inputs for the Regulatory Cost Model are presented in Table 2.

E. Summary

Asbestos millboard is essentially a heavy cardboard product which can be used for gasketing, insulation, fireproofing, and resistance against corrosion and rot. It is typically used in gasketing applications and as a liner in industrial boilers, furnaces, and kilns.

The only processor of asbestos millboard in 1985 was Quin-T Corporation's Erie, PA plant. This plant consumed 435 tons of asbestos and produced 581

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 Millboard	581 tons	$0.75 tons/ton	1.005	$1,760/ton	25 years	$1,760/ton	N/A	Quin-T (1986a)
Standard Board	N/A	N/A	N/A	$2,560/ton[b]	25 years	$2,560/ton	80%[b]	Quin-T (1986a) Nicolet (1986)
Premium Board	N/A	N/A	N/A	$6,800/ton[b]	25 years	$6,800/ton	20%[b]	Babcock & Wilcox (1986) Carborundum (1986) Cotronics (n.d.) Janos (1986) Nicolet (1986)

N/A: Not Applicable.

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

[b]See Attachment for explanations.

tons of millboard. Quin-T Corporation plans to stop processing asbestos in 1988.

The major substitutes for asbestos millboard are mineral boards. If asbestos were banned, it is estimated that standard mineral boards would capture 80 percent of the market and that premium mineral boards would capture the remaining 20 percent. The price of asbestos millboard is $0.88/lb. The average price of standard mineral board is $1.28/lb. and the average price of premium mineral board is $3.40/lb.

ATTACHMENT

The projected market shares for standard board and for premium board were estimated by Ray Heidt, Sales Manager, Quin-T Corporation (the only domestic producer of asbestos millboard).

The price of standard board was computed by averaging the prices of the two standard board products. The average of Quin-T Corporation's mineral board ($1.23/lb.) and Nicolet, Inc.'s Nampro 901(R) ($1.33/lb.) is $1.28/lb.

The price of premium board was computed by averaging the prices of the five premium board products. The average of Janos Corporation's Nuboard 1800(R) ($2.92/lb.), Nicolet Inc.'s Nampro 911(R) ($2.46/lb.), Cotronics Corporation's Ceramic Board 360(R) ($1.88/lb.), Babcock & Wilcox Company's Kaowool(R) board ($4.70/lb.), and Carborundum Corporation's GH Board(R) ($5.05/lb.) is $3.40/lb.

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IV. ASBESTOS PIPELINE WRAP

A. Product Description

Pipeline wrap is an asbestos felt product. It is composed of at least 85 percent asbestos with the balance being cellulose fibers and binders such as starch and latex. It is manufactured on conventional papermaking machines in a process similar to that of asbestos roofing felt. The ingredients are combined and mixed with water. This mixture is then fed through a series of machines that apply heat and heavy rollers to produce a felt of uniform thickness. The felt is then coated by pulling it through a bath of hot asphalt or coal tar until it is thoroughly saturated. The paper then passes over another series of rollers which set the coal tar or asphalt onto the felt. Next, it passes over a series of cooling rollers that reduce the temperature and provide a smooth surface finish. The felt is finally air-dried, rolled, and packaged for marketing (Krusell and Cogley 1982).

Pipeline wrap is primarily used by the oil and gas industry for coating its pipelines.[1] There is also some use by the chemical industry for underground hot water and steam piping. Pipeline wrap is occasionally used in above-ground applications, such as for special piping in cooling towers.

Pipeline wrap itself is only one product used in the coal tar enamel method of coating pipes. The coal tar enamel process involves five steps. First, a primer is applied directly onto the pipe. Second, when the primer dries, heated coal tar is applied to the pipe as it is rotated. Third, a glass mat is applied over the coal tar. Fourth, the asbestos felt is wrapped onto the pipe by high-speed wrapping machines. Finally, the pipe is coated

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[1]The Department of Transportation has mandated that all oil and gas pipelines be coated.

with kraft paper[2] (Power 1986a). The asbestos felt helps protect the pipe from moisture, corrosion, rot, and abrasion.

B. Producers and Importers of Asbestos Pipeline Wrap

There were three primary processors and one secondary processor of asbestos pipeline wrap in 1981. The primary processors were: Celotex Corporation, Johns-Manville Corporation (now Manville Sales Corporation), and Nicolet, Incorporated (TSCA 1982a). The secondary processor was Aeroquip Corporation (TSCA 1982b). There are currently no domestic processors of asbestos pipeline wrap (ICF 1986). However, Nicolet, Inc. is selling the product out of inventory and may restart production if demand warrants it (Nicolet 1986a). In addition, Power Marketing Group distributes asbestos pipeline wrap which it imports from Manville Sales Corp. (formerly Johns-Manville Corp.) plants in Canada. No other importers of asbestos pipeline wrap were identified, and neither firm is aware of any other producers or distributors of this product in the U.S. (ICF 1984; ICF 1986).

C. Trends

In 1981, 2,150,615 squares of asbestos pipeline wrap were produced (TSCA 1982b). Nicolet, Inc. has refused to divulge information on 1985 fiber consumption or pipeline wrap output. Power Marketing Group has provided information from which one can estimate output and fiber consumption for both companies. Total fiber consumption and pipeline wrap production are presented in Table 1. Finally, it should be noted that 1986 output may be much lower because Nicolet, Inc. has stopped producing the product and is only selling it out of inventory.

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[2]Kraft paper consists of wood and cellulose fibers.

Table 1. 1985 Asbestos Fiber Consumption and Asbestos Pipeline Wrap Production[a]

	Fiber Consumption (in short tons)	Pipeline Wrap Production (in squares)[b]
Total	3,333.3	742,383

[a]Computations underlying these estimates are in the Attachment.

[b]1 square = 100 square feet

D. Substitutes

The use of asbestos in pipeline wrap is desirable because of its resistance to chemicals, rotting, and decay; its dimensional stability; and its heat resistance (Rood 1986). It is also unaffected by corrosive environments, cannot be attacked by vermin, and performs in the most severe salt water conditions (Power 1986a). These qualities are important for underground pipeline wrap that is used to prevent the deterioration of pipeline buried in earth or under water.

Power Marketing Group and Nicolet, Inc. both sell a non-asbestos mineral felt which can be used instead of asbestos pipeline wrap. Power Marketing Group sells its mineral felt for $5.80/100 square feet, the same price as its asbestos felt. This product appears to have the same advantages as the asbestos product -- resistance to chemicals, rotting, and decay; dimensional stability; and heat resistance (Power 1986b). However, it does not have the proven track record of asbestos felt because it is a new product. There are instances of asbestos pipeline wrap being in the ground for over fifty years, a track record which makes companies reluctant to replace this successful and proven product.

Nicolet, Inc. refers to its mineral felt as Safelt(R). Safelt(R) is a combination of minerals, fibers, and binders. It contains a minimum of 75 percent non-biodegradable components. Safelt(R) is available in two types -- 960 and 966. Safelt 966 is more dense and is therefore sold in a thinner layer (Nicolet n.d.). They are both priced $6.20/100 square feet (Nicolet 1986a), but product literature states that application costs are lower than asbestos wrap because of their superior wrapping characteristics (Nicolet n.d.). This characteristic is not modeled because Nicolet officials would not quantify this advantage and coaters could neither confirm or deny its existence.

Power Marketing Group also sells a fiberglass felt called Duraglass(R). It is priced $5.80/100 square feet. They have had problems, however, in using it in the coal tar enamel method because it does not seem to bond well. Power Manufacturing is currently in the process of reformulating the product in order to rectify this problem (Power 1986b). A summary of the characteristics of the asbestos substitutes is presented in Table 2.

The All American crude oil pipeline, a major cross-country pipeline, is being coated with a new coal tar system which does not use any asbestos or mineral felt. A 20 mil thickness of coal tar enhanced urethane is applied first. It is followed by a 1.5 inch urethane foam layer. The final step is to apply a covering of Polykin tape (Pipeline Digest 1986). Since this method has no history, we do not know its advantages and disadvantages.

These are the only direct substitutes for asbestos pipeline wrap in the coal tar enamel method of coating pipes. However, there are seven other methods of coating pipes: asphalt enamel, thin-film powder, bonded polyethylene, tape, extruded polyethylene, sintered polyethylene, and insulation (Pipeline Digest 1986). The 1985 market shares and output levels for these processes are presented in Table 3.

The coal tar enamel method is the only method of coating pipes that presently uses asbestos pipeline wrap. In 1985 it accounted for 14.39 percent of the pipeline coating market (Pipeline Digest 1986). In the event of an asbestos ban, pipeline coaters and oil industry representatives believe that asbestos felt used in the coal tar enamel method will be replaced by mineral and fiberglass felts, both of which are good substitutes (Arco 1986, Energy Coatings 1986). They do not expect the market share (14.39 percent) held by the coal tar enamel method to be taken over by any one or all of the other seven methods just because asbestos felt will be unavailable. Thus, it has

Table 2. Substitutes for Asbestos Pipeline Wrap

Product	Manufacturer	Advantages	Disadvantages	References
Asbestos Felt	Nicolet, Inc. Ambler, PA; Power Marketing Group Houston, TX	Historical performance. Chemical resistance. Dimensional stability. Heat and rot resistance. Resistant to salt water and vermin attack.	Potential environmental and occupational health hazards.	Krusell and Cogley (1982) Power (1986b)
Mineral Felt	Nicolet, Inc. Ambler, PA; Power Marketing Group Houston, TX	Low application cost. Chemical resistance. Dimensional stability Heat and rot resistance.	Unproven in the marketplace.	Power (1986a)
Fiberglass Felt	Power Marketing Group Houston, TX	Chemical resistance. Dimensional stability. Heat and rot resistance.	Does not bond well. Unproven in the marketplace.	Power (1986a)

Table 3. 1985 Market Shares and Output of Pipeline Coating Processes

Process	Output (square feet)	Market Share (percent)
Asphalt Enamel	200,000	0.03
Coal Tar Enamel	88,439,891	14.39
Thin-Film Powder	263,807,418	42.39
Bonded Polyethylene	28,293,723	4.60
Tape	8,251,037	1.34
Extruded Polyethylene	196,255,978	31.93
Sintered Polyethylene	13,704,375	2.23
Insulation	15,602,441	2.54

Source: Pipeline Digest (1986).

been assumed that substitution will be entirely for asbestos felt rather than for the coal tar enamel method.

The inputs for the Regulatory Cost Model are presented in Table 4. It has been assumed that Power Marketing Group or some other company will formulate a more successful fiberglass felt which will take 20 percent of the market (Arco 1986). The remaining 80 percent of the market will be taken by mineral felt. Because this is a new product, there is no data on projected market shares. As a result, it is assumed that the current market shares of the producers of the asbestos product will apply to the substitutes as well.[3] This will result in a 48 percent (0.80 x 0.60) projected market share for Power Marketing Group's mineral felt and a 32 percent (0.80 x 0.40) projected market share for Safelt(R) (Nicolet's mineral felt).

E. Summary

Asbestos pipeline wrap is a felt product used in the coal tar enamel method of coating pipes. This product is not being produced in the U.S., although one company was selling it out of inventory and another company was importing it from Canada and distributing it. Total domestic production of this product is estimated to have been 296,949 squares in 1985.

It has been assumed that adequate substitutes exist for asbestos felt, and, therefore, pipeline coaters will not switch to alternate methods of coating pipes in the case of a complete asbestos ban. It is estimated that 20 percent of the market will be taken by fiberglass felt that costs $5.80/square. The remaining 80 percent will be taken by mineral felts. Because the two distributors of asbestos felt are also the major distributors of mineral felt, it is assumed that they will both retain their current market shares. Hence Power Marketing's mineral felt will capture 48 percent of the

[3]We cannot look at the trends in market shares because 1981 data for Power Marketing Group are not available.

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 Felt	296,949 squares[a]	0.0044900 tons/square	2.5	$5.80/square	25 years	$5.80/square	N/A	Power (1986b) Power (1987)
Mineral Felt	N/A	N/A	N/A	$5.80/square	25 years	$5.80/square	48%[a]	Power (1987)
Safelt(R)	N/A	N/A	N/A	$6.20/square	25 years	$6.20/square	32%[a]	Nicolet (1986)
Duraglass(R)	N/A	N/A	N/A	$5.80/square	25 years	$5.80/square	20%[a]	Power (1987)

N/A: Not Applicable.

[a]See Attachment for explanation.

market at a price of $5.80/square, and Nicolet's Safelt(R) will capture 32 percent of the market at a price of $6.20/square.

ATTACHMENT

The asbestos fiber consumption and asbestos pipeline wrap output for Power Marketing Group and Nicolet, Inc. were computed using the following methodology. Power Marketing Group estimated that 100 square feet of saturated pipeline felt weigh 13 lbs. Because the saturated felt is 23 percent asphalt or tar coating, the unsaturated felt weighs 10.57 lbs. (13/1.23). Because the unsaturated felt is approximately 85 percent asbestos, 100 square feet of pipeline wrap contain 8.98 lbs. of asbestos (10.57 * .85). Therefore, the asbestos product coefficient is 0.00449 (8.98 lbs./square / 2,000 lbs./ton) tons square.

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V. BEATER-ADD GASKETS

A. Product Description

Gaskets can be described as materials used to seal one compartment of a device from another in non-dynamic applications such as engine and exhaust manifolds. Asbestos gaskets, used mainly to seal connections and prevent leakage of fluids between solid surfaces, can be classified into two categories: beater-add and compressed sheet. Compressed sheet gaskets are discussed in Section XXVII.

Asbestos beater-add gaskets, are less dense, use shorter asbestos fibers, and have lower tensile strength than compressed asbestos sheet gaskets. Consequently, beater-add gaskets are used in less severe applications and at temperatures ranging up to 750°F. At temperatures between 250-750°F asbestos beater-add gasketing can withstand pressure ranging between vacuum and 1,000 psi (Union Carbide 1987). Beater-add gasketing comes in a continuous roll form (reducing waste during die cutting), is more dimensionally uniform, and is less expensive than sheet gasketing (ICF 1986).

Asbestos beater-add gasketing is manufactured[1] by a technique employing a paper making process, using fourdrinier or cylindrical paper machines to make paper from a viscous slurry of asbestos and liquid binders. The asbestos fibers are incorporated within various elastomeric binders and other fillers to form the beater-add paper. These products are used extensively for internal combustion applications and for the sealing component of spiral wound gaskets (Union Carbide 1987). Beater-add gaskets generally contain 60 to 80 percent asbestos in combination with 20 to 40 percent binders and are used primarily in the transportation and chemical industries as:

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[1]The binder is added during the beater process, hence the name "beater-add".

- head, carburetor, exhaust manifold, and transmission gaskets to prevent leakage of oil, fuel, water, gas, or low pressure steam in automobiles, trains, airplanes, and ships; and,
- flange, spiral wound, and general service industrial gaskets to prevent leakage and potential reactions of chemicals in reactors, compressors, heat exchangers, distillation columns, and similar apparatus (ICF 1986).

The particular binder used in a beater-add paper determines the material's suitability for use in water, oil, fuel, or chemical environments. Since the proportion of fiber to binder determines the intended temperature range, different grades of asbestos beater-add gaskets are available for different temperature use limits. Latex is the most popular binder, but styrene-butadiene, acrylic, acrylonitrile, neoprene, fluoroelastomeric polymers, rubber, polytetrafluoroethylene (PTFE), and silicone polymers are also used (Krusell and Cogley 1982).

Gasketing paper is usually produced in a sheet or sheet roll that varies in thickness from approximately 1/64 inch to 3/16 inch. Gaskets are fabricated to customer-specified sizes and dimensions from these sheet rolls. They may be used in this form with no further fabrication required, or they may be processed further by reinforcing them with wire insertions or by jacketing the paper with various metal, foils, plastics, or cloth (ICF 1986).

B. Producers and Importers of Asbestos Beater-Add Gasketing

In 1985, four companies, at five locations, Armstrong World Industries (Fulton, NY), Hollingsworth & Vose (East Walpole, MA), Lydall Corp. (Hoosick Falls, NY and Covington, TN), and Quin-T Corporation (Erie, PA) produced asbestos beater-add gasketing. A fifth company, Boise Cascade Corporation (Beaver Falls, NY) produced beater-add gaskets in 1981, but did not supply information for the ICF survey. In order to account for the estimated production of this company, a methodology was developed to allocate the industry averaged trend to the non-responding companies (Appendix A). The consumption in this category for 1985 is estimated, therefore, to be 12,436.4 tons of fibers used to produce 16,505 tons of beater-add gasketing. Table 1 lists the total production of beater-add gaskets. The beater-add gasketing market was estimated to be worth $24.8 million in 1985, based on an average price of $0.75 per pound (ICF 1986).

Beater-add gasketing is not imported to the United States. Beater-add gaskets[2] were, however, imported by foreign automobile manufacturers. Kawasaki, Toyota, and Suzuki have in total reported imports of 361.35 tons. Other auto makers also imported beater-add gaskets, but the actual import volume for 1985 was not available (ICF 1986).

C. Trends

Between 1981 and 1985, Rogers Corp. (Rogers, CT), Nicolet, Inc. (Norristown, PA), and Celotex (Lockland, OH), three manufacturers that formerly produced asbestos beater-add gasketing, either substituted for asbestos with other materials or discontinued their operations. During those four years one company, Lydall Corp. (Hoosick Falls, NY), initiated production.[3] Total production of asbestos beater-add gasketing paper declined by 37 percent between 1981 and 1985 resulting in a reduction from 26,039 tons to 16,505 tons (ICF 1986, ICF 1985).

All six manufacturers are currently producing substitutes for their products. The substitutes currently hold about a 50 percent share of the gasket market (ICF 1986), but as concern about asbestos grows and substitutes gain wider acceptance, the production of beater-add asbestos gaskets is likely to decline further (ICF 1986).

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[2]Gaskets, as opposed to gasketing, are custom made by secondary processors for their customers.

[3]Lydall Corp. purchased the beater-add gasketing business of Rogers Corp. in 1984, and subsequently moved the operation to their Hoosick Falls, NY location.

Table 1. Production of Asbestos Beater-Add Gasketing and Asbestos Fiber Consumption

	1985 Fiber Consumption (short tons)	1985 Production (short tons)	Reference
Total	12,436.4	16,505	ICF (1986)

D. Substitutes

Asbestos is a chemically inert, nearly indestructible substance that can be processed into fibers. Asbestos fibers partially adsorb the binder with which they are mixed during processing, and subsequently intertwine within it and become the strengthening matrix of the product. Gaskets made using asbestos contain as much as 80 percent asbestos fiber, some of which has been employed as a filler. The balance of the product is the binder which holds the asbestos in the matrix. Industry leaders indicate that they have been unable to find a single substitute for asbestos that can reproduce all of its qualities and have been forced to replace asbestos fiber with a combination of substitute materials, including cellulose, aramid, glass, PTFE, graphite, and ceramic fibers. Asbestos used as a filler has been replaced by other fillers (e.g., clay, mica).

Formulations of substitute products most often include a combination of substitute fibers and fillers in order to reproduce the properties of asbestos necessary for a particular application. Formulation of substitute products is done so as to meet the performance requirements on an application-by-application basis (ICF 1986). For the purposes of this analysis, the substitute products have been grouped into six major categories according to the type of asbestos substitute used:

- cellulose fiber,
- aramid,
- fibrous glass,
- polytetrafluoroethylene (PTFE),
- graphite, and,
- ceramic fiber mixtures (ICF 1986; Palmetto Packing 1986).

Table 2 presents the characteristics of the substitute materials.

The estimated current market shares for the different substitute formulations are presented in Table 3. For all beater-add applications, asbestos-based producers still occupy 50 percent of the market. It is evident

Table 2. Substitutes for Asbestos Beater-Add Gasketing Paper

Product	Advantages	Disadvantages	Remarks	Reference
Cellulose	Inexpensive. Good carrier web.	Not heat resistant. Useful to 350°F. Not chemically resistant.	Useful for low temperature applications only.	ICF 1986; ICF 1985; Mach. Des., July 10, 1986.
Aramid	Very strong. Tear resistant. High tensile strength.	Hard to cut. Wears out cutting dyes quickly. 800°F temperature limit.		ICF 1986; ICF 1985; Mach. Des., July 10, 1986.
Glass Fibers	Good tensile properties. Chemical resistant.	More expensive than asbestos.	Often used in the auto industry.	ICF 1986; ICF 1985; Mach. Des., July 10, 1986.
PTFE	Low friction. Chemical resistant. FDA approved to contact food and medical equipment.	Not as resilient as asbestos. Deforms under heavy loads.	Used primarily in the chemical industry.	ICF 1986; Palmetto Packing 1986a.
Graphite	Heat resistant to 5000°F. Chemical resistant. Light weight.	More expensive. Brittle. Frays.	Fastest growing substitute in the auto market in high temperature seals.	ICF 1986; ICF 1985; Mach. Des., July 10, 1986; Union Carbide 1987.
Ceramic Paper	High heat resistance. Chemical resistant. Strong.	Not oil resistant. Not resilient. More expensive than asbestos.		ICF 1986; ICF 1985; Mach. Des., July 10, 1986.

Table 3. Estimated Market Share for Asbestos Substitute Fibers in Beater-Add Gasketing

Fiber	Estimated Market Share (percent)	References
Cellulose	25	ICF 1986 Palmetto Packing 1986
Aramid	30	ICF 1986 Palmetto Packing 1986
Glass	20	ICF 1986 Palmetto Packing 1986
PTFE	10	ICF 1986 Palmetto Packing 1986
Graphite	10	Union Carbide 1987
Ceramic	5	ICF 1986

from the survey of asbestos processors, however, that the market share of asbestos-free beater-add gaskets is increasing rapidly as companies replace asbestos in some applications. One obstacle to complete replacement of asbestos gaskets by substitute products is military contract specifications that require asbestos gaskets.

1. Cellulose Fiber Mixtures

Cellulose fibers are generally milled from newsprint or other waste forms of cellulose (e.g., vegetable matter) in the presence of additives which ease grinding and prevent fires during processing. Cellulose fiber gaskets usually contain between 20 and 25 percent cellulose fiber and 50 to 55 percent fillers and thickeners. The remaining 25 percent is usually an elastomeric binder (ICF 1986).

Traditionally, cellulose fibers do not resist pressure well and crush easily. However, proprietary methods have been found to reinforce fibers. This results in excellent crush resistance, excellent dimensional stability, and good sealability below 350°F. Cellulose gaskets can substitute for asbestos beater-add gaskets in low temperature applications (below 350°F) such as with oil, gas, organic solvents, fuels, and low pressure steam.

Three producers of asbestos beater-add gaskets also produce cellulose based gaskets. They are Armstrong World Industries, Hollingsworth & Vose, and Lydall Corporation (ICF 1986).

Armstrong World Industries of Fulton, NY, the largest producer of asbestos containing beater-add gaskets, produces a line of asbestos-free, cellulose based gaskets, Syntheseal(R). Armstrong indicated that the asbestos-free formulation costs more to produce and yields a product comparable in quality to the asbestos product for applications with an operating temperature under 350°F (Armstrong 1985).

Hollingsworth & Vose also produces a line of cellulose based, asbestos-free gaskets. The formulation includes mineral fillers and an elastomeric binder. The company cited no quality problems with their asbestos-free gasket line that costs more to produce (ICF 1986a).

The Lydall Corporation also produces cellulose based gaskets that cost more than the asbestos formulation. Company officials indicated that these cellulose based products can only be used in temperatures below 350°F (ICF 1986).

Reinforced cellulose based gaskets have increased in popularity in the past few years. These gaskets can duplicate all asbestos performance parameters, except high temperature resistance. Although they can be used at a maximum continuous operating temperature of 350°F, their life is substantially shortened in temperatures over 95°F and they cannot be used in even mild pressure applications (Union Carbide 1987). But in the right operating environment, manufacturers indicate that the service life of these asbestos-free gaskets is the same as that of asbestos gaskets (ICF 1986).

In the event of an asbestos ban, cellulose fiber formulations in combination with clay and mineral thickeners are estimated to capture 25 percent of the gasketing market (Table 3). Prices would be expected to rise 20 percent to $0.90 per pound due to increased material and production costs (ICF 1986, Palmetto Packing 1986).

2. Aramid Mixture

Aramid fibers are used in asbestos-free gaskets because they are highly heat resistant and strong (ten times stronger than steel, by weight). Aramids are at least seven times more expensive than asbestos, by weight, but as they are less dense and stronger, less is needed for reinforcement purposes. At high temperatures (above 800°F), the fiber physically degrades, and it can only be used in applications where pressure service is below 1,000 psi (Union Carbide 1987).

Aramid gaskets are usually 20 percent aramid fiber, by weight, and 60 to 65 percent filler. The remaining 20 to 25 percent is binder that keeps the fibers in a matrix. Typical applications include gasketing for internal combustion engines in off-highway equipment, diesel engines, and compressors. These applications require a very strong gasketing material that will withstand moderate temperatures (ICF 1986).

Thermo-Tork (R) is a trade name for the line of aramid-containing gaskets that Armstrong World Industries markets for operating temperatures over 350°F (Armstrong 1987). The content is a proprietary mixture of aramid fibers and other fibers and fillers that changes according to intended operating parameters. Many types of Thermo-Tork (R) gaskets are available, each with different combinations of suitable operating temperature and pressure ranges (Armstrong 1987). The various types of gasket were designed for specific applications, such as:

- small engines and motors,
- sealing fuels, fluids, and hot oils,
- sealing gases, water, and low pressure steam, and
- compressors and transmissions (Armstrong 1985).

Suitable temperatures can range up to 800°F, and pressures can range up to 1500 pounds per square inch. Armstrong indicated no diminished quality with the non-asbestos gaskets. In fact, greater sealability is often found with the Thermo-Tork (R) gaskets.

Hollingsworth & Vose identified strength and high temperature resistance as the reasons for selecting aramids for asbestos beater-add replacement. Their formulation includes mineral fillers and elastomeric binders. The estimated cost of the aramid product was 1.5 to 3 times as much as the asbestos product resulting in gaskets that cost $1.69 per pound (ICF 1986).

Although aramid products are expensive, their high temperature and pressure limits make them very attractive for gasket applications. Thus, the estimated market share for aramid products would be about 30 percent of the total asbestos market in the event of an asbestos ban (ICF 1986).

3. Fibrous Glass Mixtures

Fibrous glass is generally coated with a binder such as neoprene, tetrafluoroethylene (TFE), or graphite in the manufacturing process to make gaskets. The glass fibers are relatively easy to manufacture into this material.

Fibrous glass gaskets can be divided into two groups, "E" glass gaskets, and "S" glass gaskets, depending upon the type of glass fiber used in the formulation. "E" glass is one of the more common glass fibers, and it is occasionally manufactured into a gasketing which is used as a jacket around a plastic core of carbon or aramid fibers and other material (OGJ 1986).

"E" glass gaskets are suitable for applications where the operating temperature is below 1000°F. Above this temperature, the gasketing loses 50 percent of its tensile strength. The material can be used with most fluids except strong caustics.

The second type of fiber, "S" glass, was developed by NASA and is recognized as the superior glass fiber in use today (OGJ 1986). This material is occasionally used as a jacket around a core of graphite and other fibers. This beater-add gasketing is caustic resistant and can be used in applications with operating temperatures that reach 1500°F (OGJ 1986).

It is estimated that glass gaskets will capture 20 percent of the total asbestos beater-add gasketing market and will cost twice as much as the asbestos material. Thus, the price will be $1.50 per pound (Palmetto Packing 1986, ICF 1986).

4. Polytetrafluoroethylene (PTFE)

Fibers of polytetrafluoroethylene (PTFE) are used as substitutes for asbestos in gaskets because of their chemical resistance to all but the most powerful oxidizing agents, acids, and alkalies in temperatures ranging from -450°F to 500°F (Chem. Eng. News 1986). PTFE also has good dielectric strength and impact resistance.

PTFE can be used in specialized applications because it has been approved by the FDA for contact with food and in medical equipment. In addition, it does not stain the fluid with which it has contact (Krussel and Cogley 1982). The finished product is 3.5 times as expensive as the asbestos product resulting in gasketing material costs of $2.62 per pound. PTFE gaskets will capture an estimated 10 percent of the total asbestos market in the case of an asbestos ban (Palmetto Packing; ICF 1986).

5. Graphite

Flexible graphite[4] is made from natural flake graphite, expanded several hundred times into a light, fluffy material by mixing with nitric or sulfuric acid. It is then calendered into a sheet (without additives or binders) (Chem. Eng. News 1986). It is extremely heat resistant and inherently fire-safe (because it does not contain binders). Graphite gaskets are suitable for applications where the operating temperatures reach 5000°F in non-oxidizing atmospheres. In the presence of oxygen, the material is limited to use below 800°F (Chem. Eng. News 1986). The gaskets have excellent

[4]Other forms of graphite with similar properties are also available (e.g., carbonized viscose rayon), but are grouped in the category for convenience.

chemical resistance with the exception of strong mineral acids and can be used up to 1,500 psi[5] (Union Carbide 1987).

Graphite material is often used in oil refineries and oil field applications because of its high temperature resistance. A wire can be added to increase strength in high temperature, high pressure applications. (OGJ 1986).

Graphite is an expensive material, but the addition of various fillers helps keep the cost competitive with other substitute materials. Graphite gaskets are estimated to cost twice as much as asbestos beater-add gaskets, resulting in a cost of $1.50 per pound. This substitute's market share is estimated to be 10 percent of the total asbestos gasketing market, but this value is likely to rise to 50 percent for internal combustion engines, and to 20 percent for all applications (Union Carbide 1987).

6. Ceramic Mixtures

Ceramic mixtures are made from high purity silica/alumina fibers that are thoroughly interlaced in the production process and bonded with either an elastomeric or inorganic binder. The elastomeric binder can be used when operating temperatures do not rise above 800°F, while inorganic binders can be used for all operating temperatures. Ceramic fiber products are heat resistant, chemical resistant, and very strong; this enables them to be used under stressful operating conditions.

Three major companies that produce ceramic paper used for gasketing purposes are: Cotronics Corporation, Carborundum Corporation, and Quin-T Corporation. Only Quin-T is also an asbestos beater-add gasketing producer. Quin-T indicated that their formulation for asbestos free gaskets was

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[5]Unlike other gasketing materials that exhibit a temperature/pressure dependence, flexible graphite is able to withstand high pressures independent of temperatures.

proprietary, but did state that the ceramic mixture products could capture 5 percent of the asbestos gasketing market.

The manufacturer stated that the ceramic mixture is not as resilient as asbestos and not as resistant to oil, but claimed that this was not detrimental to the function of gaskets in most applications.

The price of ceramic gaskets is estimated to be three times that of the asbestos products they replace, resulting in a cost of $2.25 per pound. The service life of the substitute product is 5 years, as is that of the asbestos gasket (ICF 1986).

E. Summary

It appears that substitutes for asbestos containing gaskets currently exist. These products cost more to produce, however, and may not perform as well in all applications. Because no single substitute fiber exists, manufacturers have been forced to replace asbestos with a combination of substitute materials, including cellulose, aramid, glass, graphite, PTFE and ceramic fibers. The substitute materials are a combination of fibers and fillers designed on an application-by-application basis.

The estimation of market shares and prices of the substitute formulations in the event of an asbestos ban relies to a large extent upon educated judgments of industry experts. Table 4 summarizes the findings of this analysis, and presents the data inputs for the Asbestos Regulatory Cost Model.

Table 4. Data Inputs for Asbestos Regulatory Cost Model
(005) Beater-Add Gasketing Paper

Product	Output	Product Asbestos Coefficient	Consumption/ Production Ratio	Price	Useful Life	Equivalent Price	Market Share	Reference
Asbestos Gasketing	16,505 tons	0.75349 tons/ton	1.02	$1,500/ton	5 years	$1,500/ton	N/A	ICF 1986.
Cellulose	N/A	N/A	N/A	$1,800/ton	5 years	$1,800/ton	25%	ICF 1986.
Aramid	N/A	N/A	N/A	$3,380/ton	5 years	$3,380/ton	30%	ICF 1986.
Fibrous Glass	N/A	N/A	N/A	$3,000/ton	5 years	$3,000/ton	20%	ICF 1986; Palmetto Packing.
PTFE	N/A	N/A	N/A	$5,240/ton	5 years	$5,240/ton	10%	ICF 1986; Palmetto Packing.
Graphite	N/A	N/A	N/A	$9,740/ton	5 years	$3,000/ton	10%	ICF 1986; Union Carbide 1987.
Ceramic	N/A	N/A	N/A	$4,500/ton	5 years	$4,500/ton	5%	ICF 1986.

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