REGULATORY IMPACT ANALYSIS OF CONTROLS ON ASBESTOS AND ASBESTOS PRODUCTS

FINAL REPORT

VOLUME I
TECHNICAL REPORT

Prepared for:
Christine Augustyniak
Office of Toxic Substances
U.S. Environmental Protection Agency

January 19, 1989

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DISCLAIMER

This document is a draft. It has not been released formally by the Office of Toxic Substances, U.S. Environmental Protection Agency. It is being circulated for comments on its technical merit and policy implications.

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A. Introduction

Many studies have shown that individuals who are exposed to asbestos fibers have increased risks of contracting a number of diseases, including cancers of the lung, the gastrointestinal tract, the lining of the lung and abdominal cavities (mesothelioma), and asbestosis. Initially, these findings were confined to environments with relatively high concentrations of asbestos fibers; that is, workplaces where asbestos was mined or where asbestos-containing products were produced. More recent evidence, however, points toward elevated risks at the lower concentrations typically associated with nonoccupational exposure. The most important of the diseases are lung cancer and mesothelioma. Over 90 percent of individuals who contract these diseases die from them.

Cognizant of this scientific evidence and its obligations under the Toxic Substances Control Act (TSCA), the Environmental Protection Agency (EPA) Office of Toxic Substances has investigated a number of alternative asbestos control strategies, ranging from controls on exposure to asbestos in certain products and activities, to product bans and a phase-down of asbestos fiber usage over time.

The purpose of this Regulatory Impact Analysis (RIA) is to identify, quantify, and, where feasible, value benefits and costs of various regulatory alternatives for controlling exposure to asbestos, ranging from "staged" bans on asbestos products (i.e., bans on products at different points in time) to fiber phase-down options both with and without product bans. The study attempts to meet four goals: (1) to identify properly the potential benefits and costs of asbestos controls; (2) to review some of the key relationships and issues that would affect the magnitude of the benefits and costs of the controls; (3) to project the expected benefits and costs of asbestos controls, and (4) to assess the distribution of the costs and benefits. This study will identify explicitly the logic behind the development of benefit and cost projections, thereby allowing the public to make a more informed judgment concerning potential benefits and costs of asbestos controls.

This RIA for asbestos and asbestos products has been revised to incorporate the comments received from the public concerning the August 1985 version. Because of this, the current version of the RIA reflects the efforts the Agency has devoted to (1) improving and updating the asbestos product markets information used in the analysis, (2) revising the cost simulation model, and (3) refining the exposure estimates for some products and activities. All of these efforts to improve the analysis are in response to comments of reviewers both in the Agency and among the public.

The regulatory alternatives examined in this RIA represent a range of possible options for controlling asbestos exposures. No single alternative, however, is identified as the preferred regulatory alternative. Instead, these alternatives were selected to assist in the Agency's regulatory options selection process. Thus, the costs and benefits of the regulatory alternatives presented in this RIA are designed to provide quantitative and qualitative information on the possible range of costs and benefits of various different types and timing of options. Using this information, the Agency can also examine combinations of control alternatives based on the results of the other regulatory alternatives.

This RIA estimates the costs and benefits of a number of alternatives for reducing or eliminating exposure to asbestos. These alternatives are specified in terms of product bans, phase-downs of fiber usage, and selective exemptions of certain products. Table ES-1 lists the product category number and

TABLE ES-1. LIST OF ASBESTOS PRODUCTS

Product #	Product Category
1.	Commercial Paper
2.	Rollboard
3.	Millboard
4.	Pipeline Wrap
5.	Beater-add Gaskets
6.	High-grade Electrical Paper
7.	Roofing Felt
8.	Acetylene Cylinders
9.	Flooring Felt
10.	Corrugated Paper
11.	Specialty Papers
12.	Vinyl-Asbestos Floor Tile
13.	Asbestos Diaphragms
14.	Asbestos-Cement Pipe
15.	Flat A-C Sheets
16.	Corrugated A-C Sheets
17.	A-C Shingles
18.	Drum Brake Linings (OEM)
19.	Disc Brake Pads, LMV (OEM)
20.	Disc Brake Pads (HV)
21.	Brake Blocks
22.	Clutch Facings
23.	Automatic Transmission Components
24.	Friction Materials
25.	Asbestos Protective Clothing
26.	Asbestos, Thread, Yarn, and Other Cloth
27.	Asbestos Sheet Gasketing
28.	Asbestos Packing
29.	Roof Coatings and Cements
30.	Non-Roofing Coatings, Compounds, and Sealants
31.	Asbestos-Reinforced Plastics
32.	Missile Liner
33.	Sealant Tape
34.	Battery Separators
35.	Arc Chutes
36.	Drum Brake Linings (Aftermarket)
37.	Disc Brake Pads, LMV (Aftermarket)

description of each product. Note that there are two entries for light/medium vehicle drum and disc brakes (products 18, 19, 36, and 37), one corresponding to the original equipment market (brakes installed on new vehicles) and the other to the aftermarket (replacement brakes). In most of the regulatory alternatives described below, these two submarkets are treated identically in terms of the timing and nature of regulations to which they would be subject. However, one alternative would regulate the original equipment and aftermarket segments of these brake markets differently, so the separation of these two markets into the original equipment and aftermarkets is maintained throughout the analysis. Except where noted, however, the two segments are treated identically.

In terms of these product categories, the specific regulatory alternatives examined in this RIA are as follows:

Alternative B:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 25 (protective clothing and construction products, except for A/C sheet and shingle) in 1987

Alternative BX:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 25 (protective clothing and construction products, except for A/C sheet and shingle) in 1987
- Products 13 and 32 (diaphragms and missile liner) exempt from regulation

Alternative D:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

Alternative DX:

- Fiber Phase-Down from 1987 to 1997

- Bans on Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

- Products 13 and 32 (diaphragms and missile liner) exempt from regulation

Alternative E:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992

Alternative F:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992

- Bans of all Remaining Products in 1997.

Alternative FX:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992

- Bans of all Remaining Products in 1997 except Products 13 and 32 (diaphragms and missile liner).

Alternative G:

- Bans of all Products in 1987

Alternative GX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1987

Alternative H:

- Bans of all Products in 1992

Alternative HX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1992

Alternative I:

- Bans of all Products in 1997

Alternative IX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1997

Alternative J:

- Bans of Products 1, 2, 4, 7, 9, 10, 12, 15, 16, 17, and 25 in 1987
- Bans of Products 5, 18, 19, 20, 21, 22, 23, 24, and 27 in 1991
- Bans of Products 14, 36, and 37 in 1994.

The identification system for the alternatives were developed in a previous version of the RIA. To maintain continuity between versions of the RIA, the same system of identification is used in this version. Hence, some of these alternatives were contained in the original version of the RIA; others have been specified since that time in light of the cost/benefit results obtained. Alternatives B, D, E, and F existed in the original RIA, while alternatives G, H, I, and J are newer alternatives developed in the process of evaluating the costs and benefits of the various regulatory alternatives.

Alternatives whose identifiers contain an "X" are modified versions of other alternatives with the single added condition that two product categories (missile liner and asbestos diaphragms) are exempted from either an asbestos fiber phase-down or asbestos-containing product bans. Exemption, or "X", alternatives are specified for those alternatives in which these two product categories would otherwise be regulated (B, D, F, G, H, and I). Finally, Alternative J was developed based on the cost/benefit results for the other alternatives. This alternative is a 3-stage asbestos product ban in which (1) the effective ban dates are slightly modified (1987, 1991, and 1994), (2) some of the asbestos products are not banned at any stage of the regulation, and (3) the original equipment market and the aftermarket drum and disc brake markets for light/medium vehicles are regulated separately in that they are banned at different times.

B. Limitations of the Analysis

The cost and benefit estimates reported in this RIA are based on extensive model development, detailed data collection, and intensive review of relevant literature. However, there are limitations to the results presented. First, only one source of benefits associated with reduced exposure to asbestos -- reduced cancer cases -- is estimated quantitatively in this RIA. Although asbestos causes other health effects, the cancer risks of asbestos exposure are well-known and well-researched and hence, are estimated quantitatively here. This quantification of only cancer cases avoided implies that the numerical estimates of the benefits developed in this RIA are lower bounds for the benefits of controlling exposure to asbestos. Asbestosis, for example, can have a significant impact in terms of medical care expenses, reduced productivity, and deterioration of quality of life.

Families of workers exposed to asbestos, furthermore, are not taken into account in this analysis, so that any health effects associated with these secondary exposures are not included in the estimates of benefits presented here. Finally, lack of exposure data for some asbestos products prevented a quantitative assessment of benefits for these categories even though benefits are likely to exist for these products. For all of these reasons, the benefits estimates of the asbestos regulatory alternatives reported in this RIA are quite likely to be underestimates of the true social benefits of the regulatory alternatives.

Similarly, the costs estimated in this RIA are likely to be overestimates for several reasons. First, the central case cost estimates developed in this analysis assume no decline in the prices of asbestos substitutes as time passes and as additional experience using these substitutes is gained. Second, the model for calculating the costs of the regulatory alternatives does not include cost-reduction benefits of using lower-cost substitutes for asbestos-containing products, i.e., asbestos-containing product substitute prices are always assumed to be greater than or equal to the price of the asbestos-containing product (on an equal service life basis). Finally, the cost estimation model assumes that in the absence of asbestos-containing products, users will switch to non-asbestos products in proportion to the existing market shares of these substitutes, and not proportionately more toward the lower cost substitutes.

C. Costs and Benefits of Regulatory Alternatives

For each of the regulatory alternatives examined in this RIA, three different baselines of asbestos product market growth over time were modeled: Low, Moderate, and High Declines, as outlined in Chapter III. In addition, two different discounting assumptions for calculating the present values of the costs and the benefits of the regulatory alternatives were used: 3 percent discounting for both costs and benefits (benefits are discounted from the time of exposure in this analysis) and 0 percent discounting for benefits and 3 percent discounting for costs. In the results presented below, costs and benefits reflecting both sets of discounting assumptions are presented using the "Low Decline" baseline asbestos product growth rate assumption outlined in the Chapter III of the RIA. Selecting this baseline as the "central case" amounts to assuming the highest levels of asbestos use through time. Results for all regulatory alternatives using the other two baseline growth rate assumptions are reported in Appendix G - Sensitivity Analyses.

The quantitatively estimated costs and benefits of Alternatives B, BX, D, DX, E, F, FX, G, GX, H, HX, I, IX, and J are presented in Table ES-2. The table lists for each alternative (1) the total domestic welfare cost imposed, (2) the total number of cancer cases avoided, and (3) the cost per cancer case avoided. There are two sets of these results in the table corresponding to the two different discounting assumption -- 3 percent for both costs and benefits and 3 percent for costs and 0 percent for benefits.

Table ES-2 indicates that the aggregate U.S. welfare losses attributable to the fourteen regulatory alternatives range from a low of about $603 million (Alternative E) to just under $7 billion (Alternative G), depending on the regulatory alternative considered. The lowest welfare costs for the U.S. are, of course, the regulatory alternatives that ban the fewest products (Alternatives E and J) and the highest are those that ban more products (or phase down all fiber usage) and ban them earlier -- Alternatives B, G, and H. Clearly, the costs of many of the regulatory alternatives are reduced significantly by excluding certain products, such as asbestos diaphragms and missile liner, from both the asbestos fiber phase down and product bans, as both the "X" alternatives and Alternatives E and J indicate.

The figures in the table reporting the quantitatively estimated benefits also indicate that the number of cancer cases avoided changes dramatically across the alternatives (using the undiscounted cancer cases avoided figures), from a low of 90 cases avoided (for Regulatory Alternative IX) to a high of 329 cases avoided (Regulatory Alternative G). To some extent, however, the costs imposed by the regulatory alternatives rise and fall as the numbers of cancer

TABLE ES-2. SUMMARY OF COSTS AND BENEFITS OF ALTERNATIVES
(Low Decline Baseline)

Discounting Scenario and Costs* and Benefits	Alternative						
	B	BX	D	DX	E	F	FX
3-Costs/3-Benefits Discounting							
Total Cost ($1,000,000's):	$ 3,560	1,079	3,607	1,126	603	3,486	1,008
Total Cancers Avoided:	208	208	210	210	145	150	150
Cost Per Case ($1,000,000's):	17.1	5.2	17.2	5.4	4.2	23.2	6.7
3-Costs/0-Benefits Discounting							
Total Cost ($1,000,000's):	$ 3,560	1,079	3,607	1,126	603	3,486	1,008
Total Cancers Avoided:	266	266	268	268	193	200	200
Cost Per Case ($1,000,000's):	13.4	4.1	13.5	4.2	3.1	17.4	5.0

* Total domestic cost

Note: Table contains rounded entries.

TABLE ES-2. SUMMARY OF COSTS AND BENEFITS OF EXEMPTION ALTERNATIVES
(Low Decline Baseline)
(continued)

Discounting Scenario and Costs* and Benefits	Alternative G	GX	H	HX	I	IX	J
<u>3-Costs/3-Benefits Discounting</u>							
Total Cost ($1,000,000's):	$ 6,934	2,286	4,868	1,385	3,085	607	748
Total Cancers Avoided:	266	266	154	153	63	62	122
Cost Per Case ($1,000,000's):	26.0	8.6	31.7	9.1	49.3	9.7	6.1
<u>3-Costs/0-Benefits Discounting</u>							
Total Cost ($1,000,000's):	$ 6,934	2,286	4,868	1,385	3,085	607	748
Total Cancers Avoided:	329	328	206	205	91	90	167
Cost Per Case ($1,000,000's):	21.1	7.0	23.7	6.8	34.1	6.7	4.5

* Total domestic cost

Note: Table contains rounded entries.

cases avoided rise and fall. This produces a cost-per-cancer-case avoided (using the 3 percent discount rate for both costs and benefits) that ranges from a low of about $4.2 million per case avoided (Alternative E) to a high of about $49 million per case avoided (Alternative I). Most of the overall cost-per-cancer-case-avoided figures, however, are in the $5 million to $30 million range. Alternatives that exempt some asbestos products, such as diaphragms and missile liner, from the phase down and product bans, of course, are those with costs per case avoided in the lower end of the range, and those that do not typically are in the higher end of the range.

Appendix G, the sensitivity analysis, presents more detailed output from these model runs. Appendix G contains tables that provide tabulations of welfare effects, by party affected and by market, under each of the three possible baseline growth rate assumptions, and for the fourteen regulatory alternatives. The results for these numerous distinct scenarios are consistent with expectations. For example, using the High and Moderate Decline baselines (in which the decline of asbestos products over time is more rapid than in the Low Decline baseline) reduces both the costs of the regulatory alternatives and their benefits. Total costs discounted at 3 percent for these alternatives range from a low of about $243 million (J - High Decline) to over $6 billion (G - Low Decline).

Appendix G also reports some illustrative results for some regulatory options and baseline conditions not considered in the fourteen alternatives discussed in detail in the RIA. One regulatory option is to require engineering controls for some of the asbestos products to reduce asbestos exposures. To illustrate this, model runs using engineering controls on replacement brakes for drum brakes and LMV disc brake pads, rather than bans on these asbestos brakes, are presented in Appendix G.

Finally, two potentially important factors not included in the "central case" analysis of this RIA could have a significant impact on both the costs and the benefits of the regulatory alternatives. First, there is the distinct possibility that substitutes for asbestos products might become cheaper over time as both experience with their use and the cumulative volume of their production increase. Substantial empirical evidence for downward trends in prices due to "experience" exists. This suggests that the costs estimated in this RIA may be higher than they ultimately will turn out to be as asbestos product substitute costs decline over time. Second, in many cases data on releases of and exposures to asbestos were not available. The "base case" analysis in this RIA assumes that in these cases these releases and exposures are zero, which is not likely to be true. This assumption could impart a substantial downward bias to the quantitative benefits estimates for the regulatory alternatives.

To illustrate the potential impact on the costs and benefits of 1) allowing for declining prices of asbestos product substitute prices over time, and 2) introducing release and exposure information where such information is available, a number of sensitivity scenarios were estimated using Regulatory Alternative J. For declining substitute prices, an across-the-board decline of one percent per year is assumed. Although this may overestimate the rate of decline for some products that have been in existence for some time, it may underestimate the rate of decline for other, newer products or products with new applications. On balance, the across-the-board rate of decline of one percent per year roughly corresponds to typical historical price trends for many products, as discussed in Chapter IV of this RIA.

For products and exposure settings in which no data were available to estimate releases and asbestos exposures directly, two different alternative exposure scenarios were developed, as described in Appendix A-6 of this RIA. First, where possible, for occupational exposures in manufacturing, installation, and repair and disposal, exposures in these settings were estimated based on analogous exposure settings for product for which exposure information exists. This was done for one product's manufacturing stage, eight products' repair and disposal stage, and nine products' installation stage. The basic rationale for this procedure is that similar activities involving roughly similar exposure settings and concentrations are likely to result in similar exposures.

In some non-occupational exposure settings for which data did not exist but in which exposures are likely, one percent of the asbestos content of the product was assumed to be released per year over the life of the product. These releases would be caused by normal weathering of products or by various activities, such as cutting, sawing, and sanding, that occur to the products in the course of their use.

Table ES-3 tabulates the results of these sensitivity analyses using Regulatory Alternative J (the 3-stage product ban at dates 1987, 1991, and 1994, exempting a number of products such as missile liner and diaphragms, regulating original equipment and aftermarket drum and disc brakes separately). The table lists the total costs, total cancer cases avoided, and the implied cost per cancer case avoided, using (1) both the 3 percent discount rate for both costs and benefits and the alternative discounting scenario of 0 percent for benefits and 3 percent for costs, and (2) the Low Decline baseline. Five distinct scenarios are presented: 1) the base case presented above for Regulatory Alternative J, 2) declining substitute prices alone, 3) additional occupational exposure assumptions, 4) additional non-occupational exposure

TABLE ES-3: SENSITIVITY ANALYSIS FOR DECLINING SUBSTITUTE PRICES AND ALTERNATIVE ASBESTOS EXPOSURE ASSUMPTIONS USING REGULATORY ALTERNATIVE J
(Low Decline Baseline)

Discounting Scenario and Costs* and Benefits	Base Case	Declining Substitute Prices**	Additional Occupational Exposure	Additional Nonoccupational Exposure	All Sensitivity
<u>3-Costs/3-Benefits Discounting</u>					
Total Cost ($1,000,000's):	$ 748	510	748	748	510
Total Cancers Avoided:	122	122	153	177	209
Cost Per Case ($1,000,000's):	6.1	4.2	4.9	4.2	2.5
<u>3-Costs/0-Benefits Discounting</u>					
Total Cost ($1,000,000's):	748	$ 510	748	748	510
Total Cancers Avoided:	167	167	208	240	281
Cost Per Case ($1,000,000's):	4.5	3.1	3.6	3.1	1.8

* Total domestic cost
** All substitute prices assumed to decline at 1 percent per year

Note: Table contains rounded entries.

assumptions, and 5) declining substitute prices and both sets of additional exposure assumptions simultaneously.

As the figures in the table indicate, allowing for a decline of all asbestos product substitute prices at a rate of one percent per year reduces the estimated costs by almost one-third. Because it is the difference between the asbestos product price and the cost of substitutes that is counted as a cost in the consumer surplus losses, not the absolute level of the prices of substitutes, even moderate declines over time of the prices of substitutes can produce fairly large reductions in the costs of banning asbestos products.

The added occupational exposures, as the table indicates, suggest that an additional 41 cancer cases (undiscounted) might be avoided by Alternative J if the additional occupational exposures assumed are accurate. An even larger number of cancer cases, some 73 additional cases, might be avoided by this alternative if the additional non-occupational exposures developed are accurate. Costs and benefits allowing for both declining substitute prices over time and the two additional sets of exposures are shown in the final column of the table. As these figures indicate, the impacts of each of the three sensitivity assumptions are independent and additive, at least for this regulatory alternative. That is, the decline in costs for this combination of sensitivity assumptions is the same as for the declining substitutes prices alone scenario, and that the increased benefits for this scenario equal the sum of the increased benefits for the two benefit-side sensitivity analyses conducted independently.

Finally, the cost per cancer case avoided (using the 3 percent discounting for both costs and benefits) falls from the base case level of $6 million to $2.5 million for all three sensitivity assumptions combined. Again, although these are sensitivity analyses, on the exposures side the assumptions concerning added exposures to asbestos are intended to address lack of data -- exposure settings in which exposures are believed to occur, but for which data do not exist. On the costs of substitutes side, the assumption of a 1 percent decline in all substitute prices is illustrative only. However, for many substitute products, over time costs and prices may well decline as accumulated production and manufacturing experience make these cheaper to produce and to use in place of asbestos products.

I. BACKGROUND

Asbestos is a naturally occurring substance applied in a wide variety of industrial uses because of its desirable properties and because it can be produced at prices competitive with those of available substitutes. Exposure to asbestos dust has been shown to increase significantly an individual's risk of contracting a number of potentially serious diseases.

The Toxic Substances Control Act (TSCA) of 1976 requires the U.S. Environmental Protection Agency (EPA) to evaluate toxic substances such as asbestos and to determine if they pose unreasonable risks to health or the environment. The unreasonable risk determination is based on a comparison of the costs of controlling the risk against the benefits of controlling that risk. The Office of Toxic Substances (OTS) has performed a preliminary evaluation of the risks posed by asbestos products and has determined that all uses of asbestos products may pose an unreasonable risk due to the potential for exposure to asbestos throughout the life cycle of the asbestos products; that is, the mining, milling, manufacturing, processing, use, and disposal of the asbestos product. Therefore, all uses of asbestos should be controlled as long as control costs are "reasonable" relative to the risks posed.

The purpose of this RIA is to identify, quantify, and, where feasible, value benefits and costs of various regulatory alternatives for controlling exposure to asbestos, ranging from "staged" bans on asbestos products (i.e., bans on products at different points in time) to fiber phase-down options both with and without product bans. The RIA attempts to meet four goals: (1) to identify properly the potential benefits and costs of asbestos controls; (2) to review some of the key relationships and issues that would affect the magnitude of the benefits and costs of the controls; (3) to project the expected benefits and costs of asbestos controls, and (4) to assess the distribution of the costs and benefits. This study will identify explicitly the logic behind the development of benefit and cost projections, thereby allowing the public to make a more informed judgment concerning potential benefits and costs of asbestos controls.

Finally, this RIA is designed primarily to provide data and results for use in the process of assessing alternative asbestos control strategies. Thus, the specific regulatory alternatives discussed in this document are intended primarily to guide the options selection and development process by providing information on a wide variety of regulatory alternatives. By comparing results of the different scenarios discussed here, the costs and benefits of alternative regulatory strategies can be assessed.

A. Asbestos Background

Since 1900, it has become increasingly evident that exposure to asbestos dust can significantly increase an individual's risk of contracting diseases, including cancers. Such diseases frequently end in death, and when they do not, activity is reduced as respiratory function is restricted. Initially, the findings on the hazards of asbestos were confined to occupationally exposed individuals, but more recent evidence points to the likelihood that even low exposures of the non-occupationally exposed are potentially hazardous. In response to such information, the U.S. Government has taken steps to reduce human exposure to asbestos. Although asbestos use is declining in the United States, it is still used in a variety of applications and asbestos dust is still being released into the environment.

The only method of completely removing these risks is to remove asbestos from the marketplace by eliminating the asbestos products, by eliminating the asbestos fiber used to produce these products, or both. Thus, one advantage of a combined ban and phase-down approach is that selected products can be eliminated quickly with a ban, and all others can be eliminated over time through the fiber phase-down rule.

1. Historical Perspective

The unique physical properties of asbestos fiber have made it an important component in many diverse manufacturing activities. Used since the first millennium B.C., asbestos became increasingly important after 1850. During the 20th century, however, evidence of the adverse health effects associated with asbestos exposure at all stages of production and consumption has been mounting.

Beginning in 1900 with the first autopsy report of pulmonary fibrosis in an asbestos worker, asbestos has been linked with numerous ailments, including asbestosis, a chronic fibrotic lung disease caused by asbestos fiber inhalation; malignant mesothelioma, a cancer of the pleura or peritoneum; bronchial carcinoma (lung cancer); and cancers of the gastrointestinal tract.

Since the initial asbestosis report in 1900, awareness of potential dangers of asbestos has grown, albeit slowly. High lung cancer rates in asbestosis victims were first observed in 1935. The tie between asbestos and malignant mesothelioma was documented in 1953. In 1960 it was reported that, in addition to miners, residents of asbestos mining towns are prone to mesothelioma, indicating that even very brief exposure to asbestos may pose health risks.

Increased knowledge of the effects of asbestos on individuals has precipitated two types of governmental response: enactment of compensation laws, and promulgation of various regulations governing asbestos use. As early as 1913, asbestos-related illness was included by three States under workman's compensation laws. By 1979, as a result of statutory extensions, 90 percent of the work force was covered by such provisions.

Federal regulations implemented during the past decade have restricted worker and consumer exposure to asbestos fibers. However, some of the more recent medical studies imply that the current asbestos problem has a somewhat different focus than previously believed. In the past, Federal regulations concerning asbestos worker safety and worker's compensation laws covering asbestos-related disease addressed the problems of a relatively small group of workers experiencing high levels of asbestos exposure. Evidence now indicates that low-level asbestos exposure in both occupational and nonoccupational settings is also a problem. However, while evidence of the health problems associated with asbestos accumulates, asbestos production and use continue, due mostly to its relative cost advantage in some areas of manufacturing.

2. History of Asbestos Regulation

Federal regulatory action on asbestos has taken a variety of forms. Regulations have been promulgated by the EPA, Consumer Product Safety Commission (CPSC), Department of Transportation (DOT), Food and Drug Administration (FDA), Mine Safety and Health Administration (MSHA), and the Occupational Safety and Health Administration (OSHA).

In 1972, OSHA promulgated regulations to reduce worker exposure to asbestos dust in occupational settings (37 FR 11318). These regulations mandated introduction of new materials handling systems and other measures to limit the maximum level of airborne asbestos fibers in the workplace to 5 fibers/cubic centimeter (f/cc) of air initially, with reduction to 2 f/cc of air by 1976.

In 1980, the National Institute for Occupational Safety and Health (NIOSH), which acts as advisor to OSHA, recommended a twenty-fold decrease in the maximum asbestos-fiber-exposure limit permissible in the workplace. NIOSH suggested increased use of asbestos substitutes and implementation of more extensive medical testing procedures. Employers were encouraged to report aggregate medical information to their employees and to arrange transfers for asbestos workers with respiratory disease to lower exposure jobs. In addition, further regulations to protect all workers exposed to asbestos and additional rules for air sampling were recommended for asbestos product manufacturers.

Recently, OSHA issued a final rule implementing many of these recommendations and lowering the workplace standard to 0.2 f/cc of air as an 8-hour time-weighted average (51 FR 22612). In 1974, MSHA prescribed maximum exposure levels to asbestos dust for workers in domestic mines of 5 f/cc of air (39 FR 24316). In 1978, this requirement was lowered to 2 f/cc (43 FR 54064).

Under the authority of the Consumer Product Safety Act (CPSA, 15 U.S.C. 2051), the CPSC has issued rules banning consumer patching compounds containing respirable asbestos (16 CFR Part 1304) and artificial emberizing materials containing respirable asbestos (16 CFR Part 1305). The CPSC took those actions based on findings that the use of those products in the household would result in increased risk of cancer. Earlier, the Food and Drug Administration under the Federal Hazardous Substances Act (FHSA, 15 U.S.C. 1261) banned "general use garments containing asbestos other than garments having a bona fide application for personal protection against thermal injury and so constructed that the asbestos fibers will not become airborne under reasonably foreseeable conditions of use" (16 CFR 1500.17). The FHSA is now administered by the CPSC.

In 1980, CPSC issues a general order requiring persons to furnish information on the use of asbestos in certain consumer product categories. CPSC has also measured potential consumer exposure to asbestos from such products as asbestos millboard, asbestos paper products, and stove door gaskets. In 1986, CPSC issued labeling requirements for "household products containing intentionally added asbestos that, under any reasonably foreseeable conditions of handling and use are likely to release asbestos fibers" (51 FR 33911, September 24, 1986).

EPA has undertaken regulatory action on asbestos under the Clean Air Act, the Clean Water Act, and TSCA. In 1971, under the authority of the Clean Air Act, EPA designated asbestos a hazardous air pollutant. On April 6, 1973 (38 FR 8820), EPA promulgated the national emission standard for asbestos. The standard prohibited visible emissions from asbestos mills and from nine different manufacturing industries, specified certain work practices for demolition of structures that contain friable asbestos, limited to less than 1 percent the asbestos content of spray-on materials used for certain insulation applications, and prohibited most uses of asbestos tailings for surfacing roadways.

The asbestos NESHAP regulation has been revised several times. On October 14, 1975 (40 FR 48292), it was revised to prohibit all uses of asbestos-containing waste and asbestos tailings in road construction. Regulation of demolition and renovation was expanded, and the "no visible emissions" requirement was extended to additional asbestos-using manufacturers. The revisions also dealt with waste disposal requirements for asbestos mills and manufacturing facilities. Furthermore, the regulation prohibited insulating with either friable, molded insulating materials or with wet-applied insulating materials that become friable when dry. Revised in 1977 and again in 1978, the regulation currently prohibits visible emissions from milling, manufacturing, and asbestos waste disposal activities (43 FR 26372). It also prohibits the use of asbestos-containing materials for surfacing roadways and provides work practices guidelines in demolition and renovation operations.

The 1978 decision by the U.S. Supreme Court in Adamo Wrecking Company vs. United States held that the work practice provisions in the asbestos standard were not emission standards and that the Clean Air Act Amendments of 1970 did not empower EPA to issue non-emission (e.g., work practice) standards. However, Congress acted to broaden EPA's Authority by amending Section 112 of the Act, and EPA in 1984 repromulgated the CAA rule (49 FR 13658). The 1977 Amendments allow EPA to promulgate design, equipment, and operational standards to control hazardous emission sources where a numerical emission limit is not feasible. Although the 1977 Amendments allowed promulgation of non-emission standards, they did not specifically authorize enforcement of these standards. The question of enforceability of non-emission standards, in general, was resolved through passage in 1978 of the Health Services Research, Health Statistics, and Health Care Technology Act. This act equated design, equipment, work practice, and operational standards with emission standards, thereby allowing EPA to enforce both emission and non-emission standards.

In 1973, EPA cited asbestos as a potential source of water pollution (38 FR 22606). Effluent limitation guidelines for asbestos manufacturing were promulgated in 1974 and 1975 (39 FR 7528 and 40 FR 1874).

As mentioned earlier, TSCA provides a broad range of alternative control options that EPA might exercise in its efforts to safeguard the environment from toxic substances. Under Section 6 of TSCA, EPA published a rule May 27, 1982 (47 FR 23360), requiring inspection of public and private primary and secondary schools in the United States to sample friable material to determine whether or not it contained asbestos. The schools also were required to notify any parent-teacher organizations of the inspection results and to educate their employees on methods of reducing the risks of exposure.

In 1986, President Reagan signed into law the Asbestos Hazard Emergency Response Act (AHERA), which enacted Title II of the Toxic Substances Control Act (TSCA). Title II requires EPA to promulgate regulations requiring the identification and abatement of asbestos hazards in the nation's schools and to develop a model accreditation plan for persons who inspect for asbestos, who develop management plans for asbestos abatement, and who perform asbestos abatements. On October 30, 1987, EPA promulgated rules requiring every school district to inspect every school building for friable and non-friable asbestos and to file a management plan for every school building by October 12, 1988 (52 FR 41826, October 30, 1987).

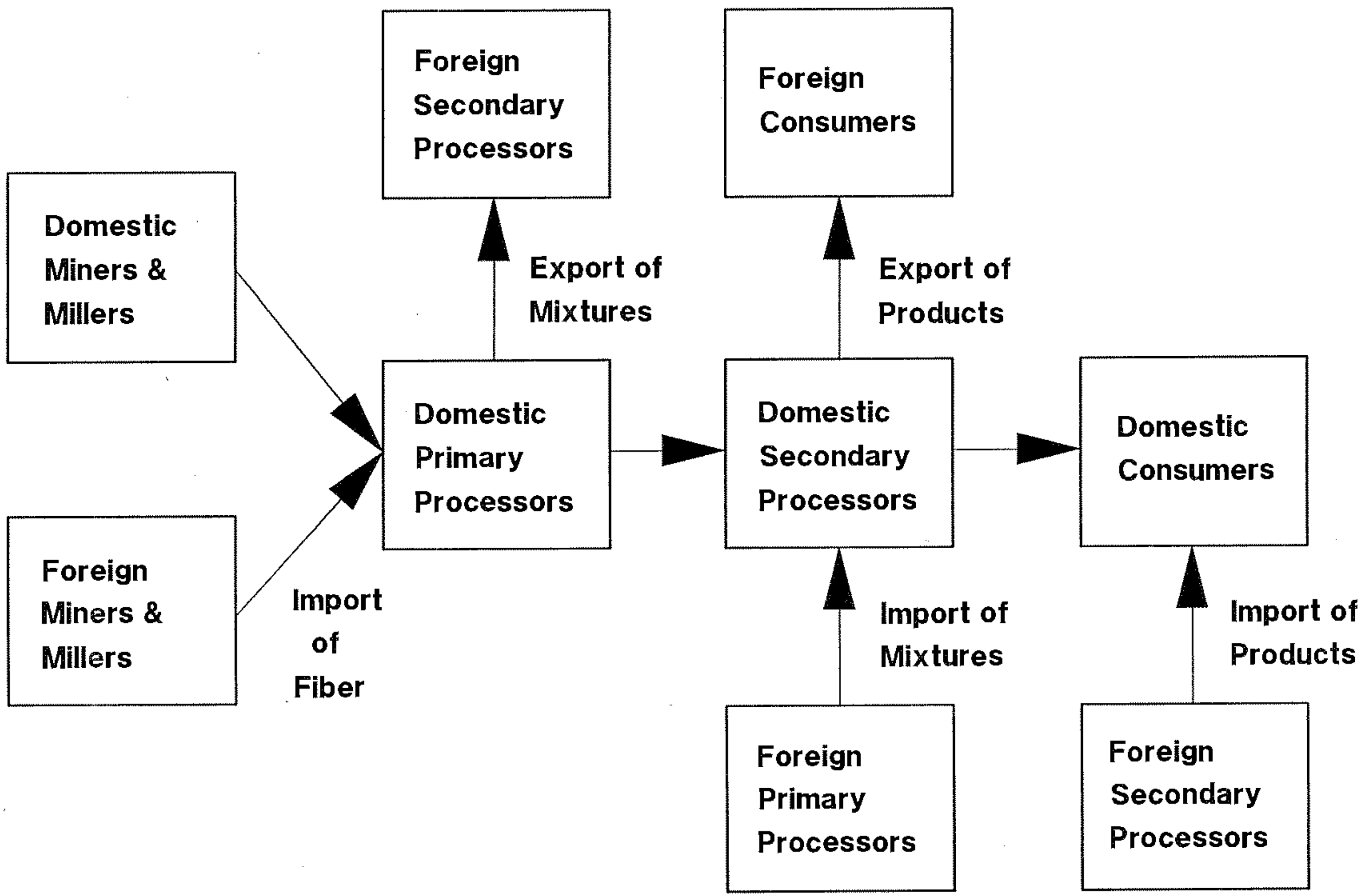
In 1986, EPA promulgated a rule under Section 6 of TSCA to extend the protection of the OSHA Asbestos Standard to state and local employees who engage in asbestos abatement and who are not covered by and OSHA-approved state plan or equivalent state regulations (51 FR 15722, April 25, 1986). (The OSHA act does not cover state and local employees.) In 1987, EPA amended to rule to make it consistent with OSHA's regulations, which had been recently revised (52 FR 5618, February 25, 1987).

On July 30, 1982, EPA also published a rule under Section 8(a) of TSCA requiring manufacturers, processors, and importers of asbestos to make detailed reports to EPA (47 FR 33198). The rule required data on worker exposure to asbestos; the quantity of asbestos and asbestos products manufactured, imported, and exported; and waste and pollution control equipment. Some of the data used in this analysis were received by EPA in response to the asbestos-reporting rule.

B. <u>Asbestos Use Overview</u>

Asbestos fibers have been used in the manufacture of a variety of products intended for industrial and consumer use. The concentration of fiber within the final product depends on the application, but all products are formulated according to the diagram in Figure I-1. As illustrated, asbestos fiber from domestic or imported sources (in 1985, approximately 92 percent of the asbestos

FIGURE I-1. U.S. AND WORLD ASBESTOS MARKETS



fiber consumed in the U.S. was imported from Canada) is mixed with other ingredients by a "primary processor" to form an asbestos mixture. This mixture is then processed further, by a "secondary processor" to form a product that can be used in one or many applications. It is important to note that the output of the primary or secondary processor can be exported or imported and that final products come from many sources.

In 1981, the production of asbestos-containing goods was distributed among the thirty five product categories identified in Table I-1. By 1985, however, production in some of these areas had ceased and fiber consumption (including imports) was reported as zero.

Table I-1 also reports fiber consumption for all of the product categories that continued to be produced in 1985 and reports the output of final products in appropriate units. The number of firms producing asbestos-containing products between 1981 and 1985 declined, with only 180 primary processing plants producing in 1985 compared to 210 in 1981.

C. Nature of the Regulatory Alternatives

Despite the declining U.S. usage of asbestos fiber during the past years, continued uncontrolled use of asbestos poses a substantial risk to both workers and the population at large. Hence, a number of different regulatory alternatives for controlling exposures to asbestos were considered in this Regulatory Impact Analysis. These include:

- bans of certain asbestos-containing products;
- phase-downs of asbestos use; and
- combinations of these two approaches.

Product bans are a direct method of avoiding exposures to asbestos. This form of regulation typically makes the most sense if (1) substitutes for asbestos or for the product itself are available at reasonable cost, and (2) cost effective means for reducing exposure are not known or are not

TABLE I-1. ASBESTOS FIBER CONSUMPTION AND FINAL PRODUCTION FOR ASBESTOS PRODUCT CATEGORIES

TSCA #	Product Category	Asbestos Fiber Consumed (short tons)	Production Volume	Number of Plants
1	Commercial Paper	0.0	0 tons	0
2	Rollboard	0.0	0 tons	0
3	Millboard	435.8	581 tons	1
4	Pipeline Wrap	1,333.3	296,949 squares	1
5	Beater-Add Gaskets	12,436.4	16,505 tons	5
6	High Grade Electrical Paper	744.0	698 tons	1
7	Roofing Felt	0.0	0 tons	0
8	Acetylene Cylinders	584.1	392,121 pieces	3
9	Flooring Felt	0.0	0 tons	0
10	Corrugated Paper	0.0	0 tons	0
11	Specialty Paper	92.1	434 tons	2
12	V/A Floor Tile	10,374.0	18,300,000 square yards	1
13	Asbestos Diaphragms	977.0	9,770 pieces	1
14	A/C Pipe	32,690.8	15,062,708 feet	3
15	A/C Sheet, Flat	2,578.8	22,621 squares	2
16	A/C Sheet, Corrugated	0.0	0 squares	0
17	A/C Shingles	3,893.0	176,643 squares	1
18	Drum Brake Linings (OEM)	6,642.3	34,713,675 pieces	13
19	Disc Brake Pads, LMV (OEM)	1,089.2	10,077,464 pieces	13
20	Disc Brake Pads (HV)	117.6	156,820 pieces	2
21	Brake Blocks	2,643.6	4,570,266 pieces	8
22	Clutch Facings	993.5	7,237,112 pieces	3
23	Automatic Trans. Components	2.5	585,500 pieces	2
24	Friction Materials	1,602.5	8,719,541 pieces	5
25	Asbestos Protective Clothing	0.0	0 tons	0
26	Asbestos Thread, etc.	558.0	1,125 tons	1
27	Sheet Gaskets	5,441.1	3,607,408 square yards	6
28	Asbestos Packing	2.1	3 tons	2
29	Roof Coatings	29,551.2	75,977,365 gallons	31
30	Non-Roofing Coatings	2,951.4	9,612,655 gallons	51
31	Asbestos-Reinforced Plastics	812.1	4,835 tons	8
32	Missile Liner	700.0	4,667 tons	6
33	Sealant Tape	1,660.2	423,048,539 feet	4
34	Battery Separators	1.0	2,046 pounds	2
35	Arc Chutes	13.5	900 pieces	1
36	Drum Brake Linings (A/M)	18,049.4	94,328,903 pieces	**
37	Disc Brake Pads, LMV (A/M)	6,030.0	55,791,708 pieces	**
		145,000.5		179

** Number of plants producing OEM and aftermarket (A/M) brakes cannot be distinguished.

Source: ICF Asbestos Market Survey

sufficiently certain to guarantee avoidance of exposure. Some of the product bans examined in this RIA are "staged" bans of products in the sense that groups of products are banned at different points of time in the future. Such a strategy allows for banning products earlier if feasible substitutes already exist and for banning groups of products later for which substitution for asbestos may require more time.

A phase-down of asbestos usage is another option for regulating asbestos exposure. A phase-down of asbestos fiber use would operate much like quota systems often used for certain imported goods. For example, yearly limits on the total amount of asbestos fiber allowed to be mined or imported could be defined. If these quotas declined over time, smaller and smaller quantities of asbestos fiber would be embodied in products over time. Although the end result of this form of regulation is similar to product bans (if fiber use is phased down to zero, the end result is the same as a complete asbestos product ban), the operation of a phase-down in the short run is different. A phase-down reduces asbestos use over time, allowing some time for substitutes to be developed and for any dislocations associated with an immediate ban to be mitigated or avoided by spreading the asbestos use reduction over time. A phase-down has the added benefit of distributing the asbestos use allowed to those activities for which it is the most costly to substitute away from asbestos use.*

Finally, combinations of the two regulatory approaches were also considered. For example, some products could be banned immediately while the fiber use in the remaining products is phased-down over time. Similarly, the timing of a phase-down and of various product bans can be altered to create

* This conclusion assumes that the mechanism for allocating fiber under a phase-down is competitive or that the rights to the scarce fiber can be reallocated by market forces after the initial allocation.

distinct regulatory alternatives.*

This RIA reviews all of the qualitative and quantitative efforts undertaken to evaluate the many different regulatory alternatives considered. No "preferred" alternative is identified in this RIA because the primary purpose of this report is to provide information, data, and results for a wide variety of possible regulatory alternatives for use in the options selection process. Thus, the particular regulatory alternatives presented in this RIA are designed to span a number of possible control strategies for asbestos. By providing information for many options under different conditions, the relative advantages of different approaches can be assessed qualitatively and quantitatively.

The remainder of Volume I of this RIA is organized as follows:

- Chapter II outlines the different regulatory alternatives evaluated and presents the theoretical approach for measuring the costs and benefits of the various regulatory alternatives considered;
- Chapter III summarizes the data developed for quantitative estimation of the costs and benefits for the regulatory alternatives; and
- Chapter IV presents the estimated costs and benefits for the regulatory alternatives considered.

Appendices that support the analyses and results in this RIA follow Volume I of this RIA. These contain (1) additional detail concerning the theoretical and computational procedures employed in evaluating the regulatory alternatives including computer model codes (Volume II), (2) sources and other information relating to asbestos product markets data collected and developed

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* Other methods of regulating asbestos exposure are also being explored in this regulatory process. Such methods as engineering controls to reduce exposure in certain activities involving asbestos products could be feasible depending on the risk reduction offered and the costs associated with them. These alternative methods of regulating asbestos are not examined in detail in this version of the RIA, although some illustrative results appear in Appendix G of this RIA.

for the quantitative cost and benefit estimates presented in the RIA (Volume III), and (3) sensitivity analysis of the cost/benefit results using alternative assumptions regarding future asbestos use in products (Volume IV).

II. APPROACH FOR COST/BENEFIT ANALYSIS

This chapter of the Regulatory Impact Analysis outlines the theoretical approach developed for estimating the costs and benefits of the regulatory alternatives for controlling exposure to asbestos analyzed in this RIA. The alternatives considered in this RIA are presented to assist in the options selection process, so the specific alternatives examined here are designed to illustrate quantitatively the range of costs and benefits of various types of options.

A. Approach for Estimating Benefits

Only one source of benefits associated with reduced exposure to asbestos -- reduced cancer cases -- is estimated quantitatively in this RIA. Although asbestos causes other health effects, the cancer risks of asbestos exposure are well-known and well-researched and hence, are estimated quantitatively here. This quantification of only cancer cases avoided implies that the numerical estimates of the benefits developed in this RIA are lower bounds for the benefits of controlling exposure to asbestos. Asbestosis, for example, can have a significant impact in terms of medical care expenses, reduced productivity, and deterioration of quality of life. Furthermore, families of workers exposed to asbestos are not taken into account in this analysis, so that any health effects associated with these secondary exposures are not included in the estimates of benefits presented here. Finally, lack of exposure data for some asbestos products prevented a quantitative assessment of benefits for these categories even though benefits are likely to exist for these products. For all of these reasons, the benefits estimates of the asbestos regulatory alternatives reported in this RIA are quite likely to be underestimates of the true social benefits of the regulatory alternatives.

1. Benefits Model Overview

The approach developed for estimating the reduction in mortality due to controlling asbestos exposure applies to all of the different regulatory alternatives considered. Put simply, the reduction in mortality due to asbestos controls equals the baseline level of risk minus the risks remaining under the relevant regulatory alternative. For example, the mortality reduction benefits of banning some of the asbestos products equals the level of risk associated with the baseline less the risks remaining due to the non-banned products; the benefits equal the risks avoided by banning these products.

The health benefits model developed for estimating the benefits of asbestos controls is designed to project the health benefits from regulation-induced changes in asbestos exposures due to releases from asbestos products manufactured over the period 1987-2000. Regulatory alternatives may change the quantities of asbestos products manufactured over the next twenty years, and hence, the number of people exposed to asbestos fiber. The level of exposure is assumed to remain constant at the 1985 level except where impacted by the OSHA 0.2 f/cc PEL. Dose-response relationships between exposure level and disease death rates, for lung cancer, mesothelioma, and gastrointestinal cancer, are combined with the numbers of people exposed both with and without the regulatory alternative's requirements and their levels of exposure to estimate the number of cancer deaths avoided by the regulatory alternative. Finally, when combined with the estimated cure rates for the different asbestos-related cancers, the number of deaths avoided can be translated into the number of cancer cases avoided by each regulatory alternative.

This overview of the benefits approach indicates that two distinct tasks are necessary: (1) derivation of exposure estimates for both the baseline and the regulatory alternatives, and (2) development of dose-response relationships to estimate cancer cases based on the duration and intensity of exposure to asbestos. Each of these steps is discussed below.

2. Exposure Estimation

Health effects of exposure to asbestos products manufactured between 1987 and 2000 are estimated on a product by product basis. For each product, the population at risk is subdivided into the following exposure categories:

- Primary manufacturing, both occupational and nonoccupational;
- Secondary manufacturing, both occupational and nonoccupational;
- Installation, both occupational and nonoccupational;
- Use, both occupational and nonoccupational; and
- Disposal or repair, both occupational and nonoccupational.

Occupational exposure occurs among individuals employed in the manufacture, installation, use, and repair or disposal of the asbestos product. Nonoccupational exposure can be subdivided into ambient exposure and consumer exposure. Ambient exposure occurs among persons living or working close to the site of manufacture, use, repair, or disposal of asbestos products. Consumer exposure occurs among those consumers who personally install, use, repair, or dispose of asbestos products. The timing of exposures depends on the activity that gives rise to exposure. Exposures from releases during product installation, for example, are assumed to be contemporaneous with those from primary and secondary product manufacturing, while exposures during repair or disposal are assumed to occur at the end of the average product life. Finally, exposures during product use are assumed to be evenly distributed across the time from product manufacture to repair or disposal. The methods used to estimate these sources of exposure are summarized in the following subsections.

a. <u>Approach for Estimating Occupational Exposure</u>

The basic approach for estimating occupational exposures was to update previous studies and data sources for the many sources of occupational asbestos exposure, as outlined in a previous study (ICF 1988). Available occupational exposure and air emission data from NIOSH, academic, and industry studies were supplemented by OSHA Compliance data and the ICF Exposure Survey (ICF 1988). The ICF Exposure Survey, which covered both occupational exposures and air releases, was sent to all miners/millers of asbestos, primary and secondary manufacturers of asbestos products, and several relevant industry groups. OSHA Compliance data were supplied by the OSHA Office of Management Data Systems for the SICs corresponding to manufacturing, construction, and automotive servicing.

Although most of the analysis in this RIA is disaggregated to the level of some 35 asbestos product markets, the limited availability of exposure data on products at this level of disaggregation forced the estimation of exposure levels to a higher level of aggregation. Hence, exposure estimates were developed for eight groups of asbestos products. However, these aggregated product-category exposures were applied to product-specific worker populations and population distributions, thus retaining as much detailed product-specific risk information as possible. The analysis also assumes that job category exposures for all products in a given product category are identical, which is reasonable given that similar job activities in related products are likely to generate similar exposures. The product categories for which detailed exposure analysis was conducted are:

- Paper products;
- Friction products;
- Asbestos cement products;
- Asbestos-reinforced plastics;
- Coatings;

- Packings and gaskets;
- Textiles; and
- Miscellaneous uses.

Finally, the approach for developing exposure estimates does not include products either no longer produced in the U.S. or no longer imported into the U.S., such as commercial paper, corrugated paper, rollboard, flooring felt, roofing felt (imported only), corrugated A/C sheet (imported only), and vinyl asbestos floor tile.*

In the approach developed for estimating occupational exposures, current exposure levels associated with each job category or task are based on historical data. Both geometric and arithmetic means of the raw measurement data are computed. The geometric mean represents a typical (median) exposure level for a worker performing a particular job, assuming that the observations follow a log normal distribution which is common for exposure data. The arithmetic mean, on the other hand, represents average worker exposure. The arithmetic means are used in the health benefits model to assess the consequences of exposure since total health benefits are dependent on all worker exposures, high, low, and typical.

Total 1985 worker populations for primary and secondary product manufacturing for each product were calculated by summing the worker populations for each separate asbestos product producer identified and surveyed during the ICF Market Survey. These total worker populations were then distributed into specific job categories (corresponding to monitoring tests and results) according to the population distributions for workers in these job categories contained in the information submitted under the 1981 TSCA Section

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* Occupational exposure levels and population factors for products no longer produced or used in the U.S. are presented in Appendix G of the occupational asbestos exposure assessment, ICF (1988).

8(a) requirement. Exposed populations for mining and milling were obtained through telephone contacts with company representatives.

Since installation, repair, and removal jobs are intermittent, populations for brake repair and construction are calculated as full-time equivalents (FTEs). The FTE population is the number of workers working 250 days/year and 8 hours/day at installing, repairing, and removing the total quantity of an asbestos product manufactured or imported each year (quantity information for each asbestos product were developed in the ICF Asbestos Market Survey). Short-term exposures, which represent exposure during the period of time in which the actual task is performed, were applied to this population.

OSHA's recently promulgated final 0.2 f/cc PEL raises a significant issue in projecting current and future occupational asbestos exposures. The approach used in this analysis assumes that for those operations where 8-hour TWA exposures are currently below 0.2 f/cc, work practices will remain unchanged. However, for those operations where the 8-hour TWA exposures in 1985 were estimated to be above 0.2 f/cc, work practices will be changed either with the addition of engineering controls or respirators to reduce the exposures to the 0.2 f/cc PEL.* Thus, in these cases, exposure estimates were reduced to 0.2 f/cc.

b. Approach for Estimating Non-Occupational Exposure

Non-occupational exposures were estimated using two methods, each corresponding to a separate class of exposure. One method was used to estimate the exposures that occur due to consumer installation, use, and repair of asbestos products, such as brakes. Another method was developed to estimate the ambient emissions associated with production activities involving asbestos

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* The estimated exposures in excess of the .2 f/ml PEL are due to older readings, i.e., prior to the promulgation of the final OSHA standard.

and the exposures of populations that result. The approaches developed for each of these sources of exposure are discussed separately below and in more detail in Appendix A-4.

i. Non-Occupational Exposure in Product Use

The approach for estimating non-occupational exposure to asbestos is outlined in detail in Versar (1987). This method focused on five exposure categories:

- Airborne emissions from brake use;
- Consumer exposure from coatings, sealants, and paints;
- Consumer exposure from asbestos vinyl floor tile;
- Consumer exposure during brake repair; and
- Consumer exposure to other asbestos products.

For airborne emissions from brakes, existing estimates in the literature of emissions of asbestos during braking were updated using more current information on vehicle use, brake types, and vehicle types. Using these estimates of emissions, the total emissions of asbestos in the U.S. were calculated based on the number of vehicles registered, the average number of miles driven per year, and the distribution of vehicles across cars, trucks, and motorcycles. The total emissions of asbestos in 24 different cities across the U.S. were also computed based on gasoline usage and average vehicle mileage information. Ambient concentrations of asbestos due to these emissions were estimated using a computerized dispersion model of emissions, land area, and meteorological characteristics of the 24 different cities. Finally, exposures on a national level were developed using several methods, including best-case and worst-case assumptions. Worst-case estimates were generated by assuming that rural areas experienced the same ambient concentrations of asbestos as the group of small cities in the 24 cities modeled and that all other areas experience ambient concentrations at the levels of similar sized cities in the group of 24 cities modeled. Best-case estimates, on the other hand, assumed zero ambient concentrations in rural areas. The approach used to estimate consumer exposures to vinyl asbestos floor tile was based on existing studies of asbestos inhalation and emission rates both in removal of tiles and in ordinary wear, as discussed in Versar (1987).

For consumer exposures to asbestos during brake repair, Versar applied the fiber concentration estimates for different phases of brake repair contained in several existing articles to the kinds and durations of activities involved in consumer "do-it-yourself" brake repair.

For the other asbestos products, Versar either found no data to estimate consumer exposures or no evidence of exposure during product use because some of these products are formulated in such a way that the asbestos fibers are bound within other materials. The lack of data for estimating exposures for some products and activities implies that the benefits estimated for the regulatory alternatives examined in this RIA are likely to be underestimated.

ii. Ambient Exposure Estimation

Ambient exposures due to product manufacture were estimated by first calculating the emissions attributable to asbestos product manufacturing activities and then modeling the transport of the asbestos fibers to the surrounding population.

To calculate emissions, air releases were estimated for each mining/milling and product manufacturing facility using site-specific data and engineering estimates of baghouse collection efficiencies, as discussed in detail in ICF (1988). Air releases from brake servicing and construction, however, were calculated as annual industry emissions due to the lack of site specific information in these geographically widespread industries.

The approach for estimating air releases during milling and primary manufacturing was based mostly on model plant analyses developed by the EPA

Office of Air Quality Planning and Standards (OAQPS) and the EPA Exposure Assessment Branch as discussed in ICF (1988). Under this approach, emission rates from these activities were estimated using information on plant characteristics -- stack dimensions, exhaust gas velocity, temperature, and flow rate, collection efficiencies of control devices, and asbestos collection by the control devices. These estimates were combined with production information from the Asbestos Market Survey to produce annual emissions of asbestos from these operations.

The approach for the second step in developing estimates of ambient exposures -- modeling fiber transmission and exposure of the surrounding populations -- was developed by Versar (1988). The emissions estimates developed by ICF (1988) were combined with population information by ZIP Code. Versar then generated exposure estimates by plant using an atmospheric dispersion model based on the populations surrounding each plant and the emissions estimated for each plant. The resulting exposure estimates were then aggregated by product category for use in the health effects estimation model.

3. Dose-Response Relationships

Numerous human and animal studies have documented the correlation of exposure to asbestos fibers with increased incidence of certain diseases, including asbestosis, lung cancer, mesothelioma, gastrointestinal cancer, and other cancers. While much of the research has focused on effects of exposure to the levels of asbestos typically associated with occupational exposures before 1972, evidence indicates that even low exposures are likely to be hazardous. Studies indicate that at low concentrations, lung cancer and mesothelioma present the greatest threat to human health (Jacob and Anspach 1964; Peto 1979). According to the Nicholson report (USEPA 1986), there are fourteen epidemiologic studies demonstrating increasing exposure to various forms of asbestos. Similarly, there are four studies providing quantitative data demonstrating a dose-response relationship for mesothelioma.

The asbestos-related diseases that are analyzed in this study are lung cancer, mesothelioma and gastrointestinal cancer. To the extent that other cancers and asbestosis are induced by low exposures, restricting the estimates of the health benefits of controls on asbestos to these specific cancers will underestimate the benefits.

In developing dose-response relationships for exposure to asbestos in both the baseline and under the regulatory alternatives, a number of key factors were considered. These are reviewed briefly below.

a. Time Between Onset of Exposure and Diagnosis of Asbestos-Related Disease

This analysis is restricted to health changes from regulation-induced changes in exposure to asbestos between 1987 and 2000. These effects would not be expected to be apparent until after 1997 because of the long time that usually elapses between onset of exposure and diagnosis of an asbestos-related disease. For example, the time between onset of exposure and diagnosis of disease for lung cancer usually ranges from 20 to 40 years. This range can be partially explained by the apparent action of asbestos to increase the general population risk by a factor proportional to cumulative exposure. Because the general population risk is very low before age 40, cases of asbestos-induced cancer are unlikely to be observed before this age, no matter what the age of initial exposure.* According to Seidman et al. (1979), a minimum time period of 10 years is usually observed between onset of exposure and diagnosis of disease.

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* Seidman et al. (1979) reported a shorter lag time when initial exposures occurred at the cancer ages (over age 40), which would be consistent with this explanation.

Mesothelioma also has a long time lag to diagnosis (i.e. 20 to 50 years) from onset of exposure, but this appears to be independent of age at first exposure (Peto et al. 1982). Peto also indicates a minimum period of 10 to 15 years is usually observed between onset of exposure and diagnosis of the disease. Among insulation workers, the ratio of excess lung cancer to mesothelioma has been shown to be greater when exposure started later, over 25 years of age, rather than between 18 and 25 years. If the ratio of excess lung cancer to mesothelioma continues to fall with reduction in age at first exposure, mesothelioma may constitute the major health hazard when asbestos exposure begins in childhood.

b. Level and Duration of Exposure

At present, there is no evidence of a safe level of asbestos exposure for lung cancer or mesothelioma. Epidemiological studies of these dose-response relationships have been performed with heavily exposed industrial cohorts. The data from these studies, which have been reviewed in the Nicholson report (USEPA 1986), lead to the conclusion that excess mortality from lung cancer and mesothelioma is proportional to both the level and duration of exposure to asbestos fibers. The most direct evidence for a linear dose-response relationship for lung cancer comes from two studies -- Henderson and Enterline (1979) and Dement et al. (1982). Data available for mesothelioma are also consistent with a linear relationship to cumulative exposure (Seidman et al. 1979, Hobbs et al. 1980, Jones et al. 1980). None of these studies shows any evidence of a threshold level of exposure below which exposure to asbestos is considered to be safe.

c. Fiber Type

Although chrysotile is the main type of asbestos fiber used in the United States, A/C pipe contains large quantities of crocidolite. However, when the slopes of lung cancer dose-response curves estimated from studies of various populations of asbestos workers are compared, no clear distinction can be found between the experience of individuals exposed to chrysotile and individuals exposed to other fibers (CPSC 1983, NRC 1984). A similar lack of consistency in the observed relationship between type of fiber to which the population was exposed and incidence of pleural or peritoneal mesothelioma is seen (NRC 1984).

Several commissions and study groups have reviewed cancer risks among cohorts exposed to asbestos fibers and observed that risks appear to vary from one study to another possibly because of exposure to different fiber types (ORCA 1984; WHO 1985). Some have hypothesized that chrysotile asbestos poses a lesser carcinogenic hazard than other forms of asbestos (Langer 1986). The Nicholson report (USEPA 1986) acknowledged that some of the lowest unit risk factors observed for lung cancer are among cohorts exposed to chrysotile asbestos. However, this report also points out that the unit risk factors estimated from the studies by Dement et al. (1983) and McDonald et al. (1983) for textile production workers using predominantly chrysotile are among the highest factors seen in all studies of asbestos-induced lung cancer. One hypothesis is that long and thin fibers are more potent carcinogens than short fibers. Support for this hypothesis comes principally from laboratory studies of rats and hamsters in which a higher incidence of mesothelioma was seen in animals injected with fibers longer than 8 micrograms in length and less than 2.5 micrograms in diameter (Stanton et al. 1981), However, as noted by Bertrand and Pexerat (1980), none of the studies conducted to date demonstrates a threshold at which fibers become less carcinogenic or not carcinogenic at all. Doll and Peto (1985) have also examined evidence on fiber length potency and concluded, as many other scientists have, that longer fibers appear to be more carcinogenic, but they note that the boundary between hazardous and non-hazardous fiber dimensions has not been established. Furthermore, the animal results are based on routes of exposure, primarily injection, that are not comparable to the respiratory route through which many people are exposed. Therefore, there is no firm evidence that potency varies from one asbestos fiber type to another.Therefore, in this analysis, it is assumed that the dose response constants do not vary according to the fiber type or dimension to which the person is exposed.

d. Dose-Response Models

Based on the above discussion, this analysis uses the linear, no-threshold dose-response relationships proposed by Nicholson (1983) and used by OSHA (1986) to develop benefits estimates for the final .2 f/cc PEL to convert information on asbestos exposure levels into excess lung cancer and mesothelioma death rates for each time period. Using these linear, no-threshold dose-response relationships is appropriate because they are the foundation of the final OSHA .2 f/cc PEL and thus have received substantial review in both the scientific and regulatory communities. Also, the Nicholson report (U.S. EPA 1986) considered the linear, no-threshold model in an extensive review of the work by several other agencies and committees. It was noted that a linear, no threshold model was supported in publications by a cross-section of scientific opinion including the Committee on Asbestos (ACA) of the British Health and Safety Commission (1979a,b), the Ontario Royal Commission (ORCA 1984), the National Academy of Sciences (NAS 1984) , and the Chronic Hazard Advisory Panel on Asbestos (USCPSC 1983). Use of the no-threshold model for carcinogens is consistent with the Guidelines for Carcinogen Assessment (51 FR 33992) published by U.S. EPA in 1986.

Following the approach used in the OSHA (1986) analysis, asbestos-related excess death rates from gastrointestinal cancer are assumed to be equal to 10 percent of those for lung cancer in each time period. This analysis follows OSHA's relative risk model for lung cancer which includes a minimum 10-year latency period between onset of exposure and increased risk of death from cancer. For mesothelioma, this analysis also follows OSHA use of an absolute risk model.

The relative risk model for lung cancer used in this analysis includes a minimum 10-year latency period between onset of exposure and increased risk of death from cancer. The form of these relationships is as follows:

$$I_L = I_E * [1 + K_L * f * d_{(t-10)}] \qquad \text{for } t > 10$$

$$I_L = I_E \qquad \text{for } t <= 10$$

where:

I_L = age-specific lung cancer death rate with exposure to asbestos

I_E = age-specific lung cancer death rate without exposure to asbestos

t = time from onset of exposure until current age (years)

$d_{(t-10)}$ = duration of exposure from onset until 10 years (latency period) before current age (years)

f = intensity of exposure (f/cc)

K_L = dose-response constant

$I_L - I_E$ = absolute excess lung cancer death rates due to asbestos exposure.

The mesothelioma absolute risk model is:

$$I_M = K_M * f * [(t-10)^3 - (t-10-d)^3] \qquad \text{for } t > 10+d$$

$$I_M = K_M * f * (t-10)^3 \qquad \text{for } 10 + d >= t < d$$

$$I_M = 0 \qquad \text{for } t <= 10$$

where:

t = time since first exposure (years)

d = total duration of exposure (years)

f = level of exposure (f/cc)

K_M = dose-response constant

Data inputs used to specify these dose-response relationships are presented in Chapter III.

4. Projection of Health Benefits

Health benefits of the regulatory alternatives for asbestos products manufactured after 1987, estimated on a product-by-product basis, are equal to the difference between the adverse health effects from asbestos exposure without and with the alternatives. To estimate the adverse health effects from exposure to asbestos in the baseline and under the regulatory alternatives, the population at risk is divided into homogeneous exposure categories and into age cohorts. Next, the health effects attributable to the first year of exposure for the members of each age and exposure subgroup, both in the baseline and with the regulatory alternative, are estimated using an adaptation of the life table model described in Eddy (1980).

The health effects model tracks an individual for each age and exposure subgroup starting from a single year of exposure, by five year periods, until age 90, at which point the probability of being alive is assumed to zero. For each five-year period the probability of dying of asbestos-related cancers is estimated as the product of the probability of being alive in that time period and the probability of dying from an asbestos-related cancer if alive. The probability of being alive during any five year time period decreases with age. The probabilities of dying from asbestos-related cancers if alive are estimated using the Nicholson dose-response relationships and the exposure data. These probabilities increase with time elapsed since the initiation of exposure since exposure as follows. The dose-response relationships assume a minimum ten-year latency period between exposure and excess cancer risks. Thus, the probability of dying from an asbestos -related cancer will be zero for the first two five year periods after exposure. After ten years, the probability of dying of an asbestos-related cancer increases with time since onset of exposure. In the case of mesothelioma, the absolute risk model generates death rates that increase with time since exposure. In the case of lung cancer (and gastrointestinal cancer which is estimated as 10 percent of the lung cancer rate) the excess risks remain constant over time relative to the baseline lung cancer death rates. However, the baseline lung cancer death rates increase with age and, therefore, the probability of excess lung cancer or gastrointestinal cancer increases with age or time since onset of exposure. Thus, for each age cohort, the probabilities of dying from asbestos-related cancers attributable to a single year of exposure increase with time since the onset of exposure except at the older ages where competing causes of death reduce the probability of observing deaths from asbestos-related cancers.

The probabilities of observing deaths from asbestos-related cancers in each five year time period for an individual from each age-exposure subgroup are multiplied by the number of people in the population subgroup to generate estimates of the expected asbestos-related cancers in the subgroup attributable to the single year of exposure. These estimates follow the same time distribution relative to exposure as the individual probabilities -- no cases for ten years followed by an increasing and then decreasing number with age.

Estimates of deaths from asbestos-related cancers are generated for exposures both with and without the regulations and the differences in asbestos-related cancers computed for each five year period. These differences, avoided cancers, are the estimate health benefits for the regulation. When these avoided cancers are aggregated across age-cohorts, their resultant time distribution ranges from 10 to 80 years with most cases occurring 35 to 60 years after exposure.

The results for each population age-exposure subgroup for each product are added for each five-year time period after the start of the analysis to determine, for each product, the total avoided cancer deaths during each time period attributable to the regulatory alternative. In doing this aggregation it is assumed that the avoided cancer deaths are distributed uniformly throughout each five-year period. Furthermore, the aggregation of the avoided cancer deaths estimated for different exposure categories has to take into account the timing of exposures.

Exposures from releases during product installation are assumed to be contemporaneous with those from primary and secondary product manufacturing. Exposures from repair or disposal are assumed to occur at the end of the average product life. Exposures during product use are assumed to be evenly distributed across the time from product manufacture to repair or disposal. The estimated avoided cancer deaths for the repair/disposal category are shifted forward in time by a number of years equal to the average product life before being added to the estimates for primary and secondary manufacturing and installation. The estimated avoided cancer deaths for one year of exposure in the use exposure category are assumed to be replicated for each year of use of the product, shifted forward in time one year at a time from the time of manufacture. Thus estimates are obtained for the number of avoided deaths from lung cancer, gastrointestinal cancer, and mesothelioma attributable to the regulation's impact on each product's manufacture in the first year of the analysis.

After the avoided cancer deaths attributable to asbestos releases from products manufactured during the first year of the analysis have been estimated, the avoided cancer deaths for products manufactured in all subsequent years of the analysis are estimated by multiplying the first year estimates by the ratio of the level of production in the subsequent year compared to that in the first year. The ratio of future to current production varies according to general trends in the industry baselines as well as according to features of the regulatory alternatives.

The total number of avoided cancer deaths attributable to the regulations impact on asbestos products manufactured 1987-2000 for each product for each five-year period after the start of the analysis are then calculated by aggregating the deaths avoided associated with each year of manufacture. The timing of the cases relative to the start of the analysis is preserved by assuming that the deaths in any five-year period are uniformly distributed, and by shifting the estimated avoided deaths for any given year of manufacture forward in time by the number of years from the beginning of the analysis. The total numbers of avoided excess cancer cases for each five year period are estimated by dividing the estimated numbers of cancer deaths by the death rates for each type of cancer.

Finally, the present value of benefits are calculated assuming two discount rates, zero percent and three percent. In all cases, benefits are discounted from time of exposure to the beginning year of the analysis. In some cases, the time of exposure is relatively close to the present, for example, exposures in manufacturing products occur between the beginning of the analysis (1986) and the end of the simulation period for manufacturing activities (the year 2000 for this model). On the other hand, exposures due to repair and disposal may occur far in the future, especially for those products that have long useful lives. In these cases, the benefits are discounted from a time of exposure in the future that is beyond the time horizon of the simulation period for manufacturing because the benefits modeling simulates exposures throughout product life cycles attributable to asbestos products manufactured during the 1986 to 200 simulation period.

B. Approach for Estimating Costs

The regulatory options considered in this analysis include phase-downs of asbestos fiber usage over time, bans on products that use asbestos, and combinations of these two types of regulatory schemes. To estimate the costs associated with the various regulatory options actually examined, a microeconomic model of the asbestos industry was developed. This model is general in scope and estimates the costs experienced by the many different economic entities associated with asbestos fiber and product market, both in the U.S. and internationally. Before proceeding with the details of the methods used to estimate the costs of the regulatory alternatives, however, some preliminary comments concerning the nature of the welfare economics that provide the foundation of this analysis are appropriate.

1. Welfare Economics Foundations of the Approach

An intervention that alters the existing equilibrium in one market or across several markets will lead to welfare effects or changes in benefits enjoyed by participants in these markets. The analysis of these welfare effects can be carried out in two ways (1) a "distribution" analysis that measures effects on individual groups, and (2) an "efficiency" analysis that measures the net effects on society. Distribution analysis, unlike efficiency analysis, not only identifies the gross losers and gainers, but also the magnitudes of these losses and gains, transfers across individual groups, and therefore, the residual "deadweight" losses or gains to society. Efficiency analysis only identifies the net losses or gains, if any, to individual groups and the deadweight losses or gains to society.

Understanding how distribution analysis differs from efficiency analysis is helpful in understanding estimates of producer and consumer surplus losses generated by economic models. However, the term "efficiency losses" is used in a specific sense here because the benefits of the regulations modeled do not appear. Instead, this section focuses on only the cost impact of the regulations. Since the benefits may well exceed the costs of the regulations, the net impact of the regulations may clearly be positive in social welfare terms. In economists' terminology, this implies that "deadweight" welfare gains ensue, since social benefits of the regulations may exceed social costs. However, because the analytical methods discussed in this chapter focus only on the costs of the regulatory alternatives, when losses are called "deadweight" in this section, these are defined as cost burdens experienced by market participants net of any transfers between them, but evaluated prior to adjusting for benefits.

Given this perspective, the goal of the cost analyses presented in this chapter is not only to define and measure the net social costs of the various regulatory alternatives, but also to identify the economic entities who bear the costs (or who enjoy the benefits in certain circumstances) imposed by the regulatory alternatives.

Finally, although there are differences in the details of estimating the costs of different regulatory alternatives, certain elements of analysis are common to all of them. These include the structure and linkages of the markets potentially affected by the alternatives, the economic entities affected, and the baseline relative to which any welfare effects of the alternatives experienced by these entities can be measured. Hence, before addressing the specific methods used to estimate the costs of each type of regulation, it is useful to review the economic structure of the potentially affected markets, the entities affected, and the baseline developed for the analysis.

2. Economic Structure of Asbestos Markets and Baseline Specification

The essential function of the economic models of asbestos regulations is to mathematically describe the economic interactions between the asbestos fiber market and the numerous output markets that use the fiber as an input in the production of a good. Quantities of the output good demanded determine each individual market's demand for fiber. The total fiber demanded determines the price of the fiber, which in turn determines the price in each output market. The supply schedule in the fiber market incorporates the supply to U.S. from domestic and foreign sources. Figure II-1 shows the interactions of the U.S. and world markets for fiber and asbestos products.

The link between the fiber market and the other output markets is vital to the simulation of the alternative regulatory scenarios. To understand how these policies are modeled, consider, for example, a single year in the simulation of a fiber phase-down. For the phase-down alternative, a fiber "cap" is imposed, which, in essence, is a ceiling on fiber usage during that year. With demand exceeding fiber supply, the price to consumers rises.* This increase in price restricts usage of fiber in downstream markets resulting in less output of these goods and, consequently, higher prices.

The linkages between the asbestos product markets and the fiber market also operate in the reverse direction. Consider a ban of some, but not all, asbestos products. In this case, certain downstream asbestos products are banned. This curb on output reduces the demand for asbestos fiber, resulting

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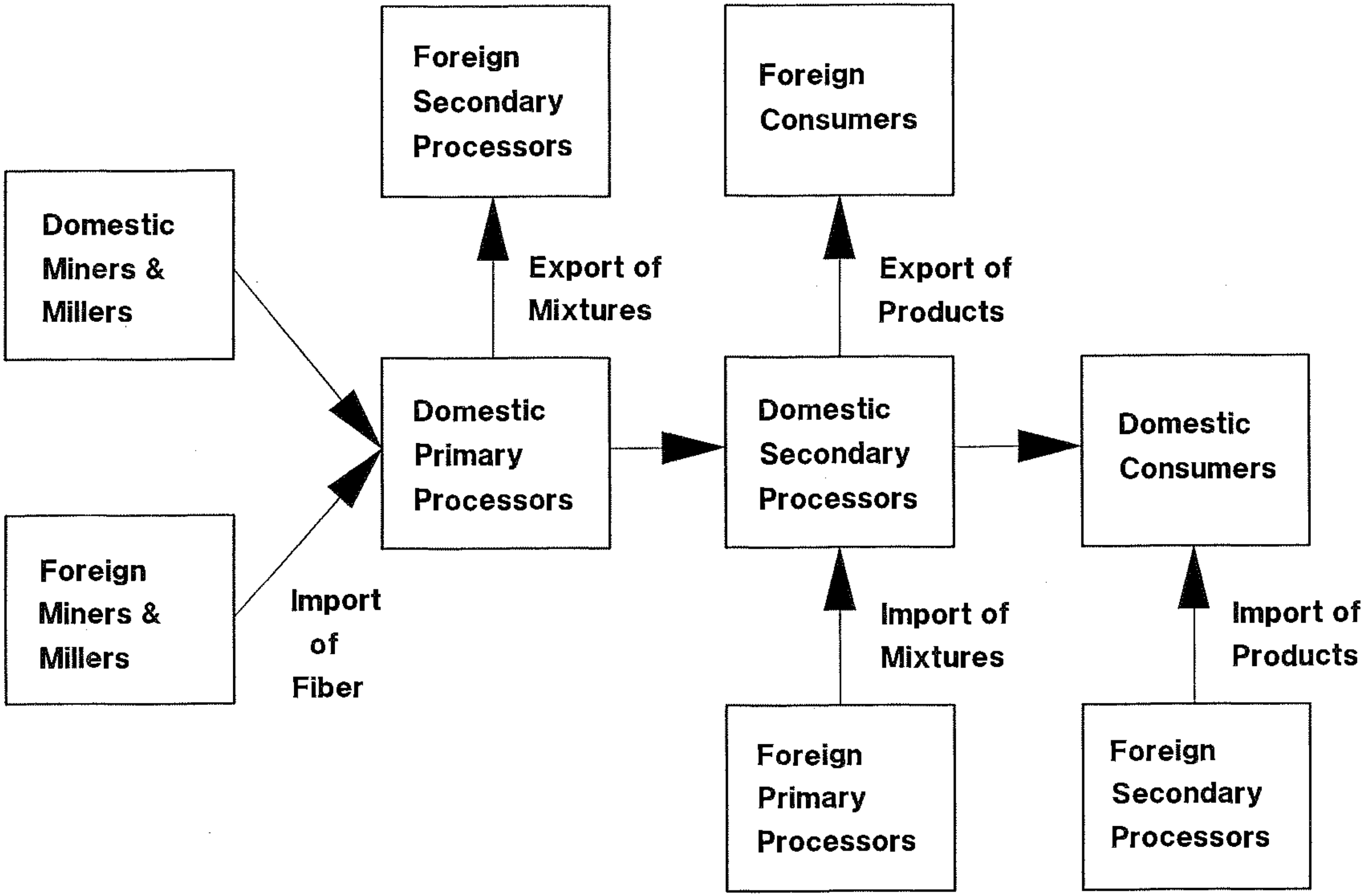
* Here the reference is to consumers of fibers who use it as an input for the production of goods, i.e., primary processors.

FIGURE II-1. U.S. AND WORLD ASBESTOS MARKETS



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in a decreased price of fiber in the market. This translates to lower product prices in the non-banned downstream markets. Thus, banning some products can benefit consumers and producers of other products precisely because of the vertical and horizontal structure of the affected markets.

The welfare effects computed by the cost estimation models consist of transfers and "deadweight" losses caused by the regulation.* For example, consider an increase in the price of asbestos fiber due to a regulatory restriction on the total amount of fiber that may be sold or imported during a given year (a fiber "cap"). In general, this will cause consumer and producer surplus losses in all downstream markets. Consumers either pay higher prices for asbestos products or switch to more costly substitutes. Producers of these products may suffer profit losses and reductions in the value of their equipment as asbestos fiber's price rises. Furthermore, losses in producer surplus also occur in the fiber market because the quantity cap limits the quantity that can be supplied and competitive forces produce a decline in the price of fiber received by these producers.

On the other hand, some downstream consumer and producer surplus losses and some of the producer surplus losses in the fiber market represent transfers to those who are permitted to mine or use fiber, which are valuable rights when a regulatory option restricts the available fiber supply. Hence, parties that hold these rights are made better off. Thus, not all losses of producer and consumer surplus in the fiber and product markets are net losses to society because at least some of these losses may be transferred to other economic entities. Finally, there are foreign entities at all levels of asbestos use and production whose losses or gains are not included in computing welfare

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* As explained earlier, deadweight losses as referred to in this section do not consider the benefits side of regulations.

effects on domestic parties. Welfare effects of the regulatory alternatives not only must be developed by the nature of the economic entity affected, but also in terms of whether the entities are included in the U.S. welfare analysis or not.

Net changes in domestic and world welfare are distinguished, (net of the explicit health-related benefits, of course) in this analysis. Except for the foreign miners and millers, foreign primary processors, and the foreign asbestos product purchasers, all other parties are included in the computation of net domestic (i.e., U.S.) welfare changes due to the regulation. That is, adding all domestic welfare changes yields the domestic net welfare impact of a regulatory alternative. Adding the individual welfare change of all parties (including foreign entities) on the other hand, gives the net world welfare change. Given the fact that a major share of U.S. fiber supply comes from foreign suppliers, their share of the producer surplus loss (caused by all forms of regulation) may be substantial. Since these foreign losses are not considered part of U.S. welfare, the impact of the regulations on net U.S. welfare may be substantially different from their net impact on world welfare.

Finally, all of the welfare changes computed using the techniques described in this section are defined relative to a "baseline", which is the state of the world that would have developed had no regulation been imposed. In essence, the baseline is the equilibrium that would have existed in the absence of regulation. Specifying this baseline is not necessarily easy because the analysis spans several decades, making the evolution of the many markets that use asbestos difficult to ignore. Consequently, modeling future gains and losses of market participants due to regulatory interventions requires that the individual markets using asbestos be scrutinized closely to determine their future paths of growth or decline.

One final issue in the baseline specification is that market expectations about proposed regulatory implementation may affect the baseline definition. In many instances, market participants anticipate the enactment of regulations. If this happens, some of the adjustments induced by the policy may occur before the regulation is actually effective. However, because of the difficulties of determining these anticipatory responses, no efforts were made to adjust baseline values for any endogenous anticipations of market participants.

3. Regulatory Options Cost Model

Although a number of different regulatory options are reported in this analysis, these are comprised of different combinations and timing of the two basic phase-down and product ban alternatives. Hence, the discussion below describes the operation of the cost model for a fiber phase-down alone, for product bans alone, and for a combined fiber phase-down and product ban.

a. Fiber Phase-Down

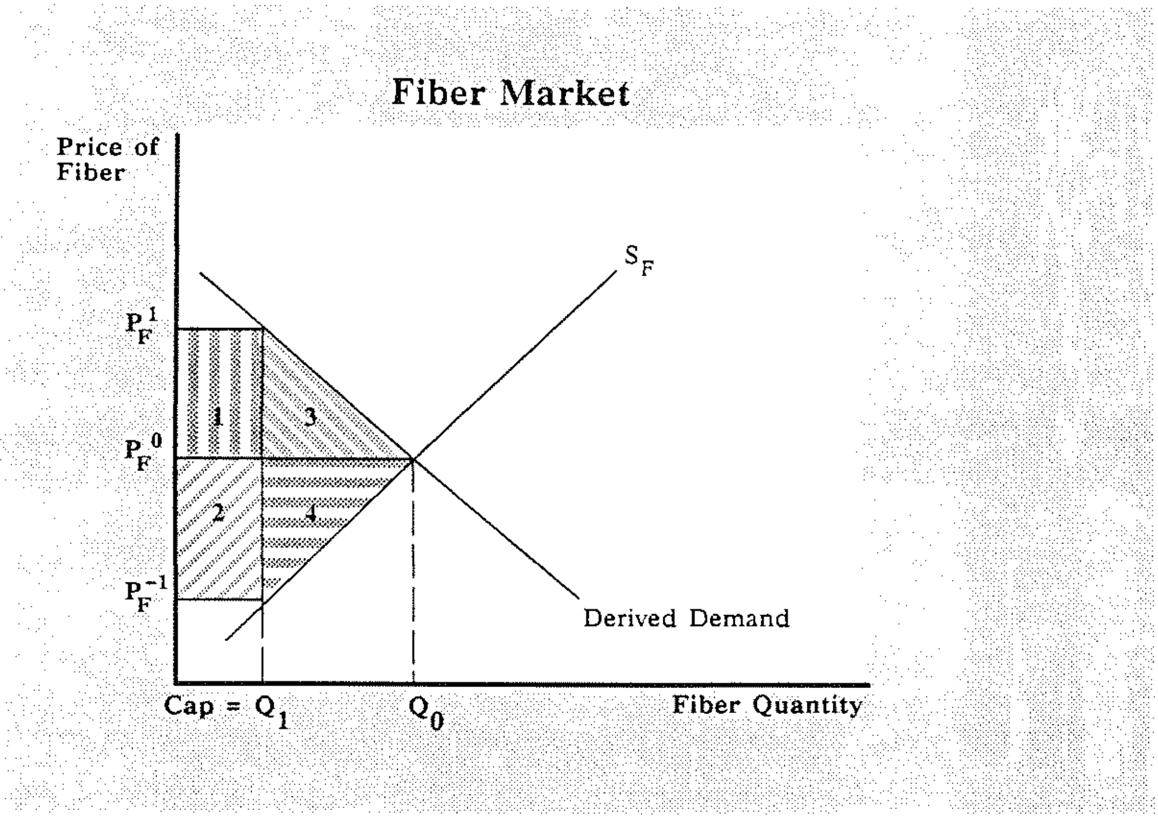
Figure II-2 shows graphically the fiber market (top panel) and one of the many markets that use fiber at a particular point in time (bottom panel). The fiber market panel shows the impact of a cap on the total usage of fiber (a one year snapshot of the entire phase-down procedure) -- which reduces fiber consumption and production to Q_1 from Q_0.

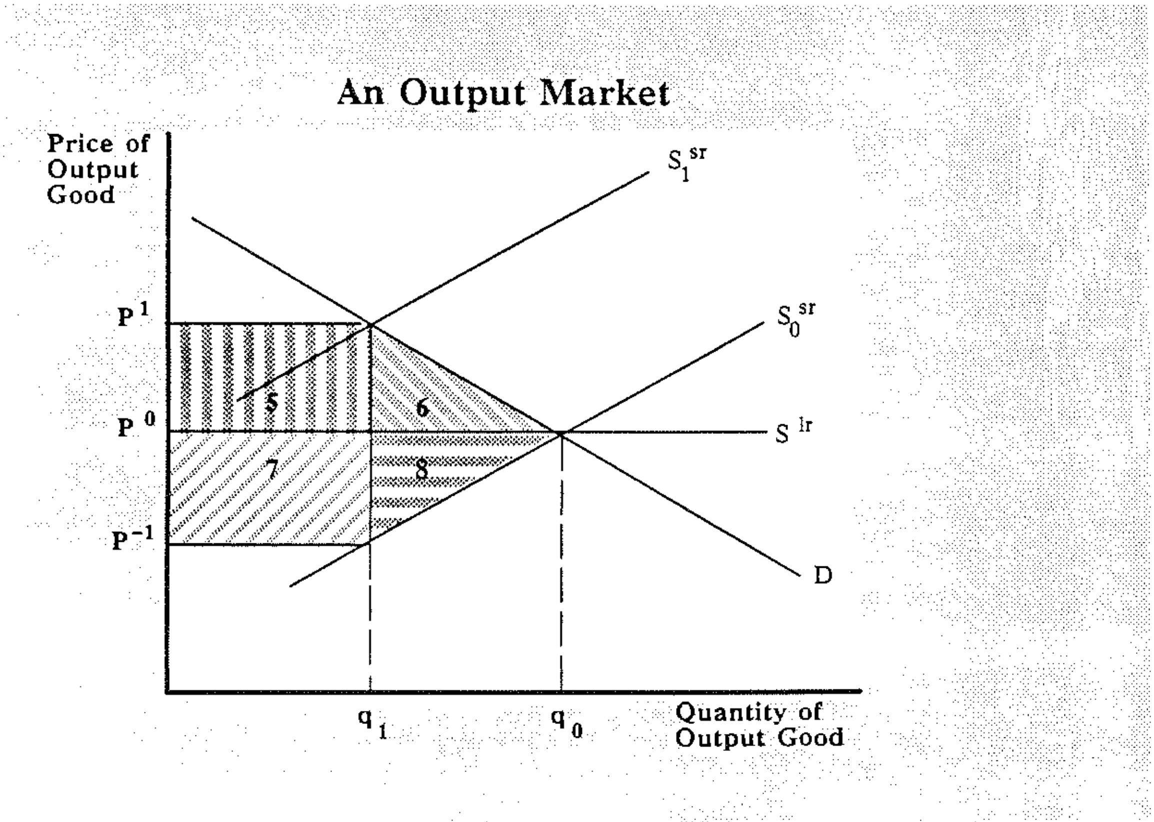
The result of this restriction of fiber usage translates into two effects of interest. First, the value of the right to purchase or use a unit of fiber is positive if the cap in the fiber market is effective in reducing consumption.* That is, as long as Q_1 is less than Q_0, these rights are valuable. The value of the right to purchase or use one unit of fiber in this

* The right could also refer to the right to sell fiber. Depending on how the restriction on the use of asbestos fiber is actually implemented, the value could accrue to either those who mine or import fiber or those who purchase or use the fiber.

FIGURE II-2

FIBER USAGE PHASEDOWN





period of time is equal to the difference between $P^1{}_F$ and $P^{-1}{}_F$ (in the top panel), since $P^1{}_F$ represents the value to users of the marginal unit of fiber and $P^{-1}{}_F$ measures the marginal fiber supply price by the competitive producers of fiber.

The second consequence is that the total cost of producing fiber-using outputs rises, reflecting the higher "full" price of fiber (where "full" price equals the price of the fiber itself plus the value of the right to purchase of use the fiber). This increased cost of production of the output goods is represented as an upward shift of the supply schedules in these output markets ($S^0{}_{sr}$ to $S^1{}_{sr}$ in the bottom panel).

This analysis assumes that the long-run supplies of the output goods using asbestos fiber are perfectly elastic, so that there is no producer surplus to lose in the long run. Hence, the supply schedules appear flat, as is S^{lr} in the bottom panel of Figure II-2.* However, there may be "quasi-rents" that accrue to factors in these markets and which can be forfeited in the short run if the price that producers receive falls. For example, amortization payments for a factory building are "quasi-rents" which might be foregone for some period of time if no other economically viable use exists that yields a higher return. In the long run, however, these payments are necessary to retain producers in this industry. Thus, areas 7 and 8 above the output market short run supply schedules represent short run producer surpluses. In the long run, since the supply curves for the output goods are perfectly elastic, no producer surplus losses in these markets exist. Instead, the cost of the regulation that is borne in these markets is shouldered by consumers of these output goods.

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* The supply function in the fiber market, however, is assumed to be both the short-run and the long-run curve. Hence, producer surplus exists in that market even in the long run.

In the efficiency analysis, three different areas in these graphs are the central focus. These are:

- Area 4 in the fiber market -- the deadweight losses borne by factors of production associated with the supply of fiber;

- Areas 6 in the output markets -- the deadweight losses borne by consumers of the products made from asbestos fiber (area 6 in each output market is taken into account); and

- Areas 8 in the output markets -- the short run deadweight losses borne by factors of production (other than those in the fiber market) associated with the supply of each of these different products.

Areas 4, 6, and 8 represent the net burdens imposed on various participants in these markets in the short run (prior to considering the value of rights to use or purchase fiber). That is, these areas measure the net impacts on society after subtracting any transfers between economic entities. However, for purposes of performing distribution analysis, it is precisely the gross welfare effects and the transfers between economic actors that are of interest. To discuss the distribution of the gains and losses imposed on various members of society, the analysis must backtrack to gross gains and losses; the net losses that are the center of attention in the efficiency perspective are not sufficient for the distribution analysis.

In terms of Figure II-2, the analysis in this section is concerned not only with areas 4, 6, and 8, but also with areas 2, 5, and 7. These rectangular areas are important because by adding them to the triangles that are the focus of the efficiency analysis, the gross gains and losses experienced by the participants in these markets in the short-run are revealed. In particular:

- Area 2 in the fiber market is added to area 4 to obtain the total loss of producer surplus by the factors associated with fiber production;

- Areas 5 in the output markets are added to areas 6 to obtain an estimate of the gross short run consumer surplus losses experienced in these output markets;* and

- Areas 7 in the output markets are added to areas 8 to obtain the gross short run producer surplus losses experienced by factors (other than those in the fiber market) associated with the production of these output goods.**

Areas 1 and 3 in the fiber market are precisely equal to the sum of areas 5, 6, 7, and 8 across all of the output markets. That is, (1) the sum of areas 5 and 7 in all of the output markets equals area 1 in the fiber market, and (2) the sum of areas 6 and 8 in the output markets equals area 3 in the fiber market. Thus, if 5, 6, 7, and 8 are examined separately, areas 1 and 3 need not be analyzed.

With this taxonomy of gross losses, it is possible to understand why the triangular areas are identified as the net losses to society. Combined, rectangular areas 5, 7, and 2 measure precisely the total value of the rights to use or purchase the limited supply of scarce fiber during a phase-down. This can be understood by noting first that the upward shift of the short-run supply curve in the output market (from S^0_{sr} to S^1_{sr}) is caused by the rise in the "full" price of fiber. In other words, the "full" price of fiber rises by the difference between P^1_F and P^0_F, and this price increase is directly translated into a vertical shift of the short run supply functions in the

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* The areas under the demand curves in the output markets represents strictly speaking, the combined surpluses of the consumers of final goods and of "downstream" producers who purchase these intermediate output goods to fashion final consumption goods.

** Note that areas 8 in the output markets do not incorporate area 4 in the fiber market for technical reasons. Basically, since there are multiple downstream purchasers of fiber, representing fiber market producer surplus in the output markets is quite difficult using standard output market supply functions that have intuitive interpretations. Therefore, the approach used in this model measures producer surplus of fiber producers in the fiber market itself.

output markets.* Therefore, the difference between P_1 and P_{-1} in the output markets directly reflects the rise in the full price of fiber (P^1_F - P^0_F). It is reasonably intuitive, as a consequence, that areas 5 and 7 in the output markets measure the portion of the total value of rights to use or to purchase fiber (areas 1 + 2) represented by area 1 in the fiber market. Similarly, areas 6 and 8 in the output markets (when summed across all output markets) equal area 3 in the fiber market.

The remainder of the value of the rights to use fiber is produced by the drop in the supplier price of fiber from P^0_F to P^{-1}_F. In other words, the value of the rights to use or purchase fiber is derived from the combination of a rise in the demand price for fiber (from P^0_F to P^1_F) and a fall in the price necessary to pay producers of fiber for their reduced output (P^0_F to P^{-1}_F). As a result, those who enjoy the right to use or to purchase fiber gain areas 2, 5, and 7 at the expense of the factors of production in both the fiber and the output markets, and the consumers of the output goods made with fiber. Because areas 5 and 7, summed across all output markets, equal area 1 in the fiber market, the fiber users' gain can be measured as the sum of areas 1 and 2 in the fiber market. Areas 4, 6, and 8 can be identified as the deadweight, or social loss in this framework. All of the rectangular areas represent transfers from the three groups of market participants to those who have the right to use or purchase fiber; after subtracting these transfers from gross losses, only the triangular areas (4, 6, and 8) remain.

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* The assumption that the higher "full" price of fiber is not completely passed on to the buyers of output goods is significant. Because this is a short-run analysis, the producers in the output markets bear some of the burden of the regulation. In fact, the extent to which consumer (or gross) prices do not rise by the full amount of the increased fiber price, translated into production cost increases for the output goods, indicates the extent to which producers bear this burden. Thus, (P_0 - P_{-1}) is commonly thought of as a measure of the proportion of the total burden of the regulation (P^1 - P_{-1}) borne by producers in the output markets.

Although this analysis identifies all losses and transfers across markets, it is necessary to distinguish between the burden borne by domestic and foreign parties. First of all, the rights to use or purchase fiber are welfare gains which are assumed normally to accrue only to domestic parties. However, a major share (approximately 92%) of the producer surplus loss in the fiber market is borne by foreign miners and millers because they are major suppliers of asbestos fiber to the United States. On the other hand, the distribution of downstream output market losses is dependent on the trade orientation of each individual market. If a market is export oriented, i.e., domestic consumption is less than the domestic production, all consumer and producer surplus losses are borne by domestic parties -- foreign purchasers do not bear any losses. It is assumed that they can switch to alternative sources of asbestos product supply and will do so rather than pay a higher price to U.S. producers. For markets with no trade, all losses are obviously borne by domestic parties. For markets with an import orientation, i.e., domestic consumption is greater than domestic production, all consumer surplus losses are borne by domestic purchasers. However, since foreign primary processors are assumed to be identical in terms of short-run producer surplus to their domestic counterparts, producer surplus losses in these markets are borne by domestic and foreign primary processors in the ratio of the amounts supplied.

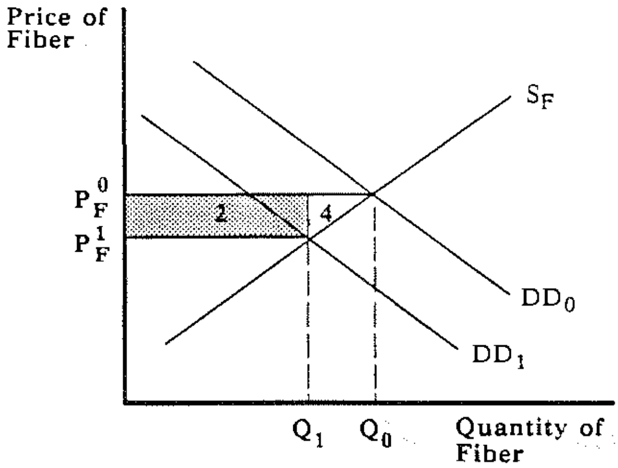
b. Product Bans

Figure II-3 shows graphically the impact of banning one or more output goods on the fiber market (top panel), a representative non-banned market (middle panel), and a representative banned market (bottom panel). The mechanics of staged ban regulation are simpler than those described in the previous section for fiber usage phase-down. First, the price of fiber falls, since the product bans reduce the derived demand for fiber. Consequently, the

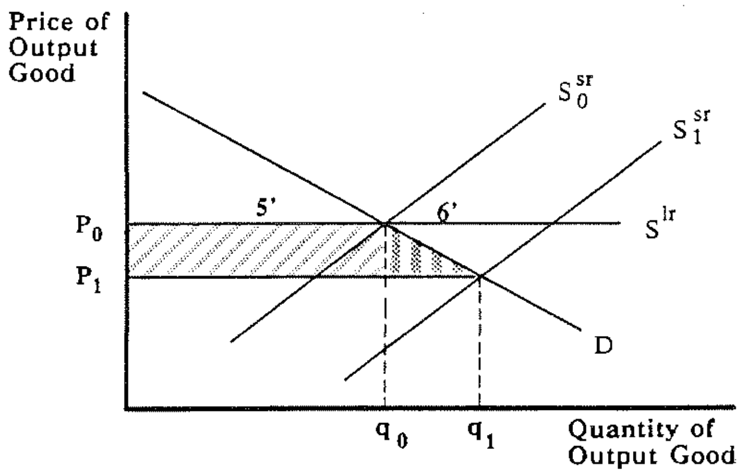
FIGURE II-3

STAGED BAN

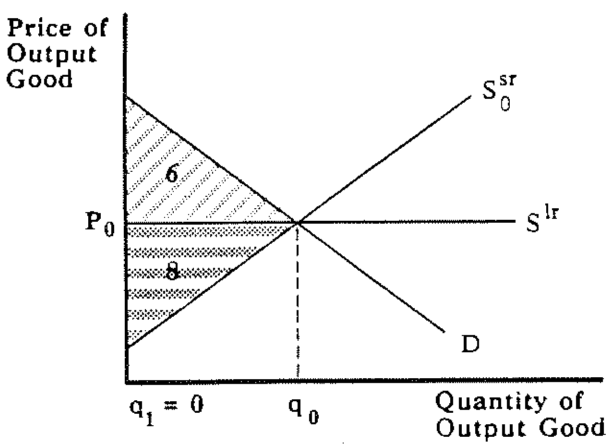
Fiber Market



A Non-Banned Output Market



A Banned Output Market



remaining users of fiber are made better off. In the top panel of Figure II-3, the fiber market derived demand curve is shifted inward, reflecting the product bans. Since fiber supply is upward-sloping, the price of fiber falls from P^0_F to P^1_F. The gross loss of fiber market producer surplus is the sum of areas 2 and 4 (top panel of Figure II-3), and the gain to the remaining purchasers of fiber, i.e., the output markets that are not banned, is area 2. The fall in price of fiber results in a drop in the price, from P_0 to P_1, of the output products in the non-banned markets. The gain in consumer surplus in each non-banned output market is the sum of areas 5′ and 6′ (middle panel of Figure II-3). Area 2 corresponds to the sum of areas 5′ and 6′ across all the remaining (non-banned) output markets. Area 4 in the fiber market is the "deadweight" loss borne by the factors of production associated with the supply of fiber.

The bottom panel of Figure II-3 shows the losses borne by the banned markets. Area 6 identifies the consumer surplus loss. Since this analysis assumes that long-run supplies of output goods using asbestos fiber are perfectly elastic, there are no producer surpluses to lose in the long run. However, there may be "quasi-rents" that accrue to factors in these markets which can be forfeited in the short-run. Thus, areas 8 above the banned output markets' supply schedules represent short run producer surplus losses.

Finally, the analytical distinction between domestic and foreign parties can now be made clear. As before, a major share of producer surplus loss in the fiber market is borne by foreign miners and millers. The remaining producer surplus loss is borne by their domestic counterparts. Consumer surplus losses in banned markets are borne totally by domestic purchasers whereas consumer surplus gains in non-banned markets are shared by domestic and foreign purchasers in the ratio of their respective demands.* This is so because foreign purchasers will not be affected by product bans given their alternative sources of supply. On the other hand, "quasi-rent" losses in all banned markets are borne by domestic and foreign primary processors in the ratio of the amounts supplied.

c. Combinations of Fiber Phase-Down and Product Bans

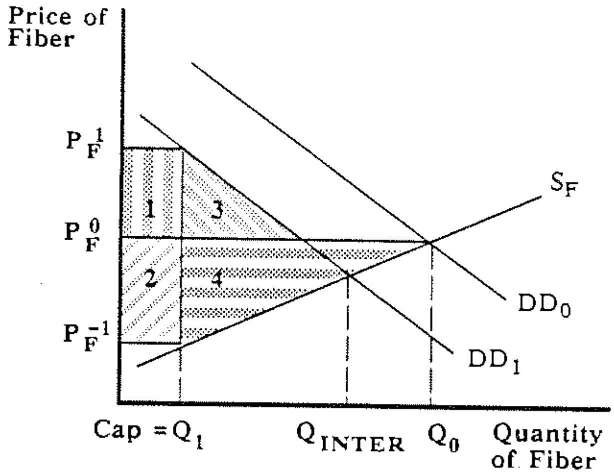
Figure II-4 shows graphically the impact of banning one or more output goods followed by imposing a cap on the total usage of fiber. The ban of certain output goods results in a reduced derived demand for fiber, shown by the inward movement of the derived demand in the top panel. A cap on the total fiber usage is then imposed on the recomputed derived demand (Q_{inter}). The bans reduce the demand for fiber from Q_0 to Q_{inter} and the cap further reduces fiber consumption and production to Q_0 to Q_{inter}. The mechanics of modeling this regulation are in two stages. First, the staged ban element of the regulation is simulated. This causes an "intermediate" drop in the price of fiber since the product bans reduce the derived demand of fiber to Q_{inter}. As in subsection b, areas 6 and 8 in the banned markets are computed and represent loss of consumer surplus and "quasi-rents" respectively (bottom panel of Figure II-4). However, since this is an intermediate step for the non-banned output markets no computations are made for them. The second stage involves the effects of the fiber cap, which reduces fiber consumption and production to Q_1 (top panel of Figure II-4). From this point on the analysis is similar to

* The only gain to foreigners accrues to foreign purchasers, given a decrease in the price of downstream products caused by a staged ban. This is the net gain to foreign purchasers (prior to adding the losses suffered by the foreign primary processors and foreign domestic miners and millers) and accrues to the purchasers of goods produced by U.S. primary processors. The net gain to the remaining foreign fiber producers and purchasers (who purchase goods produced by non-U.S. primary processors) due to the drop in the price of asbestos fiber caused by a staged ban is captured by the slope of the asbestos fiber supply curve.

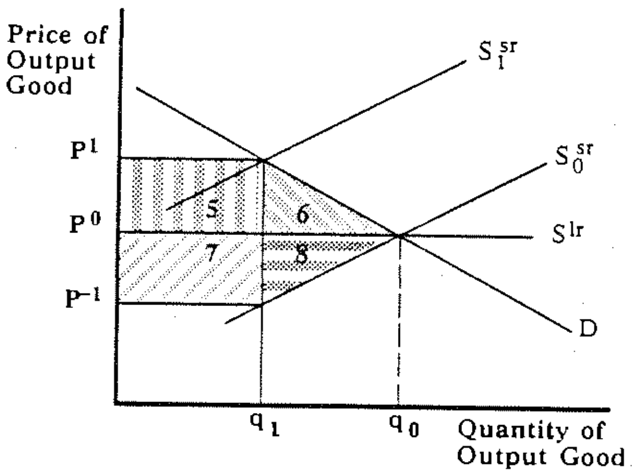
FIGURE II-4

COMBINATION OF STAGED BAN AND FIBER USAGE PHASEDOWN

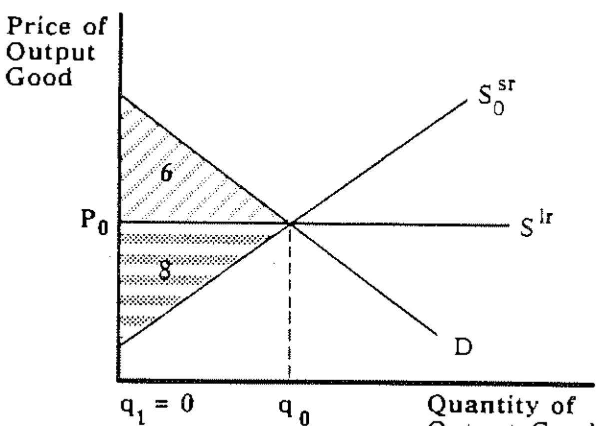
Fiber Market



A Non-Banned Output Market



A Banned Output Market



that described in subsection a. The result of this restriction of fiber usage translates into two effects of interest. First, the value of the right to use or purchase a unit of fiber has a positive price if the fiber cap is effective in reducing consumption. That is, as long as Q_1 is less than Q_{inter}, these rights are valuable. The value of the right to purchase, sell, or use one unit of fiber in this period of time is equal to the difference between $P^1{}_F$ and $P^{-1}{}_F$, since $P^1{}_F$ represents the value to the remaining users of the marginal unit of fiber and $P^{-1}{}_F$ measures the marginal fiber supply price by the competitive producers of fiber.

The second consequence, as before, is that the total cost of producing fiber-using output rises, reflecting the higher "full" price of fiber. This increased cost of production of the non-banned output goods is represented as an upward shift of the supply schedules in these output markets ($S^0{}_{sr}$ to $S^1{}_{sr}$), as shown in the middle panel of Figure II-4.

Areas 1-8 in the fiber and the non-banned output markets have the same interpretation as that in subsection a. However, (1) area 1 in the fiber market equals the sum of areas 5 and 7 in all the non-banned output markets, and (2) area 3 in the fiber market equals the sum of areas 6 and 8 in all the non-banned output markets.

The triangular areas in all three panels of Figure II-4 are the "deadweight" losses. These are:

- <u>Area 4 in the fiber market</u> which represents the deadweight losses borne by factors of production associated with the supply of fiber; and
- <u>Areas 6 and 8 in the output markets</u> which represent the deadweight losses borne by consumers of the products made from asbestos fiber and the short-run deadweight losses borne by factors of production (other than those in the fiber market) associated with the supply of each of these different products respectively.

The rectangular areas in Figure II-4 are important for identifying gross losses and gains experienced by market participants. In particular:

- <u>Area 2 in the fiber market is added to area 4</u> to obtain the total loss of producer surplus by the factors associated with fiber production;

- <u>Area 5 in the non-banned output markets are added to area 6 in all output markets</u> to obtain an estimate of the gross consumer surplus losses experienced in all output markets;

- <u>Area 7 in the non-banned output markets are added to area 8 in all output markets</u> to obtain an estimate of the gross short-run producer surplus losses experienced by factors (other than those in the fiber market) associated with the production of all goods; and

- <u>Area 1 in the fiber market is added to area 2</u> to obtain the total value of the rights inherent in the allocation of the limited supply of scarce fiber during the phase-down.*

The distinction between domestic and foreign parties is exactly as in the case where only fiber usage phase-down was implemented, with the exception of losses in the banned markets.

d. <u>Product Exemptions</u>

Some of the alternatives considered call for exemptions of certain product categories from the regulatory mechanism. In the "product bans only" alternatives, the exempted product categories get fiber at the world supply price based on the equilibrium that exists in after the required products have been banned. In the case of phase-down of fiber usage, the regulated products pay the "full price" of fiber whereas the exempted products pay the "supply price" of fiber based on the "cap" quantity and the quantity demanded by the exempted products. In either case, the fiber price facing the

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* Alternatively, the measure of the value of these rights can be obtained by the sum of area 2 in the fiber market and areas 5 and 7 in the non-banned output markets.

exempted products under regulation is lower than the price in the baseline, and therefore, a net consumer surplus gain accrues to the exempted product markets.

d. Engineering Controls

The product categories that are exempted from regulation may be subject to alternative regulation in the form of engineering controls.* The per unit cost of engineering controls is first offset against the decrease in the price of the product (due to a lower fiber price facing the exempted products). If the cost increase due to the engineering controls exceeds the cost decrease due to declining fiber prices, this net cost increase is transmitted as a higher product price, thereby causing consumer surplus losses as well. Because it is possible for the decreased cost of fiber to be larger or smaller than the increased costs associated with the engineering controls, the net welfare impact on exempted markets subject to engineering controls cannot be ascertained *a priori*.

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* This is true in the sensitivity analyses for aftermarket drum brake pads and disc brake linings for light & motor vehicles.

III. DATA FOR ESTIMATING COSTS AND BENEFITS

The previous chapter outlined the basic theoretical structure of the models used to estimate the costs and benefits of the various regulatory alternatives for controlling exposure to asbestos. As that discussion makes clear, a large amount of data is required to produce quantitative estimates of these costs and benefits. This chapter presents these input data in as concise and understandable a form as possible. Details of the derivations of the data and the sources used appear in appendices referenced throughout this chapter.

A. Data Inputs for Estimating Benefits

The input data for the benefits estimation divide into several distinct groups -- exposure data, dose-response data, and background information on population characteristics, mortality rates, and cure rates for the cancers analyzed in this study. This section presents these groups of data used in the benefits estimation procedures.

1. Data Inputs for Estimating Exposure

Quantitative benefits estimates under each of the various regulatory alternatives depend on how far below the baseline exposure are the estimated exposures under each regulatory alternative. This, in turn, depends on the output of each product and the number of people exposed and exposure level in each setting under the relevant regulatory alternative. Thus, from an analytical perspective, the benefits of a given regulatory alternative are driven by the difference between the exposures in the baseline and the exposures under the regulation.

As outlined in the previous chapter, the health effects of exposure to asbestos products manufactured between 1987 and 2000 are estimated on a product-by-product basis. For each product, the population at risk is subdivided into the following exposure categories:

- Primary manufacturing, both occupational and nonoccupational;
- Secondary manufacturing, both occupational and nonoccupational;
- Installation, both occupational and nonoccupational;
- Use, both occupational and nonoccupational; and
- Disposal or repair, both occupational and nonoccupational.

Occupational exposure occurs among individuals employed in the manufacture, installation, use, and repair or disposal of the asbestos product. Nonoccupational exposure can be subdivided into ambient exposure and consumer exposure. Ambient exposure occurs among persons living or working close to the site of manufacture, use, repair, or disposal of the product. Consumer exposure occurs among those consumers who personally install, use, repair, or dispose of the asbestos product.

For each exposure category for each product, data on the mean level of exposure and the number of people exposed in a single year from products manufactured in 1985 have been derived from compilations of exposure data presented in detail in Versar (1987) and ICF (1988). In general, the occupational exposure information was generated using emissions estimates produced by ICF while the nonoccupational data were estimated using emissions estimates developed by ICF and dispersion modelling by Versar (1988). Appendix A.4 of this RIA reviews the calculations and assumptions used to develop the detailed inputs for the benefits model from the information provided in the ICF and Versar studies.

The complete set of estimated exposure levels and numbers of people exposed is presented in Tables III-1 through III-5. These tables report both occupational and nonoccupational populations exposed and levels of exposure in the five categories of asbestos-related activities based on 1985 estimates of

TABLE III-1. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO PRIMARY MANUFACTURING PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	12	145	5,747,875	0.0232
4. Pipeline Wrap	35	134	4,847,937	0.0476
5. Beater-add Gsskets	235	110	37,082,888	0.0373
6. High-grade Elect. Paper	27	113	254,772	0.405
7. Roofing Felt				
8. Acetylene Cylinders	206			
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	2	111		
12. V/A Floor Tile				
13. Diaphragms	650	87	19,744,593	0.00000185
14. A/C Pipe	286	270	3,313,602	0.167
15. A/C Flat Sheet	53	478	21,232,368	0.0218
16. A/C Corrugated Sheet				
17. A/C Shingles	11	473	891,143	0.00361
18. Drum Brake Linings (OEM)	421	385	9,292,154	0.0575
19. Disc Brake Pads, LMV (OEM)	140	390	3,681,659	0.0214
20. Disc Brake Pads, HV	15	385	1,704,883	0.000000827
21. Brake Blocks	283	377	9,785,424	0.00388
22. Clutch Facings	239	406	8,761,571	0.0027
23. Auto. Transmiss. Comp.	11	113		
24. Friction Materials	191	398	12,922,247	0.00234
25. Protective Clothing				
26. Thread, yarn etc.	78	457	16,306,866	0.00214
27. Sheet Gaskets	167	208	43,468,616	0.00561
28. Asbestos Packings	9	198	7,031,484	0.0000534
29. Roof Coatings	582	273	84,570,429	0.00233
30. Non-Roofing Coatings	553	220	70,389,388	0.0000394
31. Asb. Reinforced Plastics	157	164	19,925,386	0.0018
32. Missile Liners	380	220		
33. Sealant Tape	134	220		
34. Battery Separators	207			
35. Arc Chutes	2			
36. Drum Brake Linings (A/M)	1,144	385	25,249,953	0.0575
37. Disc Brake Pads, LMV (A/M)	776	390	20,383,263	0.0214
38. Mining and Milling	155	121	841,214	0.407

TABLE III-2. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO SECONDARY MANUFACTURING PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	448	57		
4. Pipeline Wrap				
5. Beater-add Gaskets	1,296	57		
6. High-grade Elect. Paper	30	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	149	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)	731	125		
19. Disc Brake Pads, LMV (OEM)	46	146		
20. Disc Brake Pads, HV				
21. Brake Blocks	19	127		
22. Clutch Facings	48	166		
23. Auto. Transmiss. Comp.				
24. Friction Materials	28	195		
25. Protective Clothing				
26. Thread, yarn etc.	208	408		
27. Sheet Gaskets	885	276		
28. Asbestos Packings	25	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics	529	239		
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	1,988	125		
37. Disc Brake Pads, LMV (A/M)	254	146		
38. Mining and Milling				

TABLE III-3. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO INSTALLATION OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	396	439	171,136,373	0.000018
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	933	296	171,136,373	0.0000264
15. A/C Flat Sheet	49	723	171,136,373	0.00000298
16. A/C Corrugated Sheet	7	723	171,136,373	0.00000043
17. A/C Shingles	323	130	171,136,373	0.00000052
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings			210,250	1.04
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Mining and Milling				

TABLE III-4. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO USE OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grede Elect. Paper				
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)			60,943,018	0.00058
19. Disc Brake Pads, LMV (OEM)			34,659,752	0.00064
20. Disc Brake Pads, HV				
21. Brake Blocks			226,546,000	0.0061
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)			165,602,982	0.00058
37. Disc Brake Pads, LMV (A/M)			191,886,248	0.00064
38. Mining and Milling				

TABLE III-5. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO REPAIR/DISPOSAL OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	263	296	171,136,373	0.0000067
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet	61	2,080	171,136,373	0.0000173
16. A/C Corrugated Sheet	9	2,080	171,136,373	0.0000025
17. A/C Shingles	225	244	171,136,373	0.0000067
18. Drum Brake Linings (OEM)			49,442,265	0.0123
19. Disc Brake Pads, LMV (OEM)			27,453,272	0.00624
20. Disc Brake Pads, HV	117	390	170,871,494	0.000000587
21. Brake Blocks	3,985	388	170,871,494	0.0000171
22. Clutch Facings	73	125		
23. Auto. Transmiss. Comp.				
24. Friction Materials	43	120		
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	86,398	378	134,351,509	0.0123
37. Disc Brake Pads, LMV (A/M)	32,568	386	151,989,122	0.00624
38. Mining and Milling				

asbestos-related production activities. In some cases, additional information useful for developing exposure estimates exists concerning production activities after 1985. In the exposure assessment study (ICF 1988), this information was taken into account. Similarly, this additional information is taken into account in the cost/benefit modeling through the estimated future growth rates for each asbestos-containing product. Hence, to render the exposure information reported in the exposure assessment document consistent with the time frame of the cost/benefit calculation models, the exposure data developed in the exposure assessment was adjusted (as outlined in Appendix A.4 of this RIA) from post-1985 production activity levels to 1985 production activity levels. These adjustments are then "undone" as the cost model moves through the early years of the simulation period.

In each table, when no data are listed for a particular product or exposure setting, this means that no data were available for the particular product and exposure category. In many of these cases, no exposure occurs. However, if in some cases exposures occur even though no data are available, the estimated benefits for the regulatory alternatives will be biased downward. One of the analyses conducted to determine the sensitivity of the cost/benefit results focuses on this lack of exposure information. The results of that analysis are discussed in Chapter IV of this RIA. Finally, as the tables indicate, the light/medium vehicle disc and drum brakes are separated into the original equipment and aftermarkets. This is necessary because one of the regulatory alternatives treats the aftermarket differently from the original equipment market. In particular, the aftermarket is banned a number of years after the original equipment market in Regulatory Alternative J. The exposure estimates presented for these two brake markets separated into the original equipment and aftermarkets were derived from overall brake market exposures and concentrations as outlined in Appendix A.4 of this RIA.

2. Data Inputs for Projecting Health Effects

As discussed in the previous chapter, the dose-response relationships used to estimate cancers attributable to asbestos exposure are the linear no-threshold dose-response relationships proposed by Nicholson (1983). In addition to the exposure information, the following data inputs are also used in the projections of health effects.

Dose-response constants were estimated using data from human studies of asbestos related diseases. As Table III-6 indicates, these vary in magnitude considerably. The values for the dose-response constants used in this analysis are the mean values proposed by the CPSC (1983) of 1.0E-2 $(f\text{-}yr/cc)^{-1}$ for lung cancer and 1.0E-8 $(f\text{-}yr/cc)^{-1}$ for mesothelioma.

The unit measure for exposure level in the equations used in the OSHA analysis is fibers per cubic centimeter (f/cc). These equations were developed from studies that used disease data from occupationally exposed workers with a typical exposure of 8 hours per day, 250 days per year and a breathing rate of 1.3 cu m/hour. For a worker so exposed, an exposure level of 1 f/cc is equivalent to 2,600 million fibers breathed per year (1 x 1,000,000 x 1.3 x 8 x 250). However, OSHA's dose-response relationships are used in this study for exposure categories and activities where exposure levels, breathing rates, and hours-exposed-per-year may all be different than those for a full-time worker. Hence, the exposure levels for these other categories in terms of millions-of-fiber-breathed-per-year were derived based on the exposure time, estimated breathing rate, and numbers of days per year for each exposure category and setting in this study. The resulting estimates of exposure -- in terms of millions of fibers breathed per year -- were then divided by a normalizing factor of 2,600 millions of fibers per year to convert these exposure levels

Table III-6. Estimated Values of Lung Cancer and Mesothelioma Dose-Response Constants

Mortality Study	Estimated Value Lung Cancer Constant $(f\text{-}yr/cc)^{-1}$	Estimated Value Mesothelioma Constant $(f\text{-}yr/cc)^{-1}$
Finkelstein et al. 1983	4.8 E-2	1.2 E-7
Seidman et al. 1979, pp. 61-89	6.8 E-2	5.7 E-8
Dement et al. 1982	2.3-4.4 E-2	
Selikoff et al. 1979, pp. 569-585	1.0 E-2	1.5 E-8
Peto 1980, pp. 829-836	1.0 E-2	7.0 E-10
Henderson and Enterline 1979, pp. 117-126	3.3-5.0 E-3	
Hughes and Weill 1980, pp. 627-637	3.1 E-3	
Rubino et al. 1979	1.7 E-3	
Nicholson et al. 1979	1.2 E-3	
McDonald et al. 1980	6.0 E-4	
Berry and Newhouse 1983, pp. 1-7	6.0 E-4	

Source: Chronic Hazard Advisory Panel on Asbestos. 1983 (July). Report to the U.S. Consumer Product Safety Commission. Washington D.C. p. II-129.

into OSHA's full-time-equivalent worker exposure level (measured as f/cc) before use in the dose-response relationships.

For all products and exposure categories, future exposure levels are assumed to remain constant at the levels presented in the exposure data tables (Tables III-1 through III-5 in the previous subsection). Changes in production levels are assumed to change the number of people exposed.

<u>Age-specific five-year death rates for lung cancer, gastrointestinal cancer, mesothelioma, and all other causes attributable to asbestos exposure and to background causes are estimated.</u> This analysis assumes that mesothelioma death rates do not depend on age, sex, race, or smoking habits. However, excess lung cancer and gastrointestinal cancer death rates and other mortality rates do vary according to these demographic characteristics. For simplicity, it is assumed that the nonoccupational population is identical to the U.S. population in terms of sex, race, and smoking habits, and age distribution for 1980 (see Table III-7) and will remain constant until 2000. All occupational categories are assumed to have the same demographic characteristics and stay constant until 2000. These are estimated from industry data for 1983 (see Table III-7). Smoking habits are assumed to be the same as in the general population. If the population was allowed to change over time, the benefits estimates would be lower. For all products and exposure categories, future exposure levels are assumed to remain constant at the levels presented in the exposure data tables (Tables III-1 through III-5 in the previous subsection). Changes in production levels are assumed to change the number of people exposed.

Age-specific five-year baseline lung cancer rates were taken from the Vital Statistics of the United States for 1977 (U.S. Department of Health and Human Services, 1981). Baseline lung cancer for the year 1990 is projected

Table III-7. Sex, Race, and Age Distribution of Exposed Populations

Characteristic	Proportion of Population (Decimal Share)	
	Occupational	Nonoccupational
	1983	1980
Sex		
Male	0.79	0.49
Female	0.21	0.51
Race		
White	0.88	0.88
Nonwhite	0.12	0.12
Age		
0 - 9	0.0	0.146
10 - 19	0.1	0.174
20 - 29	0.205	0.176
30 - 39	0.210	0.139
40 - 49	0.193	0.108
50 - 59	0.175	0.099
60 - 69	0.117	0.083
70 - 79	0.0	0.055
80 - 89	0.0	0.020

Sources: For occupational: Research Triangle Institute 1985 (August). Regulatory Impact Analysis of Controls on Asbestos and Asbestos Products. Prepared for the Office of Pesticides and Toxic Substances, U.S. EPA. Washington, D.C. Appendix B. For nonoccupational: UDOC. 1980. U.S. Department of the Census. Statistical Abstract of the United States. Washington D.C.: Bureau of the Census.

using the 1977 rates and inflated for the older cohorts as suggested in Doll and Peto (1981). Increases of 2 percent per year for men over 50 and 4 percent per year for women over 40 are assumed. These increases are projected because of past increases in smoking. Since smoking rates have been declining in recent years, the projected 1990 lung cancer death rates are likely to overstate the baseline death rates that will be observed in the twenty-first century.

Five-year death rates for all causes by sex, race, and age are estimated based on the 1978 U.S. life tables and are assumed to remain constant in the future (Cooper et al. 1983). All persons alive at age 89 are assumed to die during their ninetieth year.

Finally, to estimate the avoided cases of cancer from the estimates of avoided cancer deaths, the cure rates for the three asbestos-related cancers are estimated from the equation:

$$(\text{Relative survival rate at time } t) = c + (1-c)\,(1-b)^t$$

where:

- c = cancer cure rate (the proportion of people with the disease for whom it is no longer life threatening);
- b = annual mortality rate for dying patients; and
- t = time since diagnosis (years).

Estimated values for both c and b are obtained using publicly available data on survival for lung cancer, gastrointestinal cancer (Axtell et al. 1986) and mesothelioma (Chahinian 1982). The values of the cure rates estimated and used in the analysis are 8 percent for lung cancer, 36 percent for gastrointestinal cancer, and 2 percent for mesothelioma. The cure rates were used to convert estimates of cancer deaths to estimates of cancer cases as follows: Cases = Deaths / (1 - Cure Rate).

B. Data Inputs for Estimating Costs

As is apparent from the discussion of the theoretical approach for estimating the costs presented in the previous chapter, a large amount of detailed information is required to develop quantitative estimates of the regulatory alternatives' costs using these approaches. This section presents the data used in developing quantitative cost estimates for the various regulatory options. Detailed presentations of the derivations of and sources for the data appear in the Appendices to this report, as noted below.

The data elements required as inputs for the Asbestos Regulatory Cost Model (ARCM) consist of three separate classes of data: (1) data required for each separate asbestos product market, (2) information on substitutes for each asbestos product, and (3) data on the asbestos fiber market. This section describes these groups of input data and reports the values of the variables used in the model. Of course, all of these data interact in the ARCM to produce year-by-year estimates of quantities, prices, and related information for both the baseline and the regulatory scenarios, as shown in the following chapter. Hence, the purpose here is simply to indicate what these input values are and in which appendix more detail is provided on derivations and sources.

a. Data for Asbestos Product Markets

The data required for each asbestos product market consist of:

- Baseline prices and domestic production quantities for all product markets in 1985.*

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* The model is designed to accept information for any year as input. To avoid confusion, we refer to 1985 as this is the year for which all data are available at the time of writing.

- Amount of asbestos (in tons) used per unit of output, in all output markets. This coefficient can be derived if information on the amount of asbestos fiber used in each output market (for the same data year) is available. It is computed as the ratio of the amount of asbestos fiber used by a market to the baseline output quantity produced. In the remainder of this section this coefficient is referred to as the Product Asbestos Coefficient (PAC).

- The service life of the asbestos product. This is necessary for calculating the present values of substitute prices.

- The consumption-production ratio for all output markets. This ratio captures the import-export orientation of each market and can be computed by taking the ratio of domestic consumption to domestic production of output goods. A value greater than one implies an import orientation, and a value less than one implies an export orientation.

- Baseline output quantities for all product markets, for the specified period. These are obtained by applying the annual growth rates developed in the Baseline Projections Model described in Appendix A.1 to the output quantity data available for the data year.

- Quasi-rents (i.e., short-run producer surplus) per unit of output and the duration of these quasi-rents, by market.

The first four of these six pieces of information required for the ARCM were obtained through an extensive survey of asbestos product manufacturers and importers designed to update previous information on asbestos markets and products. This results of this survey are reported in detail in Appendix F. Based on the survey, Table III-8 reports for each product, the (1) the baseline quantity (1985 value), (2) the baseline price (1985 value), (3) the ratio of imports to domestic production, (4) ratio of asbestos fiber usage per unit of the product, and (5) the service life of the asbestos product. Again, as the table indicates, there are 35 distinct asbestos product categories. In modeling the effects of the various regulatory alternatives, however, two product categories, drum and disc brakes for light/medium vehicles, have been

TABLE III-8. ASBESTOS PRODUCT MARKET DATA USED IN ARCM

Product Category	1985 Quantity (incl. imports)	1985 Price ($/unit)	Consumption Production Ratio	Product Asbestos Coefficient	Life of Asbestos Product (years)
1. Commercial Paper	0 tons	n/a	n/a	n/a	n/a
2. Rollboard	0 tons	n/a	n/a	n/a	n/a
3. Millboard	581 tons	1,760.00	1.0050	0.7500861	25.0
4. Pipeline Wrap	296,949 squares	5.80	2.5000	0.0044900	25.0
5. Beater-add Gaskets	16,505 tons	1,500.00	1.0200	0.7534929	5.0
6. High-grade Electrical Paper	698 tons	5,060.00	1.0000	1.0659026	3.0
7. Roofing Felt*	283,200 tons	6.65	Imports Only	0.0045000	18.0
8. Acetylene Cylinders	392,121 pieces	90.00	1.0000	0.0014896	1.0
9. Flooring Felt	0 tons	n/a	n/a	n/a	n/a
10. Corrugated Paper	0 tons	n/a	n/a	n/a	n/a
11. Specialty Papers	434 tons	4,300.00	1.0000	0.2122120	1.0 **
12. Vinyl-Asbestos Floor Tile	18,300,000 sq. yards	n/a	1.0000	0.0005700	***
13. Asbestos Diaphragms	9,770 pieces	215.87	1.0000	0.1000000	1.0 **
14. Asbestos-Cement Pipe	15,062,708 feet	8.94	1.0128	0.0021703	50.0
15. Flat A-C Sheets	22,621 squares	181.00	1.1500	0.1140003	25.0
16. Corrugated A-C Sheets*	3,859 squares	277.00	Imports Only	0.0855000	30.0
17. A-C Shingles	176,643 squares	113.00	1.3700	0.0220388	40.0
18. Drum Brake Linings (OEM)	34,713,675 pieces	0.63	1.1500	0.0001913	4.0
19. Disc Brake Pads, LMV (OEM)	10,077,464 pieces	0.42	1.1900	0.0001081	4.0
20. Disc Brake Pads (HV)	156,820 pieces	10.00	1.0000	0.0007499	0.5
21. Brake Blocks	4,570,266 pieces	5.74	1.0100	0.0005784	0.5
22. Clutch Facings	7,237,112 pieces	1.71	1.1200	0.0001373	5.0
23. Automatic Transmission Components	585,500 pieces	1.60	1.0000	0.0000043	5.5
24. Friction Materials	8,719,541 pieces	34.65	1.0000	0.0001836	0.5
25. Asbestos Protective Clothing	0 tons	n/a	n/a	n/a	n/a
26. Asbestos, Thread, Yarn, and Other Cloth	1,125 tons	3,300.00	1.5110	0.4960000	1.0
27. Asbestos Sheet Gasketing	3,607,408 sq. yards	5.69	1.0700	0.0015083	5.0
28. Asbestos Packing	3 tons	60,400.00	1.0000	0.7000000	1.0
29. Roof Coatings and Cements	75,977,365 gallons	2.49	1.0000	0.0003889	10.0
30. Non-Roofing Coatings, Compounds, and Sealants	9,612,655 gallons	13.90	1.0000	0.0003070	10.0
31. Asbestos-Reinforced Plastics	4,835 tons	5,260.00	1.0300	0.1679628	1.0
32. Missile Liner	4,667 tons	14,000.00	1.0000	0.1499893	1.0 **
33. Sealant Tape	423,048,539 feet	0.07	1.0000	0.0000039	20.0
34. Battery Separators	****** not modeled ******				
35. Arc Chutes	****** not modeled ******				
36. Drum Brake Linings (A/M)	94,328,903 pieces	0.63	1.1500	0.0001913	4.0
37. Disc Brake Pads, LMV (A/M)	55,791,708 pieces	0.42	1.1900	0.0001081	4.0

* Quantity reported for 1985 are imports only.
** Life is one use.
*** Product is no longer made or sold in the United States.

divided into the original equipment market and the aftermarket, the latter of which refers to replacements of brakes. This is to facilitate analysis of options that regulate the original equipment and aftermarket sectors differently (e.g., Regulatory Alternative J). In addition, two product categories -- battery separators and arc chutes -- are not simulated due to lack of detailed information on substitutes for these products. These are extremely small users of asbestos, so their absence from the explicit simulation is not likely to affect the quantitative estimates of the costs and benefits of the regulatory alternatives for the other products. Arc chutes and battery separators are, however, intended to be included in the product bans or phase-downs of fiber use over time (their exclusion from the simulation is not intended to indicate an exemption). As a result, while there are 35 physically distinct product categories, the analysis operates in terms of 37 separate products because of the possibly different regulatory treatment for the two brake product markets, of which 35 are actually included in the simulations.

The baseline growth rates for each product were developed for three alternative scenarios. The "High Decline" scenario is based on the actual growth rates experienced in each of these product markets from 1981 to 1985. These two years were selected as basepoints for computing these growth rates because these are the two years with the most complete information: 1981 was the TSCA Section 8(a) reporting requirement, which yielded a fairly complete accounting of asbestos use, and 1985 is the year for which data were collected in the ICF Asbestos Market survey. The term decline is used because virtually all products experienced negative rates of growth during this period. Thus, the "High Decline" scenario uses the actual negative rates of growth for each product to project the baseline usage of fiber and the output of the products through time. This is reported in Table III-9 as "High Decline".

TABLE III-9. BASELINE GROWTH RATES OF ASBESTOS PRODUCTS: 1985-2000

Product Category	Growth Rates 1985-2000 (%) Low Decline	Moderate Decline	High Decline
1. Commercial Paper	n/a	n/a	n/a
2. Rollboard	n/a	n/a	n/a
3. Millboard	0.00	-16.15	-32.31
4. Pipeline Wrap	0.00	-19.51	-39.03
5. Beater-Add Gaskets	0.00	-5.39	-10.77
6. High Grade Electrical Paper	0.00	-0.14	-0.28
7. Roofing Felt	0.00	0.00	0.00
8. Acetylene Cylinders	0.00 a	-8.41 a	-16.82 a
9. Flooring Felt	n/a	n/a	n/a
10. Corrugated Paper	n/a	n/a	n/a
11. Specialty Paper	0.00	-16.25	-32.50
12. V/A Floor Tile	n/a	n/a	n/a
13. Asbestos Diaphragms	0.00	0.00	0.00
14. A/C Pipe	0.00	-5.98	-11.95
15. A/C Sheet, Flat	0.00 b	-26.36 b	-52.72 b
16. A/C Sheet, Corrugated	0.00	0.00	0.00
17. A/C Shingles	0.00	-4.89	-9.78
18. Drum Brake Linings (OEM)	c	c	c
19. Disc Brake Pads, LMV (OEM)	c	c	c
20. Disc Brake Pads (HV)	0.00	-17.67	-35.33
21. Brake Blocks	0.00	-15.96	-31.93
22. Clutch Facings	0.00	-0.27	-0.54
23. Automatic Transmission Components	0.00 d	0.00 d	0.00 d
24. Friction Materials	0.00	-8.13	-16.26
25. Asbestos Protective Clothing	n/a	n/a	n/a
26. Asbestos Thread, etc.	0.00	-16.96	-33.92
27. Sheet Gaskets	0.00	-11.59	-23.17
28. Asbestos Packing	0.00 e	-14.92 e	-29.84 e
29. Roof Coatings	0.00 f	-0.76 f	-1.53 f
30. Non-Roofing Coatings	0.00 g	-13.94 g	-27.89 g
31. Asbestos-Reinforced Plastics	0.00 h	-10.48 h	-20.96 h
32. Missile Liner	0.00	0.00	0.00
33. Sealant Tape	0.00	3.27	6.54
34. Battery Separators	***	***	***
35. Arc Chutes	***	***	***
36. Drum Brake Linings (A/M)	c	c	c
37. Disc Brake Pads, LMV (A/M)	c	c	c

a Growth rate for 1985-86 is -21.42%.

b Growth rate for 1985-86 is -77.17%.

c Growth rates for this category are based on the Brakes Model and are different for each year. See next table for all growth rates.

d Growth rate for 1985-86 is -54.70%, for 1986-87 is -78.30%, and for 1987-88 is -4.40%.

e Growth rate for 1985-86 is -66.67%.

f Growth rate for 1985-86 is -26.33%.

g Growth rate for 1985-86 is -19.41%.

h Growth rate for 1985-86 is -12.10%.

n/a: Not applicable as products are no longer made or sold in the United States.

*** This product is not included in the ARCM simulations.

The second scenario for projecting the baseline usage of fiber and output of the asbestos products was to halve the rates of decline in the High Decline scenario to product the "Moderate Decline" scenario. This is also shown in Table III-9. Finally, the "Low Decline" scenario was generated by assuming that the future output (and usage of fiber) of each product market would remain the same as the 1985 figure developed in the ICF survey. This Low Decline scenario, as shown in Table III-9, represents the largest amount of fiber consumption and product output over the course of the simulation.

It is difficult to identify one of the baseline growth rate scenarios as the correct one for several reasons. The "High Decline" baseline, in effect, assumes that future substitution away from asbestos and asbestos products would continue to occur through the future at the rates experienced in the past. On the other hand, the "No-Decline" baseline assumes no continued substitution away from asbestos in the future. The former assumption is probably an overstatement of future declines in asbestos products because eventually the pace of substitutions may decline as substitutes for remaining products and uses become increasingly difficult to identify. On the other hand, assuming no further substitution in the future would probably overstate the levels of future asbestos product output. Because of this uncertainty, the results presented in this RIA are provided for all three of the baseline product growth rate scenarios.

There are a few exceptions to the general rules outlined above for developing the baseline product market growth rates. For a few products, such as missile liner, so little was known about the past, present, and future output and usage of fiber that the growth rate was set equal zero. In a few other cases, additional information was available from the ICF survey concerning the output of products in 1986, 1987, and 1988. In these cases, the listed growth rates reflect this information.

Finally, two products (disc and drum brake OEM and aftermarkets for light and medium vehicles -- Products 18, 19, 36, and 37) have growth rates developed using a more detailed modeling procedure that yielded year-by-year growth rates throughout the duration of the simulation. These year-by-year growth rates (for the Low, Moderate, and the High Decline baseline scenarios) are reported in Table III-10. The methods and data used to estimate these growth rates are discussed in Appendix A-1 of this RIA.

Finally, the quasi-rents for each product market are shown in Table III-11. As discussed in the previous chapter, quasi-rents are payments that are necessary in the long run to the producers and factors of production involved in supplying goods to maintain supply, but which are forfeitable in the short run. Naturally, the amount of these quasi-rents that are actually lost under any given regulation depends on a number of factors which are generated in the course of simulating the regulation. Thus, Table III-11 reports only the total quasi-rents that would be lost if all markets were banned immediately (the Domestic & World Quasi-Rent Loss columns).

b. Asbestos Product Substitutes

Another set of inputs to the ARCM consists of information on substitutes for each asbestos product. The following information is necessary for estimating product demand curves, and therefore, the derived demand curve for asbestos fiber.

- Price of the substitute in 1985 in the same units as the price of the asbestos product.
- The market share for each substitute. This refers to the share of the existing market that shall switch to the substitute, given the non-availability of the asbestos product.

TABLE III-10. BASELINE GROWTH RATES OF PRODUCTS 18, 19, 36, AND 37: 1985-2000

	Growth Rates 1985-2000 (%)											
	18. Drum Brake Linings (OEM)			19. Disc Brake Pads, LMV (OEM)			36. Drum Brake Linings (A/M)			37. Disc Brake Pads, LMV (A/M)		
Year	Low Decline	Moderate Decline	High Decline	Low Decline	Moderate Decline	High Decline	Low Decline	Moderate Decline	High Decline	Low Decline	Moderate Decline	High Decline
1985-1986[a]	1.52	1.52	1.52	-54.05	-54.05	-54.05	-3.54	-3.54	-3.54	-6.25	-6.25	-6.25
1986-1987	3.56	-7.94	-17.15	3.57	-17.14	-30.95	-8.66	-8.66	-8.66	-7.04	-7.04	-7.04
1987-1988	0.59	-11.98	-24.56	0.54	-24.60	-49.73	6.46	6.46	6.46	-1.36	-1.36	-1.36
1988-1989	-1.94	-15.95	-34.63	-1.92	-34.62	-100.00	-0.16	-0.16	-0.16	-4.07	-4.07	-4.07
1989-1990	-7.87	-23.22	-53.93	-7.89	-53.94	0.00	-1.45	-1.45	-1.45	-18.35	-18.35	-18.35
1990-1991	-3.18	-22.55	-100.00	-3.16	-100.00	0.00	-1.95	-6.48	-10.11	-6.64	-9.13	-10.79
1991-1992	11.51	-16.37	0.00	11.57	0.00	0.00	4.85	0.18	-3.90	-4.15	-7.03	-9.04
1992-1993	6.46	-29.03	0.00	6.44	0.00	0.00	-0.02	-4.61	-8.98	-8.57	-11.87	-14.29
1993-1994	-5.83	-52.92	0.00	-5.92	0.00	0.00	-3.45	-7.40	-11.53	-22.28	-26.73	-24.82
1994-1995	-3.23	-100.00	0.00	-3.27	0.00	0.00	-0.80	-9.93	-20.35	-5.83	-14.25	-13.31
1995-1996	6.89	0.00	0.00	6.95	0.00	0.00	7.26	-4.84	-7.58	-1.93	-9.86	-13.39
1996-1997	8.68	0.00	0.00	8.69	0.00	0.00	2.70	-10.37	-12.65	-6.99	-16.47	-21.18
1997-1998	-2.40	0.00	0.00	-2.47	0.00	0.00	-4.62	-16.05	-16.39	-19.60	-32.36	-29.38
1998-1999	-5.26	0.00	0.00	-5.31	0.00	0.00	-1.59	-19.15	-26.97	-4.02	-18.12	-14.70
1999-2000	4.61	0.00	0.00	4.59	0.00	0.00	7.43	-7.92	-11.25	1.77	-12.76	-18.05

[a] Growth rates for 1985-86 are based on actual information available.

TABLE III-11. QUASI-RENT LOSSES ASSOCIATED WITH AN IMMEDIATE BAN OF ALL ASBESTOS PRODUCTS

Product Category	Industry Segment Classification	Conversion Cost Perpetuity ($/unit)	Reformulation Cost Perpetuity ($)	Domestic Quasi-Rent Loss ('000 $)	World Quasi-Rent Loss ('000 $)
1. Commercial Paper	Papers and Felts	0.19	0	0.00	0.00
2. Rollboard	Papers and Felts	0.19	0	0.00	0.00
3. Millboard	Papers and Felts	0.19	0	1.58	1.58
4. Pipeline Wrap	Papers and Felts	0.001	0	4.24	10.61
5. Beater-add Gaskets	Papers and Felts	0.19	0	44.80	45.70
6. High-grade Electrical Paper	Papers and Felts	0.19	0	1.89	1.89
7. Roofing Felt	Asbestos Roofing Felt	0.00	0	0.00	0.00
8. Acetylene Cylinders	Acetylene Cylinders	0.00	0	0.00	0.00
9. Flooring Felt	Papers and Felts	0.19	0	0.00	0.00
10. Corrugated Paper	Papers and Felts	0.19	0	0.00	0.00
11. Specialty Papers	Papers and Felts	0.19	0	1.18	1.18
12. Vinyl-Asbestos Floor Tile	Vinyl-Asbestos Floor Tile	0.00	0	0.00	0.00
13. Asbestos Diaphragms	Chlor-Alkali Industry	19,801.60	0	2,763,737.60	2,763,737.60
14. Asbestos-Cement Pipe	Asbestos-Cement Pipe	0.21	0	45,188.12	45,766.53
15. Flat A-C Sheets	Asbestos-Cement Sheet	19.27	0	1,421.68	1,634.93
16. Corrugated A-C Sheets	Asbestos-Cement Sheet	19.27	0	0.00	1,062.33
17. A-C Shingles	Asbestos-Cement Shingle	3.31	0	8,352.69	11,443.19
18. Drum Brake Linings (OEM)	Friction Products	0.005	248,500	5,693.81	6,547.88
19. Disc Brake Pads, LMV (OEM)	Friction Products	0.005	308,000	4,040.04	4,807.65
20. Disc Brake Pads (HV)	Friction Products	0.005	24,500	361.20	361.20
21. Brake Blocks	Friction Products	0.005	154,000	2,504.67	2,529.71
22. Clutch Facings	Friction Products	0.005	31,500	918.72	1,028.97
23. Automatic Transmission Components	Friction Products	0.005	10,500	154.11	154.11
24. Friction Materials	Friction Products	0.005	105,000	2,122.82	2,122.82
25. Asbestos Protective Clothing	Textiles and Packing	0.00	0	0.00	0.00
26. Asbestos Thread, Yarn, etc.	Textiles and Packing	0.00	0	0.00	0.00
27. Asbestos Sheet Gasketing	Sheet Gasketing	0.16	0	8,245.50	8,822.69
28. Asbestos Packing	Textiles and Packing	0.00	0	0.00	0.00
29. Roof Coatings and Cements	Coatings and Sealants	0.00	40,600	580.00	580.00
30. Non-Roofing Coatings, etc.	Coatings and Sealants	0.00	78,400	1,120.00	1,120.00
31. Asbestos-Reinforced Plastics	Asbestos-Reinforced Plastics	0.00	16,800	233.01	240.00
32. Missile Liner	Coatings and Sealants	0.00	12,600	180.00	180.00
33. Sealant Tape	Coatings and Sealants	0.00	7,000	100.00	100.00
34. Battery Separators	Textiles and Packing	***	***	***	***
35. Arc Chutes	Arc Chutes	***	***	***	***
36. Drum Brake Linings (A/M)	Friction Products	0.005	248,500	9,023.38	10,376.89
37. Disc Brake Pads, LMV (A/M)	Friction Products	0.005	308,000	7,170.51	8,532.91
				2,861,201.57	2,871,210.37

*** Product is not included in ARCM simulations.

- The service life of the substitute. This information is used to obtain the present value of the substitute's price, for the life of the asbestos product.

Much of this information was obtained from the ICF Asbestos Market Survey conducted in 1986 to update existing information on asbestos product markets and substitutes. Appendix F reports the results of this Use and Substitutes survey. As indicated in that appendix, the survey results divide the product markets into submarkets for which a given substitute is appropriate. Hence, there are actually far more than the 35 physically distinct product markets to consider for purposes of defining substitution possibilities and timing.

Table III-12 summarizes the substitutes information reported in detail in Appendix F of this RIA on a product-by-product basis. This table lists name of the relevant substitute, its price, its useful life, and the market share which this substitute would capture in the absence of the asbestos-containing product.

c. Asbestos Fiber Market

Given the information on the amount of asbestos used per unit of output, and the amount of output in all product markets, the additional data elements required for this market are:

- Price of asbestos fiber per ton in 1985. This price will be a weighted average of the prices for the various grades of asbestos fiber, i.e., the price of the "representative" asbestos fiber, which is assumed to be the only one used in the downstream markets.

- The elasticity of fiber supply. This is used in conjunction with price and quantity data to obtain the equation for the fiber supply curve.

- The proportion of fiber supply imported from foreign nations.

TABLE III-12

SUMMARY OF SUBSTITUTES INFORMATION FOR ASBESTOS-CONTAINING PRODUCTS

Product Category/ Substitute Name	Price	Useful Life	Market Share
1. <u>Commercial Paper</u>	N/A	N/A	N/A
2. <u>Rollboard</u>	N/A	N/A	N/A
3. <u>Millboard</u>			
Standard Board	$2,560/ton	25 years	80%
Premium Board	$6,800/ton	25 years	20%
4. <u>Pipeline Wrap</u>			
Mineral Felt	$5.80/square	25 years	48%
Safelt(R)	$6.20/square	25 years	32%
Duraglass(R)	$5.80/square	25 years	20%
5. <u>Beater Add Gaskets</u>			
Cellulose	$1,800/ton	5 years	25%
Aramid	$3,380/ton	5 years	30%
Fibrous Glass	$3,000/ton	5 years	20%
PTFE	$5,240/ton	5 years	10%
Graphite	$3,000/ton	5 years	10%
Ceramic	$4,500/ton	5 years	5%
6. <u>Electrical Paper</u>			
Aramid Paper	$10.48/lb.	3 years	80%
Ceramic Paper	$7.04/lb.	3 years	20%
7. <u>Asbestos Felt</u>			
Fiberglass Felt	$3.85/square	18 years	40%
Modified Bitumen	$7.48/square	18 years	50%
Single-Ply Membrane	$29.26/square	18 years	10%
8. <u>Acetylene Cylinders</u>			
Glass Fiber Filler	$93.00/ton	1 per cylinder	100%

TABLE III-12

SUMMARY OF SUBSTITUTES INFORMATION FOR ASBESTOS-CONTAINING PRODUCTS
(continued)

Product Category/ Substitute Name	Price	Useful Life	Market Share
9. Flooring Felt			
N/A			
10. Corrugated Paper			
N/A			
11. Specialty Papers			
Diatomaceous Earth and Cellulose Filter Paper	$4,000/ton	1 use	50%
Loose Cellulose Fiber Filter Paper	$2,000/ton	1 use	50%
12. Vinyl-Asbestos Floor Tile			
N/A			
13. Asbestos Diaphragms			
Mercury and Membrane Cells	N/A	N/A	N/A
14. A/C Pipe and Fittings			
PVC Pipe	$11.08	50 years	92.63%
Ductile Iron Pipe	$15.87	50 years	7.37%
15. A/C Flat Sheet			
Calcium Silicate Construction/Utility Flat Sheet	$182.00	25 years	76%
Non-Calcium Silicate Construction/Utility Flat Sheet	$417.00	25 years	4%
Substitute Laboratory Work Sheet	$217.00	25 years	20%

TABLE III-12

SUMMARY OF SUBSTITUTES INFORMATION FOR ASBESTOS-CONTAINING PRODUCTS
(continued)

Product Category/ Substitute Name	Price	Useful Life	Market Share
16. Corrugated A/C Sheet			
FRP	$246	20 years	48%
Aluminum	$188	20 years	32%
Steel	$157	15 years	11%
PVC	$301	20 years	9%
17. A/C Shingles			
Wood Siding and Roofing	$162/square	30 years	32%
Vinyl Siding	$106/square	50 years	27%
Asphalt Roofing Shingles	$ 49/square	20 years	20%
Aluminum Siding	$128/square	50 years	19%
Tile Roofing	$173/square	50 years	2%
18. Drum Brake Linings (OEM)			
NAO	$0.79/piece	5 years	99%
Semi-Metallic	$1.09/piece	4 years	1%
19. Disc Brake Pads, LMV (OEM)			
Semi-Metallic	$0.67/piece	7.4 years	100%
20. Disc Brake Pads (Heavy Vehicles)			
Semi-Metallic	$12.50/piece	0.75 years	100%
21. Brake Blocks			
NAO	$8.04/piece	0.65 years	99.5%
Full-Metallic	$6.89/piece	0.5 years	0.5%

TABLE III-12

SUMMARY OF SUBSTITUTES INFORMATION FOR ASBESTOS-CONTAINING PRODUCTS (continued)

Product Category/ Substitute Name	Price	Useful Life	Market Share
22. Clutch Facings			
Woven fiberglass (European product)	$2.92/piece	7.5 years	50%
Woven fiberglass (U.S. Product)	$2.92/piece	7.5 years	30%
Molded aramid fiber, fiberglass, cellulose and ceramic fiber (Nuturn's product)	$2.55/piece	6.25 years	10%
Molded fiberglass	$2.55/piece	6.25 years	10%
23. Automatic Transmission Components			
Cellulose	$2.00/piece	4-7 years	100%
24. Friction Materials			
Fiberglass and Kevlar(R)	$34.65/piece	0.5 years	100%
25. Protective Clothing			
N/A			
26. Asbestos Textiles			
Glass Fiber Mixtures	$ 3,460	1 year	50%
Ceramic Fiber Mixtures	$ 7,920	1 year	15%
Aramid Fiber Mixtures	$19,800	1 year	15%
Carbon Fiber Mixtures	$52,800	1 year	10%
PBI Fiber Mixtures	$79,200	1 year	10%

TABLE III-12

SUMMARY OF SUBSTITUTES INFORMATION FOR ASBESTOS-CONTAINING PRODUCTS
(continued)

Product Category/ Substitute Name	Price	Useful Life	Market Share
27. Sheet Gaskets			
Aramid	$ 9.72	5 years	30%
Fibrous Glass	$11.38	5 years	25%
Graphite	$11.38	5 years	15%
Cellulose	$ 6.83	5 years	15%
PTFE	$19.91	5 years	10%
Ceramic	$11.38	5 years	5%
28. Asbestos Packings			
Aramid	$135,900	1 year	30%
Fibrous Glass	$120,800	1 year	30%
PTFE	$211,400	1 year	15%
Graphite	$120,800	1 year	10%
PBI	$181,200	1 year	15%
29. Roof Coatings			
Cellulose Mixture	$2.95/gal	10 years	87.42%
Polyethylene Mixture	$3.36/gal	10 years	7.62%
Other Mixtures	$3.03/gal	10 years	4.95%
30. Non-Roof Coatings			
Fiber Mixture	$15.10/gal	10 yrs	70%
Non-Fiber Mixture	$14.42/gal	10 yrs	30%
31. Plastics			
Glass-Reinforced Plastic	$ 1.40/lb.	1 year	47.9%
Teflon-Reinforced Plastic	$ 2.25/lb.	1 year	42.5%
Product X	$11.22/lb.	1 year	7.4%
Porcelain	$ 4.08/lb.	1 year	1.4%
Silica-Reinforced Plastic	$ 3.00/lb.	1 year	0.5%
Carbon-Reinforced Plastic	$47.25/lb.	1 year	0.3%

TABLE III-12

SUMMARY OF SUBSTITUTES INFORMATION FOR ASBESTOS-CONTAINING PRODUCTS (continued)

Product Category/ Substitute Name	Price	Useful Life	Market Share
32. Missile Liner			
Kevlar(R) Liner	$ 29,000/ton	1 use	80%
Ceramic Fiber Liner	$140,000/ton	1 use	20%
33. Sealant Tape			
Cellulose Tape	$0.05/ft.	15 years	56.4%
Structural Urethane	$0.07/ft.	20 years	36.8%
Carbon-Based Tape	$0.32/ft.	20 years	6.6%
Non-Curing Tape	$0.10/ft.	N/A	0.2%
34. Battery Separators			
N/A			
35. Arc Chutes			
N/A			
36. Drum Brake Linings (Aftermarket)			
NAO	$0.79/piece	5 years	99%
Semi-Metallic	$1.09/piece	4 years	1%
37. Disc Brake Pads, LMV (Aftermarket)			
Semi-Metallic	$0.67/piece	7.4 years	100%

The weighted average asbestos fiber price of $323.80 is based on 1985 Bureau of Mines data.* The same source reports the proportion of fiber imported from foreign nations as 91.6 percent. The derivation of the elasticity of supply for fiber is reported in Appendix A.2. Based on that analysis, the elasticity of fiber supply is assumed to be 1.46.

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* U. S. Department of the Interior, "1986 Bureau of Mines Minerals Yearbook." Bureau of Mines, USDOI, Washington, D.C.

IV. COST/BENEFIT RESULTS

This section reports the estimated costs and benefits of the seven regulatory alternatives examined in this analysis. As is true with any modeling of complex economic behavior and highly technical exposure and dose-response relationships, the qualitative results can be sensitive to the input assumptions. Thus, a number of different "runs" of the cost and benefit models were performed using alternative input data to test and document the sensitivity of the results to different input assumptions. Most of these are reported in detail in Appendix G. The results presented here are considered to be the "central" results of the analysis, based on mostly likely values of the important input parameters and the relevant policy variables, and thus most relevant for options selection. In addition to these base case cost/benefit results, however, this chapter also reports the results of a set of sensitivity analyses conducted using just one of the regulatory options. These sensitivity analyses concern the impacts on the costs and benefits of possible declines in the future prices of asbestos product substitutes and of additional information about the levels of occupational and nonoccupational exposures for products and exposure settings in which data were not available for the RIA.

The regulatory alternatives examined in this RIA represent a range of possible options for controlling asbestos exposures. No single alternative, however, is identified as the preferred regulatory alternative. Instead, these alternatives were selected to assist in the Agency's regulatory options selection process. Using the results for these policy options, the costs and benefits of alternative combinations and timing of options can be assessed quantitatively and qualitatively.

Finally, the quantitative estimates of the costs and benefits of the regulatory alternatives should be interpreted with care. As Chapter II of this volume of the RIA emphasizes, the benefits estimated quantitatively in this RIA are a subset of all of the benefits attributable to the regulatory alternatives. For example, only cancer cases are considered in the analysis, so that asbestosis and other asbestos-related diseases are not explicitly included in the benefit estimates presented below. In addition, exposure information was not available for many of the product/exposure settings, although such exposures may well occur. Hence, additional benefits beyond those quantitatively estimated in the base case presented in this RIA may exist.

Similarly, the costs estimated in this RIA are likely to be overestimates for several reasons. First, the central case cost estimates developed in this analysis assume no decline in the prices of asbestos substitutes as time passes and as additional experience using these substitutes is gained. Second, the model for calculating the costs of the regulatory alternatives does not include cost-reduction benefits of using lower-cost substitutes for asbestos-containing products, i.e., asbestos-containing product substitute prices are always assumed to be greater than or equal to the price of the asbestos-containing product (on an equal service life basis). Finally, the cost estimation model assumes that in the absence of asbestos-containing products, users will switch to non-asbestos products in proportion to the existing market shares of these substitutes, and not proportionately more toward the lower cost substitutes.

A. Costs and Benefits of Regulatory Alternatives

1. Specification of Regulatory Alternatives

Fourteen regulatory alternatives involving product bans, fiber phase-downs, and combinations of the two policies (as well as exemptions of certain product categories) were considered in detail for this RIA. Product bans in each of these alternatives prohibit the manufacture, importation, or sale of the specific products banned. Since the timing and scope of the bans in the various alternatives are different, the bans are referred to as "staged" bans. Phase-downs of fiber use, on the other hand, operate as quotas, so that gradually decreasing amount of fiber can be mined or imported (in products or as fiber) over time. As the phase-down occurs, asbestos fiber is allocated to the uses that face the highest costs of foregoing use of the fiber until the phase-down is completed. Thus, once the phase-down is completed, the result is the same as a complete ban on all asbestos products.

The fourteen specific regulatory alternatives examined in this RIA are:

<u>Alternative B</u>:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 25 (protective clothing and construction products, except for A/C sheet and shingle) in 1987

<u>Alternative BX</u>:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 25 (protective clothing and construction products, except for A/C sheet and shingle) in 1987
- Products 13 and 32 (diaphragms and missile liner) exempt from regulation

<u>Alternative D</u>:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing, construction products) in 1987

<u>Alternative DX</u>:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987
- Products 13 and 32 (diaphragms and missile liner) exempt from regulation

Alternative E:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992

Alternative F:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992

- Bans of all Remaining Products in 1997.

Alternative FX:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992

- Bans of all Remaining Products in 1997 except Products 13 and 32 (diaphragms and missile liner).

Alternative G:

- Bans of all Products in 1987

Alternative GX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1987

Alternative H:

- Bans of all Products in 1992

Alternative HX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1992

Alternative I:

- Bans of all Products in 1997

Alternative IX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1997

Alternative J:

- Bans of Products 1, 2, 4, 7, 9, 10, 12, 15, 16, 17, and 25 in 1987
- Bans of Products 5, 18, 19, 20, 21, 22, 23, 24, and 27 in 1991
- Bans of Products 14, 36, and 37 in 1994.

For each of these regulatory alternatives, three different baselines of asbestos product market growth over time were modeled: High, Moderate, and Low Declines, as outlined in Chapter III of this RIA. The results presented in this chapter reflect the "Low Decline" baseline growth rate assumptions outlined in the previous chapter. As Chapter III pointed out, the "Low Decline" baseline assumes the highest levels of future asbestos use and, as such, probably overstates both the level of future production of asbestos products and therefore, the costs of the regulatory alternatives. Results using the other two baseline growth rate assumptions are reported in Appendix G - Sensitivity Analyses. Two different discounting scenarios for calculating the present value of the costs and benefits of the regulatory alternatives were used: 3 percent for both costs and benefits, and 3 percent for costs and 0 percent for benefits. In addition, when benefits are discounted, they are discounted from the time of exposure (e.g., the time of manufacture for manufacturing-related exposures, the time of future repair and disposal for those types of exposures).

In addition to the input data presented in Chapter III, two other pieces of information are necessary to complete the model specifications for the regulatory alternatives. These are the fiber phase-down schedule for each case in which it is relevant and the exact mechanism for allocating the valuable rights to mine, use, or purchase asbestos fiber to economic entities.

The fiber phase-down schedule in each relevant case is designed to reduce fiber consumption across the time horizon of the phase-down in equal increments, starting at the level of fiber usage in the beginning of the scenario (1986 in these cases) <u>adjusted for any product bans</u>. That is, the fiber cap schedule in designed to reduce fiber consumption by non-banned product markets in equal increments over time, so in cases in which products are banned, the fiber usage associated with these products is first subtracted from the total before determining the fiber phase-down schedule. Table IV-1 shows the fiber cap schedule for Alternatives B and D, the two alternatives in which a phase-down is used. Finally, the value of the rights to use, purchase, or mine asbestos fiber are assumed to accrue to the government. Should these instead be allocated to various of the parties associated with these asbestos markets, their losses would be reduced by the value of these rights.

2. <u>Results</u>

The aggregated costs and benefits of Regulatory Alternatives B, BX, D, DX, E, F, FX, G, GX, H, HX, I, IX, and J are presented in Table IV-2. The table lists for each alternative (1) the total domestic welfare cost imposed, (2) the total number of cancer cases avoided, and (3) the cost per cancer case avoided. There are two sets of these results in the table corresponding to the two different discounting assumption -- 3 percent for both costs and benefits and 3 percent for costs and 0 percent for benefits.

Table IV-1. Fiber Cap Schedules for Phase-Down Scenarios
Low Decline Baseline
(tons)

Year	Alternative B	Alternative D
1987	88,902.58	83,138.57
1988	80,012.32	74,824.72
1989	71,122.07	66,510.86
1990	62,231.81	58,197.00
1991	53,341.55	49,883.14
1992	44,451.29	41,569.29
1993	35,561.03	33,255.43
1994	26,670.77	24,941.57
1995	17,780.52	16,627.71
1996	8,890.26	8,313.86
1997	0.00	0.00

TABLE IV-2. SUMMARY OF COSTS AND BENEFITS OF ALTERNATIVES
(Low Decline Baseline)

Discounting Scenario and Costs* and Benefits	Alternative B	BX	D	DX	E	F	FX
<u>3-Costs/3-Benefits Discounting</u>							
Total Cost ($1,000,000's):	$ 3,560	1,079	3,607	1,126	603	3,486	1,008
Total Cancers Avoided:	208	208	210	210	145	150	150
Cost Per Case ($1,000,000's):	17.1	5.2	17.2	5.4	4.2	23.2	6.7
<u>3-Costs/0-Benefits Discounting</u>							
Total Cost ($1,000,000's):	$ 3,560	1,079	3,607	1,126	603	3,486	1,008
Total Cancers Avoided:	266	266	268	268	193	200	200
Cost Per Case ($1,000,000's):	13.4	4.1	13.5	4.2	3.1	17.4	5.0

* Total domestic cost

Note: Table contains rounded entries.

TABLE IV-2. SUMMARY OF COSTS AND BENEFITS OF EXEMPTION ALTERNATIVES
(Low Decline Baseline)
(continued)

Discounting Scenario and Costs* and Benefits	Alternative G	GX	H	HX	I	IX	J
<u>3-Costs/3-Benefits Discounting</u>							
Total Cost ($1,000,000's):	$ 6,934	2,286	4,868	1,385	3,085	607	748
Total Cancers Avoided:	266	266	154	153	63	62	122
Cost Per Case ($1,000,000's):	26.0	8.6	31.7	9.1	49.3	9.7	6.1
<u>3-Costs/0-Benefits Discounting</u>							
Total Cost ($1,000,000's):	$ 6,934	2,286	4,868	1,385	3,085	607	748
Total Cancers Avoided:	329	328	206	205	91	90	167
Cost Per Case ($1,000,000's):	21.1	7.0	23.7	6.8	34.1	6.7	4.5

* Total domestic cost

Note: Table contains rounded entries.

Table IV-2 indicates that the aggregate U.S. welfare losses attributable to the fourteen regulatory alternatives range from a low of about $603 million (Alternative E) to just under $7 billion (Alternative G), depending on the regulatory alternative considered. The lowest welfare costs for the U.S. are, of course, the regulatory alternatives that ban the fewest products (Alternatives E and J) and the highest are those that ban more products (or phase down all fiber usage) and ban them earlier -- Alternatives B, G, and H. Clearly, the costs of each regulatory alternative are reduced significantly by excluding certain products, such as asbestos diaphragms and missile liner, from both the asbestos fiber phase down and product bans, as both the "X" alternatives and Alternatives E and J indicate.

The figures in the table reporting the quantitatively estimated benefits also indicate that the number of cancer cases avoided changes dramatically across the alternatives (using the undiscounted cancer cases avoided figures), from a low of 90 cases avoided (for Regulatory Alternative IX) to a high of 329 cases avoided (Regulatory Alternative G). To some extent, however, the costs imposed by the regulatory alternatives rise and fall as the numbers of cancer cases avoided rise and fall. This produces a cost-per-cancer-case-avoided (using the 3 percent discount rate for both costs and benefits) that ranges from a low of about $4.2 million per case avoided (Alternative E) to a high of about $49 million per case avoided (Alternative I). Most of the overall cost-per-cancer-case-avoided figures, however, are in the $5 million to $30 million range. Alternatives that exempt diaphragms and missile liner from the phase down and product bans, of course, are those with costs per case avoided at the lower end of the range, and those that do not typically are in the higher end of the range.

While the aggregated costs and benefits of the fourteen regulatory alternatives presented in Table IV-2 are informative, product-by-product comparisons are also useful. Appendix G for this RIA contains detailed tables for each of the fourteen regulatory alternative under each baseline (Low, Moderate, and High Declines). Clearly, these are too numerous to place in the body of this chapter. Instead, detailed cost and benefit results are presented here only for Alternative J. Appendix G contains identical detailed information for each of the other combinations of regulatory alternatives and baselines.

Tables IV-3 through IV-5 present detailed cost and benefit information for Regulatory Alternative J. The first table reports the welfare losses and gains of each distinct set of parties affected by Regulatory Alternative J, e.g., domestic miners and millers, domestic primary processors, foreign product purchasers, etc., using the 3 percent discount rate for costs. These are the gains and losses of each set of parties in their capacities as, for example, primary processors.*

Table IV-3 also reports the aggregate world welfare loss and the aggregate welfare change for the U.S. taken as a whole due to Regulatory Alternative J. Tables IV-4 and IV-5 report detailed product-by-product cost and benefits results for Regulatory Alternative J using the 3 percent discount rate for costs and benefits for Table IV-4 and 3 percent for costs and 0 percent for benefits in Table IV-5. These tables present the welfare cost imposed by the regulatory alternative <u>on U.S. entities</u> for each separate product in column

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* Under phase downs of asbestos fiber which occur in alternatives B, BX, D, and DX, however, valuable rights to use and purchase asbestos fiber during a phase down might be allocated to some of these parties, so that their net gains or losses might be affected by ownership of these rights. Hence, detailed results tables in Appendix G for these phase down scenarios reflect these valuable rights during the phase down, but these are allocated to the government alone rather than any individual parties.

TABLE IV-3. WELFARE EFFECTS BY PARTY FOR ALTERNATIVE J - LOW DECLINE BASELINE

(Present values, in million dollars, discounted at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.31	.00	7.31
Foreign Miners & Millers		79.76	.00	79.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		77.58	.00	77.58
Foreign Primary Processors		8.64	.00	8.64
Domestic Product Purchasers	663.54	.00	.00	663.54
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	748.43
World Welfare:	836.84

Note: Negative entries are welfare gains.

TABLE IV-4. COSTS AND BENEFITS BY PRODUCT CATEGORY FOR ALTERNATIVE J - LOW DECLINE BASELINE

(Costs discounted at 3%; Benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beeter-Add Gaskets	207.38	.04	207.42	7.7573	26.74
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	3.1110	72.33
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	8.3800	1.72
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.9927	3.57
20	Disc Brake Pads HV	.01	.31	.33	.2165	1.51
21	Brake Blocks	17.10	2.17	19.27	14.4204	1.34
22	Clutch Facings	24.66	.81	25.48	.6049	42.12
23	Automatic Trans. Components	.17	.13	.30	.0005	637.88
24	Friction Materials	.20	1.86	2.06	.5244	3.92
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	2.4658	66.75
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	106.2551	.19
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	15.8541	.23
38	Mining and Milling	.00	7.31	7.31	1.1258	6.50
	Total			748.43 *	166.7950	4.49

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

TABLE IV-5. COSTS AND BENEFITS BY PRODUCT CATEGORY FOR ALTERNATIVE J - LOW DECLINE BASELINE

(Costs discounted at 3%; Benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	207.38	.04	207.42	5.8793	35.28
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	2.2514	99.94
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	6.3280	2.28
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.7495	4.72
20	Disc Brake Pads HV	.01	.31	.33	.1641	1.99
21	Brake Blocks	17.10	2.17	19.27	10.9292	1.76
22	Clutch Facings	24.66	.81	25.48	.4585	55.57
23	Automatic Trans. Components	.17	.13	.30	.0004	841.65
24	Friction Materials	.20	1.86	2.06	.3974	5.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	1.8688	88.08
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	76.7895	.26
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	11.5777	.31
38	Mining and Milling	.00	7.31	7.31	.8457	8.65
	Total			748.43 *	122.3435	6.12

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

three, which is also divided into consumer and producer welfare losses in columns one and two. The fourth column of these two tables reports the number of cancer cases avoided on a product-by-product basis. The fifth column of these tables reports the cost-per-cancer-case-avoided for the regulatory alternative, which is simply the number of cancer cases avoided divided by the cost of the regulatory alternative in each market.

Finally, listed at the bottom of these tables are (1) the cost of the regulation to U.S. entities taken as a whole, (2) the total number of cancer cases avoided across all products, and (3) the implied cost-per-cancer-case-avoided for all products taken together.

These detailed tables provide a significant amount of information concerning the costs and benefits of Regulatory Alternative J. First, several of the product markets (e.g., Commercial Paper, Rollboard), as the tables indicate, contribute neither costs nor benefits, since these products are no longer produced or consumed in the U.S. Second, a number of products that are still either produced or imported to the U.S. are not banned in this scenario. These products (e.g., diaphragms, thread, acetylene cylinders) actually gain from the regulation because the product bans cause the price of asbestos fiber to fall (the consumer surplus loss and total loss entries are negative indicating welfare gains). This yields increased consumer surplus to consumers of these products. Third, the bulk of the costs of the regulatory alternative is borne by consumers through higher costs for asbestos products and substitutes for these products. That is, the producer surplus losses amount to only about 10 percent of the total domestic cost of the regulation. Fourth, the product-by-product details indicate that although there is a wide range for the product-specific cost-per-cancer-case-avoided figures, the cost per case tends to be lower for products that contribute the largest number of cancer cases (e.g., the friction product categories). Thus, the cost-per-case-avoided for this set of products are among the lowest, for example, $260,000 per case for drum brake linings in the aftermarket using the 3 percent discounting for both costs and benefits. Overall, the cost-per-case-avoided ranges from the $230,000 per case for aftermarket drum brakes to a high of over $800 million per case for automatic transmission components (although this latter figure is produced by the extremely small estimated cases avoided for this product).

These product-by-product costs and benefits are quite useful in understanding which markets yield high benefits and which impose relatively higher costs. This information, contained in its entirety in Appendix G of this RIA, can be used to "fine tune" the regulatory alternatives and to explore other combinations of policies.

B. Sensitivity Analyses

Appendix G presents more detailed output from these model runs. The tables presented in Appendix G provide tabulations of welfare effects, by party affected and by market under the two different discounting scenarios, under the three possible baseline growth rate assumptions, and for each of the fourteen regulatory alternatives. The results for these numerous distinct cases are consistent with expectations. For example, using the High and Moderate Decline baselines (in which the decline of asbestos products over time is more rapid than in the Low Decline baseline) reduces the costs of the regulatory alternatives and their benefits. Similarly, using high discount rates reduces the benefits and the costs. The total costs for these alternatives discounted at 3 percent ranges from a low of about $243 million (J - High Decline) to over $6 billion (G - Low Decline).

Appendix G also reports some illustrative results for some regulatory options and baseline conditions not considered in the fourteen alternatives discussed in detail in this Regulatory Impact Analysis. One regulatory option is to require engineering controls for some of the asbestos products to reduce asbestos exposures. To illustrate this possibility, model runs using engineering controls on replacement brake markets (for drum brakes and LMV disc brakes), rather than bans on these asbestos brakes, are presented in Appendix G.

Finally, two potentially important factors not included in the "central case" analysis of this RIA could have a significant impact on both the costs and the benefits of the regulatory alternatives. First, there is the distinct possibility that substitutes for asbestos products might become cheaper over time as both experience with their use and the cumulative volume of their production increase. Substantial empirical evidence for downward trends in prices due to "experience" exists. This suggests that the costs estimated in this RIA may be higher than they ultimately will turn out to be as asbestos product substitute costs decline over time. Second, in many cases data on releases of and exposures to asbestos were not available. The "base case" analysis in this RIA assumes that in these cases these releases and exposures are zero, which is not likely to be true. This assumption could impart a substantial downward bias to the quantitative benefits estimates for the regulatory alternatives.

To illustrate the potential impact on the costs and benefits of 1) allowing for declining prices of asbestos product substitute prices over time, and 2) introducing release and exposure information where such information is available, a number of sensitivity scenarios were estimated using Regulatory Alternative J. For declining substitute prices, an across-the-board decline of one percent per year is assumed. The basis for the possible decline in asbestos substitute prices over time is primarily the empirical observation in the business and economics literature of both economies of scale and experience curves (both of which lead to reduced prices for goods over time).* However, the results presented for this scenario are designed to indicate the sensitivity of the costs of the regulatory alternatives to changing substitute prices over time, hence the one percent fall per year in all asbestos substitute prices is an assumption made for illustrative purposes. Although this may overestimate the rate of decline for some products that have been in existence for some time, it may underestimate the rate of decline for other, newer products or products with new applications.

For products and exposure settings in which no data were available to estimate releases and asbestos exposures directly, two different alternative exposure scenarios were developed, as described in detail in Appendix A-6. First, where possible, for occupational exposures in manufacturing, installation, and repair and disposal, exposures in these settings were estimated based on analogous exposure settings for product for which exposure information exists. This was done for one product's manufacturing stage, eight products' repair and disposal stage, and nine products' installation stage. The basic rationale for this procedure is that similar activities involving roughly similar probable exposure paths and concentrations are likely to result in similar exposures. Tables IV-6 through IV-8 tabulate the additional occupational exposure information developed for this sensitivity analysis for these three different exposure settings (primary manufacturing, installation, and repair and disposal).

In some non-occupational exposure settings for which data did not exist but in which exposures are likely, one percent of the asbestos content of the

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* Recent articles concerning pricing, costs, and the experience (or learning) curve include Bass (1980), Lieberman (1984), and Gilman (1982).

TABLE IV-6. ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS FOR PRIMARY MANUFACTURING

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt				
8. Acetylene Cylinders		200		
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Mining and Milling				

TABLE IV-7. ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS FOR INSTALLATION OF PRODUCTS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	20	57		
4. Pipeline Wrap	2,725	52		
5. Beater-add Gaskets	53,417	57		
6. High-grade Elect. Paper	300	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	350	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets	5,741	276		
28. Asbestos Packings	2	276		
29. Roof Coatings				
30. Non-Roofing Coatings	1,780	364		
31. Asb. Reinforced Plastics				
32. Missile Liners	260	57		
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Mining and Milling				

TABLE IV-8. ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS FOR REPAIR/DISPOSAL OF PRODUCTS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	20	57		
4. Pipeline Wrap	2,725	18		
5. Beater-add Gaskets	53,417	57		
6. High-grade Elect. Paper	300	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	350	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	1,458	296		
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets	5,741	276		
28. Asbestos Packings	2	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Mining and Milling				

product was assumed to be released per year over the life of the product. These releases would be caused by normal weathering of products or by various activities, such as cutting, sawing, and sanding that occur to the products in the course of their use. The assumptions are described in greater detail in Appendix A-6 of this RIA. Table IV-9 tabulates these additional nonoccupational exposure assumptions for exposures in use of asbestos products. describes the procedures used to develop these additional non-occupational exposure data.

Table IV-10 tabulates the results of these sensitivity analyses using Regulatory Alternative J (the 3-stage product ban at dates 1987, 1991, and 1994, exempting a number of products such as missile liner and diaphragms, regulating original equipment and aftermarket drum and disc brakes separately). The table lists the total costs, total cancer cases avoided, and the implied cost per cancer case avoided, using (1) both the 3 percent discount rate for both costs and benefits and the alternative discounting scenario of 0 percent for benefits and 3 percent for costs, and (2) the Low Decline baseline. Five distinct scenarios are presented: 1) the base case presented above for Regulatory Alternative J, 2) declining substitute prices alone, 3) additional occupational exposure assumptions, 4) additional non-occupational exposure assumptions, and 5) declining substitute prices and both sets of additional exposure assumptions simultaneously.

As the figures in the table indicate, allowing for a decline of all asbestos product substitute prices at a rate of one percent per year reduces the estimated costs by almost one-third. Because it is the difference between the asbestos product price and the cost of substitutes that is counted as a cost in the consumer surplus losses, not the absolute level of the prices of substitutes, even moderate declines over time of the prices of substitutes can

TABLE IV-9. ADDITIONAL NONOCCUPATIONAL EXPOSURE ASSUMPTIONS FOR USE OF PRODUCTS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard			171,136,373	0.000026148
4. Pipeline Wrap			171,136,373	0.000080247
5. Beater-add Gaskets			171,136,373	0.003730921
6. High-grade Elect. Paper			171,136,373	0.000372
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe			171,136,373	0.000980582
15. A/C Flat Sheet			171,136,373	0.000154728
16. A/C Corrugated Sheet			171,136,373	0.000016497
17. A/C Shingles			171,136,373	0.000145989
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV			171,136,373	0.000352845
21. Brake Blocks				
22. Clutch Facings			171,136,373	0.000297445
23. Auto. Transmiss. Comp.				
24. Friction Materials			171,136,373	0.004813187
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets			171,136,373	0.001631991
28. Asbestos Packings			171,136,373	0.0001872
29. Roof Coatings			171,136,373	0.004433279
30. Non-Roofing Coatings			171,136,373	0.000442663
31. Asb. Reinforced Plastics			171,136,373	0.001218152
32. Missile Liners				
33. Sealant Tape			171,136,373	0.000126915
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Mining and Milling				

TABLE IV-10. SENSITIVITY ANALYSIS FOR DECLINING SUBSTITUTE PRICES AND ALTERNATIVE ASBESTOS EXPOSURE ASSUMPTIONS USING REGULATORY ALTERNATIVE J
(Low Decline Baseline)

Discounting Scenario and Costs* and Benefits	Base Case	Declining Substitute Prices**	Additional Occupational Exposure	Additional Nonoccupational Exposure	All Sensitivity
<u>3-Costs/3-Benefits Discounting</u>					
Total Cost ($1,000,000's):	$ 748	510	748	748	510
Total Cancers Avoided:	122	122	153	177	209
Cost Per Case ($1,000,000's):	6.1	4.2	4.9	4.2	2.5
<u>3-Costs/0-Benefits Discounting</u>					
Total Cost ($1,000,000's):	748	$ 510	748	748	510
Total Cancers Avoided:	167	167	208	240	281
Cost Per Case ($1,000,000's):	4.5	3.1	3.6	3.1	1.8

* Total domestic cost
** All substitute prices assumed to decline at 1 percent per year
Note: Table contains rounded entries.

produce fairly large reductions in the costs of banning asbestos products. The added occupational exposures, as the table indicates, suggest that an additional 41 cancer cases (undiscounted) might be avoided by Alternative J if the additional occupational exposures assumed are accurate. An even larger number of cancer cases, some 73 additional cases, might be avoided by this alternative if the additional non-occupational exposures developed are accurate. Costs and benefits allowing for both declining substitute prices over time and the two additional sets of exposures are shown in the final column of the table. As these figures indicate, the impacts of each of the three sensitivity assumptions are independent and additive, at least for this regulatory alternative. That is, the decline in costs for this combination of sensitivity assumptions is the same as for the declining substitutes prices alone scenario, and that the increased benefits for this scenario equal the sum of the increased benefits for the two benefit-side sensitivity analyses conducted independently.

Finally, the cost per cancer case avoided (using the 3 percent discounting for both costs and benefits) falls from the base case level of about $6 million to $2.5 million for all three sensitivity assumptions combined. Again, although these are sensitivity analyses, on the exposures side the assumptions concerning added exposures to asbestos are intended to address lack of data -- exposure settings in which exposures are believed to occur, but for which data do not exist. On the costs of substitutes side, the assumption of a 1 percent decline in all substitute prices is illustrative only. However, for many substitute products, over time costs and prices may well decline as accumulated production and manufacturing experience make these cheaper to produce and to use in place of asbestos products.

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REGULATORY IMPACT ANALYSIS OF CONTROLS ON ASBESTOS AND ASBESTOS PRODUCTS

FINAL REPORT

VOLUME II
APPENDIX A-E

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VOLUME II

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APPENDIX A -- MODELS AND COMPUTATIONAL PROCEDURES

This appendix reports the details of the specific computational techniques and computer models developed for the analysis of the regulatory alternatives for asbestos. The appendix is organized into five separate sections, each of which presents details concerning different models and computational procedures developed. These five sections are as follows:

<u>Section A.1</u> -- Presents procedures and models associated with estimating the baseline growth rates for the asbestos products modeled in this analysis. These consist of growth rate projections methods for non-brake products and a model of baseline growth rates for brake products.

<u>Section A.2</u> -- Outlines the method used by Research Triangle Institute (1985) to estimate the supply function for fiber to the U.S. This provides the elasticity of fiber supply for use in the Asbestos Regulatory Cost Model (ARCM).

<u>Section A.3</u> -- Presents the exact calculations performed and the computer model for the ARCM.

<u>Section A.4</u> -- Presents information on the calculations required to develop health model exposure inputs from data reported in ICF (1988) and Versar (1987) and an overview of the computational methods of the health model.

<u>Section A.5</u> -- Presents the computer model used to estimate the health effects in the baseline and under the different regulatory alternatives considered in this analysis.

<u>Section A.6</u> -- Reviews the procedures used and the results of efforts to estimate occupational and nonoccupational exposure information for products and exposure settings for which exposures are suspected by for which no quantitative data are available.

A.1 BASELINE PROJECTIONS MODELS

This appendix presents the analyses performed to estimate baseline quantities of outputs for each of the asbestos product markets and to estimate the baseline growth rates for asbestos products over the course of the several decade timeframe considered in this study. The baseline quantities of asbestos product outputs were developed based on the information collected in the survey of asbestos product manufacturers, which is reported in detail in Appendix F. However, because information for some manufacturers of asbestos products was not available, techniques were required for developing total production volume estimates in light of these nonrespondents. Thus, the first section of this appendix reports the methods used to estimate total production volumes for each asbestos product market based on the survey results.

Given these total production volumes for each asbestos product markets, the next step is to define the future outputs of these markets in the absence of regulatory controls, that is, the baseline. These baseline growth rates are important in the simulation modeling because they determine the evolution of the asbestos fiber and products markets over time and thus determine the characteristics of the markets that will be affected by the various regulatory alternatives examined.

Two different analyses were conducted to develop baseline growth rate estimates for the numerous asbestos product markets. Growth rates for the vast majority of these product markets were developed using a very straightforward projection technique based on the 1981 to 1985 growth experienced in each market. Using this information, as outlined in the second section below, three different baseline growth rate scenarios were developed, ranging from a scenario in which the future output of each product was simply set equal to its 1985 (in most cases) output, to one in which the baseline future growth rates for each product were set equal to their 1981 to 1985 growth rates. Section 2 below outlines this method and the resulting growth rate series in detail.

The second analysis undertaken to develop baseline growth rate figures focused on two products exclusively -- disc brake pads and drum brakes for light and medium weight vehicles. Unlike most of the other product markets, a great deal is known about current and past use of asbestos in brakes and about trends in substituting non-asbestos brakes in newer vehicles. Coupled with the facts that future sales forecasts for automobiles are available (and of reasonably high quality) and that scrappage rates for older vehicles are reasonably well-documented, this implies that a more sophisticated model of future asbestos brake product may be warranted. That is, given the quantity and quality of information available about the future determinants of asbestos brake production, a model that captures the influences of these determinants in a coherent fashion seems appropriate. Thus, a "brake model" was developed to predict future baseline growth rates for asbestos brake production. This model is presented in detail in Section 3 below.

1. Derivation of Total Production Volumes of Asbestos Products

This section describes the three possible methods of accounting for non-respondents to the survey and presents the results for the methods that appear to be the best estimates for actual output of asbestos-containing products in 1985.

210 firms were surveyed and responses were received from 191 of them. The balance of 19 are classified as non-respondents and are listed in Exhibit A.1.1-1 along with their products. Of the 191 firms that have responded, 118 processed asbestos in 1985 and 73 did not.

1.1 Adjustment Methods

Because the asbestos regulatory cost model (ARCM) estimates the total costs of regulating asbestos, the model requires total production of asbestos-containing products to obtain accurate results. Some firms have been unwilling to provide this information, so it must be estimated using the other information to which we have access -- 1981 TSCA 8(a) production data, 1985 production and fiber consumption survey data, and Bureau of Mines (BOM) fiber consumption data. Although a number of methods of adjustment could be imaged, three reasonable ones were identified that make use of these data sources.

Method 1: This method assumes that the trends in asbestos products' production among non-respondents are identical to those of respondents in each product category. Therefore, it is assumed that the 1985 asbestos product output of all non-respondents has changed from 1981 by the same percentage amount as the 1981 asbestos product output of all respondents. For instance, if 1985 output of all responding firms in a given category was 75 percent of their 1981 level, Method 1 would assume that the 1985 output of each non-respondent was also 75 percent of its 1981 level.

Method 2: This method assumes that the changes in asbestos product production among non-respondents between 1981 and 1985 are identical to the changes in asbestos production among all respondents who are still processing in each product category. Thus, the 1981 asbestos product output of all non-respondents is assumed to change between 1981 and 1985 by the same percentage as did the asbestos product output of all respondents who are still processing. For instance, if 1985 output of all responding firms that processed asbestos in 1985 was 80 percent of their 1981 level, Method 2 assumes that the 1985 output of each non-respondent was also 80 percent of its 1981 level. The Attachment provides mathematical formulations of Method 1 and Method 2 as well as an illustrative example.

Method 3: A third adjustment method assumes that non-respondents account for all the difference in asbestos fiber consumption between the 1985 ICF survey and 1985 BOM data. This "missing" fiber can then be apportioned among non-respondents in each BOM category based on their 1981 fiber consumption (derived using 1981 asbestos product-coefficients). This apportioned fiber can then be converted to output using the 1985 asbestos product-coefficients. For instance, if BOM 1985 fiber consumption in friction products is 40,000 tons and the ICF estimate is 30,000 tons, the non-respondents might be assumed to account for the remaining 10,000 tons. If the 1981 fiber consumption of non-respondents was 20,000 tons, each non-respondent would be assumed to have consumed 1/2 (10,000/20,000) its 1981 fiber total. This fiber total could then be converted to output in each ICF product category.

Although this third adjustment method appears at first to be the most promising, several considerations argue against using this method. First, in a few cases the ICF reported estimate exceeds the BOM estimate, so that following this third method of adjustment would require that known fiber use

Exhibit A.1.1-1. Asbestos Survey Non-Respondents

Company	Products
Abex Corporation	Drum Brake Linings (18)[a] Disc Brake Pads for Light and Medium Vehicles (19) Brake Blocks (21)
Allied Automotive	Drum Brake Linings (18) Disc Brake Pads for Light and Medium Vehicles (19) Disc Brake Pads for Heavy Vehicles (20) Brake Blocks (21)
Alsop Engineering Company	Specialty Paper (11)
American Cyanamid	Non-Roofing Adhesives, Sealants, and Compounds (30)
Beaver Industries, Inc.	Specialty Paper (11)
Boise Cascade Corporation	Beater-Add Gaskets (5)
Brake Systems	Drum Brake Linings (18) Disc Brake Pads for Light and Medium Vehicles (19)
Brassbestos	Drum Brake Linings (18) Disc Brake Pads for Light and Medium Vehicles (19)
Capco Pipe Company, Inc.	Asbestos-Cement Pipe (14)
Crane Packing	Asbestos Packing (28)
Karnak Chemical Corporation	Roof Coatings and Cements (29)
Koch Asphalt Company	Roof Coatings and Cements (29) Missile Liner (32)
Koppers Company	Roof Coatings and Cements (29)
Minnesota Mining & Manufacturing Company	Non-Roofing Adhesives, Sealants, and Compounds (30)
Mortell Company	Non-Roofing Adhesives, Sealants, and Compounds (30)
National Paint & Oil Company	Roof Coatings and Cements (29)

Exhibit A.1.1-1 (Continued)

Company	Products
Raymark Corporation	Brake Blocks (21) Clutch Facings (22) Automatic Transmission Components (23) Friction Materials (24)
Steelcote Manufacturing	Non-Roofing Adhesives, Sealants, and Compounds (30)
Wheeling Brake Block Manufacturing	Brake Blocks (21) Friction Materials (24)

[a]Numbers in parentheses indicate new TSCA product category numbers.

in several industries be removed. Second, BOM's method of data collection involves the possibility (indeed, a strong likelihood) that significant double-counting and misclassification could occur. As a result, it is likely that for many of the BOM product groups the BOM totals are not reliable. Similarly, it may also be the case that BOM's total fiber consumption figure (171.6 thousand short tons) is also probably in excess of the actual 1985 fiber consumption. These considerations are explored further in the final section below. Finally, the 1985 survey results combined with the 1981 survey strongly suggest that the rates of output change among the component products that compose many of the BOM product groups were different. Hence, to allocate (apparently) missing fiber defined as the difference between the BOM and ICF estimates would not be appropriate since the evidence suggests that the component product categories in the BOM groups change at different rates.

1.2 Results

The problem that this analysis attempts to solve is a difficult one since trying to determine the outputs of nonrespondents based on several related pieces of information can yield multiple answers. Nevertheless, there are guides to selecting adjustments. First, any adjustments should appear to be reasonable and consistent with common sense. Second, adjustments should result in estimates that are consistent, to the extent possible, with all of the information available. Finally, adjustments should attempt to use all of the information in the survey, including information obtained from respondents concerning the activities of non-respondents. Hence, in selecting the recommended adjustment for each product category all of these considerations were taken into account and are described below.

Exhibit A.1.1-2 presents 1981 asbestos production data, reported 1985 asbestos production data (quantities reported in the 1985 survey), and Method 1 and Method 2 adjusted 1985 asbestos production data. Adjusted 1985 asbestos production data are the same as reported 1985 asbestos production data for 22 of the 36 product categories because there are no non-respondents in these product categories. Adjusted 1985 data using Methods 1 and 2 were computed for 12 of the remaining 14 products. These adjustment methods could not generate estimates for 2 product categories (specialty paper and automatic transmission components) because the only respondents have ceased processing asbestos.

Both methods of adjustment yield the same total production estimates whenever all the respondents processed asbestos in 1985. This occurs in 2 of the 12 cases. In all other cases, Method 2 yields a higher estimate because it models non-respondents based on only the <u>non-zero</u> respondents, while Method 1 models them based on <u>all</u> respondents. The difference between the two estimates ranges widely, however, in most cases the difference is approximately 15-25 percent.

Method 2 is recommended in almost all cases for making the required adjustments for two reasons. First, it is fair to assume that a company that refused to provide production information is probably still processing asbestos. Many of the non-respondents cited the cost and difficulty of obtaining this information as the reason for their refusal. If they did not process asbestos, this probably would not be true. Second, Method 2 yields estimates which are broadly more consistent with BOM data. Although both

Exhibit A.1.1-2 Adjusted 1985 Domestic Asbestos Production

Product	1981 Production	Reported 1985 Production	Adjusted 1985 Production (Method 1)	Adjusted 1985 Production (Method 2)
Commercial Paper (1)	936 tons	0 tons	0 tons	0 tons
Rollboard (2)	0 tons	0 tons	0 tons	0 tons
Millboard (3)	2,767 tons	581 tons	581 tons	581 tons
Pipeline Wrap (4)	2,150,615 squares	296,949 squares	296,949 squares	296,949 squares
Beater-Add Gaskets (5)	26,039 tons	15,023 tons	16,463 tons	16,505 tons
High-Grade Electrical Paper (6)	706 tons	698 tons	698 tons	698 tons
Roofing Felt (7)	3,107,538 squares	0 squares	0 squares	0 squares
Acetylene Cylinders (8)	819,212 pieces	392,121 pieces	392,121 pieces	392,121 pieces
Flooring Felt (9)	127,403 tons	0 tons	0 tons	0 tons
Corrugated Paper (10)	46 tons	0 tons	0 tons	0 tons
Specialty Paper (11)	2,090 tons	0 tons	a/ tons	a/ tons
Vinyl-Asbestos Floor Tile (12)	58,352,864 sq. yds.	18,300,000 sq. yds.	18,300,000 sq. yds.	18,300,000 sq. yds.
Asbestos Diaphragms (13)	N/A pieces	50 pieces	b/ pieces	b/ pieces
Asbestos-Cement Pipe (14)	25,060,263 feet	13,432,916 feet	14,983,125 feet	15,062,708 feet
Asbestos-Cement Flat Sheet (15)	452,683 squares	22,621 squares	22,621 squares	22,621 squares
Asbestos-Cement Corrugated Sheet (16)	105,628 squares	0 squares	0 squares	0 squares
Asbestos-Cement Shingle (17)	266,670 squares	176,643 squares	176,643 squares	176,643 squares
Drum Brake Linings (18)	162,263,833 pieces	71,673,204 pieces	129,042,578 pieces	129,042,578 pieces
Disc Brake Pads - LMV (19)	110,644,603 pieces	27,285,544 pieces	56,208,100 pieces	65,869,172 pieces
Disc Brake Pads - HV (20)	896,720 pieces	9,964 pieces	16,678 pieces	156,820 pieces
Brake Blocks (21)	21,284,408 pieces	2,652,010 pieces	4,143,346 pieces	4,570,266 pieces
Clutch Facings (22)	7,396,110 pieces	7,233,476 pieces	7,237,112 pieces	7,237,112 pieces
Automatic Transmission Components (23)	381,500 pieces	530,000 pieces	c/ pieces	c/ pieces
Friction Materials (24)	17,732,455 pieces	8,592,178 pieces	8,718,609 pieces	8,719,541 pieces
Asbestos Protective Clothing (25)	0 tons	0 tons	0 tons	0 tons
Asbestos Cloth, Yarn, and Thread (26)	5,901 tons	1,125 tons	1,125 tons	1,125 tons
Sheet Gaskets (27)	10,353,431 sq. yds.	3,607,408 sq. yds.	3,607,408 sq. yds.	3,607,408 sq. yds.
Asbestos Packing (28)	714 tons	149 tons	3 tons	3 tons
Roof Coatings and Cements (29)	80,795,905 gallons	67,031,499 gallons	73,781,734 gallons	75,977,365 gallons
Non-Roofing Adhesives, Sealants, and Compounds (30)	35,544,826 gallons	7,352,819 gallons	9,019,715 gallons	9,612,655 gallons
Asbestos-Reinforced Plastic (31)	12,388 tons	4,835 tons	4,835 tons	4,835 tons
Missile Liner (32)	4,006 tons	1,008 tons	14,236 tons	14,526 tons
Sealant Tape (33)	328,347,768 feet	423,048,539 feet	423,048,539 feet	423,048,539 feet
Battery Separator (34)	2,226 pounds	2,046 pounds	2,046 pounds	2,046 pounds
Arc Chutes (35)	20,406 pieces	900 pieces	900 pieces	900 pieces
Miscellaneous Products (36)	d/	0 tons	0 tons	0 tons

a/ Method 1 and Method 2 adjustments could not be made for this product category. See text for explanation.

b/ Method 1 and Method 2 adjustments could not be made for this product category because most of the firms were not surveyed in 1981 or 1985. Total industry production is estimated based on information supplied by Chlorine Institute.

c/ S.K. Wellman was the only positive 1985 respondent, but it plans to stop processing in 1987. There is one non-respondent, however, we do not believe it is appropriate to make an adjustment on the basis of only one company which no longer processes. Hence, the non-respondent's 1985 production is assumed to be equal to its 1981 production.

d/ Consistent units for this category do not exist.

methods yield estimates that are lower than BOM's data, Method 2 yields estimates of total asbestos use that are closer to BOM's total.

Exhibit A.1.1-3 reports the final adjusted quantities for all of the 36 asbestos-containing products. In addition to the product quantities, both the implied amount of fiber consumed in each category and the method of adjustment are shown in the table. The "Method of Adjustment" column reflects the 22 products for which no adjustment was required ("No Adjustment") and the 10 for which Method 2 is recommended ("Method 2").

Exhibit A.1.1-3 also indicates that other methods are recommended for three product categories -- specialty paper (11), automatic transmission components (23), and missile liner (32). As stated above, method 2 could not be used to make corrections for specialty paper (11) or automatic transmission components (23) because all of the respondents in those categories indicated that they had stopped (or plan to stop) processing asbestos.[1] Since the adjustments use information on respondents' production levels, clearly these corrections are infeasible. Furthermore, the BOM estimates for the broader product categories cannot be used to determine 1985 production for these two products because so many other products are included in the BOM totals. Hence, in these cases, setting 1985 production equal to 1981 production for the non-respondents is recommended because no other adjustment method appears to be feasible. This assumption is likely to overstate the production levels for these products, but this is not quantitatively important because 1981 asbestos fiber consumption by these companies was less than 400 tons.

An alternative method for adjusting the 1985 reported quantities for and missile liner (32) is recommended. In this case, Method 2 produced results that diverged widely from expectations and the BOM data. Method 2 estimated that consumption of asbestos fiber in missile liner was 2,180 tons while BOM estimated that fiber consumption for Insulation Materials was 700 tons. The reason Method 2 yields such large estimates in this case is that the 1985 respondents in these categories produced small amounts in 1981, while the 1981 industry leaders refused to respond to the 1985 survey. However, output from these small companies increased greatly from 1981 to 1985. Consequently, when the large growth rate of these small firms is applied to the 1981 industry leaders, a very large estimate of 1985 production results.

Finally, the Method 2 adjustment for missile liner (32) is an order of magnitude greater than the 1981 fiber consumption level, again because of the same problem that affected the packings and gaskets category. Adjusting the estimate of fiber consumption in missile liner (32) by assuming the BOM figure for insulation material to be correct -- missile liners is the only product that falls into this category -- is recommended. Although the BOM data are not always accurate due to misclassification and multiple-classification, missile liner is the only product in this BOM category. Furthermore, given the nature of the product, it seems less likely that much misclassification could occur in this category. Hence, assuming that the single non-respondent in this category accounts for the entire difference between our survey data and BOM data in this category seems reasonable. Therefore, the ICF and BOM estimates for this category are identical.

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[1] The only processing respondent in automatic transmission components (23) had indicated it planned to stop processing asbestos in March 1987.

Exhibit A.1.1-3 Final Adjusted 1985 Domestic Asbestos Production

Product	Final Adjusted 1985 Production	1985 Fiber Consumption	Adjustment Method
Commercial Paper (1)	0 tons	0.0 tons	No Adjustment a/
Rollboard (2)	0 tons	0.0 tons	No Adjustment
Millboard (3)	581 tons	435.8 tons	No Adjustment
Pipeline Wrap (4)	296,949 squares	1,333.3 tons	No Adjustment
Beater-Add Gaskets (5)	16,505 tons	12,436.4 tons	Method 2 b/
High-Grade Electrical Paper (6)	698 tons	744.0 tons	No Adjustment
Roofing Felt (7)	0 squares	0.0 tons	No Adjustment
Acetylene Cylinders (8)	392,121 pieces	584.1 tons	No Adjustment
Flooring Felt (9)	0 tons	0.0 tons	No Adjustment
Corrugated Paper (10)	0 tons	0.0 tons	No Adjustment
Specialty Paper (11)	434 tons	92.1 tons	Other c/
Vinyl-Asbestos Floor Tile (12)	18,300,000 sq. yds.	10,374.0 tons	No Adjustment
Asbestos Diaphragms (13)	9,770 pieces	977.0 tons	Other d/
Asbestos-Cement Pipe (14)	15,062,708 feet	32,690.8 tons	Method 2
Asbestos-Cement Flat Sheet (15)	22,621 squares	2,578.8 tons	No Adjustment
Asbestos-Cement Corrugated Sheet (16)	0 squares	0.0 tons	No Adjustment
Asbestos-Cement Shingle (17)	176,643 squares	3,893.0 tons	No Adjustment
Drum Brake Linings (18)	129,042,578 pieces	24,691.8 tons	Method 2
Disc Brake Pads - LMV (19)	65,869,172 pieces	7,119.2 tons	Method 2
Disc Brake Pads - HV (20)	156,820 pieces	117.6 tons	Method 2
Brake Blocks (21)	4,570,266 pieces	2,643.6 tons	Method 2
Clutch Facings (22)	7,237,112 pieces	993.5 tons	Method 2
Automatic Transmission Components (23)	585,500 pieces	2.5 tons	Other e/
Friction Materials (24)	8,719,541 pieces	1,602.5 tons	Method 2
Asbestos Protective Clothing (25)	0 tons	0.0 tons	Method 2
Asbestos Cloth, Yarn, and Thread (26)	1,125 tons	558.0 tons	Method 2
Sheet Gaskets (27)	3,607,408 sq. yds.	5,441.1 tons	Method 2
Asbestos Packing (28)	3 tons	2.1 tons	Method 2
Roof Coatings and Cements (29)	75,977,365 gallons	29,551.2 tons	Method 2
Non-Roofing Adhesives, Sealants, and Compounds (30)	9,612,655 gallons	2,951.4 tons	Method 2
Asbestos-Reinforced Plastic (31)	4,835 tons	812.1 tons	No Adjustment
Missile Liner (32)	4,667 tons	700.0 tons	BOM estimate f/
Sealant Tape (33)	423,048,539 feet	1,660.2 tons	No Adjustment
Battery Separator (34)	2,046 pounds	1.0 tons	No Adjustment
Arc Chutes (35)	900 pieces	13.5 tons	No Adjustment
Miscellaneous Products (36)	0 tons	0.0 tons	No Adjustment

Footnotes on next page.

Exhibit A.1.1-3 (Continued)

FOOTNOTES

a/ No adjustment was made in product categories where all companies responded.

b/ Method 2 adjustment is described in the text.

c/ 1085 asbestos production in this category wes set equal to the 1981 production of the two non-respondents because all respondents no longer process asbestos.

d/ 1985 ssbestos production in this category was estimated based on information supplied by the Chlorine Institute.

e/ 1985 asbestos production for this category has been asjusted by assuming that the nonrespondent produced at its 1981 level. See text for explanation.

f/ 1985 asbestos production for this category was set equal to the BOM estimate for insulation. See text for explanation.

1.3. Comparison with BOM Data

In addition to the 1981 and 1986 production data, the recommended adjusted figures can also be compared with the BOM's 1985 fiber usage. However, because BOM uses only 13 product categories, both the ICF reported and the ICF recommended adjusted production data have been multiplied by fiber-to-output ratios to yield fiber consumption for each product category. These fiber consumption quantities were then sorted and summed according to the groups of products that compose each BOM category.

Exhibit A.1.1-4 shows the resulting ICF reported fiber consumption, the ICF adjusted consumption, and the BOM estimate of total fiber consumption for each BOM product category. In most cases, the adjusted ICF estimates are fairly close to the BOM estimates. Except for a few cases, differences between the ICF and BOM estimates are small over- and under-estimates. The explanation for these small divergences could be the result of several factors: (1) applying fiber-to-output ratios to the ICF production data (to obtain fiber consumption) that do not exactly match those experienced by all consumers of fiber; (2) misreporting of fiber use by survey respondents; and (3) misreporting of fiber use by the BOM survey respondents.

This last possible reason for the many small differences between the two sets of estimates is important to point out. In 1985 BOM altered the method by which it obtains asbestos consumption information. The current method uses a survey of domestic miners and millers in combination with import data from the Census Bureau to estimate fiber consumption.

In addition to the small positive and negative divergences between the BOM and ICF estimates of fiber consumption in these BOM categories, two larger differences are in the two estimates of fiber consumption in the Coatings and Compounds category and the total fiber used. The Adjusted ICF estimate for Coatings and Compounds is 3.0 thousand short tons and the BOM estimate is 25.5 thousand short tons. Note that this is the ICF Adjusted estimate.

At first glance one might conclude that the ICF estimate for this category is too low. However, it is possible that it is the BOM estimate that is not quite accurate. There are several reasons that argue for the ICF estimate an against the BOM estimate. First, the adjusted ICF estimate makes sense when one considers the 1981 quantity, the reported 1985 quantity, and the 1981 production levels of the non-respondents in this category. There are five non-respondents in this category which accounted for about 25 percent of the 1981 production quantity of about 35,000,000 gallons. The reported 1985 production level for the respondents was only slightly above 7,000,000 gallons (see Exhibit A.1.1-2 for these figures), while the ICF adjusted quantity for 1985 (using Method 2) is almost 10,000,000 gallons. This implies that the estimated production levels for the nonrespondents is slightly less than half of their level in 1981, which does not seem to be unreasonable in a market in which the respondents' production (75 percent of 1981 output) declined by 70 percent between 1981 and 1985.

Second, if the BOM estimate of fiber consumption for Coatings and Compounds is correct for 1985, then this implies that the nonrespondents in this category would have to have produced more than 7 times their total 1981 production in 1985. This does not seem to be reasonable given that production by respondents declined by about 70 percent during that period.

Exhibit A.1.1-4. 1985 Domestic Asbestos Fiber Consumption
(in thousands of short tons)

Product Category	ICF (Reported)[a]	ICF (Adjusted)[b]	BOM[c]
Asbestos-Cement Pipe	29.6	32.7	30.9
Asbestos-Cement Sheet	6.4	6.5	7.3
Coatings and Compounds	2.3	3.0	25.5
Flooring Products	10.4	10.4	7.7
Friction Products	20.2	37.2	37.4
Insulation Materials	0.2	0.7	0.7
Packings and Gaskets	5.1	5.6	7.1
Paper Products	13.7	15.0	18.5
Plastics	0.8	0.8	0.8
Roofing Products	26.1	29.6	28.9
Textiles	0.6	0.6	1.3
Other	3.2	3.2	5.5
Total	118.6	145.1	171.6

[a]ICF survey of primary processors of asbestos.

[b]ICF estimates.

[c]U.S. Department of the Interior, Bureau of Mines, Bureau of Mineral Minerals Yearbook.

Another reason to believe that the ICF estimate for this category is probably more accurate is that the possibility of misclassifying, and more serious, double-classifying fiber use is particularly severe in the case of Coatings and Compounds. Coatings and compounds are very similar to Roofing Products. We believe that a substantial amount of fiber use in the BOM data is double-classified in these two categories. BOM's estimates of fiber consumption in these two categories over the 1981 to 1985 period are quite revealing. These are tabulated in Exhibit A.1.1-5.

The table shows that for these two categories, BOM's estimate of fiber usage for the two products together until 1985 seem reasonable. The 1985 total, however, is much higher than any previous year. Furthermore, the split of the total fiber used between the Coatings and Compounds and Roofing Products categories changed dramatically across the years. Note, however, that the ICF estimate of total fiber use in these two categories (33 thousand tons) is approximately the same as the BOM total for 1984 (31.6 thousand tons).

Another aspect of the BOM survey is also relevant here. The BOM survey attempts to determine fiber purchases, not necessarily use of fiber during the year. To the extent that firms are stockpiling fiber for use in future years, the BOM estimates of fiber purchases will be larger than actual fiber use during 1985.

Finally, the reported 1981 production level in 1981 for Coatings and Compounds and for Roofing Products were about 35 million gallons and 80 million gallons respectively. These imply that 1981 fiber usage was about 31.5 thousand tons for Roofing Products and 11 thousand tons for Coatings and Compound. Thus, in 1981 the amount of fiber used in Coatings and Compounds was far less than that used in Roofing Products, which is consistent with the ICF estimates for 1985 but inconsistent with BOM's 1981 figures for fiber usage in 1981.

Based on these considerations, using the ICF estimate for Coatings and Compounds and, consequently, the ICF estimate for total 1985 fiber consumption, is recommended.

Exhibit A.1.1-5. Selected Bureau of Mines (BOM)
Asbestos Fiber Consumption Data
(in thousands of short tons)

	1981	1982	1983	1984	1985
Coatings and Compounds	14.4	27.7	13.0	23.8	25.5
Roof Products	17.6	7.7	7.2	7.8	28.9
Total	32.0	35.4	20.2	31.6	54.4

ATTACHMENT

Method 1

Mathematical Formulation:

Let X_i represent 1981 asbestos production for a 1985 respondent (i ranges from 1 to R, where R is the number of respondents).

Let X_j represent 1981 asbestos production for a 1985 non-respondent (j ranges from 1 to N, where N is the number of non-respondents).

Let Y_i represent 1985 asbestos production for a 1985 respondent.

Let Y_j represent corrected 1985 asbestos production for a 1985 non-respondent.

$$Y_j = \frac{\sum_{i=1}^{R} Y_i}{\sum_{i=1}^{R} X_i} \times X_j$$

Example:

Suppose three companies produced asbestos-cement pipe in 1981. Company A produced 200 tons, Company B produced 500 tons, and Company C produced 100 tons. In 1985, Company B has told us it produced 450 tons of asbestos-cement pipe, Company C has told us it produced 0 tons of asbestos-cement pipe, and Company A has refused to respond. Total production for Companies B and C was 600 (500 + 100) tons in 1981, and it fell to 450 (450 + 0) in 1985. Thus, 1985 output of respondents was 75 percent (450/600) of 1981 production. We would then assume that the same decline was true for Company A and estimate its 1985 output to be 150 (0.75 x 200) tons.

Method 2

Mathematical Formulation:

Let Z_k represent 1981 asbestos production for a 1985 non-zero respondent (k ranges from 1 to P, where P is the number of non-zero respondents).

Let Z_j represent 1981 asbestos production for a 1985 non-respondent (j ranges from 1 to N, where N is the number of non-respondents).

Let Y_k represent 1981 asbestos production for a 1985 non-zero respondent.

Let Y_j represent corrected 1985 asbestos production for a 1985 non-respondent.

$$Y_j = \frac{\sum_{K=1}^{P} Y_k}{\sum_{k=1}^{R} Z_k} \times Z_j$$

Example:

Suppose three companies produced asbestos-cement pipe in 1981. Company A produced 200 tons, Company B produced 500 tons, and Company C produced 100 tons. In 1985, Company B has told us it produced 450 tons of asbestos-cement pipe, Company C has told us it produced 0 tons of asbestos-cement pipe, and Company A has refused to respond. Total production for the non-zero respondents (Company B) was 500 tons in 1981, and fell to 450 in 1985. Thus, 1985 output of the non-zero respondents was 90 percent (450/500) of 1981 production. We would then assume that the same was true for Company A and estimate its 1985 output to be 180 (0.90 x 200) tons.

2. Baseline Growth Rate Projections for Asbestos Products

This section describes the methods and rationale for the alternative baseline growth rate assumptions used in the calculations of costs and benefits. The projections of product growth rates presented in this section are based on the large amount of information generated in the course of conducting the survey of asbestos products described in Appendix F. Along with historical information concerning the evolution of asbestos markets, the information obtained in the survey concerning 1985 production quantities is invaluable as a guide to developing appropriate assumptions for the future development of these markets.

The remainder of this section is organized as follows:

- Subsection 2.1 reviews the findings of the ICF survey of 1985 production volumes for asbestos products and computes the growth rates actually experienced during the 1981 to 1985 period, and

- Subsection 2.2 outlines the methods used to develop alternative baseline growth rates for the asbestos products.

2.1 1985 Survey Results and Actual Growth Rates from 1981 to 1985

Exhibit A.1.2-1 shows the 1981 production quantities for the asbestos products, the ICF adjusted 1985 quantities of these products developed from the ICF survey, the implied annual rates of growth for the products from the 1981 to 1985 experience, and the amount of fiber used in each product in 1985. Note first that 5 of the 36 products are no longer produced in 1985 according to the ICF survey. Of the remaining 31 products, 3 do not have definable rates of growth because in two cases (products 2 and 25) both 1981 and 1985 quantities are zero, and in the case of Miscellaneous Products (36), no consistent units or definitions exist. This leaves 28 products for which meaningful non-zero growth rates are definable.

In most cases, the actual experience during the 1981 to 1985 period was fairly steep declines in output. There are, however, a few cases in which actual experience during the 1981 to 1985 period was an increase, suggesting that new uses or expanded use of these products occurred during that period. However, in all cases in which positive growth occurred (including the newly classified products 32 and 33), the amount of fiber used in the product category is extremely small relative to the total, as shown in the column listing the amount of fiber for each product market. Furthermore, in the case of product 23, the source of the positive growth between 1981 and 1985 is the introduction of a new product line which is now being phased out by the product's maker. In this case, the ICF survey contains detailed information concerning the 1985, 1986, 1987, and 1988 production volumes for this company, so projecting the future production volumes for this market is reasonably straightforward as discussed below.

Exhibit A.1.2-1. Comparison of Actual and Estimated Product Growth Rates

Product	1981 Production	Final Adjusted 1985 Production	Growth Rate 1981 - 1985	Original Growth Rate	1985 Fiber Consumption
Commercial Paper (1)	936 tons	0 tons	-100.00%	-3.83%	0.0 tons
Rollboard (2)	0 tons	0 tons	N/A	N/A	0.0 tons
Millboard (3)	2,767 tons	581 tons	-32.31%	-3.83%	435.8 tons
Pipeline Wrap (4)	2,150,615 squares	296,949 squares	-39.04%	-12.50%	1,333.3 tons
Beater-Add Gaskets (5)	26,039 tons	16,505 tons	-10.77%	-2.22%	12,436.4 tons
High-Grade Electrical Paper (6)	706 tons	698 tons	-0.28%	-12.50%	744.0 tons
Roofing Felt (7)	3,107,538 squares	0 squares	-100.00%	-13.02%	0.0 tons
Acetylene Cylinders (8)	819,212 pieces	392,121 pieces	-16.82%	N/A	584.1 tons
Flooring Felt (9)	127,403 tons	0 tons	-100.00%	-6.41%	0.0 tons
Corrugated Paper (10)	46 tons	0 tons	-100.00%	-3.83%	0.0 tons
Specialty Paper (11)	2,090 tons	434 tons	-32.50%	-3.83%	92.1 tons
Vinyl-Asbestos Floor Tile (12)	58,352,864 sq. yds.	18,300,000 sq. yds.	-25.17%	-6.41%	10,374.0 tons
Asbestos Diaphragms (13)	N/A pieces	9,770 pieces	N/A	N/A	977.0 tons
Asbestos-Cement Pipe (14)	25,060,263 feet	15,062,708 feet	-11.95%	-6.11%	32,690.8 tons
Asbestos-Cement Flat Sheet (15)	452,683 squares	22,621 squares	-52.72%	-3.18%	2,578.8 tons
Asbestos-Cement Corrugated Sheet (16)	105,628 squares	0 squares	-100.00%	-3.18%	0.0 tons
Asbestos-Cement Shingle (17)	266,670 squares	176,643 squares	-9.78%	-3.18%	3,893.0 tons
Drum Brake Linings (18)	162,263,833 pieces	129,042,578 pieces	-5.57%	2.60%	24,691.8 tons
Disc Brake Pads - LMV (19)	110,644,603 pieces	65,869,172 pieces	-12.16%	3.30% b/	7,119.2 tons
Disc Brake Pads - HV (20)	896,720 pieces	156,820 pieces	-35.33%	4.81% b/	117.6 tons
Brake Blocks (21)	21,284,408 pieces	4,570,266 pieces	-31.93%	4.78%	2,643.6 tons
Clutch Facings (22)	7,396,110 pieces	7,237,112 pieces	-0.54%	4.78%	993.5 tons
Automatic Transmission Components (23)	381,500 pieces	585,500 pieces	11.30%	4.78%	2.5 tons
Friction Materials (24)	17,732,455 pieces	8,719,541 pieces	-16.26%	4.78%	1,602.5 tons
Asbestos Protective Clothing (25)	0 tons	0 tons	N/A	-15.60%	0.0 tons
Asbestos Cloth, Yarn, and Thread (26)	5,901 tons	1,125 tons	-33.92%	-15.60%	558.0 tons
Sheet Gaskets (27)	10,353,431 sq. yds.	3,607,408 sq. yds.	-23.17%	-2.22%	5.441.1 tons
Asbestos Packings (28)	714 tons	3 tons	-74.54%	-2.22%	2.1 tons
Roof Coatings and Cements (29)	80,795,905 gallons	75,977,365 gallons	-1.53%	-10.74%	29,551.2 tons
Non-Roofing Adhesives, Sealants, and Compounds (30)	35,544,826 gallons	9,612,655 gallons	-27.89%	-10.09%	2,951.4 tons
Asbestos-Reinforced Plastic (31)	12,388 tons	4,835 tons	-20.96%	-53.60%	812.1 tons
Missile Liner (32)	4,006 tons	4,667 tons	3.89%	N/A	700.0 tons
Sealant Tape (33)	328,347,768 feet	423,048,539 feet	6.54%	N/A	1,660.2 tons
Battery Separator (34)	2,226 pounds	2,046 pounds	-2.09%	N/A	1.0 tons
Arc Chutes (35)	20,406 pieces	900 pieces	-54.17%	N/A	13.5 tons
Miscellaneous Products (36)	a/	0 tons	N/A	-10.09%	0.0 tons

a/ Consistent units do not exist for this product.

b/ These are the growth rates actually used in the PEM. They are not the same as the growth rates in the RIA.

N/A: This information is either not available or not applicable.

2.2 Baseline Product Growth Rates

In brief, the basic approach for developing baseline product growth rate projections is to define three alternative scenarios for the non-brake markets (treated separately in the next section). These are:

- Low Decline -- growth rates equal to zero for all products except where more detailed information is available;

- High Decline -- growth rates equal to actual 1981 to 1985 experience; and

- Moderate Decline -- growth rates equal to one-half of the actual 1981 to 1985 declines.

The Low Decline scenario is very likely to overstate the amount of asbestos used in the future as well as the outputs of the asbestos products because the actual experience has been substantial declines over time. However, this scenario provides, in a sense, an upper bound for the amount of asbestos and the outputs of the asbestos products for the future, thereby probably overstating both the costs and the benefits of the regulatory alternatives. The High Decline scenario may well understate the future outputs of these products since it is conceivable that the high declines in the outputs of these products in the recent past may not continue. Thus, one might argue that the High Decline scenario offers a lower bound for the costs and benefits of the Regulatory Alternatives. Finally, the Moderate Decline scenario represents the midpoint of the two extremes.

There are a few exceptions to the general assumption that future production for these products will either be the same as in 1985 or that the future growth rates will be equal to (or one-half of) the 1981 to 1985 experience. These are cases in which the ICF survey produced additional information about various companies' production plans in 1986 and 1987. In some cases companies indicated that their 1986 production levels would be zero, and in one case, a company provided its 1986 production level and indicated that it would cease processing asbestos during 1987. In these cases, this additional information is taken into account for setting the 1986 and 1987 production levels, but that from these years forward, the future growth rates follow the assumption listed above.

The special cases in which additional information beyond 1985 is available are products 8, 12, 15, 23, 28, 29, 30, and 31. Hence, in Table 2A for example, the 1985 to 1986 growth rate for the Low Decline scenario is not zero, as it is for the other products. In one case, the 1985 to 1986 growth rate recommended is -100 percent, because the survey indicated that the product quantity would be zero in 1986. In the other cases, the 1985 to 1986 growth rate is negative, but not large in absolute value, indicating that some additional information about 1986 production plans was available from the survey. Finally, in the Low Decline Scenario, except in the case of product 23 (for which there is information on 1987 production as well), the recommended growth rate after 1986 for these special cases is zero.

The Low Decline growth rates from 1985 to 1988 for product 23 were developed based on very detailed information provided by one of the two producers of this product. This company provided its production quantities for 1985, 1986, and 1987 for product 23, so specific rates of growth can be associated with each year. However, this product also is produced by one nonrespondent company for whom little, if any, information is available. Hence, as outlined in a the previous subsection, the 1985 quantity of product 23 is assumed to be equal to the 1981 production of the nonrespondent plus the reported production for the respondent company. The 1985 to 1986 growth rate for this product is computed from the reported drop in production by the respondent based on continued production by the nonrespondent equal to its 1981 production level. Similarly, the 1986 to 1987 growth rate for this product is computed from the reported drop in production by the respondent and an unchanged level of production for the nonrespondent. Since the respondent indicated that it would cease producing this asbestos product during 1987, the 1987 to 1988 growth rate reflects this exit from the market and the growth rate for the product after this time is assumed to be zero, consistent with the assumption that the nonrespondent would continue to produce at its 1981 level (because no other information is available).

Finally, there are a few cases in which the 1981 to 1985 experience was positive growth. These are products 23, 32, and 33. Product 23, as discussed above, has growth rates for post-1985 years based on the actual experience of a company in this market, and this information suggests that this market will experience declines in 1986 and 1987. However, several considerations suggest that in the cases of products 32 and 33, the future growth rates will not be positive. The case of sealant tape, product 33, is one in which growth occurred during the 1981 to 1985 period. However, the ICF survey suggests that during the same period, the quantity of asbestos fiber used <u>per foot of tape</u> declined. Hence, the rate of increase of sealant tape footage production is not indicative of the rate of increase of <u>fiber usage</u> in this category -- which was about 2 percent per year during this period, rather than the 6 percent output growth listed in the table. Furthermore, the ICF survey also indicates that many competitive substitute materials are now available or are nearly on the market. Thus, one would not necessarily expect the 1981 to 1985 trend in asbestos usage to continue for this product. In light of these considerations, the zero future growth assumption in all scenarios for this product seems reasonable.

Missile liner (32) is another category in which positive growth appears to have occurred during the 1981 to 1985 period. However, one should consider two important facts for this product. First, the 1985 total production figure is based on the BOM estimate of 1985 fiber usage. As outlined in the previous section, this procedure was necessary because the respondents in this category produced very small amounts of missile liner in 1981, but grew substantially (in percentage terms) between 1981 and 1985. Applying this percentage growth to the single non-respondent results in a very large estimate for 1985 missile liner because the non-respondent's 1981 production was large. Given the data problems for this category, and the fact that the BOM category including this product contains only missile liner, using the BOM estimate is reasonable. However, as outlined in that same previous memorandum and as indicated in Exhibit A.1.2-2 above, the BOM estimates should not necessarily be regarded as absolutely correct. Second, the amount of fiber used in missile liner is, for the most part, confidential information given the nature of the ultimate product into which the fiber goes. Most of this information is classified by DoD and, hence, not available to the study. Finally, the future course of missile production is extremely difficult to predict because it depends on the economic viability of the space shuttle and on future strategic arms policies.

Exhibit A.1.2-2A ARCM Product Growth Rates - Low Decline

Product	Recommended Growth Rate 1985-1986	Recommended Growth Rate 1986-1987	Recommended Growth Rate 1987-1988	Recommended Growth Rate 1988-2000
Commercial Paper (1)	N/A	N/A	N/A	N/A
Rollboard (2)	N/A	N/A	N/A	N/A
Millboard (3)	0.00%	0.00%	0.00%	0.00%
Pipeline Wrap (4)	0.00%	0.00%	0.00%	0.00%
Beater-Add Gaskets (5)	0.00%	0.00%	0.00%	0.00%
High-Grade Electrical Paper (6)	0.00%	0.00%	0.00%	0.00%
Roofing Felt (7)	N/A	N/A	N/A	N/A
Acetylene Cylinders (8)	-21.42%	0.00%	0.00%	0.00%
Flooring Felt (9)	N/A	N/A	N/A	N/A
Corrugated Paper (10)	N/A	N/A	N/A	N/A
Specialty Paper (11)	0.00%	0.00%	0.00%	0.00%
Vinyl-Asbestos Floor Tile (12)	-100.00%	N/A	N/A	N/A
Asbestos Diaphragms (13)	0.00%	0.00%	0.00%	0.00%
Asbestos-Cement Pipe (14)	0.00%	0.00%	0.00%	0.00%
Asbestos-Cement Flat Sheet (15)	-77.17%	0.00%	0.00%	0.00%
Asbestos-Cement Corrugated Sheet (16)	0.00%	0.00%	0.00%	0.00%
Asbestos-Cement Shingle (17)	0.00%	0.00%	0.00%	0.00%
Drum Brake Linings (18)	a/	a/	a/	a/
Disc Brake Pads - LMV (19)	a/	a/	a/	a/
Disc Brake Pads - HV (20)	0.00%	0.00%	0.00%	0.00%
Brake Blocks (21)	0.00%	0.00%	0.00%	0.00%
Clutch Facings (22)	0.00%	0.00%	0.00%	0.00%
Automatic Transmission Components (23)	-54.70%	-78.30%	-4.40%	0.00%
Friction Materials (24)	0.00%	0.00%	0.00%	0.00%
Asbestos Protective Clothing (25)	N/A	N/A	N/A	N/A
Asbestos Cloth, Yarn, and Thread (26)	0.00%	0.00%	0.00%	0.00%
Sheet Gaskets (27)	0.00%	0.00%	0.00%	0.00%
Asbestos Packings (28)	-66.67%	0.00%	0.00%	0.00%
Roof Coatings and Cements (29)	-26.33%	0.00%	0.00%	0.00%
Non-Roofing Adhesives, Sealants, and Compounds (30)	-19.41%	0.00%	0.00%	0.00%
Asbestos-Reinforced Plastic (31)	-12.10%	0.00%	0.00%	0.00%
Missile Liner (32)	0.00%	0.00%	0.00%	0.00%
Sealant Tape (33)	0.00%	0.00%	0.00%	0.00%
Battery Separator (34)	b/	b/	b/	b/
Arc Chutes (35)	b/	b/	b/	b/
Miscellaneous Products (36)	N/A	N/A	N/A	N/A

a/ Growth rates for this product were estimated using a separate model and are presented in the next section.

b/ These categories were not included in the ARCM.

N/A: Growth rates are not applicable for this product because qantity produced is zero.

Exhibit A.1.2-2B ARCM Product Growth Rates - Moderate Decline

Product	Recommended Growth Rate 1985-1986	Recommended Growth Rate 1986-1987	Recommended Growth Rate 1987-1988	Recommended Growth Rate 1988-2000
Commercial Paper (1)	N/A	N/A	N/A	N/A
Rollboard (2)	N/A	N/A	N/A	N/A
Millboard (3)	-16.15%	-16.15%	-16.15%	-16.15%
Pipeline Wrap (4)	-19.51%	-19.51%	-19.51%	-19.51%
Beater-Add Gaskets (5)	-5.39%	-5.39%	-5.39%	-5.39%
High-Grade Electrical Paper (6)	-0.14%	-0.14%	-0.14%	-0.14%
Roofing Felt (7)	N/A	N/A	N/A	N/A
Acetylene Cylinders (8)	-8.41%	-8.41%	-8.41%	-8.41%
Flooring Felt (9)	N/A	N/A	N/A	N/A
Corrugated Paper (10)	N/A	N/A	N/A	N/A
Specialty Paper (11)	-16.25%	-16.25%	-16.25%	-16.25%
Vinyl-Asbestos Floor Tile (12)	-100.00%	N/A	N/A	N/A
Asbestos Diaphragms (13)	0.00%	0.00%	0.00%	0.00%
Asbestos-Cement Pipe (14)	-5.98%	-5.98%	-5.98%	-5.98%
Asbestos-Cement Flat Sheet (15)	-26.36%	-26.36%	-26.36%	-26.36%
Asbestos-Cement Corrugated Sheet (16)	0.00%	0.00%	0.00%	0.00%
Asbestos-Cement Shingle (17)	-4.89%	-4.89%	-4.89%	-4.89%
Drum Brake Linings (18)	a/	a/	a/	a/
Disc Brake Pads - LMV (19)	a/	a/	a/	a/
Disc Brake Pads - HV (20)	-17.67%	-17.67%	-17.67%	-17.67%
Brake Blocks (21)	-15.96%	-15.96%	-15.96%	-15.96%
Clutch Facings (22)	-0.27%	-0.27%	-0.27%	-0.27%
Automatic Transmission Components (23)	-54.70%	-78.30%	-4.40%	0.00%
Friction Materials (24)	-8.13%	-8.13%	-8.13%	-8.13%
Asbestos Protective Clothing (25)	N/A	N/A	N/A	N/A
Asbestos Cloth, Yarn, and Thread (26)	-16.96%	-16.96%	-16.96%	-16.96%
Sheet Gaskets (27)	-11.59%	-11.59%	-11.59%	-11.59%
Asbestos Packings (28)	-66.67%	-14.92%	-14.92%	-14.92%
Roof Coatings and Cements (29)	-0.76%	-0.76%	-0.76%	-0.76%
Non-Roofing Adhesives, Sealants, and Compounds (30)	-13.94%	-13.94%	-13.94%	-13.94%
Asbestos-Reinforced Plastic (31)	-10.48%	-10.48%	-10.48%	-10.48%
Missile Liner (32)	0.00%	0.00%	0.00%	0.00%
Sealant Tape (33)	3.27%	3.27%	3.27%	3.27%
Battery Separator (34)	b/	b/	b/	b/
Arc Chutes (35)	b/	b/	b/	b/
Miscellaneous Products (36)	N/A	N/A	N/A	N/A

a/ Growth rates for this product were estimated using a separate model and are presented in the next section.

b/ These categories were not included in the ARCM.

N/A: Growth rates are not applicable for this product because qantity produced is zero.

Exhibit A.1.2-2C ARCM Product Growth Rates - High Decline

Product	Recommended Growth Rate 1985-1986	Recommended Growth Rate 1986-1987	Recommended Growth Rate 1987-1988	Recommended Growth Rate 1988-2000
Commercial Paper (1)	N/A	N/A	N/A	N/A
Rollboard (2)	N/A	N/A	N/A	N/A
Millboard (3)	-32.31%	-32.31%	-32.31%	-32.31%
Pipeline Wrap (4)	-39.03%	-39.03%	-39.03%	-39.03%
Beater-Add Gaskets (5)	-10.77%	-10.77%	-10.77%	-10.77%
High-Grade Electrical Paper (6)	-0.28%	-0.28%	-0.28%	-0.28%
Roofing Felt (7)	N/A	N/A	N/A	N/A
Acetylene Cylinders (8)	-16.82%	-16.82%	-16.82%	-16.82%
Flooring Felt (9)	N/A	N/A	N/A	N/A
Corrugated Paper (10)	N/A	N/A	N/A	N/A
Specialty Paper (11)	-32.50%	-32.50%	-32.50%	-32.50%
Vinyl-Asbestos Floor Tile (12)	-100.00%	N/A	N/A	N/A
Asbestos Diaphragms (13)	0.00%	0.00%	0.00%	0.00%
Asbestos-Cement Pipe (14)	-11.95%	-11.95%	-11.95%	-11.95%
Asbestos-Cement Flat Sheet (15)	-52.72%	-52.72%	-52.72%	-52.72%
Asbestos-Cement Corrugated Sheet (16)	0.00%	0.00%	0.00%	0.00%
Asbestos-Cement Shingle (17)	-9.78%	-9.78%	-9.78%	-9.78%
Drum Brake Linings (18)	a/	a/	a/	a/
Disc Brake Pads - LMV (19)	a/	a/	a/	a/
Disc Brake Pads - HV (20)	-35.33%	-35.33%	-35.33%	-35.33%
Brake Blocks (21)	-31.93%	-31.93%	-31.93%	-31.93%
Clutch Facings (22)	-0.54%	-0.54%	-0.54%	-0.54%
Automatic Transmission Components (23)	-54.70%	-78.30%	-4.40%	0.00%
Friction Materials (24)	-16.26%	-16.26%	-16.26%	-16.26%
Asbestos Protective Clothing (25)	N/A	N/A	N/A	N/A
Asbestos Cloth, Yarn, and Thread (26)	-33.92%	-33.92%	-33.92%	-33.92%
Sheet Gaskets (27)	-23.17%	-23.17%	-23.17%	-23.17%
Asbestos Packings (28)	-66.67%	-29.84%	-29.84%	-29.84%
Roof Coatings and Cements (29)	-1.53%	-1.53%	-1.53%	-1.53%
Non-Roofing Adhesives, Sealants, and Compounds (30)	-27.89%	-27.89%	-27.89%	-27.89%
Asbestos-Reinforced Plastic (31)	-20.96%	-20.96%	-20.96%	-20.96%
Missile Liner (32)	0.00%	0.00%	0.00%	0.00%
Sealant Tape (33)	3.27%	3.27%	3.27%	3.27%
Battery Separator (34)	b/	b/	b/	b/
Arc Chutes (35)	b/	b/	b/	b/
Miscellaneous Products (36)	N/A	N/A	N/A	N/A

a/ Growth rates for this product were estimated using a separate model and are presented in the next section.

b/ These categories were not included in the ARCM.

N/A: Growth rates are not applicable for this product because qantity produced is zero.

Therefore, it again does not seem unreasonable to assume a zero growth rate in all scenarios for this product as well.

3. Asbestos Brake Production Forecast

3.1 Introduction

This section presents the three sets of baseline growth rates for asbestos drum brakes in light and medium vehicles (product category 18) and asbestos disc brakes in light and medium vehicles (product category 19) to be used in the Asbestos Regulatory Cost Model (ARCM). It reviews the methodology underlying the model and presents the input data used, the assumptions made, and the results obtained. This model generates forecasts of changes in output of asbestos drum brakes and asbestos disc brakes which, along with the 1985 levels of output of these categories, provide the baseline forecast of asbestos product quantities for these two categories in the ARCM. Growth rates for the other products being modeled are derived separately.

Drum brake systems consist primarily of two parts -- a round brake drum which is attached to the rotating wheel and axle and a pair of curved, semi-circular brake shoes which are inside the drum. The vehicle is stopped when the brake shoes are forced out against the brake drum. This action creates friction, which arrests the motion of the axle and the wheel. The brake shoes are lined with asbestos because of its thermal stability, reinforcing properties, flexibility, and resistance to wear. Because each wheel is attached to a drum and each drum contains two brake shoes and asbestos linings, there are eight linings on a vehicle that has front and rear drum brakes.

Disc brake systems consist primarily of two parts -- a flat, circular rotor which is attached to the rotating wheel and axle and a caliper which contains two flat disc brake pads that are suspended on either side of the rotor. The vehicle is stopped by pressing the brake pads onto the rotor in much the same way that bicycle hand brakes are pressed onto a bicycle wheel. This creates friction which arrests the motion of the axle and the wheel. The brake pads consist of asbestos because of its thermal stability, reinforcing properties, flexibility, and resistance to wear. Because each wheel is attached to a rotor and each rotor requires two disc pads to stop it, there are eight pads on a vehicle that has front and rear disc brakes.

Estimating total sales of asbestos disc brakes and asbestos drum brakes involves two distinct exercises. One is estimating sales of brakes in new vehicles and the other is estimating sales of replacement brakes on existing vehicles. Further complicating the projection analysis is the fact that many future brakes will not be made of asbestos mixtures. Some will continue to be asbestos, but others will be composed of substitutes such as semi-metallic or aramid fiber mixtures.

The task of estimating new brake sales is relatively straightforward -- depending primarily on the forecasts for new car sales and the type of brake system installed as original equipment -- however, forecasting replacement sales is much more complex. Replacement brake sales depend on a number of factors including:

- sales of new light vehicles in previous years;
- the type of brakes installed as original equipment (i.e., disc vs. drum);

- the composition of brakes installed as original equipment (i.e., asbestos vs. non-asbestos);

- the expected life of brakes, which, in turn, depends on:

  -- the number of miles a brake lasts;

  -- the type of surface and environment the vehicle is driven on; and

  -- the number of miles the vehicle on which it is placed is driven annually;

- the survival probability or scrappage rate for existing vehicles which depends on:

  -- new vehicle prices;
  -- used vehicle prices;
  -- scrap values; and
  -- repair costs.

Correctly accounting for all these influences is quite difficult. Our methodology tries to address all of these issues in an operational and systematic manner by making a number of assumptions drawn from aggregated data. These assumptions pertain to the following: type of future brake systems (proportion of drum brakes to disc brakes), composition of future brake systems (proportion of asbestos brakes to non-asbestos brakes), average life of brake systems, survival probabilities for light vehicles (cars and light trucks), current stock of light vehicles, and future sales of light vehicles.

The rest of this memorandum consists of five sections. Section 3.2 outlines the methodology used; Section 3.3 deals with the key assumptions made and data used for producing our forecasts; Section 3.4 reports the results of our forecasts; Section 3.5 discusses the sensitivity of these results to various data inputs; and Section 3.6 summarizes the conclusions.

3.2 Methodology

Brake forecasts have been developed for four product categories: asbestos disc brakes on trucks, asbestos drum brakes on trucks, asbestos disc brakes on cars, and asbestos drum brakes on cars. Although the same procedures have been used to develop forecasts for all four categories, the methodology will be described in detail using the first category as an example.

There are four major steps in forecasting asbestos brake sales:

- estimate the outstanding stock of asbestos brake pads or linings, by model year, in 1985;

- compute the future stock of brake pads or linings on existing vehicles, by model year;

- compute the future stock of asbestos brake pads or linings on vehicles not yet built, by model year, and

- compute annual replacement and new asbestos brake pad or lining sales.

The outstanding stock of asbestos disc brake pads in trucks, by model year, in 1985 is obtained by multiplying the outstanding number of trucks in 1985 by three factors: the number of brake pads or linings (8) on each truck (this gives us the number of brake pads or linings on the existing stock of trucks), the percentage of total brake pads or linings which are disc brake pads (this gives us the total number of disc brake pads on the existing stock of trucks), and the percentage of disc brake pads which are asbestos (this gives us the total number of asbestos disc brake pads on the existing stock of trucks).

The future stocks (1986 and beyond) of asbestos disc brakes on existing trucks, by model year, are obtained by multiplying the existing stock of brakes by the appropriate survival probabilities. This can best be illustrated through an example.

Suppose there are 100 disc brake pads on 1970 model year trucks outstanding in 1985. To compute the number of disc brake pads on 1970 model year trucks outstanding in 1986, we multiply 100 by the conditional probability that a truck that has survived fifteen years will survive into its sixteenth year. The conditional probability can be computed by dividing the sixteen year survival probability by the fifteen year survival probability (38.5 percent/44.8 percent or 0.859 in this case). This computation is performed for each year from 1986 until the year 2000 for each model year. For example, multiplying 100 by 0.859 yields 86 as the number of disc brakes on 1970 model year trucks outstanding in 1986.

The future stocks (1986 and beyond) of asbestos disc brake pads in trucks not yet built is computed in two steps. We first compute the number of new asbestos disc brake pads that will be installed in trucks each year. This is forecasted truck sales multiplied by the percentage of total brake pads and linings which are disc pads (assumed to be 55 percent), the percentage of disc brake pads which are asbestos (assumed to be 15 percent), and the number of brake pads or linings per truck (8). The second step is to take this number and to project it into the future by multiplying it by the appropriate truck survival probability. For instance, if 100 asbestos disc brakes on 1987 trucks are produced in 1987, we multiply 100 by the one year survival probability for trucks to generate the stock of these brake pads existing on surviving trucks in 1988. To generate the stock of these brake pads existing on surviving trucks in 1989 we multiply 100 by the two year survival for trucks; this process is repeated for each year of the forecast.

To estimate the number of disc brake pads that were replaced in 1986, we computed the number of trucks that were built in 1982, 1978, 1974, 1970, 1966, 1962, and 1958, (all brakes are assumed to be replaced every four years, as discussed below) that are still surviving. The number of surviving trucks of each model year is then multiplied by 8 (to get the total number of brake pads), by the percentage of disc brake pads installed on trucks of that model year, (to get the number of disc brake pads), and by the percentage of disc brake pads which were asbestos in that model year (to get asbestos disc brake pads). This gives us the number of replacement asbestos disc brake pad sales for trucks in 1986. When we add this number to the number of new asbestos disc brake pads on 1986 trucks, we have our forecast for total 1986 asbestos disc brake pad sales for trucks. This step is repeated for each year of the forecast.

This methodology is then repeated for the other three categories -- asbestos drum brake linings on trucks, asbestos disc brake pads on cars, and asbestos drum brake linings on cars. Appendix A presents the mathematical formulation which underlies the model.

3.3 Key Assumptions and Data Inputs

3.3.1 Type of Brake Systems

The data on types of brake systems are derived from data in various issues of Ward's Automotive Yearbook.[2] The data had to be derived using certain simplifying assumptions because it was either unavailable for some years or not exactly the information we needed. Specifically, we need to know the percentage of all brake systems on cars and on trucks that are disc and the percentage that are drum for each model year.

The first data series we examined was percentage of domestic cars with disc brake systems. Ward's Automotive Yearbook 1986 provides this information for domestic cars for the years 1954-1985. Because no domestic cars had disc brake systems prior to 1966, we have assumed that all brakes on cars of earlier model years are drum brakes. Second, we have assumed that disc brakes were placed only on front axles. Therefore, to obtain the percentage of total brake systems, we must multiply the percentage of cars with front disc brakes by 0.5. All remaining brakes are assumed to be drum brakes. This method is used for the years 1963-1974. Separate data for imported cars is not available. Therefore, it has been assumed that the domestic percentages also apply to imports.

Ward's Automotive Yearbook 1976 and subsequent issues provide separate data for imported cars. Therefore, we used this information for model years 1975-1985 to compute a weighted average of the percentage of all cars with disc brakes. Once again, it was assumed that all other brakes are drum brakes. Ward's Automotive Yearbook 1978 and subsequent issues provide data on cars with disc brakes on both the front and rear axles. Accordingly, this information is used in computing the weighted average of the percentage of all cars with drum brakes for model years 1977-1985.

This last computation is the one we would have ideally used for all model years if the data had been available. However, the simplifying assumptions we have made should not alter our results greatly. Domestic cars accounted for approximately 75 percent of all U.S. sales for model years 1963-1974 so the percentage of disc brakes on domestic cars and the percentage of disc brakes on all cars will not differ significantly. In addition, the numbers are similar in the years for which we have data -- 1975-1985. Second, data on cars with disc brakes on both front and rear axles is not available prior to model year 1977 (model year 1978 for imports). Since only 3.2 percent of all

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[2] Ward's Automotive Yearbook, 1976-1986.

cars had disc brakes on both axles in 1977, it is not likely that a significant number of cars, if any, in earlier model years had disc brakes on both axles. Table A.1.3-1 presents the data for the percentage of brakes that are disc.

The data for trucks is not as complete as the car data. First of all, data on disc brakes on trucks for model years prior to 1976 is unavailable. In addition, separate data for imported trucks is not available. Finally, there is no information on trucks with front and rear disc brakes.

As a result, we have assumed that the percentage of disc brakes on trucks is the same as the percentage of disc brakes on cars for model years prior to 1976. Furthermore, we have assumed that the percentage of disc brakes on domestic cars is the same as the percentage of disc brakes on all (domestic and imported) cars. Because disc brakes are placed on the rear wheels of predominantly luxury and high-performance cars, it is likely that a very small percentage, if any, of trucks have rear disc brakes. Therefore, we have assumed that no trucks have rear disc brakes. Finally, it should be noted that Ward's Automotive Yearbook 1982 and subsequent issues only provide data for power disc brakes. In model years 1979 and 1980, 100 percent of trucks had either manual or power disc brakes. It has been assumed that this holds true for subsequent years and all front brakes which are not power disc are manual disc for model years 1981-1985.

The final assumptions we need are for the percentage of future brake systems that will be disc brakes. We have assumed that the 1985 percentages for both cars and trucks will apply for model year 1986 and all future model years. Thus, 53.4 percent of all car brake systems will be disc brakes while 50 percent of all truck brake systems will be disc brakes. It should be noted that this may understate the number of disc brakes and overstate the number of drum brakes slightly because more cars may move to front and rear disc brakes in the future, but this will be examined in the sensitivity analysis. Table A.1.3-1 presents the data for the percentage of car brakes that are disc while Table A.1.3-2 presents the data for the percentage of truck brakes that are disc.

3.3.2 Composition of Brake Systems

Before 1982, all brake pads and linings were made using asbestos. However, currently between 80 percent and 90 percent of all disc brake pads are made using asbestos substitutes, and between 5 percent and 10 percent of all drum brake linings are made using asbestos substitutes (ICF 1987). We have assumed that 85 percent (the midpoint of the 80 percent to 90 percent range) of all current and future original equipment market (OEM) disc brakes will not contain asbestos. We have also assumed that 7.5 percent (the midpoint of the 5 percent and 10 percent range) of all current and future OEM drum brakes will not contain asbestos. These are conservative assumptions because they assume that no further substitution away from asbestos will occur.

We could not find data on the percentage of disc and drum brakes made using asbestos for vehicles manufactured between 1982 and 1986. However, we know that 1982 was the first year that non-asbestos disc and drum brakes were used (ICF 1987). Therefore, we have assumed a linear decline in asbestos brake composition from 100 percent in 1981 to the known 1986 levels. Thus,

Table A.1.3-1 Disc Brake as A Percentage of Total Brakes for Model Years 1963-2000 Cars

Model Year	Domestic Car Sales	Percentage of Domestic Cars with Front Disc Brakes Only	Percentage of Domestic Cars with Front and Rear Disc Brakes	Imported Car Sales	Percentage of Imported Cars with Front Disc Brakes Only	Percentage of Imported Cars with Front and Rear Disc Brakes	Disc Brakes as a Percentage of Total Car Brakes
1963	*	0.0%	0.0%	*	N/A	N/A	0.0%
1964	*	0.0%	0.0%	*	N/A	N/A	0.0%
1965	*	0.0%	0.0%	*	N/A	N/A	0.0%
1966	*	4.0%	0.0%	*	N/A	N/A	2.0%
1967	*	6.1%	0.0%	*	N/A	N/A	3.1%
1968	*	12.7%	0.0%	*	N/A	N/A	6.4%
1969	*	27.8%	0.0%	*	N/A	N/A	13.9%
1970	*	41.0%	0.0%	*	N/A	N/A	20.5%
1971	*	63.1%	0.0%	*	N/A	N/A	31.6%
1972	*	73.6%	0.0%	*	N/A	N/A	36.8%
1973	*	85.7%	0.0%	*	N/A	N/A	42.9%
1974	*	84.1%	0.0%	*	N/A	N/A	42.1%
1975	6,789,707	92.6%	0.0%	1,662,278	94.5%	0.0%	46.5%
1976	8,391,841	98.8%	0.0%	1,687,745	90.8%	0.0%	48.7%
1977	*	96.8%	3.2%	*	N/A	N/A	51.6%
1978	9,239,287	96.8%	3.2%	1,976,516	90.1%	9.9%	52.2%
1979	9,500,893	96.9%	3.1%	2,304,334	87.7%	12.3%	52.4%
1980	6,957,191	97.1%	2.9%	2,362,727	84.5%	15.5%	53.0%
1981	7,086,429	97.8%	2.2%	2,241,768	80.3%	19.7%	53.2%
1982	5,585,044	98.6%	1.4%	2,191,937	80.7%	19.3%	53.2%
1983	6,156,864	97.0%	3.0%	2,305,512	79.1%	20.9%	53.9%
1984	8,624,742	97.0%	3.0%	1,878,169	67.1%	32.9%	54.2%
1985	8,472,599	97.3%	2.7%	2,476,586	79.1%	20.9%	53.4%
1986-2000	*	N/A	N/A	*	N/A	N/A	53.4%

* Not applicable.

N/A = Not available.

Source: Ward's Automotive Yearbook (1976-1986), see text for explanation.

Table A.1.3-2. Disc Brakes as a Percentage of Total Brakes for Model Years 1955-2000 Trucks

Model Year	Percentage of Domestic Trucks with Front Disc Brakes	Disc Brakes as a Percentage of Total Truck Brakes
1955	0.0%	0.0%
1956	0.0%	0.0%
1957	0.0%	0.0%
1958	0.0%	0.0%
1959	0.0%	0.0%
1960	0.0%	0.0%
1961	0.0%	0.0%
1962	0.0%	0.0%
1963	0.0%	0.0%
1964	0.0%	0.0%
1965	0.0%	0.0%
1966	4.0%	2.0%
1967	6.1%	3.1%
1968	12.6%	6.3%
1969	27.8%	13.9%
1970	63.1%	31.6%
1971	73.6%	36.8%
1972	85.7%	42.9%
1973	84.1%	42.1%
1974	92.6%	46.3%
1975	98.8%	49.4%
1976	97.8%	48.9%
1977	99.2%	49.6%
1978	99.9%	50.0%
1979	100.0%	50.0%
1980	100.0%	50.0%
1981	100.0%	50.0%
1982	100.0%	50.0%
1983	100.0%	50.0%
1984	100.0%	50.0%
1985	100.0%	50.0%
1986-2000	100.0%	50.0%

Source: Ward's Automotive Yearbook (1977-1986), see text for explanation.

asbestos disc brake composition declines linearly from 100 percent in 1981 to 15 percent in 1986 (17 percent each year), and asbestos drum brake composition declines linearly from 100 percent in 1981 to 92.5 percent in 1986 (1.5 percent each year). Table A.1.3-3 and Table A.1.3-4 present a summary of the type and composition of existing and future brake systems on the wheels of cars and light trucks.

One further assumption we made related to the type and composition of brakes is that brakes used for replacement would be of the same type as those placed originally on the vehicle. For instance, if a car was originally produced with an asbestos disc brake pad, we will assume that it will be replaced by an asbestos disc brake pad, even though it may be possible to replace an asbestos disc brake pad with a non-asbestos disc brake pad. This assumption has been made after having detailed discussions with automobile manufacturers who recommend this practice for safety reasons. See Appendix F to this RIA. They claim that replacing asbestos disc brake pads with non-asbestos disc brake pads involves redesigning the whole brake system, and a simple exchange of one pad for another may cause safety hazards. Furthermore, the American Society of Mechanical Engineers (ASME) concluded that use of asbestos-free materials as direct substitutes in vehicles designed for asbestos-based linings may be restricted for the following reasons: (1) braking balance between front and rear breaks may be adversely affected; (2) parking brake capacity may be reduced; and (3) no meaningful brake lining effectiveness ratings exist (ASME 1987). It should be noted that this assumption is probably also a conservative one and will cause us to overestimate the sale of asbestos brakes if asbestos brakes are actually replaced with non-asbestos brakes.

3.3.3 Average Life of Brakes

The rate at which vehicles in operation have their brakes replaced is a key assumption having a direct bearing on replacement brake sales. The rate of replacement installation for a given collection of vehicles is influenced by (1) the number of miles an average vehicle is driven, (2) the age of existing brake systems, and (3) the useful life of brake linings. The useful life of brake linings, in turn, depends on the weight and other characteristics of the vehicle, the driving habits of the operator, and the location of vehicle operation (city/highway). A detailed study of the influence of each one of the listed variables on replacement sales should be done to determine the size of the brake replacement market. Such a study, however, is outside the scope of the present assignment. For the purpose of this forecast the average number of miles that brakes are expected to last is estimated and then divided by the number of miles an average vehicle is expected to be driven in a year. This computes the average useful life for the brakes on a given collection of vehicles.

The U.S. Department of Transportation (DOT) estimated annual average miles travelled per passenger car to the year 2000 to be 10.5 thousand miles (DOT 1976). This is a dated forecast, so we decided to review more recent data which are presented in Table A.1.3-5. An average car was driven 9,809 miles in 1984 while an average light truck was driven 9,974 miles. For forecasting

Table A.1.3-3. Type and Composition of Brake Systems on the Wheels of Passenger Cars, by Model Year (percent)

Year	Asbestos Drum	Non-Asbestos Drum	Total Drum	Asbestos Disc	Non-Asbestos Disc	Total Disc
1954-1965	100.0	0.0	100.0	0.0	0.0	0.0
1966	98.0	0.0	98.0	2.0	0.0	2.0
1967	96.9	0.0	96.9	3.1	0.0	3.1
1968	93.6	0.0	93.6	6.4	0.0	6.4
1969	86.1	0.0	86.1	13.9	0.0	13.9
1970	79.5	0.0	79.5	20.5	0.0	20.5
1971	68.4	0.0	68.4	31.6	0.0	31.6
1972	63.2	0.0	63.2	36.8	0.0	36.8
1973	57.1	0.0	57.1	42.9	0.0	42.9
1974	57.9	0.0	57.9	42.1	0.0	42.1
1975	53.5	0.0	53.5	46.5	0.0	46.5
1976	51.3	0.0	51.3	48.7	0.0	48.7
1977	48.4	0.0	48.4	51.6	0.0	51.6
1978	47.8	0.0	47.8	52.2	0.0	52.2
1979	47.6	0.0	47.6	52.4	0.0	52.4
1980	47.0	0.0	47.0	53.0	0.0	53.0
1981	46.8	0.0	46.8	53.2	0.0	53.2
1982	46.1	0.7	46.8	44.1	9.1	53.2
1983	44.7	1.4	46.1	35.6	18.3	53.9
1984	43.7	2.1	45.8	26.6	27.6	54.2
1985	43.8	2.8	46.6	17.1	36.3	53.4
1986-2000	43.1	3.5	46.6	8.0	45.4	53.4

Sources: Ward's Automotive Yearbook (1976-1986) and ICF, see text for explanation.

Table A.1.3-4. Type and Composition of Brake Systems on the Wheels of Light Trucks, by Model Year (percent)

Year	Asbestos Drum	Non-Asbestos Drum	Total Drum	Asbestos Disc	Non-Asbestos Disc	Total Disc
1954-1965	100.0	0.0	100.0	0.0	0.0	0.0
1966	98.0	0.0	98.0	2.0	0.0	2.0
1967	96.9	0.0	96.9	3.1	0.0	3.1
1968	93.7	0.0	93.7	6.3	0.0	6.3
1969	86.1	0.0	86.1	13.9	0.0	13.9
1970	68.4	0.0	68.4	31.6	0.0	31.6
1971	63.2	0.0	63.2	36.8	0.0	36.8
1972	57.1	0.0	57.1	42.9	0.0	42.9
1973	57.9	0.0	57.9	42.1	0.0	42.1
1974	53.7	0.0	53.7	46.3	0.0	46.3
1975	50.6	0.0	50.6	49.4	0.0	49.4
1976	51.1	0.0	51.1	48.9	0.0	48.9
1977	50.4	0.0	50.4	49.6	0.0	49.6
1978	50.0	0.0	50.0	50.0	0.0	50.0
1979	50.0	0.0	50.0	50.0	0.0	50.0
1980	50.0	0.0	50.0	50.0	0.0	50.0
1981	50.0	0.0	50.0	50.0	0.0	50.0
1982	49.3	0.7	50.0	41.5	8.5	50.0
1983	48.5	1.5	50.0	33.0	17.0	50.0
1984	47.8	2.2	50.0	24.5	25.5	50.0
1985	47.0	3.0	50.0	16.0	34.0	50.0
1986-2000	46.3	3.7	50.0	7.5	42.5	50.0

Sources: Ward's Automotive Yearbook (1977-1986) and ICF, see text for explanation.

Table A.1.3-5. Average Annual Miles Travelled

Year	Passenger Cars (miles)	Single Unit Trucks (miles)
1965	9,387	10,003
1970	9,978	9,807
1975	9,634	8,882[a]
1980	9,135	10,070
1982	9,533	9,805
1983	9,654	9,704
1984	9,809	9,974

[a]According to the source for this data series, this entry is not comparable to previous years for reasons not explained in the source.

Source: Motor Vehicle Manufacturers Association, Motor Vehicle Facts and Figures '86, 1986, p. 52.

purposes, we have used a figure of 10,000 miles for the average number of miles a car or light truck is driven each year.[3]

Reliable brake life data are not readily available. In part, this is because data on brake replacement are expensive to collect primarily because replacement occurs in service stations, independent repair shops, self-service fleet shops, and new car and truck dealerships throughout the country. In December 1980, DOT reported that front brake drum linings and/or disc pads would be replaced every 30-35 thousand miles and rear brake drum linings and/or disc pads would be replaced every 45-50 thousand miles (DOT, 1980).[4] These data are consistent with the opinions of industry experts who estimate that brakes last between 30,000 and 50,000 miles with 40,000 being average (ICF 1986). Thus, on average all four brakes have been assumed to be replaced every 40,000 miles. Combining this with the assumption of 10,000 miles driven per year on average, we have concluded that all brake linings (or pads) are replaced every four years.

3.3.4 Survival Probabilities

Table A.1.3-6 presents the survival probabilities for passenger cars and light trucks that were used to make the forecasts (Wharton Econometrics 1983). Sixty-eight percent of all cars manufactured 10 years ago are in operation today, while 78 percent of all light trucks manufactured 10 years ago are in operation today. Cars are not expected to survive in significant numbers for more than 21 years while trucks are not expected to survive in significant numbers for more than 30 years. These survival probabilities are assumed to apply to both the current stock of outstanding cars and to all future cars.

3.3.5 Outstanding Stock of Light Vehicles

The data on the outstanding stock of light vehicles (cars and trucks), by model year, as of 1985 were obtained from two sources. The data for cars produced after 1970 and the data for trucks produced after 1969 were obtained from R.L. Polk & Co. Because this source did not provide disaggregated data for earlier years, we estimated the outstanding stock of earlier model years by multiplying the vehicles produced in those years by the appropriate survival probabilities. The data used are presented in Table A.1.3-7. Because cars are assumed not to survive in significant quantities after 21 years, the first car model year we have presented is 1964. Because

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[3] It is important to note that the miles-driven assumptions have to be chosen so that the brake like is an integer number of years for the forecasting model as discussed below.

[4] DOT cited the 1975 Hunter Job Service Analysis which reported 35 million axle sets (1 axle set contains 4 pads or linings) of replacement sales in 1976. This figure was adjusted to 50 million in order to account for facilities that are not covered by the Hunter survey. This figure corresponds to five axle sets being replaced for every 100,000 miles. It is not clear whether this data included truck brakes, but we have assumed that truck brakes and car brakes have the same expected life, because we could not obtain separate data.

Table A.1.3-6. Cumulative Survival Probabilities for Passenger Cars and Light Trucks (percent)

Vehicle Age	Cars	Light Trucks
1	99.8	99.6
2	99.5	98.9
3	98.8	97.8
4	97.7	96.6
5	95.9	95.0
6	93.3	93.0
7	89.5	90.5
8	83.9	87.2
9	77.1	82.9
10	68.1	77.7
11	56.6	71.9
12	45.1	65.2
13	34.9	58.2
14	26.5	51.4
15	20.0	44.8
16	14.9	38.5
17	11.2	32.5
18	8.4	27.1
19	6.2	22.1
20	4.4	17.8
21	3.1	14.1
22	0.0	11.1
23		8.6
24		6.5
25		4.9
26		3.7
27		2.7
28		2.0
29		1.5
30		1.1
31		0.0

Source: Wharton Econometric Forecasting Associates, 1983.

Table A.1.3-7. Light Vehicles Outstanding in 1985 By Model Year (in thousands)

Model Year	Passenger Cars	Light Trucks
1954	0	0
1955	0	11
1956	0	14
1957	0	18
1958	0	21
1959	0	36
1960	0	47
1961	0	61
1962	0	95
1963	0	141
1964	251	196
1965	411	276
1966	560	362
1967	700	419
1968	1,081	595
1969	1,428	1,005
1970	2,154	1,105
1971	2,534	1,105
1972	3,713	1,603
1973	4,883	1,952
1974	5,196	2,050
1975	4,836	1,677
1976	7,195	2,437
1977	8,735	3,059
1978	9,503	3,429
1979	9,602	3,669
1980	8,502	2,088
1981	8,039	2,075
1982	7,322	2,181
1983	7,716	2,495
1984	10,401	3,819
1985	11,042	4,682
Total	115,804	42,723

Sources: Cars after 1969 and Trucks after 1970 -- R.L. Polk & Co. published in Motor Vehicle Facts & Figures '86, pps. 26-7.

Cars before 1969 and Trucks before 1970 -- Derived by ICF using Motor Vehicle Manufacturers Association, Motor Vehicle Facts & Figures '86, 1986, p.7 and survival probabilities provided by Wharton Econometric Forecasting Associates, 1983 (as explained in text).

cars are assumed not to survive in significant quantities after 21 years, the first car model year we have presented in 1964. Because trucks are assumed not to survive in significant quantities after 30 years, the first truck model year presented is 1955.

3.3.6 Future Sales of Light Vehicles

Forecasting consumer behavior is always difficult. Vehicle sales are subject to large year-to-year fluctuations. This point is illustrated by Table A.1.3-8 which presents new car and light truck sales and percentage changes in these sales. In addition, new car sales are influenced strongly by factors that are difficult to predict -- business cycles, energy prices, and the prices of alternative transportation such as used cars or public transit. We have used DRI's 1986 forecasts for new car and light truck sales and have relied on them to have taken most of the relevant factors into account in making their forecasts. These data are presented in Table A.1.3-9.[5]

A summary of all the major assumptions and data inputs for this analysis is provided in Table A.1.3-10.

3.4 Results

Table A.1.3-11 presents the forecasts for asbestos disc brake pads and for total disc brake pads for both cars and light trucks. Notice that sales of total disc brake pads are increasing while sales of asbestos disc brake pads are decreasing. Total disc brake pad sales are increasing for a number of reasons. First of all, disc brakes will claim a larger share of the total stock of brakes as we move into the future. This will occur because older vehicles which had drum brakes on both axles or only the rear axle will be scrapped and replaced with vehicles that have disc brakes on the front axle or on both axles. Second, the total stock of brakes will increase as we move into the future. This will occur because the number of new vehicles solid exceeds the number of vehicles scrapped. These two factors will both cause replacement sales of total disc brakes to increase. Finally, new vehicle sales are forecast to be cyclical with a rising trend. As a result, new total disc brakes will increase over time. The net result of these three effects is an increase in sales of total disc brakes. It is important to note that the cyclical nature of the car and truck industries may result in some years in which there is actually a decline in forecasted sales, even though the trend is clearly positive.

Asbestos disc brake pad sales are decreasing despite the facts that the stock of vehicles is growing and that new car sales are increasing. This occurs because the stock of asbestos disc brakes is decreasing. Cars with asbestos disc brakes are being scrapped and replaced with cars with semi-metallic disc brakes. Because we assume that only 15 percent of new disc brakes contain asbestos, this effect dominates the other two and the net effect is a decline in asbestos disc brake sales. Figure A.1.3-1 graphically

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[5] It should be noted that we examined forecasts of light vehicle sales made by General Motors and concluded that they were not significantly different from the Data Resource's Inc. forecasts. The General Motors forecasts are confidential business information (CBI).

Table A.1.3-8. New Car and Light Truck Sales, 1970-1985
(in thousands)

Year	Passenger Cars	Percent Change From Previous Year	Light Trucks	Percent Change From Previous Year
1985	11,042	6.3	4,682	14.4
1984	10,391	13.2	4,093	30.1
1983	9,182	15.0	3,129	22.2
1982	7,982	-6.5	2,560	13.3
1981	8,536	-4.9	2,260	-9.1
1980	8,979	-15.9	2,487	-28.5
1979	10,673	-5.7	3,480	-15.3
1978	11,314	1.2	4,109	11.8
1977	11,183	10.6	3,675	15.5
1976	10,110	17.2	3,181	28.4
1975	8,624	-2.6	2,478	-7.8
1974	8,853	-22.5	2,688	-14.6
1973	11,424	4.4	3,148	19.7
1972	10,940	6.8	2,629	25.4
1971	10,242	21.9	2,096	15.7
1970	8,400	-	1,811	-

Source: Motor Vehicle Manufacturers Association, Motor Vehicle Facts and Figures '86, 1986, p. 7.

Table A.1.3-9. Annual Sales Forecasts for Passenger Cars and Light Trucks (in thousands)

Year	Passenger Cars	Light Trucks
1986	10,900	4,510
1987	11,300	4,660
1988	11,300	4,750
1989	11,100	4,630
1990	11,300	4,650
1991	11,500	4,680
1992	11,700	4,770
1993	11,900	4,910
1994	12,100	5,040
1995	12,300	5,180
1996	12,300	5,250
1997	12,200	5,270
1998	12,200	5,330
1999	12,300	5,410
2000	12,400	5,520

Source: Data Resources, Inc., U.S. Long-Term Review (Spring 1986).

Table A.1.3-10. Summary of Assumptions and Data Inputs

Assumption/Data Input	Description
Type of Brake System	Type of brake system is derived from data in Ward's Automotive Yearbook (1976-1986); it is assumed that 53.4 percent of new car brakes will be disc and 46.6 percent will be drum; and it is assumed that 50 percent of new truck brakes will be disc and 50 percent will be drum.
Composition of Brake System	Composition of brake system is based on transcribed telephone conversations with industry experts; it is assumed that 15 percent of all new disc brakes will contain asbestos; and it is assumed that 92.5 percent of all new drum brakes will contain asbestos.
Average Life of Brakes	Disc and drum brakes on both cars and light trucks are assumed to have an average life of 4 years based on a 1980 DOT report and transcribed telephone conversations with industry experts.
Survival Probabilities	Survival probabilities for cars and light trucks are based on a 1983 Wharton Econometrics report.
Outstanding Stock of Light Vehicles	The outstanding stock of cars and light trucks is based on data from R.L. Polk & Co.
Future Sales of Light Vehicles	Future sales of cars and light trucks is based on forecasts published by Data Resources, Inc.

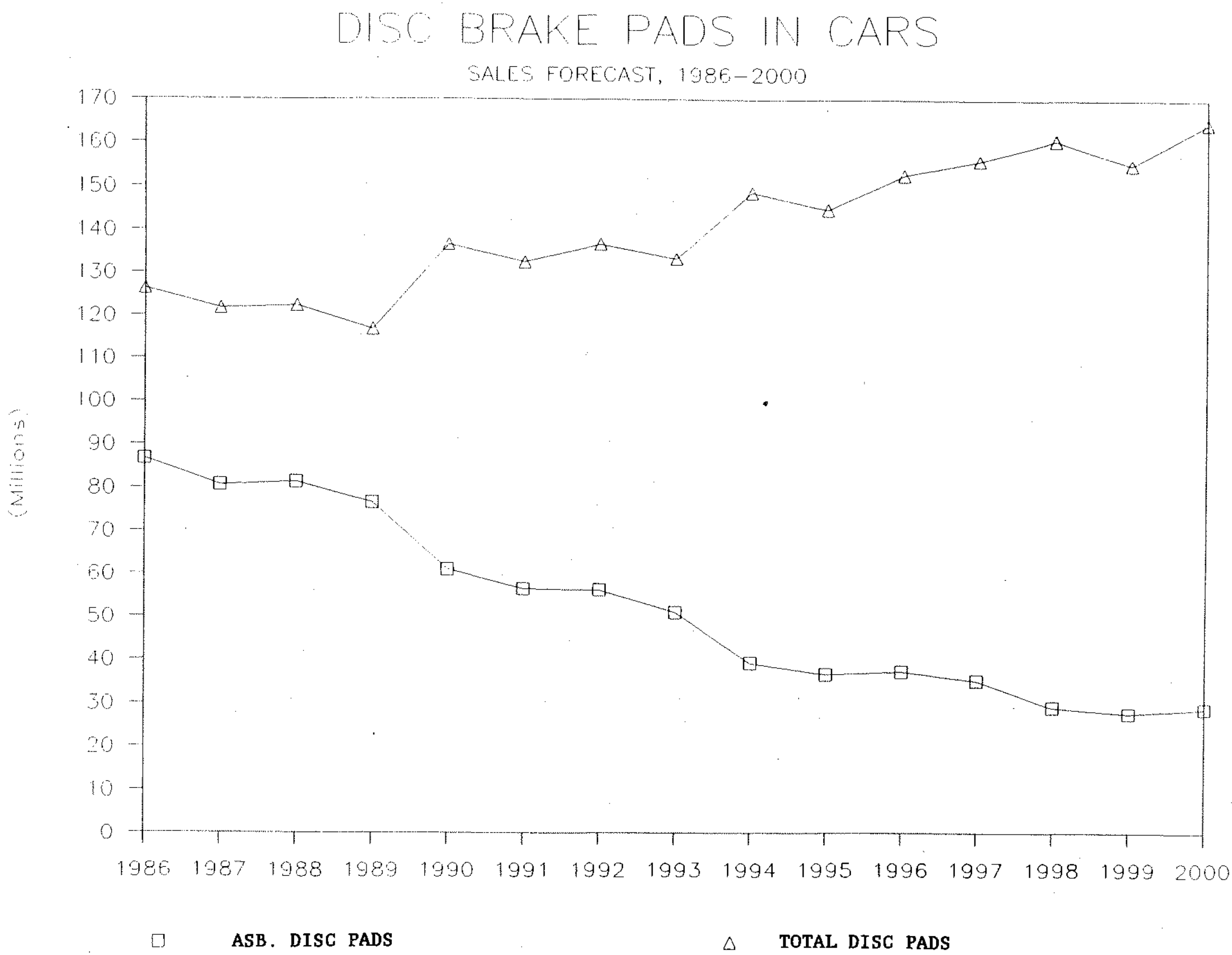
Table A.1.3-11. Sales Forecast of Total Disc Brake Pads and Asbestos Disc Brake Pads, 1986-2000, for A Four Year Brake Life (in thousands)

	Light Trucks		Passenger Cars	
Year	Total Disc Pads	Asbestos Disc Pads	Total Disc Pads	Asbestos Disc Pads
1986	47,741	32,407	126,319	86,739
1987	46,901	31,057	121,759	80,726
1988	45,228	29,078	122,407	81,374
1989	45,316	29,540	116,936	76,630
1990	56,157	26,725	136,703	60,995
1991	55,098	25,717	132,532	56,495
1992	55,050	23,945	136,634	56,239
1993	55,580	23,782	133,235	51,008
1994	64,059	20,619	148,561	39,224
1995	62,926	19,941	144,704	36,665
1996	64,472	18,991	152,570	37,369
1997	66,369	18,801	155,924	35,218
1998	72,082	16,218	160,638	29,113
1999	70,345	15,698	154,975	27,670
2000	73,351	15,588	164,451	28,836
Total	880,673	348,104	2,108,350	784,302

Detail may not add to totals due to rounding.

Source: ICF, see text.

Figure A.1.3-1


DISC BRAKE PADS IN CARS
SALES FORECAST, 1986-2000
(Millions)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
ASB. DISC PADS
TOTAL DISC PADS

presents the results for cars while Figure A.1.3-2 graphically presents the results for trucks.

Table A.1.3-12 presents forecasts for asbestos drum brake linings and for total drum brake linings for both cars and light trucks. Two general points are worth noting. First, sales of asbestos drum brake linings closely mirror sales of total brake linings. This occurs because more than 92.5 percent of all drum brakes sold in any year are asbestos. Second, the difference between asbestos drum brakes and total drum brakes is growing over time. This is a direct result of the assumptions which underlie these forecasts. In any given year, 92.5 percent of all new drum brakes are asbestos, and between 92.5 percent and 100 percent of all replacement brakes are asbestos. The exact percentage of replacement drum brakes that is asbestos is a function of the stock of drum brakes. It starts out being exactly 100 percent in 1986 and approaches 92.5 percent over time. (It would reach exactly 92.5 percent in trucks in 2017 (1986 + 31) and in cars in 2008 (1986 + 22).)

It is also important to note that the behavior of asbestos drum brake sales in cars and in trucks differs. The basic underlying trends are the same, but some number differ in magnitude, and this causes the net effects to diverge. First of all, the percentage of drum brakes that are asbestos in declining for both types of vehicles. Second, the stock of asbestos drum brakes is declining for cars but increasing for trucks. The share of asbestos drum brakes to total brakes is declining for both vehicles. However, the stock of total truck brakes is growing so fast that the net effect is an increase in replacement asbestos drum brakes sales. The stock of total truck brakes is growing fast because new truck sales greatly outnumber truck scrappage. Because the stock of total car brakes is growing more slowly, the net effect is that replacement asbestos drum brake sales do not change much. The same arguments apply to the new vehicle market. Because truck sales grow faster than car sales, new asbestos drum brakes in trucks increase faster than new asbestos drum brakes in cars. The net result of all these effects is that sales of asbestos drum brakes in trucks increase while sales of asbestos drum brakes in cars fluctuate but remain fairly constant. Figure A.1.3-3 graphically presents the results for trucks while Figure A.1.3-4 graphically presents the results for cars. Two points are worth noting. First, sales of asbestos drum brake linings closely mirror sales of total brake linings. This occurs because more than 92.5 percent of all drum brakes are asbestos in any year. Second, the difference between asbestos drum brakes and total drum brakes is growing over time. This makes sense when we consider the assumptions which underlie these forecasts. In any given year, 92.5 percent of all new drum brakes are asbestos, and between 92.5 percent and 100 percent of all replacement brakes are asbestos. The percentage of replacement drum brakes that is asbestos is a function of the stock of drum brakes. It starts out being almost 100 percent and approaches 92.5 percent over time. (It would reach exactly 92.5 percent in trucks in 2017 (1986 + 31) and in cars in 2008 (1986 + 22). Figure A.1.3-3 graphically presents the results for trucks while Figure A.1.3-4 graphically presents the results for cars.

Table A.1.3-13 presents the forecasts for asbestos brake sales in four categories: light truck asbestos drum brake sales, light truck asbestos disc brake sales, passenger car asbestos drum brake sales, and passenger car asbestos disc brake sales. The following points summarize the major findings already discussed:

Figure A.1.3-2

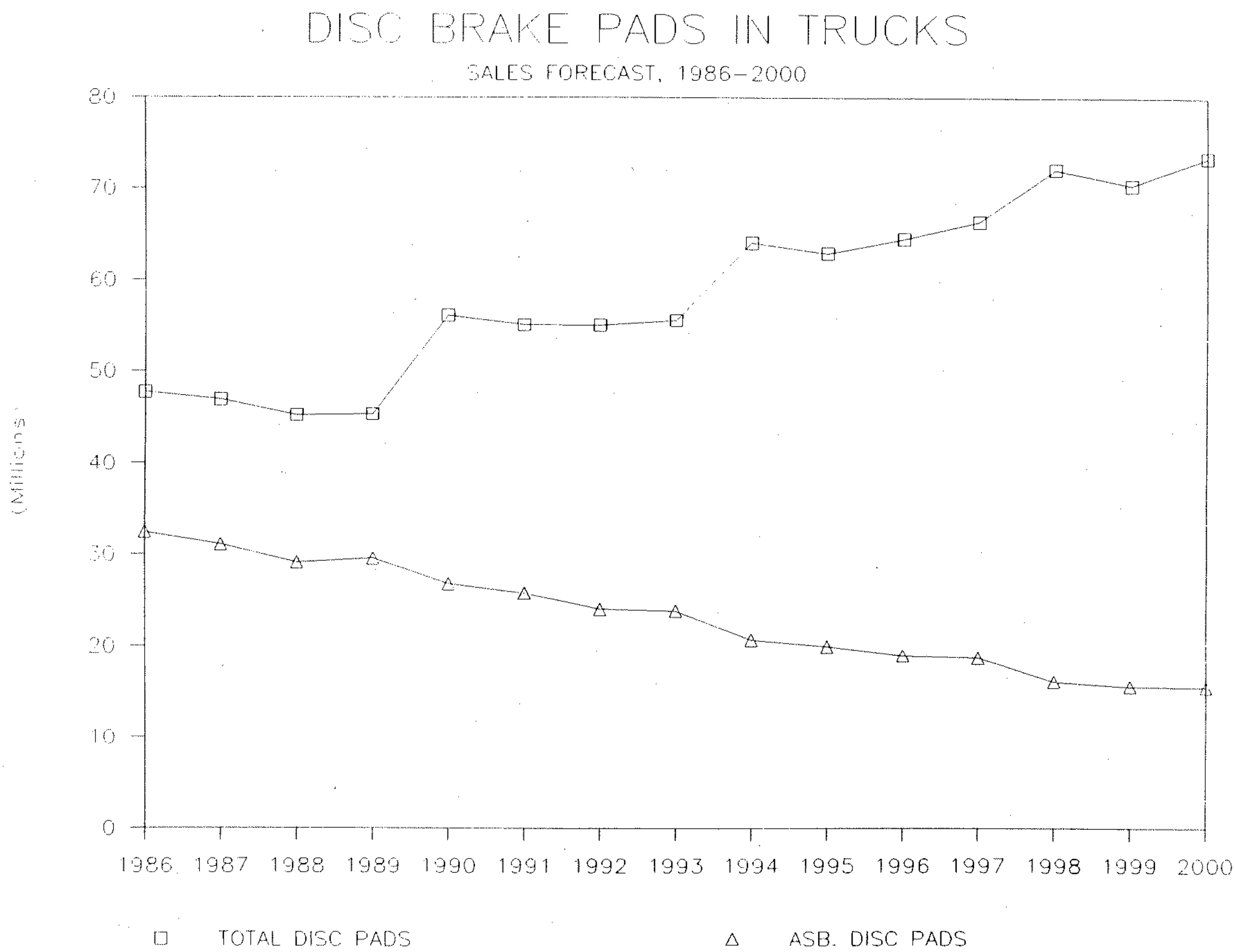

DISC BRAKE PADS IN TRUCKS
SALES FORECAST, 1986-2000
(Millions)
0
10
20
30
40
50
60
70
80
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TOTAL DISC PADS
ASB. DISC PADS

Table A.1.3-12. Sales Forecast of Total Drum Brake Linings and Asbestos Drum Brake Linings, 1986-2000, Four Year Brake Life (in thousands)

	Light Trucks		Passenger Cars	
Year	Total Drum Linings	Asbestos Drum Linings	Total Drum Linings	Asbestos Drum Linings
1986	61,045	59,692	137,762	134,714
1987	58,644	57,246	130,125	126,965
1988	60,624	59,199	136,771	133,612
1989	61,244	59,852	134,742	131,639
1990	62,466	59,869	131,113	125,283
1991	61,071	58,478	128,290	122,435
1992	63,912	61,167	138,005	131,815
1993	66,500	63,695	139,147	132,815
1994	66,755	62,923	133,824	125,405
1995	65,874	62,081	131,710	123,391
1996	69,478	65,465	142,139	133,269
1997	73,425	69,228	147,593	138,298
1998	73,064	68,135	141,316	131,189
1999	71,652	66,830	136,901	127,098
2000	75,881	70,785	146,380	135,938
Total	991,636	944,645	2,055,818	1,953,867

Detail may not add to total due to rounding.

Source: ICF, see text.

Figure A.1.3-3

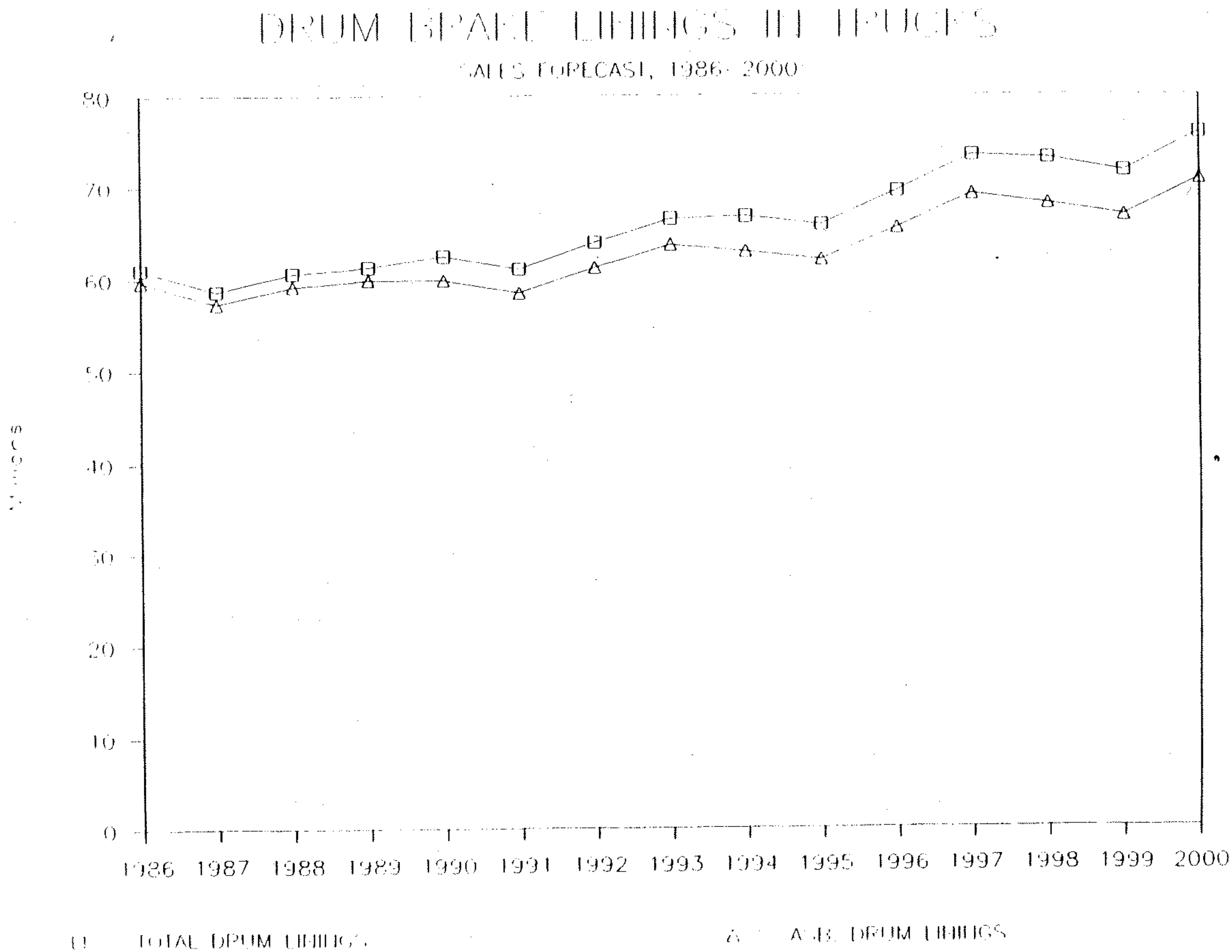
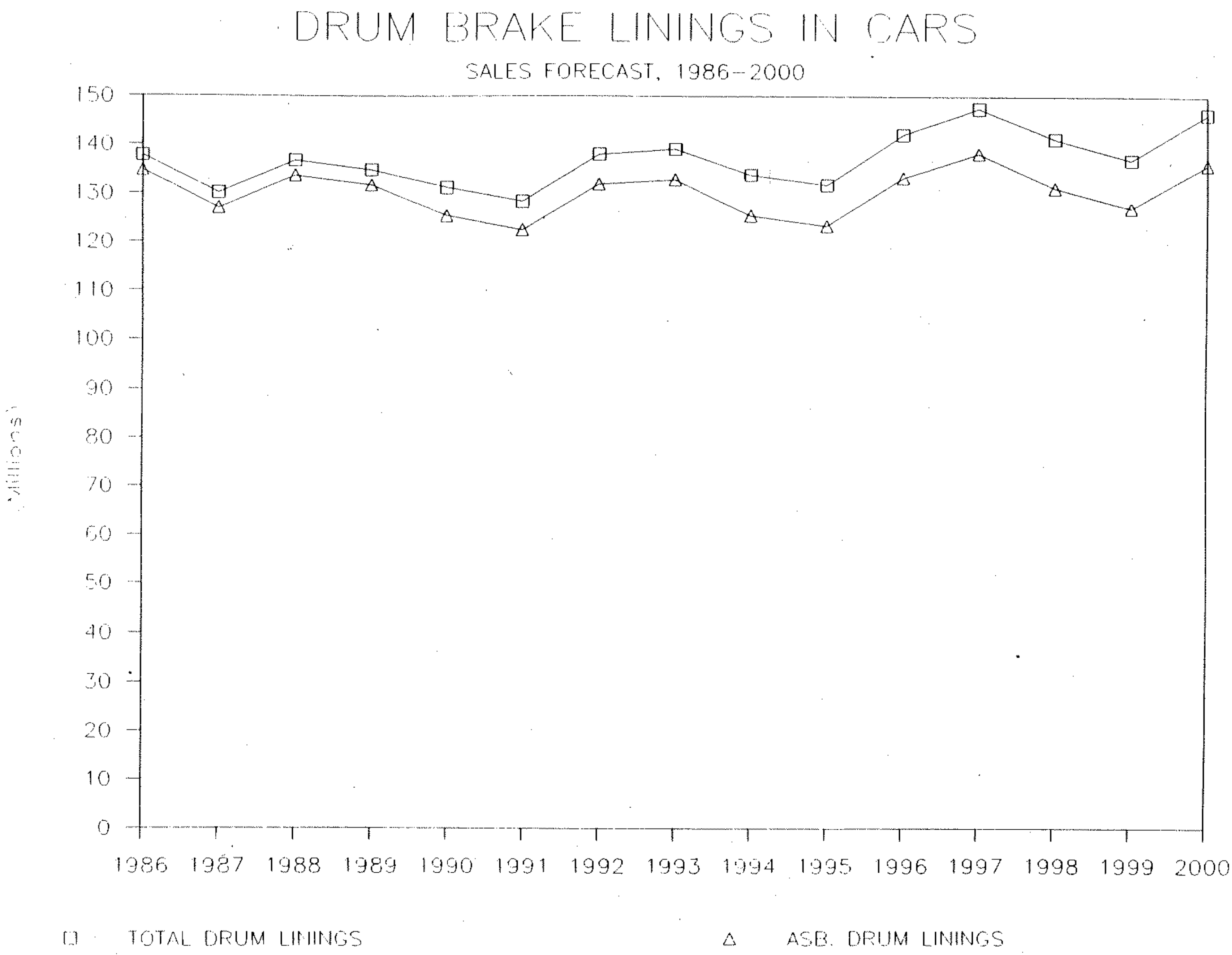

DRUM BRAKE LININGS IN TRUCKS
SALES FORECAST, 1986-2000
80
70
60
50
40
30
20
10
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TOTAL DRUM LININGS
A.B. DRUM LININGS

Figure A.1.3-4



DRUM BRAKE LININGS IN CARS
SALES FORECAST, 1986–2000
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
(Millions)
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TOTAL DRUM LININGS
ASB. DRUM LININGS

Table A.1.3-13. Sales Forecast of Asbestos Drum Brake Linings and Asbestos Disc Brakes Pads, 1986-2000, Four Year Brake Life (in thousands)

Year	Light Trucks		Passenger Cars		Total	
	Drum	Disc	Drum	Disc	Drum	Disc
1986	59,692	32,407	134,714	86,739	194,406	119,146
1987	57,246	31,057	126,965	80,726	184,211	111,783
1988	59,199	29,078	133,612	81,374	192,811	110,452
1989	59,852	29,540	131,639	76,630	191,491	106,170
1990	59,869	26,725	125,283	60,995	185,152	87,719
1991	58,478	25,717	122,435	56,495	180,914	82,211
1992	61,167	23,945	131,815	56,239	192,982	80,184
1993	63,695	23,782	132,815	51,008	196,510	74,790
1994	62,923	20,619	125,405	39,224	188,327	59,843
1995	62,081	19,941	123,391	36,665	185,473	56,606
1996	65,465	18,991	133,269	37,369	198,733	56,360
1997	69,228	18,801	138,298	35,218	207,526	54,019
1998	68,135	16,218	131,189	29,113	199,324	45,331
1999	66,830	15,698	127,098	27,670	193,928	43,368
2000	70,785	15,588	135,938	28,836	206,723	44,425
Total	944,645	348,104	1,953,867	784,302	2,898,512	1,132,406

Detail may not add to total due to rounding.

Source: ICF, see text.

- future asbestos drum brake sales in trucks are cyclical, but rising;

- although total future disc brake sales in trucks increase, asbestos disc brake sales in trucks decline;

- future asbestos drum brake sales in cars are cyclical with no discernible upward or downward trend; and

- although total future disc brake sales in cars increase, asbestos disc brake sales in cars decline over time.

A more detailed understanding of the factors driving the market can be obtained by looking at a breakdown of brake sales into new brakes and replacement brakes. These results are presented in Tables A.1.3-14 through A.1.3-17 and in Figures A.1.3-5 through A.1.3-8.

Table A.1.3-14 presents the results for asbestos drum brake sales in trucks. We can see that new sales cycle with a slight upward trend and replacement sales rise slightly. This occurs because new brake sales closely mirror new truck sales, and the stock of existing trucks grows slightly over time. The breakdown is shown graphically in Figure A.1.3-5.

It is worth noting that replacement sales of asbestos drum brakes drop significantly in 1987. The major reason for this drop is that asbestos drum brakes in model year 1971 and 1975 trucks are noticeably fewer than asbestos drum brakes in model year 1970 and 1974 trucks (see Attachment B-2). Because the model assumes that all 1971 and 1975 brakes will be replaced in 1987 and that all 1970 and 1974 brakes will be replaced in 1986, there is a significant decline in 1987 forecasted replacement sales relative to 1986. The effects of these two model years can be observed in 1991, 1995, and 1999, although it is less pronounced as fewer of these vehicles continue to survive.

Table A.1.3-15 presents the results for asbestos disc brake sales in trucks. We can see that new sales cycle with a slight upward trend while replacement sales decline dramatically. This decline occurs because the existing trucks with asbestos disc brakes are being scrapped and replaced with trucks with non-asbestos disc brakes. Thus, the stock of asbestos disc brakes in trucks is declining across time. Once again new brake sales closely follow new truck sales. The breakdown is shown graphically in Figure A.1.3-6.

It is worth noting that replacement sales of asbestos disc brakes decline noticeably in 1990, 1994, and 1998. The major reason for this decline is that we assume all truck brake are replaced every fourth year. Thus, in 1990, we are replacing brakes on 1966, 1970, 1974, 1978, 1982, and 1986 model year trucks. The two most recent model years (1982 and 1986) are assumed to have a lower percentage of asbestos disc brakes (substitution starts in 1982). In 1989, we replace brakes on 1965, 1969, 1973, 1977, 1982, and 1985. Only the 1985 trucks are assumed to have a lower percentage of asbestos disc brakes. The fact that two model years in the 1990 replacement group have a reduced asbestos percentage while only one model year in the 1989 replacement group has a reduced asbestos percentage accounts for this significant decline. The same event occurs in 1994. The only difference is that three model years in the replacement group (1982, 1986, and 1990) have a lower asbestos percentage and only two model years in the 1993 replacement group (1983 and 1987) have a

Table A.1.3-14. Asbestos Drum Brake Linings for Light Trucks Sales Forecasts, 1986-2000 (in thousands)

Year	Total Sales	New Sales	Replacement Sales
1986	59,692	16,687	43,005
1987	57,246	17,242	40,004
1988	59,199	17,575	41,624
1989	59,852	17,168	42,684
1990	59,869	15,910	43,959
1991	58,478	15,318	43,160
1992	61,167	16,872	44,295
1993	63,695	18,019	45,676
1994	62,923	17,353	45,570
1995	62,081	16,946	45,135
1996	65,465	17,871	47,594
1997	69,228	19,388	49,840
1998	68,135	19,277	48,858
1999	66,830	18,500	48,330
2000	70,785	19,425	51,360
Total	944,645	263,551	681,094

Detail may not add to total due to rounding.

Source: ICF, see text.

Figure A.1.3-5

ASBESTOS DRUM BRAKES: TRUCKS

SALES FORECASTS, 1986-2000

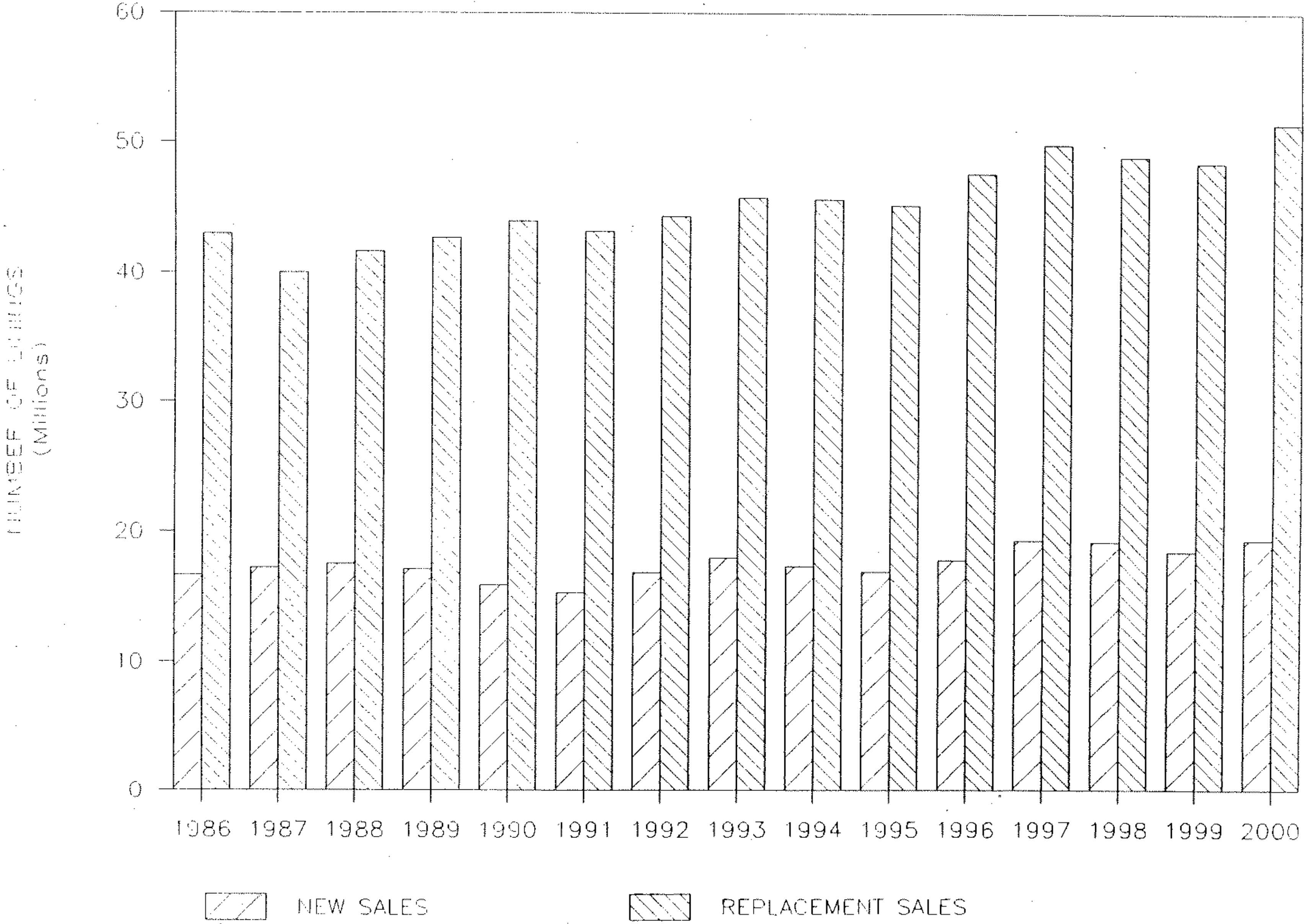


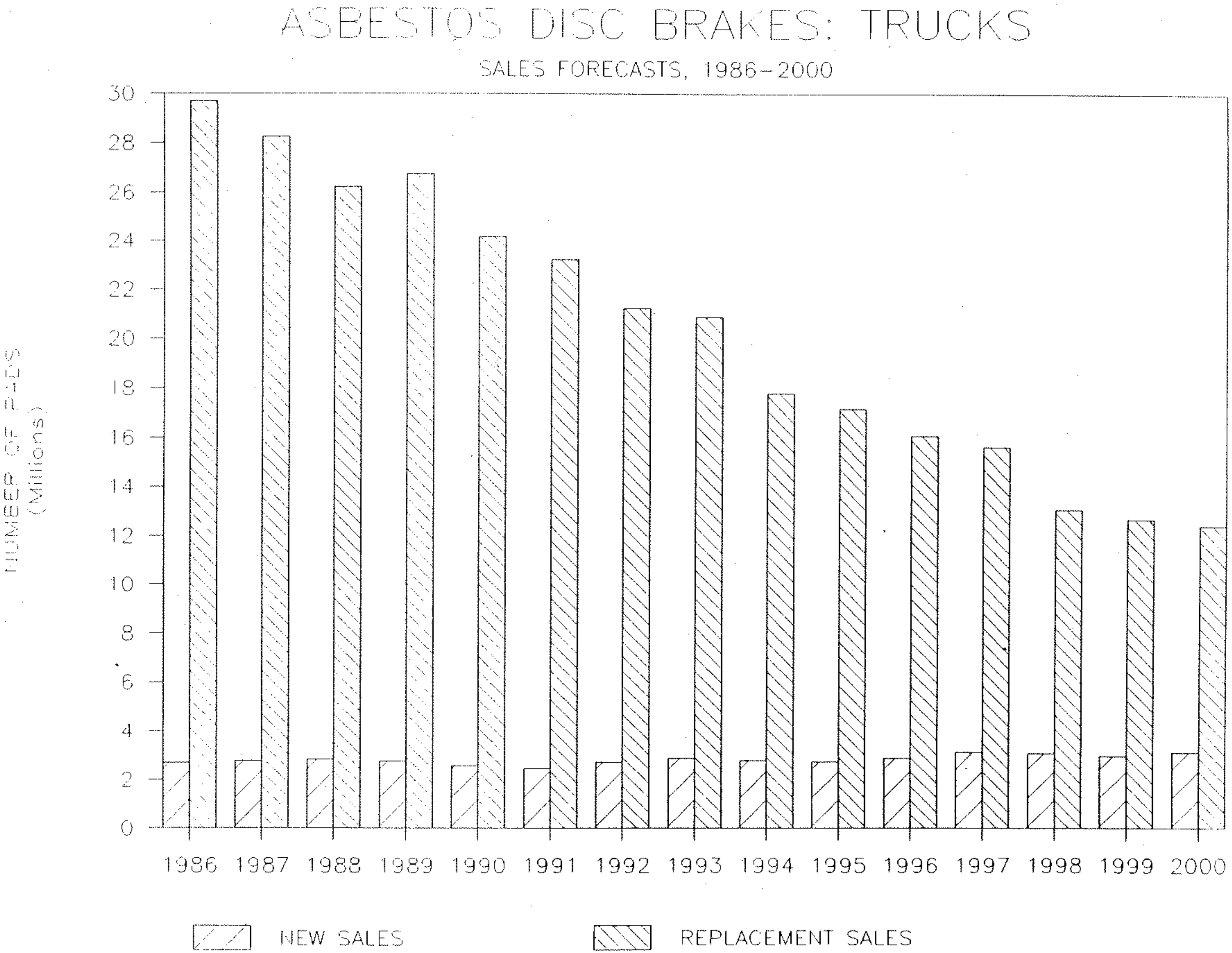
Table A.1.3-15. Asbestos Disc Brake Pads for Light Trucks Sales Forecast, 1986-2000 (in thousands)

Year	Total Sales	New Sales	Replacement Sales
1986	34,407	2,706	29,701
1987	31,057	2,796	28,261
1988	29,078	2,850	26,228
1989	29,540	2,784	26,756
1990	26,725	2,580	24,145
1991	25,717	2,484	23,233
1992	23,945	2,736	21,209
1993	23,782	2,922	20,860
1994	20,619	2,814	17,805
1995	19,941	2,748	17,193
1996	18,991	2,898	16,093
1997	18,801	3,144	15,657
1998	16,218	3,126	13,092
1999	15,698	3,000	12,698
2000	15,588	3,150	12,438
Total	348,104	42,738	305,366

Detail may not add to total due to rounding.

Source: ICF, see text.

Figure A.1.3-6


ASBESTOS DISC BRAKES: TRUCKS
SALES FORECASTS, 1986-2000
NUMBER OF PADS
(Millions)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
NEW SALES
REPLACEMENT SALES

lower asbestos percentage. Finally, this occurs again in 1998 for the same reason. This time we have four model years rather than three model years with a lowered asbestos content in the replacement group.

Table A.1.3-16 presents the results for asbestos drum brake sales in cars. We can see that new sales exhibit year fluctuations with an upward trend, while replacement sales exhibit yearly fluctuations with no upward or downward trend. One might expect the replacement sales to show a slight decline since new cars have fewer drum brakes than older cars, but this is outweighed by the fact that the stock of outstanding cars is rising as we move further into the future. New brake sales again closely follow new car sales. The breakdown is shown graphically in Figure A.1.3-7.

A close examination of Table A.1.3-16 reveals an interesting pattern. Asbestos drum brake replacement sales decline in 1987, 1991, 1995, and 1999, but they increase in 1988, 1992, 1996, and 2000. The primary reason for this drop is the asbestos drum brakes on 1971 and 1975 model year cars are significantly fewer than asbestos drum brakes on 1970 and 1974 model year cars. The primary reason for this increase is that there are more asbestos drum brakes on 1976 and 1984 model year cars than on 1975 and 1983 model year cars. Once again, we see that a noticeable pattern repeats itself every four years.

Table A.1.3-17 presents the results for asbestos disc brake sales in cars. We can see that new sales rise while replacement sales decline dramatically. This parallels the case of disc brake sales in trucks. Cars with asbestos disc brakes are being scrapped and replaced with cars with non-asbestos disc brakes. Thus, the stock of asbestos disc brakes is declining across time. Once again new brake sales closely follow new car sales. The breakdown is shown graphically in Figure A.1.3-8. It is worth noting that replacement asbestos disc sales on cars decline significantly in 1990, 1994, and 1998. These are the same years in which a noticeable decline in replacement asbestos disc sales on trucks decline significantly, and the reason is the same. Specifically, the number of model years in the replacement group which have a lower asbestos percentage increases relative to the previous year. The only difference between cars and trucks is that the decline in cars is steeper. This occurs because the stock of total disc brakes for cars is not growing as fast as the stock of total disc brakes for trucks. Detailed printouts of all the results, by model year, are presented in Attachments A-D.

3.5 Sensitivity Analysis

There are six key assumptions and data inputs that have been used for making the forecasts. The assumptions pertain to:

- type of brake systems (disc versus drum brake system) -- we have assumed a 55 percent/45 percent split for cars and a 50 percent/50 percent split for trucks in 1986 and the future years;

- composition of brakes -- we have assumed 15 percent of new disc brakes and 92.5 percent of new drum brakes to contain asbestos throughout the forecast period; and

- average life of brakes-- we have assumed a four year life.

Table A.1.3-16. Asbestos Drum Brake Linings for Passenger Cars Sales Forecast, 1986-2000 (in thousands)

Year	Total Sales	New Sales	Replacement Sales
1986	134,714	37,588	97,127
1987	126,965	38,967	87,998
1988	133,612	38,967	94,645
1989	131,639	38,277	93,361
1990	125,283	35,174	90,109
1991	122,435	34,139	88,296
1992	131,815	38,277	93,538
1993	132,815	40,691	92,124
1994	125,405	37,932	87,472
1995	123,391	36,553	86,838
1996	133,269	39,312	93,957
1997	138,298	42,760	95,538
1998	131,189	41,381	89,808
1999	127,098	38,967	88,131
2000	135,938	40,691	95,247
Total	1,953,867	579,676	1,374,191

Detail may not add to total due to rounding.

Source: ICF, see text.

Figure A.1.3-7

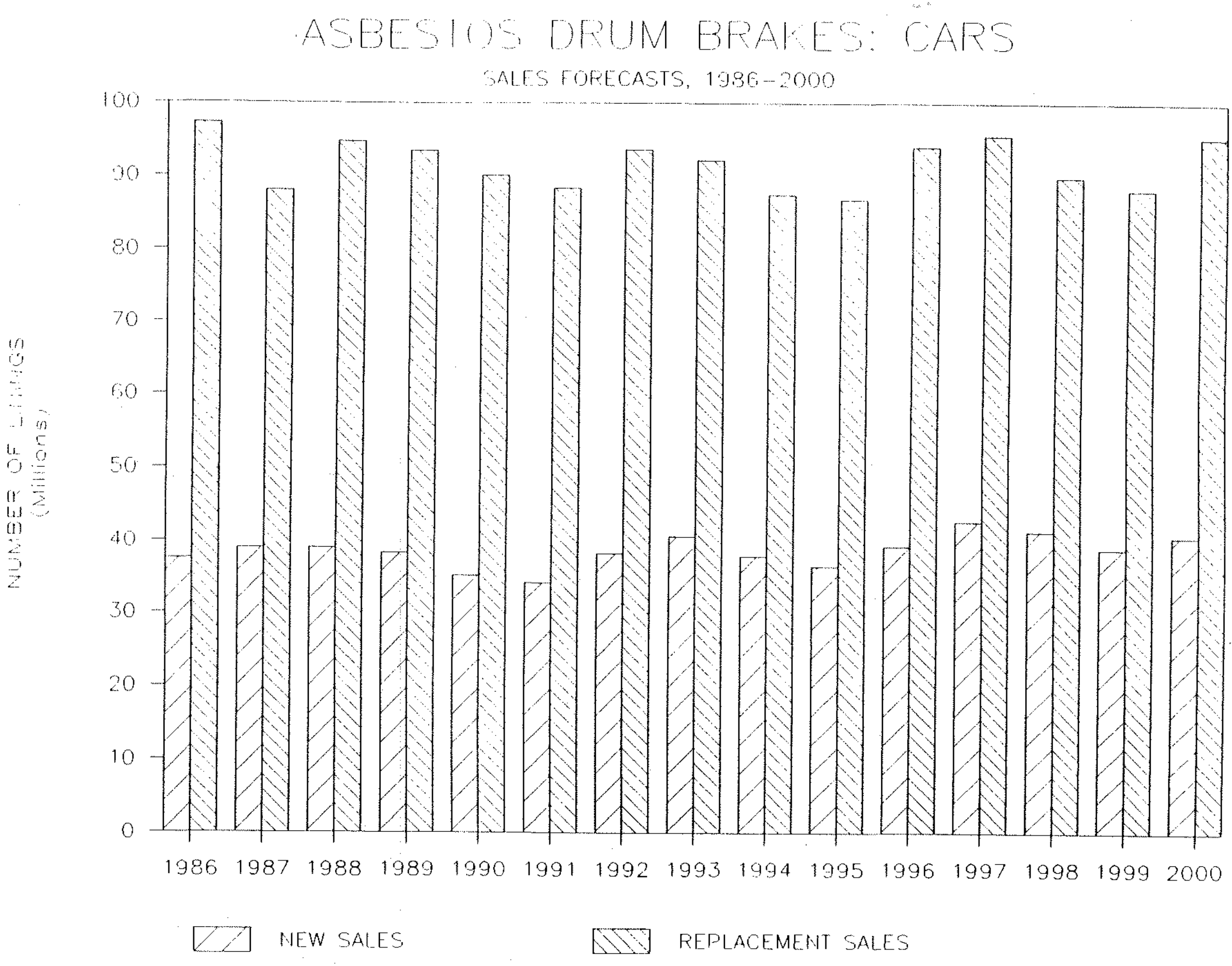

ASBESTOS DRUM BRAKES: CARS
SALES FORECASTS, 1986-2000
NUMBER OF LININGS
(Millions)
100
90
80
70
60
50
40
30
20
10
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
NEW SALES
REPLACEMENT SALES

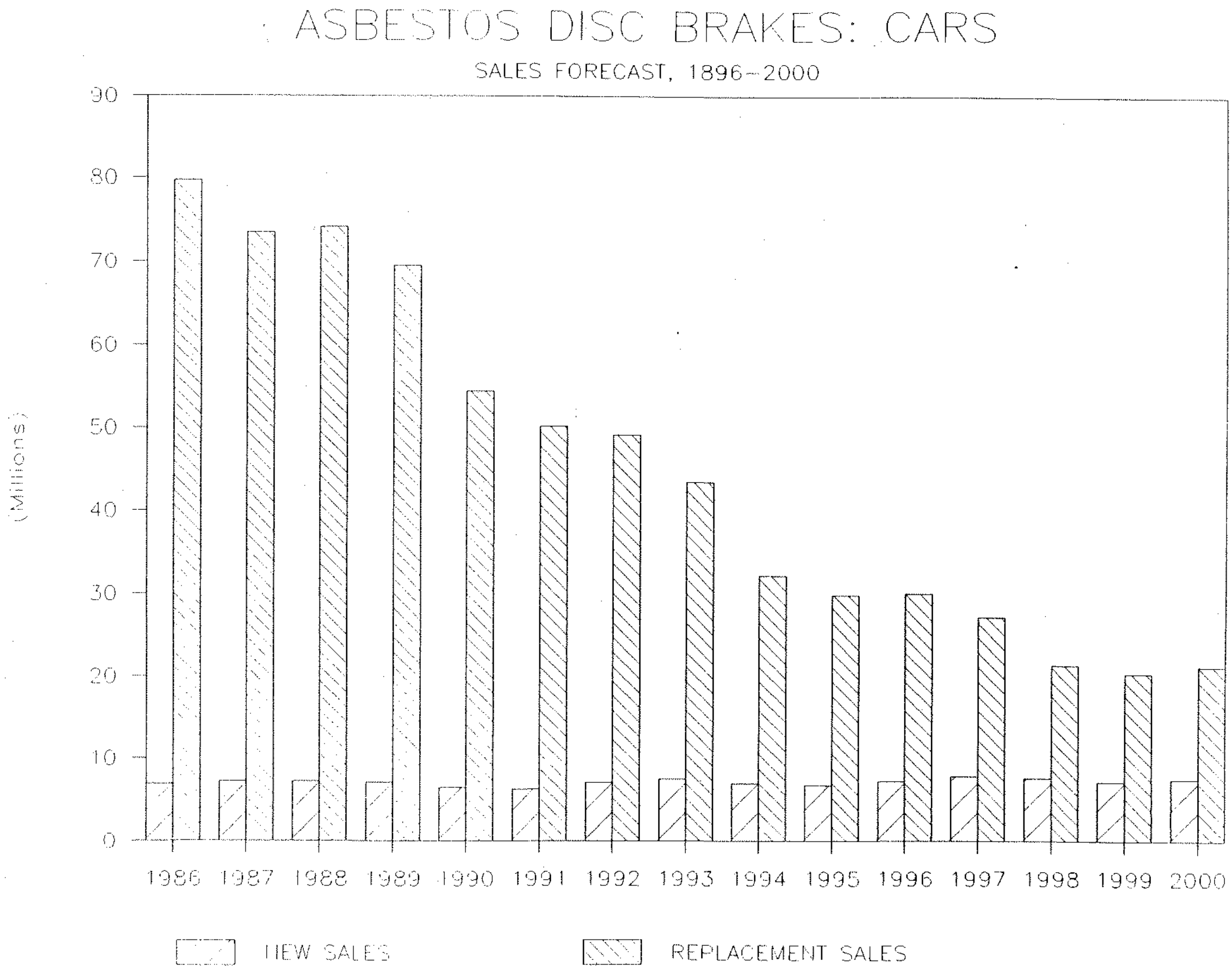
Table A.1.3-17. Asbestos Disc Brake Pads for Passenger Cars Sales Forecast, 1986-2000 (in thousands)

Year	Total Sales	New Sales	Replacement Sales
1986	86,739	6,985	79,755
1987	80,726	7,241	73,485
1988	81,374	7,241	74,133
1989	76,630	7,113	69,517
1990	60,995	6,536	54,459
1991	56,495	6,344	50,151
1992	56,239	7,113	49,126
1993	51,008	7,561	43,446
1994	39,224	7,049	32,175
1995	36,665	6,792	29,872
1996	37,369	7,305	30,064
1997	35,218	7,946	27,272
1998	29,113	7,690	21,424
1999	27,670	7,241	20,429
2000	28,836	7,561	21,275
Total	784,302	107,718	676,584

Detail may not add to total due to rounding.

Source: ICF, see text.

Figure A.1.3-8



ASBESTOS DISC BRAKES: CARS
SALES FORECAST, 1896-2000
(Millions)
90
80
70
60
50
40
30
20
10
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
NEW SALES
REPLACEMENT SALES

In this section, we present the impact of changing these key assumptions on the results of our forecasts.

Table A.1.3-18 presents the results for brake sales if we assume a five year brake life, while Table A.1.3-19 presents the results for brake sales if we assume a three year brake life. Obviously, a shorter brake life leads to more sales in all categories. For example, a one year decrease in brake life from 4 years to 3 years increases the asbestos disc brake pad sales in light trucks in 1986 from approximately 31,163,000 to 37,987,000. In addition, a longer brake life leads to fewer sales in all categories. for instance, a one year increase in brake life from 4 years to 5 years decreases the asbestos disc brake pads in light trucks in 1986 from 31,163,000 to 22,434,000. The more subtle changes occur in the trends in each category. As the brake life changes, different groups of model years take on either more or less importance. This is particularly important for model years in which a large swing in vehicle production or a large decline in the percentage of brakes composed of asbestos took place.

These points are illustrated in a number of instances. For example, if we look at the forecasted sales of drum brakes in light trucks assuming a five year brake life, we see a large decline in 1990 and 1995. The major reason for this is the steep decline in truck sales between 1979 and 1980. In 1985, there were approximately 3.7 million outstanding 1979 trucks and only 2.1 million outstanding 1980 trucks. Because the brakes on all the 1979 trucks are assumed to be replaced in 1989 and 1994 and the brakes on all the 1980 trucks are assumed to be replaced in 1990 and 1995 when the brake life is five years, there is a large fall in forecasted sales for these particular years.

The car market is characterized by more declines than the truck market. In particular, we see declines in 1988, 1990, 1991, 1995, 1999, and 2000 in drum brake sales. The decline is not always attributable to the same model years. For instance, the 1988 decline occurs mainly because there are fewer 1968 and 1973 model year cars than 1967 and 1972 model year cars. By 1993, these cars represent a small fraction of the outstanding vehicles, and the decline does not recur. The 1991 decline is similar in that is does not recur in 1996. The 1990 decline, however, does recur in 1995 and 2000 because in this case there are declines in 1990, 1980, and 1975 model year cars and their effects are able to endure.

This disc brake market will follow these declining patterns in general, and it will be augmented by the overriding decline expected as a result of the shift to non-asbestos disc brakes. For example, we see a large decline in forecasted disc brake sales between 1989 and 1990 in trucks. Part of this decline is attributable to the drop in truck sales between 1979 and 1980, and part is attributable to the drop in asbestos disc brakes on 1985 trucks relative to 1984 trucks. Because the drum brake forecasts are driven primarily by the stock of outstanding vehicles, any year in which drum brake sales are forecasted to fall will correspond to a fall in disc brake sales. In some cases, this fall will be large because of the compounded effects shift to non-asbestos brakes.

The patterns discussed for a five year brake life can be seen when the brake life is assumed to be three years, but they are not always as distinct because more model years are replaced every year. For example, the fall in truck sales between 1979 and 1980 manifests itself in declining drum brake

Table A.1.3-18. Forecast of Drum and Disc Brakes Sales, 1986-2000, Five Year Brake Life (in thousands)

Year	Light Trucks		Passenger Cars		Total	
	Drum	Disc	Drum	Disc	Drum	Disc
1986	45,019	22,686	108,471	70,226	153,491	92,912
1987	48,109	24,948	109,360	68,300	157,469	93,248
1988	50,953	25,635	109,244	66,368	160,197	92,003
1989	53,852	27,433	113,715	64,067	167,567	91,500
1990	46,413	20,036	104,556	52,671	150,969	72,707
1991	46,831	18,022	102,460	45,226	149,292	63,248
1992	50,290	19,082	106,530	42,093	156,819	61,176
1993	53,044	19,434	108,802	40,122	161,846	59,556
1994	55,191	20,390	110,298	38,715	165,489	59,105
1995	51,129	15,618	104,311	32,021	155,440	47,638
1996	52,255	13,570	105,893	26,749	158,149	40,319
1997	56,247	14,178	113,766	26,894	170,013	41,072
1998	58,031	14,302	114,702	26,262	172,734	40,564
1999	58,199	14,562	110,726	25,106	168,924	39,668
2000	57,224	12,502	108,768	23,199	165,991	35,701
Total	782,789	282,397	1,631,602	648,019	2,414,391	930,416

Detail may not add to total due to rounding.

Source: ICF, see text.

Table A.1.3-19. Forecast of Drum and Disc Brakes Sales,
1986-2000, Three Year Brake Life
(in thousands)

Year	Light Trucks		Passenger Cars		Total	
	Drum	Disc	Drum	Disc	Drum	Disc
1986	73,611	38,906	169,982	116,312	243,593	155,218
1987	74,230	41,320	172,000	114,773	246,230	156,093
1988	78,929	42,438	170,161	105,540	249,090	147,978
1989	74,856	34,565	164,195	91,451	239,051	126,016
1990	75,585	36,117	165,988	89,287	241,573	125,404
1991	78,961	36,060	162,928	78,429	241,889	114,489
1992	77,440	29,279	163,409	66,662	240,849	95,941
1993	80,066	30,508	168,342	65,447	248,407	95,955
1994	81,991	29,713	163,275	56,507	245,266	86,220
1995	81,071	24,235	164,265	47,937	245,335	72,172
1996	84,541	25,228	170,410	47,843	254,951	73,071
1997	87,102	24,519	169,622	43,275	256,724	67,795
1998	86,867	20,627	169,835	38,599	256,702	59,226
1999	89,000	21,187	172,050	38,498	261,050	59,685
2000	91,778	20,764	173,499	36,730	265,277	57,494
Total	1,216,027	454,467	2,519,960	1,037,290	3,735,987	1,492,757

Detail may not add to total due to rounding.

Source: ICF, see text.

forecasts for 1988 and 1991. However, by 1994 many other model years have become important and an increase in sales is forecasted. Thus, the three year brake life scenario reduces the importance of any one model year.

Once again drum brake sales closely mirror the stock of vehicles. Because both disc brake forecasts have a downward trend, they always fall whenever forecasted drum brake sales fall, and they increase only in years in which forecasted drum brake sales also increase.

In addition to altering the brake life, there are two other assumptions that can be altered: brake type and brake composition. Changing either one of these has very similar effects because they both effectively alter future new and replacement asbestos brake sales. Table A.1.3-20 compares the results of assuming that all new disc brake pads are asbestos-free by 1991 (the year ASME has concluded industry could replace asbestos in the OEM) or by 1989 with the current assumption that fifteen percent of all disc brakes continue to be made with asbestos. If asbestos disc brake pads are replaced with semi-metallic pads on all new cars by 1991, the car forecast is reduced by over 75 percent by the year 2000, if asbestos disc brake pads are replaced with semi-metallic pads on all new cars by 1989, the car forecast is reduced by almost 80 percent by the year 2000. The same holds true for trucks, but the effect is not quite as strong because the stock of total truck disc brakes is growing faster than the stock of total car disc brakes.

It is worth pointing out that noticeable declines occur in 1990, 1994, and 1998. This decline occurs for the same reason noted earlier. The replacement group in these years includes one more set of model year cars with a lower asbestos percentage than the replacement group in the preceding year. Once again the decline is greater in cars than in trucks because the total stock of disc brakes on cars is growing slower than the stock of disc brakes on trucks.

Finally, it is worth pointing out that forecasts of disc brakes in light trucks are very similar to forecasts of disc brakes in cars by 2000 under the moderate and high decline scenarios. This may appear surprising because annual car sales greatly exceed annual truck sales. This result is occurring because trucks have a much longer life than cars. These two scenarios assume that asbestos disc brakes on new cars will be phased out. As a result, the sales of asbestos brakes will come from older vehicles, and the stock of truck with asbestos disc brakes will eventually equal the stock of cars with asbestos brakes because of their longer life.

Table A.1.3-21 compares the results of assuming that all new drum brake linings are asbestos-free by (the year ASME has concluded industry could replace asbestos in the OEM) or by 1995 with the current assumption that 92.5 percent of all drum brakes continue to be made with asbestos. If asbestos drum brake linings are replaced on all new cars, the car forecast is reduced by approximately 85 percent by the year 2000, and as we continue to move out further in time, this assumption becomes more significant because it affects a greater number of vehicles. Once again, the same holds true for trucks, but the effect is not quite as strong.

The decline in drum brake forecasts is not as significant as the disc brake forecasts simply because fewer non-asbestos drum brake are produced. Once again, it is worth nothing that noticeable declines occur in 1990, 1994, and 1998 for the same reason mentioned earlier. The replacement group in

Table A.1.3-20. Asbestos Disc Brake Pad Sales Forecast Under Different Assumptions (in thousands)

Year	Low Decline Cars	Low Decline Light Trucks	Moderate Decline Cars	Moderate Decline Light Trucks	High Decline Cars	High Decline Light Trucks
1986	86,739	32,407	86,739	32,407	86,739	32,407
1987	80,726	31,057	79,278	30,497	78,312	30,125
1988	81,374	29,078	78,478	27,938	76,547	27,178
1989	76,630	29,540	72,362	27,870	69,517	26,756
1990	60,995	26,725	55,766	24,661	54,459	24,145
1991	56,495	25,717	48,736	22,693	47,793	22,333
1992	56,239	23,945	46,297	20,107	44,410	19,373
1993	51,008	23,782	39,277	19,246	36,497	18,171
1994	39,224	20,619	27,067	15,811	25,789	15,312
1995	36,665	19,941	22,459	14,306	21,649	13,981
1996	37,369	18,991	20,685	12,456	19,065	11,793
1997	35,128	18,801	16,304	11,378	13,917	10,407
1998	29,113	16,218	10,150	8,574	9,053	8,124
1999	27,670	15,698	7,817	7,512	7,382	7,269
2000	28,836	15,588	6,864	6,510	5,993	6,014
Total	784,302	348,104	618,278	281,964	597,123	273,386

Assumptions

Low Decline : 15 percent of new vehicles are made with asbestos disc brake systems in 1986-2000.

Moderate Decline : 15 percent of 1986 vehicles are made with asbestos disc brake systems, 0 percent of vehicles made after 1990 are made with asbestos disc brake systems. (A linear decline is assumed in the intermediate years.)

High Decline : 15 percent of 1986 vehicles are made with asbestos disc brake systems, 0 percent of vehicles made after 1988 are made with asbestos disc brake systems. (A linear decline is assumed in the intermediate years.)

Detail may not add to total due to rounding.

Source: ICF, see text.

Table A.1.3-21. Asbestos Drum Brake Lining Sales Forecast Under Different Assumptions (in thousands)

Year	Low Decline Cars	Low Decline Light Trucks	Moderate Decline Cars	Moderate Decline Light Trucks	High Decline Cars	High Decline Light Trucks
1986	134,714	59,692	134,714	59,692	134,714	59,692
1987	126,965	57,246	122,635	55,331	119,172	53,798
1988	133,612	59,199	124,952	55,293	118,025	52,169
1989	131,639	59,852	118,879	54,129	108,672	49,551
1990	125,283	59,869	109,650	52,798	97,144	47,141
1991	122,435	58,478	99,239	48,118	80,682	39,829
1992	131,815	61,167	97,837	46,146	78,309	37,504
1993	132,815	63,695	88,701	44,152	69,686	35,725
1994	125,405	62,923	76,414	40,667	59,981	33,274
1995	123,391	62,081	64,676	35,244	46,946	27,331
1996	133,269	65,465	61,761	33,322	43,483	25,165
1997	138,298	69,228	53,912	31,312	36,514	23,452
1998	131,189	68,135	43,750	27,792	29,140	20,996
1999	127,098	66,830	34,554	23,290	20,261	16,355
2000	135,938	70,785	31,524	21,741	17,695	14,800
Total	1,953,867	944,645	1,263,200	629,028	1,060,424	536,783

Assumptions

Low Decline : 92.5 percent of new vehicles are made with asbestos drum brake systems in 1986-2000.

Moderate Decline : 92.5 percent of 1986 vehicles are made with asbestos drum brake systems, 0 percent of vehicles made after 1994 are made with asbestos drum brake systems. (A linear decline is assumed in the intermediate years.)

High Decline : 92.5 percent of 1986 vehicles are made with asbestos drum brake systems, 0 percent of vehicles made after 1990 are made with asbestos drum brake systems. (A linear decline is assumed in the intermediate years.)

Detail may not add to total due to rounding.

Source: ICF, see text.

these years includes one more set of model year cars with a lower asbestos percentage than the replacement group in the preceding year. The decline is again greater in cars because the stock of drum brakes on cars is growing slower than the stock of drum brakes on trucks.

Once again, we notice the effect of the longer service life of trucks as truck sales approach car sales by 2000 in the high decline scenario. The effect is less noticeable because drum brake are assumed to be on more vehicles than disc brakes, and they are assumed to be phased out later. Appendices F-M provide detailed printout of the results for the medium and high decline scenarios, by model year.

Finally, we looked at the effect of altering our assumption about the type of brake system. Table A.1.3-22 presents the results when we assume that all light vehicles (cars and trucks) have 60 percent disc brake systems (instead of 55 percent of cars and 50 percent of trucks) and 40 percent drum brake systems (instead of 45 percent of cars and 50 percent of trucks). (This would be likely to occur as more vehicles switched to all disc brake systems.) As would be expected, the total sale of asbestos disc brakes rises while the total sale of asbestos drum brakes falls relative to our base case. In addition, the total number of asbestos brakes falls because a smaller percentage of disc brakes contains asbestos. It is also worth noting that the shift to disc brakes will not cause an increase in sales of asbestos disc brakes because it is outweighed by the substitution away from asbestos and toward semi-metallic in disc brake applications. The total sale of asbestos disc brake pads in cars and trucks increases from 1,162,415,000 to 1,203,125,000 while the sale of asbestos drum brake linings decreases from 3,000,781,000 to 2,729,618,000.

Table A.1.3-23 presents the forecasts of asbestos disc brakes and asbestos drum brakes in both cars and light trucks for the three ARCM scenarios, while Table A.1.3-24 presents the growth rates implied by these forecasts. These forecasts and growth rates are valid when new (OEM) and replacement (Aftermarket) sales are considered together. In order to simulate the two sub-markets (new and replacement sales) independently, the forecasts are also made separately. Tables A.1.3-25-A.1.3-28 show the forecast of sales of new and replacement brakes assuming a low, moderate, and high decline scenario respectively. Table A.1.3-28 presents the growth rates implied by these forecasts for new and replacement brakes separately. The ARCM will take the 1985 production volumes determined from the ICF survey for these asbestos products and then multiply them by the growth rates to compute the baseline production quantities.

3.6 Conclusions

This analysis leads to the following conclusions:

- Annual sales of asbestos drum brake linings for both trucks and cars are forecasted to increase slightly. The total annual sale of asbestos drum brake linings will increase from approximately 193,000,000 in 1986 to 202,000,000 in 2000.

Table A.1.3-22. Sales Forecast of Asbestos Drum Brake Linings and Asbestos Disc Brake Pads, Under Different Assumptions[a] (in thousands)

Year	Light Trucks		Passenger Cars		Total	
	Drum	Disc	Drum	Disc	Drum	Disc
1986	59,692	31,163	133,424	83,473	193,115	114,635
1987	53,798	30,971	121,446	78,461	175,244	109,433
1988	55,684	29,482	128,093	80,357	183,777	109,839
1989	56,418	30,494	126,217	75,074	182,636	105,568
1990	56,687	26,532	119,041	59,543	175,728	86,515
1991	52,083	26,372	112,208	56,144	164,292	82,515
1992	54,397	24,941	121,002	56,802	175,399	81,743
1993	56,774	25,060	121,756	51,682	178,530	76,742
1994	56,378	21,363	114,083	39,913	170,461	61,276
1995	52,726	21,285	108,860	38,152	161,586	59,437
1996	55,566	20,553	117,774	39,422	173,340	59,975
1997	58,875	20,531	122,063	37,508	180,938	58,039
1998	58,152	17,721	115,318	31,319	173,470	49,040
1999	54,936	17,559	109,976	30,180	164,912	47,739
2000	58,213	17,605	117,698	31,646	175,910	49,251
Total	840,380	361,629	1,788,957	789,677	2,629,337	1,151,307

[a] Sixty percent of brakes produced after 1986 are disc and 40 percent are drum, as opposed to the baseline assumption of 55 percent disc and 45 percent drum.

Detail may not add to total due to rounding.

Source: ICF, see text.

Table A.1.3-23. Sales Forecasts of Asbestos Drum Brake Linings and Asbestos Disc Brake Pads in Cars and Light Trucks (in thousands)

	Disc Brake Pads (LMV)			Drum Brake Linings (LMV)		
	Low Decline	Medium Decline	High Decline	Low Decline	Medium Decline	High Decline
1985	137,836	137,836	137,836	198,735	198,735	198,735
1986	119,146	119,146	119,146	194,406	194,406	194,406
1987	111,783	109,775	108,437	184,211	177,966	172,970
1988	110,452	106,416	103,725	192,811	180,245	170,194
1989	106,170	100,233	96,273	191,491	173,008	158,223
1990	87,720	80,427	78,604	185,152	162,448	144,285
1991	82,212	71,429	70,126	180,913	147,357	120,511
1992	80,184	66,404	53,783	192,982	143,983	115,813
1993	74,790	58,523	54,668	196,510	132,853	105,411
1994	59,843	42,878	41,101	188,328	117,081	93,255
1995	56,606	36,765	35,630	185,472	99,920	74,277
1996	56,360	33,141	30,858	198,734	95,083	68,648
1997	53,929	27,682	24,324	207,526	85,224	59,966
1998	45,331	18,724	17,177	199,324	71,532	50,136
1999	43,368	15,329	14,651	193,928	57,844	36,616
2000	44,424	13,374	12,007	206,723	53,265	32,495

Table A.1.3-24. Growth Rates for Asbestos Disc Brake Pads and Asbestos Drum Brake Linings in Cars and Light Trucks (percent)

	Disc Brake Pads (LMV)			Drum Brake Linings (LMV)		
	Low Decline	Medium Decline	High Decline	Low Decline	Medium Decline	High Decline
1986	-0.14	-0.14	-0.14	-0.02	-0.02	-0.02
1987	-0.06	-0.08	-0.09	-0.05	-0.08	-0.11
1988	-0.01	-0.03	-0.04	0.05	0.01	-0.02
1989	-0.04	-0.06	-0.07	-0.01	-0.04	-0.07
1990	-0.17	-0.20	-0.18	-0.03	-0.06	-0.09
1991	-0.06	-0.11	-0.11	-0.02	-0.09	-0.16
1992	-0.02	-0.07	-0.09	0.07	-0.02	-0.04
1993	-0.07	-0.12	-0.14	0.02	-0.08	-0.09
1994	-0.20	-0.27	-0.25	-0.04	-0.12	-0.12
1995	-0.05	-0.14	-0.13	-0.02	-0.15	-0.20
1996	0.00	-0.10	-0.13	0.07	-0.05	-0.08
1997	-0.04	-0.16	-0.21	0.04	-0.10	-0.13
1998	-0.16	-0.32	-0.29	-0.04	-0.16	-0.16
1999	-0.04	-0.18	-0.15	-0.03	-0.19	-0.27
2000	0.02	-0.13	-0.18	0.07	-0.08	-0.11

Table A.1.3-25. Sales Forecast of Drum and Disc Brakes under Low Decline Assumption[a]
(in thousands)

	Asbestos Drum Brake Linings						Asbestos Disc Brake Pads (LMV)					
	New Sales (OEM)			Replacement Sales (A/M)			New Sales (OEM)			Replacement Sales (A/M)		
Year	Car	Light Trucks	Total	Car	Light Trucks	Total	Car	Light Trucks	Total	Car	Light Trucks	Total
1986	37,588	16,687	54,275	97,127	43,005	140,132	6,985	2,706	9,691	79,755	29,701	109,456
1987	38,967	17,242	56,209	87,998	40,004	128,002	7,241	2,796	10,037	73,485	28,261	101,746
1988	38,967	17,575	56,542	94,645	41,624	136,269	7,241	2,850	10,091	74,133	26,228	100,361
1989	38,277	17,168	55,445	93,361	42,684	136,045	7,113	2,784	9,897	69,517	26,756	96,273
1990	35,174	15,910	51,084	90,109	43,959	134,068	6,536	2,580	9,116	54,459	24,145	78,604
1991	34,139	15,318	49,457	88,296	43,160	131,456	6,344	2,484	8,828	50,151	23,233	73,384
1992	38,277	16,872	55,149	93,538	44,295	137,833	7,113	2,736	9,849	49,126	21,209	70,335
1993	40,691	18,019	58,710	92,124	45,676	137,800	7,561	2,922	10,483	43,446	20,860	64,306
1994	37,932	17,353	55,285	87,472	45,570	133,042	7,049	2,814	9,863	32,175	17,805	49,980
1995	36,553	16,946	53,499	86,838	45,135	131,973	6,792	2,748	9,540	29,872	17,193	47,065
1996	39,312	17,871	57,183	93,957	47,594	141,551	7,305	2,898	10,203	30,064	16,093	46,157
1997	42,760	19,388	62,148	95,538	49,840	145,378	7,946	3,144	11,090	27,272	15,657	42,929
1998	41,381	19,277	60,658	89,808	48,858	138,666	7,690	3,126	10,816	21,424	13,092	34,516
1999	38,967	18,500	57,467	88,131	48,330	136,461	7,241	3,000	10,241	20,429	12,698	33,127
2000	40,691	19,425	60,116	95,247	51,360	146,607	7,561	3,150	10,711	21,275	12,438	33,713

[a] 15 percent of new vehicles are made with asbestos disc brake systems in 1986-2000 and 92.5 percent of new vehicles are made with asbestos drum brake systems in 1986-2000.

Source: ICF, see text.

Table A.1.3-26. Sales Forecast of Drum and Disc Brakes under Moderate Decline Assumption[a]
(in thousands)

	Asbestos Drum Brake Linings						Asbestos Disc Brake Pads (LMV)					
	New Sales (OEM)			Replacement Sales (A/M)			New Sales (OEM)			Replacement Sales (A/M)		
Year	Car	Light Trucks	Total	Car	Light Trucks	Total	Car	Light Trucks	Total	Car	Light Trucks	Total
1986	37,588	16,687	54,275	97,127	43,005	140,131	6,985	2,706	9,691	79,755	29,701	109,455
1987	34,637	15,326	49,964	87,998	40,004	128,003	5,793	2,237	8,030	73,485	28,261	101,745
1988	30,308	13,669	43,977	94,645	41,624	136,269	4,345	1,710	6,055	74,133	26,228	100,361
1989	25,518	11,445	36,963	93,361	42,684	136,045	2,845	1,114	3,959	69,517	26,756	96,273
1990	19,541	8,839	28,380	90,109	43,959	134,069	1,307	516	1,823	54,459	24,145	78,603
1991	15,173	6,808	21,981	84,066	41,309	125,376	0	0	0	48,736	22,693	71,428
1992	12,759	5,624	18,383	85,077	40,522	125,599	0	0	0	46,297	20,107	66,404
1993	9,042	4,004	13,047	79,658	40,148	119,806	0	0	0	39,277	19,246	58,523
1994	4,215	1,928	6,143	72,199	38,739	110,938	0	0	0	27,067	15,811	42,877
1995	0	0	0	64,675	35,244	99,919	0	0	0	22,459	14,306	36,765
1996	0	0	0	61,760	33,322	95,082	0	0	0	20,685	12,456	33,140
1997	0	0	0	53,912	31,311	85,223	0	0	0	16,304	11,378	27,681
1998	0	0	0	43,749	27,791	71,541	0	0	0	10,150	8,574	18,723
1999	0	0	0	34,553	23,290	57,843	0	0	0	7,817	7,512	15,330
2000	0	0	0	31,524	21,741	53,265	0	0	0	6,864	6,510	13,374

[a] 15 percent of 1986 vehicles are made with asbestos disc brake systems, 0 percent of vehicles made after 1990 are made with asbestos disc brake systems and 92.5 percent of 1986 vehicles are made with asbestos drum brake systems, 0 percent of vehicles made after 1994 are made with asbestos drum brake systems. (A linear decline is assumed in the intermediate years.)

Source: ICF, see text.

Table A.1.3-27. Sales Forecast of Drum and Disc Brakes under High Decline Assumption[a]
(in thousands)

	Asbestos Drum Brake Linings						Asbestos Disc Brake Pads (LMV)					
	New Sales (OEM)			Replacement Sales (A/M)			New Sales (OEM)			Replacement Sales (A/M)		
Year	Car	Light Trucks	Total	Car	Light Trucks	Total	Car	Light Trucks	Total	Car	Light Trucks	Total
1986	37,588	16,687	54,275	97,127	43,005	140,131	6,985	2,706	9,691	79,755	29,701	109,455
1987	31,174	13,794	44,967	87,998	40,004	128,003	4,827	1,864	6,691	73,485	28,261	101,745
1988	23,380	10,545	33,925	94,645	41,624	136,269	2,414	950	3,364	74,133	26,228	100,361
1989	15,311	6,867	22,178	93,361	42,684	136,045	0	0	0	69,517	26,756	96,273
1990	7,035	3,182	10,217	90,109	43,959	134,069	0	0	0	54,459	24,145	78,603
1991	0	0	0	80,682	39,829	120,511	0	0	0	47,793	22,333	70,125
1992	0	0	0	78,309	37,504	115,813	0	0	0	44,410	19,373	63,783
1993	0	0	0	69,686	35,725	105,411	0	0	0	36,497	18,171	54,668
1994	0	0	0	59,981	33,274	93,255	0	0	0	25,789	15,312	41,102
1995	0	0	0	46,946	27,331	74,277	0	0	0	21,649	13,981	35,630
1996	0	0	0	43,483	25,165	68,648	0	0	0	19,065	11,793	30,858
1997	0	0	0	36,514	23,452	59,966	0	0	0	13,917	10,407	24,323
1998	0	0	0	29,140	20,996	50,136	0	0	0	9,053	8,124	17,177
1999	0	0	0	20,261	16,355	36,616	0	0	0	7,382	7,269	14,651
2000	0	0	0	17,695	14,800	32,495	0	0	0	5,993	6,014	12,007

[a] 15 percent of 1986 vehicles are made with asbestos disc brake systems, 0 percent of vehicles made after 1988 are made with asbestos disc brake systems and 92.5 percent of 1986 vehicles are made with asbestos drum brake systems, 0 percent of vehicles made after 1990 are made with asbestos drum brake systems. (A linear decline is assumed in the intermediate years.)

Source: ICF, see text.

Table A.1.3-28. Baseline Growth Rates of Drum and Disc (LMV) Brakes used in the ARCM: 1986-2000

	Growth Rates 1985-2000 (%)											
	18. Drum Brake Linings (OEM)			19. Disc Brake Pads, LMV (OEM)			36. Drum Brake Linings (A/M)			37. Disc Brake Pads, LMV (A/M)		
Year	Low Decline	Moderate Decline	High Decline	Low Decline	Moderate Decline	High Decline	Low Decline	Moderate Decline	High Decline	Low Decline	Moderate Decline	High Decline
1986-1987	3.56	-7.94	-17.15	3.57	-17.14	-30.95	-8.66	-8.66	-8.66	-7.04	-7.04	-7.04
1987-1988	0.59	-11.98	-24.56	0.54	-24.60	-49.73	6.46	6.46	6.46	-1.36	-1.36	-1.36
1988-1989	-1.94	-15.95	-34.63	-1.92	-34.62	-100.00	-0.16	-0.16	-0.16	-4.07	-4.07	-4.07
1989-1990	-7.87	-23.22	-53.93	-7.89	-53.94	0.00	-1.45	-1.45	-1.45	-18.35	-18.35	-18.35
1990-1991	-3.18	-22.55	-100.00	-3.16	-100.00	0.00	-1.95	-6.48	-10.11	-6.64	-9.13	-10.79
1991-1992	11.51	-16.37	0.00	11.57	0.00	0.00	4.85	0.18	-3.90	-4.15	-7.03	-9.04
1992-1993	6.46	-29.03	0.00	6.44	0.00	0.00	-0.02	-4.61	-8.98	-8.57	-11.87	-14.29
1993-1994	-5.83	-52.92	0.00	-5.92	0.00	0.00	-3.45	-7.40	-11.53	-22.28	-26.73	-24.82
1994-1995	-3.23	-100.00	0.00	-3.27	0.00	0.00	-0.80	-9.93	-20.35	-5.83	-14.25	-13.31
1995-1996	6.89	0.00	0.00	6.95	0.00	0.00	7.26	-4.84	-7.58	-1.93	-9.86	-13.39
1996-1997	8.68	0.00	0.00	8.69	0.00	0.00	2.70	-10.37	-12.65	-6.99	-16.47	-21.18
1997-1998	-2.40	0.00	0.00	-2.47	0.00	0.00	-4.62	-16.05	-16.39	-19.60	-32.36	-29.38
1998-1999	-5.26	0.00	0.00	-5.31	0.00	0.00	-1.59	-19.15	-26.97	-4.02	-18.12	-14.70
1999-2000	4.61	0.00	0.00	4.59	0.00	0.00	7.43	-7.92	-11.25	1.77	-12.76	-18.05

- Annual sales of disc brake pads are forecasted to increase for both cars and trucks, but annual sales of asbestos disc brake pads will fall dramatically. This will occur because vehicles with asbestos disc brake pads will be scrapped and replaced with vehicles with semi-metallic disc brake pads. The total annual sale of asbestos pads will fall from approximately 115,000,000 in 1986 to 45,000,000 in 2000.

- Yearly fluctuations in vehicles sales are not forecasted to have a dramatic effect on brake sales because the vast majority of brakes are sold as replacement brakes.

- The results presented in this paper tend to be conservative because they are based on the assumptions that the disc brake substitution in new vehicles away from asbestos remains at its current level, that all asbestos pads are actually replaced with asbestos pads, and that no substitution away from asbestos in drum brakes takes place.

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LIST OF ATTACHMENTS

L-2 Future Sales of Asbestos Drum Brakes for Cars - High Decline.

M-1 Outstanding Stock of Asbestos Disc Brakes in Cars - High Decline.

M-2 Future Sales of Asbestos Disc Brakes for Cars - High Decline.

ATTACHMENT A

This attachment presents a mathematical formulation of the model which underlies this analysis. The formulation is presented only for one of the four categories -- asbestos disc brakes in trucks. However, the equation can be extended to the other three categories.

$$TS_j = OEMS_j + RS_j \qquad (1)$$

where:

TS_j = total sale of asbestos disc brakes for trucks in year j.

$OEMS_j$ = original equipment market sale of asbestos disc brakes for trucks in year j.

RS_j = replacement sale of asbestos disc brakes for trucks in year j.

$$OEMS_j = 8K_i * NTS_j \quad \text{(for all i = j)} \qquad (2)$$

where:

K_i = percentage of total truck pads and linings which are asbestos disc in year i.

NTS_i = new truck sales in year j.

$$K_i = T_i * C_i \qquad (3)$$

where:

T_i = percentage of total truck pads and linings which are disc pads in year i.

C_i = percentage of total disc pads which are asbestos in year i.

$$RS_j = \mathop{\hat{E}}_{i=j-31}^{j-1} 8K_i * OT_{ij}\ g + \mathop{\hat{E}}_{i=j-31}^{j-1} 8K_j * FT_{ij}\ g \qquad (4)$$

where

g = 1 if (j-i)/4 = integer
g = 0 else

K_i = percentage of total truck pads and linings which are asbestos disc in model year i.

OT_{ij} = stock of outstanding trucks of model year i in year j for i § 1985.

FT_{ij} = stock of outstanding trucks of model year i in year j for i þ 1986.

$$OT_{ij} = OT_{ij-1} * P_{j-1-i,\ j-i} \qquad (5)$$

where

$P_{j-1-i,\ j-i}$ = conditional probability that a truck which has survived j-1-i years survives into its j-i year.

$$FT_{ij} = FT_{ij-1} * P_{j-i} \qquad (6)$$

where

P_{j-i} = probability that a truck will survive into its j-i year.

EXHIBIT B-1: OUTSTANDING STOCK OF ASBESTOS DRUM BRAKES IN LDTs

MODEL YEAR	NUMBER OF ASBESTOS DRUM BRAKE PADS IN LDTs ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)														
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	169	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	226	166	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	256	192	141	0	0	0	0	0	0	0	0	0	0	0	0
1959	439	325	244	179	0	0	0	0	0	0	0	0	0	0	0
1960	601	438	325	244	179	0	0	0	0	0	0	0	0	0	0
1961	774	585	427	316	237	174	0	0	0	0	0	0	0	0	0
1962	1,206	909	686	501	371	278	204	0	0	0	0	0	0	0	0
1963	1,842	1,392	1,049	792	578	428	321	236	0	0	0	0	0	0	0
1964	3,676	2,848	2,153	1,623	1,225	894	662	497	364	0	0	0	0	0	0
1965	3,692	2,907	2,252	1,702	1,283	969	707	524	393	288	0	0	0	0	0
1966	4,665	3,695	2,909	2,254	1,703	1,284	970	708	524	393	288	0	0	0	0
1967	5,470	4,405	3,490	2,747	2,128	1,609	1,213	916	668	495	371	272	0	0	0
1968	7,949	6,482	5,221	4,136	3,256	2,522	1,906	1,437	1,085	792	587	440	323	0	0
1969	6,108	5,093	4,154	3,345	2,650	2,086	1,616	1,222	921	695	507	376	282	207	0
1970	6,078	5,130	4,278	3,489	2,810	2,226	1,752	1,358	1,026	774	584	426	316	237	174
1971	5,393	4,635	3,913	3,263	2,661	2,143	1,697	1,336	1,035	783	590	445	325	241	181
1972	6,795	5,923	5,090	4,297	3,583	2,922	2,353	1,864	1,467	1,137	859	648	489	357	264
1973	7,904	6,980	6,084	5,228	4,414	3,680	3,001	2,417	1,915	1,507	1,168	883	665	502	367
1974	8,968	8,005	7,070	6,162	5,295	4,470	3,727	3,040	2,448	1,939	1,527	1,183	894	674	509
1975	6,865	6,226	5,557	4,908	4,278	3,676	3,103	2,588	2,110	1,700	1,346	1,060	821	621	468
1976	9,338	8,641	7,835	6,994	6,177	5,384	4,627	3,906	3,257	2,656	2,139	1,694	1,334	1,033	781
1977	11,726	10,990	10,170	9,222	8,232	7,270	6,337	5,446	4,597	3,833	3,126	2,518	1,994	1,570	1,216
1978	13,216	12,564	11,776	10,897	9,882	8,821	7,790	6,790	5,835	4,926	4,107	3,349	2,698	2,137	1,682
1979	14,281	13,761	13,082	12,262	11,346	10,289	9,184	8,111	7,070	6,076	5,129	4,277	3,488	2,809	2,225
1980	8,176	7,956	7,666	7,288	6,831	6,321	5,732	5,117	4,519	3,939	3,385	2,857	2,383	1,943	1,565
1981	8,163	7,991	7,776	7,492	7,123	6,676	6,178	5,602	5,001	4,416	3,849	3,308	2,792	2,328	1,899
1982	8,617	8,474	8,296	8,073	7,778	7,395	6,931	6,414	5,816	5,192	4,585	3,996	3,434	2,899	2,417
1983	9,376	9,261	9,107	8,915	8,676	8,359	7,947	7,449	6,893	6,250	5,579	4,927	4,295	3,691	3,116
1984	13,652	13,500	13,334	13,113	12,837	12,492	12,037	11,443	10,725	9,925	9,000	8,034	7,095	6,184	5,314
1985	15,855	15,744	15,569	15,378	15,123	14,804	14,407	13,881	13,197	12,369	11,446	10,379	9,265	8,182	7,132
1986	16,687	16,620	16,503	16,320	16,120	15,853	15,519	15,102	14,551	13,834	12,966	11,998	10,880	9,712	8,577
1987	--	17,242	17,173	17,052	16,863	16,656	16,380	16,035	15,604	15,035	14,294	13,397	12,397	11,242	10,035
1988	--	--	17,575	17,505	17,382	17,188	16,977	16,696	16,345	15,905	15,325	14,570	13,656	12,636	11,459
1989	--	--	--	17,168	17,099	16,979	16,790	16,584	16,310	15,966	15,537	14,970	14,232	13,340	12,344
1990	--	--	--	--	15,910	15,846	15,735	15,560	15,369	15,115	14,796	14,399	13,874	13,189	12,362
1991	--	--	--	--	--	15,318	15,257	15,150	14,981	14,797	14,552	14,246	13,863	13,357	12,699
1992	--	--	--	--	--	--	16,872	16,805	16,686	16,501	16,298	16,028	15,691	15,269	14,712
1993	--	--	--	--	--	--	--	18,019	17,947	17,821	17,623	17,406	17,118	16,758	16,307
1994	--	--	--	--	--	--	--	--	17,353	17,284	17,162	16,971	16,763	16,485	16,138
1995	--	--	--	--	--	--	--	--	--	16,946	16,878	16,760	16,573	16,370	16,099
1996	--	--	--	--	--	--	--	--	--	--	17,871	17,800	17,674	17,478	17,263
1997	--	--	--	--	--	--	--	--	--	--	--	19,388	19,310	19,175	18,961
1998	--	--	--	--	--	--	--	--	--	--	--	--	19,277	19,200	19,065
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	18,500	18,426
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19,425
TOTAL	208,161	209,080	210,904	212,864	214,029	215,014	217,934	222,249	226,012	229,287	233,475	239,005	244,201	248,326	253,182

EXHIBIT B-2: FUTURE SALES OF ASBESTOS DRUM BRAKES FOR LDTs

SALES FORECASTS: DRUM BRAKE PADS FOR LIGHT DUTY TRUCKS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	256	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	325	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	325	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	316	0	0	0	0	0	0	0	0	0	0	0
1962	1,206	0	0	0	371	0	0	0	0	0	0	0	0	0	0
1963	0	1,392	0	0	0	428	0	0	0	0	0	0	0	0	0
1964	0	0	2,153	0	0	0	662	0	0	0	0	0	0	0	0
1965	0	0	0	1,702	0	0	0	524	0	0	0	0	0	0	0
1966	4,665	0	0	0	1,703	0	0	0	524	0	0	0	0	0	0
1967	0	4,405	0	0	0	1,609	0	0	0	495	0	0	0	0	0
1968	0	0	5,221	0	0	0	1,906	0	0	0	587	0	0	0	0
1969	0	0	0	3,345	0	0	0	1,222	0	0	0	376	0	0	0
1970	6,078	0	0	0	2,810	0	0	0	1,026	0	0	0	316	0	0
1971	0	4,635	0	0	0	2,143	0	0	0	783	0	0	0	241	0
1972	0	0	5,090	0	0	0	2,353	0	0	0	859	0	0	0	264
1973	0	0	0	5,228	0	0	0	2,417	0	0	0	883	0	0	0
1974	8,968	0	0	0	5,295	0	0	0	2,448	0	0	0	894	0	0
1975	0	6,226	0	0	0	3,676	0	0	0	1,700	0	0	0	621	0
1976	0	0	7,835	0	0	0	4,627	0	0	0	2,139	0	0	0	781
1977	0	0	0	9,222	0	0	0	5,446	0	0	0	2,518	0	0	0
1978	13,216	0	0	0	9,882	0	0	0	5,835	0	0	0	2,698	0	0
1979	0	13,761	0	0	0	10,289	0	0	0	6,076	0	0	0	2,809	0
1980	0	0	7,666	0	0	0	5,732	0	0	0	3,385	0	0	0	1,565
1981	0	0	0	7,492	0	0	0	5,602	0	0	0	3,308	0	0	0
1982	8,617	0	0	0	7,778	0	0	0	5,816	0	0	0	3,434	0	0
1983	0	9,261	0	0	0	8,359	0	0	0	6,250	0	0	0	3,691	0
1984	0	0	13,334	0	0	0	12,037	0	0	0	9,000	0	0	0	5,314
1985	0	0	0	15,378	0	0	0	13,881	0	0	0	10,379	0	0	0
1986	16,687	0	0	0	16,120	0	0	0	14,551	0	0	0	10,880	0	0
1987	--	17,242	0	0	0	16,656	0	0	0	15,035	0	0	0	11,242	0
1988	--	--	17,575	0	0	0	16,977	0	0	0	15,325	0	0	0	11,459
1989	--	--	--	17,168	0	0	0	16,584	0	0	0	14,970	0	0	0
1990	--	--	--	--	15,910	0	0	0	15,369	0	0	0	13,874	0	0
1991	--	--	--	--	--	15,318	0	0	0	14,797	0	0	0	13,357	0
1992	--	--	--	--	--	--	16,872	0	0	0	16,298	0	0	0	14,712
1993	--	--	--	--	--	--	--	18,019	0	0	0	17,406	0	0	0
1994	--	--	--	--	--	--	--	--	17,353	0	0	0	16,763	0	0
1995	--	--	--	--	--	--	--	--	--	16,946	0	0	0	16,370	0
1996	--	--	--	--	--	--	--	--	--	--	17,871	0	0	0	17,263
1997	--	--	--	--	--	--	--	--	--	--	--	19,388	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	19,277	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	18,500	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19,425
TOTAL SALES:	59,692	57,246	59,199	59,852	59,869	58,478	61,167	63,695	62,923	62,081	65,465	69,228	68,135	66,830	70,785
NEW SALES:	16,687	17,242	17,575	17,168	15,910	15,318	16,872	18,019	17,353	16,946	17,871	19,388	19,277	18,500	19,425
REPLACEMENT SALES:	43,005	40,004	41,624	42,684	43,959	43,160	44,295	45,676	45,570	45,135	47,594	49,840	48,858	48,330	51,360

EXHIBIT C-1: OUTSTANDING STOCK OF ASBESTOS DISC BRAKES IN LDTs

MODEL YEAR	NUMBER OF ASBESTOS DISC BRAKE PADS IN LDTs ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)														
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	47	37	29	23	17	13	10	7	5	4	3	0	0	0	0
1967	85	68	54	43	33	25	19	14	10	8	6	4	0	0	0
1968	250	204	164	130	102	79	60	45	34	25	18	14	10	0	0
1969	943	787	642	517	409	322	250	189	142	107	78	58	44	32	0
1970	2,401	2,026	1,690	1,378	1,110	879	692	536	405	306	231	168	125	94	69
1971	2,835	2,437	2,057	1,715	1,399	1,127	892	703	544	411	310	234	171	127	95
1972	4,859	4,235	3,639	3,072	2,562	2,089	1,683	1,333	1,049	813	614	463	350	255	189
1973	5,869	5,183	4,517	3,882	3,277	2,733	2,228	1,795	1,422	1,119	867	655	494	373	272
1974	6,886	6,146	5,428	4,731	4,066	3,432	2,862	2,334	1,880	1,489	1,172	908	686	517	391
1975	6,133	5,561	4,964	4,384	3,821	3,284	2,772	2,312	1,885	1,518	1,203	947	734	554	418
1976	8,936	8,269	7,498	6,693	5,911	5,152	4,428	3,738	3,117	2,542	2,047	1,622	1,277	989	748
1977	11,540	10,816	10,008	9,076	8,101	7,155	6,236	5,359	4,524	3,772	3,076	2,478	1,963	1,545	1,197
1978	13,216	12,564	11,776	10,897	9,882	8,821	7,790	6,790	5,835	4,926	4,107	3,349	2,698	2,137	1,682
1979	14,281	13,761	13,082	12,262	11,346	10,289	9,184	8,111	7,070	6,076	5,129	4,277	3,488	2,809	2,225
1980	8,176	7,956	7,666	7,288	6,831	6,321	5,732	5,117	4,519	3,939	3,385	2,857	2,383	1,943	1,565
1981	8,163	7,991	7,776	7,492	7,123	6,676	6,178	5,602	5,001	4,416	3,849	3,308	2,792	2,328	1,899
1982	7,152	7,034	6,886	6,700	6,456	6,138	5,753	5,323	4,827	4,309	3,806	3,317	2,850	2,406	2,006
1983	6,514	6,434	6,327	6,194	6,027	5,808	5,521	5,175	4,789	4,342	3,876	3,423	2,984	2,564	2,165
1984	7,433	7,350	7,260	7,140	6,989	6,801	6,553	6,230	5,839	5,404	4,900	4,374	3,863	3,367	2,893
1985	5,969	5,927	5,861	5,789	5,693	5,573	5,424	5,226	4,968	4,657	4,309	3,907	3,488	3,080	2,685
1986	2,706	2,695	2,676	2,646	2,614	2,571	2,517	2,449	2,360	2,243	2,103	1,946	1,764	1,575	1,391
1987	--	2,796	2,785	2,765	2,734	2,701	2,656	2,600	2,530	2,438	2,318	2,172	2,010	1,823	1,627
1988	--	--	2,850	2,839	2,819	2,787	2,753	2,708	2,651	2,579	2,485	2,363	2,214	2,049	1,858
1989	--	--	--	2,784	2,773	2,753	2,723	2,689	2,645	2,589	2,520	2,428	2,308	2,163	2,002
1990	--	--	--	--	2,580	2,570	2,552	2,523	2,492	2,451	2,399	2,335	2,250	2,139	2,005
1991	--	--	--	--	--	2,484	2,474	2,457	2,429	2,401	2,360	2,310	2,248	2,166	2,059
1992	--	--	--	--	--	--	2,736	2,725	2,706	2,676	2,643	2,599	2,544	2,476	2,386
1993	--	--	--	--	--	--	--	2,922	2,910	2,890	2,858	2,823	2,776	2,717	2,644
1994	--	--	--	--	--	--	--	--	2,814	2,803	2,783	2,752	2,718	2,673	2,617
1995	--	--	--	--	--	--	--	--	--	2,748	2,737	2,718	2,688	2,655	2,611
1996	--	--	--	--	--	--	--	--	--	--	2,898	2,886	2,866	2,834	2,799
1997	--	--	--	--	--	--	--	--	--	--	--	3,144	3,131	3,109	3,075
1998	--	--	--	--	--	--	--	--	--	--	--	--	3,126	3,113	3,092
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	3,000	2,988
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,150
TOTAL	124,391	120,276	115,636	110,440	104,676	98,583	92,677	87,011	81,403	75,998	71,090	66,840	63,042	59,615	56,802

EXHIBIT C-2:FUTURE SALES OF ASBESTOS DISC BRAKES FOR LDTs

SALES FORECASTS: DISC BRAKE PADS FOR LIGHT DUTY TRUCKS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	47	0	0	0	17	0	0	0	5	0	0	0	0	0	0
1967	0	68	0	0	0	25	0	0	0	8	0	0	0	0	0
1968	0	0	164	0	0	0	60	0	0	0	18	0	0	0	0
1969	0	0	0	517	0	0	0	189	0	0	0	58	0	0	0
1970	2,401	0	0	0	1,110	0	0	0	405	0	0	0	125	0	0
1971	0	2,437	0	0	0	1,127	0	0	0	411	0	0	0	127	0
1972	0	0	3,639	0	0	0	1,683	0	0	0	614	0	0	0	189
1973	0	0	0	3,882	0	0	0	1,795	0	0	0	655	0	0	0
1974	6,886	0	0	0	4,066	0	0	0	1,880	0	0	0	686	0	0
1975	0	5,561	0	0	0	3,284	0	0	0	1,518	0	0	0	554	0
1976	0	0	7,498	0	0	0	4,428	0	0	0	2,047	0	0	0	748
1977	0	0	0	9,076	0	0	0	5,359	0	0	0	2,478	0	0	0
1978	13,216	0	0	0	9,882	0	0	0	5,835	0	0	0	2,698	0	0
1979	0	13,761	0	0	0	10,289	0	0	0	6,076	0	0	0	2,809	0
1980	0	0	7,666	0	0	0	5,732	0	0	0	3,385	0	0	0	1,565
1981	0	0	0	7,492	0	0	0	5,602	0	0	0	3,308	0	0	0
1982	7,152	0	0	0	6,456	0	0	0	4,827	0	0	0	2,850	0	0
1983	0	6,434	0	0	0	5,808	0	0	0	4,342	0	0	0	2,564	0
1984	0	0	7,260	0	0	0	6,553	0	0	0	4,900	0	0	0	2,893
1985	0	0	0	5,789	0	0	0	5,226	0	0	0	3,907	0	0	0
1986	2,706	0	0	0	2,614	0	0	0	2,360	0	0	0	1,764	0	0
1987	--	2,796	0	0	0	2,701	0	0	0	2,438	0	0	0	1,823	0
1988	--	--	2,850	0	0	0	2,753	0	0	0	2,485	0	0	0	1,858
1989	--	--	--	2,784	0	0	0	2,689	0	0	0	2,428	0	0	0
1990	--	--	--	--	2,580	0	0	0	2,492	0	0	0	2,250	0	0
1991	--	--	--	--	--	2,484	0	0	0	2,400	0	0	0	2,166	0
1992	--	--	--	--	--	--	2,736	0	0	0	2,643	0	0	0	2,386
1993	--	--	--	--	--	--	--	2,922	0	0	0	2,823	0	0	0
1994	--	--	--	--	--	--	--	--	2,814	0	0	0	2,718	0	0
1995	--	--	--	--	--	--	--	--	--	2,748	0	0	0	2,655	0
1996	--	--	--	--	--	--	--	--	--	--	2,898	0	0	0	2,799
1997	--	--	--	--	--	--	--	--	--	--	--	3,144	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	3,126	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	3,000	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,150
TOTAL SALES:	32,407	31,057	29,078	29,540	26,725	25,717	23,945	23,782	20,619	19,941	18,991	18,801	16,218	15,698	15,588
NEW SALES:	2,706	2,796	2,850	2,784	2,580	2,484	2,736	2,922	2,814	2,748	2,898	3,144	3,126	3,000	3,150
REPLACEMENT SALES:	29,701	28,261	26,228	26,756	24,145	23,233	21,209	20,860	17,805	17,193	16,093	15,657	13,092	12,698	12,438

EXHIBIT D-1: OUTSTANDING STOCK OF ASBESTOS DRUM BRAKES IN CARS

MODEL YEAR	NUMBER OF ASBESTOS DRUM BRAKE PADS IN CARS ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)														
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	2,314	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	3,114	2,194	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	4,011	2,847	2,006	0	0	0	0	0	0	0	0	0	0	0	0
1968	6,080	4,488	3,185	2,244	0	0	0	0	0	0	0	0	0	0	0
1969	7,392	5,544	4,092	2,904	2,046	0	0	0	0	0	0	0	0	0	0
1970	10,206	7,672	5,754	4,247	3,014	2,123	0	0	0	0	0	0	0	0	0
1971	10,480	7,808	5,869	4,402	3,249	2,306	1,624	0	0	0	0	0	0	0	0
1972	14,255	10,758	8,015	6,025	4,518	3,335	2,367	1,668	0	0	0	0	0	0	0
1973	17,291	13,129	9,909	7,382	5,549	4,162	3,072	2,180	1,536	0	0	0	0	0	0
1974	19,211	14,866	11,288	8,519	6,347	4,771	3,578	2,641	1,874	1,320	0	0	0	0	0
1975	17,589	14,015	10,845	8,235	6,215	4,630	3,480	2,610	1,927	1,367	963	0	0	0	0
1976	25,726	21,381	17,037	13,184	10,011	7,555	5,629	4,231	3,173	2,342	1,662	1,171	0	0	0
1977	32,108	28,360	23,571	18,782	14,534	11,036	8,329	6,205	4,664	3,498	2,582	1,832	1,291	0	0
1978	35,634	32,746	28,923	24,039	19,155	14,823	11,255	8,494	6,328	4,757	3,568	2,633	1,869	1,317	0
1979	36,844	34,538	31,739	28,034	23,300	18,566	14,367	10,909	8,233	6,134	4,611	3,458	2,552	1,811	1,276
1980	33,086	31,738	29,753	27,341	24,150	20,071	15,993	12,376	9,397	7,092	5,284	3,972	2,979	2,199	1,560
1981	31,564	30,708	29,457	27,614	25,376	22,414	18,629	14,844	11,487	8,722	6,583	4,904	3,686	2,765	2,041
1982	28,962	28,428	27,658	26,531	24,871	22,855	20,187	16,778	13,369	10,346	7,856	5,929	4,417	3,320	2,490
1983	29,115	28,790	28,260	27,494	26,374	24,724	22,720	20,068	16,679	13,290	10,284	7,809	5,894	4,391	3,300
1984	37,331	37,068	36,656	35,980	35,005	33,579	31,478	28,927	25,550	21,236	16,921	13,094	9,942	7,504	5,590
1985	37,468	37,355	37,092	36,679	36,004	35,027	33,601	31,498	28,945	25,567	21,249	16,932	13,102	9,949	7,509
1986	37,588	37,512	37,400	37,137	36,723	36,046	35,069	33,641	31,536	28,980	25,597	21,275	16,952	13,118	9,961
1987	--	38,967	38,889	38,772	38,499	38,071	37,369	36,356	34,875	32,693	30,043	26,536	22,055	17,574	13,599
1988	--	--	38,967	38,889	38,772	38,499	38,071	37,369	36,356	34,875	32,693	30,043	26,536	22,055	17,574
1989	--	--	--	38,277	38,201	38,086	37,818	37,397	36,708	35,713	34,258	32,115	29,512	26,067	21,665
1990	--	--	--	--	35,174	35,103	34,998	34,752	34,365	33,732	32,817	31,480	29,511	27,119	23,953
1991	--	--	--	--	--	34,139	34,071	33,968	33,729	33,354	32,739	31,852	30,555	28,643	26,321
1992	--	--	--	--	--	--	38,277	38,201	38,086	37,818	37,397	36,708	35,713	34,258	32,115
1993	--	--	--	--	--	--	--	40,691	40,610	40,488	40,203	39,755	39,023	37,965	36,419
1994	--	--	--	--	--	--	--	--	37,932	37,857	37,743	37,477	37,060	36,377	35,391
1995	--	--	--	--	--	--	--	--	--	36,553	36,480	36,370	36,114	35,712	35,054
1996	--	--	--	--	--	--	--	--	--	--	39,312	39,233	39,115	38,840	38,408
1997	--	--	--	--	--	--	--	--	--	--	--	42,760	42,675	42,546	42,247
1998	--	--	--	--	--	--	--	--	--	--	--	--	41,381	41,298	41,174
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	38,967	38,889
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40,691
TOTAL	477,367	470,914	466,363	462,711	457,085	451,922	451,982	455,805	457,361	457,733	460,845	467,339	471,934	473,794	477,227

EXHIBIT D-2: FUTURE SALES OF ASBESTOS DRUM BRAKES FOR CARS

SALES FORECASTS: DRUM BRAKE LININGS FOR CARS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	3,114	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	2,847	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	3,185	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	2,904	0	0	0	0	0	0	0	0	0	0	0
1970	10,206	0	0	0	3,014	0	0	0	0	0	0	0	0	0	0
1971	0	7,808	0	0	0	2,306	0	0	0	0	0	0	0	0	0
1972	0	0	8,015	0	0	0	2,367	0	0	0	0	0	0	0	0
1973	0	0	0	7,382	0	0	0	2,180	0	0	0	0	0	0	0
1974	19,211	0	0	0	6,347	0	0	0	1,874	0	0	0	0	0	0
1975	0	14,015	0	0	0	4,630	0	0	0	1,367	0	0	0	0	0
1976	0	0	17,037	0	0	0	5,629	0	0	0	1,662	0	0	0	0
1977	0	0	0	18,782	0	0	0	6,205	0	0	0	1,832	0	0	0
1978	35,634	0	0	0	19,155	0	0	0	6,328	0	0	0	1,869	0	0
1979	0	34,538	0	0	0	18,566	0	0	0	6,134	0	0	0	1,811	0
1980	0	0	29,753	0	0	0	15,993	0	0	0	5,284	0	0	0	1,560
1981	0	0	0	27,614	0	0	0	14,844	0	0	0	4,904	0	0	0
1982	28,962	0	0	0	24,871	0	0	0	13,369	0	0	0	4,417	0	0
1983	0	28,790	0	0	0	24,724	0	0	0	13,290	0	0	0	4,391	0
1984	0	0	36,656	0	0	0	31,478	0	0	0	16,921	0	0	0	5,590
1985	0	0	0	36,679	0	0	0	31,498	0	0	0	16,932	0	0	0
1986	37,588	0	0	0	36,723	0	0	0	31,536	0	0	0	16,952	0	0
1987	--	38,967	0	0	0	38,071	0	0	0	32,693	0	0	0	17,574	0
1988	--	--	38,967	0	0	0	38,071	0	0	0	32,693	0	0	0	17,574
1989	--	--	--	38,277	0	0	0	37,397	0	0	0	32,115	0	0	0
1990	--	--	--	--	35,174	0	0	0	34,365	0	0	0	29,511	0	0
1991	--	--	--	--	--	34,139	0	0	0	33,354	0	0	0	28,643	0
1992	--	--	--	--	--	--	38,277	0	0	0	37,397	0	0	0	32,115
1993	--	--	--	--	--	--	--	40,691	0	0	0	39,755	0	0	0
1994	--	--	--	--	--	--	--	--	37,932	0	0	0	37,060	0	0
1995	--	--	--	--	--	--	--	--	--	36,553	0	0	0	35,712	0
1996	--	--	--	--	--	--	--	--	--	--	39,312	0	0	0	38,408
1997	--	--	--	--	--	--	--	--	--	--	--	42,760	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	41,381	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	38,967	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40,691
TOTAL SALES:	134,714	126,965	133,612	131,639	125,283	122,435	131,815	132,815	125,405	123,391	133,269	138,298	131,189	127,098	135,938
NEW SALES:	37,588	38,967	38,967	38,277	35,174	34,139	38,277	40,691	37,932	36,553	39,312	42,760	41,381	38,967	40,691
REPLACEMENT SALES:	97,127	87,998	94,645	93,361	90,109	88,296	93,538	92,124	87,472	86,838	93,957	95,538	89,808	88,131	95,247

EXHIBIT E-1: OUTSTANDING STOCK OF ASBESTOS DISC BRAKES IN CARS

MODEL YEAR	NUMBER OF ASBESTOS DISC BRAKE PADS IN CARS ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)														
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	64	45	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	128	91	64	0	0	0	0	0	0	0	0	0	0	0	0
1968	415	307	218	153	0	0	0	0	0	0	0	0	0	0	0
1969	1,193	895	661	469	330	0	0	0	0	0	0	0	0	0	0
1970	2,632	1,978	1,484	1,095	777	548	0	0	0	0	0	0	0	0	0
1971	4,835	3,602	2,707	2,031	1,499	1,064	749	0	0	0	0	0	0	0	0
1972	8,300	6,264	4,667	3,508	2,631	1,942	1,378	971	0	0	0	0	0	0	0
1973	12,968	9,847	7,432	5,537	4,162	3,121	2,304	1,635	1,152	0	0	0	0	0	0
1974	13,944	10,791	8,194	6,184	4,607	3,463	2,597	1,917	1,360	958	0	0	0	0	0
1975	14,952	11,914	9,220	7,000	5,283	3,936	2,959	2,219	1,638	1,162	819	0	0	0	0
1976	24,760	20,578	16,397	12,689	9,635	7,272	5,417	4,072	3,054	2,254	1,600	1,127	0	0	0
1977	33,136	29,268	24,325	19,383	14,999	11,389	8,595	6,404	4,813	3,610	2,665	1,891	1,332	0	0
1978	37,201	34,186	30,196	25,097	19,997	15,475	11,750	8,868	6,607	4,966	3,725	2,749	1,951	1,375	0
1979	38,612	36,196	33,263	29,380	24,418	19,457	15,057	11,433	8,628	6,428	4,832	3,624	2,675	1,898	1,337
1980	35,071	33,643	31,538	28,982	25,599	21,276	16,953	13,119	9,961	7,518	5,601	4,210	3,158	2,331	1,654
1981	33,584	32,673	31,342	29,381	27,000	23,848	19,821	15,794	12,222	9,280	7,004	5,218	3,922	2,942	2,171
1982	25,913	25,436	24,746	23,738	22,253	20,450	18,062	15,012	11,962	9,257	7,029	5,305	3,952	2,971	2,228
1983	21,926	21,682	21,282	20,705	19,862	18,619	17,110	15,113	12,561	10,009	7,745	5,881	4,438	3,307	2,486
1984	21,707	21,554	21,314	20,921	20,354	19,525	18,303	16,820	14,857	12,348	9,839	7,614	5,781	4,363	3,251
1985	15,065	15,019	14,914	14,748	14,476	14,084	13,510	12,665	11,638	10,280	8,544	6,808	5,268	4,000	3,019
1986	6,985	6,971	6,950	6,901	6,824	6,698	6,517	6,251	5,860	5,385	4,757	3,953	3,150	2,438	1,851
1987	--	7,241	7,227	7,205	7,154	7,074	6,944	6,756	6,481	6,075	5,583	4,931	4,098	3,266	2,527
1988	--	--	7,241	7,227	7,205	7,154	7,074	6,944	6,756	6,481	6,075	5,583	4,931	4,098	3,266
1989	--	--	--	7,113	7,099	7,077	7,028	6,949	6,821	6,636	6,366	5,968	5,484	4,844	4,026
1990	--	--	--	--	6,536	6,523	6,503	6,458	6,386	6,268	6,098	5,850	5,484	5,039	4,451
1991	--	--	--	--	--	6,344	6,331	6,312	6,268	6,198	6,084	5,919	5,678	5,323	4,891
1992	--	--	--	--	--	--	7,113	7,099	7,077	7,028	6,949	6,821	6,636	6,366	5,968
1993	--	--	--	--	--	--	--	7,561	7,546	7,524	7,471	7,388	7,251	7,055	6,767
1994	--	--	--	--	--	--	--	--	7,049	7,035	7,014	6,964	6,887	6,760	6,577
1995	--	--	--	--	--	--	--	--	--	6,792	6,779	6,759	6,711	6,636	6,514
1996	--	--	--	--	--	--	--	--	--	--	7,305	7,291	7,269	7,217	7,137
1997	--	--	--	--	--	--	--	--	--	--	--	7,946	7,930	7,906	7,851
1998	--	--	--	--	--	--	--	--	--	--	--	--	7,690	7,674	7,651
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	7,241	7,227
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7,561
TOTAL	353,391	330,181	305,380	279,446	252,701	226,339	202,077	180,371	160,698	143,492	129,881	119,798	111,677	105,049	100,410

EXHIBIT E-2: FUTURE SALES OF ASBESTOS DISC BRAKES FOR CARS

SALES FORECASTS: DISC BRAKE PADS FOR CARS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	218	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	469	0	0	0	0	0	0	0	0	0	0	0
1970	2,632	0	0	0	777	0	0	0	0	0	0	0	0	0	0
1971	0	3,602	0	0	0	1,064	0	0	0	0	0	0	0	0	0
1972	0	0	4,667	0	0	0	1,378	0	0	0	0	0	0	0	0
1973	0	0	0	5,537	0	0	0	1,635	0	0	0	0	0	0	0
1974	13,944	0	0	0	4,607	0	0	0	1,360	0	0	0	0	0	0
1975	0	11,914	0	0	0	3,936	0	0	0	1,162	0	0	0	0	0
1976	0	0	16,397	0	0	0	5,417	0	0	0	1,600	0	0	0	0
1977	0	0	0	19,383	0	0	0	6,404	0	0	0	1,891	0	0	0
1978	37,201	0	0	0	19,997	0	0	0	6,607	0	0	0	1,951	0	0
1979	0	36,196	0	0	0	19,457	0	0	0	6,428	0	0	0	1,898	0
1980	0	0	31,538	0	0	0	16,953	0	0	0	5,601	0	0	0	1,654
1981	0	0	0	29,381	0	0	0	15,794	0	0	0	5,218	0	0	0
1982	25,913	0	0	0	22,253	0	0	0	11,962	0	0	0	3,952	0	0
1983	0	21,682	0	0	0	18,619	0	0	0	10,009	0	0	0	3,307	0
1984	0	0	21,314	0	0	0	18,303	0	0	0	9,839	0	0	0	3,251
1985	0	0	0	14,748	0	0	0	12,665	0	0	0	6,808	0	0	0
1986	6,985	0	0	0	6,824	0	0	0	5,860	0	0	0	3,150	0	0
1987	--	7,241	0	0	0	7,074	0	0	0	6,075	0	0	0	3,266	0
1988	--	--	7,241	0	0	0	7,074	0	0	0	6,075	0	0	0	3,266
1989	--	--	--	7,113	0	0	0	6,949	0	0	0	5,968	0	0	0
1990	--	--	--	--	6,536	0	0	0	6,386	0	0	0	5,484	0	0
1991	--	--	--	--	--	6,344	0	0	0	6,198	0	0	0	5,323	0
1992	--	--	--	--	--	--	7,113	0	0	0	6,949	0	0	0	5,968
1993	--	--	--	--	--	--	--	7,561	0	0	0	7,388	0	0	0
1994	--	--	--	--	--	--	--	--	7,049	0	0	0	6,887	0	0
1995	--	--	--	--	--	--	--	--	--	6,792	0	0	0	6,636	0
1996	--	--	--	--	--	--	--	--	--	--	7,305	0	0	0	7,137
1997	--	--	--	--	--	--	--	--	--	--	--	7,946	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	7,690	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	7,241	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7,561
TOTAL SALES:	86,739	80,726	81,374	76,630	60,995	56,495	56,239	51,008	39,224	36,665	37,369	35,218	29,113	27,670	28,836
NEW SALES:	6,985	7,241	7,241	7,113	6,536	6,344	7,113	7,561	7,049	6,792	7,305	7,946	7,690	7,241	7,561
REPLACEMENT SALES:	79,755	73,485	74,133	69,517	54,459	50,151	49,126	43,446	32,175	29,872	30,064	27,272	21,424	20,429	21,275

EXHIBIT F-1: OUTSTANDING STOCK OF ASBESTOS DRUM BRAKES IN LDTs

MODEL YEAR	NUMBER OF ASBESTOS DRUM BRAKE PADS IN LDTs ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	230	169	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	301	226	166	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	346	256	192	141	0	0	0	0	0	0	0	0	0	0	0	0
1959	602	439	325	244	179	0	0	0	0	0	0	0	0	0	0	0
1960	796	601	438	325	244	179	0	0	0	0	0	0	0	0	0	0
1961	1,027	774	585	427	316	237	174	0	0	0	0	0	0	0	0	0
1962	1,595	1,206	909	686	501	371	278	204	0	0	0	0	0	0	0	0
1963	2,377	1,842	1,392	1,049	792	578	428	321	236	0	0	0	0	0	0	0
1964	4,669	3,676	2,848	2,153	1,623	1,225	894	662	497	364	0	0	0	0	0	0
1965	4,661	3,692	2,907	2,252	1,702	1,283	969	707	524	393	288	0	0	0	0	0
1966	5,792	4,665	3,695	2,909	2,254	1,703	1,284	970	708	524	393	288	0	0	0	0
1967	6,707	5,470	4,405	3,490	2,747	2,128	1,609	1,213	916	668	495	371	272	0	0	0
1968	9,532	7,949	6,482	5,221	4,136	3,256	2,522	1,906	1,437	1,085	792	587	440	323	0	0
1969	7,236	6,108	5,093	4,154	3,345	2,650	2,086	1,616	1,222	921	695	507	376	282	207	0
1970	7,072	6,078	5,130	4,278	3,489	2,810	2,226	1,752	1,358	1,026	774	584	426	316	237	174
1971	6,188	5,393	4,635	3,913	3,263	2,661	2,143	1,697	1,336	1,035	783	590	445	325	241	181
1972	7,694	6,795	5,923	5,090	4,297	3,583	2,922	2,353	1,864	1,467	1,137	859	648	489	357	264
1973	8,854	7,904	6,980	6,084	5,228	4,414	3,680	3,001	2,417	1,915	1,507	1,168	883	665	502	367
1974	9,889	8,968	8,005	7,070	6,162	5,295	4,470	3,727	3,040	2,448	1,939	1,527	1,183	894	674	509
1975	7,419	6,865	6,226	5,557	4,908	4,278	3,676	3,103	2,588	2,110	1,700	1,346	1,060	821	621	468
1976	9,962	9,338	8,641	7,835	6,994	6,177	5,384	4,627	3,906	3,257	2,656	2,139	1,694	1,334	1,033	781
1977	12,334	11,726	10,990	10,170	9,222	8,232	7,270	6,337	5,446	4,597	3,833	3,126	2,518	1,994	1,570	1,216
1978	13,716	13,216	12,564	11,776	10,897	9,882	8,821	7,790	6,790	5,835	4,926	4,107	3,349	2,698	2,137	1,682
1979	14,676	14,281	13,761	13,082	12,262	11,346	10,289	9,184	8,111	7,070	6,076	5,129	4,277	3,488	2,809	2,225
1980	8,352	8,176	7,956	7,666	7,288	6,831	6,321	5,732	5,117	4,519	3,939	3,385	2,857	2,383	1,943	1,565
1981	8,300	8,163	7,991	7,776	7,492	7,123	6,676	6,178	5,602	5,001	4,416	3,849	3,308	2,792	2,328	1,899
1982	8,724	8,617	8,474	8,296	8,073	7,778	7,395	6,931	6,414	5,816	5,192	4,585	3,996	3,434	2,899	2,417
1983	9,481	9,376	9,261	9,107	8,915	8,676	8,359	7,947	7,449	6,893	6,250	5,579	4,927	4,295	3,691	3,116
1984	13,748	13,652	13,500	13,334	13,113	12,837	12,492	12,037	11,443	10,725	9,925	9,000	8,034	7,095	6,184	5,314
1985	15,919	15,855	15,744	15,569	15,378	15,123	14,804	14,407	13,881	13,197	12,369	11,446	10,379	9,265	8,182	7,132
1986	--	16,687	16,620	16,503	16,320	16,120	15,853	15,519	15,102	14,551	13,834	12,966	11,998	10,880	9,712	8,577
1987	--	--	15,326	15,265	15,158	14,989	14,805	14,560	14,253	13,870	13,364	12,705	11,908	11,020	9,993	8,920
1988	--	--	--	13,669	13,615	13,519	13,369	13,205	12,986	12,713	12,371	11,920	11,332	10,621	9,828	8,912
1989	--	--	--	--	11,445	11,400	11,319	11,194	11,056	10,873	10,644	10,358	9,980	9,488	8,893	8,229
1990	--	--	--	--	--	8,839	8,804	8,742	8,644	8,538	8,397	8,220	7,999	7,708	7,327	6,868
1991	--	--	--	--	--	--	6,808	6,781	6,733	6,658	6,577	6,468	6,331	6,161	5,937	5,644
1992	--	--	--	--	--	--	--	5,624	5,602	5,562	5,500	5,433	5,343	5,230	5,090	4,904
1993	--	--	--	--	--	--	--	--	4,004	3,988	3,960	3,916	3,868	3,804	3,724	3,624
1994	--	--	--	--	--	--	--	--	--	1,928	1,920	1,907	1,886	1,863	1,832	1,793
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	208,390	208,161	207,164	205,090	201,357	195,522	188,131	180,027	170,679	159,548	146,651	134,065	121,719	109,667	97,951	86,781

EXHIBIT F-2: FUTURE SALES OF ASBESTOS DRUM BRAKES FOR LDTs

SALES FORECASTS: DRUM BRAKE PADS FOR LIGHT DUTY TRUCKS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1957	301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	256	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	325	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	325	0	0	0	0	0	0	0	0	0	0	0	0
1961	1,027	0	0	0	316	0	0	0	0	0	0	0	0	0	0	0
1962	0	1,206	0	0	0	371	0	0	0	0	0	0	0	0	0	0
1963	0	0	1,392	0	0	0	428	0	0	0	0	0	0	0	0	0
1964	0	0	0	2,153	0	0	0	662	0	0	0	0	0	0	0	0
1965	4,661	0	0	0	1,702	0	0	0	524	0	0	0	0	0	0	0
1966	0	4,665	0	0	0	1,703	0	0	0	524	0	0	0	0	0	0
1967	0	0	4,405	0	0	0	1,609	0	0	0	495	0	0	0	0	0
1968	0	0	0	5,221	0	0	0	1,906	0	0	0	587	0	0	0	0
1969	7,236	0	0	0	3,345	0	0	0	1,222	0	0	0	376	0	0	0
1970	0	6,078	0	0	0	2,810	0	0	0	1,026	0	0	0	316	0	0
1971	0	0	4,635	0	0	0	2,143	0	0	0	783	0	0	0	241	0
1972	0	0	0	5,090	0	0	0	2,353	0	0	0	859	0	0	0	264
1973	8,854	0	0	0	5,228	0	0	0	2,417	0	0	0	883	0	0	0
1974	0	8,968	0	0	0	5,295	0	0	0	2,448	0	0	0	894	0	0
1975	0	0	6,226	0	0	0	3,676	0	0	0	1,700	0	0	0	621	0
1976	0	0	0	7,835	0	0	0	4,627	0	0	0	2,139	0	0	0	781
1977	12,334	0	0	0	9,222	0	0	0	5,446	0	0	0	2,518	0	0	0
1978	0	13,216	0	0	0	9,882	0	0	0	5,835	0	0	0	2,698	0	0
1979	0	0	13,761	0	0	0	10,289	0	0	0	6,076	0	0	0	2,809	0
1980	0	0	0	7,666	0	0	0	5,732	0	0	0	3,385	0	0	0	1,565
1981	8,300	0	0	0	7,492	0	0	0	5,602	0	0	0	3,308	0	0	0
1982	0	8,617	0	0	0	7,778	0	0	0	5,816	0	0	0	3,434	0	0
1983	0	0	9,261	0	0	0	8,359	0	0	0	6,250	0	0	0	3,691	0
1984	0	0	0	13,334	0	0	0	12,037	0	0	0	9,000	0	0	0	5,314
1985	15,919	0	0	0	15,378	0	0	0	13,881	0	0	0	10,379	0	0	0
1986	--	16,687	0	0	0	16,120	0	0	0	14,551	0	0	0	10,880	0	0
1987	--	--	15,326	0	0	0	14,805	0	0	0	13,364	0	0	0	9,993	0
1988	--	--	--	13,669	0	0	0	13,205	0	0	0	11,920	0	0	0	8,912
1989	--	--	--	--	11,445	0	0	0	11,056	0	0	0	9,980	0	0	0
1990	--	--	--	--	--	8,839	0	0	0	8,538	0	0	0	7,708	0	0
1991	--	--	--	--	--	--	6,808	0	0	0	6,577	0	0	0	5,937	0
1992	--	--	--	--	--	--	--	5,624	0	0	0	5,433	0	0	0	4,904
1993	--	--	--	--	--	--	--	--	4,004	0	0	0	3,868	0	0	0
1994	--	--	--	--	--	--	--	--	--	1,928	0	0	0	1,863	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	58,633	59,692	55,331	55,293	54,129	52,798	48,118	46,146	44,152	40,667	35,244	33,322	31,312	27,792	23,290	21,741
NEW SALES:	15,919	16,687	15,326	13,669	11,445	8,839	6,808	5,624	4,004	1,928	0	0	0	0	0	0
REPLACEMENT SALES:	42,714	43,005	40,004	41,624	42,684	43,959	41,310	40,522	40,148	38,739	35,244	33,322	31,312	27,792	23,290	21,741

EXHIBIT G-1: OUTSTANDING STOCK OF ASBESTOS DISC BRAKES IN LDTs

MODEL YEAR	NUMBER OF ASBESTOS DISC BRAKE PADS IN LDTs ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	58	47	37	29	23	17	13	10	7	5	4	3	0	0	0	0
1967	104	85	68	54	43	33	25	19	14	10	8	6	4	0	0	0
1968	300	250	204	164	130	102	79	60	45	34	25	18	14	10	0	0
1969	1,118	943	787	642	517	409	322	250	189	142	107	78	58	44	32	0
1970	2,793	2,401	2,026	1,690	1,378	1,110	879	692	536	405	306	231	168	125	94	69
1971	3,253	2,835	2,437	2,057	1,715	1,399	1,127	892	703	544	411	310	234	171	127	95
1972	5,501	4,859	4,235	3,639	3,072	2,562	2,089	1,683	1,333	1,049	813	614	463	350	255	189
1973	6,574	5,869	5,183	4,517	3,882	3,277	2,733	2,228	1,795	1,422	1,119	867	655	494	373	272
1974	7,593	6,886	6,146	5,428	4,731	4,066	3,432	2,862	2,334	1,880	1,489	1,172	908	686	517	391
1975	6,628	6,133	5,561	4,964	4,384	3,821	3,284	2,772	2,312	1,885	1,518	1,203	947	734	554	418
1976	9,534	8,936	8,269	7,498	6,693	5,911	5,152	4,428	3,738	3,117	2,542	2,047	1,622	1,277	989	748
1977	12,138	11,540	10,816	10,008	9,076	8,101	7,155	6,236	5,359	4,524	3,772	3,076	2,478	1,963	1,545	1,197
1978	13,716	13,216	12,564	11,776	10,897	9,882	8,821	7,790	6,790	5,835	4,926	4,107	3,349	2,698	2,137	1,682
1979	14,676	14,281	13,761	13,082	12,262	11,346	10,289	9,184	8,111	7,070	6,076	5,129	4,277	3,488	2,809	2,225
1980	8,352	8,176	7,956	7,666	7,288	6,831	6,321	5,732	5,117	4,519	3,939	3,385	2,857	2,383	1,943	1,565
1981	8,300	8,163	7,991	7,776	7,492	7,123	6,676	6,178	5,602	5,001	4,416	3,849	3,308	2,792	2,328	1,899
1982	7,241	7,152	7,034	6,886	6,700	6,456	6,138	5,753	5,323	4,827	4,309	3,806	3,317	2,850	2,406	2,006
1983	6,587	6,514	6,434	6,327	6,194	6,027	5,808	5,521	5,175	4,789	4,342	3,876	3,423	2,984	2,564	2,165
1984	7,485	7,433	7,350	7,260	7,140	6,989	6,801	6,553	6,230	5,839	5,404	4,900	4,374	3,863	3,367	2,893
1985	5,993	5,969	5,927	5,861	5,789	5,693	5,573	5,424	5,226	4,968	4,657	4,309	3,907	3,488	3,080	2,685
1986	--	2,706	2,695	2,676	2,646	2,614	2,571	2,517	2,449	2,360	2,243	2,103	1,946	1,764	1,575	1,391
1987	--	--	2,237	2,228	2,212	2,188	2,161	2,125	2,080	2,024	1,950	1,854	1,738	1,608	1,458	1,302
1988	--	--	--	1,710	1,703	1,691	1,672	1,652	1,625	1,590	1,548	1,491	1,418	1,329	1,229	1,115
1989	--	--	--	--	1,114	1,109	1,101	1,089	1,076	1,058	1,036	1,008	971	923	865	801
1990	--	--	--	--	--	516	514	510	505	498	490	480	467	450	428	401
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	127,944	124,391	119,717	113,939	107,081	99,274	90,736	82,159	73,672	65,396	57,449	49,922	42,903	36,472	30,677	25,508

EXHIBIT G-2:FUTURE SALES OF ASBESTOS DISC BRAKES FOR LDTs

SALES FORECASTS: DISC BRAKE PADS FOR LIGHT DUTY TRUCKS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	47	0	0	0	17	0	0	0	5	0	0	0	0	0	0
1967	0	0	68	0	0	0	25	0	0	0	8	0	0	0	0	0
1968	0	0	0	164	0	0	0	60	0	0	0	18	0	0	0	0
1969	1,118	0	0	0	517	0	0	0	189	0	0	0	58	0	0	0
1970	0	2,401	0	0	0	1,110	0	0	0	405	0	0	0	125	0	0
1971	0	0	2,437	0	0	0	1,127	0	0	0	411	0	0	0	127	0
1972	0	0	0	3,639	0	0	0	1,683	0	0	0	614	0	0	0	189
1973	6,574	0	0	0	3,882	0	0	0	1,795	0	0	0	655	0	0	0
1974	0	6,886	0	0	0	4,066	0	0	0	1,880	0	0	0	686	0	0
1975	0	0	5,561	0	0	0	3,284	0	0	0	1,518	0	0	0	554	0
1976	0	0	0	7,498	0	0	0	4,428	0	0	0	2,047	0	0	0	748
1977	12,138	0	0	0	9,076	0	0	0	5,359	0	0	0	2,478	0	0	0
1978	0	13,216	0	0	0	9,882	0	0	0	5,835	0	0	0	2,698	0	0
1979	0	0	13,761	0	0	0	10,289	0	0	0	6,076	0	0	0	2,809	0
1980	0	0	0	7,666	0	0	0	5,732	0	0	0	3,385	0	0	0	1,565
1981	8,300	0	0	0	7,492	0	0	0	5,602	0	0	0	3,308	0	0	0
1982	0	7,152	0	0	0	6,456	0	0	0	4,827	0	0	0	2,850	0	0
1983	0	0	6,434	0	0	0	5,808	0	0	0	4,342	0	0	0	2,564	0
1984	0	0	0	7,260	0	0	0	6,553	0	0	0	4,900	0	0	0	2,893
1985	5,993	0	0	0	5,789	0	0	0	5,226	0	0	0	3,907	0	0	0
1986	--	2,706	0	0	0	2,614	0	0	0	2,360	0	0	0	1,764	0	0
1987	--	--	2,237	0	0	0	2,161	0	0	0	1,950	0	0	0	1,458	0
1988	--	--	--	1,710	0	0	0	1,652	0	0	0	1,491	0	0	0	1,115
1989	--	--	--	--	1,114	0	0	0	1,076	0	0	0	971	0	0	0
1990	--	--	--	--	--	516	0	0	0	498	0	0	0	450	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	34,123	32,407	30,497	27,938	27,870	24,661	22,693	20,107	19,246	15,811	14,306	12,456	11,378	8,574	7,512	6,510
NEW SALES:	5,993	2,706	2,237	1,710	1,114	516	0	0	0	0	0	0	0	0	0	0
REPLACEMENT SALES:	28,130	29,701	28,261	26,228	26,756	24,145	22,693	20,107	19,246	15,811	14,306	12,456	11,378	8,574	7,512	6,510

EXHIBIT H-1: OUTSTANDING STOCK OF ASBESTOS DRUM BRAKES IN CARS

MODEL YEAR	NUMBER OF ASBESTOS DRUM BRAKE PADS IN CARS ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	D	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	2,009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	3,285	2,314	0	D	0	0	0	0	0	0	0	0	0	0	0	0
1966	4,388	3,114	2,194	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	5,434	4,011	2,847	2,006	D	0	0	0	0	0	0	0	0	0	0	0
1968	8,107	6,080	4,488	3,185	2,244	D	0	0	0	0	0	0	0	0	0	0
1969	9,834	7,392	5,544	4,092	2,904	2,046	0	0	0	0	0	0	0	0	0	0
1970	13,699	10,206	7,672	5,754	4,247	3,014	2,123	0	0	0	0	0	0	0	0	0
1971	13,886	10,480	7,808	5,869	4,402	3,249	2,306	1,624	0	0	0	0	0	0	0	0
1972	18,773	14,255	10,758	8,015	6,025	4,518	3,335	2,367	1,668	0	0	0	0	0	0	0
1973	22,345	17,291	13,129	9,909	7,382	5,549	4,162	3,072	2,180	1,536	0	0	0	0	0	0
1974	24,109	19,211	14,866	11,288	8,519	6,347	4,771	3,578	2,641	1,874	1,320	0	0	0	0	0
1975	21,162	17,589	14,015	10,845	8,235	6,215	4,630	3,480	2,610	1,927	1,367	963	0	0	0	0
1976	29,125	25,726	21,381	17,037	13,184	10,011	7,555	5,629	4,231	3,173	2,342	1,662	1,171	0	0	0
1977	34,940	32,108	28,360	23,571	18,782	14,534	11,036	8,329	6,205	4,664	3,498	2,582	1,832	1,291	0	0
1978	38,012	35,634	32,746	28,923	24,039	19,155	14,823	11,255	8,494	6,328	4,757	3,568	2,633	1,869	1,317	0
1979	38,408	36,844	34,538	31,739	28,034	23,300	18,566	14,367	10,909	8,233	6,134	4,611	3,458	2,552	1,811	1,276
1980	34,008	33,086	31,738	29,753	27,341	24,150	20,071	15,993	12,376	9,397	7,092	5,284	3,972	2,979	2,199	1,560
1981	32,156	31,564	30,708	29,457	27,614	25,376	22,414	18,629	14,844	11,487	8,722	6,583	4,904	3,686	2,765	2,041
1982	29,288	28,962	28,428	27,658	26,531	24,871	22,855	20,187	16,778	13,369	10,346	7,856	5,929	4,417	3,320	2,490
1983	29,321	29,115	28,790	28,260	27,494	26,374	24,724	22,720	20,068	16,679	13,290	10,284	7,809	5,894	4,391	3,300
1984	37,444	37,331	37,068	36,656	35,980	35,005	33,579	31,478	28,927	25,550	21,236	16,921	13,094	9,942	7,504	5,590
1985	37,543	37,468	37,355	37,092	36,679	36,004	35,027	33,601	31,498	28,945	25,567	21,249	16,932	13,102	9,949	7,509
1986	--	37,588	37,512	37,400	37,137	36,723	36,046	35,069	33,641	31,536	28,980	25,597	21,275	16,952	13,118	9,961
1987	--	--	34,637	34,568	34,464	34,222	33,841	33,217	32,317	31,000	29,061	26,705	23,588	19,605	15,621	12,088
1988	--	--	--	30,308	30,247	30,156	29,944	29,611	29,065	28,277	27,125	25,428	23,367	20,639	17,154	13,669
1989	--	--	--	--	25,518	25,467	25,391	25,212	24,931	24,472	23,808	22,839	21,410	19,675	17,378	14,443
1990	--	--	--	--	--	19,541	19,502	19,443	19,306	19,091	18,740	18,232	17,489	16,395	15,066	13,307
1991	--	--	--	--	--	--	15,173	15,143	15,097	14,991	14,824	14,551	14,156	13,580	12,730	11,698
1992	--	--	--	--	--	--	--	12,759	12,734	12,695	12,606	12,466	12,236	11,904	11,419	10,705
1993	--	--	--	--	--	--	--	--	9,042	9,024	8,997	8,934	8,834	8,672	8,437	8,093
1994	--	--	--	--	--	--	--	--	--	4,215	4,206	4,194	4,164	4,118	4,042	3,932
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	487,277	477,367	466,584	453,383	437,001	415,825	391,874	366,763	339,563	308,466	274,019	240,507	208,254	177,272	148,220	121,663

EX"IBIT H-2: FUTURE SALES OF ASBESTOS DRUM BRAKES FOR CARS

SALES FORECASTS: DRUM BRAKE LININGS FOR CARS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	3,285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	3,114	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	2,847	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	3,185	0	0	0	0	0	0	0	0	0	0	0	0
1969	9,834	0	0	0	2,904	0	0	0	0	0	0	0	0	0	0	0
1970	0	10,206	0	0	0	3,014	0	0	0	0	0	0	0	0	0	0
1971	0	0	7,808	0	0	0	2,306	0	0	0	0	0	0	0	0	0
1972	0	0	0	8,015	0	0	0	2,367	0	0	0	0	0	0	0	0
1973	22,345	0	0	0	7,382	0	0	0	2,180	0	0	0	0	0	0	0
1974	0	19,211	0	0	0	6,347	0	0	0	1,874	0	0	0	0	0	0
1975	0	0	14,015	0	0	0	4,630	0	0	0	1,367	0	0	0	0	0
1976	0	0	0	17,037	0	0	0	5,629	0	0	0	1,662	0	0	0	0
1977	34,940	0	0	0	18,782	0	0	0	6,205	0	0	0	1,832	0	0	0
1978	0	35,634	0	0	0	19,155	0	0	0	6,328	0	0	0	1,869	0	0
1979	0	0	34,538	0	0	0	18,566	0	0	0	6,134	0	0	0	1,811	0
1980	0	0	0	29,753	0	0	0	15,993	0	0	0	5,284	0	0	0	1,560
1981	32,156	0	0	0	27,614	0	0	0	14,844	0	0	0	4,904	0	0	0
1982	0	28,962	0	0	0	24,871	0	0	0	13,369	0	0	0	4,417	0	0
1983	0	0	28,790	0	0	0	24,724	0	0	0	13,290	0	0	0	4,391	0
1984	0	0	0	36,656	0	0	0	31,478	0	0	0	16,921	0	0	0	5,590
1985	37,543	0	0	0	36,679	0	0	0	31,498	0	0	0	16,932	0	0	0
1986	--	37,588	0	0	0	36,723	0	0	0	31,536	0	0	0	16,952	0	0
1987	--	--	34,637	0	0	0	33,841	0	0	0	29,061	0	0	0	15,621	0
1988	--	--	--	30,308	0	0	0	29,611	0	0	0	25,428	0	0	0	13,669
1989	--	--	--	--	25,518	0	0	0	24,931	0	0	0	21,410	0	0	0
1990	--	--	--	--	--	19,541	0	0	0	19,091	0	0	0	16,395	0	0
1991	--	--	--	--	--	--	15,173	0	0	0	14,824	0	0	0	12,730	0
1992	--	--	--	--	--	--	--	12,759	0	0	0	12,466	0	0	0	10,705
1993	--	--	--	--	--	--	--	--	9,042	0	0	0	8,834	0	0	0
1994	--	--	--	--	--	--	--	--	--	4,215	0	0	0	4,118	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	140,102	134,714	122,635	124,952	118,879	109,650	99,239	97,837	88,701	76,414	64,676	61,761	53,912	43,750	34,554	31,524
NEW SALES:	37,543	37,588	34,637	30,308	25,518	19,541	15,173	12,759	9,042	4,215	0	0	0	0	0	0
REPLACEMENT SALES:	102,560	97,127	87,998	94,645	93,361	90,109	84,066	85,077	79,658	72,199	64,676	61,761	53,912	43,750	34,554	31,524

EXHIBIT 1-1: OUTSTANDING STOCK OF ASBESTOS DISC BRAKES IN CARS

MODEL YEAR	NUMBER OF ASBESTOS DISC BRAKE PADS IN CARS ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	90	64	45	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	174	128	91	64	0	0	0	0	0	0	0	0	0	0	0	0
1968	554	415	307	218	153	0	0	0	0	0	0	0	0	0	0	0
1969	1,588	1,193	895	661	469	330	0	0	0	0	0	0	0	0	0	0
1970	3,533	2,632	1,978	1,484	1,095	777	548	0	0	0	0	0	0	0	0	0
1971	6,406	4,835	3,602	2,707	2,031	1,499	1,064	749	0	0	0	0	0	0	0	0
1972	10,931	8,300	6,264	4,667	3,508	2,631	1,942	1,378	971	0	0	0	0	0	0	0
1973	16,758	12,968	9,847	7,432	5,537	4,162	3,121	2,304	1,635	1,152	0	0	0	0	0	0
1974	17,500	13,944	10,791	8,194	6,184	4,607	3,463	2,597	1,917	1,360	958	0	0	0	0	0
1975	17,990	14,952	11,914	9,220	7,000	5,283	3,936	2,959	2,219	1,638	1,162	819	0	0	0	0
1976	28,032	24,760	20,578	16,397	12,689	9,635	7,272	5,417	4,072	3,054	2,254	1,600	1,127	0	0	0
1977	36,058	33,136	29,268	24,325	19,383	14,999	11,389	8,595	6,404	4,813	3,610	2,665	1,891	1,332	0	0
1978	39,685	37,201	34,186	30,196	25,097	19,997	15,475	11,750	8,868	6,607	4,966	3,725	2,749	1,951	1,375	0
1979	40,252	38,612	36,196	33,263	29,380	24,418	19,457	15,057	11,433	8,628	6,428	4,832	3,624	2,675	1,898	1,337
1980	36,048	35,071	33,643	31,538	28,982	25,599	21,276	16,953	13,119	9,961	7,518	5,601	4,210	3,158	2,331	1,654
1981	34,214	33,584	32,673	31,342	29,381	27,000	23,848	19,821	15,794	12,222	9,280	7,004	5,218	3,922	2,942	2,171
1982	25,865	25,913	25,436	24,746	23,738	22,253	20,450	18,062	15,012	11,962	9,257	7,029	5,305	3,952	2,971	2,228
1983	21,959	21,926	21,682	21,282	20,705	19,862	18,619	17,110	15,113	12,561	10,009	7,745	5,881	4,438	3,307	2,486
1984	22,098	21,707	21,554	21,314	20,921	20,354	19,525	18,303	16,820	14,857	12,348	9,839	7,614	5,781	4,363	3,251
1985	15,095	15,065	15,019	14,914	14,748	14,476	14,084	13,510	12,665	11,638	10,280	8,544	6,808	5,268	4,000	3,019
1986	--	6,985	6,971	6,950	6,901	6,824	6,698	6,517	6,251	5,860	5,385	4,757	3,953	3,150	2,438	1,851
1987	--	--	5,793	5,781	5,764	5,723	5,660	5,555	5,405	5,185	4,860	4,466	3,945	3,279	2,613	2,022
1988	--	--	--	4,345	4,336	4,323	4,292	4,245	4,166	4,054	3,888	3,645	3,350	2,959	2,459	1,959
1989	--	--	--	--	2,845	2,839	2,831	2,811	2,780	2,729	2,655	2,546	2,387	2,194	1,938	1,610
1990	--	--	--	--	--	1,307	1,305	1,301	1,292	1,277	1,254	1,220	1,170	1,097	1,008	890
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	374,828	353,391	328,733	301,038	270,846	238,900	206,253	174,995	145,934	119,557	96,112	76,035	59,231	45,155	33,640	24,478

EXHIBIT I-2: FUTURE SALES OF ASBESTOS DISC BRAKES FOR CARS

SALES FORECASTS: DISC BRAKE PADS FOR CARS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	218	0	0	0	0	0	0	0	0	0	0	0	0
1969	1,588	0	0	0	469	0	0	0	0	0	0	0	0	0	0	0
1970	0	2,632	0	0	0	777	0	0	0	0	0	0	0	0	0	0
1971	0	0	3,602	0	0	0	1,064	0	0	0	0	0	0	0	0	0
1972	0	0	0	4,667	0	0	0	1,378	0	0	0	0	0	0	0	0
1973	16,758	0	0	0	5,537	0	0	0	1,635	0	0	0	0	0	0	0
1974	0	13,944	0	0	0	4,607	0	0	0	1,360	0	0	0	0	0	0
1975	0	0	11,914	0	0	0	3,936	0	0	0	1,162	0	0	0	0	0
1976	0	0	0	16,397	0	0	0	5,417	0	0	0	1,600	0	0	0	0
1977	36,058	0	0	0	19,383	0	0	0	6,404	0	0	0	1,891	0	0	0
1978	0	37,201	0	0	0	19,997	0	0	0	6,607	0	0	0	1,951	0	0
1979	0	0	36,196	0	0	0	19,457	0	0	0	6,428	0	0	0	1,898	0
1980	0	0	0	31,538	0	0	0	16,953	0	0	0	5,601	0	0	0	1,654
1981	34,214	0	0	0	29,381	0	0	0	15,794	0	0	0	5,218	0	0	0
1982	0	25,913	0	0	0	22,253	0	0	0	11,962	0	0	0	3,952	0	0
1983	0	0	21,682	0	0	0	18,619	0	0	0	10,009	0	0	0	3,307	0
1984	0	0	0	21,314	0	0	0	18,303	0	0	0	9,839	0	0	0	3,251
1985	15,095	0	0	0	14,748	0	0	0	12,665	0	0	0	6,808	0	0	0
1986	--	6,985	0	0	0	6,824	0	0	0	5,860	0	0	0	3,150	0	0
1987	--	--	5,793	0	0	0	5,660	0	0	0	4,860	0	0	0	2,613	0
1988	--	--	--	4,345	0	0	0	4,245	0	0	0	3,645	0	0	0	1,959
1989	--	--	--	--	2,845	0	0	0	2,780	0	0	0	2,387	0	0	0
1990	--	--	--	--	--	1,307	0	0	0	1,277	0	0	0	1,097	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	103,713	86,739	79,278	78,478	72,362	55,766	48,736	46,297	39,277	27,067	22,459	20,685	16,304	10,150	7,817	6,864
NEW SALES:	15,095	6,985	5,793	4,345	2,845	1,307	0	0	0	0	0	0	0	0	0	0
REPLACEMENT SALES:	88,618	79,755	73,485	74,133	69,517	54,459	48,736	46,297	39,277	27,067	22,459	20,685	16,304	10,150	7,817	6,864

EXHIBIT J-1: OUTSTANDING STOCK OF ASBESTOS DRUM BRAKES IN LDTs

MODEL YEAR	NUMBER OF ASBESTOS DRUM BRAKE PADS IN LDTs ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	230	169	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	301	226	166	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	346	256	192	141	0	0	0	0	0	0	0	0	0	0	0	0
1959	602	439	325	244	179	0	0	0	0	0	0	0	0	0	0	0
1960	796	601	438	325	244	179	0	0	0	0	0	0	0	0	0	0
1961	1,027	774	585	427	316	237	174	0	0	0	0	0	0	0	0	0
1962	1,595	1,206	909	686	501	371	278	204	0	0	0	0	0	0	0	0
1963	2,377	1,842	1,392	1,049	792	578	428	321	236	0	0	0	0	0	0	0
1964	4,669	3,676	2,848	2,153	1,623	1,225	894	662	497	364	0	0	0	0	0	0
1965	4,661	3,692	2,907	2,252	1,702	1,283	969	707	524	393	288	0	0	0	0	0
1966	5,792	4,665	3,695	2,909	2,254	1,703	1,284	970	708	524	393	288	0	0	0	0
1967	6,707	5,470	4,405	3,490	2,747	2,128	1,609	1,213	916	668	495	371	272	0	0	0
1968	9,532	7,949	6,482	5,221	4,136	3,256	2,522	1,906	1,437	1,085	792	587	440	323	0	0
1969	7,236	6,108	5,093	4,154	3,345	2,650	2,086	1,616	1,222	921	695	507	376	282	207	0
1970	7,072	6,078	5,130	4,278	3,489	2,810	2,226	1,752	1,358	1,026	774	584	426	316	237	174
1971	6,188	5,393	4,635	3,913	3,263	2,661	2,143	1,697	1,336	1,035	783	590	445	325	241	181
1972	7,694	6,795	5,923	5,090	4,297	3,583	2,922	2,353	1,864	1,467	1,137	859	648	489	357	264
1973	8,854	7,904	6,980	6,084	5,228	4,414	3,680	3,001	2,417	1,915	1,507	1,168	883	665	502	367
1974	9,889	8,968	8,005	7,070	6,162	5,295	4,470	3,727	3,040	2,448	1,939	1,527	1,183	894	674	509
1975	7,419	6,865	6,226	5,557	4,908	4,278	3,676	3,103	2,588	2,110	1,700	1,346	1,060	821	621	468
1976	9,962	9,338	8,641	7,835	6,994	6,177	5,384	4,627	3,906	3,257	2,656	2,139	1,694	1,334	1,033	781
1977	12,334	11,726	10,990	10,170	9,222	8,232	7,270	6,337	5,446	4,597	3,833	3,126	2,518	1,994	1,570	1,216
1978	13,716	13,216	12,564	11,776	10,897	9,882	8,821	7,790	6,790	5,835	4,926	4,107	3,349	2,698	2,137	1,682
1979	14,676	14,281	13,761	13,082	12,262	11,346	10,289	9,184	8,111	7,070	6,076	5,129	4,277	3,488	2,809	2,225
1980	8,352	8,176	7,956	7,666	7,288	6,831	6,321	5,732	5,117	4,519	3,939	3,385	2,857	2,383	1,943	1,565
1981	8,300	8,163	7,991	7,776	7,492	7,123	6,676	6,178	5,602	5,001	4,416	3,849	3,308	2,792	2,328	1,899
1982	8,724	8,617	8,474	8,296	8,073	7,778	7,395	6,931	6,414	5,816	5,192	4,585	3,996	3,434	2,899	2,417
1983	9,481	9,376	9,261	9,107	8,915	8,676	8,359	7,947	7,449	6,893	6,250	5,579	4,927	4,295	3,691	3,116
1984	13,748	13,652	13,500	13,334	13,113	12,837	12,492	12,037	11,443	10,725	9,925	9,000	8,034	7,095	6,184	5,314
1985	15,919	15,855	15,744	15,569	15,378	15,123	14,804	14,407	13,881	13,197	12,369	11,446	10,379	9,265	8,182	7,132
1986	--	16,687	16,620	16,503	16,320	16,120	15,853	15,519	15,102	14,551	13,834	12,966	11,998	10,880	9,712	8,577
1987	--	--	13,794	13,738	13,642	13,490	13,325	13,104	12,828	12,483	12,028	11,435	10,718	9,918	8,993	8,028
1988	--	--	--	10,545	10,503	10,429	10,313	10,186	10,018	9,807	9,543	9,195	8,742	8,193	7,582	6,875
1989	--	--	--	--	6,867	6,840	6,792	6,716	6,634	6,524	6,386	6,215	5,988	5,693	5,336	4,938
1990	--	--	--	--	--	3,182	3,169	3,147	3,112	3,074	3,023	2,959	2,880	2,775	2,638	2,472
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	208,390	208,161	205,632	200,439	192,151	180,716	166,625	153,076	139,992	127,305	114,898	102,943	91,398	80,351	69,876	60,200

EXHIBIT J-2: FUTURE SALES OF ASBESTOS DRUM BRAKES FOR LDTs

MODEL YEAR	SALES FORECASTS: DRUM BRAKE PADS FOR LIGHT DUTY TRUCKS, 1986-2000 (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1957	301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	256	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	325	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	325	0	0	0	0	0	0	0	0	0	0	0	0
1961	1,027	0	0	0	316	0	0	0	0	0	0	0	0	0	0	0
1962	0	1,206	0	0	0	371	0	0	0	0	0	0	0	0	0	0
1963	0	0	1,392	0	0	0	428	0	0	0	0	0	0	0	0	0
1964	0	0	0	2,153	0	0	0	662	0	0	0	0	0	0	0	0
1965	4,661	0	0	0	1,702	0	0	0	524	0	0	0	0	0	0	0
1966	0	4,665	0	0	0	1,703	0	0	0	524	0	0	0	0	0	0
1967	0	0	4,405	0	0	0	1,609	0	0	0	495	0	0	0	0	0
1968	0	0	0	5,221	0	0	0	1,906	0	0	0	587	0	0	0	0
1969	7,236	0	0	0	3,345	0	0	0	1,222	0	0	0	376	0	0	0
1970	0	6,078	0	0	0	2,810	0	0	0	1,026	0	0	0	316	0	0
1971	0	0	4,635	0	0	0	2,143	0	0	0	783	0	0	0	241	0
1972	0	0	0	5,090	0	0	0	2,353	0	0	0	859	0	0	0	264
1973	8,854	0	0	0	5,228	0	0	0	2,417	0	0	0	883	0	0	0
1974	0	8,968	0	0	0	5,295	0	0	0	2,448	0	0	0	894	0	0
1975	0	0	6,226	0	0	0	3,676	0	0	0	1,700	0	0	0	621	0
1976	0	0	0	7,835	0	0	0	4,627	0	0	0	2,139	0	0	0	781
1977	12,334	0	0	0	9,222	0	0	0	5,446	0	0	0	2,518	0	0	0
1978	0	13,216	0	0	0	9,882	0	0	0	5,835	0	0	0	2,698	0	0
1979	0	0	13,761	0	0	0	10,289	0	0	0	6,076	0	0	0	2,809	0
1980	0	0	0	7,666	0	0	0	5,732	0	0	0	3,385	0	0	0	1,565
1981	8,300	0	0	0	7,492	0	0	0	5,602	0	0	0	3,308	0	0	0
1982	0	8,617	0	0	0	7,778	0	0	0	5,816	0	0	0	3,434	0	0
1983	0	0	9,261	0	0	0	8,359	0	0	0	6,250	0	0	0	3,691	0
1984	0	0	0	13,334	0	0	0	12,037	0	0	0	9,000	0	0	0	5,314
1985	15,919	0	0	0	15,378	0	0	0	13,881	0	0	0	10,379	0	0	0
1986	--	16,687	0	0	0	16,120	0	0	0	14,551	0	0	0	10,880	0	0
1987	--	--	13,794	0	0	0	13,325	0	0	0	12,028	0	0	0	8,993	0
1988	--	--	--	10,545	0	0	0	10,186	0	0	0	9,195	0	0	0	6,875
1989	--	--	--	--	6,867	0	0	0	6,634	0	0	0	5,988	0	0	0
1990	--	--	--	--	--	3,182	0	0	0	3,074	0	0	0	2,775	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	58,633	59,692	53,798	52,169	49,551	47,141	39,829	37,504	35,725	33,274	27,331	25,165	23,452	20,996	16,355	14,800
NEW SALES:	15,919	16,687	13,794	10,545	6,867	3,182	0	0	0	0	0	0	0	0	0	0
REPLACEMENT SALES:	42,714	43,005	40,004	41,624	42,684	43,959	39,829	37,504	35,725	33,274	27,331	25,165	23,452	20,996	16,355	14,800

EXHIBIT K-1: OUTSTANDING STOCK OF ASBESTOS DISC BRAKES IN LDTs

MODEL YEAR	NUMBER OF ASBESTOS DISC BRAKE PADS IN LDTs ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	58	47	37	29	23	17	13	10	7	5	4	3	0	0	0	0
1967	104	85	68	54	43	33	25	19	14	10	8	6	4	0	0	0
1968	300	250	204	164	130	102	79	60	45	34	25	18	14	10	0	0
1969	1,118	943	787	642	517	409	322	250	189	142	107	78	58	44	32	0
1970	2,793	2,401	2,026	1,690	1,378	1,110	879	692	536	405	306	231	168	125	94	69
1971	3,253	2,835	2,437	2,057	1,715	1,399	1,127	892	703	544	411	310	234	171	127	95
1972	5,501	4,859	4,235	3,639	3,072	2,562	2,089	1,683	1,333	1,049	813	614	463	350	255	189
1973	6,574	5,869	5,183	4,517	3,882	3,277	2,733	2,228	1,795	1,422	1,119	867	655	494	373	272
1974	7,593	6,886	6,146	5,428	4,731	4,066	3,432	2,862	2,334	1,880	1,489	1,172	908	686	517	391
1975	6,628	6,133	5,561	4,964	4,384	3,821	3,284	2,772	2,312	1,885	1,518	1,203	947	734	554	418
1976	9,534	8,936	8,269	7,498	6,693	5,911	5,152	4,428	3,738	3,117	2,542	2,047	1,622	1,277	989	748
1977	12,138	11,540	10,816	10,008	9,076	8,101	7,155	6,236	5,359	4,524	3,772	3,076	2,478	1,963	1,545	1,197
1978	13,716	13,216	12,564	11,776	10,897	9,882	8,821	7,790	6,790	5,835	4,926	4,107	3,349	2,698	2,137	1,682
1979	14,676	14,281	13,761	13,082	12,262	11,346	10,289	9,184	8,111	7,070	6,076	5,129	4,277	3,488	2,809	2,225
1980	8,352	8,176	7,956	7,666	7,288	6,831	6,321	5,732	5,117	4,519	3,939	3,385	2,857	2,383	1,943	1,565
1981	8,300	8,163	7,991	7,776	7,492	7,123	6,676	6,178	5,602	5,001	4,416	3,849	3,308	2,792	2,328	1,899
1982	7,241	7,152	7,034	6,886	6,700	6,456	6,138	5,753	5,323	4,827	4,309	3,806	3,317	2,850	2,406	2,006
1983	6,587	6,514	6,434	6,327	6,194	6,027	5,808	5,521	5,175	4,789	4,342	3,876	3,423	2,984	2,564	2,165
1984	7,485	7,433	7,350	7,260	7,140	6,989	6,801	6,553	6,230	5,839	5,404	4,900	4,374	3,863	3,367	2,893
1985	5,993	5,969	5,927	5,861	5,789	5,693	5,573	5,424	5,226	4,968	4,657	4,309	3,907	3,488	3,080	2,685
1986	--	2,706	2,695	2,676	2,646	2,614	2,571	2,517	2,449	2,360	2,243	2,103	1,946	1,764	1,575	1,391
1987	--	--	1,864	1,857	1,843	1,823	1,801	1,771	1,734	1,687	1,625	1,545	1,448	1,340	1,215	1,085
1988	--	--	--	950	946	940	929	918	903	884	860	828	788	738	683	619
1989	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0	0
1990	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	127,944	124,391	119,344	112,808	104,842	96,533	88,017	79,472	71,023	62,796	54,910	47,463	40,546	34,240	28,595	23,594

EXHIBIT K-2: FUTURE SALES OF ASBESTOS DISC BRAKES FOR LDTs

SALES FORECASTS: DISC BRAKE PADS FOR LIGHT DUTY TRUCKS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	47	0	0	0	17	0	0	0	5	0	0	0	0	0	0
1967	0	0	68	0	0	0	25	0	0	0	8	0	0	0	0	0
1968	0	0	0	164	0	0	0	60	0	0	0	18	0	0	0	0
1969	1,118	0	0	0	517	0	0	0	189	0	0	0	58	0	0	0
1970	0	2,401	0	0	0	1,110	0	0	0	405	0	0	0	125	0	0
1971	0	0	2,437	0	0	0	1,127	0	0	0	411	0	0	0	127	0
1972	0	0	0	3,639	0	0	0	1,683	0	0	0	614	0	0	0	189
1973	6,574	0	0	0	3,882	0	0	0	1,795	0	0	0	655	0	0	0
1974	0	6,886	0	0	0	4,066	0	0	0	1,880	0	0	0	686	0	0
1975	0	0	5,561	0	0	0	3,284	0	0	0	1,518	0	0	0	554	0
1976	0	0	0	7,498	0	0	0	4,428	0	0	0	2,047	0	0	0	748
1977	12,138	0	0	0	9,076	0	0	0	5,359	0	0	0	2,478	0	0	0
1978	0	13,216	0	0	0	9,882	0	0	0	5,835	0	0	0	2,698	0	0
1979	0	0	13,761	0	0	0	10,289	0	0	0	6,076	0	0	0	2,809	0
1980	0	0	0	7,666	0	0	0	5,732	0	0	0	3,385	0	0	0	1,565
1981	8,300	0	0	0	7,492	0	0	0	5,602	0	0	0	3,308	0	0	0
1982	0	7,152	0	0	0	6,456	0	0	0	4,827	0	0	0	2,850	0	0
1983	0	0	6,434	0	0	0	5,808	0	0	0	4,342	0	0	0	2,564	0
1984	0	0	0	7,260	0	0	0	6,553	0	0	0	4,900	0	0	0	2,893
1985	5,993	0	0	0	5,789	0	0	0	5,226	0	0	0	3,907	0	0	0
1986	--	2,706	0	0	0	2,614	0	0	0	2,360	0	0	0	1,764	0	0
1987	--	--	1,864	0	0	0	1,801	0	0	0	1,625	0	0	0	1,215	0
1988	--	--	--	950	0	0	0	918	0	0	0	828	0	0	0	619
1989	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0	0
1990	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	34,123	32,407	30,125	27,178	26,756	24,145	22,333	19,373	18,171	15,312	13,981	11,793	10,407	8,124	7,269	6,014
NEW SALES:	5,993	2,706	1,864	950	0	0	0	0	0	0	0	0	0	0	0	0
REPLACEMENT SALES:	28,130	29,701	28,261	26,228	26,756	24,145	22,333	19,373	18,171	15,312	13,981	11,793	10,407	8,124	7,269	6,014

EXHIBIT L-1: OUTSTANDING STOCK OF ASBESTOS DRUM BRAKES IN CARS

MODEL YEAR	NUMBER OF ASBESTOS DRUM BRAKE PADS IN CARS ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	2,009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	3,285	2,314	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	4,388	3,114	2,194	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	5,434	4,011	2,847	2,006	0	0	0	0	0	0	0	0	0	0	0	0
1968	8,107	6,080	4,488	3,185	2,244	0	0	0	0	0	0	0	0	0	0	0
1969	9,834	7,392	5,544	4,092	2,904	2,046	0	0	0	0	0	0	0	0	0	0
1970	13,699	10,206	7,672	5,754	4,247	3,014	2,123	0	0	0	0	0	0	0	0	0
1971	13,886	10,480	7,808	5,869	4,402	3,249	2,306	1,624	0	0	0	0	0	0	0	0
1972	18,773	14,255	10,758	8,015	6,025	4,518	3,335	2,367	1,668	0	0	0	0	0	0	0
1973	22,345	17,291	13,129	9,909	7,382	5,549	4,162	3,072	2,180	1,536	0	0	0	0	0	0
1974	24,109	19,211	14,866	11,288	8,519	6,347	4,771	3,578	2,641	1,874	1,320	0	0	0	0	0
1975	21,162	17,589	14,015	10,845	8,235	6,215	4,630	3,480	2,610	1,927	1,367	963	0	0	0	0
1976	29,125	25,726	21,381	17,037	13,184	10,011	7,555	5,629	4,231	3,173	2,342	1,662	1,171	0	0	0
1977	34,940	32,108	28,360	23,571	18,782	14,534	11,036	8,329	6,205	4,664	3,498	2,582	1,832	1,291	0	0
1978	38,012	35,634	32,746	28,923	24,039	19,155	14,823	11,255	8,494	6,328	4,757	3,568	2,633	1,869	1,317	0
1979	38,408	36,844	34,538	31,739	28,034	23,300	18,566	14,367	10,909	8,233	6,134	4,611	3,458	2,552	1,811	1,276
1980	34,008	33,086	31,738	29,753	27,341	24,150	20,071	15,993	12,376	9,397	7,092	5,284	3,972	2,979	2,199	1,560
1981	32,156	31,564	30,708	29,457	27,614	25,376	22,414	18,629	14,844	11,487	8,722	6,583	4,904	3,686	2,765	2,041
1982	29,288	28,962	28,428	27,658	26,531	24,871	22,855	20,187	16,778	13,369	10,346	7,856	5,929	4,417	3,320	2,490
1983	29,321	29,115	28,790	28,260	27,494	26,374	24,724	22,720	20,068	16,679	13,290	10,284	7,809	5,894	4,391	3,300
1984	37,444	37,331	37,068	36,656	35,980	35,005	33,579	31,478	28,927	25,550	21,236	16,921	13,094	9,942	7,504	5,590
1985	37,543	37,468	37,355	37,092	36,679	36,004	35,027	33,601	31,498	28,945	25,567	21,249	16,932	13,102	9,949	7,509
1986	--	37,588	37,512	37,400	37,137	36,723	36,046	35,069	33,641	31,536	28,980	25,597	21,275	16,952	13,118	9,961
1987	--	--	31,174	31,111	31,018	30,799	30,457	29,895	29,085	27,900	26,155	24,035	21,229	17,644	14,059	10,880
1988	--	--	--	23,380	23,333	23,263	23,100	22,842	22,422	21,814	20,925	19,616	18,026	15,922	13,233	10,544
1989	--	--	--	--	15,311	15,280	15,234	15,127	14,959	14,683	14,285	13,703	12,846	11,805	10,427	8,666
1990	--	--	--	--	--	7,035	7,021	7,000	6,950	6,873	6,746	6,563	6,296	5,902	5,424	4,791
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	487,277	477,367	463,120	442,998	416,434	382,817	343,835	306,243	270,486	235,970	202,762	171,077	141,406	113,957	89,516	68,608

EXHIBIT L-2: FUTURE SALES OF ASBESTOS DRUM BRAKES FOR CARS

MODEL YEAR	SALES FORECASTS: DRUM BRAKE LININGS FOR CARS, 1986-2000 (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	3,285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	3,114	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	2,847	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	3,185	0	0	0	0	0	0	0	0	0	0	0	0
1969	9,834	0	0	0	2,904	0	0	0	0	0	0	0	0	0	0	0
1970	0	10,206	0	0	0	3,014	0	0	0	0	0	0	0	0	0	0
1971	0	0	7,808	0	0	0	2,306	0	0	0	0	0	0	0	0	0
1972	0	0	0	8,015	0	0	0	2,367	0	0	0	0	0	0	0	0
1973	22,345	0	0	0	7,382	0	0	0	2,180	0	0	0	0	0	0	0
1974	0	19,211	0	0	0	6,347	0	0	0	1,874	0	0	0	0	0	0
1975	0	0	14,015	0	0	0	4,630	0	0	0	1,367	0	0	0	0	0
1976	0	0	0	17,037	0	0	0	5,629	0	0	0	1,662	0	0	0	0
1977	34,940	0	0	0	18,782	0	0	0	6,205	0	0	0	1,832	0	0	0
1978	0	35,634	0	0	0	19,155	0	0	0	6,328	0	0	0	1,869	0	0
1979	0	0	34,538	0	0	0	18,566	0	0	0	6,134	0	0	0	1,811	0
1980	0	0	0	29,753	0	0	0	15,993	0	0	0	5,284	0	0	0	1,560
1981	32,156	0	0	0	27,614	0	0	0	14,844	0	0	0	4,904	0	0	0
1982	0	28,962	0	0	0	24,871	0	0	0	13,369	0	0	0	4,417	0	0
1983	0	0	28,790	0	0	0	24,724	0	0	0	13,290	0	0	0	4,391	0
1984	0	0	0	36,656	0	0	0	31,478	0	0	0	16,921	0	0	0	5,590
1985	37,543	0	0	0	36,679	0	0	0	31,498	0	0	0	16,932	0	0	0
1986	--	37,588	0	0	0	36,723	0	0	0	31,536	0	0	0	16,952	0	0
1987	--	--	31,174	0	0	0	30,457	0	0	0	26,155	0	0	0	14,059	0
1988	--	--	--	23,380	0	0	0	22,842	0	0	0	19,616	0	0	0	10,544
1989	--	--	--	--	15,311	0	0	0	14,959	0	0	0	12,846	0	0	0
1990	--	--	--	--	--	7,035	0	0	0	6,873	0	0	0	5,902	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	140,102	134,714	119,172	118,025	108,672	97,144	80,682	78,309	69,686	59,981	46,946	43,483	36,514	29,140	20,261	17,695
NEW SALES:	37,543	37,588	31,174	23,380	15,311	7,035	0	0	0	0	0	0	0	0	0	0
REPLACEMENT SALES:	102,560	97,127	87,998	94,645	93,361	90,109	80,682	78,309	69,686	59,981	46,946	43,483	36,514	29,140	20,261	17,695

EXHIBIT M-1: OUTSTANDING STOCK OF ASBESTOS DISC BRAKES IN CARS

MODEL YEAR	NUMBER OF ASBESTOS DISC BRAKE PADS IN CARS ESTIMATED TO BE IN OPERATION BY MODEL YEAR (IN THOUSANDS)															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	90	64	45	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	174	128	91	64	0	0	0	0	0	0	0	0	0	0	0	0
1968	554	415	307	218	153	0	0	0	0	0	0	0	0	0	0	0
1969	1,588	1,193	895	661	469	330	0	0	0	0	0	0	0	0	0	0
1970	3,533	2,632	1,978	1,484	1,095	777	548	0	0	0	0	0	0	0	0	0
1971	6,406	4,835	3,602	2,707	2,031	1,499	1,064	749	0	0	0	0	0	0	0	0
1972	10,931	8,300	6,264	4,667	3,508	2,631	1,942	1,378	971	0	0	0	0	0	0	0
1973	16,758	12,968	9,847	7,432	5,537	4,162	3,121	2,304	1,635	1,152	0	0	0	0	0	0
1974	17,500	13,944	10,791	8,194	6,184	4,607	3,463	2,597	1,917	1,360	958	0	0	0	0	0
1975	17,990	14,952	11,914	9,220	7,000	5,283	3,936	2,959	2,219	1,638	1,162	819	0	0	0	0
1976	28,032	24,760	20,578	16,397	12,689	9,635	7,272	5,417	4,072	3,054	2,254	1,600	1,127	0	0	0
1977	36,058	33,136	29,268	24,325	19,383	14,999	11,389	8,595	6,404	4,813	3,610	2,665	1,891	1,332	0	0
1978	39,685	37,201	34,186	30,196	25,097	19,997	15,475	11,750	8,868	6,607	4,966	3,725	2,749	1,951	1,375	0
1979	40,252	38,612	36,196	33,263	29,380	24,418	19,457	15,057	11,433	8,628	6,428	4,832	3,624	2,675	1,898	1,337
1980	36,048	35,071	33,643	31,538	28,982	25,599	21,276	16,953	13,119	9,961	7,518	5,601	4,210	3,158	2,331	1,654
1981	34,214	33,584	32,673	31,342	29,381	27,000	23,848	19,821	15,794	12,222	9,280	7,004	5,218	3,922	2,942	2,171
1982	25,865	25,913	25,436	24,746	23,738	22,253	20,450	18,062	15,012	11,962	9,257	7,029	5,305	3,952	2,971	2,228
1983	21,959	21,926	21,682	21,282	20,705	19,862	18,619	17,110	15,113	12,561	10,009	7,745	5,881	4,438	3,307	2,486
1984	22,098	21,707	21,554	21,314	20,921	20,354	19,525	18,303	16,820	14,857	12,348	9,839	7,614	5,781	4,363	3,251
1985	15,095	15,065	15,019	14,914	14,748	14,476	14,084	13,510	12,665	11,638	10,280	8,544	6,808	5,268	4,000	3,019
1986	--	6,985	6,971	6,950	6,901	6,824	6,698	6,517	6,251	5,860	5,385	4,757	3,953	3,150	2,438	1,851
1987	--	--	4,827	4,818	4,803	4,769	4,716	4,629	4,504	4,320	4,050	3,722	3,287	2,732	2,177	1,685
1988	--	--	--	2,414	2,409	2,402	2,385	2,358	2,315	2,252	2,160	2,025	1,861	1,644	1,366	1,089
1989	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0	0
1990	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL	374,828	353,391	327,767	298,144	265,113	231,878	199,267	168,071	139,111	112,886	89,666	69,905	53,528	40,004	29,167	20,770

EXHIBIT M-2: FUTURE SALES OF ASBESTOS DISC BRAKES FOR CARS

SALES FORECASTS: DISC BRAKE PADS FOR CARS, 1986-2000
(IN THOUSANDS)

MODEL YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	218	0	0	0	0	0	0	0	0	0	0	0	0
1969	1,588	0	0	0	469	0	0	0	0	0	0	0	0	0	0	0
1970	0	2,632	0	0	0	777	0	0	0	0	0	0	0	0	0	0
1971	0	0	3,602	0	0	0	1,064	0	0	0	0	0	0	0	0	0
1972	0	0	0	4,667	0	0	0	1,378	0	0	0	0	0	0	0	0
1973	16,758	0	0	0	5,537	0	0	0	1,635	0	0	0	0	0	0	0
1974	0	13,944	0	0	0	4,607	0	0	0	1,360	0	0	0	0	0	0
1975	0	0	11,914	0	0	0	3,936	0	0	0	1,162	0	0	0	0	0
1976	0	0	0	16,397	0	0	0	5,417	0	0	0	1,600	0	0	0	0
1977	36,058	0	0	0	19,383	0	0	0	6,404	0	0	0	1,891	0	0	0
1978	0	37,201	0	0	0	19,997	0	0	0	6,607	0	0	0	1,951	0	0
1979	0	0	36,196	0	0	0	19,457	0	0	0	6,428	0	0	0	1,898	0
1980	0	0	0	31,538	0	0	0	16,953	0	0	0	5,601	0	0	0	1,654
1981	34,214	0	0	0	29,381	0	0	0	15,794	0	0	0	5,218	0	0	0
1982	0	25,913	0	0	0	22,253	0	0	0	11,962	0	0	0	3,952	0	0
1983	0	0	21,682	0	0	0	18,619	0	0	0	10,009	0	0	0	3,307	0
1984	0	0	0	21,314	0	0	0	18,303	0	0	0	9,839	0	0	0	3,251
1985	15,095	0	0	0	14,748	0	0	0	12,665	0	0	0	6,808	0	0	0
1986	--	6,985	0	0	0	6,824	0	0	0	5,860	0	0	0	3,150	0	0
1987	--	--	4,827	0	0	0	4,716	0	0	0	4,050	0	0	0	2,177	0
1988	--	--	--	2,414	0	0	0	2,358	0	0	0	2,025	0	0	0	1,089
1989	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0	0
1990	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0	0
1991	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	0
1992	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0
1993	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0	0
1994	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	0
1995	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0
1996	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0
1997	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0
1999	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
2000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
TOTAL SALES:	103,713	86,739	78,312	76,547	69,517	54,459	47,793	44,410	36,497	25,789	21,649	19,065	13,917	9,053	7,382	5,993
NEW SALES:	15,095	6,985	4,827	2,414	0	0	0	0	0	0	0	0	0	0	0	0
REPLACEMENT SALES:	88,618	79,755	73,485	74,133	69,517	54,459	47,793	44,410	36,497	25,789	21,649	19,065	13,917	9,053	7,382	5,993

A.2 FIBER SUPPLY FUNCTION ESTIMATION

Bans on selected asbestos-containing products and restrictions on asbestos fiber consumption may significantly disrupt the upstream market for asbestos fiber. In particular, the price of asbestos fiber as well as the quantity of asbestos fiber produced may change. This appendix first examines the asbestos fiber industry and conditions in the asbestos fiber market. The results of this examination are then used to estimate the elasticity of supply of asbestos fiber. This is a measure of the percentage change in the quantity of fiber supplied in response to a one percent change in fiber price. The elasticity of supply is used to estimate the extent to which the price of asbestos fiber would fall in response to a products ban or other exogenous shifts in fiber demand.

1. Asbestos Fiber Industry Profile

Asbestos is characterized by high tensile strength, non-combustibility, and resistance to chemical and thermal corrosion. These properties render it useful in a broad range of manufacturing activities. Several different mineral fiber types fall into the asbestos group; chrysotile, amosite, and crocidolite are the primary commercial fibers.

Chrysotile is the principal variety, constituting, by weight, 93 percent of U.S. consumption and virtually all of North American production in 1982. Chrysotile is graded according to fiber length. Since most North American production of asbestos occurs in Canada, the Quebec grading system provides a general industry standard. The Quebec system grades fibers from Grade 1 (longest) to Grade 8 (shortest). Further grading divisions are based on other physical and mineralogical characteristics such as color, tensile strength, and chemical composition.

Asbestos is mined through a number of techniques, including open pit, surface, and underground workings. In the important U.S. districts around Morrisville, Vermont, and Copperopolis, California, open pit techniques are used. The mined ore is milled close to the mine site and the fiber generally separated from surrounding rock by a dry process. Wet-milling and reprocessing of waste tailings have proven particularly useful in the production of short fibers and reduces harmful dust emissions (Clifton 1975, 1980). One U.S. mill currently uses the wet process.

1.1 Asbestos Production

Exhibit A.2.1-1 lists asbestos fiber production data for the United States, Canada, and the world. The United States is a relatively small producer of asbestos, producing about 1 percent of world asbestos fiber in 1982. U.S. production grew substantially in the 1960s and peaked in 1973 at 136,00 metric tons. Since 1973, U.S. production has declined 54 percent to 63,000 metric tons. The U.S. export data of Exhibit A.2.1-1 show that a growing proportion of U.S. production of asbestos fiber is exported. Thus, although Clifton (1983a) observes that the net import reliance of the United States was 74 percent in 1982, over 90 percent of U.S. production was exported and approximately 98 percent of U.S fiber consumption was supplied by foreign fiber producers. As shown in Exhibit A.2.1-2, three asbestos fiber producers currently operate in the United States: Calavaras Asbestos Corporation and

Exhibit A.2.1-1 Time Series of U.S. Production, Exports, and Imports of Asbestos Fiber, Canadian, and World Production (10^3 metric tons)

Year	U.S. production	U.S. exports	U.S. imports	Canadian production	World production
1982	63.52	58.77	241.74	821.96[a]	4,310.59[b]
1981	75.59	64.42	337.62	1,181.03	4,479.78[c]
1980	80.13	48.67	327.30	1,355.44	4,808.31
1979	93.29	43.29	513.08	1,499.55	4,906.39[d]
1978	93.10	41.78	570.02	1,398.0	4,693.28[d]
1977	92.29	34.16	550.70	1,587.57	4,793.45[d]
1976	104.9	42.57	596.74	1,542.38	5,086.07[d]
1975	89.47	33.08	488.52	1,022.78	4,138.76
1974	102.09	56.01	695.28	1,624.59	4,158.19
1973	136.12	54.45	719.15	1,627.59	4,186.68
1972	119.51	48.09	667.44	1,548.46	3,705.39
1971	118.78	53.19	618.30	1,561.25	3,585.64
1970	113.7	42.25	589.29	1,511.98	3,494.78
1969	114.25	32.82	630.27	1,459.07	3,265.99
1968	109.53	37.42	660.61	1,403.09	3,008.44
1967	111.78	43.3	585.40	1,311.8	2,910.40
1966	114.24	42.37	659.22	1,366.06	2,972.11
1965	107.35	39.02	652.96	1,280.31	2,814.88
1964	91.74	24.64	670.93	1,238.93	2,768.51
1963	60.44	9.11	606.04	1,151.18	2,506.35
1962	48.28	2.68	613.39	1,111.98	2,409.26
1961	47.91	3.45	559.46	1,060.71	2,513.61
1960	41.02	5.02	507.53	1,011.89	2,214.16
1959	41.02	4.05	647.05	972.41	2,050.82
1958	41.29	2.75	584.69	839.66	1,864.79
1957	39.66	2.62	619.54	949.27	1,887.48

[a] Canadian production as shipments.

[b] Estimated.

[c] Preliminary.

[d] Revised.

Sources: USDOI. 1972-1982. U.S. Department of the Interior. Minerals yearbook. Washington, DC: U.S. Bureau of Mines.

Energy, Mines, and Resources Canada. 1983 (January-September). Asbestos export summary. Ottawa, Canada.

Metals and Minerals Group. 1981. Asbestos historical statistics: 1970-81. Ottawa, Canada: Department of Industry, Trade, and Commerce.

Exhibit A.2.1-2 U.S. Deposits Mined Over the Past Decade

Mine	Owner	Remarks
Arizona:		
Chrysotile	Jaquays Mining Corporation	Closed in 1982.
California:		
Santa Cruz	Atlas Asbestos Corporation	Closed in 1979.
Copperopolis	Calaveras Asbestos Corporation	Previously owned by Pacific Asbestos Corp. Closed year end 1974. Reopened as Copperopolis in 1975.
Christie	Coalinga Asbestos Co., Inc.	Closed year end 1974.
Santa Rita	Union Carbide Corporation	
North Carolina:		
Hippy	Powhaten Mining Company	Ceased operation in 1979.
Boot Hill	Powhaten Mining Company	Ceased operation in 1972.
Vermont:		
Lowell	Vermont Asbestos Group	Previously owned by the GAF Corporation. Mine scheduled for closure in March 1975. Remained open for operation after purchase by an employee group in 1975.

Source: USDOI. 1957-1983. U.S. Department of the Interior. Minerals yearbook. Washington, DC: Bureau of Mines.

Union Carbide Corporation, both with mines in California, and the Vermont Asbestos Group (Clifton, 1983b).

Canada is a major world producer of asbestos. It shipped 821,000 metric tons in 1982, 19 percent of world production. Canadian shipments peaked at 1,627,000 metric tons in 1973. Like the United States, Canada has experienced a sharp reduction in shipments since 1978. Canada is the leading source of asbestos fiber for the U.S. market, supplying approximately 95 percent by weight of all imported fiber (see Exhibit 3). Crocidolite and amosite are exclusively supplied to the United States by South Africa (Clifton, 1983a, p. 13).

Current and recent U.S. and Canadian producers of asbestos fiber are listed in Exhibits A.2.1-2 and A.2.1-4. Past production figures and current capacity estimates for Canadian producers indicate the industry is experiencing a period of prolonged excess fiber capacity in North America. This has led to both permanent and temporary closings of mines and mills over the past decade in both the United States and Canada.

In the United States, four mines have closed since 1974 and two others have continued operation under new ownership. In Canada, one mine closed for lack of reserves and another closed after less than 2 years of operation. Temporary closings and a dramatic change in the structure of ownership over the past few years also have occurred. "Foreign" ownership of Canadian mines and mills (e.g., Johns-Manville, Eternit, General Dynamics, Turner & Newall, and Rio Tinto-Zinc) has been replaced by Canadian interests. These interests include financial and legal intervention on behalf of the Quebec and Newfoundland provincial governments. A Quebec provincial corporation, Société Nationale de l'Amiante (SNA) now owns and operates five commercial asbestos deposits. In the process, vertical ties between mining and milling of asbestos and production of asbestos products have been weakened considerably. Thus, recent and substantial changes in the structure of asbestos fiber production in North America apparently have occurred. In North America, the asbestos fiber industry has become, more than ever, an industry of relatively few producers, with the top four producers accounting for approximately 80 percent of North American capacity.

Costs of asbestos fiber production have been affected by a variety of influences over the past decade. Using aggregate data for Canadian asbestos mines, the ratio of energy and materials costs (in real terms) to the output of the mines has increased by about 60 percent over the last decade. The ratio of labor costs (in real terms) to the output has increased by 40 percent over the last decade. Both these values suggest that, at least in aggregate terms, operating costs have increased a good deal. It is interesting to note that between 1979 and 1980, the first year of a dramatic production decline in Canada, these ratios each declined by almost 10 percent.

The cost of meeting environmental and health regulations probably had a major impact on the cost of producing asbestos during the mid-1970s. In the United States, GAF, Inc., claimed that the expense of investing in equipment required to meet the new environmental and health regulations in the United States was a major reason it chose to close the Lowell mine. The permissible limits of exposure to asbestos in mines and mills were reduced in Canada as well and firms were required to upgrade their environmental controls. In addition, indirect increases in the cost of asbestos fiber production in

Exhibit A.2.1-3 Time Series of U.S. Imports by Country of Origin: Canada, Republic of South Africa, and Other (10^3 metric tons)

Year	Canada	Republic of South Africa	Other	Total
1982	229.1	11.4	1.3	241.8
1981	318.4	17.1	2.1	337.6
1980	315.5	10.3	1.5	327.3
1979	495.9	16.3	0.8	513.0
1978	543.2	24.9	1.9	570.0
1977	516.1	20.4	14.2	550.7
1976	560.4	18.2	18.1	596.7
1975	456.9	16.3	15.3	488.5
1974	670.7	21.5	3.1	695.3
1973	693.8	22.8	2.6	719.2

Sources: USDOI. 1973-1983. U.S. Department of the Interior. Minerals yearbook. Washington, DC: Bureau of Mines.

Exhibit A.2.1-4 Recent, Current, and Prospective Commercial Asbestos Deposits in Canada

Mine	Owner	Mill capacity (metric tons) Ore/day	Fiber/yr	Remarks
Producers:				
Newfoundland:				
Baie Verte	Baie Verte Mines, Inc.	6,600	80,000	Formerly owned by Advocate Mines Ltd. with major interests held by Johns-Manville and Eternit. Expropriated by the Government of Newfoundland in September 1982 after mine closure. Subsequently sold to Transpacific Asbestos Corporation. Mine reactivated as Baie Verte Mines.
Quebec:				
East Broughton	Jim Walter Corporation through Carey Canada, Inc.	6,800	210,000	
Asbestos Hill	Société nationale de l'amiante (SNA), an arm of the Quebec provincial government	5,400	90,000	All four are former Asbestos Corporation Limited (ACL) mines purchased by SNA in 1982. ACL formerly owned by General Dynamics.
British Canadian	SNA	12,000		
King Beaver	SNA	7,000	210,000	
Normandie	SNA			
Bell Asbestos Mine	SNA	2,700	55,000	Closed because reserves exhausted. Purchased in 1980 by SNA from Turner & Newall, Ltd.
Black Lake	Lake Asbestos of Quebec Ltd.	9,000	235,000	Lake Asbestos is a subsidiary of

(continued)

Exhibit A.2.1-4 (continued)

Mine	Owner	Mill capacity (metric tons) Ore/day	Fiber/yr	Remarks
Quebec (continued):				
Thetford Mines	Lake Asbestos of Quebec	4,000		the U.S. firm ASARCO.
Jeffrey Mine	Johns-Manville Canada, Inc.	30,000	450,000	Sold to private Canadian interests in 1983.
British Columbia:				
Cassiar Mine	Brinco Mining, Ltd.	5,000	100,000+	Formerly owned by Rio Tinto-Zinc Corporation, Ltd.
Prospective producers:				
Ontario:				
Matchewan	United Asbestos, Inc.	3,600	100,000+	Inactive. Operated from late 1975 to March 1977.
Quebec:				
Amos	Abitibi Asbestos Mining Company, Ltd.	11,000		Feasibility study has been undertaken.
Chibougamau	McAdam Mining Corporation, Ltd.	4,500		Feasibility study has been undertaken.

recent years has come in the form of thousands of lawsuits claiming health damage owing to asbestos exposure. The "third party" suits mostly originate in the United States, but both Canadian and U.S. firms are subject to the judicial rulings. Johns-Manville specifically cited the expected liability from these suits as the principal reason for its filing for bankruptcy in 1983. It claimed that the number of lawsuits could jump to 52,000 and cost it $2 billion by the end of the century (C&EN, 1983).

Another type of cost, the so-called user cost, will also influence production. If firms expect that asbestos fiber will be worth less in the future, then the user cost of producing asbestos fiber in the present will decline. This may very well be the expectation of asbestos fiber producers. If so, it makes estimating the direction and magnitude of shifts in the cost structure of the industry very difficult indeed.

1.2 Asbestos Consumption

The world production figures of Exhibit 1 suggest that world consumption of asbestos has not declined as dramatically as it has in North America and Western Europe. Indeed, it has been estimated that, until recently, consumption of asbestos fiber has been rising about 4.4 percent annually in developing nations, largely because of rapid growth in construction activity and freedom from regulation. After peaking around 1970, consumption of asbestos fiber in North America and Western Europe has declined markedly. As shown in Exhibit A.2.1-5, U.S. asbestos fiber consumption for all three commercial types has dropped since the early 1970s, but this drop was most dramatic since 1978. Total U.S. consumption of asbestos decreased from 607,000 metric tons in 1977 to 247,000 metric tons in 1982. Exhibit 3 shows that asbestos fiber imports fell from 551,000 metric tons in 1977 to 242,000 metric tons in 1982.

Exhibit A.2.1-6 shows the U.S. consumption of chrysotile asbestos fiber by fiber grade from 1974 to 1982. The most dramatic declines in consumption have come in the larger grade fibers. By way of illustration, short fibers (Grades 6 and 7) constituted 63 percent of consumption by weight in 1974. In 1982, these grades accounted for 84 percent of consumption by weight and nearly 60 percent of consumption by sales value.

Exhibit A.2.1-7 shows fiber consumption in the United States by end use in 1982. In recent years, only consumption of asbestos friction materials and asbestos-based coatings and compounds has remained relatively stable. The products bans considered by the U.S. Environmental Protection Agency (EPA) would have a proportionally larger impact on consumption of longer fibers, especially in the case of asbestos/cement (A/C) pipe. All other things equal, if the products ban is put into effect, the North American market would be principally for short fibers.

The decline in U.S. consumption of asbestos can probably be attributed in large part to leftward shifts in demand for asbestos associated with health concerns. Some of this shift is attributable to regulation. In 1972, the Occupational Safety and Health Administration (OSHA) promulgated regulations requiring reductions in asbestos dust levels in the workplace and in 1983 issued notice of intent to tighten exposure limits further. In 1973 EPA promulgated the national emission standard for asbestos, which was subsequently revised to its final form in 1978. The current EPA regulation

Exhibit A.2.1-5 Time Series of U.S. Asbestos Consumption by Fiber Type (10^3 metric tons)

Year	Chrysotile	Crocidolite	Amosite	Total asbestos
1982	229.8	16.0	0.7	246.5
1981	334.1	14.0	0.7	348.8
1980	347.8	10.5	0.4	358.7
1979	546.4	13.6	0.5	560.5
1978	600.6	16.9	1.2	618.7
1977	578.6	24.5	3.8	606.9[c]
1976	634.2	19.4	4.1	657.7[c]
1975	517.9	20.6	11.6	550.1[c]
1974	724.1	33.9	8.5	766.5[c]
1973	761.5[a]	16.3	3.9	781.7[c]
1972	698.7[b]	14.2	5.2	718.1[c]

[a]Adjusted to reflect only 96 percent of apparent consumption. Data collected on completely revised form and expanded list of consumers.

[b]Adjusted to reflect only 95 percent of apparent consumption. Data collected on completely revised form and expanded list of consumers.

[c]Total does not include anthophyllite.

Source: USDOI. 1972-1982. U.S. Department of the Interior. Minerals yearbook--asbestos. Washington, DC: Bureau of Mines.

Exhibit A.2.1-6 Time Series of U.S. Consumption of Chrysotile Fibers by Grade (10^3 metric tons)

Year	Grades 1 & 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total	Grade 8
1982	-	2.3	18.4	15.0	18.8	175.3	229.8	-
1981	0.1	3.8	75.0	54.9	20.5	179.8	334.1	-
1980	0.4	3.9	88.6	94.3	25.0	135.6	347.8	-
1979	3.8	13.1	90.2	154.1	64.5	220.7	546.4	-
1978	4.2	14.4	99.1	169.4	70.9	242.6	600.6	-
1977	4.4	15.8	108.4	186.1	77.8	266.4	658.9	-
1976	1.5	13.5	92.9	66.1	48.0	411.9	634.2	0.2
1975	1.0	12.4	100.2	70.6	66.1	267.4	517.9	0.2
1974	1.1	21.0	116.9	124.6	92.8	361.4	724.14	6.4

Source: USDOI. 1974-1982. U.S. Department of the Interior. Minerals yearbook. Washington, DC: Bureau of Mines.

Exhibit A.2.1-7 U.S. Asbestos Consumption by End Use, Grade, and Type--1982
(10^3 metric tons)

	Chrysotile									
	Grades 1 & 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total	Crocido-lite	Amo-site	Total asbestos
A/C pipe	--	--	15.6	5.0	1.0	--	21.6	16.0	--	37.6
A/C sheet	--	--	0.2	1.0	7.2	2.4	10.8	--	--	10.8
Flooring products	--	--	--	--	--	49.0	49.0	--	--	49.0
Roofing products	--	--	--	--	3.0	4.0	7.0	--	--	7.0
Packing and gaskets	--	--	0.4	0.5	0.8	11.9	13.6	--	--	13.6
Insulation:										
Thermal	--	--	--	--	--	--	--	--	0.2	0.2
Electrical	--	--	--	--	--	0.7	0.7	--	--	0.7
Friction products	--	--	1.0	7.9	6.7	37.3	52.9	--	--	52.9
Coatings and compounds	--	--	--	--	--	25.0	25.0	--	--	25.0
Plastics	--	--	--	0.2	--	0.2	0.4	--	--	0.4
Textiles	--	1.1	--	--	--	--	1.1	--	--	1.1
Paper	--	--	--	0.1	--	1.5	1.6	--	--	1.6
Other	--	1.2	1.2	0.3	0.1	43.3	46.1	--	0.5	46.6
Total	--	2.3	18.4	15.0	18.8	175.3	229.8	16.0	0.7	246.5

A/C = Asbestos/cement

Source: USDOI. 1982. U.S. Department of the Interior. Minerals yearbook. Washington, DC: Bureau of Mines.

limits emissions from milling and manufacturing, prohibits certain uses of asbestos-containing materials, provides for work practices in demolition and renovation operations, and specifies procedures for waste disposal and disposal site maintenance. EPA also has taken action on asbestos exposure under the Toxic Substances Control Act (TSCA) of 1976, requiring inspection of schools to identify asbestos hazards and establishing a reporting rule in 1982. A number of additional agencies, including the Food and Drug Administration (FDA) and the Consumer Product Safety Commission (CPSC) also have imposed regulations on the use and handling of asbestos. These rules either prohibit or raise the cost of asbestos use to manufacturers of asbestos-containing products, encouraging the use of asbestos substitutes. In addition, the growing number and size of tort suits related to asbestos exposure in the 1970s raised the implicit cost of asbestos use to the manufacturers of asbestos products. Finally, consumers, perhaps alerted by the press surrounding the regulations and tort suits, have probably voluntarily reduced their consumption of some asbestos-containing products.

1.3 Asbestos Prices

The price of asbestos fiber can vary considerably with its grade, color, tensile strength, purity, and other physical characteristics. Exhibits A.2.1-8 and A.2.1-9 present posted prices for various fiber grades for Vermont and Quebec asbestos fiber. In 1983, Grade 3 (tensile grade) asbestos had an average posted price of $1,962 (Canadian) per metric ton in Quebec, and Grade 7 had an average posted price of $234 (Canadian) per metric ton: the longer fibers were over eight times more expensive. Similar price differentials among grades also hold for Vermont. Vermont prices, when corrected for the exchange rate between Canadian and U.S. dollars, are very close to Quebec prices. It is generally acknowledged that because of the production dominance of Quebec fiber producers, Quebec prices lead the market. Posted prices nearly doubled between 1972 and 1977 in nominal terms. Since that time, the nominal price has been relatively steady. In real terms, however, the price of asbestos fiber has declined dramatically since 1977 (see Exhibit A.2.1-10). Actual prices paid for asbestos may deviate from the posted price for a variety of reasons. For example, it is generally acknowledged that over the past few years of slack demand considerable price discounting relative to posted price has occurred.

Large, long-term purchasers of asbestos can ordinarily negotiate contracts at prices below the posted or "spot" price. The significance of these influences is suggested by the time series of "shipment" prices presented in Exhibit A.2.1-11. Based on data from the Canadian Minerals Yearbook, these prices were up to 25 percent below posted prices in 1982. The reader should be cautioned, however, that these shipment prices, particularly for the years in which supplies were tight from the late 1960s to the mid-1970s, reflect transfer pricing policies from wholly owned fiber producers to parent firms in the United States. As a result, they too may deviate from competitive market prices.

2. Estimating the Supply Elasticity of Asbestos Fiber

In principle, two general methods can be used to make the estimate of the own price elasticity of supply: econometric estimation based on past market data and engineering cost estimation based upon analysis of production costs for various production technologies or plants. The former is the primary

Exhibit A.2.1-8 Time Series of Posted Prices: Chrysotile by Grade for Vermont[a]

Year	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Month
1983	1360	798	660	407	188	Jan.
1982	1237	865	589	396	179	Jan.
1981	NA	NA	NA	NA	NA	--
1980	NA	729	521	351	226	Jan.
1979	NA	729	521	351	226	July
1978	NA	651	504	313	207	Jan.
1977	NA	477	344	228	139	Jan.
1976	NA	418	306	200	122	Jan.
1975	NA	484	259	173	114	Jun.
1974	NA	337	196	131	82	May
1973	NA	295	171	114	69	Feb.
1972	NA	295	171	114	69	Jan.
1971	NA	220	174	116	70	July
1970	380	271	158	105	68	Jan.
1969	369	263	153	102	66	Jan.
.968	332	241	144	96	62	Aug.
1967	332	240	153	93	58	April
1966	NA	NA	NA	NA	NA	--
1965	345	236	133	88	58	All
1964	374	251	131	86	58	All
1963	374	251	131	86	58	All
1962	374	251	131	86	58	All
1961	374	251	131	86	58	May
1960	397	200	131	86	58	All
1959	397	200	131	86	58	Nov.
1958	399	191	136	86	58	(1-7)
1957	399	191	136	86	58	Dec.

NA = Not applicable.

[a]Nominal prices are in $/short ton 1957-1977 and $/metric ton 1978-1983 and are averages of posted ranges.

Sources: USDOI. 1957-1983. U.S. Department of the Interior. Minerals yearbook. Washington, DC: Bureau of Mines.

Economic Report of the President. 1983. Washington, DC: U.S. Government Printing Office.

International Monetary Fund. International Financial Statistics.

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Exhibit A.2.1-9 Time Series of Posted Prices: Chrysotile by Grade for Quebec (Canadian dollars)[a]

Year	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Month	Index for conversion to U.S. dollars
1983	NA	NA	1962	1280	726	513	234	Jan.	81.14[a]
1982	NA	NA	1099	1053	592	417	189	Jan.	81.01
1981	NA	NA	1762	1161	653	460	208	Jan.	83.41
1980	NA	NA	1585	1074	637	419	196	Jan.	85.53
1979	NA	2530	1449	936	534	376	183	Jan.	85.39
1978	NA	2168	1233	793	412	309	160	Jan.	87.73
1977	3650	1986	1275	615	358	260	145	July	94.11
1976	3496	1879	1177	661	335	240	144	July	101.40
1975	3496	1879	1177	661	335	240	144	Dec.	98.29
1974	2428	1320	818	447	252	180	111	Aug.	102.26
1973	1745	945	588	327	193	129	80	May	99.98
1972	1615	875	544	305	180	120	76	All	100.94
1971	1615	875	544	305	180	120	76	July	99.02
1970	1525	825	524	294	171	114	72	Jan.	95.80
1969	1480	800	508	286	166	110	71	Jan.	92.86
1968	1410	760	484	181	156	104	66	April	92.80
1967	1410	760	474	267	153	101	66	April	92.27
1966	NA	NA	NA	NA	NA	NA	NA	--	--
1965	1410	758	455	255	136	95	60	Jan.	93.02
1964	1443	742	613	213	135	86	60	All	93.10
1963	1443	742	613	213	135	86	60	All	92.52
1962	1443	742	613	213	135	86	60	All	92.78
1961	1443	742	613	213	135	86	60	All	95.87
1960	1443	742	613	213	135	86	60	All	100.39
1959	1443	742	613	213	135	86	60	Nov.	104.93
1958	1710	1020	525	218	140	89	60	All	103.72
1957	1710	1020	525	218	140	89	60	All	101.55

NA = Not applicable.

[a]Nominal prices are in $/short ton 1957-1977 and $/metric ton 1978-1983 and are averages of the posted ranges.

Sources: USDOI. 1957-1983. U.S. Department of the Interior. Minerals yearbook. Washington, DC: Bureau of Mines.

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Exhibit A.2.1-10 Time Series of Real Prices of Canadian Shipments by Grade[a] (1972 $/metric ton)

Year	Grade 4	Grade 5	Grade 6	Grade 7
1982	322.706	217.552	135.770	58.3244
1981	351.269	236.602	147.696	63.4756
1980	361.430	265.298	152.126	68.4363
1979	355.840	252.906	153.315	72.1097
1978	371.401	256.976	164.587	79.2072
1977	406.554	278.548	174.340	86.7593
1976	379.938	262.756	175.014	85.7501
1975	290.329	220.809	145.809	81.5917
1974	248.207	210.313	134.407	71.2544
1973	207.218	161.979	111.391	60.5346
1972	215.478	158.873	107.636	57.4687
1971	228.078	176.328	108.703	55.3574
1970	228.602	175.026	119.714	57.7482
1969	228.363	176.759	120.926	57.8577
1968	223.486	164.284	107.142	55.5637
1967	232.716	168.107	106.130	54.7906
1966	232.046	164.621	103.454	52.5432
1965	234.611	175.953	99.347	57.6890
1964	235.231	171.595	104.056	54.3703
1963	254.703	172.613	110.799	56.7035
1962	260.124	176.181	116.678	55.7624
1961	278.092	187.673	123.922	62.3672
1960	296.272	199.880	130.978	67.1271
1959	310.524	215.013	139.171	72.8721
1958	310.140	205.690	139.675	72.6393
1957	294.632	205.169	139.320	72.4532

[a]Shipment prices are equal to the ratio of the value of shipments to quantity shipped.

Sources: Energy, Mines, and Resources Canada. Various years. Canadian minerals yearbook. Ottawa, Canada.

Statistics Canada. 1959-1977. Production and shipments of asbestos by Canadian mines. Publication #26-205--Asbestos. Ottawa, Canada.

Statistics Canada. 1978-1981. Production and shipments of asbestos by Canadian mines. Publication #26-224--Asbestos. Ottawa, Canada.

Exhibit A.2.1-11 Time Series of Nominal Prices of Canadian Shipments by Grade[a] (Canadian $/short ton)

Year	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7
1982	--	749.1	505.004	315.163	135.389
1981	1,142.75	747.152	503.255	314.150	135.013
1980	1,018.14	685.019	502.820	288.325	129.707
1979	936.14	617.975	439.214	266.257	125.231
1978	922.43	577.856	399.824	256.078	123.237
1977	1,041.60	549.014	376.154	235.431	117.161
1976	1,003.50	449.926	311.158	207.253	101.546
1975	982.01	337.236	256.484	168.475	94.774
1974	495.31	253.470	214.772	137.257	72.765
1973	425.75	198.890	155.469	106.914	58.102
1972	397.09	193.617	142.755	96.715	51.638
1971	395.23	200.676	155.143	95.643	48.707
1970	390.09	198.023	151.614	103.700	50.024
1969	381.75	193.680	149.914	102.56.	49.070
1968	397.79	180.379	132.596	86.476	44.846
1967	406.42	180.120	130.116	82.145	42.408
1966	381.06	175.173	124.274	78.098	39.665
1965	384.62	170.188	127.637	72.067	41.848
1964	332.86	166.846	121.710	73.805	38.564
1963	396.42	179.042	121.337	77.885	39.859
1962	400.90	179.643	121.672	80.579	38.510
1961	394.39	182.493	123.157	81.321	40.927
1960	438.18	184.000	124.136	81.344	41.689
1959	429.47	181.535	125.699	81.361	42.602
1958	341.11	179.193	118.844	80.702	41.970
1957	341.58	170.948	119.041	80.834	42.038

[a]Shipment prices are equal to the ratio of the value of shipments to quantity shipped.

Sources: Energy, Mines, and Resources Canada. Various years. Canadian minerals yearbook. Ottawa, Canada.

Statistics Canada. 1959-1977. Production and shipments of asbestos by Canadian mines. Publication #26-205--Asbestos. Ottawa, Canada.

Statistics Canada. 1978-1981. Production and shipments of asbestos by Canadian mines. Publication #26-224--Asbestos. Ottawa, Canada.

approach selected for this study. However, rough engineering cost data are the used to check the results of the econometrically derived estimates.

2.1 Econometric Estimation

Estimating the supply elasticity of asbestos econometrically presents formidable difficulties. Given the above-described asbestos fiber grades and types, microeconomic theory suggests a multimarket approach that available data are not able to support. To narrow the scope and simplify the commodity definition, the econometric analysis focuses on North American production and consumption of short, chrysotile fiber (Quebec Grades 6 and 7). As previously discussed, this fiber's type and grade account for much of the North American fiber trade and its relative role is likely to grow even larger under the proposed products ban.

A variety of econometric models were formulated and estimated. Assuming a perfectly competitive fiber market, the most attractive of these, on strictly theoretical grounds, were versions of the "prototype micro model" as described, for example, by Intriligator (1978). A general form of such a model is shown in Equations 1 through 3.

$$Q_s = \alpha_s + \beta_1 P_a + \beta_2 P_f + \epsilon_s \tag{1}$$

$$Q_d = \alpha d_s + \beta_3 P_a + \beta_4 P_s + \beta_5 I + \epsilon_d \tag{2}$$

$$Q_d = Q_s \tag{3}$$

where

Q_s = quantity supplied;

Q_d = quantity demanded;

P_a = price of asbestos;

P_f = price of factors of production;

P_s = the price of asbestos substitutes; and

I = income.

Simultaneous equation models of this general type were estimated using two-stage least squares with up to 26 years of data. The results were disappointing; the coefficients estimated were sometimes of the wrong sign and rarely differed significantly from zero. Models estimated included dummy variables to reflect various structural changes in the market and models with lag terms to reflect partial adjustment and adaptive expectation behavior. Either the data base was not large enough to support estimation of these multiequation formulations or some underlying feature of the economic model was misspecified. Consequently, single-equation models were estimated using the available data.

The econometric model that ultimately provided the estimate of supply elasticity adopted is the very simplest two-variable version of a supply equation with a log-linear (constant elasticity) specification:

$$\ln Q = \alpha + \beta \ln P_a \tag{4}$$

Equation 4 was estimated from 1977 to 1981 annual data. The quantity variable is the estimated annual metric tonnage of short fiber (Grades 6 and 7) produced and consumed in North America (as defined in Exhibit 12). The price variable is the consumption-weighted average shipment price of Grades 6 and 7 asbestos fiber converted to constant U.S. dollars. As noted above, these prices are substantially lower than current posted prices. These and other raw data are listed in Exhibit A.2.1-12.

The parameter estimates and associated standard errors that resulted from the ordinary least squares regression are presented as

$$\ln Q = \underset{(3.56)}{6.32} + \underset{(0.78)}{1.46} \ln P_a \tag{5}$$

The price elasticity of supply is directly interpretable as the coefficient in $\ln P_a$. It is positive and statistically significant (different from zero) at the 0.80 level. The supply of short asbestos fibers is therefore estimated to be "elastic"; a shift in demand of 10 percent would result in a 6.7 percent change in price.

The logic of this specification can be supported in at least two ways. First, one can contend that the supply function of asbestos fiber was relatively stationary over the estimation period and that shifts in demand "trace" points along the supply function. If this is indeed the case, the identification problem, implicit in single-equation models of this type, would be eliminated. Alternatively, if the industry, because of its high degree of concentration, is more monopolistic in character than it is perfectly competitive, the price and quantity variables may be tracing out a monopoly-like industry response function to shifts in demand given a stable industry cost function.

Whichever the case, the short (5-year) time series used to estimate the relationship makes the assumption of a stable supply or cost function more tenable. In particular, the estimation period if coincident with the period of contracting demand and postdates some of the changes that may reasonably be thought to have shifted supply (e.g., asbestos exposure regulations and general strikes). In addition, the errors-in-measurement problem associated with the price variable may have been reduced in this period because transfer pricing distortions may have been mitigated by virtue of divestiture trends and the smaller gains to be realized.

2.2 Engineering Cost Analysis

In a separate analysis, engineering cost data were used to derive a supply elasticity estimate. Capital, capacity, and operating data for a number of mines in Canada and the United States were used to construct a crude supply function for North America. The data were obtained from nonconfidential portions of U.S. Bureau of Mines field reports and supplemented by judgment and rough estimation where detailed or mine-specific data were lacking. The cost estimates were constructed so as to represent "intermediate-term" average variable costs. In general, this means that the cost of replacement capital needed to operate the mines under the current mining plan was included as a cost of production, but major capital investment

Exhibit A.2.1-12 Time Series (1977-1982) of the Price and Quantity Variables Used in the Regression Equation to Estimate the Supply Elasticity[a]

Year	Can. prod. of #6 (S tons)	Can. prod. of #7 (S tons)	Tot. est.[b] U.S. prod. of #6, 7 (S tons)	U.S. expt. of short fibers (S tons)	Can. tot. exp. of short fibers (S tons)	Can. exp. of short fibers to U.S. (S tons)	Unit value[c] of #6 ($/S ton)	Unit value[c] of #7 ($/S ton)	Canadian exchange rate (Can. $/U.S. $)	GNP deflator
1981	199,585	426,435	51,646	15,422.5	597,727	292,118	314.150	135.013	0.8341	195.51
1980	281,854	441,866	54,746	12,995.9	621,938	288,915	288.325	129.707	0.8553	178.64
1979	285,250	582,750	63,736	11,572.1	817,628	438,114	266.257	125.231	0.8539	163.42
1978	228,127	583,626	63,612	20,569.9	780,649	455,279	256.078	123.237	0.8773	150.42
1977	286,035	562,199	63,054	19,479.0	782,038	429,372	235.431	117.161	0.9411	140.05

S tons = short tons.
GNP = Gross National Product.

[a]The quantity value used in the regression is the approximate quantity of asbestos Grades 6 and 7 produced in North America, less exports, and is given as:

Q = Canadian production of 6 + Canadian production of 7 + U.S. production of 6 and 7 - total Canadian exports of 6 through 9* - U.S. exports of refuse fiber + Canadian exports of 6 through 9 to the United States.

*Exports of Grades 8 and 9 are assumed to be negligible.

The price variable is a weighted price of Grades 6 and 7 of chrysotile based on unit values of Canadian shipments and is given as:

$$P = \frac{\text{Unit value 6}}{\text{Canadian production of 6 and 7}} + \frac{\text{Unit value 7}}{\text{Canadian production of 6 and 7}}$$

[b]The estimate of U.S. production of Grades 6 and 7 is based on nonconfidential production proportions supplied by the U.S. Bureau of Mines.

[c]The unit value of fiber is in 1972 U.S. dollars and is based on the value and quantity of Quebec chrysotile shipments: $ value of total shipments/quantity shipped.

Sources: USDOI. Various years. U.S. Department of the Interior. Minerals yearbook. Washington, DC: Bureau of Mines.

Economic Report of the President. 1983. Washington, DC: U.S. Government Printing Office.

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Statistics Canada. 1959-1981. Publications #26-205 and 26-224. Production and shipments of asbestos by Canadian mines. Ottawa, Canada.

in deposit development was not. Also included in the average variable cost estimates were estimates of operating cost, including the cost of labor, supplies, energy, and administration. Capital costs reflect mine and mill plant and equipment cots as well as infrastructure costs.

The cost per ton of ore was calculated by adding the capital and operating costs, and a cost per ton of fiber was derived by dividing the cost per ton of ore by the estimated ratio of fiber capacity to ore capacity for the mine. This average cost per ton of fiber for each mine was then compared to an estimate of the average revenue a given mine would receive for a ton of fiber as a rough test of the validity of the engineering cost estimates. The average revenue estimate was the 1982 weighted price of fiber based on Bureau of Mines proportions of production by grade and either the shipment or posted prices previously discussed. The weighted posted price for all grades in North America is estimated to be about \$612 (U.S.); the weighted shipment price is estimated to be about \$452 (U.S.).

When production costs were compared to the average weighted prices for a given mine, 11 of the 13 mines had cots that were lower than either of the price estimates. Of the remaining two mines, one had costs higher than the shipment price an lower than the posted price, and the other had cots higher than both the shipment and posted prices.

To estimate the supply elasticity, the Canadian mines were ranked in order of increasing cost per ton of fiber, and the capacities of the ranked mines were summed to form a measure of total fiber supplied at a given cost. The plot of total cost per ton of fiber against the cumulated capacity forms an automated intermediate term supply curve for Canadian fiber. The supply elasticity is estimated by regressing the natural logarithm of the summed capacity against the natural logarithm of the cost per ton of fiber:

$$\ln \text{(capacity)} = \alpha + \beta \ln \text{(cost)} \tag{6}$$

where β is directly interpretable as the supply elasticity. The same procedure was used to obtain the supply elasticity for U.S. mines.

The elasticity of supply for asbestos fiber for Canada estimated in this fashion was found to be 1.726. The U.S. elasticity was 0.671. Estimates of the supply elasticity were also derived using pooled data for all North American producers and for composite and individual fiber grades. Due to fiber grade differences, the varying prices among fiber grades, and the fact that different mixes of the various grades are produced at the individual mines, different supply elasticities may apply for the different fiber grades. Thus, a single elasticity estimate for all fiber grades may be imprecise.

The estimated supply elasticities by fiber grades vary widely. Interestingly, for Grade 7, the estimate over all North American producers is 1.45, with a standard error of 0.204.

2.3 Interpreting the Results

The supply elasticity estimate for asbestos fiber presented above must obviously be used with caution; the standard error of the econometric estimate suggests populations whose true elasticity of supply could easily range from 0.71 to 2.27. The sensitivity of the result also can be estimated by adding another observation to the data set. Based on an unofficial estimate of Canadian production of Grades 6 and 7 fibers in 1982, rerunning the regression with 1982 data yields an estimate of the supply elasticity of 2.59. This is an extreme example since 1982 was a year of generally depressed economic conditions, but it reinforces the point that the "true" supply elasticity may vary substantially from that selected for analysis.

As noted above, microeconomic theory suggests an economic model of the fiber market that is much more complex than any of the specifications employed in this study. For example, interaction with the world market for asbestos fiber and the joint production features of fiber production are clearly relevant to the supply decisions that characterize the industry. Furthermore, the literature on the theory of exhaustible resources introduces further time-dependent considerations that might be considered in the characterization of firm behavior. For asbestos, the prospect of continued declines in demand suggest that user cost may be dropping, thereby stimulating current production despite declining real prices.

Microeconomic theory and business practice also distinguish between short and long-run supply adjustments to changing prices. These notions were behind the applications of lagged adjustment and pure expectations models employed in the simultaneous equation framework discussed above. Although the application of such models is subject to reservation (Griliches, 1967), the microeconomic principle is that supply tends to be more elastic as firms adjust fixed inputs over time. This argues perhaps for treating the current estimate as being on the low side of a longer term supply response to declining demand in North America. Such an inference should be made cautiously in the absence of a clearer understanding of the influence of the lag structure of production, the quantity of asbestos reserves, and the interactive influences between the North American and world markets and among different grades of asbestos fiber.

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A.3 BAN/PHASE-DOWN SIMULATION MODEL

A number of the regulatory alternatives examined in this study consist of product bans, fiber phase-downs, or combinations of these policies. To examine the costs of these different alternatives and to generate information for the exposure and health effects models to use in estimating their benefits, the Asbestos Regulatory Cost Model (ARCM) was developed and computerized. The theoretical underpinnings of the ARCM are reviewed in Chapter II in the main body of the RIA report, and data inputs for the model are presented in Chapter III of the RIA.

The theoretical approach of the ARCM presented in Chapter II of this RIA is presented in terms of smooth demand and supply functions for ease of exposition. However, the actual computational procedures are, for the most part, conducted in terms of "step functions", which are analytically the same as the more convenient and conventional functions familiar from textbooks, but are more consistent with the character of the underlying data available to the model. Thus, Section 1 below presents the ARCM's approach in terms of these step-functions.

Section 2 reviews the exact welfare effects computations performed by the ARCM for simulating product bans and fiber phase-downs. Finally, Section 3 presents an annotated copy of the FORTRAN computer code for this interactive model.

1. ARCM in Step-Function Format

This section discusses the approach used in the ARC model for the estimation of the supply curves in all markets, product demand curves, individual market derived demand curves for asbestos fiber, and the asbestos fiber demand curve.

1.1 Supply Curves

1.1.1 Asbestos Fiber Market

The elasticity of supply of asbestos fiber to the U.S. from domestic and foreign sources was estimated using a simple econometric model.[1] A log-linear (constant elasticity) specification was used and the parameter estimates were reported as:

$$\ln Q = 6.32 + 1.46 \ln P_a$$

where:

Q = the estimated annual metric tonnage of short fiber (Grades 6 and 7) produced and consumed in North America, and

P_a = the consumption-weighted average shipment price of Grades 6 and 7 converted to constant U.S. dollars.

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[1] The derivation of this equation and its econometric estimation is discussed in Appendix A.2 above.

Since this implies an elasticity of 1.46, the ARC Model uses this as the default. Using the quantity and price of asbestos fiber in the data year, the ARC model translates this (constant) elasticity into an equation for a linear supply curve. The exact computation is:

$$Q_a = \prod_{i=1}^{N} (Q_i \cdot PAC)$$

$$SLOPE = P_a/(SELAST \cdot Q_a)$$

$$INTERCEPT = P_a - (SLOPE \cdot Q_a)$$

where:

Q_a = total quantity of asbestos fiber consumed by all markets in 1985;

PAC = Product Asbestos Coefficient (as described in Section 3);

Q_i = output quantity in product market 'i' in 1985;

N = number of product markets;

SLOPE = slope of asbestos fiber supply curve;

P_a = price of asbestos fiber reported in 1985;

SELAST = fiber supply elasticity, as described above; and

INTERCEPT = ordinate intercept of the fiber supply curve.

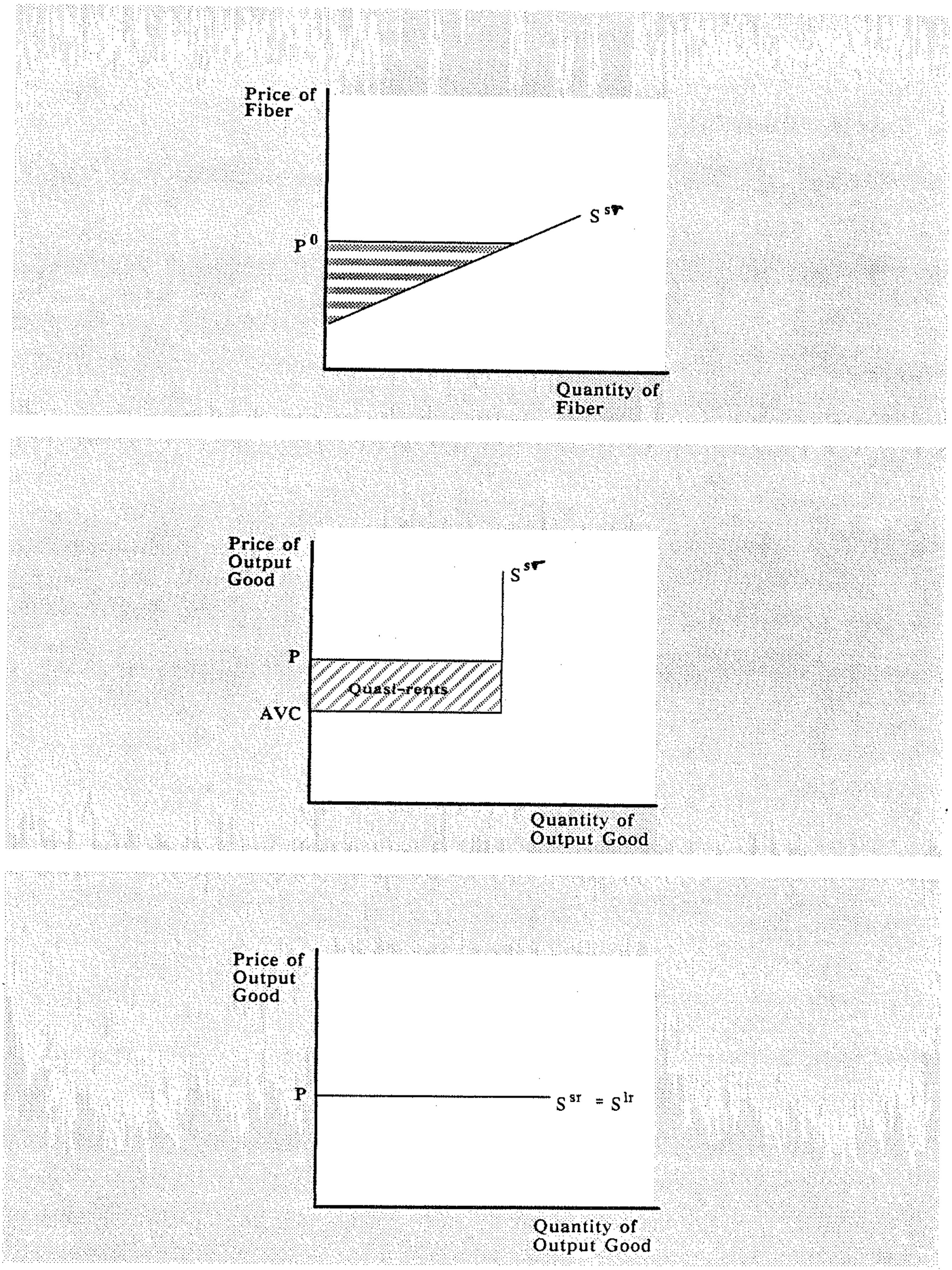
It should be noted that it is the supply of asbestos fiber to the U.S. from domestic and foreign sources that is modeled above. Since this is the short-run and long-run supply function, producer surplus will exist in this market in the long run, given the positive slope of the supply curve.

1.1.2 Product Markets

The supply schedules in the output markets are short-run curves. Short-run schedules with upward slopes imply that some factors earn rents in the short-run. However, there are no long-run rents. The rents earned by factors of production in markets exhibiting upward sloping short-run curves are shown as the shaded area in the top panel of Exhibit A.3-1. However, data available for this modeling were not sufficient to generate upward sloping supply functions. Instead, supply curves at the level of average variable costs were designed based on the price and other engineering cost data gathered in the survey and by PEI's survey of capital convertibility and the costs of exit from the various asbestos product markets.

Given these supply functions, quasi-rents for all product markets are incorporated as shown in the middle panel of Exhibit A.3-1. The shaded area between price and the average variable cost measures the quasi-rents earned in the short-run. These quasi-rents that accrue to factors of production in the

Exhibit A.3-1



Price of Fiber
S^{sr}
P^0
Quantity of Fiber
Price of Output Good
S^{sr}
P
Quasi-rents
AVC
Quantity of Output Good
Price of Output Good
P
$S^{sr} = S^{lr}$
Quantity of Output Good

short-run and can be forfeited if the price that producers receive falls. Thus, the shaded area represents short-run producer surplus. In the long-run, since the supply curve for output is assumed to be perfectly elastic, no producer surplus losses in these markets exist. Instead, the cost of regulation is borne entirely by consumers of these output goods. Finally, if quasi-rents do not exist in the short-run the short-run supply schedules coincide with the long run schedules, which are assumed to be perfectly elastic (bottom panel of Exhibit A.3-1), and average variable cost is equal to price.

1.2 Demand Curves

A number of output goods use asbestos fiber. The demand for these products gives rise to the demand for asbestos fiber. Hence, characteristics of the demand function in each output market help to determine the shape and the location of the fiber demand function.

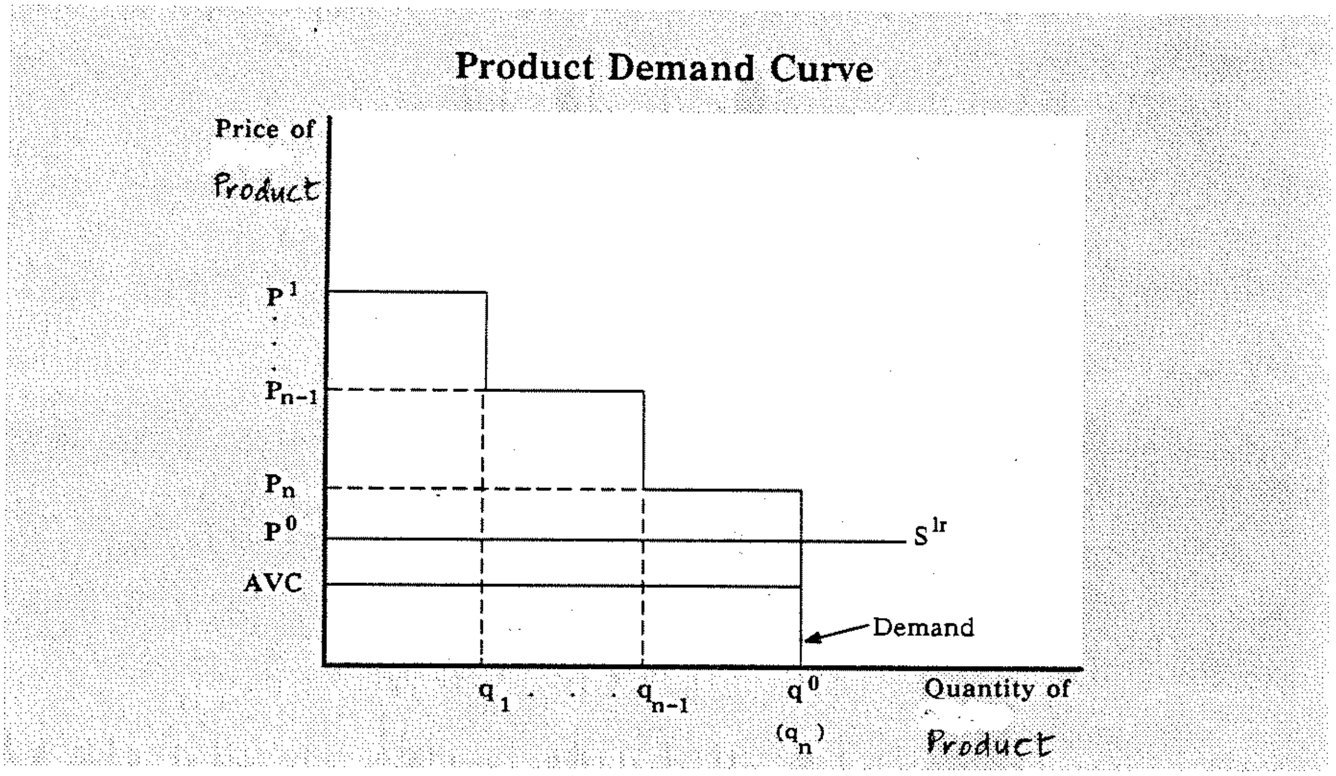
The approach used by the ARCM to estimate demand curves in all markets, as described here, attempts to use all possible information from the use and substitutes analysis, but not go beyond that information. Step demand functions are suggested most directly by this type of analysis (which is the only information available regarding the demand of each asbestos product).

A step demand function is a continuous non-smooth function (Exhibit A.3-2). It depicts purchaser behavior as ceasing to demand certain quantities of asbestos products once certain prices of these products are reached because they switch to non-asbestos substitutes. The amount of demand that switches to the non-asbestos substitute good is determined by the quantity of the asbestos product currently used in a manner for which the use of the particular substitute product is appropriate.

The principal advantage of using step demand functions in the ARC model is that construction of the demand functions do not require assumptions in addition to those already necessary to perform the use and substitutes analysis. Furthermore, such a specification does not assume that demand for the product decreases (increases) at a constant rate as its price increases (decreases). Not only would such an assumption go beyond available data, it may also be particularly inappropriate in cases where the cheapest substitute product is much more expensive then the asbestos product. In such a case, a small change in the price of the asbestos product should not induce large substitution away from the product (a linear downward-sloped demand curve, on the other hand, would imply some amount of such substitution).

On the other hand, the use of step demand functions have certain minor disadvantages. First, the use of currently available substitutes analysis indicates that for a few markets the substitutes are (presently) cheaper than the asbestos product itself. Since full substitution has yet to occur, this information contradicts an assumption underlying step demand functions that full substitution occurs once the price of the asbestos product exceeds that of the substitute. Instead, use of step demand curves requires some method to handle data that suggest that presently available substitutes are cheaper than the asbestos product. As described in the next sub-section, the model assumes such substitutes to have the same price as the asbestos product in 1985.

Exhibit A.3-2



Product Demand Curve
Price of
Product
P^1
P_{n-1}
P_n
P^0
AVC
S^{lr}
Demand
q_1
q_{n-1}
q^0
(q_n)
Quantity of
Product

The other disadvantage of step demand functions is that they dictate the complete and instantaneous substitution for a product given a large enough rise in the price of the asbestos product. Though this response may seem unrealistic, a step demand function is the best available alternative. The other alternatives either do not use all the information available from the use and substitutes analysis or impose outside assumptions not necessarily justified by or consistent with available information .

The exact manner in which the step demand functions are generated is outlined below.

1.2.1 Product Demand Curves

Each step in the demand curve corresponds to the price of a particular substitute, and its associated quantity. Exhibit A.3-2 shows the product demand curve for a market with non-zero quasi-rents. (For markets with no quasi-rents, average variable cost is equal to the baseline price.) The price of each substitute provides the height of each step; and the quantities provide the lengths of the corresponding steps. However, the asbestos product and its substitute(s) may differ in their useful lives, so calculating the price of the substitute(s) for comparison with the price of the asbestos products must be done carefully. The formulae used to calculate the present value prices of substitutes are as follows:

Let:

r = firm's real discount rate;

TC = total cost of the product, which is the sum of the installation and delivered purchase costs;[2]

Na = useful life of the asbestos product;

Ns = useful life of the substitute product; and

PV = present value price of the substitute product calculated for life of the asbestos product.

(1) If the life of the substitute product equals that of the asbestos product, the present value price of the substitute is calculated simply as TC the sum of the installation and delivered purchase costs, i.e.,

$$PV = TC$$

[2] The formulae listed here do not include annual O&M costs because such costs were always considered "equivalent" across all substitutes and the asbestos product.

(2) If the life of the substitute product is <u>not</u> equal to that of the asbestos product, the present value price of the substitute is computed as:[3]

$$PV = TC \cdot (1 + r)^{Ns - Na} \cdot \frac{(1 + r)^{Na} - 1}{(1 + r)^{Ns} - 1}$$

(3) Finally, if the present value price of any substitute is less than the price of the asbestos product in the data year, it is set equal to the price of the asbestos product.

The quantities associated with each step are computed based on the market share of each substitute.

The baseline domestic production quantities for all asbestos product markets with an import orientation i.e., markets with a consumption-production ratio greater than one, are adjusted by the consumption-production ratio to obtain the baseline domestic consumption quantity. The domestic consumption quantity is distributed in the ratio of the market shares of substitute(s), i.e., the shares of the existing market that switch to the substitutes, given the non-availability of the asbestos product.

For markets with an export orientation, i.e., markets with a consumption-production ratio less than one, an additional step is generated. This adjustment for export oriented markets is based on the assumption that foreign consumers have other options, such as purchasing the product from foreign suppliers. Thus, the height of this step is the baseline price of the asbestos product. The corresponding length is obtained by taking the difference in the domestic production and domestic consumption quantities, i.e., the amount of exports. Hence, it is assumed that foreign consumers will not tolerate any increase in the price of these imports above the baseline price. The only adjustment for import oriented markets is mentioned above. This quantity is then used as the appropriate baseline quantity. For all other modeling purposes these markets are treated exactly the same as those markets with no trade, i.e., markets with a consumption-production ratio of one. The only other differences arise in the distribution analysis, which is described below.

1.2.2 <u>Product Derived Demand Curves</u>

The total derived demand for fiber is obtained by the horizontal summation of the individual product (derived) demands for fiber. However, these product-by-product derived demands must be computed carefully to account for non-zero quasi-rents in the product markets, since quasi-rents increase a product market's derived demand for fiber.

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[3] The procedure used to calculate present value prices assigns the present value of the remaining useful life of the longer lasting product as a proportion of the asbestos that product's useful life. This procedure assumes that present values can be distributed linearly over time. Given the need to convert present value prices to the same useful life of the asbestos product (which is necessary for estimating consumer surplus), this procedure was deemed adequate for purposes of the ARC model.

For markets with zero quasi-rents, the height of each derived demand step is obtained by first calculating the difference between the height of the corresponding step in the product demand curve and the baseline product price in the data year. This difference is then multiplied by the product asbestos coefficient and the result added to the baseline asbestos fiber price in the data year, i.e.,

$$P^f{}_n = (P_n - P^0) \cdot PAC + P^0{}_F$$

where:

$P^f{}_n$ = height of the n^{th} step in the product derived demand curve (Exhibit A.3-3);

P_n = height of the n^{th} step in the product demand curve (Exhibit A.3-2);

P^0 = baseline product price (Exhibit A.3-2);

PAC = product asbestos coefficient; and

$P^0{}_F$ = baseline asbestos fiber price (Exhibit A.3-4).

The step-length is obtained by multiplying the corresponding step length in the product demand curve by the PAC, i.e.,

$$q^f{}_n = q_n \cdot PAC$$

where:

$q^f{}_n$ = length of the n^{th} step in the product derived demand curve (Exhibit A.3-3);

q_n = length of the n^{th} step in the product demand curve (Exhibit A.3-2); and

PAC = product asbestos coefficient.

The baseline fiber quantity used by each market is obtained by multiplying the baseline product quantity by the PAC, i.e.,

$$q^0{}_{f,i} = q^0 \cdot PAC$$

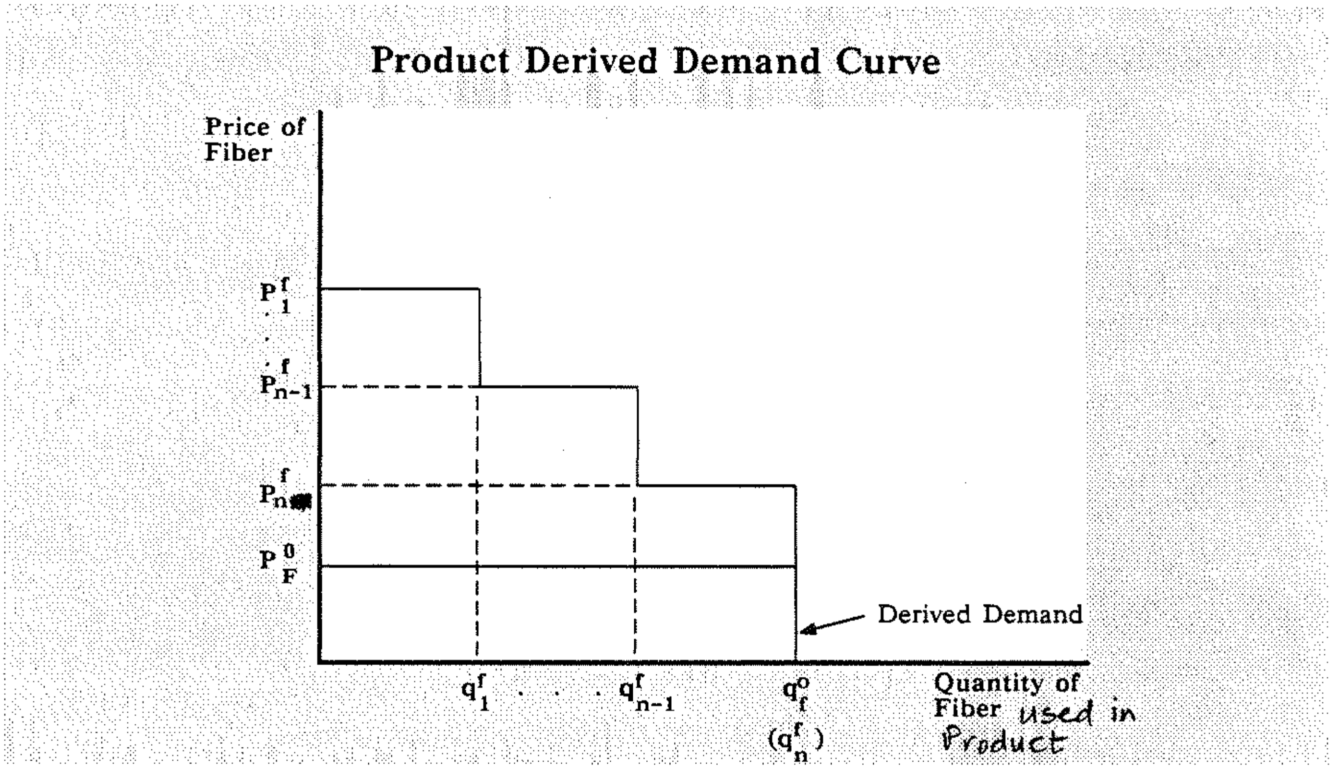
where:

$q^0{}_{f,i}$ = baseline fiber quantity used by a product market 'i' (Exhibit A.3-3);

q^0 = baseline product quantity (Exhibit A.3-2); and

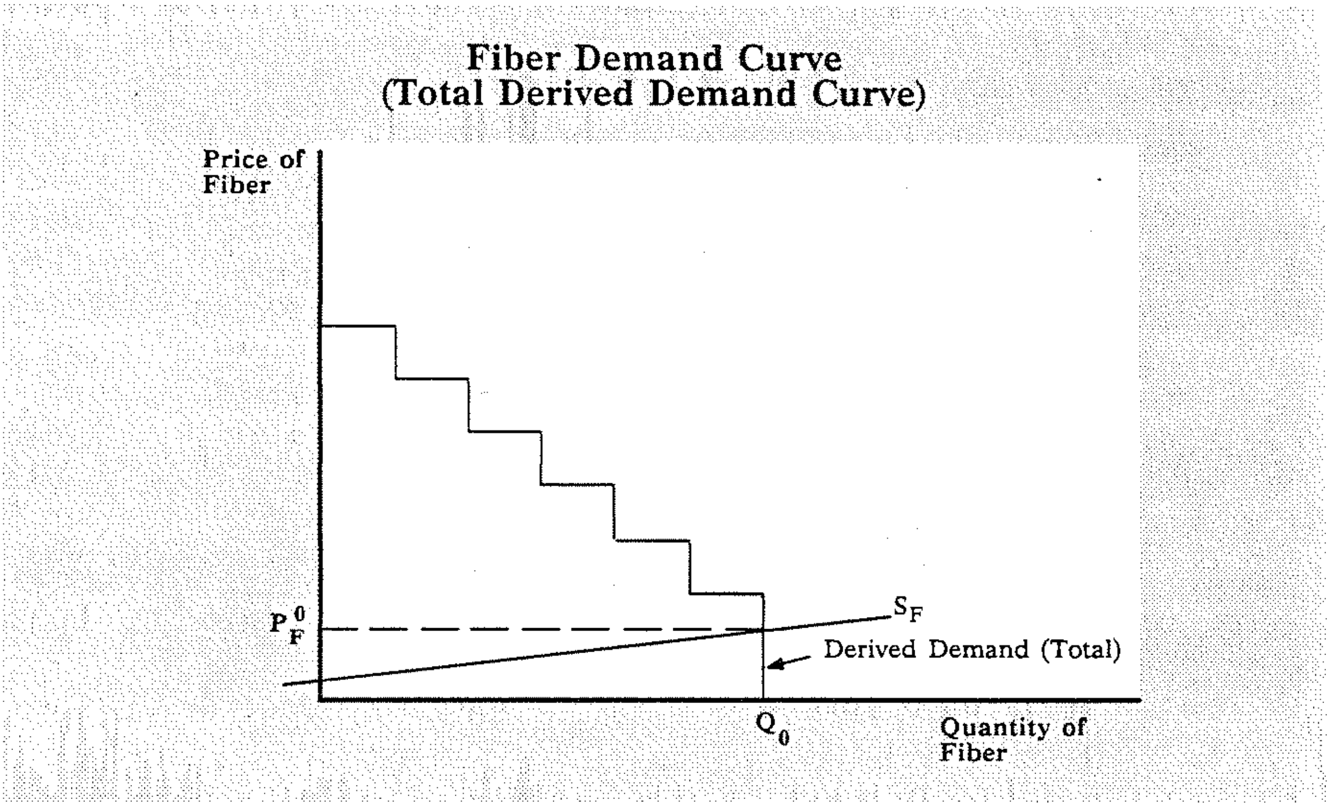
PAC = product asbestos coefficient.

Exhibit A.3-3



Product Derived Demand Curve
Price of Fiber
P_1^f
P_{n-1}^f
P_n^f
P_F^0
Derived Demand
q_1^f . . . q_{n-1}^f
q_f^o (q_n^f)
Quantity of Fiber used in Product

Exhibit A.3-4


Fiber Demand Curve
(Total Derived Demand Curve)
Price of Fiber
P_F^0
S_F
Derived Demand (Total)
Q_0
Quantity of Fiber

For markets with existing quasi-rents, the procedure outlined above is followed with one modification. The willingness of primary producers with quasi-rents, to bid away their quasi-rents in order to obtain asbestos fiber is incorporated in this procedure. This is achieved by adjusting upwards the maximum price of asbestos fiber the producers are willing to pay. Computationally, the height of each step is the difference between the height of the corresponding step in the product demand curve and the product's average variable cost in the data year rater than the product's price., i.e,

$$P^f{}_n = (P_n - AVC) \cdot PAC + P^0{}_F$$

where:

- $P^f{}_n$ = height of the n step in the product derived demand curve (Exhibit A.3-3);
- P_n = height of the n^{th} step in the product demand curve (Exhibit A.3-2);
- AVC = average variable cost per unit of output in the product market;
- PAC = product asbestos coefficient; and
- $P^0{}_F$ = baseline asbestos fiber price (Exhibit A.3-4).

1.2.3 Asbestos Fiber Demand Curve

The asbestos fiber demand curve is the horizontal summation of all product derived demand curves. The baseline fiber price is determined by identifying the intersection of the fiber demand curve and the fiber supply curve. This is achieved by using the equation of the supply function, as described earlier, i.e.,

$$Q^0 = \prod_{i=1}^{N} q^0{}_{f,i}$$

and

$$P^0{}_F = \text{INTERCEPT} + \text{SLOPE} \cdot Q_0$$

where:

- Q_0 = baseline asbestos fiber quantity in the fiber market (Exhibit A.3-4);
- $q^0{}_{f,i}$ = baseline fiber quantity used by product market 'i' (Exhibit A.3-3);
- $P^0{}_F$ = baseline asbestos fiber price (Exhibit A.3-4);
- INTERCEPT = ordinate intercept of the fiber supply curve; and
- SLOPE = slope of the asbestos fiber supply curve.

1.2.4 Baseline Computation

The baseline quantities in each product market for any one year are obtained by applying the appropriate growth rate to the previous years quantity, i.e.,

$q^0_{i,t}$ = baseline product quantity for market 'i' in year 't';

$q^0_{i,t-1}$ = baseline product quantity for market 'i' in year 't-1'; and

r_i = growth rate for market 'i' from year 't-1' to year 't'.

The baseline fiber quantities demanded by each product market are computed as explained in Section 1.2.2. The total fiber demand in the baseline, and hence the price of fiber are computed as described in the previous section.

The change in the fiber price based on the fiber price in 1985, i.e., the difference between the 1985 fiber price and the freshly computed baseline fiber price, is translated into the baseline price for each product market. This is achieved by dividing this change in fiber price by the product asbestos coefficient and adding the result to individual market prices in the data year, i.e.,

$$P^0 = P^d + (P^0_f - P^d_f)/PAC$$

where:

P^0 = baseline product price (Exhibit 2);

P^0_f = baseline asbestos fiber price (Exhibit 4);

P^d = product price in 1985;

P^d_f = asbestos fiber price in 1985; and

PAC = product asbestos coefficient.

2. Computation of Welfare Effects in the ARCM

The theoretical discussion of the welfare economic foundations underlying the ARCM in Chapter II of the RIA identified areas 1, 2, 3, and 4 in the asbestos fiber market and areas 5, 6, 7, and 8 in the output markets that represent losses and transfers to the various parties involved in asbestos. This section discusses the algorithms used by the ARCM to compute these areas.

2.1 Computation of Scenario Prices and Quantities

Prior to calculating areas 1-8, it is necessary to compute the prices and quantities in all output markets and the fiber market under the regulation option being considered. The algorithms used by the ARCM are described below.

2.1.1 Asbestos Fiber Market

The algorithm for computing prices and quantities in this market depends on the type of regulation being considered. The three types of regulation that this model is capable of simulating are:

(i) staged asbestos product bans;

(ii) staged asbestos product bans and phase down of annual asbestos fiber usage; and

(iii) phasedown of annual fiber usage.

Staged Asbestos Product Bans. After banning one or more product, the fiber demand curve is recomputed, as using the derived demands of the non-banned products only. The total quantity of fiber obtained is the scenario fiber quantity. The scenario price (P^1_F in Exhibit A.3-5) is computed by using this scenario quantity in the equation for the fiber supply curve.

Phase-down of Fiber Usage. The scenario fiber price in this case is the "full" price of fiber (P^1_F in Exhibit A.3-6). However, for calculating all of the relevant areas it is also necessary to compute the supply price of fiber (P^{-1}_f in Exhibit A.3-6). The scenario quantity is identical to the fiber cap specified. Using this value with the fiber supply equations yields P^{-1}_f. To compute P^1_F, the algorithm steps down the fiber demand function until it locates the first vertical segment (Q_g in Exhibit A.3-6) of the step-function at which the quantity is greater than (or equal to) the specified fiber cap. The "full" price of fiber then is the price associated with this particular step (P_g in Exhibit A.3-6).

Staged Product Bans and Phasedown of Usage Fiber. Scenario price and quantity in the fiber market under this scenario is computed in the same way as in the previous scenario, with one exception. The demand curve in the fiber market is recomputed, as in the case of product bans only, by excluding the derived demand of the banned markets. The fiber cap is then imposed on this newly computed fiber demand, and the calculations proceed as in the phase-down only scenario.

2.1.2 Product Markets

The scenario prices in the non-banned product market are computed using the change in the fiber price. The translation of this change is done as follows:

$$P^1_i = P^0_i + (P^1_f - P^0_f) \cdot PAC_i$$

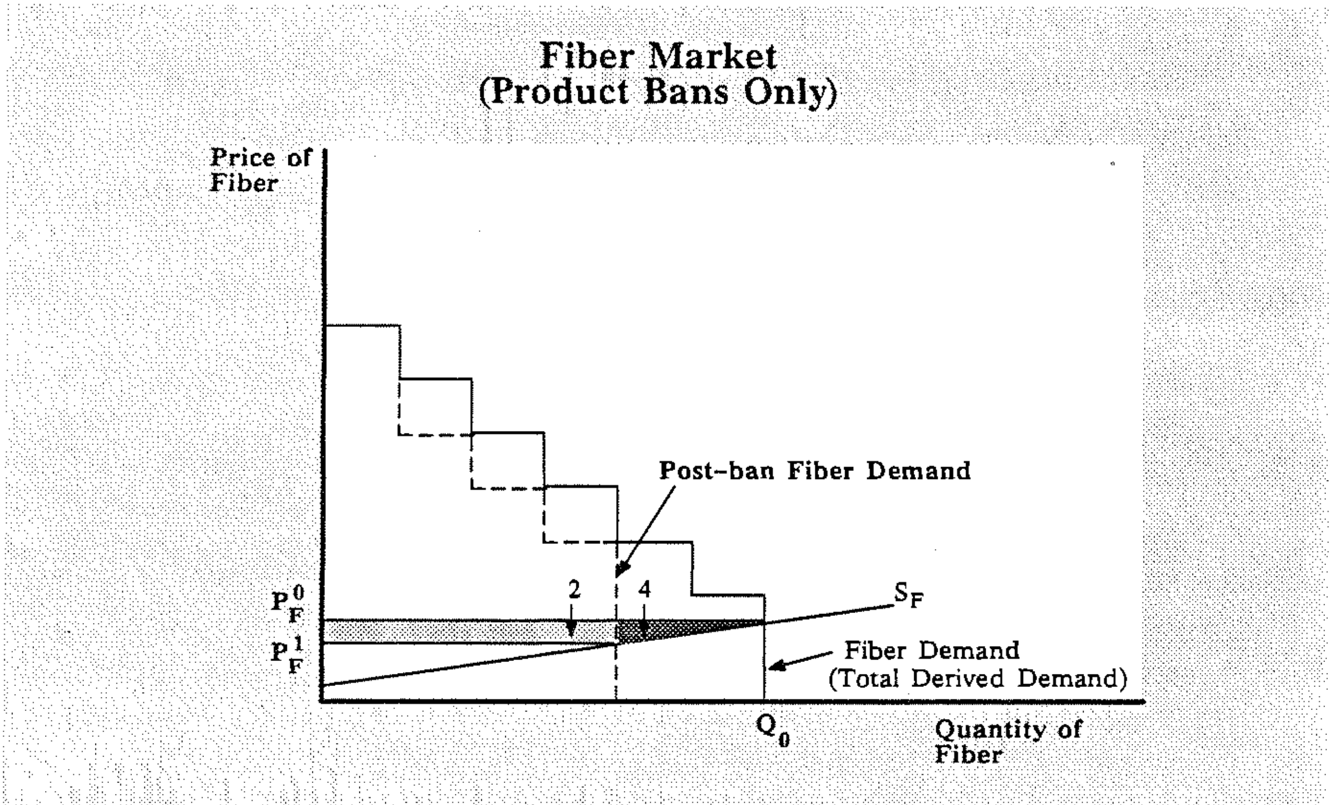
where:

P^1_i = scenario price of the i^{th} product;

P^0_i = baseline price of the i^{th} product;

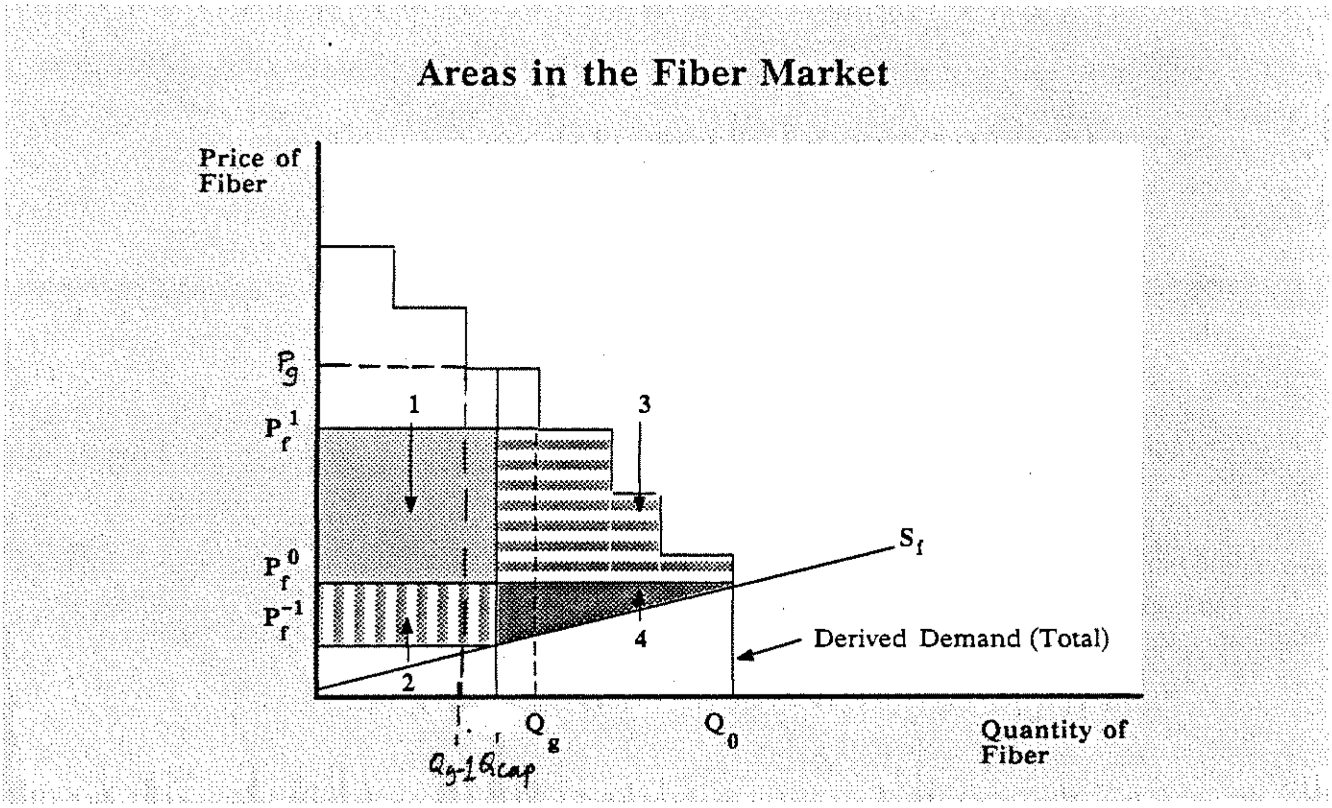
P^1_f = scenario price of asbestos fiber;

Exhibit A.3-5



Fiber Market
(Product Bans Only)
Price of Fiber
Post-ban Fiber Demand
P_F^0
P_F^1
2
4
S_F
Fiber Demand
(Total Derived Demand)
Q_0
Quantity of Fiber

Exhibit A.3-6



Areas in the Fiber Market
Price of Fiber
P_g
P_f^1
P_f^0
P_f^{-1}
1
2
3
4
S_f
Derived Demand (Total)
Q_{g-1}
Q_{cap}
Q_g
Q_0
Quantity of Fiber

$P^0{}_f$ = baseline price of asbestos fiber; and

PAC_i = Product Asbestos Coefficient for the i^{th} product.

As can be seen, $P^1{}_i < P^0{}_i$ for product bans only, since $P^1{}_f < P^0{}_f$ occurs only in these scenarios. The opposite is true for the other two regulatory options, as shown in Exhibit A.3-7.

The price-change algorithm applies for all cases and all markets with one exception. The scenario price for markets with existing quasi-rents in a scenario with a fiber cap is computed as follows:

$$P^1{}_i = AVC_i + (P^1{}_f - P^0{}_f) \cdot PAC_i$$

where:

AVC_i = average variable cost in the baseline for the i^{th} producer market, and all other variables are as defined before.

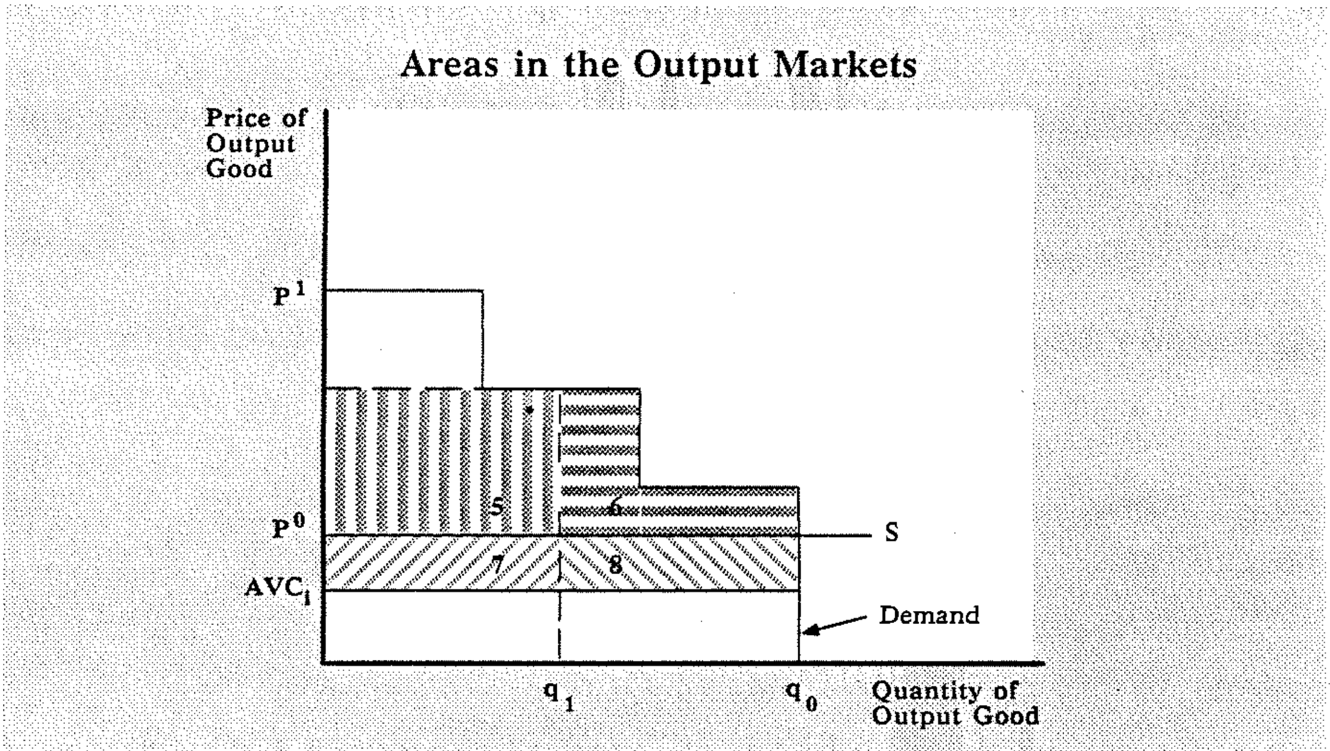
However, if the $P^1{}_f$ computed for such markets is less than $P^0{}_i$, the baseline product price, the scenario price is the same as the baseline price. Nevertheless, even in such a case, $P^1{}_i$ needs to be retained for use in the computation of areas for welfare analysis.

The methods for computing scenario quantities depends on the regulation option chosen. For staged bans the scenario quantities in all non-banned markets are the same as the baseline quantities because the price drops along the last vertical segment of the demand curve. Of course, the scenario quantities for banned markets are zero. However, for the other two regulatory options, the calculations are not as straightforward and are described in detail below.

Computation of Scenario Quantities in Non-Banned Product Markets When Fiber Cap is Imposed in the Fiber Market. The first step in computing product scenario quantities given a fiber cap is to determine the amount of asbestos fiber demanded by individual markets. To calculate this, the algorithm "steps down" the product derived demand curves until it identifies the first horizontal segment at which the height of the step is less than or equal to the "full" price of fiber. If the identified segment's height is less than the full price of fiber, then the quantity of fiber allocated to that market is the quantity associated with this step. On the other hand, the identified horizontal segment's height could be equal to the "full" price of fiber in which event the quantity of fiber allocated to this market is somewhat more complicated to describe. The quantity of fiber used by such a market cannot be estimated directly. Mathematically, it is determined as:

$$Q^f{}_{is} = Q^n{}_{if} + (Q^{n+1}{}_{if} - Q^n{}_{if}) \cdot \frac{Q_{cap} - Q_{g-1}}{Q_g - Q_{g-1}}$$

Exhibit A.3-7


Areas in the Output Markets
Price of Output Good
P1
P0
AVCi
5
6
7
8
S
Demand
q1
q0
Quantity of Output Good

where:

Q^f_{is} = scenario quantity of asbestos fiber used by the i market, as shown in Exhibit A.3-8;

Q^n_{if} = quantity of asbestos fiber associated with the horizontal step just greater than the "full" price of fiber in the demand curve of the i^{th} product (Exhibit A.3-8);

Q^{n+1}_{if} = quantity of asbestos fiber associated with the step identified whose height is equal to the "full" price of fiber in the desired demand curve of the i^{th} product (Exhibit A.3-8);

Q_{cap} = specified fiber cap (Exhibit A.3-6);

Q_{g-1} = vertical step at which the quantity is just lesser than Q_{cap} in the fiber demand curve (Exhibit A.3-9); and

Q_g = vertical step at which the quantity is just greater than Q_{cap} in the fiber demand curve (Exhibit A.3-9).

As can be seen by the above computation, if the specified fiber cap overlaps a vertical segment in the fiber demand curve, then

$$Q_{cap} = Q_g$$

and therefore,

$$Q^1_{is} = Q^{n+1}_{if}$$

After having estimated the scenario quantity of fiber used by all non-banned markets, the scenario quantity in the product markets is computed as:

$$q^i_{is} = Q^t_{is} /PAC$$

where

q^i_{is} = scenario quantity in the i^{th} product market (Exhibit A.3-7) and the other variables are as defined earlier.

2.2 Computation of Areas Used in Welfare Analysis of Markets

After computing the scenario prices and quantities for all output markets and the fiber market, the areas used in the welfare analysis can be measured.

2.2.1 Product Bans Only

The relevant areas for measuring the welfare effects of product bans alone are identified below along with the formulae used to calculate them.

Exhibit A.3-8

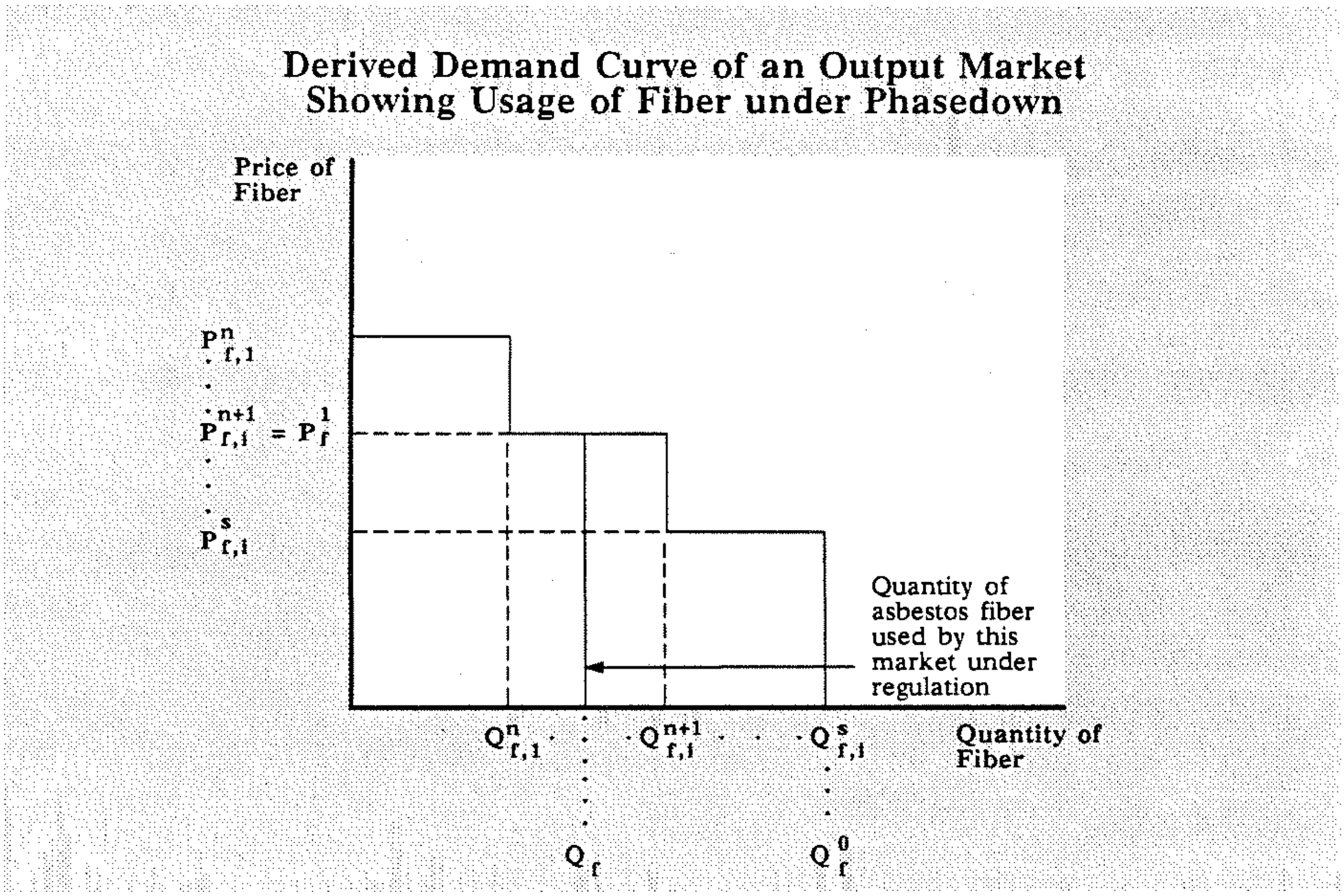
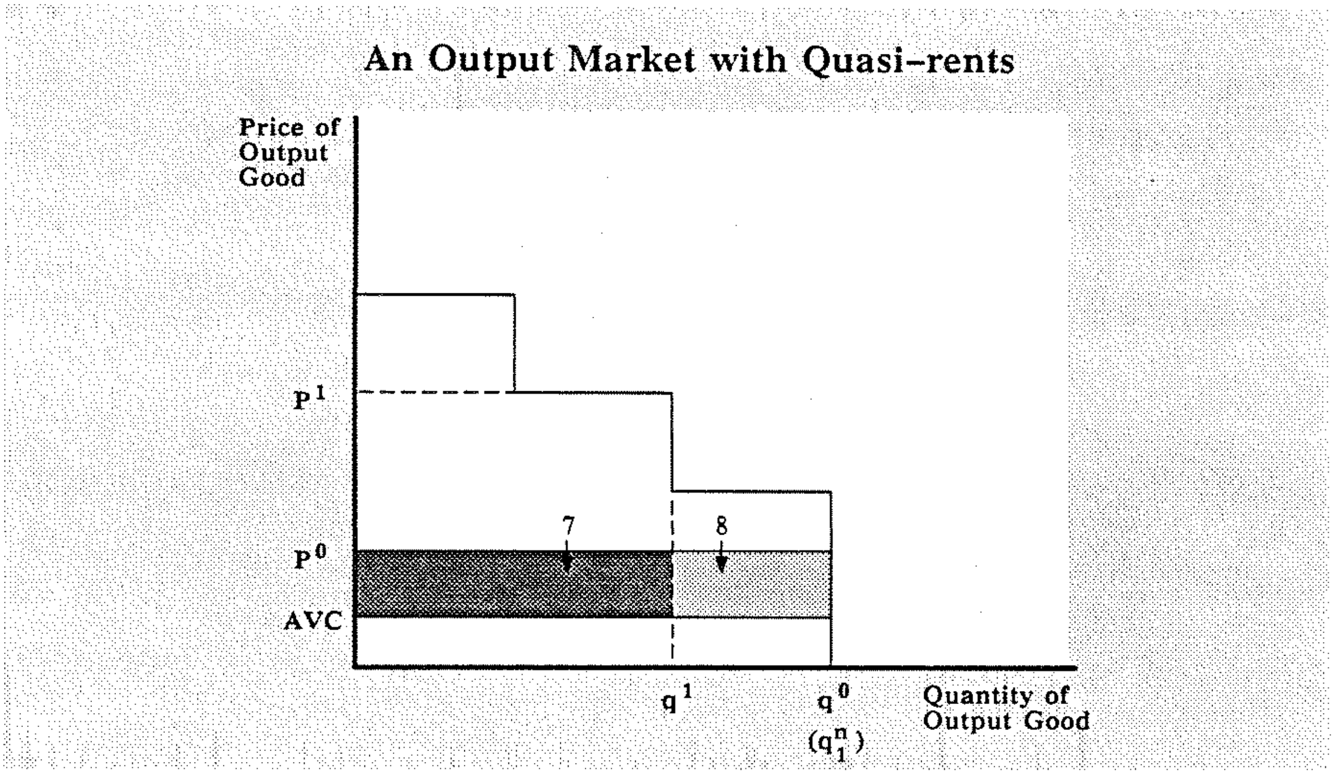

Derived Demand Curve of an Output Market
Showing Usage of Fiber under Phasedown
Price of Fiber
$P^n_{f,1}$
$P^{n+1}_{f,i} = P^1_f$
$P^s_{f,i}$
Quantity of asbestos fiber used by this market under regulation
$Q^n_{f,1}$
$Q^{n+1}_{f,i}$
$Q^s_{f,i}$
Quantity of Fiber
Q_f
Q^0_f

Exhibit A.3-9



An Output Market with Quasi-rents
Price of Output Good
P 1
P 0
AVC
7
8
q 1
q 0
(q n 1)
Quantity of Output Good

- Area 2 (Exhibit A.3-5): The loss in fiber market producer surplus transferred to the non-banned output markets in the form of gains in consumer surplus (due to the drop in the price of fiber).

$$\text{Area } 2 = Q^1 \cdot (P^0{}_f - P^1{}_f)$$

- Area 4 (Exhibit A.3-5): The deadweight losses borne by factors of production associated with the supply of fiber.

$$\text{Area } 4 = 0.5 \cdot (Q_0 - Q_1) \cdot (P^0{}_f - P^1{}_f)$$

- Area 2 + Area 4 = Total loss of producer surplus by the factors of production associated with fiber production.

- Area 6 (Exhibit A.3-10): Deadweight losses borne by consumers of each banned product.

$$\text{Area } 6_i = \prod_{n=1}^{S^i} (q^n{}_i - q^{n-1}{}_i) \cdot (P^n{}_i - P^b{}_i)$$

where S^i = number of steps in the step demand function of market "i".

- Area 8 (Exhibit A.3-10): The short-run deadweight losses borne by factors of production (other than those in the fiber market) associated with the supply of each banned market with existing quasi rents.

$$\text{Area } 8_i = q^b{}_i \cdot P^b{}_i - AVC_i$$

- Area CSG (Exhibit A.3-11): Consumer surplus gain in each non-banned market.

$$CSG_i = q^b{}_i \cdot p^b{}_i - p^s$$

Note that:

$$\text{Area } 2 = \prod_{i=1}^{N^{nb}} CSG_i$$

where N^{nb} = number of non-banned output markets.

2.2.2 Fiber Phase-down

Computing the welfare effects associated with a regulation scenario involving fiber phase-down is the same whether or not certain output markets are banned.

If certain output markets are banned prior to imposing the fiber cap, Areas 6 and 8 in the banned markets, as computed in Section 2.2.1 above, also exist and are calculated in addition to the areas identified below.

Exhibit A.3-10

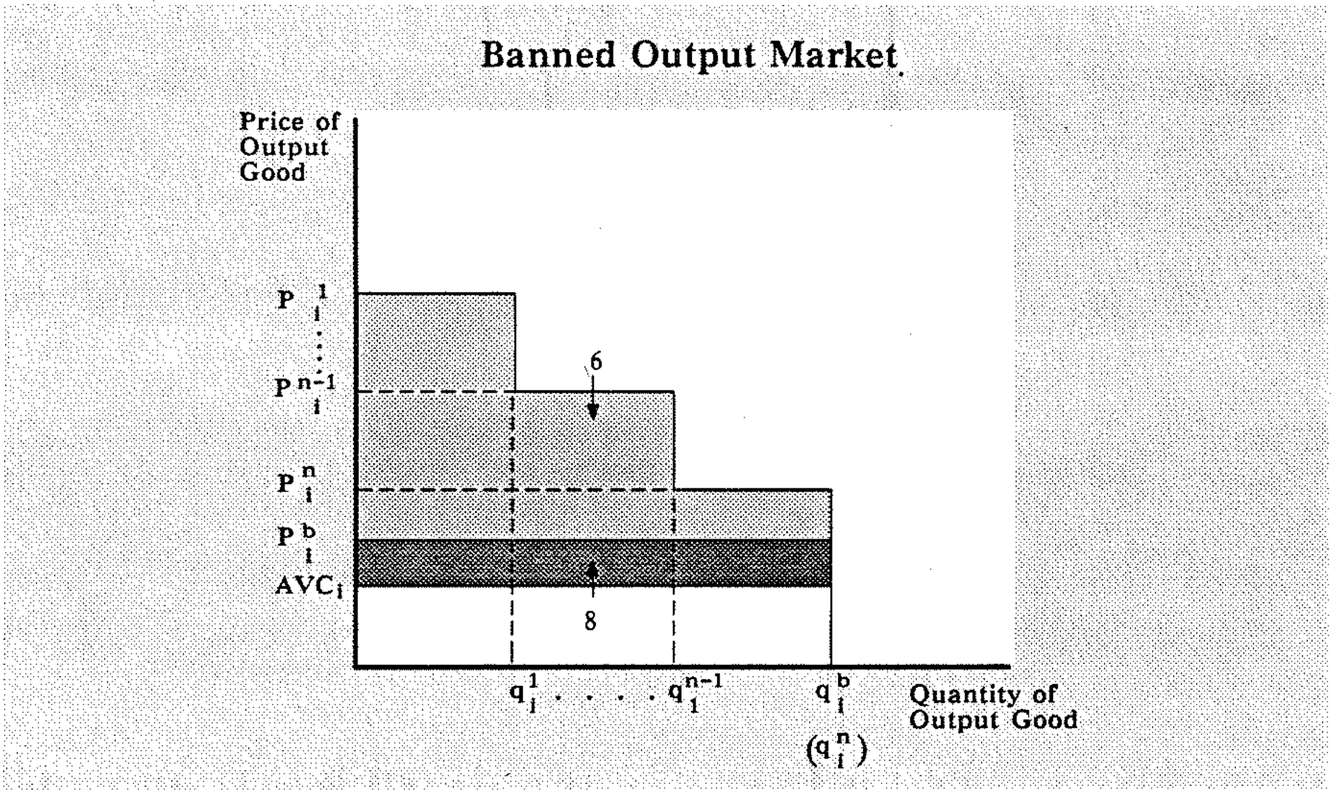
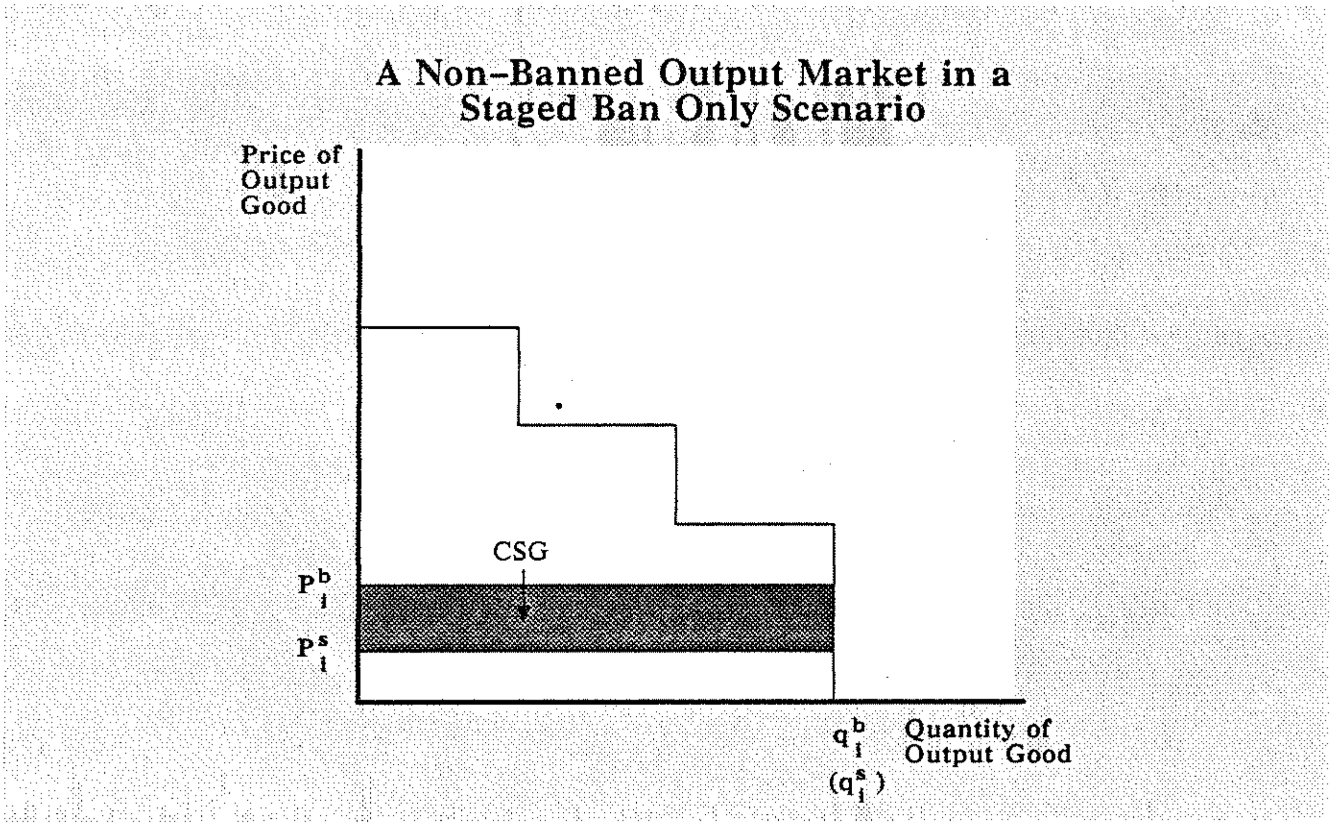


Exhibit A.3-11



Asbestos Fiber Market

- Area 1 (Exhibit A.3-6): Consumer and producer surplus losses in the downstream output markets represented in the fiber market as part of willingness to pay for fiber.

$$\text{Area } 1 = Q_{cap} \cdot (P^{0}{}_{f} - P^{-1}{}_{f})$$

- Area 2 (Exhibit A.3-6): Transfer of welfare in the form of valuable rights to purchase of use fiber derived from the producer surplus losses borne of factors of production associated with the supply of fiber.

$$\text{Area } 2 = Q_{cap} \cdot (P^{0}{}_{f} - P^{-1}{}_{f})$$

- Area 3 (Exhibit A.3-6): Deadweight losses borne by consumers of products made from asbestos fiber and the short-run deadweight losses borne by factors of production (other than those in the fiber market) associated with the supply of all products in all downstream markets, as measured in the fiber market.

$$\text{Area } 3 = \prod_{n=g}^{S^F} (Q_{n+1} - Q_n) \cdot P_n - P^{0}{}_{f} + (Q_g - Q_{cap}) \cdot (P^{1}{}_{f} - P^{0}{}_{f})$$

where: S^F = number of steps in the fiber demand function, and other variables are as defined earlier.

- Area 4 (Exhibit A.3-6): Deadweight losses borne by factors of production associated with the supply of fiber.

$$\text{Area } 4 = 0.5 \cdot (Q_0 - Q_{cap}) \cdot (P^{0}{}_{f} - P^{-1}{}_{f})$$

- Area 1 + Area 3 = Total loss in consumer and producer surplus loss in non-banned downstream product markets, as measured in the fiber market.

- Area 2 + Area 4 = Total loss of producer surplus by the factors associated with fiber supply.

Asbestos Product Markets

- Area 5 (Exhibit A.3-7): Consumer surplus loss in each non-banned market transferred to those owning the rights to purchase or use fiber in the fiber market.

$$\text{Area } 5_i = q^{1}{}_{i} \cdot (P^{1}{}_{i} - P^{0}{}_{i})$$

- Area 6 (Exhibit A.3-7): Deadweight losses borne by consumers of all non-banned products made from asbestos fiber.

$$\text{Area 6} = \sum_{n=j}^{S_i} (q^{n+1}{}_i - q^n{}_i) \cdot (P^{n+1}{}_i - P^0{}_i) + (q^j{}_i - q^1{}_i) \cdot (P^1{}_i - P^0{}_i)$$

where S_i = number of steps in demand function of product i;

and $q^j{}_i$ = quantity associated with the first vertical step greater than $q^1{}_i$ if $P^1{}_i$ is at the same level as a horizontal step;

else, $q^j{}_i = q^1{}_i$ = scenario quantity in market 'i'.

- Area 7 (Exhibit 7): Short run losses borne by factors of production (other than those in the fiber market) associated with the supply of each non-banned market and transferred to owners of the rights to purchase or use fiber in the fiber market.

  If $P^1{}_i = P^0{}_i$, then:

  $$\text{Area } 7_i = (P^0{}_i - AVC_i) \cdot q^1{}_i$$

  else if $P^1{}_i > P^0{}_i$, then[4]

  $$\text{Area } 7_i = (P^1{}_i - AVC_i) \cdot q^1{}_i$$

- Area 8 (Exhibit 7): The short-run deadweight losses borne by factors of production (other than those in the fiber market) associated with the supply of each non-banned asbestos product.

  If $P^1{}_i = P^0{}_i$, then:

  $$\text{Area } 8_i = (P^0{}_i - AVC_i) \cdot (q^0{}_i - q^1{}_i)$$

  else, if $P^1{}_i > P^0{}_i$, then:

  $$\text{Area } 8_i = (P^1{}_i - AVC_i) \cdot (q^0{}_i - q^1{}_i)$$

- Area 5_i + Area 6_i = Gross consumer surplus loss experienced in the i^{th} market.

- Area 7_i + Area 8_i = Gross short-run producer surplus losses experienced by factors (other than those in the fiber market) associated with the production of output good "i".

2.3 Welfare Analysis by Party

The eight groups affected by regulation of asbestos were identified in Section 2.2. These eight groups are made up of the parties shown below:

---

4 As explained in Section 5.1, in such cases the scenario price is the same as P^0_i the baseline price, but the value of P^1_i (which measures the increase in AVC due to higher fiber prices) is required for the computing areas 7 and 8.

(1) Domestic Miners and Millers;
(2) Foreign Miners and Millers;
(3) Importers of Bulk Fiber, Mixtures and Products;
(4) Domestic Primary Processors;
(5) Foreign Primary Processors;
(6) Domestic Purchasers; and
(7) Foreign Purchasers.
(8) U.S. Government.

The producer surplus losses in the fiber market are distributed to the domestic and foreign miners and millers in a ratio of 1:10.9.[5] This ratio can be changed interactively by the user, if desired (refer to User's Manual for details).

For all product markets that have imports, i.e., markets with a consumption-production ratio greater than one, the short-run producer surplus losses, if any, are divided between domestic and foreign primary processors in the ratio of domestically produced quantity to imported quantity. Since foreign producers of goods are assumed to be identical to domestic producers, this is the only further allocation of producer surplus losses that is required.

The consumer surplus losses are all allocated to the domestic secondary processors/consumers. Foreign consumers do not experience any surplus losses since they are assumed to have viable alternatives. However, consumer surplus gains in markets with exports, i.e., markets with a consumption- production ratio less than one, are divided between domestic and foreign consumers in the ratio of domestically consumed quantity to the exported quantity.

The distribution as described above gives the gross distribution of losses and/or gains experienced by the participants in the market associated with asbestos. However, for any form of regulation involving fiber phase-down, the allocation of the rights to purchase or use fiber to the parties identified by the user (refer to User's Manual) are added to the losses/gains identified above. This gives the actual distribution of losses/gains across all parties after allocating these rights.

The net world welfare loss is obtained by summing the losses/gains across all parties in the world. The net U.S. welfare loss, on the other hand, is obtained by summing the losses/gains for domestic miners and millers; importers of bulk fiber, mixtures, and products; domestic primary processors; and domestic secondary processors/consumers.

The discounted welfare analysis by markets and by party are available for all discount rates specified by the user. The User's Manual should be consulted for specifying scenarios, discount rates, changing default settings, and running the ARC model.

---

[5] 91.6% of asbestos fiber consumed in the U.S. is supplied by foreign miners and millers. United States Department of the Interior. "Asbestos," reprint from the 1985 bureau of Mines Minerals Yearbook, Washington, D.C.

3. ARCM Computer Code

This section provides a copy of the FORTRAN computer code for the ARCM. The code is "commented" so that the purpose and operation of each section of the program are clear.

In order to simulate declining substitute prices and engineering controls on aftermarket brakes, two standard ARCM subroutines are modified and an additional subroutine is added. This is done because the "standard" ARCM that handles phase-down of fiber usage (and normal bans) is not capable of handling the interactive "stock flow" issues that arise when aftermarket brakes are not banned within four years of the OEM brakes. (The baseline of the aftermarket brakes is dependent on the number of OEM brakes produced with a four year lag because the life of a brake is assumed to be four years.) These subroutines have appropriate "comments" at the beginning of their listings.

```
c_______________________________________________________________________
c
c
c     ASBESTOS REGULATORY COST MODEL (ARCM) : MAIN PROGRAM
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c                          Vikram Widge
c                          ICF Incorporated
c                          9300 Lee Highway
c                          Virginia 22031-1207
c
c                          (703) 934-3000
c
c     Accompanying Documentation:
c
c           1. User's Manual
c           2. Technical Support Document
c
c_______________________________________________________________________
c
c
$include:'stdsub'
$large
c
c
      program   arcm
c
$include:'stdvar'
$include:'vars.cmn'
c
      character istr(6)*55
c
c_______________________________________________________________________
c
c           this section prints the opening statement on the screen
c_______________________________________________________________________
c
c
      call vinit
      call crt_cls
      call box (0,3,15,63,vnorm)
      call pcsa (1,17,'EPA/OTS Asbestos Regulatory Cost Model (ARCM)'c,
     -          vbold)
      call pcs  (2,17,'                   Version 6.3'c)
c
      istr(1)='This program models the economic impacts and costs of'c
      istr(2)='asbestos fiber and product regulations.  It permits a'c
      istr(3)='variety of regulatory options to be implemented and'c
      istr(4)='allows flexibility in their implementation.  For'c
      istr(5)='assistance in using this model please refer to the'c
      istr(6)='accompanying user''s manual and related documentation.'c
c
      do 1 i=1,6
       call pcs (i+7,13,istr(i))
1     continue
c
      call pcs (20,20,'Please respond to queries as indicated.'c)
      call pcs (24,25,'Press any key to continue'c)
      call setcur (vy,vx)
      ipse=key_getc()
c
      call eeop (5,0)
      call pcs (9,20,'Refer any specific questions regarding'c)
      call pcs (10,20,'operation of this program to:'c)
      call pcs (12,30,'Vikram Widge'c)
      call pcs (13,30,'ICF Incorporated'c)
      call pcs (14,30,'9300 Lee Highway'c)
      call pcs (15,30,'Virginia 22031-1207'c)
      call pcs (17,30,'(703) 934-3000'c)
c
      call pcs (24,25,'Press any key to continue'c)
      call setcur (vy,vx)
      ipse=key_getc()
c
      call eeop (5,0)
      call pcsa (12,25,' Initializing... 'c,vrev)
      call setcur (vy,vx-1)
```

```
c
      call sinit
      call asbin
c
c_____________________________________________________________________________
c
c  this section sets up the product demand curves for all markets, transforms
c  data from year of data (ibyd) to specified baseyear, and calculates quasi-
c  rent perpetuities by including the reformulation cost perpetuities.
c_____________________________________________________________________________
c
c
      do 300 i=1,np
c
        do 3001 j=1,nsub(i)
            a=(1+fdiscrt)**ns(i,j)
            b=(1+fdiscrt)**na(i)
c
            do 199 iy=1,ie
              if (ns(i,j) .ne. na(i))
                aps(iy,i,j)=aps(iy,i,j)*(a/b)*(b-1)/(a-1)
c
              if (aps(iy,i,j) .lt. epp(1,i)) then
                aps(iy,i,j)=epp(1,i)
              endif
199         continue
c
3001    continue
c
        if (nsub(i) .eq. 1) then
          ps(1,i,1)=aps(1,i,1)
          ms(i,1)=ams(i,1)
c
          do 4641 iy=2,ie
            if (multsub) then
              ps(iy,i,1)=aps(iy,i,1)
            else
              ps(iy,i,1)=ps(1,i,1)
            endif
4641      continue
c
        else
          insub=0
          do 201 j=1,nsub(i)
            do 2011 k=1,insub
              if (aps(1,i,j) .eq. ps(1,i,k)) then
                ms(i,k)=ms(i,k)+ams(i,j)
                go to 201
              endif
2011        continue
c
            insub=insub+1
            ps(1,i,insub)=aps(1,i,j)
            ms(i,insub)=ams(i,j)
c
            do 4642 iy=2,ie
              if (multsub) then
                ps(iy,i,insub)=aps(iy,i,j)
              else
                ps(iy,i,insub)=ps(1,i,insub)
              endif
4642        continue
c
201       continue
          nsub(i)=insub
c
          do 4630 iy=1,ie
            do 4631 j=1,nsub(i)-1
              do 46311 k=j+1,nsub(i)
c
                if (ps(iy,i,j) .eq. ps(iy,i,k)) then
                  call eeop (5,0)
                  call setcur (12,0)
                  write (*,*) '    PRICES OF SUBSTITUTES STILL EQUAL'
                  write (*,*) '    YEAR:',baseyr+iy-1,'  MARKET:',idp(i)
                  write (*,*) '    SUBSTITUTES:',j,k
                  write (*,*) '    PRICES:',ps(iy,i,j),ps(iy,i,k)
                  call setcur (22,0)
                  stop
                endif
```

```
c
                 if (ps(iy,i,j) .gt. ps(iy,i,k)) go to 46311
                 ptemp=ps(iy,i,j)
                 if (iy .eq. 1) emtemp=ms(i,j)
                 ps(iy,i,j)=ps(iy,i,k)
                 if (iy .eq. 1) ms(i,j)=ms(i,k)
                 ps(iy,i,k)=ptemp
                 if (iy .eq. 1) ms(i,k)=emtemp
c
46311           continue
4631           continue
4630          continue
             endif
c
462          count=0
             do 4621 j=1,nsub(i)
               count=count+ms(i,j)
4621         continue
c
             if (count .ne. 1.0) then
               call eeop (5,0)
               call setcur (12,0)
               write (*,'(5x,2a,i2,a,f14.7)') 'MARKET SHARE(S) OF ',
     -         'SUBSTITUTES IN MARKET ',idp(i),' ADD TO ',count
               call setcur (22,0)
               stop
             endif
c
c
            impinf(i)=.false.
c
            if (cprat(i) .eq. -1) then
              cprat(i)=1
              impinf(i)=.true.
            endif
c
            if (cprat(i) .gt. 1) epq(1,i)=epq(1,i)*cprat(i)
c
            bbpq(i)=epq(1,i)
c
            fqe(1)=fqe(1)+epq(1,i)*awt(i)
c
            idif=baseyr-ibyd
            do 357 ij=1,idif
              if (ij .lt. 15) then
                ig=ij
              else
                ig=15
              endif
              epq(1,i)=epq(1,i)*(1+grthrt(i,ig))
357         continue
c
            bepq(1,i)=epq(1,i)
c
300         continue
c
c
c
            slope=fpe(1)/(selast*fqe(1))
            rint=fpe(1)-slope*fqe(1)
            if (selast .eq. 1) rint=0
c
            bbfq=fqe(1)
            fqe(1)=0
c
            yr=1
c
            do 4638 i=1,np
              fqe(1)=fqe(1)+epq(1,i)*awt(i)
4638        continue
c
            afpe=fpe(1)
            fpe(1)=rint+slope*fqe(1)
            if (fpe(1) .gt. afpe) go to 44444
c
            do 468 i=1,np
              aepp(i)=epp(1,i)
              epp(1,i)=(fpe(1)-afpe)*awt(i)+epp(1,i)
              bepp(1,i)=epp(1,i)
              do 4681 j=1,nsub(i)
```

```
          qs(1,i,j)=epq(1,i)*ms(i,j)
          lnsub(i,j)=.false.
 4681   continue
c
        if (rcost(i) .gt. 0) then
          qrarea(i)=ccost(i)*epq(1,i)+rcost(i)
          avc(i)=epp(1,i)-(qrarea(i)/epq(1,i))
        elseif (ccost(i) .gt. 0) then
          avc(i)=epp(1,i)-ccost(i)
        else
          go to 4683
        endif
c
        swqr(i)=1
        do 4682 j=1,nsub(i)
          lnsub(i,j)=.true.
 4682   continue
c
c_____________________________________________________________________________
c
c               adjustment of steps in export-oriented markets.
c_____________________________________________________________________________
c
c
 4683   if (cprat(i) .lt. 1) then
          do 4688 j=1,nsub(i)
            qs(1,i,j)=qs(1,i,j)*cprat(i)
 4688     continue
          nsub(i)=nsub(i)+1
          qs(1,i,nsub(i))=epq(1,i)*(1-cprat(i))
          ps(1,i,nsub(i))=epp(1,i)
c
          if (swqr(i) .eq. 1) then
            lnsub(i,nsub(i))=.true.
          else
            lnsub(i,nsub(i))=.false.
          endif
        endif
c
 468  continue
c
      bfpe(1)=fpe(1)
      bfqe(1)=fqe(1)
c
c
      yr=2
c
c_____________________________________________________________________________
c
c         this section modifies the product demand curves annually.
c_____________________________________________________________________________
c
c
 1111 qcap(yr)=qcapm(yr)
c
      do 400 i=1,np
c
        igj=baseyr-ibyd+yr-1
        if (igj .gt. 15) igj=15
c
        do 4001 j=1,nsub(i)
          qs(yr,i,j)=qs(yr-1,i,j)*(1+grthrt(i,igj))
          if (j .eq. 1) then
            qs1(yr,i,j)=qs(yr,i,j)
          else
            qs1(yr,i,j)=qs1(yr,i,j-1)+qs(yr,i,j)
          endif
 4001   continue
c
        rq=qs1(yr,i,nsub(i))
        if (rq .eq. 0.) swqr(i)=0
c
        if (swqr(i) .eq. 1) then
          qrarea(i)=ccost(i)*rq+rcost(i)
        endif
c
c       **** engineering control cost calculation ****
c
        if (rq .ne. 0) ecost(i)=(fecost(i)+vecost(i)*rq)/rq
c
```

```
          if (exmpt(idp(i))) then
            if (qcap(yr) .eq. 0) then
              qcapm(yr)=qcapm(yr)+(awt(i)*qs1(yr,i,nsub(i)))
            else
             qcap(yr)=qcap(yr)-(awt(i)*qs1(yr,i,nsub(i)))
c
             if (qcap(yr) .lt. 0) then
               call eeop (5,0)
               call setcur (12,0)
               write (*,'(10x,a,i4//)') 'MODIFIED FIBER CAP < 0 IN '//
     -                                  'YEAR ',baseyr+yr-1
               write (*,'(2(10x,a,f13.7/))') 'INPUT CAP    = ',qcapm(yr),
     -                                       'MODIFIED CAP = ',qcap(yr)
               write (*,'(/10x,a,i2)') 'ERROR AT EXEMPTED PRODUCT #',
     -                                 idp(i)
               call setcur (22,0)
               stop
             endif
c
            endif
          endif
 400    continue
c
        call iddc (0)
        call tddc (0)
        call eqpq
        if (afpe .ge. fpe(yr)) go to 2222
c
 44444  iyr=yr+baseyr-1
        call eeop (5,0)
        call setcur (12,0)
        write (*,'(15x,a//)') 'BASELINE FIBER PRICE > '//
     -                        'DATA YEAR FIBER PRICE'
        write (*,'(10x,a,i4,a,f14.7/)') 'Baseline fiber price for ',
     -                                  iyr,' = ',fpe(yr)
        write (*,'(10x,a,i4,a,f14.7)') 'Data year (',ibyd,
     -                                 ') fiber price  = ',afpe
        call setcur (22,0)
        stop
c
c
 2222   bfpe(yr)=fpe(yr)
        bfqe(yr)=fqe(yr)
        do 210 i=1,np
          bepp(yr,i)=epp(yr,i)
          bepq(yr,i)=epq(yr,i)
c
c setting price of exports equal to baseline price.
c
          if (cprat(i) .lt. 1) then
            ps(yr,i,nsub(i))=bepp(yr,i)
          endif
c
 210    continue
c
c  adjustment of fiber demand curve to reflect export
c  markets' last step adjustment.
c

        if ((enf .or. lbf) .and.
     -     (((option .eq. 1) .and.(ibchk .gt. yr)) .or.
     -     ((option .eq. 2) .and. (ibchk .gt. yr) .and.
     -      (qcap(yr) .gt. 0)) .or.
     -     ((option .eq. 3) .and. (qcap(yr) .gt. 0)))) then
          call enlbl
          call iddc (1)
        endif
c
        call tddc (1)
        if (option .eq. 3) go to 2339
        call bancsqr
        call eqpq
c
        if (option .eq. 1) then
          if (fpe(yr) .eq. 0) fpe(yr)=rint
          call aronban
          go to 8888
        endif
c
 2339   capr=.false.
```

```
      call fpc1234
      call fppfpq
      if (exf) call exempt
c
 8888 yr=yr+1
      if (.not.(yr .gt. ie)) go to 1111
c
      call benout
      call asbout
      call pcsa (15,38,' completed 'c,vrev)
c
      if (fname(3) .ne. 'lpt1') then
       call pcsa (18,15,'TO PRINT OUTPUT FILE '//
     -              fname(3)(1:lench(fname(3)))//' ENTER'c,vbold)
       call pcsa (19,15,'''PF_ARCM '//fname(3)(1:lench(fname(3)))//
     -              ''' AT THE DOS PROMPT.'c,vbold)
      endif
      call setcur (22,0)
c
      stop
      end
```

```fortran
c________________________________________________________________________
c
c
c      ARCM : CALCULATION OF AREAS 5, 6, 7 AND 8
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c________________________________________________________________________
c
c
$large
c
c________________________________________________________________________
c
c                 This subroutine calculates AREAs 5, 6, 7, and 8.
c________________________________________________________________________
c
c
      subroutine area5678 (i)
c
$include:'vars.cmn'
c
c
      area5(yr,i)=(fpp(yr,i)-bepp(yr,i))*fpq(yr,i)
      if ((fpp(yr,i) .gt. bepp(yr,i)) .or. (fpq(yr,i) .eq. 0)) then
        call sarea6 (i)
      endif
      if (swqr(i) .ne. 1) return
c
      if (fppflag(i) .eq. 1) then
        dif=tfpp(i)-avc(i)
      else
        dif=bepp(yr,i)-avc(i)
      endif
c
      if ((qcap(yr) .eq. 0) .or. (fpq(yr,i) .eq. 0)) then
        area7(yr,i)=0
        do 90 j=1,nsub(i)
          if (.not.(lnsub(i,j))) go to 90
          area8(yr,i)=area8(yr,i)+dif*qs(yr,i,j)
          area8p(yr,i)=area8p(yr,i)+dif*qs(yr,i,j)*(1/fdiscrt-1)
          lnsub(i,j)=.false.
90      continue
        swqr(i)=0
        return
      endif
c
      do 100 j=1,nsub(i)
        if (.not.(lnsub(i,j))) return
        if (fps(i,j) .gt. pf(yr)) then
          area7(yr,i)=area7(yr,i)+dif*qs(yr,i,j)
          go to 100
        elseif (fps(i,j) .eq. pf(yr)) then
          if (j .eq. 1) then
            area7(yr,i)=dif*fpq(yr,i)
          else
            area7(yr,i)=area7(yr,i)+dif*(fpq(yr,i)-qs1(yr,i,j-1))
          endif
          area8(yr,i)=area8(yr,i)+dif*(qs1(yr,i,j)-fpq(yr,i))
        elseif (fps(i,j) .lt. pf(yr)) then
          area8(yr,i)=area8(yr,i)+dif*qs(yr,i,j)
          area8p(yr,i)=area8p(yr,i)+dif*qs(yr,i,j)*(1/fdiscrt-1)
          lnsub(i,j)=.false.
          if (j .eq. 1) swqr(i)=0
        endif
100   continue
c
      return
      end
```

```
c______________________________________________________________________
c
c
c     ARCM : CALCULATION OF AREAS UNDER BANS ONLY
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c______________________________________________________________________
c
c
$large
c
c______________________________________________________________________
c
c                     This subroutine calculates the CS gains
c                     and PS losses when only bans take place.
c______________________________________________________________________
c
c
      subroutine aronban
c
$include:'vars.cmn'
c
c
      pedif=bfpe(yr)-fpe(yr)
      area2(yr)=pedif*fqe(yr)
      area4(yr)=0.5*pedif*(bfqe(yr)-fqe(yr))
      do 230 i=1,np
        if (swban(yr,i) .eq. 1) go to 230
        area5(yr,i)=(epp(yr,i)-bepp(yr,i))*epq(yr,i)
230   continue
      return
      end
```

```
c______________________________________________________________________
c
c
c      ARCM : USER AND DATA INPUT
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c______________________________________________________________________
c
c
$include:'stdsub'
$large
c
c______________________________________________________________________
c
c              This subroutine accepts data from user interactively
c              and reads data from input files.
c______________________________________________________________________
c
c
c
       subroutine asbin
c
$include:'stdvar'
$include:'vars.cmn'
c
c
       real      taps(25,im,ks),sub_dec(ks)
c
       integer   pid(10),beyr
c
       character res,dstr1*65,dstr2*52,dstr4*40,cstr2*60,
     -           cstr3*60,fstr1*60,fstr2*53,dstr5*40,dstr9*65,
     -           dstr7*65,dstr8*54,dstr0*65,fstr3*60,nyc*4,nzc*4,
     -           fstr4*53,prm1*60,prm2*65,cqc*10
c
       logical   ccap
c
c______________________________________________________________________
c
c               this section obtains the inputs from the operator.
c______________________________________________________________________
c
c
       call eeop (5,0)
       call pcs (7,10,'Three regulatory scenarios are supported '//
     -                'by this program'c)
       call pcs (10,25,'1. BAN OF PRODUCTS ONLY'c)
       call pcs (12,25,'2. BAN OF PRODUCTS AND AN 'c)
       call pcs (13,25,'      ANNUAL FIBER CAP'c)
       call pcs (15,25,'3. ANNUAL FIBER CAP ONLY'c)
 5550  call pcs (19,22,'Enter # of option desired MM'c)
       option=ichk (1,3)
       if (option .eq. -99) go to 5550
c
       call eeop (5,0)
       call pcsa (8,28,' SIMULATION PERIOD 'c,vrev)
 5551  call pcs (12,20,'Please enter BASE year MM'c)
       baseyr=ichk (-99,-99)
       if (baseyr .eq. -99) go to 5551

 5552  call pcs (14,20,'Please enter END year  MM'c)
       endyr=ichk (baseyr+1,-99)
       if (endyr .eq. -99) go to 5552
       call eeop (22,0)
c
c      if (endyr .le. baseyr) then
c        call pcsa (22,15,' END YEAR SHOULD BE GREATER THAN BASE YEAR 'c,
c    -               vrev)
c        go to 5551
c      endif
c
       ie=endyr-baseyr+1
       if ((endyr-baseyr) .gt. ny-1) then
         write (nyc,'(i2)') ny
```

```
          call pcsa (22,15,' THIS PROGRAM SUPPORTS A SPAN OF '//nyc(1:2)//
     -                     ' YEARS 'c,vrev)
          go to 5551
        endif
c
        ccap=.false.
        fname(1)='caperm.dat'
c
 4780   if ((option .eq. 1) .or. (option .eq. 2)) then
          call eeop (5,0)
          call pcsa (8,28,' PRODUCT BAN SCHEDULE 'c,vrev)
c
          do 4692 iyy=1,ny
            do 46921 ixy=1,ip
              isban(iyy,ixy)=0
 46921      continue
 4692     continue
c
 47801    call pcs (12,5,'Enter the number of years in '//
     -                   'which bans will take place MM'c)
          call yr_chk (byrs,0,22)
          call eeop (9,0)
c
          do 22 n=1,byrs
            write (nyc,'(i2)') n
            call pcs (12,15,'Enter ban year #'//nyc(1:2)//' MM'c)
            call yr_chk (byear(n),1,22)
 22       continue
c
          ibchk=99
          call eeop (9,0)
          do 33 n=1,byrs
            beyr=byear(n)-baseyr+1
            call nprd_chk (iban,22,'b',byear(n))
c
            if (iban .eq. 99) then
              ibchk=beyr
              byrs=n
c
              do 957 lm=1,ip
                do 9571 ll=beyr,ie
                  isban(ll,lm)=1
 9571           continue
 957          continue
c
              go to 4922
            endif
c
            call eeop (9,0)
            do 44 nn=1,iban
              call tsca (nn,nban,'b',12)
c
              do 55 ll=beyr,ie
                isban(ll,nban)=1
 55           continue
 44         continue
 33       continue
        endif
c
 4922   if (option .eq. 1) go to 9966
c
        call eeop (5,0)
        call pcsa (8,28,' FIBER CAP SCHEDULE 'c,vrev)
 4923   call pcs (12,5,'Please enter fiber end amount (tons) MM'c)
        endamt=rchk (0d0,-99d0)
        if (endamt .eq. -99.) go to 4923

 415    call pcs (14,5,'What year will phase down terminate? MM'c)
        call yr_chk (cendyr,1,15)
        is=cendyr-baseyr+1
        if (ccap) go to 4777
c
 416    ierr=0
        open (1,iostat=ierr,file=fname(1),status='old')
        if (ierr .le. 0) go to 418
        call file_chk (0,1)
        call pcs (16,5,'Please enter name of file containing '//
     -                 'annual fiber caps and permit value'c)
        call pcs (17,5,'allocation tonnage.  '//
     -                 '(Include path if necessary) MM'c)
```

```
        call cchk (fname(1))
        call eeop (22,0)
        go to 416
c
418     read (1,*) (qcapm(i),i=2,is-1)
        do 66 n=is,ie
          qcapm(n)=endamt
66      continue
c
4792    if (option .ne. 2) go to 4583
c
        do 4582 i=2,ie
          if (qcapm(i) .ne. 0) go to 4582
          icby=i+baseyr-1
          do 45821 n=1,byrs
            if (icby .gt. byear(n)) go to 45821
            call eeop (5,0)
            call pcsa (8,3,' YOU HAVE SPECIFIED PRODUCT BANS FOR '//
     -                 'YEAR(S) AFTER FIBER CAP GOES TO ZERO 'c,vrev)
            write (nyc,'(i4)') icby
            call pcs (10,10,'Fiber cap goes to zero in '//nyc//' 'c)
            call pcs (12,10,'One or more products have been banned '//
     -                      'in the following years:'c)
            call setcur (14,0)
            write (*,'(t15,4(5(i4,3x)/))') (byear(j),j=1,byrs)
            call pcsa (20,8,' YOU WILL BE PROMPTED FOR BAN AND '//
     -                      'FIBER CAP SCHEDULES AGAIN 'c,vrev)
            close (1)
            call pcs (24,25,'Press any key to continue'c)
            call setcur (vy,vx)
            ipse=key_getc()
            go to 4780
45821     continue
4582    continue
c
4583    cstr2='____________________________________________________________'c
        cstr3='          Year                    Fiber Cap Amount (tons)'c
        call eeop (5,0)
        call pcsa (5,28,' FIBER CAP SCHEDULE 'c,vrev)
        call pcs (6,13,cstr2)
        call pcs (8,13,cstr3)
        call pcs (9,13,cstr2)
        call setcur (11,0)
c
        if (cendyr .eq. endyr) then
          ix=ie
        else
          ix=cendyr-baseyr
        endif
c
        do 836 i=2,ix
          j=9+i

          if (i .gt. 11) then
            call more
            j=20
          endif

          write (nyc,'(i4)') baseyr+i-1
          write (cqc,'(f10.2)') qcapm(i)
          call pcs (j,22,nyc//' 'c)
          call pcs (j,vx+18,cqc//' 'c)
836     continue
c
        if (cendyr .ne. endyr) then
          j=vy+1

          if (i .gt. 11) then
            call more
            j=20
          endif

          write (nyc,'(i4)') cendyr
          call pcs (j,22,nyc//'-'c)
          write (nyc,'(i4)') endyr
          call pcs (j,vx,nyc//' 'c)
          write (cqc,'(f10.2)') endamt
          call pcs (j,vx+13,cqc//' 'c)
        endif
c
```

```
      if (ix .gt. 9) ix=10
      call pcs (ix+11,13,cstr2)
      call pcs (ix+13,10,'Do you want to change the annual '//
     -                   'fiber caps? (Y/N) MM'c)
      call ynchk (*4775,*7778)
c
4775  ccap=.true.
      go to 4922
c
4777  do 7777 kk=baseyr+1,cendyr-1
        write (nyc,'(i4)') kk
4778    call pcs (16,5,'Please enter fiber cap amount for year '//
     -                  nyc//' MM'c)
        ll=kk-baseyr+1
        qcapm(ll)=rchk (0d0,-99d0)
        if (qcapm(ll) .eq. -99.) go to 4778
7777  continue
c
      do 77771 kk=cendyr,endyr
        ll=kk-baseyr+1
        qcapm(ll)=endamt
77771 continue
      go to 4792
c
7778  prm1='______________________________________________________________'c
      prm2='                  Party                                     Tonnage'c
      rewind 1
      read (1,*)
      read (1,*) (paloc(i),i=1,9)
c
9879  call eeop (4,0)
      call pcsa (4,28,' PERMIT ALLOCATION 'c,vrev)
      call pcs (5,10,prm1)
      call pcs (7,10,prm2)
      call pcs (8,10,prm1)
c
      do 6890 i=1,9
        j=i+9
        write (nyc,'(i2)') i
        call pcs (j,13,nyc(1:2)//'. '//perm(i)//' 'c)
        write (cqc,'(f10.2)') paloc(i)
        call pcs (j,vx+6,cqc//' 'c)
6890  continue
c
      write (nyc,'(i2)') i
      call pcs (vy+2,13,nyc(1:2)//'. '//perm(i)//' 'c)
      call pcs (vy,vx+13,'ALL'c)
      call pcs (21,10,prm1)
c
      call pcs (23,10,'Do you want to change any of these '//
     -                'allocations (Y/N) MM'c)
      call ynchk (*9876,*9877)
c
9876  call eeop (23,0)
      call pcs (23,10,'Enter ID # of party with new allocation '//
     -               '(0 to end)  MM'c)
      i=ichk (0,9)
c
      if (i .eq. -99) call pty_chk (0,*9876)
      if (i .eq. 0) go to 9877
c
98761 call pcs (23,10,'Enter new allocation for '//
     -      perm(i)(1:lench(perm(i)))//' MM'c)
      paloc(i)=rchk (0d0,-99d0)
      if (paloc(i) .eq. -99.) go to 98761

      write (nyc,'(i2)') i
      call pcs (i+9,13,nyc(1:2)//'. '//perm(i)//' 'c)
      write (cqc,'(f10.2)') paloc(i)
      call pcs (vy,vx+6,cqc//' 'c)
      go to 9876
c
9877  call eeop (23,0)
2469  call pcs (23,10,'Enter # of parties to whom permits are to '//
     -                'be allocated MM'c)
      ires=ichk (1,9)
      call eeop (24,0)
c
      if (ires .eq. -99) call pty_chk (1,*2469)
c
```

```
      call eeop (23,0)
      do 9965 i=1,10
        pflag(i)=0
 9965 continue
c
      do 99651 ii=1,ires
        write (nyc,'(i1)') ii
 2472   call pcs (23,10,'Please enter ID of party #'//nyc(1:1)//' MM'c)
        pid(ii)=ichk (1,10)
        call eeop (24,0)
c
        if (pid(ii) .eq. -99) call pty_chk (0,*2472)
        if ((pid(ii) .eq. 10) .and. (ires .ne. 1))
     -     call pty_chk (2,*2469)
c
        pflag(pid(ii))=1
99651 continue
c
 9966 if ((option .eq. 1) .and. (iban .lt. ip)) go to 8693
c
      exf=.false.
      call eeop (4,0)
      call pcsa (8,28,' PRODUCT EXEMPTIONS 'c,vrev)
      call pcs (12,5,'Do any products get exempted from '//
     -               'regulation? (Y/N) MM'c)
      call ynchk (*8692,*8693)
c
 8692 exf=.true.
      call pcs (14,5,'Please enter the number of products '//
     -               'to be exempted MM'c)
      ixmpt=ichk (0,ip)
      call eeop (16,0)
c
      if (ixmpt .eq. ip) then
        call pcsa (18,20,'    YOU HAVE EXEMPTED ALL PRODUCTS 'c,vrev)
        call pcsa (19,20,' IS THERE ANY POINT IN CARRYING ON ?!! 'c,
     -                 vbold)
        call setcur (23,0)
        stop
      endif
c
      if ((ixmpt .lt. 1) .or. (ixmpt .gt. (ip-1))) then
        write (nyc,'(i2)') ip
        call pcsa (22,10,' NUMBER OF PRODUCTS SHOULD BE GREATER '//
     -                 'THAN 1 OR LESS THAN '//nyc(1:2)//' 'c,vrev)
        go to 8692
      endif
c
      do 86921 nn=1,ixmpt
        write (nyc,'(i2)') nn
        call tsca (nn,ires,'x',16)
        exmpt(ires)=.true.
86921 continue
c
 8693 if ((option .eq. 1) .and. (iban .eq. ip)) go to 8695
c
      enf=.false.
      lbf=.false.
c
      call eeop (4,0)
      call pcsa (8,28,' ENGINEERING CONTROLS 'c,vrev)
      call pcs (12,5,'Do any products have engineering controls '//
     -               'put on them? (Y/N) MM'c)
      call ynchk (*8682,*8684)
c
 8682 do 5692 iyy=1,ny
        do 56921 ixy=1,ip
          enctl(iyy,ixy)=.false.
56921   continue
 5692 continue
c
      enf=.true.
c
      call pcs (14,5,'Enter the number of years in which '//
     - 'engineering'c)
      call pcs (15,5,'controls will be put on products MM'c)
      call yr_chk (ienyrs,0,16)
      call eeop (9,0)
c
      do 522 n=1,ienyrs
```

```
          write (nyc,'(i2)') n
          call pcs (12,15,'Enter CONTROL year #'//nyc(1:2)//' MM'c)
          call eeop (14,0)
          call yr_chk (enyr(n),1,14)
 522    continue
 c
        ienchk=99
        call eeop (9,0)
        do 533 n=1,ienyrs
          ienyr=enyr(n)-baseyr+1
          call nprd_chk (ien,14,'e',enyr(n))
 c
          if (ien .eq. 99) then
              ienchk=ienyr
              ienyrs=n
 c
            do 5957 lm=1,ip
              do 59571 ll=ienyr,ie
                enctl(ll,lm)=.true.
 59571        continue
 5957       continue
 c
            go to 8684
          endif
 c
          call eeop (9,0)
          do 544 nn=1,ien
            call tsca (nn,nen,'e',12)
            do 555 ll=ienyr,ie
              enctl(ll,nen)=.true.
 555        continue
 544      continue
 533    continue
 c
 c
 8684   call eeop (4,0)
        call pcsa (8,28,' PRODUCT LABELING 'c,vrev)
        call pcs (12,5,'Do any products have labels '//
      -               'put on them? (Y/N) MM'c)
        call ynchk (*8688,*8695)
 c
 8688   do 6692 iyy=1,ny
          do 66921 ixy=1,ip
            label(iyy,ixy)=.false.
 66921    continue
 6692   continue
 c
        lbf=.true.
 c
        call pcs (14,5,'Enter the number of years in which'//
      -      ' labeling'c)
        call pcs (15,5,'requirements will be introduced MM'c)
        call yr_chk (ilyrs,0,16)
        call eeop (9,0)
 c
        do 622 n=1,ilyrs
          write (nyc,'(i2)') n
          call pcs (12,15,'Enter LABEL year #'//nyc(1:2)//' MM'c)
          call yr_chk (lyr(n),1,14)
 622    continue
 c
        ilchk=99
        call eeop (9,0)
        do 633 n=1,ilyrs
          ilyr=lyr(n)-baseyr+1
          call nprd_chk (ilbl,14,'l',lyr(n))
 c
          if (ilbl .eq. 99) then
              ilchk=ilyr
              ilyrs=n
 c
            do 6957 lm=1,ip
              do 69571 ll=ilyr,ie
                label(ll,lm)=.true.
 69571        continue
 6957       continue
 c
            go to 8695
          endif
 c
```

```
        call eeop (9,0)
        do 644 nn=1,ilbl
          call tsca (nn,nl,'l',12)
          do 655 ll=ilyr,ie
            label(ll,nl)=.true.
655       continue
644     continue
633   continue
c
8695  call eeop (4,0)
      call pcsa (8,28,' SUBSTITUTE PRICES 'c,vrev)
      call pcs (12,5,'Should different substitute prices be used'c)
      call pcs (13,5,'for each year of the simulation? (Y/N) MM'c)
      call ynchk (*8685,*8686)
c
8685  multsub=.true.
      go to 8694
c
8686  multsub=.false.
      go to 8694
c
8694  call eeop (4,0)
      call pcsa (8,28,' DISCOUNT RATES 'c,vrev)
86941 call pcs (12,5,'Please enter number of discount rates '//
     -                 'desired (upto 10) MM'c)
      nodrt=ichk (1,10)
      call eeop (14,0)
c
      if (nodrt .eq. -99) then
        call pcsa (22,10,' NUMBER OF DISCOUNT RATES SHOULD BE '//
     -                    'SPECIFIED BETWEEN 1 AND 10 'c,vrev)
        go to 86941
      endif
c
      dstr1='Please enter the discount rate(s) desired in decimal'c
      dstr8='equivalent.  For example, enter 5% as 0.05 or .05'c
      dstr9=' YOU HAVE ENTERED AN UNACCEPTABLE DISCOUNT RATE'c
      call pcs (16,5,dstr1)
      call pcs (17,5,dstr8)
c
      do 86922 i=1,nodrt
        write (nyc,'(i2)') i
8623    call pcs(19,5,'Please enter discount rate #'//
     -               nyc(1:lench(nyc))//' MM'c)
        discrt(i)=rchk (0d0,-99d0)
        call eeop (18,0)
c
        if (discrt(i) .eq. -99.) then
          call pcsa (24,13,dstr9,vrev)
          go to 8623
        endif
86922 continue
c
      dstr7='_______________________________________________________________'//
     -   '________'c
      dstr0='                Entity                               Value to be '//
     -   'used'c
      dstr4='   1. Percentage of foreign fiber supply'c
      dstr5='   2. Elasticity of fiber supply'c
      dstr9='YOU HAVE ENTERED AN UNACCEPTABLE PERCENTAGE'c
c
      fsup=91.60
      selast=1.46
c
8629  call eeop (4,0)
      call pcsa (8,30,' MISCELLANEOUS 'c,vrev)
c
      call eeop (9,0)
      call pcs (10,8,dstr7)
      call pcs (12,8,dstr0)
      call pcs (13,8,dstr7)
86291 call pcs (15,8,dstr4)
      write (cqc,'(f6.2)') fsup
      call pcs (15,vx+9,cqc(1:6)//'%'c)
      call pcs (16,8,dstr5)
      write (cqc,'(f6.2)') selast
      call pcs (16,vx+17,cqc(1:6)//' 'c)
      call pcs (17,8,dstr7)
      call eeop (18,0)
      call pcs(19,8,'Do you want to change any of the above (Y/N) MM'c)
```

```
      call ynchk (*8622,*8627)
c
8622  call pcs (21,8,'Please enter ID of item to be changed MM'c)
      ires=ichk (1,2)
      call eeop (22,0)
c
      if (ires .eq. -99) then
        call pcsa (24,15,' YOU HAVE ENTERED AN UNACCEPTABLE OPTION 'c,
     -             vrev)
        go to 8622
      endif
c
      go to (8624,8625) ires
c
8627  fsup=fsup/100.
      go to 7783
c
8624  call eeop (19,0)
      dstr1='Please enter the new percentage of foreign supply in'c
      dstr2='decimal equivalent, i.e., enter 80% as 0.8 or .8 MM'c
      call pcs (19,8,dstr1)
86241 call pcs (20,8,dstr2)
      fsup=rchk (0d0,1d0)
      call eeop (21,0)
c
      if (fsup .eq. -99.) then
        call pcsa (24,17,dstr9,vrev)
        go to 86241
      endif
c
      fsup=fsup*100.
      go to 86291
c
8625  call eeop (19,0)
86251 call pcs (19,8,'Please enter the new elasticity of '//
     -                'supply MM'c)
      selast=rchk (-99d0,-99d0)
      call eeop (20,0)
      if (selast .eq. -99.) go to 8625
c
      if (selast .lt. 1) then
        call pcsa (24,15,' AN ELASTICITY OF LESS THAN '//
     -                   'ONE IS UNACCEPTABLE 'c,vrev)
        go to 86251
      endif
c
      go to 86291
c
7783  dsup=1-fsup
c
      call eeop (9,0)
      call pcs (12,5,'Which baseline quantity decline scenario '//
     -                'would you like to use:'c)
7784  call pcs (14,5,'LOW, MODERATE, or HIGH.  Enter L/M/H MM'c)
      call cchk (res)
      call eeop (15,0)
c
      if ((res .eq. 'L') .or. (res .eq. 'l')) then
        ibgr=1
      elseif ((res .eq. 'M') .or. (res .eq. 'm')) then
        ibgr=2
      elseif ((res .eq. 'H') .or. (res .eq. 'h')) then
        ibgr=3
      else
        go to 7784
      endif
c
      fstr1='Please enter name of data file containing asbestos'c
      fstr2='product market data. (Include path if necessary)  MM'c
      fstr3='Please enter name of data file containing substitute'c
      fstr4='product data. (Include path if necessary)         MM'c
c
      call eeop (4,0)
      call pcsa (8,28,' INPUT FILES 'c,vrev)
6661  call pcs (12,5,fstr1)
      call pcs (13,5,fstr2)
      call cchk (fname(2))
      call eeop (14,0)
c
      ierr=0
```

```
      open (2,iostat=ierr,file=fname(2),status='old')
      if (ierr .le. 0) go to 6662
      call file_chk (0,2)
      go to 6661
c

6662  call pcs (15,5,fstr3)
      call pcs (16,5,fstr4)
      call cchk (fname(4))
      call eeop (17,0)
c
      ierr=0
      open (4,iostat=ierr,file=fname(4),status='old')
      if (ierr .le. 0) go to 6664
      call file_chk (0,4)
      go to 6662
c
6664  call eeop (4,0)
      call pcsa (8,28,' OUTPUT OPTIONS 'c,vrev)
c
      if (option .eq. 1) then
        cresf=0
        go to 7799
      endif
c
      call pcs (12,5,'Would you like a printout of the '//
     -                'consistency check (Y/N) MM'c)
      call ynchk (*7781,*7782)
c
7781  cresf=1
      go to 7799
c
7782  cresf=0
c
7799  call pcs (14,5,'Would you like a detailed printout (Y/N) MM'c)
      call ynchk (*7791,*7792)
c
7791    dprf=1
        go to 6660
c
7792    dprf=0
c
6660  call pcs (16,5,'Would you like the simulation output'c)
      call pcs (17,5,'to be routed to the printer or disk?'c)
1924  call pcs (19,5,'Please enter P or D                 MM'c)
      call cchk (res)
c
      if ((res .eq. 'P') .or. (res .eq. 'p')) then
        fname(3)='lpt1'
        go to 1929
      elseif ((res .eq. 'D') .or. (res .eq. 'd')) then
        go to 1926
      else
        go to 1924
      endif
c
1926  call eeop (9,0)
1927  call pcs (12,5,'Please enter name of file where simulation '//
     -                'output'c)
      call pcs (13,5,'should be stored. (Include path if '//
     -                'necessary) MM'c)
      call cchk (fname(3))
      call eeop (14,0)
c
      ierr=0
      open (3,file=fname(3),iostat=ierr,status='new')
      if (ierr .le. 0) go to 1929
      call file_chk (1,3)
      call ynchk (*1929,*1927)
c
1929  call eeop (9,0)
2927  call pcs (12,5,'Please enter name of file where BASELINE '//
     -                'indices'c)
      call pcs (13,5,'should be stored. (Include path if '//
     -                'necessary,) MM'c)
      call cchk (fname(8))
      call eeop (14,0)
c
      ierr=0
      open (8,file=fname(8),iostat=ierr,status='new')
```

```
      if (ierr .le. 0) go to 2929
      call file_chk (1,8)
      call ynchk (*2929,*2927)
c
2929  call eeop (9,0)
3927  call pcs (12,5,'Please enter name of file where ALTERNATIVE '//
     -                'indices'c)
      call pcs (13,5,'should be stored. (Include path if '//
     -                'necessary,) MM'c)
      call cchk (fname(9))
      call eeop (14,0)
c
      ierr=0
      open (9,file=fname(9),iostat=ierr,status='new')
      if (ierr .le. 0) go to 3929
      call file_chk (1,9)
      call ynchk (*3929,*3927)
c
3929  call eeop (9,0)
4927  call pcs (12,5,'Please enter name of file where cost-benefit '//
     -                'TABLES'''c)
      call pcs (13,5,'DATA should be stored. (Include path if '//
     -                'necessary,) MM'c)
      call cchk (fname(6))
      call eeop (14,0)
c
      ierr=0
      open (6,file=fname(6),iostat=ierr,status='new',form='unformatted')
      if (ierr .le. 0) go to 4929
      call file_chk (1,6)
      call ynchk (*4929,*4927)
c
4929  call eeop (4,0)
      call pcsa (12,25,' Processing... 'c,vrev)
      call setcur (vy,vx-1)
c
c_______________________________________________________________________
c
c                   this section reads the input data files
c_______________________________________________________________________
c
c
      read (2,*) fpe(1),fdiscrt,ibyd
c
      i=1
2125  read (2,'(i2,2x,a24)',end=2130) idp(i),desc(i)
      read (2,*) idp(i),awt(i),ccost(i),rcost(i),epp(1,i),epq(1,i),
     -           na(i),cprat(i),fecost(i),vecost(i),lcost(i)
c
      ccost(i)=(ccost(i)/0.04)*fdiscrt
      rcost(i)=(rcost(i)/0.04)*fdiscrt
c
      if (ibgr .eq. 1) then
        read (2,*) idp(i),(grthrt(i,k),k=1,15)
        read (2,*)
        read (2,*)
      elseif (ibgr .eq. 2) then
        read (2,*)
        read (2,*) idp(i),(grthrt(i,k),k=1,15)
        read (2,*)
      else
        read (2,*)
        read (2,*)
        read (2,*) idp(i),(grthrt(i,k),k=1,15)
      endif
c
      read (4,*) idp(i),nsub(i),(taps(1,i,j),ns(i,j),
     -                          ams(i,j),j=1,nsub(i))
      read (4,*) idp(i),(sub_dec(j),j=1,nsub(i))
c
      if (multsub) then
        do 2124 j=1,nsub(i)
          aps(1,i,j)=taps(1,i,j)*(1+sub_dec(j))**(baseyr-ibyd)
          do 21241 iy=2,ie
            aps(iy,i,j)=aps(iy-1,i,j)*(1+sub_dec(j))
21241     continue
2124    continue
      else
        do 2123 j=1,nsub(i)
          do 21231 iy=1,ie
```

```
              aps(iy,i,j)=taps(1,i,j)
 21231      continue
 2123     continue
        endif
c
        do 2126 ik=1,ny
          if ((isban(ik,idp(i)) .eq. 1) .and. (.not. exmpt(idp(i))))
     -       swban(ik,i)=1
 2126   continue
        i=i+1
        go to 2125
c
 2130   np=i-1
c
        close (1)
        close (2)
        close (4)
c
        return
        end
```

```
c
c
c
c     ARCM : OUTPUT SUBROUTINE
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c
c
c
$include:'stdsub'
$large
c
c
c
c            This subroutine writes the output to a file or printer
c
c
c
      subroutine asbout
c
$include:'stdvar'
$include:'vars.cmn'
c
      real         psl(10),csl(10),a1t(ny),a3t(ny),v(10),r(10)
c
      character    opt*40,bopt*16,bans2*100,bans1*125,temp*4,
     -             temp1*125,temp2*100
c
      character*80 bstr1,bstr2,pstr1,fstr1,cs1,cs2,cs3,p0,p1,p2
c
c
      if (option .eq. 1) then
        opt='Product ban only'
      elseif (option .eq. 2) then
        opt='Product ban and annual fiber caps'
      else
        opt='Annual fiber caps only'
      endif
c
      if (ibgr .eq. 1) then
        bopt='Low Decline'
      elseif (ibgr .eq. 2) then
        bopt='Moderate decline'
      else
        bopt='High Decline'
      endif
c
      if (fname(3) .eq. 'lpt1') then
        pgbrk='1'
      else
        pgbrk=''
      endif
c
c
c
c                  this section divides all areas by 1,000
c
c
c
      do 8893 yr=1,ie
        a1t(yr)=0
        a3t(yr)=0
        do 88931 j=1,np
          area5(yr,j)=area5(yr,j)/1000.
          area6(yr,j)=area6(yr,j)/1000.
          area7(yr,j)=area7(yr,j)/1000.
          area8(yr,j)=area8(yr,j)/1000.
          area8p(yr,j)=area8p(yr,j)/1000.
c
          if (option .eq. 1) go to 88931
          if ((swban(yr,j) .eq. 1) .or. exmpt(idp(j))) go to 88931
          a1t(yr)=a1t(yr)+area5(yr,j)+area7(yr,j)
          a3t(yr)=a3t(yr)+area6(yr,j)+area8(yr,j)
c
```

```
88931   continue
          area1(yr)=area1(yr)/1000.
          area2(yr)=area2(yr)/1000.
          area3(yr)=area3(yr)/1000.
          area4(yr)=area4(yr)/1000.
8893  continue
c
c_______________________________________________________________________________
c
c                      this section writes the summary output
c_______________________________________________________________________________
c
c
      fmt(1)='(12x,i2,2x,f16.2,1x,f14.2,21x,a)'
      fmt(2)='(/12x,a5,1x,f14.2,1x,f14.2,2x,f16.2)'
      fmt(3)='(2x,a25,1x,f13.2,1x,f12.2,1x,f12.2,1x,f12.2)'
      fmt(4)='(8x,i4,2x,f12.3,5x,f12.3,4x,f12.3,4x,f12.3)'
      fmt(5)='(15x,i2,a2,a30,f12.2)'
      fmt(12)='(/12x,a5,1x,f14.2,1x,f14.2)'
      fmt(14)='(2x,a25,15x,f12.2,1x,f12.2,1x,f12.2)'
      fmt(15)='(/2x,a25,28x,f12.2,1x,f12.2)'
c
      us1='____________________________________________________________
     -__________'
c
      call getdat (iyr,imon,iday)
      call gettim (ihr,imin,isec,i100th)
      if (iday .ge. 10) then
        write (dstr,'(2(i2,1h/),i4)') imon,iday,iyr
      else
        write (dstr,'(i2,2h/0,i1,1h/,i4)') imon,iday,iyr
      endif
      if (imin .ge. 10) then
        write (tstr,'(i2,1h:,i2)') ihr,imin
      else
        write (tstr,'(i2,2h:0,i1)') ihr,imin
      endif
c
      call pcsa (12,36,' completed 'c,vrev)
      call pcsa (15,23,' Writing output... 'c,vrev)
      call setcur (vy,vx-1)
c
      open (3,file=fname(3))
      open (6,file=fname(6),form='unformatted')
      if (fname(3) .eq. 'lpt1') write (3,'(a)') pgbrk
      ipage=0
      call header (0)
      write (3,'(//7x,a19,1x,a/)') 'Regulation Option :',opt
      write (3,'(7x,a19,1x,i4/)') 'Beginning Year    :',baseyr
      write (3,'(7x,a19,1x,i4/)') 'Ending Year       :',endyr
      write (3,'(7x,a19,1x,a/)') 'Baseline Growth   :',bopt
      write (3,'(7x,a19,1x,10(f4.1,a,2x)//)') 'Discount Rate(s)  :',
     -(discrt(i)*100.,'%',i=1,nodrt)
      fsup=fsup*100.
      dsup=dsup*100.
      write (3,'(/7x,a,f7.2/)')  'Elasticity of fiber supply :',selast
      write (3,'(7x,a,f6.1,a/)') 'Foreign fiber supply       :',fsup,'%'
      write (3,'(7x,a,f6.1,a/)') 'Domestic fiber supply      :',dsup,'%'
      iline=19
      bstr1='______________________________________________'
      if (option .eq. 3) go to 200
      write (3,'(//7x,a/)') 'PRODUCT BAN SCHEDULE'
      bstr2='    Year of Ban          TSCA Product Nos.'
      write (3,'(15x,a//,15x,a/,15x,a/)') bstr1,bstr2,bstr1
      iline=iline+7
c
      do 10 n=1,byrs
        if (ibchk .eq. 99) go to 103
        if (ibchk .eq. byear(1)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a\)') byear(n),'All Products '
          go to 105
        elseif (ibchk .eq. byear(n)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a)') byear(n),
     -                                  'All Remaining Products '
          go to 105
        endif
c
103     write (bans1,'(22x,i4)') byear(n)
        ix=byear(n)-baseyr+1
        ic=0
```

```
        flag1=0
c
        do 101 nn=1,ip
          if ((isban(ix,nn) .eq. 1) .and. (.not. exmpt(nn))) then
            temp1=bans1
            if (flag1 .eq. 0) then
              write (temp,'(i2)') nn
              bans1=temp1(1:39)//temp
              flag1=1
            else
              write (temp,'(a,i2\)') ',',nn
              bans1=temp1(1:41+ic*3)//temp
              ic=ic+1
            endif

              do 1011 m=ix,ie
              isban(m,nn)=0
 1011       continue

            endif
 101    continue

            write (3,'(a)') bans1
        iline=iline+1
 10   continue
c
      go to 102
c
 105  write (3,'(a)') bans1
      iline=iline+1
      write (bans2,'(40x,a)') 'except'
      ic=0
      do 1051 i=1,ip
        temp2=bans2
        if (exmpt(i)) then
          if (ic .eq. 0) then
             write (temp,'(a,i2)') ' ',i
          else
             write (temp,'(a,i2)') ',',i
          endif
           bans2=temp2(1:46+ic*3)//temp
           ic=ic+1
        endif
 1051 continue
      if (ic .gt. 0) write (3,'(a)') bans2
      iline=iline+1
c
 102  write (3,'(15x,a//)') bstr1
      iline=iline+3
c
c
 200  if (.not.(enf)) go to 703
      if (iline .gt. 50) call header (0)
      write (3,'(//7x,a/)') 'ENGINEERING CONTROLS SCHEDULE'
      bstr2='    Year of Control      TSCA Product Nos.'
      write (3,'(15x,a//,15x,a/,15x,a/)') bstr1,bstr2,bstr1
      iline=iline+7
c
      do 70 n=1,ienyrs
        if (ienchk .eq. 99) go to 203
        if (ienchk .eq. enyr(1)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a\)') enyr(n),'All Products '
          go to 702
        elseif (ienchk .eq. enyr(n)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a)') enyr(n),
     -                                     'All Remaining Products '
          go to 702
        endif
c
 203    write (bans1,'(22x,i4)') enyr(n)
        ix=enyr(n)-baseyr+1
        ic=0
        flag1=0
c
        do 701 nn=1,ip
          if (enctl(ix,nn)) then
            temp1=bans1
            if (flag1 .eq. 0) then
              write (temp,'(i2)') nn
              bans1=temp1(1:39)//temp
```

```
            flag1=1
          else
            write (temp,'(a,i2\)') ',',nn
            bans1=temp1(1:41+ic*3)//temp
            ic=ic+1
          endif
c
          enctl(0,nn)=.true.
          do 7011 m=ix,ie
            enctl(m,nn)=.false.
 7011     continue
c
        endif
 701  continue
c
      write (3,'(a)') bans1
      iline=iline+1
 70   continue
c
      go to 7021
c
 702  write (3,'(a)') bans1
      iline=iline+1
 7021 write (3,'(15x,a//)') bstr1
      iline=iline+3
c
 703  if (.not.(lbf)) go to 903
      if ((option .ne. 3) .and. enf) call header (0)
      if (iline .gt. 50) call header (0)
      write (3,'(//7x,a/)') 'PRODUCT LABELING SCHEDULE'
      bstr2='  Year of Labeling       TSCA Product Nos.'
      write (3,'(15x,a//,15x,a/,15x,a/)') bstr1,bstr2,bstr1
      iline=iline+7
c
      do 90 n=1,ilyrs
        if (ilchk .eq. 99) go to 503
        if (ilchk .eq. lyr(1)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a\)') lyr(n),'All Products '
          go to 902
        elseif (ilchk .eq. lyr(n)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a)') lyr(n),
     -                                  'All Remaining Products '
          go to 902
        endif
c
 503    write (bans1,'(22x,i4)') lyr(n)
        ix=lyr(n)-baseyr+1
        ic=0
        flag1=0
c
        do 901 nn=1,ip
          if (label(ix,nn)) then
            temp1=bans1
            if (flag1 .eq. 0) then
              write (temp,'(i2)') nn
              bans1=temp1(1:39)//temp
              flag1=1
            else
              write (temp,'(a,i2\)') ',',nn
              bans1=temp1(1:41+ic*3)//temp
              ic=ic+1
            endif
c
            label(0,nn)=.true.
            do 9011 m=ix,ie
              label(m,nn)=.false.
 9011       continue

          endif
 901    continue

        write (3,'(a)') bans1
        iline=iline+1
 90   continue
c
      go to 9021
c
 902  write (3,'(a)') bans1
      iline=iline+1
 9021 write (3,'(15x,a//)') bstr1
```

```
      iline=iline+3
c
903   write (3,'(5(/),7x,a)') 'PRODUCT EXEMPTIONS'
      ic=0
      do 21 i=1,ip
        temp1=bans1
        if (exmpt(i)) then
          if (ic .eq. 0) then
            write (temp,'(i2)') i
            bans1='  '//temp(1:2)
          else
            write (temp,'(a,i2)') ', ',i
            bans1=temp1(1:ic*4)//temp(1:4)
          endif
          ic=ic+1
        endif
21    continue
      if (ic .gt. 0) then
        write (3,'(/10x,a/)') 'The following products have been '//
     -                        'exempted from regulation:'
        write (3,'(15x,a)') bans1
      else
        write (3,'(/10x,a/)') 'No products have been exempted '//
     -                        'from regulation'
      endif
c
c
      if (option .eq. 1) go to 300
      if (iline .gt. 42) call header (0)
      pstr1='           Party                         Tonnage'
      write (3,'(//7x,a/)') 'FIBER PERMIT ALLOCATION (by tonnage)'
      write (3,'(15x,a//,15x,a/,15x,a/)') bstr1,pstr1,bstr1
      iline=iline+7
      aloc=0
      ipid=0
      if (pflag(10) .eq. 1) then
        write (3,'(15x,2a,7x,a)') '1. ',perm(10),'ALL'
        go to 47
      endif
      do 45 i=1,9
        if (pflag(i) .eq. 0) then
          paloc(i)=0
          go to 45
        endif
        ipid=ipid+1
        write (3,fmt(5)) ipid,'. ', perm(i),paloc(i)
        aloc=aloc+paloc(i)
        iline=iline+1
45    continue
      write (3,'(/19x,a29,1x,f12.2)') perm(11),aloc
47    write (3,'(15x,a//)') bstr1
      iline=iline+4
      if (iline .gt. 25) call header (0)
c
      write (3,'(//7x,a/)') 'FIBER CAP SCHEDULE'
      fstr1='     Year                    Fiber Cap (tons)'
      write (3,'(/10x,a/10x,a/10x,a//)') 'The fiber cap schedule '//
     -      'shown below is the effective cap ','schedule, i.e., '//
     -      'it does not include fiber demanded by','exempted markets.'
      write (3,'(15x,a//,15x,a/,15x,a/)') bstr1,fstr1,bstr1
      if (cendyr .eq. endyr) then
        ix=endyr
      else
        ix=cendyr-1
      endif
      do 20 i=baseyr+1,ix
        cap=qcap(i-baseyr+1)
        write (3,'(20x,i4,19x,f10.2)') i,cap
20    continue
c
      if (cendyr .ne. endyr) then
        write (3,'(20x,i4,a,i4,14x,f10.2)') cendyr,'-',endyr,endamt
      endif
      write (3,'(15x,a)') bstr1
      if (.not.(capr)) go to 300
      write (3,'(5(/),5x,2a/,5x,2a))') 'Note: Fiber cap schedule ',
     -'revised during model run to','      ensure that cap is ',
     -'binding in all years.'
c
300   call header (1)
```

```
      write (3,'(t20,a)') 'DESCRIPTION OF PRODUCT CATEGORIES'
      if (pgbrk .eq. '1') write (3,'(a,t20,a)') '+',
     -                     '_________________________________'
      write (3,'(/5x,a//13x,a,25x,a/5x,a/)') us1,'TSCA #',
     -       'PRODUCT DESCRIPTION',us1
      do 3001 i=1,np
        write (3,'(15x,i2,27x,a)') idp(i),desc(i)
3001  continue
      write (3,'(5x,a/)') us1
c
      do 310 j=1,np
        banm(j)=' '
        if (exmpt(idp(j))) banm(j)='X'
        if (swban(ie,j) .eq. 1) banm(j)='B'
c
        if (enctl(0,idp(j))) then
          if (banm(j)(1:1) .eq. ' ') then
            temp1=' E'
          else
            temp1=',E'
          endif
        endif
c
        if (label(0,idp(j))) then
          if (banm(j)(1:1) .eq. ' ') then
            temp2=' L'
          else
            temp2=',L'
          endif
        endif
c
        temp=banm(j)
        banm(j)=' '//temp(1:1)//temp1(1:2)//temp2(1:2)
c
310   continue
c
c
      write (6) nodrt
      do 346 i=1,nodrt
        dcsl=0
        dpsl=0
        fcsl=0
        fpsl=0
        do 30 j=1,np
          dcons(j)=0
          dpros(j)=0
          fcons(j)=0
          fpros(j)=0
c
          do 301 yr=2,ie
            area5d=area5(yr,j)/(1+discrt(i))**(yr-1)
            area6d=area6(yr,j)/(1+discrt(i))**(yr-1)
            area7d=area7(yr,j)/(1+discrt(i))**(yr-1)
            area8d=area8(yr,j)/(1+discrt(i))**(yr-1)
            ar8pd=area8p(yr,j)/(1+discrt(i))**(yr-1)
c
            cons=area5d+area6d
c
            if ((option .eq. 1) .and. (cprat(j) .lt. 1) .and.
     -          (area5d .lt. 0)) then
              dcons(j)=dcons(j)+cons*cprat(j)
              fcons(j)=fcons(j)+cons*(1-cprat(j))
            else
              dcons(j)=dcons(j)+cons
            endif
c
            pros=area7d+area8d+ar8pd
c
            if ((cprat(j) .eq. 1) .and. impinf(j)) then
              fpros(j)=fpros(j)+pros
            elseif (cprat(j) .gt. 1) then
              dpros(j)=dpros(j)+pros/cprat(j)
              fpros(j)=fpros(j)+pros*(1-1/cprat(j))
            else
              dpros(j)=dpros(j)+pros
            endif
c
301       continue
c
          dcsl=dcsl+dcons(j)
```

```
          dpsl=dpsl+dpros(j)
          fcsl=fcsl+fcons(j)
          fpsl=fpsl+fpros(j)
   30   continue
c
        fmcs=dcsl+fcsl+dpsl+fpsl
        fmdcs=dcsl+dpsl
        fmps=0
        fmdps=0
        pval=0
        do 40 yr=2,ie
c
          area1d=area1(yr)/(1+discrt(i))**(yr-1)
          area3d=area3(yr)/(1+discrt(i))**(yr-1)
          area2d=area2(yr)/(1+discrt(i))**(yr-1)
          area4d=area4(yr)/(1+discrt(i))**(yr-1)
c
          fmps=fmps+area2d+area4d
          if (option .eq. 1) go to 40
          pval=pval+(area1d+area2d)*(-1.)
   40   continue
c
        fmdps=fmps*dsup/100.
c
        discrt(i)=discrt(i)*100.
        call tabagg (1,discrt(i),fmcs,fmps,pval)
        call tabagg (2,discrt(i),fmdcs,fmdps,pval)
c
        write (3,'(a)') pgbrk
        ipage=ipage+1
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
        write (3,'(t26,a)') '            TABLE 2'
        if (pgbrk .eq. '1') write (3,'(a,t26,11x,a)') '+','_______'
        write (3,'(//t30,a)') 'WELFARE EFFECTS BY PARTY'
        if (pgbrk .eq. '1') write (3,'(a,t30,a)') '+',
     -                 '________________________'
        write (3,'(/t15,2a,f4.1,a//)') '(Present Values, in thousand ',
     -                              'dollars, at ',discrt(i),' Percent)'
        p0='_______________________________________________________________'//
     -    '_____________________'
        p1='         Party                CS Loss      PS Loss      '//
     -    'Allocation    Net Loss'
        p2='                                                        of '//
     -    'Permits'
        psl(1)=fmps*dsup/100.
        psl(2)=fmps*fsup/100.
        psl(4)=dpsl
        psl(5)=fpsl
        csl(8)=dcsl
        csl(9)=fcsl
        zero=0.
        ww=0
        usw=0
        write (3,'(//2x,a//,2(4x,a/),2x,a/)') p0,p1,p2,p0
        do 575 j=1,9
          if (pflag(10) .eq. 1) then
            aloc=1
            paloc(j)=0
          endif
          peral=0
          if (option .ne. 1) then
            peral=pval*paloc(j)/aloc
          endif
          rnl=csl(j)+psl(j)+peral
          ww=ww+rnl
          if ((j .eq. 2) .or. (j .eq. 5) .or. (j .eq. 9)) go to 555
          usw=usw+rnl
c
  555     if (j .le. 7) then
            write (3,fmt(14)) perm(j),psl(j),peral,rnl
          else
            write (3,fmt(3)) perm(j),csl(j),psl(j),peral,rnl
          endif
c
          v(j)=peral
          r(j)=rnl
c
  575   continue
```

```
          if (pflag(10) .eq. 1) then
            write (3,fmt(15)) perm(10),pval,pval
            v(10)=pval
            r(10)=pval
            usw=usw+pval
            ww=ww+pval
          else
            write (3,fmt(15)) perm(10),zero,zero
            v(10)=0
            r(10)=0
          endif
          write (3,'(2x,a/)') p0
          write (3,'(4(/),t30,a)') 'NET WELFARE LOSSES'
          if (pgbrk .eq. '1') write (3,'(a,t30,a)')'+',
     -                         '__________________'
          write (3,'(//20x,a,f16.2/)') 'U. S. Welfare: ',usw
          write (3,'(20x,a,f16.2//)') 'World Welfare: ',ww
          write (3,'(///10x,a)') 'Note: Negative entries are welfare '//
     -                           'gains.'
c
          write (6) discrt(i),(csl(j),psl(j),v(j),r(j),j=1,10),usw,ww
c
  346   continue
        if (cresf .eq. 0) go to 600
c
c_____________________________________________________________________________
c
c                    this section writes the consistency check
c_____________________________________________________________________________
c
c
        write (3,'(a)') pgbrk
        ipage=ipage+1
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
        write (3,'(t26,a)') '    MODEL CONSISTENCY CHECK'
        if (pgbrk .eq. '1') write (3,'(a,t26,a)') '+',
     -                    '_______________________'
        write (3,*)
        cs1='                               Sum of                       '//
     -    '  Sum of'
        cs2='Year      AREA 1    =   AREAs 5 & 7       AREA 3    =    '//
     -    'AREAs 6 & 8'
        cs3='        (Fiber Mkt.)   over output mkts.  (Fiber Mkt.) '//
     -    'over output mkts.'
        write (3,'(//7x,a//,3(8x,a/),7x,a//)') us1,cs1,cs2,cs3,us1
        do 59 yr=2,ie
          iyr=yr+baseyr-1
          write (3,fmt(4)) iyr,area1(yr),a1t(yr),area3(yr),a3t(yr)
   59   continue
        write (3,'(7x,a//)') us1
        y(9)='Note: 1. Banned and exempted markets are not included in '//
     -    'Areas 6'
        y(12)='         (output) or Areas 3 (fiber) as of the year of '//
     -    'ban for'
        y(13)='          purposes of the model''s consistency check.'
        y(10)='      2. Differences in decimal places are due to '//
     -    'machine rounding.'
        y(14)='      2. Difference in the consistency check is due to '//
     -    'engineering'
        y(15)='         controls and/or labeling requirements.'
c
        write (3,'(/3(10x,a/))') y(9),y(12),y(13)
c
        if (enf .or. lbf) then
          write (3,'(2(10x,a/))') y(14),y(15)
        else
          write (3,'(10x,a)') y(10)
        endif
c
  600   if (dprf .eq. 1) call detout (ie)
c
        if (fname(3) .eq. 'lpt1') write (3,'(a)') pgbrk
        endfile 3
        close (3)
c
        return
        end
```

```
c_______________________________________________________________________
c
c
c      ARCM : CALCULATION OF CS AND QR LOSSES FOR BANNED PRODUCTS
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c_______________________________________________________________________
c
c
$large
c
c_______________________________________________________________________
c
c       This subroutine calculates the CS and QR losses in banned markets.
c_______________________________________________________________________
c
c
      subroutine bancsqr
c
$include:'vars.cmn'
c
c
      do 80 i=1,np
        if (swban(yr,i) .eq. 0) go to 80
        do 801 j=1,nsub(i)
          area6(yr,i)=area6(yr,i)+(ps(yr,i,j)-epp(yr,i))*qs(yr,i,j)
          if (swqr(i) .ne. 1) go to 801
          if (lnsub(i,j)) then
            area8p(yr,i)=area8p(yr,i)+(epp(yr,i)-avc(i))*qs(yr,i,j)/
     -                     fdiscrt
            lnsub(i,j)=.false.
          endif
801     continue
        swqr(i)=0
80    continue
      return
      end
```

```
c______________________________________________________________________________
c
c
c       ARCM : BENEFIT MODEL INTERFACE ROUTINE
c
c       Version 6.31 : May 31, 1988.
c
c       Program written by:
c
c          Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c          (703) 934-3000
c
c______________________________________________________________________________
c
c
$large
c
c______________________________________________________________________________
c
c       This subroutine writes the index files for use in the Benefits Model
c______________________________________________________________________________
c
c
        subroutine benout
c
$include:'vars.cmn'
c
c
        real          bi(2:ny,ip+1),ai(2:ny,ip+1)
c
        integer       ina(ip)
c
c
        open (8,file=fname(8))
        open (9,file=fname(9))
c
        write (8,'(i2,2(5x,i4))') ie-1,baseyr,endyr
        write (9,'(i2,2(5x,i4))') ie-1,baseyr,endyr
c
        do 10 ib=1,ip
          ina(ib)=0
          do 101 ia=2,ny
            bi(ia,ib)=0
            ai(ia,ib)=0
101       continue
10      continue
c
        do 5 i=1,np
          if (na(i) .lt. 1.) then
            ina(idp(i))=1
          else
            ina(idp(i))=na(i)+0.5
          endif
5       continue
        write (8,'(37i3,a)') ina,'  1'
c
        do 20 ia=2,ie
          do 201 ib=1,np
c
            bi(ia,idp(ib))=bepq(ia,ib)/bbpq(ib)
c
            if (swban(ia,ib) .eq. 1) go to 201
            if (option .eq. 1) then
              ai(ia,idp(ib))=bi(ia,idp(ib))
            else
              if ((qcap(ia) .eq. 0) .and. (.not. exmpt(idp(i))))
     -         go to 201
              ai(ia,idp(ib))=fpq(ia,ib)/bbpq(ib)
            endif
c
201       continue
c
          bi(ia,ip+1)=bfqe(ia)/bbfq
c
          if (option .eq. 1) then
            ai(ia,ip+1)=fqe(ia)/bbfq
          else
            ai(ia,ip+1)=qcapm(ia)/bbfq
          endif
c
```

```
         write (8,'(38(f4.2,1x))') (bi(ia,ib),ib=1,ip+1)
         write (9,'(38(f4.2,1x))') (ai(ia,ib),ib=1,ip+1)
c
20    continue
c
      endfile 8
      endfile 9
c
      close (8)
      close (9)
c
      return
      end
```

```
c________________________________________________________________________
c
c
c      ARCM : DETAILED OUTPUT SUBROUTINE
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c________________________________________________________________________
c
c
$large
c
c________________________________________________________________________
c
c          . This subroutine writes the detailed output if requested
c________________________________________________________________________
c
c
      subroutine detout
c
$include:'vars.cmn'
c
c
      character    bann*6,begn(2)*11,nf*20
      character*80 ffmt(4)
c
      y(1)='              Baseline      Baseline       Scenario        '//
     -     'Scenario'
      y(2)=' Year          Price        Quantity        Price          '//
     -     'Quantity'
      fmt(6)='(12x,i4,1x,f13.2,1x,f13.2,a12,10x,a6)'
      fmt(7)='(12x,i4,1x,f13.2,1x,f13.2,1x,f13.2,1x,f15.2)'
      fmt(10)='(12x,i4,1x,f13.2,1x,f13.2,10x,a3,2x,f15.2)'
      fmt(11)='(12x,i4,1x,f13.2,1x,f13.2,8x,a6,10x,a6)'
      fmt(12)='(12x,i4,10x,a3,2x,f13.2,10x,a3,2x,f15.2)'
      fmt(13)='(12x,i4,1x,f13.2,1x,f13.2,10x,a3,1x,f16.2)'
      ffmt(1)='(9x,i4,1x,f10.2,1x,f12.2,6x,a3,9x,a3,14x,a3)'
      ffmt(2)='(9x,i4,1x,f10.2,1x,f12.2,1x,f10.2,8x,a3,4x,f14.2)'
      ffmt(3)='(9x,i4,1x,f10.2,1x,f12.2,1x,f10.2,2x,f10.2,3x,f14.2)'
      ffmt(4)='(9x,i4,1x,f10.2,1x,f12.2,7x,a3,9x,a3,4x,f14.2)'
      ifp=0
      do 70 i=1,np+1
        write (3,'(a)') pgbrk
        ipage=ipage+1
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
        write (3,'(//t28,a)') 'PRICES AND QUANTITIES BY MARKET'
        if (pgbrk .eq. '1') write (3,'(a,t28,a)') '+',
     -                 '_________________________________'
        write (3,'(/t28,a//)') '     (Undiscounted values)'
        if (i .eq. np+1) then
          y(1)='                                     Scenario    Scenario'
          y(2)='          Baseline     Baseline       Supply     '//
     -         ' Demand        Scenario'
          y(3)=' Year     Price        Quantity      Price       '//
     -         'Price        Quantity'
c
          write (3,'(t33,2a)') 'Market: ','Asbestos Fiber'
          write (3,'(/7x,a//,3(8x,a/),7x,a/)') us1,(y(k),k=1,3),us1
        else
          write (3,'(t28,a,i2,2a)') 'Market: ',idp(i),'. ',desc(i)
          if (exmpt(idp(i))) write (3,'(/t23,a)')
     -                 'This market is EXEMPTED from regulation'
          write (3,'(/7x,a//,2(8x,a/),7x,a/)') us1,y(1),y(2),us1
        endif
c
        if (i .eq. np+1) then
          write (3,ffmt(1)) baseyr,fpe(1),fqe(1),' -',' -',' -'
        else
          write (3,fmt(6)) baseyr,epp(1,i),epq(1,i),'-','   -'
        endif
c
        do 701 yr=2,ie
          iyr=baseyr+yr-1
```

```
            if (i .eq. (np+1)) then
              if (fqe(yr) .eq. 0) then
                ifp=1
                if ((option .eq. 1) .or. (qcapm(yr) .eq. 0)) then
                  write (3,ffmt(4)) iyr,bfpe(yr),bfqe(yr),'+++','+++',
     -                              fqe(yr)
                else
                  write (3,ffmt(2)) iyr,bfpe(yr),bfqe(yr),pf1(yr),'+++',
     -                              qcapm(yr)
                endif
              elseif (option .eq. 1) then
                write (3,ffmt(2)) iyr,bfpe(yr),bfqe(yr),fpe(yr),' - ',
     -                            fqe(yr)
              elseif (qcap(yr) .eq. 0) then
                ifp=1
                if (qcapm(yr) .eq. 0) then
                  write (3,ffmt(4)) iyr,bfpe(yr),bfqe(yr),'+++','+++',
     -                              qcap(yr)
                else
                  write (3,ffmt(2)) iyr,bfpe(yr),bfqe(yr),pf1(yr),'+++',
     -                              qcapm(yr)
                endif
              else
                write (3,ffmt(3)) iyr,bfpe(yr),bfqe(yr),pf1(yr),pf(yr),
     -                            qcapm(yr)
              endif
            endif
c
            if (i .le. np) then
              if (bepq(yr,i) .eq. 0.) then
                write (3,fmt(12)) iyr,'n/a',bepq(yr,i),'n/a',bepq(yr,i)
              elseif (swban(yr,i) .eq. 1) then
                bann='Banned'
                write (3,fmt(11)) iyr,bepp(yr,i),bepq(yr,i),bann,bann
              elseif (option .ne. 1) then
                if ((fpq(yr,i) .eq. 0) .or. ((qcap(yr) .eq. 0) .and.
     -              (.not. exmpt(idp(i))))) then
                  write (3,fmt(10)) iyr,bepp(yr,i),bepq(yr,i),'***',
     -                              fpq(yr,i)
                else
                  write (3,fmt(7)) iyr,bepp(yr,i),bepq(yr,i),fpp(yr,i),
     -                             fpq(yr,i)
                endif
              else
                write (3,fmt(7)) iyr,bepp(yr,i),bepq(yr,i),epp(yr,i),
     -                           epq(yr,i)
              endif
            endif
  701     continue
c
          write (3,'(7x,a,4(/))') us1
          if (option .eq. 1) go to 69
c
          if ( i .eq. (np+1)) then
            write (3,'(/7x,2a)') 'Note : 1. Scenario price is the fiber',
     -                           ' price plus the value of a permit.'
            write (3,'(/7x,a/19x,a/)') '       2. Scenario Quantity '//
     -        'includes fiber demanded by','exempted markets, if any.'
          else
            write (3,'(5(/),7x,2a)') 'Note : ''***'' indicates either ',
     -                               'scenario price is greater than'
            write (3,'(7x,2a)') '       maximum substitute price or ',
     -                          'fiber cap is zero.'
          endif
c
   69     if ((qcapm(yr) .eq. 0) .and. (i .eq. (np+1))) then
            if (option .eq. 1) then
              begn(1)='Note : '
              begn(2)='       '
              nf='(7x,a7,a)'
            else
              begn(1)='       3. '
              begn(2)='          '
              nf='(7x,a10,a)'
            endif
            write (3,nf) begn(1), '''+++'' indicates either '//
     -                   'all markets have been banned or'
            write (3,nf) begn(2),'  fiber cap is zero and '//
     -                   'price is no longer meaningful.'
          endif
```

```
c
 70   continue
      y(3)=' Market       Area 5        Area 6          Area 7         '//
     -     '  Area 8'
      y(4)='(TSCA #)'
      y(5)='Note: 1. Areas 1-4 in the fiber market are listed under '//
     -     'Areas 5-8.'
      y(6)='      2. Areas 6 & 8 include consumer and producer '//
     -     'surplus losses for'
      y(7)='         all banned, exempted, and non-banned markets. '//
     -     'Hence, this is a'
      y(8)='         complete accounting of all welfare effects.'//
     -     '  The model'
      y(11)='         consistency check, however, is defined in terms'//
     -     ' of non-banned'
      y(15)='         and non-exempted product markets and the fiber '//
     -     'market.  There-'
      y(16)='         fore, to perform this check using the '//
     -     'figures in this table,'
      y(17)='         the welfare effects in the banned and '//
     -     'exempted markets should'
      y(18)='         be excluded.  Refer to user''s guide for '//
     -     'further explanation.'
c
      fmt(8)='(13x,i2,1x,f15.3,1x,f14.3,1x,f14.3,1x,f14.3)'
      fmt(9)='(/13x,a5,1x,f12.3,1x,f14.3,1x,f14.3,1x,f14.3)'
c
      do 80  yr=2,ie
        iyr=baseyr+yr-1
        write (3,'(a)') pgbrk
        ipage=ipage+1
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
        write (3,'(t30,a,i4)') 'AREAS 1-8 FOR ',iyr
        if (pgbrk .eq. '1')write(3,'(a,t30,a)') '+','_________________'
        write (3,'(/t29,a/)') '(Undiscounted Values)'
        write (3,'(7x,a//,2(10x,a/),7x,a/)') us1,y(3),y(4),us1
        do 801 i=1,np+1
          if (i .eq. (np+1)) then
            write (3,fmt(9)) 'Fiber',area1(yr),area2(yr),area3(yr),
     -                       area4(yr)
          endif
          if (i .le. np) then
              pros=area8(yr,i)+area8p(yr,i)
              write (3,fmt(8)) idp(i),area5(yr,i),area6(yr,i),
     -                         area7(yr,i),pros
          endif
 801    continue
c
        write (3,'(7x,a/)') us1
        write (3,'(7x,a//,8(7x,a/))') (y(k),k=5,8),y(11),(y(k),k=15,18)
 80   continue
c
      return
      end
```

```
c_______________________________________________________________________________
c
c
c     ARCM : ENGINEERING CONTROL AND LABELING COSTS CHECK
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_______________________________________________________________________________
c
c
$include:'stdsub'
$large
c
c_______________________________________________________________________________
c
c      This subroutine checks to see if the costs of engg. control and/or
c      labeling added to the baseline price exceed the 1st step of the
c      product's demand function.
c_______________________________________________________________________________
c
c
      subroutine enlbl
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      character   nyc*4
c
c
      istop=0
      n=0
c
      do 10 i=1,np
        temp=0
        if (enctl(yr,idp(i))) temp=temp+ecost(i)
        if (label(yr,idp(i))) temp=temp+lcost(i)
        if (swqr(i) .eq. 1) then
          temp=temp+avc(i)
        else
          temp=temp+bepp(yr,i)
        endif
c
        if (temp .gt. ps(yr,i,nsub(i))) then
          n=n+1
c
          if (istop .eq. 0) then
            call eeop (4,0)
            write (nyc,'(i4)') baseyr+yr-1
            call pcsa (8,12,' BASELINE PRICE/AVC + ENGINEERING '//
     -         'CONTROL COSTS AND/OR 'c,vrev)
            call pcsa (9,12,' LABELING COSTS EXCEED FIRST STEP IN '//
     -         'YEAR '//nyc//' FOR:    'c,vrev)
            call setcur (12,0)
          endif
c
          if (swqr(i) .eq. 1) then
            temp=avc(i)
          else
            temp=bepp(yr,i)
          endif
c
          if (n .gt. 10) then
            call pcsa (22,12,' More to come... ',vrev)
            call pcsa (23,12,' Press any key to continue',vbold)
            ipse=key_getc()
            call eeop (10,0)
            call setcur (12,0)
          endif
c
          write (*,30) 'Product ',idp(i),swqr(i),temp,ecost(i),lcost(i),
     -                 ps(yr,i,nsub(i))
 30       format (t12,a,i2,t25,i2,5x,4f10.2)
          istop=1
        endif
```

```
c
10    continue
c
      if (istop .eq. 1) then
        call setcur (20,0)
        stop
      endif
c
      return
      end
```

```
c______________________________________________________________________
c
c
c      ARCM : EQUILIBRIUM PRODUCT PRICES AND QUANTITIES
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c______________________________________________________________________
c
c
$large
c
c______________________________________________________________________
c
c                 this subroutine calculates the equilibrium price
c                     & quantity in the asbestos fiber market.
c______________________________________________________________________
c
c
      subroutine eqpq
c
$include:'vars.cmn'
c
      integer swpe
c
c
      swpe=0
      qerat=1.0
      do 90 i=1,nstd
        fpe(yr)=slope*tfqs(i)+rint
        if ((fpe(yr) .eq. tfps(i)) .or.
     -      (fpe(yr) .ge. tfps(i+1))) then
          fqe(yr)=tfqs(i)
          go to 91
        elseif ((fpe(yr) .lt. tfps(i+1)) .and.
     -          (fpe(yr) .gt. tfps (i+2))) then
          swpe=1
          go to 90
        endif
 91     if ((fpe(yr) .gt. tfps(i)) .and.
     -      (swpe .eq. 1)) then
          fpe(yr)=tfps(i)
          fqe(yr)=(fpe(yr)-rint)/slope
          if (i .eq. 1) then
            qerat=fqe(yr)/tfqs(1)
          else
           qerat=(fqe(yr)-tfqs(i-1))/(tfqs(i)-tfqs(i-1))
          endif
        endif
 90   continue
      if (nstd .eq. 0) then
        fpe(yr)=0
        fqe(yr)=0
      endif
c
c______________________________________________________________________
c
c            This section translates fiber equilibrium price (fpe) to
c            product market equilibrium price (epp) and quantity (epq).
c______________________________________________________________________
c
c
      do 150 i=1,np
        if (fps(i,1) .lt. fpe(yr)) then
          qfe(yr,i)=0
          go to 151
        else
          do 1501 j=1,nsub(i)
            if (fps(i,j) .gt. fpe(yr)) then
              if (j .eq. nsub(i)) then
                qfe(yr,i)=fqs(yr,i,j)
                go to 151
              else
                go to 1501
              endif
```

```
              elseif (fps(i,j) .lt. fpe(yr)) then
                qfe(yr,i)=fqs(yr,i,j-1)
              else
                if (j .eq. 1) then
                  qfe(yr,i)=fqs(yr,i,1)*qerat
                else
                  qfe(yr,i)=(fqs(yr,i,j)-fqs(yr,i,j-1))*qerat+
     -                      fqs(yr,i,j-1)
                endif
                go to 151
              endif
 1501       continue
          endif
 151      epq(yr,i)=qfe(yr,i)/awt(i)
          epdif=fpe(yr)-afpe
          epp(yr,i)=epdif*awt(i)+aepp(i)
          if ((swqr(i) .eq. 1) .and. (epq(yr,i) .ne. 0)) then
            avc(i)=epp(yr,i)-qrarea(i)/epq(yr,i)
          endif
 150    continue
        return
        end
```

```
c______________________________________________________________________________
c
c
c     ARCM : CALCULATION OF SCENARIO PRICES AND CS GAINS IN EXEMPTED MARKETS
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c______________________________________________________________________________
c
c
$large
c
c______________________________________________________________________________
c
c                     This subroutine calculates the price and
c                     consumer surplus gains in exempted markets.
c______________________________________________________________________________
c
c
      subroutine exempt
c
$include:'vars.cmn'
c
c
      do 10 i=1,np
        if (.not. exmpt(idp(i))) go to 10
        tfpp(i)=0
        fppflag(i)=0
c
        fpq(yr,i)=bepq(yr,i)
        pr_drop=-1.*(pf1(yr)-bfpe(yr))*awt(i)
c
        temp=0
        if (enctl(yr,idp(i))) temp=temp+ecost(i)
        if (label(yr,idp(i))) temp=temp+lcost(i)
c
        if (swqr(i) .ne. 1) go to 20
        if (pr_drop .ge. temp) go to 20
c
        pr_inc=temp-pr_drop
        tfpp(i)=pr_inc+avc(i)
c
        if (tfpp(i) .gt. bepp(yr,i)) then
          fpp(yr,i)=tfpp(i)
          area5(yr,i)=(fpp(yr,i)-bepp(yr,i))*fpq(yr,i)
          area7(yr,i)=(bepp(yr,i)-avc(i))*fpq(yr,i)
        else
          fpp(yr,i)=bepp(yr,i)
          area5(yr,i)=0
          area7(yr,i)=(tfpp(i)-avc(i))*fpq(yr,i)
        endif
        go to 10
c
20      pr_drop=-1.*(pr_drop-temp)
        fpp(yr,i)=pr_drop+bepp(yr,i)
        area5(yr,i)=(fpp(yr,i)-bepp(yr,i))*fpq(yr,i)
        area7(yr,i)=0
c
10    continue
      return
      end
```

```
c
c
c
c     ARCM : CALCULATION OF FINAL SCENARIO FIBER PRICE AND AREAS 1, 2, 3, AND 4
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c
c
c
$include:'stdsub'
$large
c
c
c
c                  this subroutine calculates fiber price after a
c                  usage cap and then calculates areas 1, 2, 3, and 4.
c
c
c
      subroutine fpc1234
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      integer   st3,end3,flag3
c
      character res,nyc*4,nzc*15
c
c
      iy=yr+baseyr-1
      write (nyc,'(i4)') iy
40    if (qcap(yr) .ge. fqe(yr)) then
        capr=.true.
        call eeop (4,0)
        call pcsa (9,12,' THE FIBER CAP QUANTITY SPECIFIED FOR '//nyc//
     -            ' IS NOT BINDING 'c,vrev)
        call pcs (12,15,'  The relevant variable values are:'c)
        call pcs (13,15,'                                   YEAR = '//
     -               nyc//' 'c)
        write (nzc,'(f10.2)') qcap(yr)
        call pcs (14,15,'                     FIBER CAP QUANTITY = '//
     -               nzc(1:10)//' 'c)
        write (nzc,'(f15.7)') fqe(yr)
        call pcs (15,15,'                   EQUILIBRIUM QUANTITY ='//
     -               nzc//' 'c)
        call pcs (16,15,'(after bans & exemptions, if any)'c)
        write (nzc,'(f15.7)') bfqe(yr)
        call pcs (18,15,'     BASELINE EQUILIBRIUM QUANTITY = '//
     -               nzc//' 'c)
        call pcs (20,15,'  Do you want to continue? (Y/N) MM'c)
        call ynchk (*45,*44)
c
44      call setcur (22,0)
        stop
c
45      call pcs (20,15,'Please enter new fiber cap quantity for '//
     -               nyc//' MM'c)
        qcap(yr)=rchk (0d0,1d6)
c
        if (qcap(yr) .eq. -99.) go to 45
        if (qcap(yr) .ge. fqe(yr)) go to 40
c
        call eeop (4,0)
        call pcsa (12,25,' Processing... 'c,vrev)
        call setcur (vy,vx-1)
      endif
c
      qcrat=1.0
      if (qcap(yr) .eq. 0) then
        pf(yr)=tfps(1)
        st3=1
        qcrat=0
        go to 251
```

```
      endif
c
      do 250 i=1,nstd
        if (tfqs(i) .eq. qcap(yr)) then
          pf(yr)=tfps(i)
          st3=i+1
          go to 251
        elseif (tfqs(i) .gt. qcap(yr)) then
          pf(yr)=tfps(i)
          st3=i
          if (i .eq. 1) then
            qcrat=qcap(yr)/tfqs(1)
          else
            qcrat=(qcap(yr)-tfqs(i-1))/(tfqs(i)-tfqs(i-1))
          endif
          go to 251
        endif
        if (bfpe(yr) .ge. tfps(i)) then
          end3=i-1
          go to 252
        endif
250   continue
251   end3=nstd
c
252   pf1(yr)=slope*qcapm(yr)+rint
      fpdif=pf(yr)-bfpe(yr)
      if (pf(yr) .lt. bfpe(yr)) go to 300
      area1(yr)=fpdif*qcap(yr)
      area2(yr)=(bfpe(yr)-pf1(yr))*qcapm(yr)
c
      flag3=0
      do 255 j=st3,end3
        if (flag3 .eq. 0) then
          area3(yr)=(tfqs(st3)-qcap(yr))*(tfps(st3)-bfpe(yr))
          flag3=1
        else
          area3(yr)=area3(yr)+(tfqs(j)-tfqs(j-1))*(tfps(j)-bfpe(yr))
        endif
255   continue
      area4(yr)=0.5*(bfpe(yr)-pf1(yr))*(bfqe(yr)-qcapm(yr))
      return
c
300   call eeop (4,0)
      call pcsa (15,25,' PF('//nyc//') < BFPE('//nyc//') 'c,vrev)
      call setcur (22,0)
      stop
      end
```

```
c______________________________________________________________________
c
c
c     ARCM : CALCULATION OF SCENARIO PRODUCT PRICES AND QUANTITIES
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c______________________________________________________________________
c
c
$large
c
c______________________________________________________________________
c
c              this subroutine calculates the final price and
c              quantities for all the product markets, using the
c              final price and cap quantity in the fiber market.
c______________________________________________________________________
c
c
      subroutine fppfpq
c
$include:'vars.cmn'
c
c
      do 140 i=1,np
        if (exmpt(idp(i)) .or. (swban(yr,i) .eq. 1)) go to 140
        if (fps(i,1) .lt. pf(yr)) then
          qf(yr,i)=0
          go to 141
        else
          do 1401 j=1,nsub(i)
            if (fps(i,j) .lt. pf(yr)) then
              qf(yr,i)=fqs(yr,i,j-1)
              go to 141
            elseif (fps(i,j) .eq. pf(yr)) then
              if (j .eq. 1) then
                qf(yr,i)=fqs(yr,i,1)*qcrat
              else
                qf(yr,i)=(fqs(yr,i,j)-fqs(yr,i,j-1))*qcrat+
     -                    fqs(yr,i,j-1)
              endif
              go to 141
            endif
 1401     continue
        endif
        qf(yr,i)=qfe(yr,i)
 141    fpq(yr,i)=qf(yr,i)/awt(i)
c
        if (enctl(yr,idp(i))) fpp(yr,i)=ecost(i)
        if (label(yr,idp(i))) fpp(yr,i)=fpp(yr,i)+lcost(i)
c
        if (swqr(i) .eq. 1) then
          avc(i)=bepp(yr,i)-qrarea(i)/bepq(yr,i)
          fpp(yr,i)=fpp(yr,i)+fpdif*awt(i)+avc(i)
          fppflag(i)=0
c
          if (fpp(yr,i) .lt. bepp(yr,i)) then
            fppflag(i)=1
            tfpp(i)=fpp(yr,i)
            fpp(yr,i)=bepp(yr,i)
          endif
c
        else
          fppflag(i)=0
          fpp(yr,i)=fpp(yr,i)+fpdif*awt(i)+bepp(yr,i)
        endif
        call area5678 (i)
 140  continue
      return
      end
```

```
c______________________________________________________________________________
c
c
c     ARCM : OUTPUT HEADER SUBROUTINE
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c______________________________________________________________________________
c
c
$large
c
c______________________________________________________________________________
c
c     This subroutine writes the header for the output to a file or printer
c______________________________________________________________________________
c
c
      subroutine header (idt)
c
$include:'vars.cmn'
c
c
        if (ipage .ne. 0) write (3,'(a)') pgbrk
        ipage=ipage+1
c
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
c
        if (idt .eq. 1) return
c
        if (ipage .eq. 1) then
          write (3,'(t28,a)') 'REGULATION SCENARIO'
          if (pgbrk .eq. '1') write (3,'(a,t28,a)') '+',
     -                             '___________________'
        else
          write (3,'(t24,a)') 'REGULATION SCENARIO (contd.)'
          if (pgbrk .eq. '1') write (3,'(a,t24,a)') '+',
     -                          '____________________________'
        endif
c
        iline=5
c
        return
        end
```

```
c______________________________________________________________________
c
c
c      ARCM : INDIVIDUAL PRODUCT STEP-DEMAND FUNCTIONS
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c______________________________________________________________________
c
c
$large
c
c______________________________________________________________________
c
c                     This Subroutine calculates the Individual
c                       product market Derived Demand Curves.
c______________________________________________________________________
c
c
      subroutine iddc (elc_fl)
c
$include:'vars.cmn'
c
      integer elc_fl
c
c
      do 30 i=1,np
        temp=0
        if (enctl(yr,idp(i))) temp=temp+ecost(i)
        if (label(yr,idp(i))) temp=temp+lcost(i)
        temp=temp*elc_fl
c
        do 301 j=1,nsub(i)
          fps(i,j)=afpe+(ps(yr,i,j)-aepp(i)-temp)/awt(i)
          fqs(yr,i,j)=qs(yr,i,j)*awt(i)
c
          if (j .gt. 1) then
            fqs(yr,i,j)=fqs(yr,i,j)+fqs(yr,i,j-1)
          endif
c
301     continue
c
        if (swqr(i) .ne. 1) go to 30
        do 302 k=1,nsub(i)
          if (lnsub(i,k))
     -      fps(i,k)=fps(i,k)+qrarea(i)/fqs(yr,i,nsub(i))
302     continue
30    continue
c
      return
      end
```

```
c
c
c
c     ARCM : USER RESPONSE CHECK SUBROUTINES
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c
c
c
$include:'stdsub'
$large
c
c
c
c     checks for a Y/N response
c
c
c
      subroutine ynchk (*,*)
c
$include:'stdvar'
c
c
      character   res
c
c
      iy=vy
      ix=vx
c
10    call setcur (iy,ix)
      call eeol (vy,vx)
      read (*,'(a)') res
c
      if ((res .eq. 'Y') .or. (res .eq. 'y')) return 1
      if ((res .eq. 'N') .or. (res .eq. 'n')) return 2
      go to 10
c
      end
c
c
c
c
c             This subroutine scrolls the fiber cap screen one line
c             at a time to display the complete schedule.
c
c
c
      subroutine more
c
$include:'stdvar'
c
c
      call pcsa (22,28,' More to come... 'c,vrev)
      kk=vx-1
      call pcs (24,25,'Press any key to continue'c)
      call setcur (22,kk)
      ipse=key_getc()
      call eeop (22,0)
      call upscroll (1,11,20,0,79,vnorm)
c
      return
      end
c
c
c
c
c             This subroutine checks to see if output file exists
c             and informs user appropriately.
c
c
c
      subroutine file_chk (i,j)
c
$include:'stdvar'
```

```
$include:'vars.cmn'
c
c
      if (i .eq. 1) go to 10
c
      call pcsa (22,10,' FILE '//fname(j)(1:lench(fname(j)))//
     -                 ' NOT FOUND ON DEFAULT PATH 'c,vrev)
      return
c
10    call pcsa (15,15,' FILE '//fname(j)(1:lench(fname(j)))//
     -                 ' ALREADY EXISTS! 'c,vrev)
      call pcs (17,5,'Should file be overwritten (Y/N) MM'c)
c
      return
      end
c
c
c________________________________________________________________________
c
c             This subroutine checks to see if the product # is specified
c             in the valid range and returns the valid product id.
c________________________________________________________________________
c
c
      subroutine tsca (i,j,a,iy)
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      character   nyc*2,a
c
c
10    write (nyc,'(i2)') i
      call pcs (iy,5,'Enter the TSCA 8(a) product number of 'c)
c
      if (a .eq. 'b') call pcs (vy,vx,'BANNED'c)
      if (a .eq. 'x') call pcs (vy,vx,'EXEMPTED'c)
      if (a .eq. 'e') call pcs (vy,vx,'CONTROLLED'c)
      if (a .eq. 'l') call pcs (vy,vx,'LABELED'c)
c
      call pcs (vy,vx,' product #'//nyc//' MM'c)
      j=ichk (1,ip)
      call eeop (22,0)
c
      if (j .eq. -99) then
        write (nyc,'(i2)') ip
        call pcsa (22,10,' THE TSCA # OF THE PRODUCT SHOULD '//
     -        'BE BETWEEN 1 AND '//nyc//' 'c,vrev)
        go to 10
      endif
c
      return
      end
c
c
c________________________________________________________________________
c
c             This subroutine requests a year and checks to see if year is
c             specified correctly within the scenario.
c________________________________________________________________________
c
c
      subroutine yr_chk (ir,ifl,iye)
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      character   nyc*4,nzc*4
c
c
      iy=vy
      ix=vx
c
10    vy=iy
      vx=ix
c
      if (ifl .eq. 0) then
        ir=ichk (1,endyr-baseyr)
```

```
      else
        ir=ichk (baseyr+1,endyr)
      endif
c
      call eeop (iye,0)
c
      if (ir .eq. -99) then
        if (ifl .eq. 0) then
          write (nyc,'(i2)') endyr-baseyr
          call pcsa (22,10,' NUMBER OF YEARS SHOULD BE LESS '//
     -                    'THAN OR EQUAL TO '//nyc(1:2)//' 'c,vrev)
        else
          write (nyc,'(i4)') baseyr
          write (nzc,'(i4)') endyr
          call pcsa (22,25,' YEAR NOT IN SPECIFIED RANGE 'c,vrev)
          call pcsa (23,20,'SHOULD BE SPECIFIED BETWEEN '//nyc//
     -                    ' AND '//nzc//' 'c,vbold)
        endif
        go to 10
      endif
c
      return
      end
c
c
c_____________________________________________________________________
c
c             This subroutine checks to see if the number of products
c             specified are in the acceptable range.
c_____________________________________________________________________
c
c
      subroutine nprd_chk (ir,iye,a,iy4)
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      character   nyc*4,a
c
c

10    write (nyc,'(i4)') iy4
      call pcs (12,5,'Enter # of products to be 'c)
c
      if (a .eq. 'b') call pcs (vy,vx,'BANNED'c)
      if (a .eq. 'e') call pcs (vy,vx,'CONTROLLED'c)
      if (a .eq. 'l') call pcs (vy,vx,'LABELED'c)
c
      call pcs (vy,vx,' in '//nyc//' (99 for all products) MM'c)
      ir=ichk (1,99)
      call eeop (iye,0)
c
      if (ir .eq. -99) go to 10
      if ((ir .gt. ip) .and. (ir .ne. 99)) then
        write (nyc,'(i2)') ip
        call pcsa (22,20,' A MAXIMUM OF '//nyc(1:2)//
     -                  ' PRODUCTS MAY BE SPECIFIED 'c,vrev)
        go to 10
      endif
c
      return
      end
c
c
c_____________________________________________________________________
c
c             This subroutine displays the appropriate error message
c             regarding party id during the permit allocation process.
c_____________________________________________________________________
c
c
      subroutine pty_chk (i,*)
c
$include:'stdvar'
c
c
      if (i .eq. 0) then
        call pcsa (24,20,' THE PARTY ID ENTERED IS NOT VALID 'c,vrev)
      elseif (i .eq. 1) then
```

```
        call pcsa (24,10,' THE NUMBER OF PARTIES SHOULD BE '//
     -                   'SPECIFIED BETWEEN 1 AND 9 'c,vrev)
      elseif (i .eq. 2) then
        call pcsa (24,15,' GOVERNMENT CAN BE THE ONLY '//
     -                   'PARTY WHEN SPECIFIED 'c,vrev)
      endif
c
      return 1
      end
```

```
c_______________________________________________________________________
c
c
c      ARCM : CALCULATION OF AREA 6
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c_______________________________________________________________________
c
c
$large
c
c_______________________________________________________________________
c
c                      This Subroutine calculates AREA 6.
c_______________________________________________________________________
c
c
      subroutine sarea6 (i)
c
$include:'vars.cmn'
c
c
      integer st6,end6,flag6
c
c
      area6(yr,i)=0
      if (fpq(yr,i) .eq. bepq(yr,i)) return
c
      do 190 j=1,nsub(i)
        if ((qcap(yr) .eq. 0) .or. (fpq(yr,i) .eq. 0)) then
          st6=1
          fpq(yr,i)=0
          go to 193
        endif
        if (qs1(yr,i,j) .lt. fpq(yr,i)) go to 190
        if (qs1(yr,i,j) .eq. fpq(yr,i)) st6=j+1
        if (qs1(yr,i,j) .gt. fpq(yr,i)) st6=j
        go to 193
190   continue
193   flag6=0
      do 195 l=st6,nsub(i)
        if (flag6 .eq. 0) then
         area6(yr,i)=(qs1(yr,i,st6)-fpq(yr,i))*(ps(yr,i,st6)-bepp(yr,i))
          flag6=1
        else
          area6(yr,i)=area6(yr,i)+(qs1(yr,i,l)-qs1(yr,i,l-1))*
     -                              (ps(yr,i,l)-bepp(yr,i))
        endif
195   continue
      return
      end
```

```
c______________________________________________________________________________
c
c
c      ARCM : INITIALIZATION OF ALL ARRAYS
c
c      Version 6.31 : May 31, 1988.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c______________________________________________________________________________
c
c
$large
c
c______________________________________________________________________________
c
c                    This Subroutine INITializes all arrays.
c______________________________________________________________________________
c
c
      subroutine sinit
c
$include:'vars.cmn'
c
c
      do 2727 l=1,ny
        fpe(l)=0
        fqe(l)=0
        bfpe(l)=0
        bfqe(l)=0
        area1(l)=0
        area2(l)=0
        area3(l)=0
        area4(l)=0
        pf(l)=0
        pf1(l)=0
        qcap(l)=0
        qcapm(l)=0
        byear(l)=0
c
        do 3737 i=1,im
          epp(l,i)=0
          epq(l,i)=0
          bepp(l,i)=0
          bepq(l,i)=0
          area5(l,i)=0
          area6(l,i)=0
          area7(l,i)=0
          area8(l,i)=0
          area8p(l,i)=0
          qfe(l,i)=0
          qf(l,i)=0
          fpq(l,i)=0
          fpp(l,i)=0
          swban(l,i)=0
c
          do 4747 j=1,ks
            ps(l,i,j)=0
            qs(l,i,j)=0
            qs1(l,i,j)=0
            fqs(l,i,j)=0
4747      continue
3737    continue
c
        do 3738 i=1,ip
          isban(l,i)=0
3738    continue
2727  continue
c
      do 5757 i=1,im
        avc(i)=0
        swqr(i)=0
        nsub(i)=0
        fppflag(i)=0
        tfpp(i)=0
        qrarea(i)=0
c
```

```
        do 6767 j=1,ks
          fps(i,j)=0
 6767   continue
 5757 continue
c
      do 1234 i=1,10
        discrt(i)=0
 1234 continue
C
        perm(1)='Dom. Miners & Millers'
        perm(2)='Foreign Miners & Millers'
        perm(3)='Importers Of Bulk Fiber'
        perm(4)='Dom. Primary Processors'
        perm(5)='Foreign Primary Processors'
        perm(6)='Importers Of Mixtures'
        perm(7)='Importers Of Products'
        perm(8)='Dom. Product Purchasers'
        perm(9)='For. Product Purchasers'
        perm(10)='Government'
        perm(11)='Total'
C
      return
      end
```

```
c_______________________________________________________________________
c
c
c     ARCM : AGGREGATE TABLES OUTPUT SUBROUTINE
c
c     Version 6.31 : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_______________________________________________________________________
c
c
$large
c
c_______________________________________________________________________
c
c        This subroutine writes the 'welfare effects by market' tables
c_______________________________________________________________________
c
c
      subroutine tabagg (itab,drt,fibcs,fibps,pval)
c
$include:'vars.cmn'
c
c
      real         c(ip),p(ip)
c
      character    ctab*2
c
      character*80 us2,us3
c
c
      write (3,'(a)') pgbrk
      ipage=ipage+1
c
      if (itab .eq. 1) ctab='1A'
      if (itab .eq. 2) ctab='1B'
c
      write (3,'(t64,2a)') 'Date: ',dstr
      write (3,'(t64,2a)') 'Time: ',tstr
      write (3,'(t64,a,i2/)') 'Page: ',ipage
      write (3,'(t26,2a)') '            TABLE ',ctab
      if (pgbrk .eq. '1') write (3,'(a,t26,a)') '+','             ______'
      write (3,'(//t26,a)') 'WELFARE EFFECTS BY PRODUCT MARKET'
      if (pgbrk .eq. '1') write (3,'(a,t26,a)') '+',
     -               '_________________________________'
      if (itab .eq. 2) write (3,'(/t31,a)') '(Domestic Effects only)'
      write (3,'(/t15,2a,f4.1,a//)') '(Present Values, in thousand ',
     -                     'dollars, at ',drt,' percent)'
      us2=' Market          CS Loss        PS Loss          Permit'
      us3='(TSCA #)                                         Value       Sta
     -tus'
      write (3,'(7x,a//2(10x,a/),7x,a/)') us1,us2,us3,us1
c
      do 30 j=1,np
        if (itab .eq. 1) then
          cons=dcons(j)+fcons(j)
          pros=dpros(j)+fpros(j)
        else
          cons=dcons(j)
          pros=dpros(j)
        endif
c
        if (itab .eq. 2) then
          c(idp(j))=cons
          p(idp(j))=pros
        endif
c
        write (3,fmt(1)) idp(j),cons,pros,banm(j)
30    continue
c
      if (itab .eq. 2) write (6) drt,(c(i),p(i),i=1,ip),fibcs,fibps
c
      if (option .eq. 1) then
        write (3,fmt(12)) 'Fiber',fibcs,fibps
      else
        write (3,fmt(2)) 'Fiber',fibcs,fibps,pval
```

```
      endif
c
      write (3,'(7x,a/)') us1
c
      write (3,'(/10x,a/)') 'LEGEND FOR PRODUCT STATUS:'
      write (3,'(10x,a)')   '       B   Banned'
      write (3,'(10x,a)')   '       X   eXempted from regulation'
      write (3,'(10x,a)')   '       E   Engineering controls active'
      write (3,'(10x,a//)') '       L   Labeling requirements'
c
      write (3,'(/10x,a)') 'Note: 1. Negative entries are welfare'//
     -                    ' gains.'
      write (3,'(/10x,a)')  '      2. CS Loss in the Fiber market is'//
     -                    ' the sum of all downstream'
      write(3,'(10x,a)')'         producer and consumer welfare losses.'
      write (3,'(/10X,A)')  '      3. Consumer and producer surplus '//
     -                     'losses reported above are'
c
      if (itab .eq. 1) then
        write(3,'(10x,a)') '         for foreign and domestic '//
     -                    'consumers and producers.'
      else
        write(3,'(10x,a)') '         for domestic consumers and '//
     -                    'producers only.'
      endif
c
      return
      end
```

```
C
C
C
C      ARCM : TOTAL DERIVED STEP-DEMAND FUNCTIONS
C
C      Version 6.31 : May 31, 1988.
C
C      Program written by:
C
C         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
C         (703) 934-3000
C
C
C
C
$large
C
C
C
C        This subroutine calculates Total Derived Demand Curve for fiber.
C
C
c
       subroutine tddc (bflag)
c
$include:'vars.cmn'
c
c
       real    tfhq(250),tfvq(250)
c
       integer bflag
c
c
       do 5757 m=1,250
         tfps(m)=0
         tfqs(m)=0
         tfhq(m)=0
         tfvq(m)=0
5757   continue
c
       nstd=0
       do 20 i=1,np
         if ((option .eq. 1) .and. (bflag .eq. 1) .and.
     -       (swban(yr,i) .eq. 1)) go to 20
         if ((option .ne.1) .and. (bflag .eq. 1) .and.
     -       ((swban(yr,i) .eq. 1) .or. exmpt(idp(i)))) go to 20
         do 201 j=1,nsub(i)
           if (fqs(yr,i,j) .lt. 0.0001) go to 201
           do 2011 k=1,nstd
             if (fps(i,j) .eq. tfps(k)) go to 201
2011       continue
           nstd=nstd+1
           tfps(nstd)=fps(i,j)
201      continue
20     continue
c
       do 210 i=1,nstd-1
         do 2101 j=i+1,nstd
           if (tfps(i) .gt. tfps(j)) go to 2101
           ttemp=tfps(i)
           tfps(i)=tfps(j)
           tfps(j)=ttemp
2101     continue
210    continue
c
       do 10 k=1,nstd
         do 101 i=1,np
           if ((option .eq. 1) .and. (bflag .eq. 1) .and.
     -         (swban(yr,i) .eq. 1)) go to 101
           if ((option .ne.1) .and. (bflag .eq. 1) .and.
     -         ((swban(yr,i) .eq. 1) .or. exmpt(idp(i)))) go to 101
           do 1011 j=1,nsub(i)
             if (tfps(k) .le. fps(i,j)) then
               if (j .eq. 1) then
                 tfqs(k)=tfqs(k)+fqs(yr,i,1)
               else
                 tfqs(k)=tfqs(k)+fqs(yr,i,j)-fqs(yr,i,j-1)
               endif
             endif
1011       continue
```

```
101     continue
10    continue
c
      return
      end
```

```
c____________________________________________________________________________
c
c
c      ASBESTOS REGULATORY COST MODEL (ARCM) : MAIN PROGRAM
c
c      Version AMD : May 31 ,1988.
c
c      (version for use instead of arcm.for when either
c       aftermarket brakesc are not banned within 4 years
c       of OEM brakes or if declining prices of substitutes
c       are used)
c
c      Program written by:
c
c                             Vikram Widge
c                             ICF Incorporated
c                             9300 Lee Highway
c                             Virginia 22031-1207
c
c                             (703) 934-3000
c
c      Accompanying Documentation:
c
c            1. User's Manual
c            2. Technical Support Document
c
c____________________________________________________________________________
c
c
$include:'stdsub'
$large
c
c
      program   arcm
c
$include:'stdvar'
$include:'vers.cmn'
c
      integer   onsub(im)
c
      character istr(6)*55
      real      amq(ny,36:37)
c
      common/amq/amq
c
c____________________________________________________________________________
c
c            this section prints the opening statement on the screen
c____________________________________________________________________________
c
c
      call vinit
      call crt_cls
      call box (0,3,15,63,vnorm)
      call pcsa (1,17,'EPA/OTS Asbestos Regulatory Cost Model (ARCM)'c,
     -          vbold)
      call pcs  (2,17,'                    Version AMD'c)
c
      istr(1)='This program models the economic impacts and costs of'c
      istr(2)='asbestos fiber and product regulations.  It permits a'c
      istr(3)='variety of regulatory options to be implemented and'c
      istr(4)='allows flexibility in their implementation.  For'c
      istr(5)='assistance in using this model please refer to the'c
      istr(6)='accompanying user''s manual and related documentation.'c
c
      do 1 i=1,6
       call pcs (i+7,13,istr(i))
1     continue
c
      call pcs (20,20,'Please respond to queries as indicated.'c)
      call pcs (24,25,'Press any key to continue'c)
      call setcur (vy,vx)
      ipse=key_getc()
c
      call eeop (5,0)
      call pcs (9,20,'Refer any specific questions regarding'c)
      call pcs (10,20,'operation of this program to:'c)
      call pcs (12,30,'Vikram Widge'c)
      call pcs (13,30,'ICF Incorporated'c)
      call pcs (14,30,'9300 Lee Highway'c)
```

```
      call pcs (15,30,'Virginia 22031-1207'c)
      call pcs (17,30,'(703) 934-3000'c)
c
      call pcs (24,25,'Press any key to continue'c)
      call setcur (vy,vx)
      ipse=key_getc()
c
      call eeop (5,0)
      call pcsa (12,25,' Initializing... 'c,vrev)
      call setcur (vy,vx-1)
c
      call sinit
      call asbin
c
c
      if (option .ne. 1) then
        write (*,*) 'this version is for declining substitute prices'
        write (*,*) 'and currently does not support non-ban options'
        stop
      endif
c
      do 1492 i=1,np
       if ((cprat(i) .lt. 1) .and. (cprat(i) .ne. -1.)) then
        write (*,*) 'this version is for declining substitute prices'
        write (*,*) 'and currently does not support exports'
        stop
      endif
c
      onsub(i)=nsub(i)
c
 1492 continue
c
c_____________________________________________________________________
c
c  this section transforms data from year of data (ibyd) to specified
c  baseyear, and calculates quasi-rent perpetuities by including the
c  reformulation cost perpetuities.
c_____________________________________________________________________
c
c
      do 310 i=1,np
        impinf(i)=.false.
c
        if (cprat(i) .eq. -1) then
          cprat(i)=1
          impinf(i)=.true.
        endif
c
        if (cprat(i) .gt. 1) epq(1,i)=epq(1,i)*cprat(i)
c
        bbpq(i)=epq(1,i)
c
        fqe(1)=fqe(1)+epq(1,i)*awt(i)
c
        idif=baseyr-ibyd
        do 357 ij=1,idif
          if (ij .lt. 15) then
            ig=ij
          else
            ig=15
          endif
          epq(1,i)=epq(1,i)*(1+grthrt(i,ig))
 357    continue
c
        bepq(1,i)=epq(1,i)
c
 310  continue
c
c
c
      slope=fpe(1)/(selast*fqe(1))
      rint=fpe(1)-slope*fqe(1)
      if (selast .eq. 1) rint=0
c
      bbfq=fqe(1)
      fqe(1)=0
c
      yr=1
c
      do 4638 i=1,np
```

```
           fqe(1)=fqe(1)+epq(1,i)*awt(i)
  4638   continue
c
         afpe=fpe(1)
         fpe(1)=rint+slope*fqe(1)
         if (fpe(1) .gt. afpe) go to 44444
c
         do 468 i=1,np
           aepp(i)=epp(1,i)
           epp(1,i)=(fpe(1)-afpe)*awt(i)+epp(1,i)
           bepp(1,i)=epp(1,i)
c
           if (rcost(i) .gt. 0) then
             qrarea(i)=ccost(i)*epq(1,i)+rcost(i)
             avc(i)=epp(1,i)-(qrarea(i)/epq(1,i))
           elseif (ccost(i) .gt. 0) then
             avc(i)=epp(1,i)-ccost(i)
           else
             go to 468
           endif
c
           swqr(i)=1
c
  468    continue
c
         bfpe(1)=fpe(1)
         bfqe(1)=fqe(1)
c
c
         call adjust
c
         yr=2
c
c________________________________________________________________________
c
c             this section modifies the product demand curves annually.
c________________________________________________________________________
c
c
  1111   do 300 i=1,np
c
           do 3001 j=1,onsub(i)
               a=(1+fdiscrt)**ns(i,j)
               b=(1+fdiscrt)**na(i)
c
               if (ns(i,j) .ne. na(i))
     -           aps(yr,i,j)=aps(yr,i,j)*(a/b)*(b-1)/(a-1)
c
               if (aps(yr,i,j) .lt. aepp(i)) then
                 aps(yr,i,j)=aepp(i)
               endif
c
  3001     continue
c
           if (onsub(i) .eq. 1) then
             ps(yr,i,1)=aps(yr,i,1)
             ms(i,1)=ams(i,1)
           else
             insub=0
             do 201 j=1,onsub(i)
               do 2011 k=1,insub
                 if (aps(yr,i,j) .eq. ps(yr,i,k)) then
                   ms(i,k)=ms(i,k)+ams(i,j)
                   go to 201
                 endif
  2011         continue
c
               insub=insub+1
               ps(yr,i,insub)=aps(yr,i,j)
               ms(i,insub)=ams(i,j)
  201        continue
c
             nsub(i)=insub
c
             do 4631 j=1,nsub(i)-1
               do 46311 k=j+1,nsub(i)
c
                   if (ps(yr,i,j) .eq. ps(yr,i,k)) then
                     call eeop (5,0)
                     call setcur (12,0)
```

```
                    write (*,*) '    PRICES OF SUBSTITUTES STILL EQUAL'
                    write (*,*) '    YEAR:',baseyr+yr-1,'  MARKET:',idp(i)
                    write (*,*) '    SUBSTITUTES:',j,k
                    write (*,*) '    PRICES:',ps(yr,i,j),ps(yr,i,k)
                    call setcur (22,0)
                    stop
                  endif
c
                  if (ps(yr,i,j) .gt. ps(yr,i,k)) go to 46311
                  ptemp=ps(yr,i,j)
                  emtemp=ms(i,j)
                  ps(yr,i,j)=ps(yr,i,k)
                  ms(i,j)=ms(i,k)
                  ps(yr,i,k)=ptemp
                  ms(i,k)=emtemp
c
46311           continue
4631          continue
          endif
c
462       count=0
          do 4621 j=1,nsub(i)
            count=count+ms(i,j)
            lnsub(i,j)=.false.
            if (swqr(i) .eq. 1) lnsub(i,j)=.true.
4621      continue
c
          if ((count .lt. 0.999999) .or. (count .gt. 1.000001)) then
            call eeop (5,0)
            call setcur (12,0)
            write (*,'(5x,2a,i2,a,f14.7,a,i4)') 'MARKET SHARE(S) OF ',
     -      'SUBSTITUTES IN MARKET ',idp(i),' ADD TO ',count, ' IN YEAR ',
     -      yr+baseyr-1
            call setcur (22,0)
            stop
          endif
c
300     continue
c
c
        qcap(yr)=qcapm(yr)
c
c
        do 400 i=1,np
c
          cur_bseq=epq(1,i)
          do 4002 ig=baseyr-ibyd+1,yr
c
            if (ig .gt. 15) then
              igj=15
            else
              igj=ig
            endif
c
            cur_bseq=cur_bseq*(1+grthrt(i,igj))
4002      continue
c
          do 4001 j=1,nsub(i)
            qs(yr,i,j)=cur_bseq*ms(i,j)
            if (j .eq. 1) then
              qs1(yr,i,j)=qs(yr,i,j)
            else
              qs1(yr,i,j)=qs1(yr,i,j-1)+qs(yr,i,j)
            endif
4001      continue
c
          rq=qs1(yr,i,nsub(i))
          if (rq .eq. 0.) swqr(i)=0
c
          if (swqr(i) .eq. 1) then
            qrarea(i)=ccost(i)*rq+rcost(i)
          endif
c
c         **** engineering control cost calculation ****
c
          if (rq .ne. 0) ecost(i)=(fecost(i)+vecost(i)*rq)/rq
c
          if (exmpt(idp(i))) then
            if (qcap(yr) .eq. 0) then
              qcapm(yr)=qcapm(yr)+(awt(i)*qs1(yr,i,nsub(i)))
```

```
            else
             qcap(yr)=qcap(yr)-(awt(i)*qs1(yr,i,nsub(i)))
c
             if (qcap(yr) .lt. 0) then
               call eeop (5,0)
               call setcur (12,0)
               write (*,'(10x,a,i4//)') 'MODIFIED FIBER CAP < 0 IN '//
     -                                  'YEAR ',baseyr+yr-1
               write (*,'(2(10x,a,f13.7/))') 'INPUT CAP    = ',qcapm(yr),
     -                                       'MODIFIED CAP = ',qcap(yr)
               write (*,'(/10x,a,i2)') 'ERROR AT EXEMPTED PRODUCT #',
     -                                 idp(i)
               call setcur (22,0)
               stop
             endif
c
            endif
          endif
 400    continue
c
        call iddc (0)
        call tddc (0)
        call eqpq
        if (afpe .ge. fpe(yr)) go to 2222
c
 44444  iyr=yr+baseyr-1
        call eeop (5,0)
        call setcur (12,0)
        write (*,'(15x,a//)') 'BASELINE FIBER PRICE > '//
     -                        'DATA YEAR FIBER PRICE'
        write (*,'(10x,a,i4,a,f14.7/)') 'Baseline fiber price for ',
     -                                   iyr,' = ',fpe(yr)
        write (*,'(10x,a,i4,a,f14.7)') 'Data year (',ibyd,
     -                                 ') fiber price  = ',afpe
        call setcur (22,0)
        stop
c
c
 2222   bfpe(yr)=fpe(yr)
        bfqe(yr)=fqe(yr)
        do 210 i=1,np
          bepp(yr,i)=epp(yr,i)
          bepq(yr,i)=epq(yr,i)
c
c setting price of exports equal to baseline price.
c
          if (cprat(i) .lt. 1) then
            ps(yr,i,nsub(i))=bepp(yr,i)
          endif
c
 210    continue
c
c  adjustment of fiber demand curve to reflect export
c  markets' last step adjustment.
c

        if ((enf .or. lbf) .and.
     -    (((option .eq. 1) .and.(ibchk .gt. yr)) .or.
     -    ((option .eq. 2) .and. (ibchk .gt. yr) .and.
     -     (qcap(yr) .gt. 0)) .or.
     -    ((option .eq. 3) .and. (qcap(yr) .gt. 0)))) then
          call enlbl
          call iddc (1)
        endif
c
c ***** Superimposing aftermarket adjustments *****
c
        do 4926 i=1,np
          if ((idp(i) .eq. 36) .or. (idp(i) .eq. 37)) then
            do 49261 j=1,nsub(i)
              qs(yr,i,j)=amq(yr,idp(i))*ms(i,j)
c
              if (j .eq. 1) then
                qs1(yr,i,j)=qs(yr,i,j)
              else
                qs1(yr,i,j)=qs1(yr,i,j-1)+qs(yr,i,j)
              endif
c
 49261      continue
          endif
```

```
 4926   continue
c
        call iddc (0)
c
c ***************************************************
c
        call tddc (1)
        if (option .eq. 3) go to 2339
        call bancsqr
        call eqpq
c
        if (option .eq. 1) then
          if (fpe(yr) .eq. 0) fpe(yr)=rint
          call aronban
          go to 8888
        endif
c
 2339   capr=.false.
        call fpc1234
        call fppfpq
        if (exf) call exempt
c
 8888   yr=yr+1
        if (.not.(yr .gt. ie)) go to 1111
c
        call benout
        call asbout
        call pcsa (15,38,' completed 'c,vrev)
c
        if (fname(3) .ne. 'lpt1') then
         call pcsa (18,15,'TO PRINT OUTPUT FILE '//
     -               fname(3)(1:lench(fname(3)))//' ENTER'c,vbold)
         call pcsa (19,15,'''PF_ARCM '//fname(3)(1:lench(fname(3)))//
     -               ''' AT THE DOS PROMPT.'c,vbold)
        endif
        call setcur (22,0)
c
        stop
        end
```

```
c________________________________________________________________________
c
c
c     ARCM : AFTERMARKET ADJUSTMENT DUE TO OEM BAN
c            (used only with arcm_amd.for)
c
c     Version AMD : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c________________________________________________________________________
c
c
c________________________________________________________________________
c
c   Adjustment of Aftermarket due to OEM ban and calculation of OEM losses
c________________________________________________________________________
c
      subroutine adjust
c
$include:'vars.cmn'
c
      real      amq(ny,36:37),oemq(ny,18:19),amadj(ny,36:37)
      integer   oem(18:19)
c
      common/amq/amq
      common/amadj/amadj
c
c
c ***** regular baseline development for OEM and A/M *****

      do 10 i=1,np
c
        if ((idp(i) .eq. 18) .or. (idp(i) .eq. 19)) then
          oemq(1,idp(i))=bepq(1,i)
          do 20 iy=2,endyr-baseyr+1
            igj=baseyr-ibyd+iy-1
            if (igj .gt. 15) igj=15
            oemq(iy,idp(i))=oemq(iy-1,idp(i))*(1+grthrt(i,igj))
20        continue
        endif
c
        if ((idp(i) .eq. 36) .or. (idp(i) .eq. 37)) then
          amq(1,idp(i))=bepq(1,i)
          do 30 iy=2,endyr-baseyr+1
            igj=baseyr-ibyd+iy-1
            if (igj .gt. 15) igj=15
            amq(iy,idp(i))=amq(iy-1,idp(i))*(1+grthrt(i,igj))
30        continue
        endif
c
10    continue
c
c ***** baseline adjustment for A/M due to OEM bans *****
c
      oem(18)=0
      oem(19)=0
c
      do 40 i=1,np
        do 60 iy=2,endyr-baseyr+1
c
          if ((idp(i) .eq. 18) .or. (idp(i) .eq. 19)) then
            if ((swban(iy,i) .eq. 1) .and. (oem(idp(i)) .eq. 0))
     -       oem(idp(i))=iy
c
            amadj(iy,idp(i)+18)=0
c
            if (oem(idp(i)) .eq. 0) go to 40
c
            if (iy .ge. oem(idp(i))+4) then
              atemp=0
              if ((isban(iy,idp(i)+18) .eq. 1) .and.
     -            (.not. exmpt(idp(i)+18))) go to 40
c
              do 50 k=1,iy-oem(idp(i))
                if (k .eq. 4) then
                  atemp=oemq(iy-4,idp(i))*0.977
```

```
                 elseif (k .eq. 8) then
                   atemp=atemp+oemq(iy-8,idp(i))*0.839
                 elseif (k .eq. 12) then
                   atemp=atemp+oemq(iy-12,idp(i))*0.451
                 endif
 50            continue
c
               amq(iy,idp(i)+18)=amq(iy,idp(i)+18)-atemp
               amadj(iy,idp(i)+18)=atemp
c
               if (amq(iy,idp(i)+18) .le. 0) then
                 call pcs (15,10,'aftermarket qty. < or = 0'c)
                 call setcur (17,10)
                 write (*,51) 'year',iy+baseyr-1,'mkt.',idp(i)+18,
     -                 'a/m qty.',amq(iy,idp(i)+18)
 51              format (t11,a,2x,i4,3x,a,2x,i2,3x,a,2x,f10.1)
                 call setcur (20,0)
                 stop
               endif
             endif
           endif
 60      continue
 40    continue
c
       return
       end
```

```
c______________________________________________________________________________
c
c
c     ARCM : CALCULATION OF AREAS UNDER BANS ONLY
c            (version of aronban.for used with arcm_amd.for)
c
c     Version AMD : May 31, 1988.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c______________________________________________________________________________
c
c
$large
c
c______________________________________________________________________________
c
c                     This subroutine calculates the CS gains
c                     and PS losses when only bans take place.
c______________________________________________________________________________
c
c
      subroutine aronban
c
$include:'vars.cmn'
c
      real      amadj(ny,36:37)
      common/amadj/amadj
c
      pedif=bfpe(yr)-fpe(yr)
      area2(yr)=pedif*fqe(yr)
      area4(yr)=0.5*pedif*(bfqe(yr)-fqe(yr))
      do 230 i=1,np
        if (swban(yr,i) .eq. 1) go to 230
        area5(yr,i)=(epp(yr,i)-bepp(yr,i))*epq(yr,i)
c
        if ((idp(i) .eq. 36) .or. (idp(i) .eq. 37)) then
          atemp=0
          do 10 j=1,nsub(i)
            atemp=atemp+amadj(yr,idp(i))*ms(i,j)*(ps(yr,i,j)-bepp(yr,i))
 10       continue

c ***** area5 is a gain here and so is a negative entity *****
          area5(yr,i)=area5(yr,i)+atemp
        endif
c
 230  continue
      return
      end
```

A.4 EXPOSURE AND BENEFITS MODEL CALCULATION METHODS

This appendix presents details concerning the calculations required for two aspects of the benefits measurement approach outlined in Volume I of this Regulatory Impact Analysis. The first section below reviews the procedures used to translate the emissions and related results derived in the ICF (1988) and Versar (1987) studies of asbestos exposure in occupational and nonoccupational settings. The second section provides a step-by-step overview of the calculations performed by the benefits estimation model.

A. EXPOSURE CALCULATIONS

The information provided by the ICF and Versar studies of emissions and populations exposed are the basic inputs for the health model's calculations. To derive the direct inputs to the model, however, several additional steps were required. These are outlined below for each major activity giving rise to asbestos exposures as follows:

- Primary manufacturing, both occupational and nonoccupational
- Secondary manufacturing, both occupational and nonoccupational
- Installation, both occupational and nonoccupational
- Use, both occupational and nonoccupational
- Disposal or repair, both occupational and nonoccupational

It must be noted, however, that the "number of people exposed" and the "million fibers breathed per year" numbers shown for each exposure setting are correct only for the underlying quantities of each asbestos product, as reported in the ICF study. These quantities in turn were based on the latest information available for each category. The cost model, on the other hand, uses the 1985 quantity for each product category and applies appropriate growth rates to arrive at the correct quantity information in the years after 1985, provided such information was available. In order to make the inputs to the cost and benefit models consistent, the numbers reported in sections 1, 2, 3, and 5 below are adjusted as described in section 6.[1] The actual input to the health benefits model are shown in section 6.

1. Exposure from Primary Manufacturing

Emissions from primary and secondary manufacturing were combined for the dispersion modelling and are all included here under nonoccupational exposures from primary manufacturing. ICF's occupational exposure level data were presented in fibers/cubic centimeter (f/cc). These estimated exposure levels represented the arithmetic averages of the many observed occupational exposure levels for each product assuming compliance with the OSHA 0.2 f/cc PEL. To convert f/cc to units of million fibers breathed per year, it was necessary to multiply exposures measured in f/cc by the volume of air (in cubic meters) breathed per hour and hours of exposure per year. For occupational exposure, a breathing rate of 1.3 cu m/hour was assumed

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[1] Section 4 reports the data for the nonoccupational exposures from product use only as there are no occupational exposures for this exposure setting. The numbers reported were derived from emissions estimates and dispersion modelling by Versar (1988) and are not based on any quantity data *per se*, and therefore are not adjusted in section 6.

(Jennings, 1985). For many products, 2000 hours (8 hours/day x 250 days/year) of exposure per year were assumed (ICF 1988). However for products 3, 4, 5, 6, 11, and 23, exposure durations of 8 hours/day for only 209, 201, 204, 202, 202, and 202 days/year respectively were assumed (ICF 1988). Further exceptions include: product 13, 220 days/year, product 26, 240 days/year, and products 30,32, and 33, 200 days/year (ICF 1988).

Versar's nonoccupational exposure level data were presented in micrograms/cubic meter. Again, these estimated exposure levels represented the arithmetic averages of the many estimated nonoccupational exposure levels for each product. To convert micrograms/cu m to units of million fibers breathed per year it was necessary first to convert micrograms/cu m to nanograms/cc by dividing by 1000. A conversion rate of 30 f/nanogram was then used to convert these exposure levels to f/cc (USEPA, 1986). To convert f/cc to units of million fibers breathed per year, the f/cc were multiplied by volume of air breathed (in cu m) per hour and hours of exposure per year. A breathing rate of 1.1 cu m/hour was assumed for nonoccupational exposure (Jennings, 1985). For all products, 8,760 hours (24 hours/day x 365 days/year) of exposure per year were assumed (USEPA, 1986).

Finally, for the mining and milling category, exposure data from the ICF exposure assessment (ICF 1988) were combined by summing the populations exposed to each activity, and calculating a weighted average exposure level using the population weights. The data used to compute the weighted average are as follows:

	Mining	Milling
Population Exposed	44	111
Level of Exposure (million f/yr.)	49	147

The exposure data underlying the adjustments in section 6 are shown in Table A.4-1.

2. Exposure from Secondary Manufacturing

First, all nonoccupational exposures due to Secondary Manufacturing are included in the nonoccupational exposures due to Primary Manufacturing, as discussed above. Second, the numbers of people exposed from secondary manufacturing of friction products (products 18-24) in 1985 were estimated using the 8(a) CBI data for 1981, adjusted for each product by multiplying by the ratio of production in 1985 to that in 1981. Furthermore, ICF (ICF 1988) assumed the exposure levels from secondary manufacturing to be the same for all friction products (products 18-24). ICF's exposure level data were presented in f/cc. These levels represented the arithmetic average of the many observed occupational exposure levels for each product assuming compliance with the OSSA 0.2 f/cc PEL. To convert f/cc to units of million fibers breathed per year it was necessary to multiply exposures in f/cc by the

Table A.4-1. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Primary Manufacturing Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	12	145	5,747,875	0.0232
4. Pipeline Wrap	27	134	4,847,937	0.0476
5. Beater-add Gaskets	227	110	35,897,272	0.0373
6. High-grade Elect. Paper	27	113	254,772	0.405
7. Roofing Felt				
8. Acetylene Cylinders	162			
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	6	111		
12. V/A Floor Tile				
13. Diaphragms	650	87	19,744,593	0.00000185
14. A/C Pipe	286	270	3,313,602	0.167
15. A/C Flat Sheet	12	478	4,847,937	0.0218
16. A/C Corrugated Sheet				
17. A/C Shingles	11	473	891,143	0.00361
18. Drum Brake Linings	1,115	385	24,605,781	0.0575
19. Disc Brake Pads, LMV	815	390	21,421,488	0.0214
20. Disc Brake Pads, HV	14	385	1,596,558	0.000000827
21. Brake Blocks	232	377	8,034,916	0.00388
22. Clutch Facings	239	406	8,761,571	0.0027
23. Auto. Transmiss. Comp.	1	113		
24. Friction Materials	187	398	12,628,656	0.00234
25. Protective Clothing				
26. Thread, yarn etc.	78	457	16,306,866	0.00214
27. Sheet Gaskets	163	208	42,550,071	0.00561
28. Asbestos Packings	5	198	5,659,488	0.0000534
29. Roof Coatings	438	273	63,673,717	0.00233
30. Non-Roofing Coatings	497	220	59,487,018	0.0000394
31. Asb. Reinforced Plastics	138	164	17,504,019	0.0018
32. Missile Liners	380	220		
33. Sealant Tape	134	220		
34. Battery Separators	207			
35. Arc Chutes	2			
36. Mining and Milling	155	121	841,214	0.407

volume of air (in cu m) breathed per hour and hours of exposure per year. A breathing rate of 1.3 cu m/hour was assumed (Jennings, 1985). For all products 2000 hours (8 hours/day x 250 days/year) of exposure per year were assumed (ICF 1988). The exposure data underlying the adjustments in section 6 are shown in Table A.4-2.

3. Exposure from Installation

Most of the nonoccupational data were derived from emissions estimates by ICF Incorporated (ICF 1988) and dispersion modelling by Versar (Versar 1988). These exposures occur as a result of releases of asbestos to the air during occupational installation of asbestos products used in construction. These included products 7, 14, 15, 16, and 17. Consumer installation exposure exists for product 29 only, as estimated by Versar (Versar 1987). For occupational exposures, ICF data were presented in f/cc. The levels represented the arithmetic average of the many observed occupational exposure levels for each product assuming compliance with the OSHA 0.2 PEL. To convert f/cc to units of millions of fibers breathed per year, it was necessary to multiply exposures in f/cc by the volume of air breathed (in cu m) per hour and hours of exposure per year, hence a breathing rate of 1.3 cu m/hour was assumed (Jennings, 1985). For all products, although exposures were typically less than 8 hours/day, a 2000 hour (8 hours/day x 250 days/year) annual exposure was assumed for all the exposed population, since the number of people exposed were estimated as number of full-time-equivalent employees (ICF 1988).

For ambient exposures to asbestos from construction activities, Versar (1988) provided only estimates for total population exposed from installation and repair and did not allocate the exposed population to the primary products and exposure categories. Versar's estimated total number of people exposed from occupational construction activities was assumed to be equal to the number exposed from each of the products separately for modeling purposes.

For consumer installation of product 29, spray roof coatings, such coatings were assumed to be applied every 4 years (the mid-point of Versar estimate of 3-5 years) by a total of 841,000 persons (Versar 1987). Thus the number of persons exposed per year in this category was assumed to be 210,250 (841,000/4).

For ambient occupational exposures in construction activities, Versar (1988) provided only estimates for total exposures from installation and repair. To allocate these exposures to the primary products by exposure category, these total exposure levels were divided according to the proportion of emissions from each individual product and exposure category as estimated by ICF (ICF 1988, Exhibits 42-46).

For ambient exposures to occupational construction activities, Versar's exposure level data were presented in microgram/cu m. These levels represented the arithmetic average of the many estimated ambient exposures for each product. To convert microgram/cu m to units of millions fibers breathed per year it was necessary first to convert micrograms/cu m to f/cc and then multiply by volume of air breathed (in cu m) per hour and hours of exposure per year. Micrograms/cu m was converted first to nanograms/cc by dividing by 1000. A conversion rate of 30 fibers/nanogram was used to convert these exposure levels to f/cc (USEPA, 1986). A breathing rate of 1.1 cu m/hour was

Table A.4-2. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Secondary Manufacturing Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	448	57		
4. Pipeline Wrap				
5. Beater-add Gaskets	1,264	57		
6. High-grade Elect. Paper	20	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	145	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings	1,937	125		
19. Disc Brake Pads, LMV	267	146		
20. DisC Brake Pads, HV				
21. Brake Blocks	16	127		
22. Clutch Facings	48	166		
23. Auto Transmiss. Comp.				
24. Friction Materials	27	195		
25. Protective Clothing				
26. Thread, yarn etc.	208	408		
27. Sheet Gaskets	878	276		
28. Asbestos Packings	25	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics	456	239		
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Mining and Milling				

assumed (Jennings, 1985). For all ambient exposures 8,760 (24 hours/day x 365 days per year) hours of exposure per year were assumed (USEPA, 1986).

For exposures from consumer installation of product 29, an annual exposure duration of 4 hours (4 hours/day x 1 day/year) was assumed. The estimated mean exposure level for product 29 was 0.2 f/cc which was the mean exposure level from consumer installation from the three studies cited by Versar (1987). The exposure data underlying the adjustments in section 6 are shown in Table A.4-3.

4. Exposure from Use

Nonoccupational exposures from product use were derived from emissions estimates and dispersion modelling by Versar (1988). Versar presented an estimate of the average national ambient air asbestos concentration attributable to brake use in 1985 of 0.039 ng/cu m for the 226,546,000 people in the U.S. These exposures were assigned among the four brake products, drum brakes for light and medium vehicle, disc pads for light and medium vehicles, disc pads for heavy vehicles, and brake blocks for heavy vehicles, as follows:

Versar estimated that in 1985:

- Cars accounted for 31 percent of asbestos emissions;
- Light trucks accounted for 15 percent of asbestos emissions; and
- Heavy trucks accounted for 54 percent of asbestos emissions.

The national exposure level, 0.039 ng/cu m, can be subdivided using these percentages to cars, 0.012 ng/cu m (0.31 x 0.039), light trucks, 0.0058 ng/cu m (0.15 x 0.039), and heavy trucks, 0.021 ng/cu m (0.54 x 0.039). Car brakes were assumed to be 55 percent disc brakes and 45 percent drum brakes (See Appendix A.1). Emissions from brakes were estimated to be in the ratio 1.1 : 1.0 for disc : drum brakes (Letter from Lynn Delpire to Jo Mauskopf dated June 17, 1987), and thus the .012 ng/cu m was assigned to products 18 and 19 as 0.0052 ng/cu m and 0.0070 ng/cu m respectively. ICF estimates that light trucks have 50 percent drum brakes and 50 percent disc brakes (See Appendix A-1), and thus 0.0027 ng/cu m was assigned to product 18 for light trucks and 0.0030 ng/cu m was assigned to product 19, accounting for the 1.1 : 1.0 emission ratio described above. Versar assumed that heavy trucks have drum brakes only, and thus 0.021 ng/cu m was assigned to product 21. The total U.S. population was assumed to be exposed to emissions from each of the four friction products.

The ambient exposure data from emissions from use of brakes was further adjusted for the benefits analysis. The exposure levels derived above were attributable to emissions of all brakes being used in 1985. For the benefits analysis exposure data set, estimates of exposures attributable to the first year of exposure of brakes manufactured during 1985 were needed. ICF assumed a brake lifetime of 4 years for drum brakes and disc pads for light and medium vehicles, and a decline in production of approximately 0.9 percent per year since 1981 for drum brakes and 8.6 percent per year for disc pads. Thus, approximately 0.247 x (0.0052 + 0.0027) = 0.0020 ng/cu m can be assigned to

Table A.4-3. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Installation of Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	396	439	171,136,373	0.0000180
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	921	296	171,136,373	0.0000261
15. A/C Flat Sheet	16	723	171,136,373	0.00000098
16. A/C Corrugated Sheet	7	723	171,136,373	0.00000043
17. A/C Shingles	236	130	171,136,373	0.0000038
18. Drum Brake Linings				
19. Disc Brake Pads, LMV				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings			210,250	1.04
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Mining and Milling				

product 18 for drum brakes manufactured in 1985 and 0.217 x (0.0070 + 0.0030) = 0.0022 ng/cu m to product 19 for disc brakes manufactured in 1985 where the factors 0.247 and 0.217 were derived as follows:

If "N" is the number of drum brakes installed in 1982, the total number of drum brakes on the road in 1985, assuming a decline in production each year of 0.9 percent and brake life of 4 years, is given by:

$$(N + 0.991 \times N + 0.991 \times 0.991 \times N + 0.991 \times 0.991 \times 0.991 \times N) = 3.946 \times N$$

The proportion of the drum brakes on the road in 1985 that were manufactured in 1985 is thus assumed to be approximately given by:

$$(0.991 \times 0.991 \times 0.991 \times N)/3.946 \times N = 0.247$$

Similarly for disc pads, the total number on the road in 1985, assuming a decline in production each year of 8.6 percent and brake life of 4 years, is given by:

$$(N + 0.914 \times N + 0.914 \times 0.914 \times N + 0.914 \times 0.914 \times 0.914 \times N) = 3.513 \times N$$

The proportion of the disc brakes on the road in 1985 that were manufactured in 1985 is thus assumed to be approximately given by:

$$(0.914 \times 0.914 \times 0.914 \times N)/3.513 \times N = 0.217$$

Finally, no exposures from use were assigned to product 20, and 0.021 ng/cu m were assigned to product 21 (since brake blocks are assumed to have an average life of only half a year, all brake blocks were assumed to be used in the year of manufacture). The exposure data used for the health benefits analysis are shown in Table A.4-4.

5. Exposure from Repair/Disposal

Some of the nonoccupational data for estimating exposures in repair/disposal were derived from emissions estimates by ICF (1988) and dispersion modelling by Versar (1988). Other data were derived from nonoccupational exposure data compiled by Versar (1987). ICF estimated exposures from automotive rebuilding for all friction products together. The total population exposed in automotive rebuilding was the number estimated by OSHA (1986). This population was divided among the individual friction products (products 18-24) in the same proportion as those exposed in secondary manufacturing of these products in 1985.

Occupational population exposure estimates for brake repair for brakes manufactured during 1985 were estimated using the ICF estimates for sales of replacement brakes for 1989 (Appendix A.1). The sales of replacement brakes for consumer repair were netted out of these total sales estimates and then the full-time-equivalent employees required to install the remaining brakes were estimated. The ICF estimate for total replacement brakes sales in 1989 is 136,045,000 for drum brakes (product 18) and 96,273,000 for disc brakes (product 19). The total occupationally-exposed population for brake repair was estimated by adding together the exposed population estimates for

Table A.4-4. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Use of Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings			226,546,000	0.00058
19. Disc Brake Pads, LMV			226,546,000	0.00064
20. Disc Brake Pads, HV				
21. Brake Blocks			226,546,000	0.0061
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Mining and Milling				

automotive rebuilding and repair for each of the friction products.

ICF estimated the exposures from automotive rebuilding for all friction products together (ICF 1988). The exposure levels were assumed to be the same for each product. The exposure levels during occupational brake repair and rebuilding were derived from the estimates in the ICF asbestos exposure assessment by converting the f/cc estimate to million fibers/year. For this conversion breathing rates of 1.3 cu m/hour (Jennings, 1985) and annual exposures of 2000 hours (8 hours/day x 250 days/year) (ICF, 1988) were assumed.

The exposures from automotive rebuilding by primary friction product were combined with those from occupational brake repair in the exposure data set by summing the populations exposed to each activity, and calculating a weighted average exposure level using population weights. The data used for occupational exposure from repair for products 18, 19, and 21 are as follows:

	Occupational Brake Repair	Automotive Rebuilding
Population Exposed		
18	71,395	4,009
19	38,890	551
20	117	0
21	3,832	33
Level of exposure (millions f/yr.)		
18	390	133
19	390	130
20	390	0
21	390	133

For ambient nonoccupational exposure from occupational brake repair or construction removal activities, Versar provided only total population estimates and did not allocate the population exposed to the primary products (Versar 1988). In both cases, Versar's total number of people exposed from occupational brake repair or construction removal activities was assumed to be the same as the number exposed from each of the products separately.

The nonoccupational population exposed estimates from consumer brake repair for the brakes manufactured during 1985 were derived from survey data for 1981 (Versar 1987). The survey indicated that 9,132,000 people actually purchased brakes and a further 4,054,000 people who were members of the purchaser's household helped to install them. The number of people doing home brake jobs was assumed to remain constant over time and each brake job was assumed to consist of changing 4 disc pads and 4 brake drums, although the proportion of those jobs that used asbestos brakes was assumed to change over time as the population of asbestos brakes declines.

The number of consumers exposed while changing asbestos brakes in 1985 was therefore computed as, 12,922,280 (13,186,000 x 0.98) for brake drums (product 18) and 8,570,900 (13,186,000 x 0.65) for disc pads (product 19). The factors 0.98 and 0.65 were obtained from Tables 11 and 12 of Appendix A.1 and are the ratios of asbestos brakes to total brake sales for 1989 for drum and disc brakes respectively. The total number of asbestos brake drums and disc pads installed by consumers in 1989 (as they repair brakes manufactured during 1985) was calculated as 35,797,440 (0.98 x 9,132,000 x 4) and 23,743,200 (0.65 x 9,132,000 x 4) respectively.

The total nonoccupational exposed population from brake repair is estimated by adding together the estimates of the exposed population from ambient exposure from occupational brake repair and consumer installation of brakes.

For ambient nonoccupational exposure from occupational brake repair or removal of construction products Versar provided only total exposure estimates and did not allocate the exposures from repair to the individual construction or friction products. These exposure levels were divided between the individual friction or construction products according to the proportion of emissions from the specific products as estimated by ICF (1988, Tables 42-46).

The ambient exposure estimates were presented by Versar in micrograms per cubic meter. In order to convert them to units of million fibers per year the unit were first converted to nanograms/cc by dividing by 1000. These exposures were converted to f/cc by multiplying by a 30 f/nanogram conversion factor (USEPA, 1986). To convert f/cc to million fibers per year a breathing rate of 1.1 cu m/hour (Jennings, 1985) and an annual exposure duration of 8,760 hours (24 hours/day x 365 days/year) (USEPA, 1986) were assumed.

The exposure level during nonoccupational brake repair was derived from the estimates in the Versar nonoccupational exposure assessment (Versar 1987) as follows: Versar assumed that 39 percent of consumer brake repairs were done in a garage and the remaining 61 percent outdoors. For those jobs done outdoors, exposure was estimated to be at 0.71 f/cc for .3 hours for one day with a breathing rate of 1.3 cu m /hour. Thus, 0.28 (0.71 x 0.3 x 1.3) million fibers will be breathed during the year for each consumer changing brakes outside. For those jobs done in a garage, consumers were assumed to be exposed for 0.3 hours to 0.71 f/cc and then for a further 2.4 hours at 0.035 f/cc. Thus, 0.39 ((0.71 x 0.3 x 1.3)+(0.035 x 2.4 x 1.3)) million fibers will be breathed during the year by each consumer changing brakes in a garage. The weighted average exposure level for all consumers changing brakes is, consequently, 0.32 ((0.39 x 0.39) + (0.61 x 0.28)) million fibers per year. Since consumers were assumed to change an equal number of drum and disc brakes and the exposures from changing these brakes were assumed to be approximately the same, the weighted average exposure level of 0.32 million fibers/year was divided equally between products 18 and 19.

The nonoccupational exposures from releases from occupational brake repair were combined with those from consumer brake repair in the exposure data set by summing the populations exposed to each activity, and calculating a weighted average exposure level using population weights. The data used for products 18 and 19 are as follows:

	Occupational Brake Repair	Consumer Brake Repair
Population Exposed		
18	170,871,494	12,922,280
19	170,871,494	8,570,900
Level of exposure (millions f/yr.)		
18	0.00006	0.16
19	0.00003	0.16

The exposure data underlying the adjustments in section 6 are shown in Table A.4-5.

6. Adjustment of Exposure Data

The "number of people exposed" and the "million fibers breathed per year" numbers shown for each exposure setting in the previous sections are correct only for the underlying quantities of each asbestos product, as reported in the ICF (1988) study. These quantities were based on the latest information available for each category, but the ARCM (the cost model), on the other hand, uses the 1985 quantity for each product category and applies appropriate growth rates to arrive at the correct quantity information in the years after 1985, provided such information was available. In order to make the inputs to the cost and benefit models consistent, the numbers reported in the previous sections are adjusted as described in this section.

The set of exposure information in the ICF (1988) study (also referred to as the AEA in the tables) was "adjusted" by the ratio of the actual 1985 quantity to the quantity used in the ICF study because the ICF study had used the latest available quantity information. This allows the ARCM to generate its baseline from 1985 to 2000 taking into account plant closings and other post-1985 information and thereby reduce the associated exposures/populations appropriately.

The exposure assessment quantity information is listed by exposure setting, e.g., primary manufacturing, installation, etc. Cases in which the ICF study's quantity or exposure information have been revised are noted by footnotes which provide explanations for each change. Table A.4-6 shows the "adjustment" factors for the relevant exposure settings, Tables A.4-7 and A.4-8 show the "adjusted" population (number of people exposed) or the exposure level (million fibers breathed per year) for occupational and nonoccupational exposures respectively.[2]

[2] The "Use of Products" category has only nonoccupational exposure data for products 18, 19, and 21. These data were based on Versar's report and remain unchanged.

Table A.4-5. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Repair/Disposal of Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	263	296	171,136,373	0.0000067
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet	20	2,080	171,136,373	0.0000057
16. A/C Corrugated Sheet	9	2,080	171,136,373	0.0000025
17. A/C Shingles	164	244	171,136,373	0.0000049
18. Drum Brake Linings	75,404	376	183,793,774	0.0113
19. Disc Brake Pads, LMV	39,441	386	179,442,394	0.00767
20. Disc Brake Pads, HV	117	390	170,871,494	0.000000587
21. Brake Blocks	3,865	388	170,871,494	0.0000169
22. Clutch Facings	100	125		
23. Auto. Transmiss. Comp.				
24. Friction Materials	57	120		
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Mining and Milling				

Table A.4-6. Adjustment Factors for Exposed Populations and Exposure Levels

	Product Category	Units	Primary Quantity used in AEA	Secondary Quantity used in AEA	Installation Quantity used in AEA	Repair & Disp. Quantity used in AEA	Domestic 1985 Quantity (Primary)	Consumption Production Ratio	Total 1985 Quantity (incl. imports)	Total 1985 Quantity (Secondary)	Primary Adjustment Factor	Secondary Adjustment Factor	Installation Adjustment Factor	Rep. & Disp. Adjustment Factor
1.	Commercial Paper	Tons	0	0.0	0.0	0.0	0	n/a	0.0	0.0	n/a	n/a	n/a	n/a
2.	Rollboard	Tons	0	0.0	0.0	0.0	0	n/a	0.0	0.0	n/a	n/a	n/a	n/a
3.	Millboard	Tons	581	157.3	581.0	581.0	581	1.0050	583.9	157.3	1.0000	1.0000	1.0050	1.0050
4.	Pipeline Wrap	Squares	296,949 a/	0.0	296,949.0	296,949.0	296,949	2.5000	742,372.5	0.0	1.0000	n/a	2.5000	2.5000
5.	Beater-add Gaskets	Tons	15,940 b/	4,869.6	16,505.0	16,505.0	16,505	1.0200	16,835.1	4,991.9	1.0354	1.0251	1.0200	1.0200
6.	High-grade Electrical Paper	Tons	698	17.6	698.0	698.0	698	1.0000	698.0	0.7	1.0000	g/	1.0000	1.0000
7.	Roofing Felt	Tons	0	0.0	283,200.0	283,200.0	0	Imports Only	283,200.0	0.0	n/a	n/a	1.0000	1.0000
8.	Acetylene Cylinders	Pieces	308,121	0.0	n/a	n/a	392,121	1.0000	392,121.0	0.0	1.2726	n/a	n/a	n/a
9.	Flooring Felt	Tons	0	0.0	0.0	0.0	0	n/a	0.0	0.0	n/a	n/a	n/a	n/a
10.	Corrugated Paper	Tons	0	0.0	0.0	0.0	0	n/a	0.0	0.0	n/a	n/a	n/a	n/a
11.	Specialty Papers	Tons	434	587.0	434.0	434.0	434	1.0000	434.0	604.6	1.0000	1.0300	1.0000	1.0000
12.	Vinyl-Asbestos Floor Tile	Sq. Yards	0	0.0	0.0	0.0	18,300,000	1.0000	18,300,000.0	0.0	n/a	n/a	n/a	n/a
13.	Asbestos Diaphragms	Pieces	9,770 c/	0.0	n/a	n/a	9,770	1.0000	9,770.0	0.0	1.0000	n/a	n/a	n/a
14.	Asbestos-Cement Pipe	Feet	15,062,708 d/	0.0	15,062,708.0	15,062,708.0	15,062,708	1.0128	15,255,510.7	0.0	1.0000	n/a	1.0128	1.0128
15.	Flat A-C Sheets	Squares	5,165	0.0	8,560.7	8,560.7	22,621	1.1500	26,014.1	4,680.7	4.3797	n/a	3.0388	3.0388
16.	Corrugated A-C Sheets	Squares	0	0.0	3,859.0	3,859.0	0	Imports Only	3,859.0	0.0	n/a	n/a	1.0000	1.0000
17.	A-C Shingles	Squares	176,643	0.0	176,643.0	176,643.0	176,643	1.3700	242,000.9	0.0	1.0000	n/a	1.3700	1.3700
18.	Drum Brake Linings (LMV)	Pieces	91,922,402	e/	n/a	136,045,000.0	129,042,578	1.1500	148,398,964.7	d/	1.4038	e/	n/a	1.0908
19.	Disc Brake Pads (LMV)	Pieces	58,633,468	e/	n/a	96,273,000.0	65,869,172	1.1900	78,384,314.7	d/	1.1234	e/	n/a	0.8142
20.	Disc Brake Pads (HV)	Pieces	146,856	e/	n/a	156,820.0	156,820	1.0000	156,820.0	d/	1.0678	e/	n/a	1.0000
21.	Brake Blocks	Pieces	3,752,694	e/	n/a	4,570,266.0	4,570,266	1.0100	4,615,968.7	d/	1.2179	e/	n/a	1.0100
22.	Clutch Facings	Pieces	7,237,112	e/	n/a	n/a	7,237,112	1.1200	8,105,565.4	d/	1.0000	e/	n/a	n/a
23.	Automatic Transmission Components	Pieces	55,500	e/	n/a	n/a	585,500	1.0000	585,500.0	d/	10.5495	e/	n/a	n/a
24.	Friction Materials	Pieces	8,521,435	e/	n/a	n/a	8,719,541	1.0000	8,719,541.0	d/	1.0232	e/	n/a	n/a
25.	Asbestos Protective Clothing	Tons	0	0.0	0.0	0.0	0	n/a	0.0	0.0	n/a	n/a	n/a	n/a
26.	Asbestos Thread, Yarn, etc.	Tons	1,125	485.3	n/a	n/a	1,125	1.5110	1,699.9	485.3	1.0000	1.0000	n/a	n/a
27.	Asbestos Sheet Gasketing	Sq. Yards	3,519,568	841,427.6	3,607,408.0	3,607,408.0	3,607,408	1.0700	3,859,926.6	847,730.1	1.0250	1.0075	1.0700	1.0700
28.	Asbestos Packing	Tons	1 f/	1.1	3.0	3.0	3	1.0000	3.0	1.1	3.0000	1.0000	1.0000	1.0000
29.	Roof Coatings and Cements	Gallons	57,203,934	0.0	n/a	n/a	75,977,365	1.0000	75,977,365.0	0.0	1.3282	n/a	n/a	n/a
30.	Non-Roofing Coatings, etc.	Gallons	8,123,784	0.0	9,612,655.0	n/a	9,612,655	1.0000	9,612,655.0	0.0	1.1833	n/a	1.0000	n/a
31.	Asbestos-Reinforced Plastics	Tons	4,250	135.1	n/a	n/a	4,835	1.0300	4,980.1	156.7	1.1376	1.1599	n/a	n/a
32.	Missile Liner	Tons	4,667	0.0	4,667.0	n/a	4,667	1.0000	4,667.0	0.0	1.0000	n/a	1.0000	n/a
33.	Sealant Tape	Feet	423,048,539	0.0	n/a	n/a	423,048,539	1.0000	423,048,539.0	0.0	1.0000	n/a	n/a	n/a
34.	Battery Separators	Pounds	2,046	0.0	n/a	n/a	2,046	1.0000	2,046.0	0.0	1.0000	n/a	n/a	n/a
35.	Arc Chutes	Pieces	900	0.0	n/a	n/a	900	1.0000	900.0	0.0	1.0000	n/a	n/a	n/a

a/ The AEA reported 276,949 tons but population was actually based on 296,949 tons.

b/ 16,505 tons are reported in the AEA, but only 15,940 were used to estimate population in the AEA.

c/ The AEA calculated the exposed population based on a chlorine capacity (using asbestos diaphragms) of 9,295,000 metric tons in 1985. Since the ARCM uses production volumes, the utilization rate of 77% is used to calculate the actual production of chlorine in 1985. However, this does not affect the existing exposed population. (See text for explanation.)

d/ The 216,903 tons used in the AEA were converted using a conversion factor of .0144 tons/foot.

e/ Population exposed due to secondary manufacturing is calculated by applying the primary population correction factor to the existing secondary populations. (See text for explanation.)

f/ Exposed population for Asbestos Packings was recalculated entirely -- the existing exposed population associated with the output of 1 ton in primary manufacturing is 3 for occupational and 3,601,492 for nonoccupational.

g/ Production declines as some companies were reclassified as producers of Specialty Papers. However, population still increases from 20 to 30 because the companies included now had stopped processing asbestos after 1985.

Table A.4-7. Adjusted Exposed Populations (Occupational)

Product Category	Primary Population		Secondary Population		Installation Population		Repair & Disposal Population	
	Existing	Adjusted	Existing	Adjusted	Existing	Adjusted	Existing	Adjusted
1. Commercial Paper								
2. Rollboard								
3. Millboard	12	12	448	448				
4. Pipeline Wrap	35	35 a/						
5. Beater-add Gaskets	227	235	1,264	1,296				
6. High-grade Electrical Paper	27	27	20	30 e/				
7. Roofing Felt					396	396	263	263
8. Acetylene Cylinders	162	206						
9. Flooring Felt								
10. Corrugated Paper								
11. Specialty Papers	2	2 b/	145	149				
12. Vinyl-Asbestos Floor Tile								
13. Asbestos Diaphragms	650	650						
14. Asbestos-Cement Pipe	286	286			921	933		
15. Flat A-C Sheets	12	53			16	49	20	61
16. Corrugated A-C Sheets					7	7	9	9
17. A-C Shingles	11	11			236	323	164	225
18. Drum Brake Linings (LMV)	1,115	1,565	1,937	2,719 f/			75,404	86,398 g/
19. Disc Brake Pads (LMV)	815	916	267	300 f/			39,441	32,568 g/
20. Disc Brake Pads (HV)	14	15					117	117 g/
21. Brake Blocks	232	283	16	19 f/			3,865	3,935 g/
22. Clutch Facings	239	239	48	48 f/			100	73 g/
23. Automatic Transmission Components	1	11						
24. Friction Materials	187	191	27	28 f/			57	43 g/
25. Asbestos Protective Clothing								
26. Asbestos Thread, Yarn, etc.	78	78	208	208				
27. Asbestos Sheet Gasketing	163	167	878	885				
28. Asbestos Packing	3	9 c/	25	25				
29. Roof Coatings and Cements	438	582						
30. Non-Roofing Coatings, etc.	467	553 d/						
31. Asbestos-Reinforced Plastics	138	157	456	529				
32. Missile Liner	380	380						
33. Sealant Tape	134	134						
34. Battery Separators	207	207						
35. Arc Chutes	2	2						

a/ Revision of calculation of existing exposed population in the AEA -- population should be 35 instead of 27.

b/ Revision of calculation of existing exposed population in the AEA (revised Product Asbestos Coefficient used) -- population should be 2 instead of 6.

c/ Exposed population for Asbestos Packings was recalculated entirely -- the existing exposed population associated with the output of 1 ton is 3.

d/ Revision of calculation of existing exposed population in the AEA -- should be 467 instead of 497.

e/ Production declines as some companies were reclassified as producers of Specialty Papers. However, population still increases from 20 to 30 because the companies included now had stopped processing asbestos after 1985.

f/ Population exposed due to secondary manufacturing is calculated by applying the primary population correction factor to the existing secondary populations. (See text for explanation.)

g/ Rebuilding is included in repair and disposal for existing and corrected populations.

Table A.4-8. Adjusted Exposed Populations and Exposures (Nonoccupational) a/

Product Category	Primary Population		Secondary Population		Installation Exposure		Repair & Disposal Exposure	
	Existing	Adjusted	Existing	Adjusted	Existing	Adjusted	Existing	Adjusted
1. Commercial Paper								
2. Rollboard								
3. Millboard	5,747,875	5,747,875						
4. Pipeline Wrap	4,847,937	4,847,937						
5. Beater-add Gaskets	35,897,272	37,082,888 b/						
6. High-grade Electrical Paper	254,772	254,772						
7. Roofing Felt					0.000018	0.000018	0.0000067	0.0000067
8. Acetylene Cylinders								
9. Flooring Felt								
10. Corrugated Paper								
11. Specialty Papers								
12. Vinyl-Asbestos Floor Tile								
13. Asbestos Diaphragms	19,744,593	19,744,593						
14. Asbestos-Cement Pipe	3,313,602	3,313,602			0.0000261	0.0000264		
15. Flat A-C Sheets	4,847,937	21,232,368			0.00000098	0.00000298	0.0000057	0.0000173
16. Corrugated A-C Sheets					0.00000043	0.00000043	0.0000025	0.0000025
17. A-C Shingles	891,143	891,143			0.0000038	0.0000052	0.0000049	0.0000067
18. Drum Brake Linings (LMV)	24,605,781	34,542,107					0.0113	0.0123
19. Disc Brake Pads (LMV)	21,421,488	24,065,022					0.00767	0.00624
20. Disc Brake Pads (HV)	1,596,558	1,704,883					0.000000587	0.000000587
21. Brake Blocks	8,034,916	9,785,424					0.0000169	0.0000171
22. Clutch Facings	8,761,571	8,761,571						
23. Automatic Transmission Components								
24. Friction Materials	12,628,656	12,922,247						
25. Asbestos Protective Clothing								
26. Asbestos Thread, Yarn, etc.	16,306,866	16,306,866						
27. Asbestos Sheet Gasketing	42,550,071	43,468,616 b/						
28. Asbestos Packing	3,601,492	7,031,484 b/ c/						
29. Roof Coatings and Cements	63,673,717	84,570,429			1.04	1.04 d/		
30. Non-Roofing Coatings, etc.	59,487,018	70,389,388						
31. Asbestos-Reinforced Plastics	17,504,019	19,925,386 b/						
32. Missile Liner								
33. Sealant Tape								
34. Battery Separators								
35. Arc Chutes								

a/ All exposures are million fibers breathed per year.

b/ The correction factor used is for this population is the sum of the actual 1985 primary and secondary quantities divided by the sum of the primary and secondary quantities reported in the AEA. This is done because the existing primary population includes the existing secondary population.

c/ Exposed population for Asbestos Packings were recalculated entirely -- the existing exposed population associated with the output of 1 ton is 3,601,492.

d/ Based on Versar's estimates (Nonoccupational Exposures, June 17, 1987).

The major revisions to get the adjusted exposure input numbers are:

- Asbestos Diaphragms (13): The exposed population in the ICF (1988) study is calculated based on chlorine production capacity (using asbestos diaphragms) of 9,295,000 metric tons in 1985. Since the ARCM uses actual production volumes, the average capacity utilization rate of 77 percent (based on the Use and Substitutes Analysis, Appendix F) is used to calculate the volume of chlorine actually produced in 1985. However, the exposed population remains unchanged since the discrepancy resulted from two different methods for "indexing" the exposures, not underlying differences in exposure itself.

- Factors for Revising Exposure Data: The ratio of the relevant 1985 quantity, i.e., domestic production for primary manufacturing and the sum of domestic production and imports for the other categories,[3] was used to adjust the exposure data except as noted in footnotes to Tables A.4-6 through A.4-8. Furthermore, since the exposed nonoccupational population due to secondary manufacturing is included in the exposed nonoccupational population due to primary manufacturing, the adjustment factor used is the ratio of the sum of the 1985 primary and secondary quantities to the sum of the primary and secondary quantities used in the ICF study.

- Adjustments to Exposure Data (Population vs. Exposure): All the adjustment factors are applied to the ICF study's populations to get the adjusted exposure information. The exceptions to this are the adjustments to nonoccupational exposure data for installation and repair & disposal categories. The exposed populations for these two categories are assumed not to change since the exposures are not site-specific (unlike the other occupational and nonoccupational populations). Instead, the level of exposure, i.e., fibers per year, is assumed to change in relation to the change in quantity. Therefore, for these categories, it is the exposure levels that are adjusted.

- Adjustments for Imports: In most cases, the adjustment factor for exposure for installation and repair/disposal categories is the consumption-production ratio for the product because the ICF (1988) study did not typically count imports in calculating exposed populations or exposure levels in these categories. Instead these calculations were based on domestic production only.

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[3] The factors used for correcting exposure data associated with secondary manufacturing are based on the sum of domestic and imported mixtures processed by secondary processors. The exception to this are "friction products" (products 18-24), for which the primary manufacturing factor is used to correct the existing exposed populations. This is done because the ICF (1988) study used the ratio of primary processor quantities in 1985 and 1981 to calculate the 1985 populations associated with secondary manufacturing based on the relevant 1981 populations. The number of non-respondent secondary processors in 1985 for these products made it impractical to assess the exposed population directly.

Adjustment for Drum Brake Linings and Disc Brake Pads (LMV)

After the appropriate adjustments were made to the exposure data, in order to ensure consistency across the cost and benefits models, the data for drum brake linings and disc brake pads for light motor vehicles were further adjusted to distinguish between OEM and aftermarket use. The exposure data was adjusted as follows:

- The exposed populations for all exposure settings, except occupational repair and disposal, were split between OEM and aftermarket use based on the quantity split in 1985 as reported in the Use and Substitutes Analysis (Appendix F) -- 129,042,572 pieces of drum brake linings were split into 34,713,675 pieces for OEM use and 94,328,903 pieces for aftermarket use; 65,869,172 pieces of disc brake pads (LMV) were split into 10,077,464 for OEM use and 55,791,708 for aftermarket use. For example, occupational population exposed due to primary manufacturing of drum brake linings was estimated to be 1,565 persons and was split into 421 (1,565 * 34,713,675 / 129,042,572) for OEM use and 1,144 (1,565 * 94,328,903 / 129,042,572) for aftermarket use.

- The exposure levels were kept the same for both OEM and aftermarket use for all exposure settings, except occupational repair & disposal, since the populations were changed as described above.

- The total exposed occupational population due to repair & disposal of drum brake linings and disc brake pads (LMV) was attributed to aftermarket use.

Tables A.4-9 through A.4-13 show the actual inputs to the benefits model for the five exposure settings (primary manufacturing, secondary manufacturing, installation, use, and repair &disposal). The data for OEM and aftermarket use of drum brake linings appears as data for products 18 and 36 respectively, and as products 19 and 37 for the OEM and aftermarket use of disc brake pads (LMV).

Table A.4-9. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Primary Manufacturing Products for Occupational and Non-Occupational Settings

		Occupational		Nonoccupational	
		No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1.	Commercial Paper				
2.	Rollboard				
3.	Millboard	12	145	5,747,875	0.0232
4.	Pipeline Wrap	35	134	4,847,937	0.0476
5.	Beater-add Gaskets	235	110	37,082,888	0.0373
6.	High-grade Elect. Paper	27	113	254,772	0.405
7.	Roofing Felt				
8.	Acetylene Cylinders	206			
9.	Flooring Felt				
10.	Corrugated Paper				
11.	Specialty Paper	2	111		
12.	V/A Floor Tile				
13.	Diaphragms	650	87	19,744,593	0.00000185
14.	A/C Pipe	286	270	3,313,602	0.167
15.	A/C Flat Sheet	53	478	21,232,368	0.0218
16.	A/C Corrugated Sheet				
17.	A/C Shingles	11	473	891,143	0.00361
18.	Drum Brake Linings (OEM)	421	385	9,292,154	0.0575
19.	Disc Brake Pads, LMV (OEM)	140	390	3,681,659	0.0214
20.	Disc Brake Pads, HV	15	385	1,704,883	0.000000827
21.	Brake Blocks	283	377	9,785,424	0.00388
22.	Clutch Facings	239	406	8,761,571	0.0027
23.	Auto. Transmiss. Comp.	11	113		
24.	Friction Materials	191	398	12,922,247	0.00234
25.	Protective Clothing				
26.	Thread, yarn etc.	78	457	16,306,866	0.00214
27.	Sheet Gaskets	167	208	43,468,616	0.00561
28.	Asbestos Packings	9	198	7,031,484	0.0000534
29.	Roof Coatings	582	273	84,570,429	0.00233
30.	Non-Roofing Coatings	553	220	70,389,388	0.0000394
31.	Asb. Reinforced Plastics	157	164	19,925,386	0.0018
32.	Missile Liners	380	220		
33.	Sealant Tape	134	220		
34.	Battery Separators	207			
35.	Arc Chutes	2			
36.	Drum Brake Linings (A/M)	1,144	385	25,249,953	0.0575
37.	Disc Brake Pads, LMV (A/M)	776	390	20,383,263	0.0214
38.	Mining and Milling	155	121	841,214	0.407

Table A.4-10. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Secondary Manufacturing Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	448	57		
4. Pipeline Wrap				
5. Beater-add Gaskets	1,296	57		
6. High-grade Elect. Paper	30	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	149	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)	731	125		
19. Disc Brake Pads, LMV (OEM)	46	146		
20. Disc Brake Pads, HV				
21. Brake Blocks	19	127		
22. Clutch Facings	48	166		
23. Auto. Transmiss. Comp.				
24. Friction Materials	28	195		
25. Protective Clothing				
26. Thread, yarn etc.	208	408		
27. Sheet Gaskets	885	276		
28. Asbestos Packings	25	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics	529	239		
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	1,988	125		
37. Disc Brake Pads, LMV (A/M)	254	146		
38. Mining and Milling				

Table A.4-11. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Installation of Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	396	439	171,136,373	0.000018
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	933	296	171,136,373	0.0000264
15. A/C Flat Sheet	49	723	171,136,373	0.00000298
16. A/C Corrugated Sheet	7	723	171,136,373	0.00000043
17. A/C Shingles	323	130	171,136,373	0.00000052
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings			210,250	1.04
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Mining and Milling				

Table A.4-12. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Use of Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)			60,943,018	0.00058
19. Disc Brake Pads, LMV (OEM)			34,659,752	0.00064
20. Disc Brake Pads, HV				
21. Brake Blocks			226,546,000	0.0061
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)			165,602,982	0.00058
37. Disc Brake Pads, LMV (A/M)			191,886,248	0.00064
38. Mining and Milling				

Table A.4-13. Exposure Levels (in millions fibers inhaled per year) and Number of Persons Exposed to Repair/Disposal of Products for Occupational and Non-Occupational Settings

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	263	296	171,136,373	0.0000067
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet	61	2,080	171,136,373	0.0000173
16. A/C Corrugated Sheet	9	2,080	171,136,373	0.0000025
17. A/C Shingles	225	244	171,136,373	0.0000067
18. Drum Brake Linings (OEM)			49,442,265	0.0123
19. Disc Brake Pads, LMV (OEM)			27,453,272	0.00624
20. Disc Brake Pads, HV	117	390	170,871,494	0.000000587
21. Brake Blocks	3,985	388	170,871,494	0.0000171
22. Clutch Facings	73	125		
23. Auto. Transmiss. Comp.				
24. Friction Materials	43	120		
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	86,398	378	134,351,509	0.0123
37. Disc Brake Pads, LMV (A/M)	32,568	386	151,989,122	0.00624
38. Mining and Milling				

B. BENEFITS MODEL CALCULATION METHOD OVERVIEW

To estimate the adverse health effects from exposure to asbestos in the baseline and under the regulatory alternatives, the population at risk is divided into ten homogeneous exposure categories for each product and into nine age cohorts. The ten exposure categories are:

- Primary manufacturing, both occupational and nonoccupational
- Secondary manufacturing, both occupational and nonoccupational
- Installation, both occupational and nonoccupational
- Use, both occupational and nonoccupational
- Disposal or repair, both occupational and nonoccupational

The nine age groups are ten year groups from birth to age 90. Within each group, all persons are assumed to have an age equal to the mid-point of the group.

Next, the health effects attributable to the first year of product manufacture for one member of each age and exposure subgroup, both in the baseline and with the regulatory alternative, are estimated using an adaptation of the life table model described in Eddy (1980). The method used is described below and the computer model included as Appendix A-5.

The health effects model is a non-stationary Markov process containing 5 states in which an individual might reside during a given 5-year time period. These states are:

1. Alive, with no known excess lung cancer or mesothelioma or gastrointestinal cancer;

2. Dead from excess lung cancer;

3. Dead from excess gastrointestinal cancer;

4. Dead from excess mesothelioma; and

5. Dead from all other causes.

It is assumed that in the first year of exposure an individual has a probability of 1 of being in State 1 and at age 90 a probability of 1 of being dead, that is, in States 2 through 5. A "transition matrix" for each five year period is used to calculate the probabilities that an individual will enter or leave each of the possible states between the first year of exposure and age 90. The transition matrix can be written as:

$$\begin{bmatrix} P11 & P12 & P13 & P14 & P15 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

States 2 through 5 are "trapping states", in the sense that they are terminal states for an individual. The transition probabilities in the first row of the matrix are derived as follows:

P11 = 1 - (DLC + DGC + DM + DOC)
P12 = DLC
P13 = DGC
P14 = DM
P15 = DOC

where

DLC = five-year excess death rate from lung cancer attributable to first year of exposure to asbestos

DGC = five-year excess death rate from gastrointestinal cancer attributable to first year of exposure to asbestos

DM = five-year excess death rate from mesothelioma attributable to first year of exposure to asbestos

DOC = five-year death rate from all other causes

Thus, the model calculates the total expected health effects for an individual from each population age and exposure subgroup due to the first year of exposure to asbestos products manufactured in the first year of the analysis by five-year periods, starting at the individual's age at time of exposure until age 90. The model specifically performs the following operations:

1. Calculates the appropriate transition probabilities;

2. Multiplies the initial state vector by this matrix of probabilities to obtain a new state vector;

3. Records the probability of an individual's dying from asbestos-induced lung cancer, gastrointestinal cancer or mesothelioma from changes in the probability of being in states 2, 3, and 4 between the initial and new state vectors;

4. Records the product of the age at death and probability of dying during the period for the three asbestos-related cancers and all other causes;

5. Replaces the initial state vector with the new state vector.

A different transition matrix for each time period for each population subgroup for each product is needed to determine the health effects of asbestos exposure. To compute these transition matrices, the following inputs are required:

1. Age-specific five-year death rates for lung cancer attributable to asbestos exposure in the given year;

2. Age-specific five-year death rates for gastrointestinal cancer attributable to asbestos exposure in the given year;

3. Age-specific five-year death rates for mesothelioma attributable to asbestos exposure in the given year;

4. Age-specific five-year death rates due to all other causes.

The assumption is made that mesothelioma death rates do not depend on age, sex, race, or smoking habits. However, excess lung cancer and gastrointestinal cancer death rates and other mortality rates do vary according to these demographic characteristics. For simplicity, it is assumed that the nonoccupational population is identical to the U.S. population in terms of sex, race, and smoking habits, and age distribution (see Table A.4-14). All occupational categories are assumed to have the same demographic characteristics, and these are estimated from industry data (see Table A.4-14). Smoking habits are assumed to be the same as in the general population.

In this analysis, the linear, no-threshold dose-response relationships proposed by Nicholson (1983) are used to convert information on asbestos exposure levels into excess lung cancer and mesothelioma death rates for each time period. As suggested by Nicholson (1983), the excess death rates from gastrointestinal cancer are assumed to be equal to 10 percent of those for lung cancer for each time period.

For lung cancer, Nicholson postulates a relative risk model that includes a minimum 10-year latency period between onset of exposure and increased risk of death from cancer:

$$I_L = I_E * [1 + K_L * f * d_{(t-10)}] \text{ for } t > 10$$

$$I_L = I_E \quad \text{for } t <= 10$$

where

I_L = age-specific lung cancer death rate with exposure to asbestos

I_E = age-specific lung cancer death rate without exposure to asbestos

t = time from onset of exposure until current age (years)

$d_{(t-10)}$ = duration of exposure from onset until 10 years (latency period) before current age (years)

f = intensity of exposure (f/cc)

K_L = dose-response constant

$I_L - I_E$ = absolute excess lung cancer death rates due to asbestos exposure.

Table A.4-14. Sex, Race, and Age Distribution of Exposed Populations

Characteristic	Proportion of Population (Decimal Share) Occupational	Nonoccupational
Year	1983	1980
<u>Sex</u>		
Male	0.79	0.49
Female	0.21	0.51
<u>Race</u>		
White	0.88	0.88
Nonwhite	0.12	0.12
<u>Age</u>		
0 - 9	0.0	0.146
10 - 19	0.1	0.174
20 - 29	0.205	0.176
30 - 39	0.210	0.139
40 - 49	0.193	0.108
50 - 59	0.175	0.099
60 - 69	0.117	0.083
70 - 79	0.0	0.055
80 - 89	0.0	0.020

Sources: For occupational: Research Triangle Institute 1985 (August). Regulatory Impact Analysis of Controls on Asbestos and Asbestos Products. Prepared for the Office of Pesticides and Toxic Substances, U.S. EPA. Washington, D.C. Appendix B. For nonoccupational: UDOC. 1980. U.S. Department of the Census. Statistical Abstract of the United States. Washington D.C.: Bureau of the Census.

For mesothelioma, Nicholson postulates an absolute risk model:

$$I_M = K_M * f * [(t-10)^3 - (t-10-d)^3] \qquad \text{for } t > 10+d$$

$$I_M = K_M * f * (t-10)^3 \qquad \text{for } 10 + d >= t > 10+d$$

$$I_M = 0 \qquad \text{for } t <= 10$$

where

t = time since first exposure (years)

d = total duration of exposure (years)

f = level of exposure (f/cc)

K_M = dose-response constant

The dose-response constants, estimated using data from human studies of asbestos-related diseases, vary in magnitude considerably as shown in Table A.4-15. The values for the dose-response constants used in this analysis are the mean values proposed by the CPSC (1983) of 1.0E-2 $(\text{f-yr/cc})^{-1}$ for lung cancer and 1.08E-8 $(\text{f-yr/cc})^{-1}$ for mesothelioma.

The unit measure for exposure level in Nicholson's equations is fibers per cubic centimeter (f/cc). His equations were developed from studies that used disease data from occupationally exposed workers with a typical exposure of 8 hours per day, 250 days per year and a breathing rate of 1.3 cu m/hour. For a worker so exposed, an exposure level of 1 f/cc is equivalent to 2,600 million fibers breathed per year (1 x 1,000,000 x 1.3 x 8 x 250). To use Nicholson dose-response relationships for all different exposure categories where exposure levels, breathing rates and hours exposed per year may all be different than those for a full time worker, the exposure levels derived from million fibers breathed per year, as outlined in the previous subsection. The million fibers breathed per year were then divided by a normalizing factor of 2,600 to convert these exposure levels into Nicholson's full-time-equivalent worker exposure level measured as f/cc before use in the dose-response relationships presented above.

In order to compute the age-specific five-year excess death rates from lung cancer attributable to a single year of exposure the following inputs are used in Nicholson's lung cancer dose-response equation described above:

(a) Asbestos exposure level in the given year, normalized to Nicholson's occupational exposure f/cc units;

(b) Age-specific five-year baseline lung cancer death rates; and

(c) Lung cancer dose response constant.

For all products and exposure categories, the exposure levels are assumed to remain constant at the levels presented in the exposure data tables (Tables A.4-9 through A.4-13). As indicated, the million fibers breathed per year exposure levels presented in these tables are divided by the normalizing

Table A.4-15. Estimated Values of Lung Cancer and Mesothelioma Dose-Response Constants

Mortality Study	Estimated Value Lung Cancer Constant $(f\text{-}yr/cc)^{-1}$	Estimated Value Mesothelioma Constant $(f\text{-}yr/cc)^{-1}$
Finkelstein et al. 1983	4.8 E-2	1.2 E-7
Seidman et al. 1979, pp. 61-89	6.8 E-2	5.7 E-8
Dement et al. 1982	2.3-4.4 E-2	
Selikoff et al. 1979, pp. 569-585	1.0 E-2	1.5 E-8
Peto 1980, pp. 829-836	1.0 E-2	7.0 E-10
Henderson and Enterline 1979, pp. 117-126	3.3-5.0 E-3	
Hughes and Weill 1980, pp. 627-637	3.1 E-3	
Rubino et al. 1979	1.7 E-3	
Nicholson et al. 1979	1.2 E-3	
McDonald et al. 1980	6.0 E-4	
Berry and Newhouse 1983, pp. 1-7	6.0 E-4	

Source: Chronic Hazard Advisory Panel on Asbestos. 1983 (July). Report to the U.S. Consumer Product Safety Commission. Washington D.C. p. II-129.

factor of 2,600 to convert them to Nicholson's occupational exposure f/cc units. Age-specific five-year baseline lung cancer rates were taken from the Vital Statistics of the United States for 1977 (U.S. Department of Health and Human Services, 1981). A baseline lung cancer rate for the year 1990 is projected using the 1977 rates and inflating them for the older cohorts as suggested in Doll and Peto (1981). Increases of 2 percent per year for men over 50 and 4 percent per year for women over 40 are assumed. These increases are projected because of past increases in smoking. Since smoking rates have been declining in recent years, the projected 1990 lung cancer death rates are likely to overstate the baseline death rates that will be observed in the twenty-first century. Therefore, 1977 lung cancer rates have been used in this analysis. This assumption understates these rates in the beginning of the period of analysis, but is likely to overstate concentrates later in the period. The lung cancer dose response constant that is used in this analysis is 1.0 E-2 $(\text{f-yr/cc})^{-1}$, the mean value of those that are presented in Table A.4-15 as computed by the CPSC (1983).

In order to compute the five-year age-specific death rates from gastrointestinal cancer attributable to a single year of exposure, a ratio of excess gastrointestinal deaths to lung cancer deaths of 0.1 is assumed as suggested by Nicholson (1983).

In order to compute the five-year age-specific death rates from mesothelioma attributable to a single year of exposure, the following inputs are used in Nicholson's mesothelioma dose-response equation described above:

(a) Asbestos exposure level in the given year, normalized to Nicholson's occupational exposure f/cc units;

(b) Time since year of exposure; and

(c) Mesothelioma dose-response constant.

For all products and exposure categories, the exposure levels are assumed to remain constant at the levels presented in Tables A.4-9 through A.4-13. As indicated, the million fibers breathed per year exposure levels presented in these tables are divided by a normalizing factor of 2,600 to convert them to Nicholson's occupational exposure f/cc units. For each five-year period, the time since exposure is assumed to be equal to the time from exposure to the mid-point of the period. The mesothelioma dose-response constant used is 1.0 E-8 $(\text{f-yr/cc})^{-1}$, which is the mean value of those presented in Table A.4-15 as computed by the CPSC (1983).

Five-year death rates for all causes by sex, race, and age are estimated based on the 1978 U.S. life tables and are assumed to remain constant in the future (Cooper et al. 1983). All persons alive at age 89 are assumed to die during their ninetieth year.

Finally, in order to estimate the avoided cases of cancer from the estimates of avoided cancer deaths, the cure rates for the three asbestos-related cancers are estimated from the equation:

$$(\text{Relative survival rate at time } t) = c + (1-c)\,(1-b)^{t}$$

where:

c = cancer cure rate (the proportion of people with the disease for whom it is no longer life threatening);

b = annual mortality rate for dying patients; and

t = time since diagnosis (years).

Estimated values for both "c" and "b" are obtained using publicly available data on survival for lung cancer, gastrointestinal cancer (Axtell et al. 1986) and mesothelioma (Chahinian 1982). The values of the cure rates estimated and used in the analysis are 8 percent for lung cancer, 36 percent for gastrointestinal cancer[4], and 2 percent for mesothelioma.

The health effects model tracks an individual for each age and exposure subgroup starting from a single year of exposure, by five year periods, until age 90, at which point the probability of being alive is assumed to zero. For each five-year period the probability of dying of asbestos-related cancers is estimated as the product of the probability of being alive in that time period and the probability of dying from an asbestos-related cancer if alive. The probability of being alive during any five year time period decreases with age. The probabilities of dying from asbestos-related cancers if alive are estimated using the Nicholson dose-response relationships and the exposure data. These probabilities increase with time elapsed since the initiation of exposure as follows.

The dose-response relationships assume a minimum ten-year latency period between exposure and excess cancer risks. Thus, the probability of dying from an asbestos -related cancer will be zero for the first two five year periods after exposure. After ten years, the probability of dying of an asbestos-related cancer increases with time since onset of exposure. In the case of mesothelioma, the absolute risk model generates death rates that increase with time since exposure. In the case of lung cancer (and gastrointestinal cancer which is estimated as 10 percent of the lung cancer rate) the excess risks remain constant over time relative to the baseline lung cancer death rates. However, the baseline lung cancer death rates increase with age and, therefore, the probability of excess lung cancer or gastrointestinal cancer increases with age or time since onset of exposure. Thus, for each age cohort, the probabilities of dying from asbestos-related cancers attributable to a single year of exposure increase with time since the onset of exposure except at the older ages where competing causes of death reduce the probability of observing deaths from asbestos-related cancers.

The probabilities of observing deaths from asbestos-related cancers in each five year time period for an individual from each age-exposure subgroup are multiplied by the number of people in the population subgroup to generate estimates of the expected asbestos-related cancers in the subgroup attributable to the single year of exposure. These estimates follow the same time distribution relative to exposure as the individual probabilities -- no

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[4] The 36 percent cure rate for gastrointestinal cancer is the cure rate for colorectal cancer. Cure rates for other gastrointestinal cancers may differ from this rate.

cases for ten years followed by an increasing an then decreasing number with age.

Estimates of deaths from asbestos-related cancers are generated for exposures both with and without the regulations and the differences in asbestos-related cancers computed for each five year period. These differences, avoided cancers, are the estimate health benefits for the regulation. When these avoided cancers are aggregated across age-cohorts, their resultant time distribution ranges from 10 to 80 years with most cases occurring 35 to 60 years after exposure.

The results for each population age-exposure subgroup for each product are added for each five-year time period after the start of the analysis to determine, for each product, the total avoided cancer deaths during each time period attributable to the regulatory alternative. In doing this aggregation it is assumed that the avoided cancer deaths are distributed uniformly throughout each five-year period. Furthermore, the aggregation of the avoided cancer deaths estimated for different exposure categories has to take into account the timing of exposures.

Exposures from releases during product installation are assumed to be contemporaneous with those from primary and secondary product manufacturing. Exposures from repair or disposal are assumed to occur at the end of the average product life. Exposures during product use are assumed to be evenly distributed across the time from product manufacture to repair or disposal. The estimated avoided cancer deaths for the repair/disposal category are shifted forward in time by a number of years equal to the average product life before being added to the estimates for primary and secondary manufacturing and installation. The estimated avoided cancer deaths for one year of exposure in the use exposure category are assumed to be replicated for each year of use of the product, shifted forward in time one year at a time from the time of manufacture. Thus estimates are obtained for the number of avoided deaths from lung cancer, gastrointestinal cancer, and mesothelioma attributable to the regulation's impact on each product's manufacture in the first year of the analysis.

After the avoided cancer deaths attributable to asbestos releases from products manufactured during the first year of the analysis have been estimated, the avoided cancer deaths for products manufactured all subsequent years of the analysis are estimated by multiplying the first year estimates by the ratio of the level of production in the subsequent year compared to that in the first year. The ratio of future to current production varies according to general trends in the industry baselines as well as according to features of the regulatory alternatives.

The total number of avoided cancer deaths attributable to the regulations impact on asbestos products manufactured 1987-2000 for each product for each five-year period after the start of the analysis are then calculated by aggregating the deaths avoided associated with each year of manufacture. The timing of the cases is preserved by assuming that the deaths in any five-year period are uniformly distributed, and by shifting the estimated avoided deaths for any given year of manufacture forward in time by the number of years from the beginning of the analysis. Finally, the total numbers of avoided excess cancer cases for each five year period are estimated by dividing the estimated numbers of cancer deaths by the death rates for each type of cancer.

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A.5 HEALTH EFFECTS COMPUTER MODEL

This appendix presents the computer model developed for estimating the health effects associated with exposure to asbestos in both the baseline and under the various regulatory alternatives.

DESCRIPTION OF BENEFITS PROGRAM

MAIN PROGRAM -- IN AMB.FOR

1. Characterizes variables as real, integer, charter, and common, specifies their dimensions, and creates some double precision variables.

2. Reads in values for dose-response constants by product at default values $K_L = 0.01$, $K_m = 1.0 \times 10^{-8}$ for all products.

3. Sets starting age and age interval for age groups.

4. Reads in population weights by age, sex, race, for occupational, nonoccupational, and school plus occupational groups (mixed).

5. Prompts user for name of baseline index file.

6. Prompts user for name of alternative index file.

7. Opens baseline and alternative index files.

8. Prompts user for routing of output to disc file or printer. If user chooses disc file, prompts user for file name and opens output file. Cautions user if output file already exists and allows user to choose another name or to overwrite the existing file.

9. Reads in number of years for analysis (from 1-20 years) and identifies starting and ending year.

10. Reads in average lifetime for each product rounded to the nearest integer (to 1 if average lifetime is less than 1).

11. Prompts user for Exposure Categories to be estimated.

12. Prompts user for Products to be estimated.

13. Prompts user for dose-response constants to be used.

14. Prompts user for year of baseline lung-cancer deaths to be assumed, 1977 or 1990.

15. Prompts user for proportion of excess lung-cancer death rate assumed for GI cancer.

16. Prompts user for number of discount rates (1-10) and their values.

17. Prompts user to specify exposure data file, including drive specifier and name.

18. Reminds user of name of output file and asks user to wait for program terminated message.

19. CALL INTAB -- Subroutine to compose and write to the output file 4 tables containing the values for the inputs used in the analysis.

20. Reads in exposure levels in units of millions of fibers breathed per year and number of people exposed from user-specified CBI disc.

21. Initializes variables that accumulate cases, deaths, and people exposed, by product and in total, with and without the new regulations to zero (RRR, TOT1, PPP).

22. Initializes index variables to zero (BPROJ, PROJ).

23. START BAN/NO BAN Loop (2) (or New Regulation/Status Quo).

24. Initializes transition matrix to zero.

25. Initializes life-years variable (EXP1).

26. CALL DAREAD -- Subroutine to calculate from 1985 input data, number of people exposed and level of exposure for the first year of the analysis for each exposure category for each product, using new regulation or status quo production-level indexes.

27. STARTS PRODUCT Loop (36 or lower number chosen by user).

28. Initializes, for each product, single and multiple-year collecting variables, multiple-year life-years variable, average age variable, and population variable (R, RR, EX1, TA, SSI).

29. STARTS GROUP Loop for exposure categories (10 or lower number chosen by user).

30. Initializes, for each exposure category, single year collecting variable and single year life-years variable (T, E1).

31. If repair or disposal -- creates time shift variable for onset of exposure.

32. Skip to end of GROUP Loop if zero people exposed in the exposure category.

33. CALL INIT -- Subroutine to set number of people exposed, level of exposure in f/cc duration of exposure (1 year) for the product and exposure category.

34. Sets AGEMID to first Age, 5 years.

35. STARTS AGE GROUP Loop (9).

36. Sets appropriate population weight.

37. Initializes state vector to [1 0 0 0 0] for each age-group.

38. Calculates number of 5-year periods from age in 1990 to age 90 (N).

39. STARTS FIVE YEAR Loop (N).

40. Calculates age at midpoint of each 5 year period.

41. Calculates 5 year age period number (1-18) for each iteration of 5 Year Loop.

42. CALL INC -- Subroutine to calculate baseline lung cancer death rate for product, exposure, and 5 year age category -- using the 1977 and 1990 rates as specified by the user.

43. Calculates asbestos induced excess death rates for lung cancer.

44. Calculates asbestos induced excess death rates for mesothelioma.

45. CALL TRANSI -- Subroutine to calculate excess deaths from lung cancer, gastrointestinal cancer, and mesothelioma for each remaining 5 year period of lie for product, exposure, and age category for products manufactured during the first year of the analysis only.

46/ ENDS FIVE YEAR Loop.

47. Sets starting age for next age group.

48. ENDS AGE GROUP Loop.

49. CALL AG -- Subroutine to adjust estimates of excess deaths from lung, cancer, gastrointestinal cancer, and mesothelioma for the use exposure categories (4 and 9) where a given product may be used for multiple years.

50. ENDS GROUP (Exposure category) Loop.

51. CALL AGG -- Subroutine to convert estimates of excess deaths from lung cancer, gastrointestinal cancer, and mesothelioma for all exposure categories from first year product estimates to estimates for multiple years of production.

52. CALL PRNT -- Subroutine to compute excess cases from excess death estimates and to store both estimates for each product in variable RRR.

53. ENDS PRODUCT Loop.

54. CALL TOTAL -- Subroutine to write to output file estimated excess deaths and cases by five year period for all products with the new regulation and with the status quo.

55. ENDS BAN/NO BAN Loop.

56. CALL BANEFF -- Subroutine to write to output file differences between new regulation and status quo situation for each product separately and for all together. Discounted totals are also computed and presented.

57. STOP.

58. END.

Subroutine DAREAD -- in INDATA.FOR

1. Characterizes variables.

2. Reads in exposure level and population number data for 1985.

3. Reads in production projections indexes for 1987-2007 relative to 1985 by CALL FILE -- Subroutine to read in and write to output file production indexes in baseline regulation and alternative regulation situation.

4. For each product and exposure category, calculates the number of people exposed in first year of analysis by weighting 1985 population estimate by first index. Exposure level is assumed to remain constant at input level and duration of exposure is set at 1 year.

Subroutine INIT-- in INDATA.FOR

1. Characterizes variables.

2. Defines the three product and exposure category specific parameters: number of people, level of exposure, and duration of exposure, derived in DAREAD and used in the simulation.

3. Aggregates number of people exposed across exposure categories for each product.

4. Sets NO: 1 -- occupational; 2 -- nonoccupational; 3 -- school and occupational, mixed.

Subroutine INC -- in INDATA.FOR

1. Characterizes variables.

2. Calculates weighted average baseline lung cancer death rate for the 5 year period and population group (by exposure category and age) of interest using either 1977 or 1990 lung cancer death rates as required by the user. The race and sex weights vary according to whether the exposure is occupational or nonoccupational.

Subroutine TRANSI -- in CAL.FOR

1. Characterizes variables.

2. CALL LIFE -- Subroutine to calculate 5 year mortality rate for all other cases (weighted average by sex and race).

3. Calculates nonconstant elements of the transition matrix for the year and population group of interest.

4. Calculates new state vector.

5. CALL ACCUM -- Subroutine to collect cancer deaths for each 5 year period since first year of analysis.

6. Puts value of new state vector into old state vector.

Subroutine ACCUM -- in CALC.FOR

1. Characterizes variables.

2. Accumulates for each 5 year period and for each age deaths from four different causes, excess lung cancer, excess gastrointestinal cancer, excess mesothelioma, and all others.

3. Accumulates remaining life-years for exposed population for banned and unbanned products.

Subroutine LIFE -- in INDATA.FOR

1. Characterizes variables.

2. Calculates weighted average death rate for all other cases using 5-year death rates by sex and race. The race and sex weights vary according to whether the exposure is occupational or nonoccupational.

Subroutine PRNT -- in TABLES.FOR

1. Characterizes variables.

2. For each product, computes and stores total cases and average age of death from lung cancer, gastrointestinal cancer, and mesothelioma attributable to asbestos exposure.

Subroutine TOTAL -- in TABLES.FOR

1. Characterizes variables.

2. Totals and writes to output file deaths and cases of lung cancer, gastrointestinal cancer, and mesothelioma by 5 year period and for all periods for all products together for new regulation and status quo.

Subroutine BANEFF -- in TABLES.FOR

1. Characterizes variables.

2. Initializes difference variables for each product separately.

3. Computes differences for total deaths and cases by disease and product and writes them to the output file.

4. Initializes difference variables for all products together.

5. Computes differences in deaths, by disease and total, and total cases, by 5-year period with and without the new regulation for all products.

6. Calculates the total differences in deaths, by disease and total, and total cases, with and without the new regulation for all products, at 0 discount rate and up to ten other discount rates.

7. Writes to output file results of regulation effects calculations for all products.

Subroutine FILE -- in FILE.FOR

1. Characterizes variables.

2. Reads in products projection indexes, 1987-2007, relative to 1985 from base and alternative files named by the user.

3. Writes the index files to the output file.

4. Creates PROJ for no ban indexes and BPROJ for either ban or no ban indexes depending on IB = 1 or 2 respectively, (BAN/NO BAN Loop).

Subroutine AG -- in CALC.FOR

1. Characterizes variables.

2. For use exposure categories only (4 and 9) converts total excess cancer deaths for 1 year use of product to excess deaths from use of the product for the average product lifetime, adjusting timing of excess deaths for each year after first year of analysis to reflect time of exposure.

Subroutine AGG -- in CALC.FOR

1. Characterizes variables.

2. For all exposure categories, converts total excess cancer deaths for 1 year of production to excess deaths from multiple-year production by weighting the first year estimates by each subsequent year's production level index, and adding the estimates for all the years. Before adding the estimates for each year, the timing of excess deaths for each year after first year of analysis is adjusted to reflect time of exposure.

Subroutine INTAB -- in TABLES.FOR

1. Characterizes variables.

2. Writes to output file table listing files used in the analysis and time period of analysis.

3. Writes to output file exposure groups analyzed (CALL GR for Group list).

4. Writes to output file products analyzed (CALL PR for Product list), and their dose-response constants, year for baseline cancer, and GI to lung cancer ratios assumed.

5. Writes to output file table listing discount rates used.

Subroutine GR -- in TABLES.FOR

1. Characterizes variables.

2. Lists exposure group categories.

<u>Subroutine PR</u> -- in TABLES.FOR

1. Characterizes variables.

2. Lists product categories.

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C     INTERACTIVE BENEFITS MODEL FOR ASBESTOS RIA
C     WRITTEN BY JO MAUSKOPF - RESEARCH TRIANGLE INSTITUTE, NORTH
C     CAROLINA
C
C     TEL. (919) 541-6468
C
C     5/16/88
C
C
$LARGE
$NOFLOATCALLS
C
C
C
C
       COMMON/T/MANOP,MANOS,INSO,USEO,DISO,MANAP,MANAS,INSA,USEA,
      *DISA,PMANOP,PMANOS,PINSO,PUSEO,PDISO,PMANAP,PMANAS,PINSA,
      *PUSEA,PDISA
       REAL MANOP(38),MANOS(38),INSO(38),USEO(38),DISO(38),
      *MANAP(38),MANAS(38),INSA(38),USEA(38),DISA(38),PMANOP(38),
      *PMANOS(38),PINSO(38),PUSEO(38),PDISO(38),PMANAP(38),
      *PMANAS(38),PINSA(38),PUSEA(38),PDISA(38)
       DIMENSION POP(38,10),P(5,5),V(5),TOT1(2,28,4),
      *RMAX(38,10),RLEV(38,10), TA(18,4),PPP(2,38),
      * DISC(10),TT1(2,4),BPROJ(38,20),PROJ(38,20),RRR1(38,8,11),
      * R(28,4),RR(28,4),RRR2(38,8,11),TEM1(38,8,11),TEM2(38,8,11)
       REAL FKL(38),FKM(38),OWT(9,3),OSRWT(4,3)
       REAL AGE,DT,TT
       INTEGER LIFE(38),AGEST,AGEINT,NPN(38),A(38),B(10)
       INTEGER AGEMID,YEAR,IYRS
       REAL*8 PP,P,T,R,WT,V,TOT1,TT1,FDTM,FDTL,DISC,RR,
      *EXP1,EX1,E1,TA,RRR1,RRR2,PPP,TEM1,TEM2
       CHARACTER RES,PGBRK
       CHARACTER*25 FILE,FILE2,FILE3,FILE4,FILE7
       COMMON /A1/T(28,4)
       COMMON /01/ F,MAXDT,PP
        DATA FKL/.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,
      * .01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,
      *  .01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01/
       DATA FKM/.00000001,.00000001,.00000001,.00000001,
      * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
      * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
      * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
      * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
      * .00000001,.00000001,.00000001,.00000001,
      * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001/
       DATA AGEST/5/
       DATA AGEINT/10/
        DATA OWT/.0,.1,.205,.210,.193,.175,.117,.0,.0,
      * .146,.174,.176,.139,.108,.099,.083,.055,.020,
      * .06,.36,.17,.13,.11,.10,.07,.0,.0/
        DATA OSRWT/.695,.095,.185,.025,.431,.059,.449,.061,
      *  .431,.059,.449,.061/
C
       WRITE (*,'(24(/))')
       WRITE (*,*) 'THIS PROGRAM MODELS THE BENEFITS OF ASBESTOS'
       WRITE (*,*) 'PRODUCT REGULATIONS.'
       WRITE (*,*)
       WRITE (*,*) 'TO RUN THIS PROGRAM, FOLLOW THE USER FRIENDLY'
       WRITE (*,*) 'INSTRUCTIONS!'
       WRITE (*,'(8(/))')
       PAUSE 'Press the <RETURN> or the <ENTER> key to continue'
C
       WRITE (*,'(24(/))')
       WRITE (*,*) 'Please enter name of data file containing BASELINE'
       WRITE (*,*) 'indices.  (Include path if necessary.)'
       READ (*,'(A)') FILE3
       WRITE (*,'(///)')
       WRITE (*,*)'Please enter name of data file containing ALTERNATIVE'
       WRITE (*,*)'indices.  (Include path if necessary.)'
       READ (*,'(A)') FILE4
       WRITE (*,'(///)')
C
 6661  IERR3=0
       OPEN(1,IOSTAT=IERR3,FILE=FILE3,STATUS='OLD')
       IF (IERR3 .LE. 0) GO TO 6662
       WRITE (*,'(//)')
       WRITE (*,*) 'FILE ',FILE3,' NOT FOUND ON SPECIFIED PATH'
       WRITE (*,'(//)')
       WRITE (*,*) 'Please enter name of data file containing BASELINE'
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      WRITE (*,*) 'indices.  (Include path if necessary,)'
      READ (*,'(A)') FILE3
      WRITE (*,'(///)')
      GO TO 6661
6662  IERR4=0
      OPEN (2,IOSTAT=IERR4,FILE=FILE4,STATUS='OLD')
      IF (IERR4 .LE. 0) GO TO 146
      WRITE (*,'(//)')
      WRITE (*,*) 'FILE ',FILE4,' NOT FOUND ON SPECIFIED PATH'
      WRITE (*,'(//)')
      WRITE (*,*)'Please enter name of data file containing ALTERNATIVE'
      WRITE (*,*) 'indices.  (Include path if necessary,)'
      READ (*,'(A)') FILE4
      WRITE (*,'(///)')
C
 146  WRITE (*,*) 'Would you like the output to be routed to the'
      WRITE (*,*) 'printer or to a file on disk ?  Enter P or D'
      READ (*,'(A)') RES
      WRITE (*,*)
      IF ((RES .EQ. 'P') .OR. (RES .EQ. 'p')) THEN
        FILE2='LPT1'
        PGBRK='1'
        OPEN (3,FILE=FILE2)
      ELSEIF ((RES .EQ. 'D') .OR. (RES .EQ. 'd')) THEN
        PGBRK=''
        WRITE (*,*) 'Please enter desired name of OUTPUT file.'
        WRITE (*,*) '(Include path if necessary.)'
        READ (*,'(A)') FILE2
1927    IERR2=0
        OPEN (3,FILE=FILE2,IOSTAT=IERR2,STATUS='NEW')
        IF (IERR2 .LE. 0) GO TO 2929
        WRITE (*,*)
        WRITE (*,*) 'FILE ',FILE2,' ALREADY EXISTS!'
        WRITE (*,*)
1928    WRITE (*,*) 'Should file be overwritten (Y/N)?'
        READ (*,'(A)') RES
        IF ((RES .EQ. 'Y') .OR. (RES .EQ. 'y')) THEN
          OPEN (3,FILE=FILE2,STATUS='OLD')
          GO TO 2929
        ELSEIF ((RES .EQ. 'N') .OR. (RES .EQ. 'n')) THEN
          WRITE (*,*)
          WRITE (*,*) 'Enter new name of output file    --->'
          READ (*,'(A)') FILE2
          WRITE (*,*)
          GO TO 1927
        ELSE
          GO TO 1928
        ENDIF
      ELSE
        WRITE (*,*)
        WRITE (*,*) 'INVALID OPTION - PLEASE CHOOSE AGAIN'
        WRITE (*,*)
        GO TO 146
      ENDIF
C
2929    PRINT *
        WRITE (*,*) 'Please enter desired name of '//
     -              'cost-benefit TABLES'' DATA file.'
        WRITE (*,*) '(Include path if necessary.)'
        READ (*,'(A)') FILE7
2927    IERR7=0
        OPEN (7,FILE=FILE7,IOSTAT=IERR7,STATUS='NEW',FORM='UNFORMATTED')
        IF (IERR7 .LE. 0) GO TO 1929
        WRITE (*,*)
        WRITE (*,*) 'FILE ',FILE7,' ALREADY EXISTS!'
        WRITE (*,*)
2928    WRITE (*,*) 'Should file be overwritten (Y/N)?'
        READ (*,'(A)') RES
        IF ((RES .EQ. 'Y') .OR. (RES .EQ. 'y')) THEN
          OPEN (7,FILE=FILE7,STATUS='OLD',FORM='UNFORMATTED')
          GO TO 1929
        ELSEIF ((RES .EQ. 'N') .OR. (RES .EQ. 'n')) THEN
          WRITE (*,*)
          WRITE (*,*) 'Enter new name of output file    --->'
          READ (*,'(A)') FILE7
          WRITE (*,*)
          GO TO 2927
        ELSE
          GO TO 2928
        ENDIF
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C
1929  READ(1,743) IYRS,ISY,IEY
      READ(1,744) (LIFE(I),I=1,38)
      READ(2,743) IYY,ISS,IEE
 743  FORMAT(I2,2(5X,I4))
 744  FORMAT(38I3)
      WRITE (*,'(6(/))')
      WRITE (*,*) 'YOU WILL NOW SELECT THE POPULATION TO BE ANALYZED'
      WRITE (*,*) 'FOR THE PROJECTED HEALTH BENEFITS OF THE REGULATION.'
      WRITE (*,*) 'THE POPULATION CAN BE COMPOSED OF THE FOLLOWING'
      WRITE (*,*) 'TEN CATEGORIES:'
      WRITE (*,*)
      WRITE (*,*) '             0 - PRIMARY MANUFACTURING OCCUPATIONAL'
      WRITE (*,*) '             1 - SECONDARY MANUFACTURING OCCUPATIONAL'
      WRITE (*,*) '             2 - INSTALLATION OCCUPATIONAL'
      WRITE (*,*) '             3 - USE OCCUPATIONAL'
      WRITE (*,*) '             4 - REPAIR/DISPOSAL OCCUPATIONAL'
      WRITE (*,*) '             5 - PRIMARY MANUF. AMBIENT NON-OCCUP.'
      WRITE (*,*) '             6 - SECONDARY MANUF. AMBIENT NON-OCCUP.'
      WRITE (*,*) '             7 - INSTALLATION NON-OCCUPATIONAL '
      WRITE (*,*) '             8 - USE NON-OCCUPATIONAL '
      WRITE (*,*) '             9 - REPAIR/DISPOSAL NON-OCCUPATIONAL '
      WRITE (*,'(6(/))')
      PAUSE 'Press the <RETURN> or the <ENTER> key to continue'
      WRITE (*,'(10(/))')
      WRITE (*,*) 'YOU HAVE FOUR OPTIONS FOR CHOOSING THE POPULATION'
      WRITE (*,*) 'TO BE ANALYZED.  THESE OPTIONS AND THEIR CORRESPOND-'
      WRITE (*,*) 'ING REFERENCE NUMBERS ARE THE FOLLOWING;'
      WRITE (*,*)
      WRITE (*,*) '           1 - ALL CATEGORIES'
      WRITE (*,*) '           2 - ALL OCCUPATIONAL CATAGORIES'
      WRITE (*,*) '           3 - ALL NON-OCCUPATIONAL CATAGORIES'
      WRITE (*,*) '           4 - USER SELECTED GROUPS'
      WRITE (*,*)
      WRITE (*,*)
      WRITE (*,*) 'ENTER THE REFERENCE NUMBER OF YOUR CHOICE.'
      READ (*,*) IGROUP
      WRITE (*,'(24(/))')
      IF (IGROUP .EQ. 1) THEN
        NEG=10
        DO 123 I=1,NEG
          B(I)=I
 123    CONTINUE
      ENDIF
      IF (IGROUP .EQ. 2) THEN
      NEG=5
        DO 124 I=1,NEG
          B(I)=I
 124    CONTINUE
      ENDIF
      IF (IGROUP .EQ. 3) THEN
      NEG=5
        DO 125 I=6,10
          B(I-5)=I
 125    CONTINUE
      ENDIF
      IF (IGROUP .EQ. 4) THEN
      WRITE (*,*) 'HOW MANY CATEGORIES ARE YOU INTERESTED IN?'
      READ (*,*) NEG
       WRITE (*,*)
       WRITE (*,*)
      DO 126 I=1,NEG
        WRITE (*,*) 'ENTER CATEGORY ', I
        READ (*,*) B(I)
        b(i)=b(i)+1
 126  CONTINUE
      ENDIF
      WRITE (*,'(20(/))')
      WRITE (*,*) 'THIS PROGRAM GIVES YOU THE OPTION OF RUNNING THE'
      WRITE (*,*) 'MODEL FOR ALL PRODUCTS, SPECIFIC GROUPS OF PRODUCTS,'
      WRITE (*,*) 'OR ANY INDIVIDUAL PRODUCT.  IF YOU WOULD LIKE TO SEE'
      WRITE (*,*) 'A LIST OF ALL THE PRODUCTS AND THEIR REFERENCE'
      WRITE (*,*) 'NUMBERS ENTER 1, IF NOT ENTER 0.'
      READ (*,*) I
      WRITE (*,'(6(/))')
      IF (I .EQ. 1) CALL LIST
      WRITE (*,'(24(/))')
      WRITE (*,*) 'IF YOU WISH TO RUN THE MODEL FOR ALL THE PRODUCTS,'
      WRITE (*,*) 'ENTER 1, IF ONLY FOR A SUBSET OF ALL THE PRODUCTS'
      WRITE (*,*) 'ENTER 0.'
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      READ (*,*) I
      WRITE (*,'(12(/))')
       IF (I .EQ. 1) THEN
        NP=38
        DO 127 N=1,NP
          A(N)=N
127     CONTINUE
       ELSE
        WRITE (*,*)'HOW MANY PRODUCT CATAGORIES ARE YOU INTERESTED IN?'
        READ (*,*) NP
        WRITE (*,'(24(/))')
        DO 128 N=1,NP
          WRITE (*,*) 'ENTER THE PRODUCT REFERENCE # FOR PRODUCT ',N
          READ (*,*) A(N)
      WRITE (*,'(35(/))')
128     CONTINUE
        ENDIF
      WRITE (*,'(27(/))')
        WRITE (*,*) 'THE DEFAULT DOSE RESPONSE CONSTANTS ARE:'
        WRITE (*,*)
        WRITE (*,*) '        LUNG CANCER   = 0.01'
        WRITE (*,*) '        MESOTHELIOMA = 0.00000001'
        WRITE (*,*)
        WRITE (*,*)
        WRITE (*,*)
        WRITE (*,*) 'DO YOU WISH TO CHANGE THESE CONSTANTS FOR ANY'
        WRITE (*,*) 'PRODUCT CATEGORIES?'
        WRITE (*,*)
        WRITE (*,*) 'ENTER 1 IF YOU WANT TO MAKE CHANGES, AND ENTER'
        WRITE (*,*) '0 IF YOU DON"T.'
        READ (*,*) I
        WRITE (*,'(20(/))')
        IF (I .EQ. 1 ) THEN
        WRITE (*,*) 'IN HOW MANY PRODUCT CATEGORIES ARE YOU INTERESTED'
        WRITE (*,*) 'IN CHANGING AT LEAST ONE OF THE DOSE RESPONSE'
        WRITE (*,*) 'CONSTANTS? '
        READ (*,*) I
        WRITE (*,'(21(/))')
        WRITE (*,*) 'RESPOND TO THE PROMPTS TO ENTER THE REFERENCE'
        WRITE (*,*) 'NUMBERS OF THOSE PRODUCTS HAVING DOSE RESPONSE'
        WRITE (*,*) 'CONSTANTS THAT YOU WISH TO MODIFY.'
        WRITE (*,'(12(/))')
        DO 2112 N=1,I
          WRITE (*,*) 'ENTER PRODUCT NUMBER ',N, '  THAT HAS A DOSE'
          WRITE (*,*) 'RESPONSE CONSTANT TO BE CHANGED.'
          READ (*,*) NPN(N)
        WRITE (*,*)
        WRITE (*,*)
2112    CONTINUE
        WRITE (*,'(24(/))')
        DO 2113 N=1,I
         WRITE (*,*) 'THE LUNG CANCER DOSE RESPONSE CONSTANT FOR '
         WRITE (*,*) 'PRODUCT ',NPN(N),' = ',FKL(NPN(N))
         WRITE (*,*)
          WRITE (*,*) 'ENTER 1 IF YOU WISH TO CHANGE THIS, ENTER 0'
          WRITE (*,*) 'IF YOU DON"T.'
         READ (*,*) II
         WRITE (*,*)
         WRITE (*,*)
         IF (II .EQ. 1) THEN
          WRITE (*,*) 'ENTER THE NEW LUNG CANCER DOSE RESPONSE CONSTANT'
          WRITE (*,*) 'FOR PRODUCT ',NPN(N),' .'
          READ (*,*) FKL(NPN(N))
          ENDIF
         WRITE (*,'(4(/))')
          WRITE (*,*) 'THE MESOTHELIOMA DOSE RESPONSE CONSTANT FOR'
         WRITE (*,*) 'PRODUCT ',NPN(N),' = ',FKM(NPN(N))
          WRITE (*,*)
          WRITE (*,*) 'ENTER 1 IF YOU WISH TO CHANGE THIS, ENTER 0'
          WRITE (*,*) 'IF YOU DON"T.'
          READ (*,*) II
          WRITE (*,*)
          WRITE (*,*)
          IF (II .EQ. 1) THEN
          WRITE (*,*) 'ENTER THE NEW MESOTHELIOMA DOSE RESPONSE '
          WRITE (*,*) 'CONSTANT FOR PRODUCT ',NPN(N)
          READ (*,*) FKM(NPN(N))
          ENDIF
         WRITE (*,'(8(/))')
2113    CONTINUE
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      WRITE (*,'(3(/))')
      ENDIF
      WRITE(*,'(13(/))')
      WRITE(*,*) 'THIS PROGRAM GIVES YOU THE OPTION OF USING THE'
      WRITE(*,*) '1977 OR 1990 BASELINE LUNG CANCER DEATH RATES.'
      WRITE(*,*) 'IF YOU WANT TO USE 1977 RATES ENTER 1977 BELOW'
      WRITE(*,*) 'IF YOU WANT TO USE 1990 RATES ENTER 1990 BELOW.'
      READ(*,*)  IY
      WRITE(*,'(12(/))')
      WRITE(*,*) 'THIS PROGRAM ALLOWS YOU TO CHOOSE THE RATIO OF'
      WRITE(*,*) 'EXCESS GASTROINTESTINAL CANCER DEATHS TO LUNG'
      WRITE(*,*) 'CANCER DEATHS - COMMONLY ASSUMED VALUES ARE '
      WRITE(*,*) ' 0 OR 0.1. YOU MAY ENTER ANY VALUE BELOW '
      READ(*,*) GI
      WRITE (*,'(11(/))')
      WRITE(*,*)        'NOW CHOOSE THE NUMBER OF DISCOUNT RATES'
      READ(*,*) NN
      WRITE(*,*)
      WRITE (*,*) 'NOW SELECT THE',NN,' DISCOUNT RATES.  ENTER THESE'
      WRITE (*,*) 'RATES AS THEIR DECIMAL EQUIVALENTS.  AS AN '
      WRITE (*,*) 'EXAMPLE, A DISCOUNT RATE OF 10% WOULD BE ENTERED'
      WRITE (*,*) 'AS .1'
      WRITE (*,'(4(/))')
      DO 130 N=1,NN
       WRITE (*,'(A,I2)') ' ENTER DISCOUNT RATE # ',N
       READ (*,*) DISC(N)
130   CONTINUE
      WRITE (*,'(22(/))')
      WRITE (*,*) 'WHAT EXPOSED POPULATION CHARACTERIZATION FILE'
      WRITE (*,*) 'DO YOU WANT TO USE?  REMEMBER TO INCLUDE THE'
      WRITE (*,*) 'DRIVE SPECIFIER!'
      READ (*,'(A)') FILE
      OPEN(UNIT=4,FILE=FILE,FORM='FORMATTED',STATUS='OLD')
      WRITE(*,'(24(/))')
      WRITE (*,*) 'THE OUTPUT OF THIS RUN IS STORED IN THE FILE'//
     -            ' NAMED ',FILE2
      WRITE(*,*)
      WRITE(*,*)
      WRITE(*,*) 'WAIT FOR THE PROGRAM TERMINATED'//
     -            ' MESSAGE BEFORE YOU PROCEED.'
      WRITE (*,'(13(/))')
      CALL INTAB(FILE3,FILE4,FILE2,FILE,IYRS,ISY,IEY,NEG,B,NP,
     * A,FKL,FKM,IY,GI,NN,DISC,PGBRK)
101   FORMAT (1X)
202   FORMAT (10(4f20.8/))
      READ (4,101)
      READ (4,202) MANOP
      READ (4,101)
      READ (4,202) MANOS
      READ (4,101)
      READ (4,202) INSO
      READ (4,101)
      READ (4,202) USEO
      READ (4,101)
      READ (4,202) DISO
      READ (4,101)
      READ (4,202) MANAP
      READ (4,101)
      READ (4,202) MANAS
      READ (4,101)
      READ (4,202) INSA
      READ (4,101)
      READ (4,202) USEA
      READ (4,101)
      READ (4,202) DISA
      READ (4,101)
      READ (4,202) PMANOP
      READ (4,101)
      READ (4,202) PMANOS
      READ (4,101)
      READ (4,202) PINSO
      READ (4,101)
      READ (4,202) PUSEO
      READ (4,101)
      READ (4,202) PDISO
      READ (4,101)
      READ (4,202) PMANAP
      READ (4,101)
      READ (4,202) PMANAS
      READ (4,101)
```

```
          READ (4,202) PINSA
          READ (4,101)
          READ (4,202) PUSEA
          READ (4,101)
          READ (4,202) PDISA
         DO 444 K=1,38
         DO 445 I=1,8
         DO 446 J=1,11
          RRR1(K,I,J)=0.0
          RRR2(K,I,J)=0.0
          TEM1(K,I,J)=0.0
          TEM2(K,I,J)=0.0
  446    CONTINUE
  445    CONTINUE
  444    CONTINUE
         DO 447 K=1,2
         DO 448 I=1,38
         PPP(K,I)=0.0
  448    CONTINUE
  447    CONTINUE
          DO 34 K=1,2
         DO 36 I=1,28
         DO 37 J=1,4
         TOT1(K,I,J)=0.0
  37     CONTINUE
  36     CONTINUE
  34      CONTINUE
          DO 3341 I=1,38
          DO 3342 J=1,20
          BPROJ(I,J)=0.0
          PROJ(I,J)=0.0
  3342    CONTINUE
  3341    CONTINUE
C
C        IB=BASELINE/ALTERNATIVE INDEX
C
          DO 98 IB=1,2
          DO 27 K=1,5
          DO 28 KK=1,5
          P(K,KK)=0.0
  28      CONTINUE
  27      CONTINUE
         EXP1=0.0
          CALL DAREAD(POP,RMAX,RLEV,IB,BPROJ,PROJ,IYRS,PGBRK)
C
C       IP=PRODUCT INDEX  NP=NO. OF PRODUCTS(38)
C
        DO 1 IIP=1,NP
         IP=A(IIP)
         DO 46 I=1,28
         DO 47 J=1,4
         RR(I,J)=0.0
  47     R(I,J)=0.0
  46     CONTINUE
         DO 695 I=1,18
         DO 696 J=1,4
         TA(I,J)=0.0
  696    CONTINUE
  695    CONTINUE
        EX1=0.0
        SS1=0.0
C
C       IG=EXPOSURE GROUP INDEX NG=NUMBER OF EXPOSURE GROUPS(10)
C
        DO 11 IIG=1,NEG
         DO 77 I=1,28
         DO 78 J=1,4
         T(I,J)=0.0
  78     CONTINUE
  77     CONTINUE
         IG=B(IIG)
         E1=0.0
         ISH=0
         IF (IG.EQ.5.OR.IG.EQ.10) ISH=LIFE(IP)
        IF (POP(IP,IG).EQ.0.) GOTO 11
        CALL INIT(RLEV,RMAX,IP,IG,NO,POP,SS1)
        AGEMID=AGEST
C       J=AGE GROUP INDEX   NA=NO. OF AGE GROUPS(9)
        DO 5 J=1,9
        WT=OWT(J,NO)
```

```
      IF (WT.EQ.0.) GOTO 5
C
        DO 2 I=1,5
 2      V(I)=0.
        V(1)=1.
C
      N=(90-AGEMID)/5
C     IA=5 YEAR INDEX   NT=MAX NUMBER OF TIME PERIODS IN A LIFE(18)

           DO 8 IA=1,N
      AGE=(IA-1)*5+AGEMID+2.5
       IPER=IA+(AGEMID/5)
       CALL INC(OSRWT,FDIE,NO,AGE,IPER,IY)
C
C
C      LUNG CANCER
C
C
      DT=IA*5-12.5
      IF(DT .GT .MAXDT) DT=MAXDT
      IF(DT .LT. 0.) DT=0.
      FDTL=FDIE*FKL(IP)*F*DT/1.E5
C
C
C       MESOTHELIOMIA
C
      TT=(IA-1)*5+2.5
      FDTM=0.0
      IF(TT.LE.10) GOTO 10
      FDTM=FKM(IP)*F*(TT-10)**3
      IF(TT.LE.10+MAXDT) GOTO 10
      FDTM=FDTM-FKM(IP)*F*(TT-10-MAXDT)**3
        FDTM=5.*FDTM
10    YEAR=(IA*5)+1984
C
C
C
      CALL TRANSI(FDTL,FDTM,P,V,AGE,IPER,PP,WT,OSRWT,NO,
     * ISH,IP,IG,IB,IA,GI,E1,AGEMID,TA)
8     CONTINUE

 5         AGEMID=AGEMID+AGEINT
        CALL AG(T,R,IG,LIFE,IP,E1,EX1)
 11   CONTINUE
       CALL AGG(R,TOT1,IG,IP,IB,BPROJ,PROJ,RR,
     * EXP1,EX1,IYRS,TEM1,TEM2,DISC,NN)
        CALL PRNT(R,RR,28,4,2,IP,TA,SS1,IYRS,IB,PPP,DISC,NN,
     *  RRR1,RRR2)
1     CONTINUE
       CALL TOTAL(TOT1,IB,TT1,EXP1,PGBRK)
 98     CONTINUE
        CALL BANEFF(DISC,TOT1,TT1,IB,NN,RRR1,RRR2,PPP,NP,A,
     *  PGBRK,TEM1,TEM2)
      STOP
      END
```

```
      SUBROUTINE TRANSI(FDTL,FDTM,P,V,AGE,IPER,PP,WT,OSRWT,NO,
     * ISH,IP,IG,IB,IA,GI,E1,AGEMID,TA)
c
      DIMENSION P(5,5),V(5),VV(5),OSRWT(4,3),TA(18,4)
       INTEGER AGEMID
      REAL*8 S,S1,PP,P,T,FMR,AFMR,BFMR,WT,V,VV,S2,S3,
     * FDTL,FDTM,E1,TA
      COMMON /A1/T(28,4)
      CALL LIFE(IPER,FMR,OSRWT,NO)
        IF (AGE.GT.85) GOTO 39
       P(1,2)=FDTL
       P(1,3)=GI*FDTL
       P(1,4)=FDTM
       P(1,5)=FMR
       P(1,1)=1.0-(P(1,2)+P(1,3)+P(1,4)+P(1,5))
       IF(P(1,1).LE.0.0D0) P(1,1)=0.0D0
       P(2,2)=1.0
       P(3,3)=1.0
       P(4,4)=1.0
       P(5,5)=1.0
       GOTO 421
 39     P(1,1)=0.0D0
       P(1,2)=FDTL
       P(1,3)=GI*FDTL
       P(1,4)=FDTM
       P(1,5)=1.0-(P(1,2)+P(1,3)+P(1,4))
421   DO 1 I=1,5
      S=0.
      S1=0.
      DO 2 J=1,5
      S1=S1+P(I,J)
2     S=S+P(J,I)*V(J)
      IF(DABS(S1-1.0D0).GT..0000001D0) GOTO 99
1     VV(I)=S
      CALL ACCUM(T,TA,V,VV,28,4,2,IPER,FDTL,FDTM,PP,WT,AGE,
     * ISH,IP,IG,IB,IA,E1,AGEMID)
      DO 3 I=1,5
3     V(I)=VV(I)
      RETURN
99    WRITE(3,98) I,(P(I,J),J=1,5)
98    FORMAT(I4,5F11.8)
      STOP
      END

             SUBROUTINE ACCUM(T,TA,V,VV,N1,N2,N3,IPER,FDTL,FDTM,PP,WT,
     * AGE,ISH,IP,IG,IB,IA,E1,AGEMID)
C    THIS SUBROUTINE ACCUMULATES DATA.  ALL GROUPS ARE ADDED TOGETHER.
c
      REAL*8 PP,S1,T,WT,V,VV,FDTL,FDTM,E1,TA
      DIMENSION T(N1,N2),V(5),VV(5),TA(18,4)
      INTEGER IK(4),AGEMID
      DATA IK/2,3,4,5/
       RIA=(IA-1)*5.+2.5
       RISH=ISH
       IFT=(RISH/5.+.5)
       MIPER=IA+IFT
       SAGE=AGEMID
       IAGE=(AGE+2.5)/5.
      DO 1 K=1,4
      S1=(VV(IK(K))-V(IK(K)))*PP*WT
       T(MIPER,K)=T(MIPER,K)+S1
       TA(IAGE,K)=TA(IAGE,K)+S1
       E1=E1+S1*(AGE-SAGE)
 1     CONTINUE
      RETURN
      END
c
c
       SUBROUTINE AG(T,R,IG,LIFE,IP,E1,EX1)
c
         DIMENSION T(28,4),R(28,4),
     *   LIFE(38)
       REAL*8 A3,A2,R1,R2,R,T,E1,EX1
         IF(IG.NE.4.AND.IG.NE.9) GOTO 10
         N=LIFE(IP)
       RN=N
         DO 20 M=1,4
         DO 30 I=1,28
         DO 40 J=1,N
         K=(J-1)/5+1
```

```
         IF (J.LE.5)              RJ=J
         IF (J.GT.5.AND.J.LE.10)  RJ=J-5
         IF (J.GT.10.AND.J.LE.15) RJ=J-10
         IF (J.GT.15.AND.J.LE.20) RJ=J-15
         IF (J.GT.20.AND.J.LE.25) RJ=J-20
         IF (J.GT.25.AND.J.LE.30) RJ=J-25
         IF (J.GT.30.AND.J.LE.35) RJ=J-30
         IF (J.GT.35.AND.J.LE.40) RJ=J-35
         IF (J.GT.40.AND.J.LE.45) RJ=J-40
         IF (J.GT.45.AND.J.LE.50) RJ=J-45
        A3=1.-(2.*(RJ-1.)/10.)
         A2=1.-A3
         IF((I-(K-1)).LE.0) R1=0.0
         IF((I-(K-1)).GT.0) R1=T((I-(K-1)),M)
         IF((I-K).LE.0) R2=0.0
         IF((I-K).GT.0) R2=T((I-K),M)
        R(I,M)=R(I,M)+((A3*R1)+(A2*R2))
 40     CONTINUE
 30     CONTINUE
 20     CONTINUE
         EX1=EX1+RN*E1
        GOTO 60
 10     CONTINUE
        DO 70 M=1,4
        DO 80 I=1,28
        R(I,M)=R(I,M)+T(I,M)
 80     CONTINUE
 70     CONTINUE
         EX1=EX1+E1
 60     CONTINUE
        RETURN
        END
c
c
       SUBROUTINE AGG(R,TOT1,IG,IP,IB,BPROJ,PROJ,RR,
     * EXP1,EX1,IYRS,TEM1,TEM2,DISC,NN)
c
       DIMENSION R(28,4),TOT1(2,28,4),TEM1(38,8,11),TEM2(38,8,11),
     * BPROJ(38,20),PROJ(38,20),RR(28,4),DISC(10),S(4),CR(4)
       REAL*8 A3,A2,R1,R2,R,TOT1,RR,EXP1,EX1,TEM1,TEM2,DISC,S,CR
       DATA CR/1.09,1.56,1.02,1.0/
       N=IYRS
        DO 64 I=1,4
        S(I)=0.0D0
 64     CONTINUE
        DO 76 I=1,28
        DO 77 J=1,3
        S(J)=S(J)+R(I,J)
 77     CONTINUE
 76     CONTINUE
        DO 78 I=1,3
        S(4)=S(4)+S(I)
 78     CONTINUE
        IF(BPROJ(IP,1).EQ.0.0) GOTO 999
         NNN=NN+1
        IF(IB.EQ.2) GOTO 99
        DO 37 J=1,NNN
        DO 36 I=1,4
        DO 38 K=1,IYRS
        IF(J.LT.NNN)
     *  TEM1(IP,I,J)=TEM1(IP,I,J)+((BPROJ(IP,K)/BPROJ(IP,1))
     *  *S(I)*(1.0D0/(1.0D0+DISC(J))**K))
        IF(J.EQ.NNN) TEM1(IP,I,J)=TEM1(IP,I,J)+
     *  ((BPROJ(IP,K)/BPROJ(IP,1))*S(I))
 38     CONTINUE
 36     CONTINUE
       DO 22 I=5,7
       II=I-4
       TEM1(IP,I,J)=TEM1(IP,II,J)*CR(II)
 22    CONTINUE
       TEM1(IP,8,J)=TEM1(IP,1,J)*CR(1)+TEM1(IP,2,J)*CR(2)
     * +TEM1(IP,3,J)*CR(3)
 37    CONTINUE
       GOTO 95
 99     CONTINUE
        DO 57 J=1,NNN
        DO 56 I=1,4
        DO 58 K=1,IYRS
        IF(J.LT.NNN) TEM2(IP,I,J)=
     *  TEM2(IP,I,J)+((BPROJ(IP,K)/BPROJ(IP,1))
```

```
     *  *S(I)*(1.0D0/(1.0D0+DISC(J))**K))
        IF(J.EQ.NNN) TEM2(IP,I,J)=TEM2(IP,I,J)+
     *  ((BPROJ(IP,K)/BPROJ(IP,1))*S(I))
 58     CONTINUE
 56     CONTINUE
        DO 52 I=5,7
        II=I-4
        TEM2(IP,I,J)=TEM2(IP,II,J)*CR(II)
 52     CONTINUE
        TEM2(IP,8,J)=TEM2(IP,1,J)*CR(1)+TEM2(IP,2,J)*CR(2)
     *  +TEM2(IP,3,J)*CR(3)
 57     CONTINUE
 95     CONTINUE
 999    CONTINUE
      DO 10 M=1,4
      DO 20 I=1,28
      DO 30 J=1,N
      K=(J-1)/5+1
      IF(J.LE.5) RJ=J
      IF(J.GT.5.AND.J.LE.10) RJ=J-5
      IF(J.GT.10.AND.J.LE.15) RJ=J-10
      IF(J.GT.15.AND.J.LE.20) RJ=J-15
      A3=1.-(2.*(RJ-1.)/10.)
      A2=1.-A3
      IF((I-(K-1)).LE.0.0) R1=0.0
      IF((I-(K-1)).GT.0.0) R1=R((I-(K-1)),M)
      IF((I-K).LE.0.0) R2=0.0
      IF((I-K).GT.0.0) R2=R((I-K),M)
      IF(BPROJ(IP,1).GT.0.0) R1=BPROJ(IP,J)/BPROJ(IP,1)*R1
      IF(BPROJ(IP,1).GT.0.0) R2=BPROJ(IP,J)/BPROJ(IP,1)*R2
      IF(BPROJ(IP,1).EQ.0.0) R1=0.0
      IF(BPROJ(IP,1).EQ.0.0) R2=0.0
       TOT1(IB,I,M)=TOT1(IB,I,M)+((A3*R1)+(A2*R2))
      RR(I,M)=RR(I,M)+((A3*R1)+(A2*R2))
 30   CONTINUE
 20   CONTINUE
 10   CONTINUE
       DO 50 J=1,N
       IF(BPROJ(IP,1).GT.0.0) EXP1=
     * EXP1+(BPROJ(IP,J)/BPROJ(IP,1)*EX1)
 50   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FILE(IB,BPROJ,PROJ,IYRS,PGBRK)
c
      DIMENSION BPROJ(38,20),S(2,38,20),PROJ(38,20)
       CHARACTER PGBRK
       IF(IB.EQ.2) GOTO 200
       WRITE (3,*)
       WRITE (3,*)
       WRITE(3,396) PGBRK
 396   FORMAT(A,32X,'INPUT DATA 5',//)
       WRITE(3,397)
 397   FORMAT(10X,'Baseline Indexes for the 38 Products over 20 ',
     * 'Years')
       WRITE(3,797)
 797   FORMAT(1X,'________________________________________',
     * '______________________________',//)
      DO 30 K=1,IYRS
      READ(1,40) (S(1,J,K),J=1,38)
 40   FORMAT (38(F4.2,1X))
       WRITE (3,434) (S(1,J,K),J=1,38)
434    FORMAT(30(F4.2,1X),/,8(F4.2,1X))
 30   CONTINUE
        WRITE(3,797)
        WRITE(3,398) PGBRK
 398    FORMAT(A,32X,'INPUT DATA 6',//)
        WRITE(3,399)
 399    FORMAT(10X,'Regulatory Alternative Indexes for 38 ',
     * 'Products over 20 Years')
       WRITE (3,797)
       DO 50 K=1,IYRS
       READ(2,60) (S(2,J,K),J=1,38)
 60    FORMAT (38(F4.2,1X))
       WRITE (3,434) (S(2,J,K),J=1,38)
 50    CONTINUE
       WRITE (3,797)
       DO 70 I=1,38
       DO 80 J=1,IYRS
       BPROJ(I,J)=S(2,I,J)
 80    CONTINUE
 70    CONTINUE
       DO 90 I=1,38
       DO 100 J=1,IYRS
       PROJ(I,J)=S(1,I,J)
 100   CONTINUE
  90   CONTINUE
        GOTO 210
 200   DO 220 K=1,38
       DO 230 L=1,IYRS
 230   BPROJ(K,L)=PROJ(K,L)
 220   CONTINUE
 210   CONTINUE
       RETURN
       END
```

```
      SUBROUTINE DAREAD(POP,RMAX,RLEV,IB,BPROJ,PROJ,IYRS,PGBRK)
c
     COMMON/T/MANOP,MANOS,INSO,USEO,DISO,MANAP,MANAS,INSA,USEA,
     *DISA,PMANOP,PMANOS,PINSO,PUSEO,PDISO,PMANAP,PMANAS,PINSA,
     *PUSEA,PDISA
      CHARACTER PGBRK
      DIMENSION RPOP(38,10),BPROJ(38,20),REXP(38,10)
      DIMENSION RMAX(38,10),POP(38,10),RLEV(38,10),PROJ(38,20),
     *MANOP(38),MANOS(38),INSO(38),USEO(38),DISO(38),MANAP(38),
     * MANAS(38),INSA(38),USEA(38),DISA(38),PMANOP(38),PMANOS(38),
     * PINSO(38),PUSEO(38),PDISO(38),PMANAP(38),PMANAS(38),
     * PINSA(38),PUSEA(38),PDISA(38)
      EQUIVALENCE(REXP(1,1),MANOP(1))
      EQUIVALENCE(RPOP(1,1),PMANOP(1))
      CALL FILE(IB,BPROJ,PROJ,IYRS,PGBRK)
      S1=0.0
     DO 66 I=1,38
      DO 67 J=1,10
      IF(RPOP(I,J).EQ.0.)GOTO 69
      POP(I,J)=RPOP(I,J)*BPROJ(I,1)
      IF(POP(I,J).EQ.0.) GOTO 69
      S1=S1+POP(I,J)
      RMAX(I,J)=1.0
      RLEV(I,J)=REXP(I,J)
      GOTO 67
 69   CONTINUE
      POP(I,J)=0.0
      RLEV(I,J)=0.0
      RMAX(I,J)=0.0
      GOTO 67
 67   CONTINUE
 66   CONTINUE
      RETURN
      END
c
c
     SUBROUTINE INIT(RLEV,RMAX,IP,IG,NO,POP,SS1)
C  THIS SUBROUTINE DEFINES THE PRODUCT-GROUP SPECIFIC PARAMETERS
C        USED IN THE SIMULATION.
C  F=INTENSITY OF EXPOSURE,   GB=EXPOSURE AS OF 1985,
C  MAXDT=MAX DOSE ASSUMED,   V= INITIAL STATE VECTOR.
c
     DIMENSION RLEV(38,10),POP(38,10),RMAX(38,10)
     REAL*8 PP
     INTEGER IOCC(10)
     COMMON /O1/ F,MAXDT,PP
     DATA IOCC/1,1,1,1,1,2,2,2,2,2/
      F=RLEV(IP,IG)/2600.
     MAXDT=RMAX(IP,IG)
     PP=POP(IP,IG)
     SS1=SS1+PP
     NO=IOCC(IG)
       IF(IP.EQ.12.AND.IG.EQ.9) NO=3
     RETURN
     END
c
c
      SUBROUTINE INC(OSRWT,FDIE,NO,AGE,IPER,IY)
      DIMENSION OSRWT(4,3),FEG(18,4)
      REAL FDEG(18,4),FNEG(18,4)
      DATA FDEG/
     * 0.,0.,0.,.5,1.0,3.0,9.0,33.5,93.0,247.5,489.5,802.0,
     * 1330.5,1797.5,2283.0,2632.5,2300.5,1700.5,
     * 0.5,0.5,0.5,0.5,3.5,3.0,19.5,54.5,198.0,453.0,872.0,
     * 1328.5,1775.5,1857.5,2358.0,2351.0,1618.5,1264.0,
     * 0.,0.,0.,0.5,0.5,1.5,5.0,18.0,54.5,114.0,191.5,277.0,
     * 383.5,400.0,410.5,429.5,402.5,394.0,
     * 0.,0.,0.,1.0,0.5,3.0,6.5,26.0,82.0,131.0,236.5,290.0,
     * 348.0,321.5,402.0,404.5,228.5,254.0/
      DATA FNEG/
     * 0.,0.,0.,.5,1.,3.,9.,33.5,93.,247.5,518.9,850.1,
     * 1712.4,2313.4,2938.2,3388.,2960.8,2188.6,
     * .5,.5,.5,.5,3.5,3.,19.5,54.5,198.,453.,924.3,
     * 1408.2,2285.,2390.6,3034.8,3025.8,2083.,1626.8,
     * 0.,0.,0.,.5,.5,1.5,5.,18.,91.1,190.6,320.1,463.,
     * 641.,668.6,686.1,717.8,672.7,658.5,
     * 0.,0.,0.,1.,.5,3.,6.5,26.,137.,219.,395.3,484.7,
     * 581.7,537.4,671.9,676.1,381.9,424.6/
       FDIE =0.0
       DO 190 I=1,4
```

```
      IF(IY.EQ.1977) FEG(IPER,I)=FDEG(IPER,I)
      IF(IY.EQ.1990) FEG(IPER,I)=FNEG(IPER,I)
        FDIE=FDIE+FEG(IPER,I)*OSRWT(I,NO)
  190   CONTINUE
        RETURN
        END
c
c
      SUBROUTINE LIFE(IPER,FMR,OSRWT,NO)
      REAL*8 FMR
      DIMENSION OSRWT(4,3)
      REAL GMR(18,4)
      DATA GMR/
     * 1708.5,192.0,212.5,729.0,950.0,836.5,821.0,1096.5,1698.5,2825.5,
     * 4627.0,7200.0,11690.0,17182.0,26169.5,40523.0,57987.5,90208.5,
     *3212.8,258.,269.5,725.,1383.,1910.,2075.5,2804.,3965.,5504.,
     *8121.,11554.,16800.5,18976.,30980.5,43252.,44930.,56430.5,
     *1314.8,128.,125.,276.,296.5,307.,391.5,578.,958.5,1548.5,2400.5,
     *3631.,5720.,8163.5,13173.,23016.5,37474.5,70198.5,
     *2652.9,171.5,140.,314.,495.5,658.5,828.,1280.5,2020.5,2998.5,
     *4572.5,6537.5,9475.,10880.5,21493.,32254.,31325.,43367.5/
      IF(IPER.GT.18) IPER=18
      FMR=0.
      DO 1 K=1,4
1     FMR=FMR+GMR(IPER,K)*OSRWT(K,NO)/1.0E5
C    MAKE CERTAIN FMR NON ZERO
      FMR=DMAX1(FMR,0.0D0)
      RETURN
      END
```

```
      SUBROUTINE INTAB(FILE3,FILE4,FILE2,FILE,IYRS,ISY,IEY,NEG,B,
     * NP,A,FKL,FKM,IY,GI,NN,DISC,PGBRK)
c
      REAL FKL(38),FKM(38),GI
      REAL*8 DISC(10)
      INTEGER IYRS,ISY,IEY,IGROUP,B(10),NP,A(38),IY,NN
      CHARACTER PGBRK
      CHARACTER*25 FILE,FILE2,FILE3,FILE4,PROD(38)
      CHARACTER*45 GROUP(10)
      WRITE(3,10) PGBRK
 10   FORMAT(A,32X,'INPUT DATA 1',//)
      WRITE(3,20)
 20   FORMAT(30X,'Scenario Modelled')
      WRITE(3,30)
 30   FORMAT(1X,'_________________________________________',
     * '_____________________________________',//)
      WRITE(3,40)
 40   FORMAT(6X,'DATA FILES',//)
      WRITE(3,50) FILE,FILE3,FILE4,FILE2
 50   FORMAT(9X,'Exposure Data',25X,A25,/,9X,
     * 'Baseline Product Indexes',14X,A25,/,9X,
     * 'Product Indexes with Regulation',7X,A25,/,9X,
     * 'Output File',27X,A25,///)
      WRITE(3,60)
 60   FORMAT(6X,'TIME PERIOD FOR ANALYSIS',//)
      WRITE(3,70) IYRS,ISY,IEY
 70   FORMAT(9X,'Number of Years',25X,I4,/,9X,
     * 'Start Year',28X,I4,/,9X,'End Year',30X,I4,//)
      WRITE(3,30)
      WRITE(3,80) PGBRK
 80   FORMAT(A,32X,'INPUT DATA 2',//)
      WRITE(3,90)
 90   FORMAT(25X,'Exposure Groups Analyzed')
      WRITE(3,30)
      CALL GR(GROUP)
      DO 100 I=1,NEG
      WRITE(3,110) GROUP(B(I))
 110  FORMAT(15X,A45,/)
 100  CONTINUE
      WRITE(3,30)
      WRITE(3,120) PGBRK
 120  FORMAT(A,32X,'INPUT DATA 3',//)
      WRITE(3,130)
 130  FORMAT(12X,'Products Analyzed and their Dose-Response',
     * ' Parameters')
      WRITE(3,30)
      WRITE(3,140)
 140  FORMAT(1X,'PRODUCT',20X,'LUNG CANCER',4X,'MESOTHELIOMA',
     * 3X,'YEAR FOR',3X,'RATIO OF')
      WRITE(3,15)
 15   FORMAT(27X,'DOSE-RESPONSE',2X,'DOSE-RESPONSE',2X,'BASELINE',
     * 3X,'GI CANCER')
      WRITE(3,160)
 160  FORMAT(27X,' CONSTANT ',5X,' CONSTANT ',5X,' LUNG',6X,
     * 'TO LUNG')
      WRITE(3,170)
 170  FORMAT(57X,'CANCER',5X,'CANCER')
      WRITE(3,175)
 175  FORMAT(68X,'RATIO')
      WRITE(3,30)
      CALL PR(PROD)
      DO 180 I=1,NP
      WRITE(3,190) PROD(A(I)),FKL(A(I)),FKM(A(I)),IY,GI
 190  FORMAT(1X,A25,3X,F10.3,5X,F10.9,5X,I4,7X,F6.4)
 180  CONTINUE
      WRITE(3,30)
      WRITE(3,200) PGBRK
 200  FORMAT(A,32X,'INPUT DATA 4',//)
      WRITE(3,210)
 210  FORMAT(28X,'Discount Rates Used')
      WRITE(3,30)
      DO 220 I=1,NN
      RR=DISC(I)*100.
      WRITE(3,230) I,RR
 230  FORMAT(6X,I2,'.',3X,F5.2,' PERCENT',/)
 220  CONTINUE
      WRITE(3,30)
      RETURN
      END
c
```

```
c
      SUBROUTINE GR(GROUP)
      CHARACTER*45 GROUP(10)
      GROUP(1)='PRIMARY MANUFACTURING-OCCUPATIONAL'
      GROUP(2)='SECONDARY MANUFACTURING-OCCUPATIONAL'
      GROUP(3)='INSTALLATION-OCCUPATIONAL'
      GROUP(4)='USE-OCCUPATIONAL'
      GROUP(5)='REPAIR/DISPOSAL-OCCUPATIONAL'
      GROUP(6)='PRIMARY MANUFACTURING-NON-OCCUPATIONAL'
      GROUP(7)='SECONDARY MANUFACTURING-NON-OCCUPATIONAL'
      GROUP(8)='INSTALLATION-NON-OCCUPATIONAL'
      GROUP(9)='USE-NON-OCCUPATIONAL'
      GROUP(10)='REPAIR/DISPOSAL-NON-OCCUPATIONAL'
      RETURN
      END
c
c
       SUBROUTINE PR(PROD)
c
       CHARACTER*25 PROD(38)
       PROD(1)='COMMERCIAL PAPER'
       PROD(2)='ROLLBOARD'
       PROD(3)='MILLBOARD'
       PROD(4)='PIPELINE WRAP'
       PROD(5)='BEATER-ADD GASKETS'
       PROD(6)='HGH-GRD ELECTRICAL PAPER'
       PROD(7)='ROOFING FELT'
       PROD(8)='ACETYLENE CYLINDERS'
       PROD(9)='FLOORING FELT'
       PROD(10)='CORRUGATED PAPER'
       PROD(11)='SPECIALTY PAPER'
       PROD(12)='V/A FLOOR TILE'
       PROD(13)='DIAPHRAGMS'
       PROD(14)='A/C PIPE'
       PROD(15)='A/C FLAT SHEET'
       PROD(16)='A/C CORRUGATED SHEET'
       PROD(17)='A/C SHINGLES'
       PROD(18)='DRUM BRAKE LIN. NEW'
       PROD(19)='DISC BRK PADS,LV,NEW'
       PROD(20)='DISC BRK PADS,HV'
       PROD(21)='BRAKE BLOCKS'
       PROD(22)='CLUTCH FACINGS'
       PROD(23)='AUTO. TRANS. COMP.'
       PROD(24)='FRICTION MATERIALS'
       PROD(25)='ASB PROTECT. CLOTH'
       PROD(26)='ASB THRD, YARN ETC'
       PROD(27)='SHEET GASKETS'
       PROD(28)='ASBESTOS PACKINGS'
       PROD(29)='ROOF COATINGS ETC'
       PROD(30)='OTHER COAT. & SEAL.'
       PROD(31)='ASB REINF. PLAST.'
       PROD(32)='MISSILE LINERS'
       PROD(33)='SEALANT TAPE'
       PROD(34)='BATTERY SEPARATORS'
       PROD(35)='ARC CHUTES'
       PROD(36)='DRM BRK LIN.,OLD'
       PROD(37)='DISC BRK PADS,LV,OLD'
       PROD(38)='MINING/MILLING'
       RETURN
       END
c
c
      SUBROUTINE PRNT(R,RR,N1,N2,N3,IP,TA,SS1,IYRS,IB,PPP,DISC,
     * NN,RRR1,RRR2)
C     THIS SUBROUTINE AGGREGATES AND PRINTS THE DATA ASSEMBLED
C       IN THE ACCUM SUBROUTINE
c
      REAL*8 S1,S2,RT,R,RR,RRT,TA,TTA,AVA,CR,CRRT,CRT,TRT,TRRT
       REAL*8 CTRT,CTRRT,PPP,RRR1,RRR2,DISC,SST,SS
       DIMENSION CR(4),CRRT(4),CRT(4),PPP(2,38)
       DIMENSION RRR1(38,8,11),RRR2(38,8,11),DISC(10),SST(11)
       DIMENSION SS(4,11)
      DIMENSION R(28,4),RT(4),RR(28,4),RRT(4),TA(18,4),TTA(4),AVA(4)
       DATA CR/1.09,1.56,1.02,1.0/
        TRT=0.
        TRRT=0.
        CTRT=0.
        CTRRT=0.
        DO 57 I=1,11
        SST(I)=0.0D0
```

```
 57      CONTINUE
         DO 59 I=1,4
         DO 61 J=1,11
         SS(I,J)=0.0D0
 61      CONTINUE
 59      CONTINUE
       DO 3 K=1,N2
       S2=0.
       S3=0.
       DO 4 I=1,28
        N=1+NN
        DO 27 KK=1,N
        IF(KK.EQ.N) SS(K,KK)=SS(K,KK)+RR(I,K)
        IF(KK.LT.N) SS(K,KK)=SS(K,KK)+(RR(I,K)*(1.0D0/(1.0D0+
     *  DISC(KK))**(I*5-3)))
 27     CONTINUE
4      S2=S2+R(I,K)
       RT(K)=S2
         CRT(K)=RT(K)*CR(K)
 3       CONTINUE
         DO 88 K=1,3
         TRT=TRT+RT(K)
         CTRT=CTRT+CRT(K)
         DO 89 KK=1,N
         SST(KK)=SST(KK)+SS(K,KK)
 89      CONTINUE
 88      CONTINUE
        DO 6 K=1,4
        S4=0.
        DO 7 I=1,18
 7      S4=S4+TA(I,K)
 6      TTA(K)=S4
        DO 8 K=1,4
        S5=0.
         IF(TTA(K).LE.0.0001) GOTO 8
        DO 14 I=1,18
 14     S5=S5+TA(I,K)/TTA(K)*(I*5-2.5)
  8     AVA(K)=S5
         PPP(IB,IP)=SS1
         IF(IB.EQ.2) GOTO 95
         DO 47 J=1,N
         DO 49 I=1,3
         RRR1(IP,I,J)=SS(I,J)
 49      CONTINUE
         RRR1(IP,4,J)=SST(J)
         DO 51 I=5,7
         II=I-4
         RRR1(IP,I,J)=SS(II,J)*CR(II)
 51      CONTINUE
         RRR1(IP,8,J)=SS(1,J)*CR(1)+SS(2,J)*CR(2)+SS(3,J)*CR(3)
 47      CONTINUE
         GOTO 99
 95      CONTINUE
         DO 67 J=1,N
         DO 69 I=1,3
         RRR2(IP,I,J)=SS(I,J)
 69      CONTINUE
         RRR2(IP,4,J)=SST(J)
         DO 71 I=5,7
         II=I-4
         RRR2(IP,I,J)=SS(II,J)*CR(II)
 71      CONTINUE
         RRR2(IP,8,J)=SS(1,J)*CR(1)+SS(2,J)*CR(2)+SS(3,J)*CR(3)
 67      CONTINUE
 99      CONTINUE
       RETURN
       END
c
c
       SUBROUTINE TOTAL(TOT1,IB,TT1,EXP1,PGBRK)
C
C       THIS SUBROUTINE PRINTS TOTALS FOR ALL PRODUCTS
c
        REAL*8 TOT1,TT1,EXP1,TD,TC,CR,TTD,TTC,TNP
        CHARACTER PGBRK
        DIMENSION TOT1(2,28,4),TD(28),TC(28),CR(4),
     * TT1(2,4)
         DATA CR/1.09,1.56,1.02,1.00/
         TTD=0.
         TTC=0.
```

```
          TNP=0.
          DO 7 I=1,28
          TD(I)=0.
          TC(I)=0.
 7        CONTINUE
         DO 1 I=1,4
         TT1(IB,I)=0.0
  1      CONTINUE
         DO 10 K=1,4
         DO 20 J=1,28
         TT1(IB,K)=TT1(IB,K)+TOT1(IB,J,K)
 20      CONTINUE
 10      CONTINUE
         DO 42 J=1,28
         DO 43 K=1,3
         TD(J)=TD(J)+TOT1(IB,J,K)
         TC(J)=TC(J)+(TOT1(IB,J,K)*CR(K))
 43      CONTINUE
 42      CONTINUE
         DO 44 K=1,3
         TTD=TTD+TT1(IB,K)
         TTC=TTC+(TT1(IB,K)*CR(K))
 44      CONTINUE
         DO 48 K=1,4
         TNP=TNP+TT1(IB,K)
 48      CONTINUE
         IF(IB.EQ.1) GOTO 46
         WRITE(3,95) PGBRK
 95      FORMAT(A,32X,'OUTPUT DATA 2',//)
         WRITE(3,62)
 62      FORMAT(25X,'       Totals for All Products-Baseline    ',///)
         GOTO 47
 46       WRITE(3,96) PGBRK
 96       FORMAT(A,32X,'OUTPUT DATA 1 ',//)
         WRITE(3,63)
 63      FORMAT(25X,' Totals for All Products - Alternative',///)
 47      CONTINUE
          WRITE(3,30)
 30       FORMAT(1X,'________________________________________',
      *   '_____________________________________',//)
         WRITE(3,64)
 64      FORMAT(1X,'TIME SINCE',3X,'LUNG CANCER',5X,'G.I.CANCER',5X,
      *  'MESOTHELIOMA',3X,'ALL EXCESS',5X,'ALL EXCESS')
         WRITE(3,65)
 65      FORMAT(1X,'EXP. ONSET',51X,'CANCER DEATHS',2X,'CANCER CASES')
         DO 50 I=1,28
         I1=(I-1)*5
         I2=I1+5
 50      WRITE(3,60) I1,I2,(TOT1(IB,I,J),J=1,3),TD(I),TC(I)
 60      FORMAT(I4,'-',I3,3F16.5,2f15.5)
          WRITE(3,76)
 76       FORMAT(1X,/)
         WRITE(3,70) (TT1(IB,J),J=1,3),TTD,TTC
 70      FORMAT(' TOTALS ',3F16.5,2f15.5,///)
          WRITE(3,30)
           RETURN
           END
c
c
             SUBROUTINE BANEFF(DISC,TOT1,TT1,IB,NN,RRR1,RRR2,PPP,NP,
      *   A,PGBRK,TEM1,TEM2)
c
          DIMENSION TOT1(2,28,4),DISC(10),
      *   TT1(2,4),DIF1(28,4),DD(28),DC(28),CR(4),TEM1(38,8,11),
      *   DT1(4),PPP(2,38),DIFP(38,8),TRRR(8),TEM2(38,8,11),
      *   DIS(10,5),RRR1(38,8,11),RRR2(38,8,11),DIFT(38,8),TRRM(8)
          REAL*8 TOT1,TT1,DIF1,DD,DC,TDD,TDC,CR,DIFT,TRRM,
      *   DIS,DISC,EXP1,RRR1,RRR2,PPP,DIFP,TRRR,TEM1,TEM2
          INTEGER A(38),NP
          CHARACTER PGBRK
          CHARACTER*25 PROD(38)
          DATA CR/1.09,1.56,1.02,1.00/
           N=1+NN
            DO 197 K=1,N
          DO 444 I=1,8
          TRRR(I)=0.0
          TRRM(I)=0.0
 444      CONTINUE
          DO 200 I=1,38
          DO 210 J=1,8
```

```
          DIFP(I,J)=0.0D0
          DIFT(I,J)=0.0D0
          DIFT(I,J)=TEM2(I,J,K)-TEM1(I,J,K)
          DIFP(I,J)=RRR2(I,J,K)-RRR1(I,J,K)
 210      CONTINUE
 200      CONTINUE
          DO 445 I=1,8
          DO 446 J=1,38
          TRRR(I)=TRRR(I)+DIFP(J,I)
          TRRM(I)=TRRM(I)+DIFT(J,I)
 446      CONTINUE
 445      CONTINUE
          CALL PR(PROD)
          IF(K.EQ.N) RR=0.
          IF(K.LT.N) RR=DISC(K)*100.
          DO 320 JJ=1,4
          IF (JJ.EQ.2) GO TO 330
          IF(JJ.EQ.3) GOTO 830
          IF(JJ.EQ.4) GOTO 840
          WRITE(3,230) PGBRK
 230      FORMAT(A,32X,'OUTPUT DATA 3',//)
          WRITE(3,240) RR
 240      FORMAT(4X,'Cancer Deaths Avoided by Product',
      *   ' Discounted from Time of Effect at ',F5.1,'%')
          GOTO 340
 330      WRITE(3,350) PGBRK
 350      FORMAT(A,32X,'OUTPUT DATA 4',//)
          WRITE(3,360) RR
 360      FORMAT(4X,'Cancer Cases Avoided by Product',
      *   ' Discounted from Time of Effect at ',F5.1,'%')
          GOTO 340
 830      WRITE(3,47) PGBRK
 47       FORMAT(A,32X,'OUTPUT DATA 3A',//)
          WRITE(3,471) RR
 471      FORMAT(3X,'Cancer Deaths Avoided by Product',
      *   ' Discounted from Time of Exposure at ',F5.1,'%')
          GOTO 340
 840      WRITE(3,48) PGBRK
 48       FORMAT(A,32X,'OUTPUT DATA 4A',//)
          WRITE(3,472) RR
 472      FORMAT(3X,'Cancer Cases Avoided by Product',
      *   ' Discounted from Time of Exposure at ',F5.1,'%')
 340      WRITE(3,250)
 250      FORMAT(1X,'________________________________________________',
      *   '_______________________________________________',//)
          WRITE(3,260)
 260      FORMAT(8X,'PRODUCT NAME',8X,'LUNG CANCER',2X,'GI CANCER',
      *   2X,'MESOTHELIOMA',2X,'TOTAL CANCER',//)
          IF(JJ.EQ.1.OR.JJ.EQ.3) ILOW=1
          IF(JJ.EQ.1.OR.JJ.EQ.3) IHIGH=4
          IF(JJ.EQ.2.OR.JJ.EQ.4) ILOW=5
          IF(JJ.EQ.2.OR.JJ.EQ.4) IHIGH=8
          IF(JJ.EQ.1) WRITE (7) (DIFP(I,IHIGH),I=1,38),TRRR(IHIGH)
          IF(JJ.EQ.2) WRITE (7) (DIFP(I,IHIGH),I=1,38),TRRR(IHIGH)
          IF(JJ.EQ.3) WRITE (7) (DIFT(I,IHIGH),I=1,38),TRRM(IHIGH)
          IF(JJ.EQ.4) WRITE (7) (DIFT(I,IHIGH),I=1,38),TRRM(IHIGH)
          DO 290 I=1,NP
          IP=A(I)
          IF(JJ.EQ.1.OR.JJ.EQ.2)
      *   WRITE(3,280) PROD(IP),(DIFP(IP,J),J=ILOW,IHIGH)
          IF(JJ.EQ.3.OR.JJ.EQ.4)
      *   WRITE(3,280) PROD(IP),(DIFT(IP,J),J=ILOW,IHIGH)
 280      FORMAT(3X,A25,F10.5,3X,F10.5,1X,F10.5,4X,F10.5)
 290      CONTINUE
          WRITE(3,300)
 300      FORMAT(3X,//)
          IF(JJ.EQ.1.OR.JJ.EQ.2)
      *   WRITE(3,310) (TRRR(I),I=ILOW,IHIGH)
          IF(JJ.EQ.3.OR.JJ.EQ.4)
      *   WRITE(3,310) (TRRM(I),I=ILOW,IHIGH)
 310      FORMAT(12X,'TOTAL',11X,F10.5,3X,F10.5,1X,F10.5,4X,F10.5)
          WRITE(3,250)
 320      CONTINUE
 197       CONTINUE
          WRITE(3,385) PGBRK
 385      FORMAT(A,32X,'OUTPUT DATA 5',//)
          WRITE(3,395)
 395      FORMAT(24X,'Number of People Exposed in Base Year')
          WRITE(3,250)
          WRITE(3,405)
```

```
405   FORMAT(12X,'PRODUCT',12X,'NUMBER OF PEOPLE',//)
      DO 415 I=1,NP
      IP=A(I)
      WRITE(3,425) PROD(IP),PPP(2,IP)
425   FORMAT(3X,A25,3X,F10.0)
415    CONTINUE
      WRITE(3,250)
      TDD=0.
      TDC=0.
      DO 24 I=1,28
      DD(I)=0.
      DC(I)=0.
24    CONTINUE
      DO 6 I=1,NN
      DO 5 J=1,5
      DIS(I,J)=0.D0
5     CONTINUE
6     CONTINUE
      DO 10 I=1,28
      DO 20 J=1,4
      DIF1(I,J)=(TOT1(2,I,J)-TOT1(1,I,J))
20    CONTINUE
10    CONTINUE
      DO 50 J=1,4
      DT1(J)=(TT1(2,J)-TT1(1,J))
50    CONTINUE
      DO 76 I=1,28
      DO 77 K=1,3
      DD(I)=DD(I)+DIF1(I,K)
      DC(I)=DC(I)+(DIF1(I,K)*CR(K))
77    CONTINUE
76    CONTINUE
      DO 79 K=1,3
      TDD=TDD+DT1(K)
      TDC=TDC+(DT1(K)*CR(K))
79    CONTINUE
      DO 55 K=1,NN
      DO 70 J=1,3
      DO 80 I=1,28
       DIS(K,J)=DIS(K,J)+DIF1(I,J)*(1.D0/(1.D0+DISC(K))**(I*5-3))
80    CONTINUE
70    CONTINUE
55    CONTINUE
      DO 56 K=1,NN
      DO 83 I=1,28
       DIS(K,4)=DIS(K,4)+DD(I)*(1.0D0/(1.D0+DISC(K))**(I*5-3))
       DIS(K,5)=DIS(K,5)+DC(I)*(1.0D0/(1.D0+DISC(K))**(I*5-3))
83    CONTINUE
56    CONTINUE
      WRITE(3,437) PGBRK
437   FORMAT(A,32X,'OUTPUT DATA 6',//)
      WRITE(3,120)
120   FORMAT(15X,'Cancers Avoided for All Products by Time Period')
      WRITE(3,250)
       WRITE(3,87)
87     FORMAT(1X,'TIME SINCE',3X,'LUNG CANCER',3X,'GI CANCER',
     * 3X,'MESOTHELIOMA',3X,'ALL EXCESS',3X,'ALL EXCESS')
       WRITE(3,88)
88     FORMAT(1X,'START OF',46X,'DEATHS',7X,'CASES')
       WRITE(3,489)
489   FORMAT(1X,'ANALYSIS',//)
      DO 130 I=1,28
      I1=(I-1)*5
      I2=I1+5
130    WRITE(3,140) I1,I2,(DIF1(I,J),J=1,3),DD(I),DC(I)
140    FORMAT(3X,I4,'-',I3,3X,F10.4,4X,F10.4,2X,F10.4,5X,F10.2,
     * 3X,F10.2)
       WRITE(3,796)
796    FORMAT(1X,/)
     WRITE(3,78) (DT1(J),J=1,3),TDD,TDC
 78    FORMAT(4X,'TOTAL',5X,F10.4,4X,F10.4,2X,F10.4,5X,F10.2,
     * 3X,F10.2,/)
       WRITE(3,478)
478    FORMAT(1X,'DISCOUNTED TOTALS',/)
       DO 27 K=1,NN
       RR=DISC(K)*100.
       WRITE(3,81) RR,(DIS(K,J),J=1,5)
81     FORMAT(1X,F5.2,' PERCENT'3X,F10.4,4X,F10.4,2X,F10.4,5X,
     * F10.2,3X,F10.2)
27     CONTINUE
```

```
      WRITE(3,250)
      RETURN
      END
c
c
      SUBROUTINE LIST
C
      THIS SUBROUTINE LISTS TO THE SCREEN THE PRODUCT NUMBERS AND THEIR
      ASSOCIATED REFERENCE NUMBERS.
C
C
      WRITE(*,*) ' List of Products and Their Reference Numbers: '
      WRITE(*,*)
      WRITE(*,*) ' 1-COMMERCIAL PAPER         19-DISC BRK PADS,LV,NEW'
      WRITE(*,*) ' 2-ROLLBOARD                20-DISC BRK PADS,HV'
      WRITE(*,*) ' 3-MILLBOARD                21-BRAKE BLOCKS'
      WRITE(*,*) ' 4-PIPELINE WRAP            22-CLUTCH FACINGS'
      WRITE(*,*) ' 5-BEATER-ADD GASKETS       23-AUTO.TRANS.COMP '
      WRITE(*,*) ' 6-HGH-GRD ELECTRICAL PAPER 24-FRICTION MATERIALS'
      WRITE(*,*) ' 7-ROOFING FELT             25-ASB PROTECT. CLOTH'
      WRITE(*,*) ' 8-ACETYLENE CYLINDERS      26-ASB THRD,YARN,ETC'
      WRITE(*,*) ' 9-FLOORING FELT            27-SHEET GASKETS '
      WRITE(*,*) '10-CORRUGATED PAPER         28-ASBESTOS PACKINGS '
      WRITE(*,*) '11-SPECIALTY PAPER          29-ROOF COATINGS ETC'
      WRITE(*,*) '12-V/A FLOOR TILE           30-OTHER COAT. & SEAL.'
      WRITE(*,*) '13-DIAPHRAGMS               31-ASB.-REINF. PLAS'
      WRITE(*,*) '14-A/C PIPE                 32-MISSILE LINERS'
      WRITE(*,*) '15-A/C FLAT SHEET           33-SEALANT TAPE'
      WRITE(*,*) '16-A/C CORRUGATED SHEET     34-BATTERY SEPARATORS'
      WRITE(*,*) '17-A/C SHINGLES             35-ARC CHUTES'
      WRITE(*,*) '18-DRUM BRAKE LININGS,NEW   36-DRM BRK LIN,OLD'
      WRITE(*,*) '                            37-DISC BRK PADS,LV,OLD'
      WRITE(*,*) '                            38-MINING/MILLING'
      PAUSE 'Press the <RETURN> or the <ENTER> key to continue'
      RETURN
      END
```

A.6 ADDITIONAL OCCUPATIONAL AND NONOCCUPATIONAL EXPOSURE ASSUMPTIONS FOR SENSITIVITY ANALYSIS

In Volumes I and IV of this Regulatory Impact Analysis, costs and benefits of Regulatory Alternative J are examined using additional exposure assumptions for exposure settings for which exposures to asbestos are believed to occur but for which no quantitative information exists. This appendix reviews the sources for these additional exposure assumptions for both occupational and nonoccupational exposure settings.

A. Additional Occupational Exposure Assumptions

For a number of asbestos products, quantitative exposure information was not available for primary manufacturing, installation, and repair and dispose concerning occupational exposures to asbestos. Yet, exposures in these settings are believed to occur despite the lack of quantitative information. This omission of exposures that occur from the cost/benefit results presented in this RIA could cause a substantial underestimate of the actual benefits likely to be gained by the various regulatory alternatives examined.

To address this lack of data and potential underestimate of benefits, where possible, occupational exposures in a number of settings were estimated based on old studies, secondary sources, and occupational exposures associated with analogous products and exposure settings. In particular, quantitative exposure information was estimated for the following occupational exposure settings based on these "analogous products" and related imputation methods:

- Acetylene Cylinders: primary manufacturing
- Millboard: installation, repair/disposal
- Pipeline Wrap: installation, repair/disposal
- Beater-add Gaskets: installation, repair/disposal
- High-grade Electrical Paper: installation, repair/disposal
- Specialty Paper: installation, repair/disposal
- A/C Pipe: repair/disposal
- Sheet Gaskets: installation, repair/disposal
- Packings: installation, repair/disposal
- Non-Roof Coatings: installation
- Missile Liner: installation

Table A.6-1 presents a complete set of occupational exposure information including the imputed information for these exposure settings. In the right-most column of the exhibit and in the footnotes to the exhibit, explanatory notes describe the rationale for, and the sources of, the additional exposure information for these exposure settings for these products. In most cases, the additional exposure information was based on the set of activities (such as cuttings and sanding) likely to be performed with the asbestos product in the particular exposure setting for which data on exposures did not exist. The associated levels of exposure for these settings were then based on products and exposure settings which involve similar activities. Thus, the additional occupational exposures are, in some sense, "analogous" exposures based on products and exposure settings for which information concerning occupational exposures does exist.

B. Additional Nonoccupational Exposure Assumptions

In a large number of cases, quantitative information concerning nonoccupational exposures to asbestos in product use was not available, but exposures in these settings are nevertheless suspected. If these exposures do occur, then the benefits of the various regulatory alternatives examined in this RIA will underestimate the actual benefits likely to be obtained through the asbestos product controls. Hence, to examine the impact of these omitted nonoccupational exposures in 17 of the product categories, assumptions concerning the rate of release of the asbestos over time were made. The 17 products for which such assumptions were made are:

- Millboard
- Pipeline Wrap
- Beater-add Gaskets
- High-grade Electrical Paper
- Asbestos-Cement Pipe
- Flat A-C Sheets
- Corrugated A-C Sheets
- A-C Shingles
- Disc Brake Pads (HV)
- Clutch Facings
- Friction Materials
- Asbestos Sheet Gasketing
- Asbestos Packing
- Roof Coatings and Cements
- Non-Roofing Coatings, Compounds, and Sealants
- Asbestos-Reinforced Plastics
- Sealant Tape

In all cases, the assumption made regarding releases of asbestos from these products during use was that one percent of the asbestos contained in the product would be released during each year of the useful life of the product. The rationale for these releases is that various activities, such as cutting, sanding, friction-related abrasion, and similar actions that may release asbestos from the products occur throughout the life of the product. For population exposed, the assumption made was that the exposed population equals the urban population of the U.S.

Table A.6-2 presents these assumed nonoccupational exposure data for the 17 product categories affected, listing both the assumed population exposed and the exposure concentration in millions of fibers per year.

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
1. Commercial Paper	N/A[a]	N/A[a]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
2. Rollboard	N/A[a]	N/A[a]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
3. Millboard	12	145	448	57	N.K.	Similar to secondary manufacturing 57[m]	N.K.	See Notes 57[m]	Installation may include cutting to size and sanding, as does secondary manufacturing. If repair involves cutting, exposures for repair/disposal may be similar to installation and secondary manufacturing. If the material is simply removed and disposed, exposures would be lower, as asbestos is encapsulated, unless the material has begun to disintegrate from wear.
4. Pipeline Wrap	27	134	N/A[c]	N/A[c]	N.K.	See Notes 52[n]	N.K.	See Notes <23[n]	Reported installation exposures for pre-cut pipeline wrap saturated with tar range from non-detectable to 0.02 f/cc at three sites (uncertain if these are short-term or long-term exposures).[g] Mean exposure level calculated from reported data is approximately 0.02 f/cc (assuming levels reported as non-detectable to be 0.003 f/cc; the actual detection limit was not reported). Exposure from repair/disposal: reported exposures from pipe stripping and refurbishing at one site were all non-detectable (<0.003 f/cc-<0.02 f/cc) for 14 personal samples (sampling time 171-420 minutes).[g] Mean exposure level calculated to be <0.009.

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
5. Beater-Add Gaskets	227	110	1,264	57	N.K.	Similar to secondary manufacturing 57[m]	N.K.	See Notes 57[m]	Paper product installation may include cutting, as does secondary manufacturing; exposure unlikely during installation if there is no cutting, as asbestos is encapsulated. If repair involves cutting, exposures for repair/disposal may be similar to installation and secondary manufacturing. If the material is simply removed and disposed, exposures would be lower, as asbestos is encapsulated, unless the material has begun to disintegrate from wear.
6. High-Grade Electrical Paper	27	113	20	57	N.K.	Similar to secondary manufacturing 57[m]	N.K.	See Notes 57[m]	Paper product. Installation may include cutting, as does secondary manufacturing; exposures unlikely during installation if there is no cutting, as asbestos is encapsulated. If repair involves cutting, exposures for repair/disposal may be similar to installation and secondary manufacturing. If the material is simply removed and disposed, exposures would be lower, as asbestos is encapsulated, unless the material has begun to disintegrate from wear.
7. Roofing Felt	N/A[a]	N/A[a]	N/A[d]	N/A[d]	396	439	263	296	Installation includes application of roof coating by mopping.

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
8. Acetylene Cylinders	162[j]	Similar to primary manufacturing of coatings 200[m]	N/A[c]	N/A[c]	N/A[e]	N/A[e]	Exposure Unlikely		Produced by wet mixing, as are coatings; fiber introduction step most likely to lead to exposure, as for coatings. Repair/disposal exposure unlikely, as entire cylinder would be disposed or reused without removal of asbestos filler.
9. Flooring Felt	N/A[a]	N/A[a]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
10. Corrugated Paper	N/A[a]	N/A[a]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
11. Specialty Paper	6	111	145	57	N.K.	Similar to secondary manufacturing 57[m]	N.K.	See Notes 57[m]	Paper product (beverage filters). Installation may include cutting, as does secondary manufacturing; exposure unlikely if there is no cutting, as asbestos is encapsulated. If repair involves cutting, exposures for repair/disposal may be similar to installation and secondary manufacturing. If the material is simply removed and disposed, exposures would be lower, as asbestos is encapsulated, unless the material has begun to disintegrate from wear.
12. V/A Floor Tile	N/A[a]	N/A[a]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
13. Diaphragms	650	87	N/A[c]	N/A[c]	N/A[e]	N/A[e]	N/A[e]	N/A[e]	
14. A/C Pipe	286	270	N/A[c]	N/A[c]	921	296	N.K.	See Notes 296[m]	For repair/disposal of A/C pipe, the greatest exposure would occur during pipe-cutting operations, as is the case for installation. Therefore, exposures for repair/disposal are likely to be similar to installation.

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
15. A/C Flat Sheet	12	478	N/A[c]	N/A[c]	16	723	20	2,080	
16. A/C Corrugated Sheet	N/A[a]	N/A[a]	N/A[c]	N/A[c]	7	723	9	2,080	
17. A/C Shingles	11	473	N/A[c]	N/A[c]	236	130	164	244	
18. Drum Brake Linings	1,115	385	1,937	125	N/A[h]	N/A[h]	75,404	376	
19. Disc Brake Pads, LMV	815	390	267	146	N/A[h]	N/A[h]	39,441	386	
20. Disc Brake Pads, HV	14	385	<1	Similar to secondary manufacturing of Disc Brake Pads, LMV 146[m]	N/A[h]	N/A[h]	117	390	Disc Brake Pads, HV, are very similar to Disc Brake Pads, LMV, except for size. Secondary manufacturing processes would be similar.
21. Brake Blocks	232	377	16	127	N/A[h]	N/A[h]	3,865	388	
22. Clutch Facings	239	406	48	166	N/A[h]	N/A[h]	100	125	
23. Automatic Transmission Components	1	113	<1	Similar to secondary manufacturing of Specialty Paper 57[m]	N/A[f]	N/A[f]	Exposure Unlikely		Secondary manufacturing similar to Specialty Paper, as both are paper products (transmission components are 15 percent asbestos, specialty paper is 5-50 percent asbestos); processes would involve cutting and shaping. Exposure unlikely in repair/disposal, as entire transmission would be removed, and automotive transmission components are enclosed and wet.
24. Friction Materials	187	398	27	195	N/A[h]	N/A[h]	57	120	
25. Protective Clothing	N/A[a]	N/A[a]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)[a]
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
26. Thread, Yarn, etc.	78	457	208	408	See Notes N/A	See Notes N/A	See Notes N/A	See Notes N/A	The primary use of asbestos thread and yarn is for brake blocks, and clutch facings; installation and repair/disposal of these products would be included under brake blocks and clutch facings. This product is used to a lesser extent for packings and gaskets; installation and repair/disposal would be included under packings and gaskets. A small amount is used for specialty products, for which little information is available.
27. Sheet Gaskets	163	208	878	276	N.K.	Similar to secondary manufacturing 276[m]	N.K.	See Notes 276[m]	Installation may include cutting and shaping, as does secondary manufacturing; exposure is unlikely during installation if there is no cutting, as asbestos is encapsulated. One data point for installation of gaskets (assumed to be sheet gaskets, based on processes listed) is available; the number given is <0.03 fibers/cc (probably short-term).[i] This level is considerably lower than that for secondary manufacturing. If repair involves cutting, exposures for repair/disposal may be similar to installation and secondary manufacturing. If the material is simply removed and disposed, exposures would be lower, as asbestos is encapsulated, unless the material has begun to disintegrate from wear. If the gaskets are wet during use, lower exposures would be expected. Reported exposures

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
27. Sheet Gaskets (Continued)									for repair/disposal are 0.09 f/cc for removal and concurrent installation; 0.13 f/cc for removal and hand scraping; and 0.11 f/cc for removal and wire brushing.[1] These levels are very similar to that for secondary manufacturing. No details are reported on the operation monitored, the use of the gaskets, and whether the gaskets were wet or dry.
28. Asbestos Packings	5	198	25	276	N.K.	Similar to secondary manufacturing 276[m]	N.K.	See Notes 276[m]	Installation may include cutting and shaping, as does secondary manufacturing; exposure during installation is likely to be lower if there is no cutting, although it might be higher than for gaskets because installation of packing might involve more manipulation of the material. If repair involves cutting, exposures for repair/disposal may be similar to installation and secondary manufacturing. If the material is simply removed and disposed, exposures would be lower, as asbestos is encapsulated, unless the material has begun to disintegrate from wear.
29. Roof Coatings	438	273	N/A[c]	N/A[c]	N.K.	See Notes 130[n]	See Notes N/A	See Notes N/A	Installation of roofing felt includes application of coating by mopping. Up to 90 percent of roof coatings are applied by trowel or brush.[1] Application of coating by spray would probably produce higher exposures, but not very high, because roof coatings

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
29. Roof Coatings (Continued)									contain only 5-10 percent asbestos, and the fibers would be wet. Reported exposures for spray-applied asphaltic roof coating range from 0.003 to 0.15 f/cc (sampling time 342 to 432 minutes) and 0.01 to 0.3 f/cc (sampling time not given).[k] Mean exposure level calculated from reported data for spray application is approximately 0.17 f/cc. No data are available for non-spray application of roof coatings; for painting with resin coatings, reported exposures are 0.0-0.06 f/cc (sampling time 5-23 minutes.)[k] Mean exposure level calculated from reported data for painting is approximately 0.04 f/cc. Assuming that non-spray application of roof coating would produce approximately the same exposure level as painting with resin coatings, and assuming that application of roof coatings is 90 percent non-spray, the overall mean exposure level is calculated to be 0.05 f/cc. Repair/disposal of roof coatings is included under repair/disposal of roofing felt.

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
32. Missile Liners	380[j]	220	N/A[c]	N/A[c]	N.K.	See Notes 57[m]	Exposure Unlikely		Exposures during installation possible if material is cut to size; level likely to be low as liner is a rubbery material and asbestos is encapsulated. Might be comparable to secondary manufacture of paper products, as the process involves cutting and asbestos is encapsulated. Exposure unlikely from repair/disposal as missile is destroyed during use.
33. Sealant Tape	134[j]	220	N/A[c]	N/A[c]	Exposure Unlikely		See Notes N/A	See Notes N/A	Exposures during installation unlikely because material is a rubber tape, with asbestos encapsulated. Exposures during repair/disposal unlikely, as asbestos is encapsulated, unless material has begun to disintegrate from wear.
34. Battery Separators	207[j]	Similar to primary manufacturing of pipeline wrap 134[m]	N/A[c]	N/A[c]	N/A[e]	N/A[e]	Exposure Unlikely		Product is a mat-type material which may be made by a process similar to felts (e.g., pipeline wrap), with similar exposures. Exposures unlikely from repair/disposal as entire product would be disposed with asbestos enclosed and the separator would probably be wet.

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

Product	Primary Manufacturing		Secondary Manufacturing		Installation		Repair/Disposal		Notes
	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	Number of People	Million Fibers/ Year	
35. Arc Chutes	2	Similar to primary manufacturing of reinforced plastics 164[m]	N/A[c]	N/A[c]	Exposure Unlikely		Exposure Unlikely		Product is ceramic with asbestos incorporated. Details of the manufacturing process are not available, but presumably fiber introduction, mixing, and molding with heat would be included. Process used and fiber content may be similar to reinforced plastics; therefore, exposures may be similar. Exposures unlikely from installation and repair/disposal because asbestos is encapsulated in ceramic.
36. Mining/Milling	155	121	N/A	N/A	N/A	N/A	N/A	N/A	

* Occupational exposure from use of asbestos products is difficult to quantify. Workers may be exposed to asbestos in an occupational setting because of the presence of asbestos in the building or in equipment used; asbestos may be released because of wear. Asbestos released by wear of materials is part of interior and exterior ambient loading, and, therefore, should be included in non-occupational exposure rather than in occupational exposure.

N/A = Not Applicable.
N.K. = Not Known.

[a]No longer produced in U.S.

[b]No longer produced in U.S., not imported into U.S.

[c]No secondary manufacturing reported.

[d]No longer produced in U.S., no secondary manufacturing reported on imports.

[e]Included in primary manufacturing process.

[f]Included in secondary manufacturing process.

[g]Power Marketing Group, Inc. 1986. Brief presented to the United States Environmental Protection Agency relating to a proposal to phase out uses of asbestos. Pipe wrapping: Irish Pipe Coating Company, Inc., Asbestos Sampling During Pipe Wrapping; Liberty Mutual, Baumann Coating, Pipe Wrapping Operation-Airborne Asbestos; Armor Cote, Processing Line-Pipe Wrapping. Pipe stripping: Asbestos Monitoring Survey and Respirator Training and Fit Testing, Ameron-Price Co.

[h]Installation in original equipment included in secondary manufacturing process; installation of replacement parts included in repair/disposal.

Table A.6-1.

Exposure Levels (in million fibers inhaled per year) and
Number of Persons Exposed for Occupational Settings (Use of Products Not Included)*
(Continued)

[i]Liukonen LR, Still KR, Beckett RR. 1978. Asbestos exposure from gasket operations. Bremerton, WA: Industrial Hygiene Branch, Occupational and Environmental Health Service, Naval Regional Medical Center.

[j]Employees probably not exposed to asbestos full-time, based on asbestos consumption.

[k]Anderson PH, Grant MA, McInnes RG, Farino WJ. 1982. GCA Corporation. Analysis of fiber release from certain asbestos products. Draft final report. Washington, D.C.: Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency. Contract No. 68-01-5960.

[l]Rose T. 1987. Telephone conversation between Tom Rose, Rose Roofing, Arlington, VA, and ICF Inc., April 1, 1987. As cited in Asbestos Exposure Assessment.

[m]Exposure level is estimated based on comparison to other products or processes, not on actual data, and should be used with caution. See notes for individual products.

[n]Exposure level is estimated based on limited data from studies that may be old and/or not described in detail. Various assumptions are included in the estimates concerning information that may not be reported, such as sampling time and limits of detection. Estimate should be used with caution. See notes for individual products.

TABLE A.6-2. ADDITIONAL NONOCCUPATIONAL EXPOSURE ASSUMPTIONS FOR USE OF PRODUCTS

	Occupational		Nonoccupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard			171,136,373	0.000026148
4. Pipeline Wrap			171,136,373	0.000080247
5. Beater-add Gaskets			171,136,373	0.003730921
6. High-grade Elect. Paper			171,136,373	0.000372
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe			171,136,373	0.000980582
15. A/C Flat Sheet			171,136,373	0.000154728
16. A/C Corrugated Sheet			171,136,373	0.000016497
17. A/C Shingles			171,136,373	0.000145989
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV			171,136,373	0.000352845
21. Brake Blocks				
22. Clutch Facings			171,136,373	0.000297445
23. Auto. Transmiss. Comp.				
24. Friction Materials			171,136,373	0.004813187
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets			171,136,373	0.001631991
28. Asbestos Packings			171,136,373	0.0001872
29. Roof Coatings			171,136,373	0.004433279
30. Non-Roofing Coatings			171,136,373	0.000442663
31. Asb. Reinforced Plastics			171,136,373	0.001218152
32. Missile Liners				
33. Sealant Tape			171,136,373	0.000126915
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Mining and Milling				

APPENDIX B: <u>CAPITAL CONVERTIBILITY AND QUASI-RENTS DETERMINATION</u>

This appendix presents a detailed analysis of the derivation of quasi-rents used in estimating the costs and effects of the various regulatory alternatives examined in this study. The appendix is organized into two major sections. Section 1 (1) presents the theoretical approach for calculating quasi-rents, (2) indicates exactly how these estimates of quasi-rents enter the regulatory alternative simulation model, and (3) calculates quasi-rents for the various product markets. The second section of the appendix contains a report from PEI Associates on capital convertibility and the costs of exit from these various asbestos product markets. The data contained in the memoranda contained in this section are the input information for the calculations performed in first section.

1. Calculation of Quasi-Rents for Asbestos Product Markets

1.1 Introduction

The proposed regulation of asbestos products calls for bans of certain asbestos products, a phase-down of asbestos fiber use, or a combination of the two. In the case of a ban, this means that the affected products can no longer be manufactured, and in the case of the phase-down, manufacture of the asbestos-product may be limited and at the end of the phase-down period the product will no longer be manufactured. In either case, some of the affected industries may have to find an alternative use for their existing equipment (given that it has useful life remaining) by adapting or converting the equipment to manufacture substitute products.

If this conversion is feasible, there may be costs associated with doing so. On the other hand, in the event that such conversion is not feasible, the existing equipment may have to be sold to industries using similar equipment, sold as scrap, or disposed as waste in a landfill. In any case (unless conversion to the substitute manufacture is costless), the returns to capital in the asbestos-product manufacturing industries will not be the same under the regulations as in the baseline. In more formal terms, this implies that producers of the asbestos products enjoy "quasi-rents" from the use of the existing capital in the manufacture of these products in the baseline, and may suffer a loss of quasi-rents depending on the final form of the proposed regulation.[1]

This memorandum presents the calculation of the quasi-rents per unit output per year for each of the industry segments potentially affected by the regulations and is organized into three sections:

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[1] The concepts of "quasi-rent" and "rent" have a long history in economics. Traditionally, rent refers to the return to a factor of production that is permanently in fixed supply, such as land. Quasi-rent refers to the return to a factor of production that is only temporarily in fixed supply, such as the physical plant of a firm. Although this is not the only possible definition of quasi-rent, it is widely used and is the one employed here. Thus, quasi-rents are returns to an asset in a particular use which exceed those available in other uses.

- Section 1.2 presents the theoretical approach for calculating the quasi-rents per unit output per year. This approach considers transferability of capital to an alternative use (where these alternative uses consist of existing substitute products), conversion costs, sale of used equipment, disposal costs, losses in production efficiency, and reformulation costs.

- Section 1.3 presents the least cost options[2] and the relevant data used in the calculation of the quasi-rent per unit output per year for each industry segment based on engineering cost estimates.

- Section 1.4 presents the results of applying the theoretical approach to the data for each industry segment. Quasi-rents per unit output per year for each industry segment presented in this section are used as inputs for the Asbestos Regulatory Cost Model (ARCM).

1.2 Theoretical Approach for Calculating Quasi-Rents

This section presents the approach used for calculating the streams of quasi-rents enjoyed by producers of asbestos-products in the baseline, i.e, the quasi-rents per unit output per year for the period of the scenario. Each factor included in these calculations is discussed in detail below. Throughout the analysis, only existing substitute products and processes are included in considering alternative employment of the capital equipment possessed by producers of asbestos-containing products. Thus, the quasi-rents calculated here would be overestimates if new processes or products were developed in which the asbestos-related equipment could be used.

1.2.1 Quasi-Rents in a Dynamic Decision-Making Framework

The ARCM simulates prices and quantities for the various asbestos product markets and the asbestos fiber market over the period of the regulatory scenario. However, the individual firm's decision to convert from producing the asbestos product to producing the substitute product is a decision based on how it projects market conditions over time. Given rational behavior, the firm will undertake the conversion of the existing equipment only when the present value cost of using asbestos fiber becomes prohibitive, i.e., the present value cost of the asbestos product becomes greater than the present value of switching.[3] The ARCM, on the other hand, "walks" forward through time and, as such, can only model myopic producer behavior. That is, information for future periods in the model is not available until the model

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[2] Engineering cost estimates of various options available to each industry were prepared for EPA by PEI Associates. This appendix presents the least cost option for each industry segment.

[3] This is applicable for firms producing asbestos products under a phase-down. In the case of a ban, the conversion will take place in the first year of the particular product's ban. Furthermore, in cases where an asbestos product has more than one substitute, the capacity dedicated to satisfying the particular substitute segment's demand will be converted as the relevant "switching" conditions are met for that segment.

reaches those periods. Thus, dynamic rational decision making cannot be explicitly modeled in the ARCM.

Despite this limitation, our approach to modelling producer decisions regarding capital conversion during the regulation's implementation is designed to mimic rational forward-looking decisions as much as possible. In the ARCM, firms "bid" for fiber each year with the quasi-rents that accrue to them in the manufacture of the asbestos product (quasi-rents are annualized over the useful life of the existing equipment). This approach, however, yields correct conclusions regarding switching if the useful life of the equipment is less than or equal to the time spanned by the scenario. In the cases where the existing equipment may last beyond the duration of the scenario,[4] this approach will not necessarily generate correct producer decision making on the timing of switching their capital to alternative uses.

To model rational producer behavior in cases where the life of the equipment exceeds the length of the scenario, we first define the present value of quasi-rents as the costs associated with exit (conversion costs, cleanup costs, lost capital value, etc.). This makes sense because it is the costs of transferring the equipment to alternate uses (including possible loss of the entire value of the equipment) that form the surpluses, or quasi-rents, enjoyed by producers of asbestos products. Next, the present value of the quasi-rents are treated as perpetuities.[5] That is, the costs of transferring the equipment to alternative uses (or scrap as the case may be) are converted to an infinite stream of yearly quasi-rents. These are then used in the ARCM for simulating firms' bidding strategies for fiber.

Analytically, expressing quasi-rents as a perpetuity avoids under- or over-estimating quasi-rents in the ARCM and, at the same time, mimics rational forward-looking producer behavior. Firms will bid away the quasi-rent flow (expressed as a perpetuity) <u>up to the point at which it is no longer worthwhile not to convert the equipment</u>. If the fiber cost to producers exceeds the perpetuity this means that, in a present value sense, it is cheaper to convert than not to. Put differently, if the potential loss in a given year by not converting and continuing to purchase fiber exceeds the potential benefit of delaying conversion (hence, the perpetuity construction), then it is better to convert. Furthermore, as long as the full price of fiber (i.e., the valuable rights to purchase or use asbestos fiber under a fiber phase-down plus the fiber cost) continues to rise over time, the timing of the decision to convert as predicted by the ARCM using the perpetuity construction is precisely the same as that which would result from a forward-looking rational expectations model. This method also ensures that the present value of the quasi-rent loss is correctly measured and cannot exceed the original present value of the quasi-rents for the relevant equipment.

To summarize, a firm will continue producing the asbestos product until the full price of fiber is greater than the sum of the price of the cheapest substitute <u>and</u> the relevant quasi-rent perpetuity. At such a point in the

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[4] PEI reports that this may be true for all industry segments.

[5] The idea behind treating quasi-rents as perpetuities is that the quasi-rent per unit of output per year will reflect the value of avoiding the conversion costs per unit of output per year.

scenario, the capacity devoted to satisfying the demand for this particular substitute segment will be converted.[6] At this time, conversion costs will be incurred and quasi-rent perpetuity losses will cease to accrue in the following years. This process continues until all the capacity has been converted and the industry no longer manufactures the asbestos product.

1.2.2 Selection of Conversion Option for Industry Segments

The memoranda from PEI Associates present various options and their associated costs for the conversion/disposal of existing equipment available to each industry segment. The least cost option for each industry segment is selected for use in the calculation of the quasi-rent per unit output per year. The logic behind this is that when faced with an asbestos product ban or phase-down, producers will elect the course of action that preserves the greatest portion of their asset values or costs the least to implement. Hence, these are referred to as "least cost options." For example, in the memorandum on asbestos-cement pipes, four options for conversion/disposal of existing capital are identified.[7] In the case of A-C pipes, all options are plant closure options since existing equipment cannot be converted for use in the manufacture of the substitute product currently being produced. These options and their costs for an A-C pipe plant with a capacity of 200 tons per day are:[8]

- Disposal of equipment in a hazardous waste landfill $600,000
- Cleanup of equipment and resale of equipment $670,000
- Cleanup of equipment and disposal in a sanitary landfill $1,144,000
- Cleanup of equipment and sale as scrap $992,000

Therefore, the cost of the least cost option used in the calculation of quasi-rents in the A-C pipe industry is the sum of the value of the existing capital and the one-time cost of disposal of all equipment in a hazardous waste landfill.[9]

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[6] The assumptions underlying this approach are: (1) capacity is convertible in amounts equal to segment demands, and (2) the full price of the fiber remains the same or increases over the period of the scenario.

[7] Section 2 of this appendix.

[8] All costs include cleanup and repair of building where equipment has been removed.

[9] The inclusion of one-time costs in the calculation of quasi-rents is discussed below.

1.2.3 Transferability of Capital

Industries in which capital cannot be transferred into an alternative use, i.e, the manufacture of the substitute product, the quasi-rents perpetuity per unit output is calculated from the cost of the capital per unit output minus any value recouped through resale of used machinery or sale of the machinery as scrap.[10] For industries in which capital can feasibly be transferred to the manufacture of the substitute product, the perpetuity of the quasi-rents per unit output is calculated based on the conversion costs incurred (per unit output) to adapt/convert the existing machinery for use in the manufacture of the substitute product.

1.2.4 Disposal of Capital

If the capital is not transferable (or wholly transferable) in some cases it may be sold as used equipment or scrap. In any case, equipment in direct contact with asbestos will need to be cleaned prior to sale since asbestos is a hazardous substance. Furthermore, in the event that no resale or scrap markets exist, the equipment will have to be disposed of in a landfill. This can be achieved in two ways: 1) disposal of all equipment in a sanitary landfill after all equipment in contact with asbestos has been cleaned, or 2) disposal of all equipment in contact with asbestos in a hazardous waste landfill and the remaining equipment in a sanitary landfill. The actual choice will depend on the relative costs of the two options. Finally, the areas where the asbestos product is manufactured must be cleaned before any alternative production can commence.[11]

The costs of cleaning and disposal can be substantial in some cases and are included in the calculation of quasi-rents. Strictly speaking, these are one-time costs and do not quite qualify as quasi-rents for the machinery *per se*, however, they will definitely be part of the producer surplus losses suffered by the manufacturers of asbestos products once the regulation comes into effect. These costs have therefore been included in the calculation of quasi-rents, since our goal is to define producer surplus losses.

1.2.5 Losses in Production Efficiency

In addition to the costs of cleaning and disposing of certain equipment not transferable to the manufacture of the substitute product, conversion of capital may entail another economic cost -- the equipment used in the manufacture of the asbestos product may not perform as efficiently in the manufacture of the substitute product. However, this loss in production efficiency is not a contributing factor in the calculation of quasi-rents unless the loss is caused by the express use of the equipment designed for use

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[10] The PEI report indicates that in most cases the existing capital can last for a long time with minimal maintenance. Therefore, the cost of equipment used in the calculation of quasi-rents is the cost of a new installation (non-greenfield) for a relevant industry segment. This may overstate the quasi-rents because the machinery is not new, making the results upper bounds for such losses.

[11] This is also true for the cases where capital is transferable into an alternative use.

with asbestos in the manufacture of the substitute product. This means that if alternative equipment available for the manufacture of the substitute product performs better than the converted equipment, then this loss in production efficiency is definitely a contributing factor. However, if the same equipment used in the manufacture of asbestos products is used in the manufacture of substitute products and the loss in production efficiency is caused by the use of substitute materials (i.e., if a new plant set up for the manufacture of the substitute product would face the same production efficiency loss), then the loss in production efficiency is an outcome of the current state of technology and cannot be considered a contributing factor in the calculation of the quasi-rents.[12]

If the production efficiency losses qualify for inclusion in the calculation of the quasi-rents, then the percentage of capital value equal to the percentage drop in production efficiency is included in the stream of quasi-rents enjoyed by producers of the asbestos products in the baseline.

1.2.6 Reformulation Costs

Industries in which the existing equipment is converted for use in the manufacture of the substitute product may incur some "reformulation" costs, i.e., costs incurred for research and development of a suitable substitute or substitute mixture to replace asbestos in the formulation of the affected product. Reformulation costs may be incurred for each product line manufactured. For example, in the coatings and sealants industry, various types of coatings using asbestos are produced and each of these coatings will have to be reformulated with an appropriate substitute or substitute mixture.

Reformulation costs may be incurred by each individual firm if the information is proprietary. Alternatively, reformulation costs may be incurred by the industry as a whole if the new formulations are shared. The PEI memos indicate that in all cases where reformulation costs are incurred, the information is proprietary and the burden is on each individual firm.[13]

Since reformulation costs are not a function of existing capacity or current production, they cannot be included directly in the calculation of the quasi-rent per unit output. Nevertheless, the prospect of these reformulation costs certainly affect producer decisions regarding capital conversion. To introduce these costs into the ARCM, all costs other than reformulation costs are used in the calculation of quasi-rents as reported in this memorandum and the reformulation costs per year are reported separately as a separate

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[12] Given the current state of the technology, if the same machinery is utilized for manufacture of both the asbestos product and the substitute product, then the value added by the equipment to each product unit on the margin is the same in both cases. Given the fact that different units of the two products are manufactured (since there is an "efficiency loss" in one use), the value added to each unit must be different. As result, despite the inequality of technical efficiency, the values of the equipment in the two uses must be the same.

[13] Multiple plant firms are assumed to share the results of R & D if more than one plant manufactures the same formulation.

perpetuity.[14,15] Both the non-reformulation related conversion costs and the reformulation costs are used in the ARCM to calculate the actual quasi-rent per unit output using the baseline output quantity as follows:

$$AQR_p = \frac{NQR_p * Q_b + RC_p}{Q_b}$$

where:

AQR_p = Actual Quasi-Rent per unit output per year (perpetuity),

NQR_p = Non-reformulation costs Quasi-Rent per unit output per year (perpetuity),[16]

Q_b = Baseline Quantity in the year under consideration, and

RC_p = Reformulation Costs per year (perpetuity).

1.3 Data Used in the Calculation of Quasi-Rents

PEI Associates have developed equipment conversion costs for twelve industry segments.[17] Exhibit B-1 shows the mapping of various asbestos products into these industry segments. Product categories 34 (Battery Separators) and 35 (Arc Chutes) are not listed in this exhibit because these products are not included for the ARCM simulations, and therefore, no quasi-rents are calculated for them. This section identifies the least cost options for each industry segment based on the PEI memoranda.

1.3.1 Asbestos-Cement Pipe

Existing equipment in this industry segment is not transferable into alternative use.[18] The least cost option available to firms in this industry is to dispose of their existing equipment in a hazardous waste landfill. The cost of disposing of all equipment in a hazardous waste landfill and cleaning the building for reuse amounts to $600,000. The

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[14] The reasoning here is the same as for quasi-rents since a firm will be willing to incur a higher cost of production (within the limits discussed earlier) in order to avoid reformulation costs.

[15] For industry segments where more than one product is manufactured by a firm, the reformulation costs are assumed to be equally divided among the various products manufactured by a firm. In such cases, the quasi-rent per unit of output per year and the reformulation costs per year are reported for each product category.

[16] This is the non-reformulation cost quasi-rent perpetuity per unit of output calculated in this section.

[17] Section 2 of this appendix.

[18] Section 2 of this appendix.

Exhibit B-1. Mapping of Products into Asbestos Industry Segments

Asbestos Industry Segment	Asbestos Products Included
Asbestos-Cement Pipe	14. Asbestos-Cement Pipe and Fittings
Friction Products	18. Drum Brake Linings (OEM)
	19. Disc Brake Pads, LMV (OEM)
	20. Disc Brake Pads (HV)
	21. Brake Blocks
	22. Clutch Facings
	23. Automatic Transmission Components
	24. Friction Materials
	36. Drum Brake Linings (Aftermarket)
	37. Disc Brake Pads, LMV (Aftermarket)
Papers and Felts	1. Commercial Paper*
	2. Rollboard*
	3. Millboard
	4. Pipeline Wrap
	5. Beater-add Gaskets
	6. High-grade Electrical Paper
	9. Flooring Felt*
	10. Corrugated Paper*
	11. Specialty Papers
Asbestos Roofing Felt	7. Roofing Felt*
Vinyl-Asbestos Floor Tile	12. Vinyl-Asbestos Floor Tile*
Asbestos-Cement Sheet and Shingles	15. Flat A-C Sheets
	16. Corrugated A-C Sheets
	17. A-C Shingles
Textiles and Packing	25. Asbestos Protective Clothing
	26. Asbestos, Thread, Yarn, and Other Cloth
	28. Asbestos Packing
Sheet Gasketing	27. Asbestos Sheet Gasketing
Coatings and Sealants	29. Roof Coatings and Cements
	30. Non-Roofing Coatings, Compounds, and Sealants
	32. Missile Liner
	33. Sealant Tape
Asb.-Reinforced Plastics	31. Asbestos-Reinforced Plastics
Chlor-Alkali Industry	13. Diaphragms
Acetylene Cylinders	8. Filler for Acetylene Cylinders

* Product is no longer made in the United States.

estimated cost of a non-greenfield A-C pipe installation is $9.9 million for a capacity of 200 tons per day.

1.3.2 Friction Products

The existing machinery in the friction products industry can be used to manufacture non-asbestos friction products.[19] The cost of converting a facility manufacturing 15 million pieces of asbestos friction products per year is estimated to be $1,095,000. A 20 percent decline in the production rate is anticipated when substitute materials are used. However, this decline in the production rate is a function of the current technology and not a function of converting the existing equipment. Therefore, this decline in production efficiency is not included in the calculation of the quasi-rents.

Furthermore, it is estimated that research and engineering costs will amount to $600,000 per firm in order to reformulate the current asbestos mixture(s). ICF has identified 21 firms currently producing asbestos friction products.[20] Most of these firms manufacture more than one type of friction product. Twelve firms manufacture drum brake linings (18 & 36), thirteen manufacture disc brake pads for light motor vehicles (19 & 37), one manufacture disc brake pads for heavy vehicles (20), eight manufacture brake blocks (21), two manufacture clutch facings (22), one manufactures automatic transmission components (23), and four manufacture friction materials (24). Exhibit B-2 shows the various products made by each individual firm.[21]

1.3.3 Papers and Felts

The existing machinery in the papers and felts industry can readily be converted to the manufacture of substitute products.[22] However, the equipment has to be slightly modified and cleaned before it can be adapted for use in the manufacture of asbestos-substitute products. The cost of the minor modifications is estimated to be $7,000 and the equipment cleaning costs for a plant with a capacity of 8,000 tons per year is estimated to be $10,000 to $15,000.

1.3.4 Asbestos Roofing Felt

The product in this industry segment is no longer manufactured in the United States.[23]

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[19] Section 2 of this appendix.

[20] Appendix F of this report.

[21] The firms are given numbers 1 through 21 in Exhibit 2 in order to protect confidential business information. Product categories with costs associated with them are manufactured by individual firms. See Section 4 for further details.

[22] Section 2 of this appendix.

[23] Appendix F of this report.

EXHIBIT B-2. PRODUCTS MANUFACTURED BY EACH FIRM IN THE "FRICTION PRODUCTS" INDUSTRY SEGMENT

Firm	# of Products Manufactured	Reformulation Cost per Product (thousand dollars)	Distribution of Reformulation Costs by Product Category (thousand dollars)								
			18	19	20	21	22	23	24	36	37
1	5	200	200	200		200				200	200
2	6	150	150	150	150	150				150	150
3	2	600		600							600
4	2	600		600							600
5	4	300	300	300						300	300
6	4	300	300	300						300	300
7	2	600		600							600
8	2	600	600							600	
9	1	600							600		
10	5	150	150			150	150		150	150	
11	2	600		600							600
12	2	600	600							600	
13	4	300	300	300						300	300
14	4	200	200		200	200				200	
15	1	600							600		
16	6	150	150	150		150	150			150	150
17	1	600				600					
18	4	150				150	150	150	150		
19	1	600				600					
20	4	300	300	300						300	300
21	4	300	300	300						300	300
Total			3,550	4,400	350	2,200	450	150	1,500	3,550	4,400

Sources: See Text.

1.3.5 Vinyl-Asbestos Floor Tile

The product in this industry segment is no longer manufactured in the United States.[24]

1.3.6 Asbestos Felt-backed Vinyl Sheet Flooring

The product is no longer classified as a separate product since it is an application of asbestos felt.[25]

1.3.7 Asbestos-Cement Sheet and Shingle

Existing equipment in this industry segment is not transferable into alternative use.[26] The least cost option available to firms in this industry is to dispose of their existing equipment. The cost of disposing of all equipment and cleaning the building for reuse amounts to $400,000. The estimated cost of a non-greenfield A-C sheet installation is $7,856,000 for a capacity of 3,000,000 square yards per year and for an A-C shingle facility is the same for an annual capacity of 21,500 tons per year.

1.3.8 Textiles and Packing

The existing equipment can be readily converted to use asbestos-substitute materials with minimum cleaning and without significant modification.[27] Cleaning costs are expected to be insignificant.

One facility contacted by PEI indicated that carding equipment may need to be replaced. However, this facility is believed to be an exception and in general, no equipment modifications or replacement are deemed to be necessary.

1.3.9 Sheet Gasketing

Existing equipment in this industry segment can be converted to alternative use with considerable expense.[28] The cost of modifying the equipment is anticipated to be $7.2 million for a plant with a capacity of 28 tons per day. This is considered to be the least cost option since the estimated cost of a non-greenfield sheet gasketing installation with the same capacity is $59.1 million. An additional $200,000 expenditure is estimated for tearing down and cleaning the equipment.

1.3.10 Coatings and Sealants

The existing equipment in this industry segment will require no major equipment additions or modifications to convert the plant equipment to

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[24] Appendix F of this report.

[25] Appendix F of this report.

[26] Section 2 of this appendix.

[27] Section 2 of this appendix.

[28] Section 2 of this appendix.

the manufacture of substitute products.[29] A 20 percent decline in the production rate is anticipated when substitute materials are used. However, this decline in the production rate is a function of the current technology and not a function of converting the existing equipment. Therefore, this decline in production efficiency is not included in the calculation of the quasi-rents.

Furthermore, it is estimated that it may cost up to $20,000 per formulation in order to replace asbestos by a substitute or substitute mixture. ICF identified 49 firms currently producing products in the coatings and sealants category with most of these firms manufacturing more than one type of product.[30] Seventeen firms manufacture roof coatings and cements (29); 30 manufacture non-roof coatings, compounds, and sealants (30); six manufacture missile liner (32); and four manufacture sealant tape (33). Furthermore, the industry average was identified as 1.8 formulations per firm, but is considered as two formulations per firm for the purpose of calculating quasi-rents. Therefore, reformulation costs are anticipated to be $40,000 per firm. However, if a particular firm manufactures more than two products the reformulation costs are calculated as $20,000 per product. Exhibit B-3 shows the various products made by each individual firm.[31]

1.3.11 Asbestos Reinforced Plastics

The existing equipment used in the manufacture of asbestos-reinforced plastics will not require major equipment additions or modifications to convert the plant to manufacture products containing asbestos substitutes.[32]

A 10 percent decline in the production rate is anticipated when substitute materials are used. However, this decline in the production rate is a function of the current technology and not a function of converting the existing equipment. Therefore, this decline in production efficiency is not included in the calculation of the quasi-rents.

Reformulation costs are anticipated to be $30,000 per firm and ICF has identified eight manufacturers of asbestos reinforced plastics.[33]

1.3.12 Chlor-Alkali Industry

The least cost option for the chlor-alkali industry is to "retrofit" the existing diaphragm cells to membrane cells at a cost of $50

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[29] Section 2 of this appendix.

[30] Appendix F of this report.

[31] The firms are given numbers 1 through 49 in Exhibit 3 in order to protect confidential business information. Product categories with costs associated with them are manufactured by individual firms. See Section 4 for further details.

[32] Section 2 of this appendix.

[33] Appendix F of this report.

EXHIBIT B-3. PRODUCTS MANUFACTURED BY EACH FIRM IN THE "COATINGS & SEALANTS" INDUSTRY SEGMENT

Firm	# of Products Manufactured	Reformulation Cost per Product (thousand dollars)	Distribution of Reformulation Costs by Product Category			
			29	30	32	33
			(thousand dollars)			
1	1	40		40		
2	2	20		20	20	
3	1	40		40		
4	1	40	40			
5	1	40	40			
6	1	40		40		
7	1	40		40		
8	2	20	20		20	
9	1	40	40			
10	1	40		40		
11	1	40		40		
12	1	40		40		
13	1	40		40		
14	2	20	20			20
15	1	40				40
16	1	40		40		
17	1	40		40		
18	1	40		40		
19	1	40	40			
20	1	40		40		
21	1	40	40			
22	1	40		40		
23	1	40	40			
24	1	40	40			
25	1	40			40	
26	1	40		40		
27	1	40		40		
28	1	40	40			
29	1	40			40	
30	2	20	20		20	
31	1	40	40			
32	1	40		40		
33	1	40		40		
34	1	40	40			
35	1	40		40		
36	1	40		40		
37	2	20	20	20		
38	1	40		40		
39	1	40		40		
40	1	40		40		
41	2	20		20		20
42	1	40	40			
43	1	40		40		
44	1	40		40		
45	1	40		40		
46	1	40			40	
47	3	20	20	20		20
48	1	40		40		
49	1	40	40			
			-----	-------	-----	-----
Total			580	1,120	180	100

Sources: See Text.

million for a plant with a capacity of 1000 tons per day.[34] However, PEI reports that "the use of retrofitted diaphragm cells may necessitate a major modification of cell components within about 3 to 5 years after completion of retrofit because of severe operating environment." Based on this information, it is assumed that the most viable option for the chlor-alkali industry would be to "convert" the existing diaphragm cells to membrane cells at a cost of $85 million for a plant with a capacity of 1000 tons per day. The disposal of equipment that produces 1000 tons of chlorine per day is estimated to cost $3.4 million.

1.3.13 Acetylene Cylinders

The existing equipment can be readily converted to use asbestos-substitute materials with minimum cleaning and without significant modification.[35] Cleaning costs are expected to be insignificant.

1.4 Results

This section presents the results of applying the theoretical approach discussed in Section 1.2 to the data presented in Section 1.3. The results are reported as a quasi-rent perpetuity per unit output and reformulation cost perpetuity (these calculations use a 7 percent private rate of discount as used in the ARCM), where applicable. The reformulation cost perpetuity is incorporated into the ARCM's quasi-rent calculations based on the baseline output quantity, as discussed earlier. We report these perpetuities here because actual quasi-rent losses depend on the regulation being simulated. The ARCM simulates the regulation on a year-by-year basis and calculates losses in quasi-rents based on the market response to the regulation in that year.

Results are presented for each industry segment and are applicable to all products mapping into a particular segment as shown in Exhibit B-1. Exhibit B-4 summarizes the results for those industry segments with no reformulation costs and Exhibit B-5 presents the results for the industry segments with anticipated reformulation costs. Exhibit B-6 presents the quasi-rent losses for all asbestos product markets assuming that use of asbestos fiber was banned totally in 1987. Thus, the quasi-rent losses reported here would be the maximum quasi-rent losses possible.

1.4.1 Asbestos-Cement Pipe

Existing equipment in this industry segment is not transferable into alternative use. The least cost option available to firms in this industry is to dispose of their existing equipment in a hazardous waste landfill. Total conversion costs are estimated to be $10.5 million ($9,900,000 + $600,000) for a plant with an annual capacity of 3,472,222.22

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[34] Section 2 of this appendix.

[35] Section 2 of this appendix.

EXHIBIT B-4. QUASI-RENTS FOR INDUSTRY SEGMENTS WITH NO REFORMULATION COSTS

Asbestos Industry Segment	Transfer-ability of Capital	Description of Least Cost Option	Conversion Cost (dollars)	Annual Capacity to which cost is applicable	Quasi-Rent[a] Perpetuity per Unit Output (dollars/unit)
Asbestos-Cement Pipe	No	Disposal in a hazardous waste landfill	10,500,000	3,472,222.22 feet[b]	0.21 / ton
Papers and Felts					
All except Pipeline Wrap	Yes	Clean and modify equipment	22,000	8,000 tons	0.19 / ton
Pipeline Wrap	Yes	Clean and modify equipment	22,000	1,230,769.23 squares[b]	0.001 / square
Asbestos Roofing Felt[c]	n/a	n/a	n/a	n/a	n/a
Vinyl-Asbestos Floor Tile[c]	n/a	n/a	n/a	n/a	n/a
Asbestos-Cement Sheet	No	Dispose of all equipment	8,256,000	30,000 squares	19.27 / square
Asbestos-Cement Shingle	No	Dispose of all equipment	8,256,000	174,796.75 squares[a]	3.31 / square
Textiles and Packing	Yes	No significant action	none	n/a	0.00 / ton
Sheet Gasketing	Yes	Convert equipment	7,400,000	3,333,333.33 sq. yds.[b]	0.16 / sq. yd.
Chlor-alkali industry	Yes	Conversion to membrane process	88,400,000	312.5 pieces[d]	19,901.60 / piece
Acetylene Cylinders	Yes	No significant action	none	n/a	0.00 / piece

[a] The firm's discount rate is assumed to be 7 percent.

[b] The annual capacity reported here has been converted from tons.

[c] Products in this industry segment are no longer manufactured in the United States.

[d] The annual capacity here refers to the number of diaphragms used to produce 250,000 tons of chlorine.

n/a: not applicable

Sources: See Text.

EXHIBIT B-5. QUASI-RENTS FOR INDUSTRY SEGMENTS WITH REFORMULATION COSTS

Asbestos Industry Segment/ Asbestos Product Category	Transfer-ability of Capital	Description of Least Cost Option	Conversion Cost (dollars)	Annual Capacity to which cost is applicable	Quasi-Rent[a] Perpetuity per Unit Output (dollars/unit)	Reformulation[a,b] Cost Perpetuity (dollars)
Friction Products						
18. Drum Brake Linings	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	248,500
19. Disc Brake Pads, LMV (OEM)	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	308,000
20. Disc Brake Pads (HV)	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	24,500
21. Brake Blocks	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	154,000
22. Clutch Facings	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	31,500
23. Automatic Transmission Components	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	10,500
24. Friction Materials	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	105,000
36. Drum Brake Linings	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	248,500
37. Disc Brake Pads, LMV (OEM)	Yes	Convert equipment	1,095,000	15,000,000 pieces	0.005 / piece	308,000
Coatings and Sealants						
29. Roof Coatings and Cements	Yes	Convert equipment	none	n/a	0.00 / gallon	40,600
30. Non-Roof Coatings, Compounds, and Sealants	Yes	Convert equipment	none	n/a	0.00 / gallon	78,400
32. Missile Liner	Yes	Convert equipment	none	n/a	0.00 / ton	12,600
33. Sealant Tape	Yes	Convert equipment	none	n/a	0.00 / foot	7,000
Asbestos-Reinforced Plastics						
31. Asbestos-Reinforced Plastics	Yes	Convert equipment	none	n/a	0.00 / ton	16,800

[a] The firm's discount rate is assumed to be 7 percent.

[b] The reformulation cost perpetuity is a yearly total for the baseline output and is not specified per unit output. This is incorporated in the quasi-rents as described in the text.

Sources: See Text.

EXHIBIT B-6. QUASI-RENT LOSSES ASSOCIATED WITH AN IMMEDIATE BAN OF ALL ASBESTOS PRODUCTS

	Product Category	Industry Segment Classification	Conversion Cost Perpetuity ($/unit)	Reformulation Cost Perpetuity ($)	Domestic Quasi-Rent Loss ('000 $)	World Quasi-Rent Loss ('000 $)
1.	Commercial Paper	Papers and Felts	0.19	0	0.00	0.00
2.	Rollboard	Papers and Felts	0.19	0	0.00	0.00
3.	Millboard	Papers and Felts	0.19	0	1.58	1.58
4.	Pipeline Wrap	Papers and Felts	0.001	0	4.24	10.61
5.	Beater-add Gaskets	Papers and Felts	0.19	0	44.80	45.70
6.	High-grade Electrical Paper	Papers and Felts	0.19	0	1.89	1.89
7.	Roofing Felt	Asbestos Roofing Felt	0.00	0	0.00	0.00
8.	Acetylene Cylinders	Acetylene Cylinders	0.00	0	0.00	0.00
9.	Flooring Felt	Papers and Felts	0.19	0	0.00	0.00
10.	Corrugated Paper	Papers and Felts	0.19	0	0.00	0.00
11.	Specialty Papers	Papers and Felts	0.19	0	1.18	1.18
12.	Vinyl-Asbestos Floor Tile	Vinyl-Asbestos Floor Tile	0.00	0	0.00	0.00
13.	Asbestos Diaphragms	Chlor-Alkali Industry	19,801.60	0	2,763,737.60	2,763,737.60
14.	Asbestos-Cement Pipe	Asbestos-Cement Pipe	0.21	0	45,188.12	45,766.53
15.	Flat A-C Sheets	Asbestos-Cement Sheet	19.27	0	1,421.68	1,634.93
16.	Corrugated A-C Sheets	Asbestos-Cement Sheet	19.27	0	0.00	1,062.33
17.	A-C Shingles	Asbestos-Cement Shingle	3.31	0	8,352.69	11,443.19
18.	Drum Brake Linings (OEM)	Friction Products	0.005	248,500	5,693.81	6,547.88
19.	Disc Brake Pads, LMV (OEM)	Friction Products	0.005	308,000	4,040.04	4,807.65
20.	Disc Brake Pads (HV)	Friction Products	0.005	24,500	361.20	361.20
21.	Brake Blocks	Friction Products	0.005	154,000	2,504.67	2,529.71
22.	Clutch Facings	Friction Products	0.005	31,500	918.72	1,028.97
23.	Automatic Transmission Components	Friction Products	0.005	10,500	154.11	154.11
24.	Friction Materials	Friction Products	0.005	105,000	2,122.82	2,122.82
25.	Asbestos Protective Clothing	Textiles and Packing	0.00	0	0.00	0.00
26.	Asbestos Thread, Yarn, etc.	Textiles and Packing	0.00	0	0.00	0.00
27.	Asbestos Sheet Gasketing	Sheet Gasketing	0.16	0	8,245.50	8,822.69
28.	Asbestos Packing	Textiles and Packing	0.00	0	0.00	0.00
29.	Roof Coatings and Cements	Coatings and Sealants	0.00	40,600	580.00	580.00
30.	Non-Roofing Coatings, etc.	Coatings and Sealants	0.00	78,400	1,120.00	1,120.00
31.	Asbestos-Reinforced Plastics	Asbestos-Reinforced Plastics	0.00	16,800	233.01	240.00
32.	Missile Liner	Coatings and Sealants	0.00	12,600	180.00	180.00
33.	Sealant Tape	Coatings and Sealants	0.00	7,000	100.00	100.00
34.	Battery Separators	Textiles and Packing	***	***	***	***
35.	Arc Chutes	Arc Chutes	***	***	***	***
36.	Drum Brake Linings (A/M)	Friction Products	0.005	248,500	9,023.38	10,376.89
37.	Disc Brake Pads, LMV (A/M)	Friction Products	0.005	308,000	7,170.51	8,532.91
					2,861,201.57	2,871,210.37

*** Product is not included in ARCM simulations.

feet.[36] This implies a quasi-rent perpetuity of $0.21 per feet ([$10,500,000/3,472,222.22] * 0.07) as shown in Exhibit B-4.[37] Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of units of output in the industry.

1.4.2 Friction Products

The existing machinery in the friction products industry can be used to manufacture non-asbestos friction products. Total conversion costs are estimated $1,095,000 for a facility with an annual capacity of 15 million pieces of asbestos friction products.

In addition to the conversion costs, reformulation costs of $600,000 are anticipated for each firm. Since most of the firms in this industry segment manufacture more than one type of friction product, the reformulation costs have to be considered for each product category. Exhibit B-2 shows the product categories of the products manufactured by each of the 21 firms currently producing asbestos friction products. The amount of $600,000 is divided equally among the products manufactured by a particular firm with the exception of firms that manufacture OEM and aftermarket drum and disc brakes. For these firms the reformulation cost is considered to exist independently for OEM and aftermarket brakes; therefore, $600,000 is first divided into the number of products assuming OEM and aftermarket brakes are one "combined product" (i.e., 18 & 36 are treated as one product and 19 & 37 are treated as one product for this purpose) and then the amount attributed to this "combined product" is doubled.[38] The reformulation costs for each product category are then obtained by summing across firms in each category. The conversion costs are assumed to be same for all firms in this industry segment.

Exhibit B-5 shows the quasi-rent perpetuity per unit output and the reformulation cost perpetuity for each product category in this industry segment. Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of units of output in the industry.

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[36] In order to be consistent with the units reported in the asbestos use and substitutes analysis, the units for A-C pipe are converted from tons to feet (1 foot = 0.0144 tons). Furthermore, the daily capacity has been converted to an annual capacity here and later in the section by using a factor of 250. It is assumed that none of the processes considered are continuous and that plants shut down for two weeks each year for maintenance.

[37] The firm's discount rate is assumed to be four percent for all industry segments.

[38] This is done because the formulation of a substitute brakes for new cars (OEM brakes) is assumed to be different from the substitute brakes for existing cars (the aftermarket brakes). The costs associated with such reformulation may also be different, but in the absence of information the known reformulation costs are counted twice.

1.4.3 Papers and Felts

The existing machinery in the papers and felts industry can readily be converted to the manufacture of substitute products. Total conversion costs are estimated to be $22,000 ($7,000 + $15,000) for a plant with an annual capacity of 8,000 tons, i.e., a quasi-rent perpetuity of $0.19 per ton ([$22,000/8,000] * 0.07) as shown in Exhibit B-4. However, the quasi-rent perpetuity for pipeline wrap is shown as $0.001 per square since output of pipeline wrap is measured in squares.[39] Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of units of output in the industry.

1.4.4 Asbestos Roofing Felt

The product in this industry segment is no longer manufactured in the United States.

1.4.5 Vinyl-Asbestos Floor Tile

The product in this industry segment is no longer manufactured in the United States.

1.4.6 Asbestos Felt-backed Vinyl Sheet Flooring

The product is no longer classified as a separate product since it is an application of asbestos felt.

1.4.7 Asbestos-Cement Sheet and Shingles

Existing equipment in this industry segment is not transferable into alternative use. The least cost option available to firms in this industry is to dispose of their existing equipment. Total conversion costs are estimated to be $8,256,000 ($7,856,000 + $400,000) for an A-C sheet plant with an annual capacity of 30,000 squares and an A-C shingle plant with an annual capacity of 174,796.75 squares.[40] The implied quasi-rent perpetuities for A-C sheet and shingles are $19.27 per square ([$8,256,000/30,000]* 0.07) and $3.31 per square [$8,256,000/174,796.75] * 0.07) respectively as shown in Exhibit B-4. Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of units of output in the industry.

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[39] In order to be consistent with the units reported in the asbestos use and substitutes analysis, the units for pipeline wrap are converted from tons to squares (1 square = .0065 tons). Therefore, the quasi-rent perpetuity for pipeline wrap is $0.007 per square ([$22,000 /(8,000/0.0065)] * 0.04).

[40] In order to be consistent with the units reported in the asbestos use and substitutes analysis, the units for A-C sheet are converted from square yards to squares (1 square = 100 square yards) and from tons to squares (1 square = 0.123 tons) for A-C shingle. The factor used for A-C shingle is a weighted average of the factors for roofing and siding shingles.

1.4.8 Textiles and Packing

The existing equipment can be readily converted to use asbestos-substitute materials with minimum cleaning and without significant modification. Cleaning costs are expected to be insignificant. Therefore, there are no quasi-rents to be lost in this industry segment.

1.4.9 Sheet Gasketing

Existing equipment in this industry segment can be converted to alternative use but with considerable expense. Total conversion costs are estimated to be $7.4 million ($7,200,000 + $200,000) for a plant with an annual capacity of 3,333,333.33 square yards, i.e., a quasi-rent perpetuity of $0.16 per square yard ([$7,400,000/3,333,333.33] * 0.07) as shown in Exhibit B-4.[41] Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of units of output in the industry.

1.4.10 Coatings and Sealants

The existing equipment in this industry segment will require no major equipment additions or modifications to convert the plant equipment to the manufacture of substitute products. In addition to the conversion costs, reformulation costs of are anticipated for each firm. Since most of the firms in this industry segment manufacture more than one type of product, the reformulation costs have to be considered for each product category. Exhibit B-3 shows the product categories of the products manufactured by each of the 49 firms currently producing asbestos friction products. The amount of $40,000 is divided equally among the products manufactured by a particular firm except in cases where firms manufacture more than two products in which case the reformulation cost is assumed to be $20,000 per product. The reformulation costs for each product category are then obtained by summing across firms in each category. Exhibit B-5 shows the quasi-rent perpetuity per unit output and the reformulation cost perpetuity for each product category in this industry segment. Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of units of output in the industry.

1.4.11 Asbestos Reinforced Plastics

The existing equipment used in the manufacture of asbestos-reinforced plastics will not require major equipment additions or modifications to convert the plant to manufacture products containing asbestos substitutes. A total reformulation cost of $240,000 (8 * $30,000) is estimated, i.e., no quasi-rents and a reformulation cost perpetuity of $16,800 ($240,000 * 0.07) as shown in Exhibit B-5. Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of

[41] In order to be consistent with the units reported in the asbestos use and substitutes analysis, the units for sheet gasketing are converted from tons to square yards (1 square yard = 0.0021 tons).

units of output in the industry.

1.4.12 Chlor-Alkali Industry

The most viable option for the chlor-alkali industry would be to "convert" the existing diaphragm cells to membrane cells. Total conversion costs for the chlor-alkali industry are estimated to be $88.4 million ($85 million + $3.4 million) for an annual capacity of 250,000 tons. The use and substitutes analysis indicates that on an average one diaphragm is used to produce 800 tons of chlorine.[42] Since the asbestos fiber is used for producing diaphragms, the output entity in this industry is considered to be number of diaphragms. Therefore, the conversion costs are applicable to an annual capacity of 312.5 diaphragms (250,000/800). The quasi-rent perpetuity can now be calculated as $19,801.60 per diaphragm ([$88,400,000/312.5] * 0.07) as shown in Exhibit B-4. Finally, Exhibit B-6 shows the maximum loss of quasi-rents possible in this market (i.e., if the product were banned in 1987) based on the quasi-rents for unit of output and the number of units of output in the industry.

1.4.13 Acetylene Cylinders

The existing equipment can be readily converted to use asbestos-substitute materials with minimum cleaning and without significant modification. Cleaning costs are expected to be insignificant. Therefore, there are no quasi-rents to be lost in this industry segment.

[42] Appendix F of this report.

2. <u>Capital Convertibility and Product Market Exit Costs Memoranda</u>

A report by PEI Associates concerning the costs of exiting the asbestos product industries.

COST OF CAPITAL INVOLVED IN CONVERTING ASBESTOS-PRODUCT MANUFACTURING EQUIPMENT TO ASBESTOS SUBSTITUTES

by

PEI Associates, Inc.
11499 Chester Road
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Contract No. 68-02-4248
Work Assignment No. P2-1
PN 3687-38

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES

July 1987

CONTENTS

TABLES

(continued)

TABLES (continued)

SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency's Office of Pesticides and Toxic Substances (formerly the Office of Toxic Substances) has proposed a regulation to ban the use of asbestos in the commercial sector over a 10-year period. This proposed regulation prompted numerous comments, some during the comment period and others later, during the legislative hearings.

To address the comments regarding the economic impact of the proposed regulation, the Agency contracted PEI Associates, Inc., to investigate the equipment factor in the following asbestos-related industries (listed in the order of their priority):

1) Asbestos cement pipe
2) Asbestos friction materials
3) Asbestos papers/felts
4) Asbestos roofing felts (saturated)
5) Asbestos floor tiles
6) Asbestos felt-backed vinyl sheet flooring
7) Asbestos cement sheet and shingle
8) Textiles and packing
9) Sheet gasketing
10) Coatings and sealants
11) Asbestos-reinforced plastics
12) Asbestos mining and milling
13) Chlor-alkali
14) Acetylene cylinder filler
15) Arc chutes

The specific tasks to be accomplished were 1) to determine the type of equipment used in each industry segment; 2) to determine the cost of this equipment; 3) to determine whether the equipment is convertible to asbestos-substitute materials, and if not, what its scrap value is; and 4) to estimate the costs of converting a plant to the use of asbestos-substitute products.

In this report, a section is devoted to each asbestos industry segment studied. These sections include the economic impact of scrapping and disposing of current equipment (if applicable), any necessary cleanup prior to installing new equipment, cleanup and decontamination of equipment that must be scrapped, resale value of abandoned equipment, scrap value of affected equipment, and the net loss expected to be incurred by each industry segment as a result of necessary equipment replacement. How the costs were derived is also explained. The sections on acetylene cylinder filler and arc chutes contain confidential business information (CBI) and are not included in this report.

The estimated costs presented herein have an accuracy of about plus or minus 30 percent (study estimate). So that the cost numbers can be easily reconstructed, however, sums of values of components used to arrive at equipment option estimates have not been rounded; e.g., the sum of $750,000 and $345,000 is presented as $1,095,000 instead of $1,100,000 (as would be dictated by good engineering practices).

Table 1-1 lists the industry segments covered in the report and the products involved in each. Table 1-2 summarizes the equipment cost data collected, which served as a basis for the costs presented in the individual sections.

TABLE 1-1. LISTING OF ASBESTOS-CONTAINING PRODUCTS BY INDUSTRY

Capital conversion memos	Asbestos products included
AC pipe	AC pipe and fittings
Asbestos friction materials	Disc brake pads (heavy vehicles) Disc brake pads (light and medium vehicles) Drum brake linings (light and medium vehicles) Friction materials (industrial and commercial) Brake blocks Clutch facings Automatic transmission components
Asbestos papers/felts	Flooring felt Unsaturated roofing felt Beater-add gaskets Commercial paper Corrugated paper High-grade electrical paper Millboard Pipeline wrap Rollboard Specialty papers
Asbestos roofing felts (saturated)	Saturated roofing felt
Asbestos floor tile	Vinyl-asbestos floor tile
Asbestos felt-backed vinyl sheet flooring	Asbestos felt-backed vinyl sheet flooring
AC sheet and shingle	Corrugated asbestos-cement sheets Flat asbestos-cement sheets Asbestos-cement shingles
Textiles and packing	Asbestos textiles - cloth Asbestos textiles - thread, yarn, lap, etc. Asbestos packing
Sheet gasketing	Asbestos sheet gasketing
Coatings and sealants	Adhesives and sealants Paints and surface coatings
Asbestos-reinforced plastics	Asbestos-reinforced plastics
Asbestos mining and milling	Asbestos mining and milling
Chlor-alkali industry	Chlor-alkali industry
Acetylene cylinder filler	Acetylene cylinder filler
Arc chutes	Arc chutes

TABLE 1-2. SUMMARY OF COST DATA ON NEW AND USED EQUIPMENT FOR THE MANUFACTURE OF ASBESTOS-CONTAINING PRODUCTS

Industry	Equipment type[a]	New value, $	Resale value, $	Age, years	Reported scrap value, $	Scrap weight, lb	Calculated scrap value, $50/ton basis	Reported ratio of scrap value to new value	Calculated ratio of scrap value to new value	Ratio of resale value to new value
AC pipe	P - pipe machine	2,750,000	0	7	(60,000)			-0.022		
Friction	P - mixer	37,000	4,000	20	50			0.001		0.108
		37,000	12,000	10	50			0.001		0.324
	P - molding	20,000	5,000	40	50			0.003		0.250
		125,000	20,000	20	200	60	3,000	0.002	0.024	0.160
		10,000	5,000	20	200	0.5	25	0.020	0.003	0.500
		10,000	0	20		1	50		0.005	
	M - lathes, etc.	50,000	500	20	100	1.5	75	0.002	0.002	0.010
	B - boiler	100,000	10,000	4	0			0.000		0.100
	A - fabric filter	250,000	0	20	0			0.000		
	A - scrubber	30,000	0	25	0			0.000		
	P - mixer	30,000	15,000	20						0.500
	P - molding	214,000	109,000	20						0.509
		360,000	184,000	20						0.511
		165,000	84,000	20						0.509
	P - cutter	20,000	10,000	20						0.500
	P - molding	15,000	8,000	20						0.533
	P - oven	60,000	31,000	20						0.517
	M - drill, grind	85,000	43,000	20						0.506
		40,000	20,000	20						0.500
Cylinders	P - gas cyl. mfg.	250,000	50,000	10						0.200
Textile	P - blendline	40,000		20	320	4	200	0.008	0.005	
	P - card	720,000		40	2,880	36	1,800	0.004	0.003	
	P - spinning	1,496,000		60	2,700	34	1,700	0.002	0.001	
	P - winding	75,000		40	480	6	300	0.006	0.004	
	A - fabric filter	1,800,000		18	1,440	18	900	0.001	0.001	
	B - boiler	75,000		11	800	10	500	0.011	0.007	
	P - wing makeup	40,000		11	480	6	300	0.012	0.008	
AC sheet	P - mixer	90,000		20	60	3	150	0.001	0.002	
		110,000		20	100	5	250	0.001	0.002	
		100,000		20	80	4	200	0.001	0.002	
		90,000		21	80	4	200	0.001	0.002	
		90,000		21	80	4	200	0.001	0.002	
		90,000		21	80	4	200	0.001	0.002	
		90,000		21	80	4	200	0.001	0.002	
		110,000		0	80	4	200	0.001	0.002	
		110,000		1	60	3	150	0.001	0.001	
	P - sheet mill	350,000		30		30	1,500		0.004	
		200,000		25		22	1,100		0.006	
		200,000		25		22	1,100		0.006	
		200,000		25		22	1,100		0.006	
		200,000		25		22	1,100		0.006	
		200,000		20		22	1,100		0.006	
		200,000		20		22	1,100		0.006	
		250,000		12		40	2,000		0.008	
		250,000		12		40	2,000		0.008	

TABLE 1-2 (continued)

Industry	Equipment type[a]	New value, $	Resale value, $	Age, years	Reported scrap value, $	Scrap weight, lb	Calculated scrap value, $50/ton basis	Reported ratio of scrap value to new value	Calculat-ed ratio of scrap value to new value	Ratio of resale value to new value
Sheet gasket	P - paper mach.	12,000,000	50,000	70		100	5,000		0.000	0.004
Coat and seal	P - mixer	60,000	5,000	20		1	50		0.001	0.083
	P - fluffer	9,000	0	5		1.2	60		0.007	
	P - mixer	80,000	5,000	15		5	250		0.003	0.063
	A - cyclone	15,000	0	10		1	50		0.003	
	P - mixer	275,000	125,000	2	0	60	3,000	0.000	0.011	0.455
	A - fabric filter	70,000	15,000	6	0			0.000		0.214
	P - mixer	5,000		20		3	150		0.030	
		15,000	1,500	15		1.2	60		0.004	0.100
		20,000	500	30						0.025
	A - fabric filter	7,000	500	7						0.071
	P - charge hopper	500	0	7						
Plastics	A - fabric filter	12,500	0	11	0			0.000		
	P - mixer	12,500		11						
		20,000	4,000	11						0.200
Mine and mill	P - mine	6,000,000	600,000	8		1090	54,500		0.009	0.100
	P - crush	2,000,000	80,000	20	40,500	675	33,750	0.020	0.017	0.040
	P - dry	1,200,000	40,000	21	13,000	215	10,750	0.011	0.009	0.033
	P - mill	5,600,000		27	74,000	1230	61,500	0.013	0.011	
	P - tailings	400,000		20	8,500	135	6,750	0.021	0.017	
	A - fabric filter	2,600,000		22	27,000	450	22,500	0.010	0.009	
	B - utilities	1,200,000		27	20,000	100	5,000	0.017	0.004	
	Buildings	6,000,000	12,000	18	99,000	2500	125,000	0.017	0.021	0.002
Average								0.005	0.006	0.254

[a] P = process
B = boiler or utilities
A = air pollution control
M = miscellaneous

SECTION 2

CONVERSION COSTS--ASBESTOS CEMENT PIPE INDUSTRY

Determination of the economic impact of a potential ban by the U.S. Environmental Protection Agency (EPA) on the manufacture of asbestos cement (AC) pipe requires data on the cost, resale value, and convertibility of the manufacturing equipment. PEI was contacted by the Office of Pesticides and Toxic Substances to provide these data to ICF, Incorporated, for use in the economic model being used to develop the impact analysis.

The AC pipe industry was investigated with respect to equipment costs and other factors that might affect conversion. Currently, AC pipe is manufactured at only five plants (owned by three different companies):

J-M Manufacturing Company
Denison, Texas
Stockton, California

Certainteed Corporation
Hillsboro, Texas
Riverside, California

CAPCO Pipe Company, Inc.
Van Buren, Arkansas

PEI contacted these suppliers of AC pipe by telephone and/or letter. All of them responded in some manner. Site visits were made to J-M's Stockton, California, plant and Certainteed's Riverside, California, plant. CAPCO's response to PEI's request for information was very limited, but further information on the Van Buren, Arkansas, plant was obtained from the Arkansas Department of Air Pollution Control and Ecology.

Most AC pipe is used for water mains (pressure pipe) and sewer lines (nonpressure pipe). Several factors have contributed to the increase in the number of plants producing AC pipe in recent years to those listed. Among these are the potential regulation of asbestos, competition from makers of substitute pipe [e.g., polyvinyl chloride (PVC) pipe], and the drop in sewer construction resulting from EPA grant cutbacks in 1978.

PRODUCTION EQUIPMENT

Despite the fact that each manufacturer designed its own plant or plants, the equipment components at all the plants appeared to be similar and generally can be grouped as follows:

<u>Raw material receiving and handling</u>

Bag opener and fluffer
Ball mill for grinding sand to silica flour
Mixers for dry materials (silica, cement, asbestos)
Blenders for slurry (water, silica, cement, asbestos)
Conveyors (screw and/or flat)
Scales and auxiliary equipment

<u>AC pipe production</u>

Pipe machine
Mandrels
Drying ovens for initially formed pipe
Curing autoclaves
Pipe moving equipment (fork lifts, "mules," conveyors, etc.)

<u>Product handling and testing</u>

Hydrostatic testing
Pipe cutting line
Pipe lathes/milling machines
Conveyors and/or other moving equipment (e.g., overhead cranes)
Shipping and other miscellaneous equipment

<u>Support equipment</u>

Boilers for steam generation
Fabric filters for air pollution control
Storage silos
Spare parts, motors, pumps, etc.

Each component was evaluated to determine its cost as new equipment, its convertibility to other uses, its resale value, and its scrap value. Also determined was the cost of corresponding new equipment versus the cost of converting the AC pipe equipment.

REPLACEMENT COST OF EXISTING EQUIPMENT

New equipment for AC pipe is usually either custom-designed by the manufacturer or purchased and modified by the manufacturer. In 1964, a new 200-ton/day greenfield facility* cost $9 million (this cost includes all land, buildings, and equipment).[1] Based on the Chemical Engineering (CE) Plant Cost Index,[2], this plant would have cost $28 million in 1985. At the same company, a new pipe machine and associated equipment was installed in a Texas plant in 1979 for $8 million. Based on the CE Plant Cost Index, this facility would have cost $11 million in December of 1985. Factors from Peters and Timmerhaus[3] have been used to break down these total costs into subcategories.

Tables 2-1 and 2-2 show the estimated cost breakdown for installing a complete 200-ton/day AC pipe plant from the ground up, and for installing a single AC pipe production line with the necessary ancillary equipment, respectively. In the latter case, the cost assumes the infrastructure (i.e., the underlying base, building, and basic support systems) already exists. The manufacturer did not specify what other equipment was added during this pipe machine addition, but it is likely that equipment such as the bag opener and fluffer, boilers, mandrels, and pipe testing and cutting equipment were not needed. During a visit to a similar plant, PEI found that pieces of equipment appeared to be capable of supporting multiple pipe machines.

ASBESTOS SUBSTITUTION OPTIONS

Cement pipe manufacturers indicated that asbestos was the only acceptable fiber for use in a fiber-cement pipe effort by U.S. AC pipe manufacturers to find a substitute fiber. Very little equipment used in the manufacture of AC pipe can be used to manufacture PVC pipe. The two products use entirely different processes and raw materials. Scales, transfer equipment (such as conveyors and tow motors), air pollution controls, and storage silos might be usable in the manufacture of PVC pipe. Boilers are not needed because steam is not used in the production of PVC pipe. The transfer equipment for AC

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* "Greenfield facility" refers to one built from scratch on previously unoccupied land.

TABLE 2-1. ESTIMATED COST OF NEW AC PIPE PLANT INSTALLATION
(December 1985 dollars)

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	20	5,600
Purchased equipment installation	10	2,800
Instrumentation and controls (installed)	4	1,120
Piping (installed)	6	1,680
Electrical (installed)	2	560
Buildings (including services)	6	1,680
Yard improvements	2	560
Service facilities (installed)	10	2,800
Land	1	280
Total direct costs	61	17,080
Indirect costs		
Engineering and supervision	7	1,960
Construction expense	7	1,960
Contractor's fee	5	1,400
Contingency	5	1,400
Total indirect costs	24	6,720
Total fixed-capital investment	85	23,800
Working Capital	15	4,200
TOTAL CAPITAL INVESTMENT	100	28,000

TABLE 2-2. ESTIMATED COST OF NEW AC PIPE MACHINE INSTALLATION
(December 1985 dollars)

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	25	2,750
Purchased equipment installation	10	1,100
Instrumentation and controls (installed)	5	550
Piping (installed)	10	1,100
Electrical (installed)	5	550
Buildings (including services)	0	0
Yard improvements	0	0
Service facilities (installed)	5	550
Land	0	0
Total direct costs	60	6,600
Indirect costs		
Engineering and supervision	10	1,100
Construction expense	10	1,100
Contractor's fee	5	550
Contingency	5	550
Total indirect costs	30	3,300
Total fixed-capital investment	90	9,900
Working Capital	10	1,100
TOTAL CAPITAL INVESTMENT	100	11,000

pipe also has about twice the capacity that is required for PVC pipe; therefore, it probably would be sold.[4] Also, because silos and air pollution controls are generally not constructed so as to be moved, if they cannot be used in place, purchasing new ones generally costs less.

CONVERSION COSTS

Most of the equipment in place at an AC pipe plant is unique to AC pipe manufacturing and cannot be used for other purposes. Also, the extent of equipment cleanup required before such equipment can be sold is uncertain. Further, it is not known whether discarded equipment must be treated as a hazardous waste and sent to a hazardous waste landfill. Most of the equipment in use represents older technology (i.e., older than 10 years), and would be difficult to salvage for parts, motors, or auxiliary equipment because it is less efficient than newer equipment and often nearing the end of its useful life. The pipe production equipment [such as the pipe machine and mandrels, some pipe moving equipment ("mules"), and precuring ovens] and product testing and handling equipment (such as the hydrostatic testing equipment, pipe cutting line, pipe lathes, and milling machines) are specialized equipment and could only be sold to another AC pipe producer. Some equipment (such as conveyors, storage silos, and fabric filters for air pollution controls) are readily convertible to other industries, but are not readily salable because new ones can be purchased for less than it would cost to dismantle and move these relatively fragile pieces of equipment. Equipment that may have resale value includes ball mills, blenders and mixers, scales, autoclaves, fork lifts and other mobile equipment, and boilers. Much of this equipment also may have minimal (or zero) resale value because the technology is old, cleanup costs are high, and market demand is limited.

In summary, the five options available for all the equipment are 1) to clean it up and sell it for scrap, 2) to leave it in place, 3) to send it to a hazardous waste landfill, 4) to clean it up and send it to a nonhazardous waste landfill, and 5) to clean it up and sell it as used equipment. The leave-in-place option is not considered here because it is assumed that all equipment will eventually be removed to make room for other processes or in preparation to sell the building. Table 2-3 summarizes the options available for the major equipment at an AC pipe plant.

TABLE 2-3. AC PIPE EQUIPMENT OPTIONS

Process	Convert to substitute process	Resell to nonasbestos industries	Sell for scrap	Send to landfill
Raw material receiving and handling				
Bag opener and fluffer			x	x
Ball mill for grinding sand to silica flour		x	x	x
Mixers for dry materials (silica, cement, asbestos)		x	x	x
Blenders for slurry (water, silica, cement, asbestos)		x	x	x
Conveyors (screw and/or flat)	x	x	x	x
Scales and auxiliary equipment	x	x	x	x
AC pipe production				
Pipe machine			x	x
Mandrels			x	x
Drying ovens for initially formed pipe			x	x
Curing autoclaves		x	x	x
Pipe moving equipment (fork lifts, "mules," conveyors, etc.)		x	x	x
Product handling and testing				
Hydrostatic testing			x	x
Pipe cutting line			x	x
Pipe lathes/milling machines			x	x
Conveyors and/or other moving equipment (e.g., overhead cranes)	x	x	x	x
Shipping and other miscellaneous equipment		x	x	x
Support equipment				
Boilers for steam generation		x	x	x
Fabric filters for air pollution control	x	x	x	x
Storage silos	x	x	x	x
Spare parts, motors, pumps, etc.		x	x	x

Most of the major equipment components are not convertible--either to equipment for making substitutes for AC pipe (PVC, cast iron, and steel pipe) or to equipment for producing products in other industries. With good maintenance, the useful life of most AC pipe production equipment should be about 25 years. AC pipe plants are prolonging equipment life by emphasizing maintenance instead of buying new equipment, however, because of the potential ban on AC pipe production. This will tend to lower resale value and the remaining useful life of the equipment when the plants try to convert or resell the equipment. Furthermore, all the equipment is likely to enter the market at the same time, which will further depress the sale price. Telephone interviews with used equipment dealers indicate that asbestos processing equipment would be very hard to sell for the following reasons: 1) the potential for asbestos-related liability, and 2) in the period between the announcement banning asbestos and the mandatory plant closing, the equipment probably would receive minimum maintenance and thus be marginally operable.*

Neither conversion nor resale of the AC pipe equipment that has been shut down to date has been significantly successful. J-M Manufacturing had four pipe machines in 1966, but now has only one in operation.[4] One of the other machines has been scrapped, and the remaining two are inoperable and would be sold if a buyer could be found. J-M has received a bid of $60,000 to remove and bury a 10-foot machine in their Texas plant. This amount did not include cleanup of the removal site. The Johns-Manville (former owners of the J-M AC pipe facilities) Long Beach, California, plant was closed and the equipment was removed in exchange for the scrap value of the steel, but the dismantler claimed that he lost money on this effort. The 13-foot pipe machine at Manville's Greens Cove, Florida, plant was given to an Indonesian firm (IGB) in exchange for its removal. Manville, however, reportedly spent approximately $130,000 to clean and repair the AC pipe manufacturing area.[4] In addition, IGB claimed that they would have been better off by buying new equipment. Certainteed has also shut down plants in the past (three) and have only been able to obtain the salvage value of the scrap metal from these plants.

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* Personal communications from Mr. Jim Mercer, J. Little Mercer Company, Inc., Rehoboth, MA, September 29, 1986; Mr. Lawler, Lawler Company, Metuchen, NJ, September 29, 1986; Mr. Dennis Herndos, Transamerica Equipment Company, Inc., Northport, AL, September 29, 1986.

Based on the above reported costs of removing a pipe machine, repairing and cleaning up the area from which the machine was taken, and using a 0.6 plant scale index for escalating the cost of removing and burying a 10-ft machine to that required for a 13-foot machine, the cost of removal and landfill of a 200-ton/day, 13-foot AC pipe machine would be about $200,000 ($130,000 plus $70,000). This cost includes disassembling the equipment, removing it to a hazardous waste landfill, and cleaning up and repairing the area from which the equipment was removed. Tables 2-1 and 2-2 show that the value of the equipment required for the addition of a pipe machine accounts for approximately 50 percent of the cost of all the equipment required for an AC pipe plant. Assuming that removal, landfilling, and repair and cleanup of other plant components will involve activities similar to those for removing the pipe machine, the cost would be about $400,000 (not including general cleaning of the building so that it can be used for other purposes). The cost of vacuuming the building and washing down walls, ceilings, and floors should be about $0.26 per square foot.[5] Based on PEI asbestos cleanup experience, the cost of these activities is only about 25 percent of the total cost of the cleanup. These other costs include preparing and isolating the cleanup area, handling and transferring the collected asbestos dust, landfilling the wastes in an approved hazardous waste landfill facility, and demobilization. This brings the total cleanup cost to approximately $1.00 per square foot. Based on an estimated building size for a 200-ton/day pipe plant of approximately 300 feet by 300 feet with a 20-foot-high ceiling, the building cleanup would cost $200,000. Thus, the total cost of landfilling all plant equipment in a hazardous waste landfill, plus building cleanup, would be $600,000 ($200,000 plus $400,000).

The preceding costs are based on sending the scrap equipment to a hazardous waste landfill without any significant decontamination of the various pieces. A contractor who specializes in equipment cleanup compared cleaning a machine contaminated with asbestos to the physical activity required to clean corrosion. The latter requires disassembly of the machine, removal of the corrosion, and reassembly of the machine. Although asbestos is easier to remove than corrosion, having to wear protective clothing reduces the workers' productivity, so the costs should be similar. Based on this analogy, cleaning of a machine that has been handling asbestos-containing materials would cost about 25 percent of the replacement value. Of course, only equipment that is to be resold would require reassembly; equipment to be sent to a sanitary landfill would require only disassembly and cleanup. When no reassembly is involved, 10 percent of the replacement value of the equipment is a reasonable estimate. Based on the equipment costs in Tables 2-1 and 2-2, cleaning the equipment so that it could be sent to a sanitary landfill or sold as scrap would be $275,000 for a pipe machine alone (10 percent of purchased equipment cost) and $560,000 for all the equipment in the plant. Cleaning and reassembling the equipment for resale would be $690,000 for a pipe machine (25 percent of purchased equipment cost) or $1,400,000 for the entire plant's equipment. Another $260,000 (two times $130,000) should be added for the subsequent cleanup and repair of the equipment areas and an additional $200,000 for building decontamination so that it can be sold or used for other purposes.

Based on conversations with AC pipe manufacturers,[4] there is no U.S. Market for AC pipe machines. The best that an AC pipe machine owner can expect is to trade the pipe machine to a foreign manufacturer for removal, and this has not proved to be very successful.[4] Used equipment dealers usually pay from 20 to 35 percent of new equipment cost for used equipment and sell it for 30 to 50 percent.* Considering the probable poor condition of equipment used to produce AC pipe, dealers will probably pay no more than 20 percent for usable equipment that has been decontaminated. Furthermore, only equipment such as ball mills, mixers, fork lifts, and autoclaves are likely to have any resale value (see Table 2-3). Conveyors, boilers, air pollution control equipment, and spare parts have little resale value unless the equipment is on skids and was designed to be relatively portable.† At best, other plant equipment can be resold for 20 percent of its value. Subtracting the AC pipe machine and related equipment cost in Table 2-2 from

* Personal communication from Mr. Jim Mercer of J. Littler Mercer Company., Inc., Rehoboth, MA, September 29, 1986.

† Personal communications from Mr. Jim Mercer of J. Little Mercer Company, Inc., Rehoboth, MA; Mr. Lawler, Lawler Company, Metuchen, NJ; and Mr. Dennis Herndos, Transamerica Equipment Company, Inc., Northport, AL, all on September 29, 1986.

the total equipment cost in Table 2-1 yields an equipment value of $2,850,000 if purchased new. This value can actually be much lower, however, if the equipment was not designed to be moved (e.g., storage silos and air-pollution-control equipment). The maximum market value of this equipment would be $570,000. If cleanup costs for this equipment (25 percent of $2,850,000 or $710,000) are considered, reselling this portion of AC pipe plant equipment would cost the plant a net of $140,000 plus $130,000 for cleanup and repair of the plant area, for a total of $270,000. Table 2-4 summarizes these costs.

TABLE 2-4. ESTIMATED COSTS FOR AC PIPE PLANT CLOSURE OPTIONS
(December 1985 dollars)

Equipment	Hazardous waste landfill[a]	Cleanup and resale[a]	Cleanup and sanitary landfill[a,b]	Cleanup[a] and sale as scrap
AC pipe machine and directly related equipment	200,000	200,000[c]	462,000	391,000
Other plant equipment (mixers, mills, fork lifts, autoclaves, etc.)	200,000	270,000	472,000	401,000
All plant equipment plus building cleanup for reuse	600,000	670,000	1,144,000	992,000

[a] Includes cost of cleanup and repair of building area where equipment has been removed.

[b] All equipment is sent to a sanitary landfill. A significant part of the landfill cost is for removing heavy equipment from the plant and hauling it to the landfill. Assume that only 20 percent of the $70,000 for removal and landfill is hazardous waste landfill costs and sanitary landfill cost is approximately 10 percent of hazardous waste landfill cost (e.g., $15 per cubic yard compared with $150 per cubic yard).

[c] Not sellable. Cost presented includes removal of equipment, sending it to a hazardous waste landfill, and cleanup and repair of the equipment area.

EQUIPMENT RESALE VALUE

The equipment can also be disassembled, cleaned, and sold as scrap, in which case no reassembly is necessary. Based on information acquired through telephone interviews with asbestos users in several industries, the scrap value of equipment is approximately 0.5 percent of the purchase price of the equipment. Thus, the scrap value of a pipe machine would be approximately $14,000 and the scrap value of all of the plant's equipment would be $28,000. When the required equipment cleanup is considered, the net cost to the plant would be $261,000 ($275,000 less $14,000 scrap value) for the pipe machine by itself and $532,000 for all the plant's equipment. Including repair and cleanup of the equipment area and overall building cleanup would add an estimated $460,000 to these costs.

The time required for the activities discussed can vary widely, depending on availability of equipment inventory, selection of a firm for equipment and building cleanup, ability to find a used equipment dealer, and how long it takes to obtain any permits required by Federal, State, or local authorities (e.g., onsite landfill permit, if applicable). The time and costs of equipment and building cleanup also vary with current housekeeping practices and conditions. The actual equipment cleanup and removal from the building would require an estimated 2 months, and the building cleanup would require another 2 months. Planning, obtaining permits, and selecting contract firms for the cleanup and equipment removal efforts could require another 2 to 6 months. Thus, total time requirements could range between about 6 and 10 months.

GENERAL COMMENTS

The remaining useful life of the AC pipe equipment at existing plants is not known. Most of the equipment in U.S. plants appears to be 20 to 30 years old,[1,4] but with proper maintenance (one 200-ton/day plant spends approximately $100,000 to $150,000 per year for maintenance), it appears that plant equipment could last for several more years. One plant that was shut down in the late seventies was built in 1928 and had never replaced a pipe machine.

The difference in the operating rates of AC pipe equipment and PVC pipe equipment is irrelevant to this study because AC pipe equipment is not convertible to PVC pipe production.

Labor requirements for the production of AC pipe and PVC pipe differ greatly. The forming line for AC pipe requires a seven-man crew, whereas it takes only one person to operate a PVC line.[4]

SECTION 3

CONVERSION COSTS--ASBESTOS FRICTION PRODUCTS INDUSTRY

Determination of the economic impact of a potential ban by the U.S. Environmental Protection Agency (EPA) on the manufacture of asbestos friction products requires data on the cost, resale value, and convertibility of the manufacturing equipment. PEI was contracted by the Office of Pesticides and Toxic Substances to provide these data to ICF, Incorporated, for use in the economic model being used to develop the impact analysis.

Friction products are used in many kinds of industrial and commercial equipment, including the following: automobiles; off-road vehicles, including earth-moving equipment such as tractors, combines, and lawn mowers; aircraft; railroad cars; mining, drilling, and construction equipment; snowmobiles; elevators; washing machines; towmotors; chain saws; and heavy equipment such as that used in various manufacturing establishments.

PEI contacted various suppliers of asbestos friction products to obtain information related to asbestos-substitution problems and associated costs. In general, the most difficult part of converting to an asbestos substitute appears to be identifying a substitute material that has the asbestos-like properties such as high and stable frictions under heat, strength, wear resistance, and flexibility that are required for various brake and clutch lining products. The substitute materials currently being used (e.g., fiberglass, mineral wool, and Kevlar) are also considerably more expensive than asbestos materials.

Table 3-1 summarizes the information PEI obtained through contacts with asbestos friction product manufacturers.

PRODUCTION EQUIPMENT

The various manufacturers contacted and visited appeared to use similar equipment. Except perhaps for some of the molds, the same plant equipment

TABLE 3-1. ASBESTOS FRICTION PRODUCTS DATA SUMMARY

Plant	Plant size, ft², or capacity, lb/h	Equipment type	No.	New value, $	Resale value, $	Age, years	Reported scrap value, $	Scrap weight, tons	Comments
E	700 lb/h	Clutch face molds	100	250,000					Equipment conversion costs with about 50% converted. Total conversion will be about $2,250,000.
		Treatment tunnel	1	500,000					
		Rest of conversion		1,500,000					
		Total plant		50,000,000	10,000,000	30	500,000		12,000,000-part/year capacity.
									Existing plant.
F		Total plant	1	35,000,000		20			
G	1,300 lb/h	Total plant	1	2,000,000	304,000[a]	15		750	1 year conversion. Slower production. 21,600,000-part/year capacity.
H	500 lb/h								Capacity dropped to 40% after conversion. 8,320,000 parts/year.
I									Saw blades switched to diamond. Operating costs doubled. 33% slower and raw materials more expensive. Currently 95% switched to asbestos substitutes.
J									Cannot find substitute. Will shut down.
K	800 lb/h	Total plant		2,000,000	350,000	10			Assuming equipment liquidation.[b] 14,000,000-part/year capacity. To convert $1,000,000 to met. and $1,200,000 to $1,500,000 for met. and org.
L									No equipment models necessary for substitute material.[c] 14,000,000-part/year capacity currently 75% or 30,000 parts/day.
M									4 years of developmental research time required to make the conversion. Manufacturer - $200,000 for 3 full-time technicians working 4 years; customer - $500,000 for 4 years of testing transmissions, etc.; and $300,000 for engineering control costs. Another $30,000 was required for cleanup costs; outside contractor vacuumed all equipment, storage rooms, ductwork, overhead beams, etc. Some equipment was washed down with water--took 1.5 weeks. No change in productivity with substitute, just higher material costs.

[a] Equipment resale only. Current building expenses are $55,000/year in insurance and taxes. $100,000 to $600,000 to be spent on buidling before sell approval issued. Now out of business.

[b] Reportedly a typical plant would have two smaller units to total this capacity. Metallic-based substitutes cost three times more to produce. Experimenting with material 75 to 80 percent of metallic product.

[c] Three or four full-time researchers required 5 years to develop substitute material. Cleanup of old equipment would be $100,000. Will be 100% asbestos-free by November 1986.

TABLE 3-1 (continued)

Plant	Plant size, ft², or capacity, lb/h	Equipment type	No.	New value, $	Resale value, $	Age, years	Reported scrap value, $	Scrap weight, tons	Comments
A	30 lb/h	Mixer	1	37,000	4,000	20	50		Corrosion costs are $5,000 to $10,000 per new mold. 12 to 15 molds were changed over the last year, but a new substitute being developed may not require mold conversion. It takes 1 to 3 weeks to make their own mold.
			1	37,000	12,000	10	50		
		Molding	3	60,000	5,000	40	50		
				250,000	20,000	20	200	60	
				730,000	5,000	20	200	0.5	
			1000	500,000	0	20		1	Produces 25 to 30% asbestos products. Used 60 tons of asbestos to produce 120 tons of products in 1985.
		Lathes, etc.	100	50,000	500	20	100	1.5	
		Boiler	1	100,000	10,000	4	0		
		Fabric filter	11	250,000	0	20	0		
		Scrubber	1	30,000	0	25	0		
B	30 lb/h	Mixer	3	30,000	15,000	20			Drum liner production dropped from 58 to 23 ft/min. Production cost about $0.20 w/asbestos and $0.60 to $0.80 w/substitute. Will go out of business if 100% asbestos required.
			1	214,000	109,000	20			
			8	360,000	184,000	20			
			1	165,000	84,000	20			
		Slitter and cutter	5	20,000	10,000	20			
		Molding	2	15,000	8,000	20			Most equipment weighs 1500 to 4000 lb.
		Oven	1	60,000	31,000	20			
		Drill, grind	9	85,000	43,000	20			Small grinders are approximately $5,000 each and large grinders are approximately $15,000 each.
			4	40,000	20,000	20			
C	130,000 ft²	Mixer	13	100,000	30,000	6			120 employees at present; has been as high as 400.
		Molding	56	75,000	0	30			
		Slitter and cutter	8	135,000	20,000	15			
		Oven	25	20,000	0	30			
		Sanders	8	172,000	0	10			
		Grinders	12			40			
		Punch presses	10	100,000	0	30			
		Fabric filters	7	2,500,000	0	13			
		Treater towers	2	400,000	0	30			
		Solvent recovery	1	850,000	0				
		Winders		500,000	0				
D	100,000 ft²	Mixer	3	240,000	90,000	15	100	6	
		Preform mold	8	144,000	25,000	12	150	8	
		Comp. mold	35	1,500,000	375,000	18	5,000	250	
		Slitter and cutter	1	25,000	0	15	200	1	
		Arc mold	12	60,000	0	15	100	6	
		Oven	14	350,000	90,000	15	200	20	
		Finishing	25	150,000	40,000	15	250	25	
		Punch presses	3	45,000	15,000	20	100	6	
		Cent. hyd. system	1	150,000	50,000	20	150	15	
		Boilers	2	150,000	40,000	15	300	30	
		Dust collectors	5	450,000	50,000	15	500	50	
		Lab equipment	7	500,000	90,000	15	750	75	

can be used to produce both asbestos and nonasbestos brake products. Several different formulations are used for producing asbestos-containing friction materials. An article in the Kirk Othmer Encyclopedia of Chemical Technology reports 18 formulations of asbestos-containing organic friction materials.[6]

Table 3-2 presents the equipment components found in a friction products plant and the projected options for each type of equipment. The same equipment could be used in a plant producing nonasbestos friction products.

TABLE 3-2. FRICTION PRODUCTS EQUIPMENT OPTIONS

Process	Convert to substitute process	Resell to nonasbestos industries[a]	Likely to have resale value	Sell for scrap	Send to landfill
Raw material receiving and handling					
Mixers	x	x	x	x	x
Friction materials production					
Preform compression molding machines	x		x	x	x
Heated compression modling machines	x		x	x	x
Combination slitter and cutter	x		x	x	x
Curing oven	x	x		x	x
Finishing equipment (drills, grinders, etc.)	x	x	x	x	x
Support equipment					
Boiler	x	x		x	x
Air pollution controls (e.g., fabric filters)	x	x		x	x
Dynamometers	x		x	x	x

[a] Also nonfriction products industry.

REPLACEMENT COST OF EXISTING EQUIPMENT

The number of production lines and the size and kind of auxiliary services required at a friction materials production facility will depend on the types of friction products produced and the quantity sold. Auxiliary services include boilers, buildings, raw material storage, warehouses, and shipping facilities. Although production lines can often be shifted from one type of friction material to another, these lines are usually dedicated to a single composition. The cost estimate development is based on a 100,000-square-foot building with sufficient equipment available for annual production of approximately 15 million pieces of asbestos friction products.*

Tables 3-3 and 3-4 show the estimated cost breakdown for installing a friction products facility of the size and capacity just described and for replacing only that equipment exposed to asbestos or an asbestos mixture. The infrastructure (i.e., the underlying base, building, and basic support systems such as the boiler) would already exist, but wiring, piping, and some service facilities (such as conveyors and storage and shipping facilities) would have to be added. Calculations of the cost components were based on factors from Peters and Timmerhaus.[3]

Tables 3-3 and 3-4 also present the estimated costs of a new greenfield† facility ($40 million) and of the installation of friction product manufacturing equipment in a building previously used for another process or one that requires a different equipment configuration. In the latter case, if the existing equipment is merely removed and replaced with similar equipment and the existing electrical, piping, etc., are used, the cost of the new equipment and its installation would only be $4.2 million (the first two line items in Table 3-4). This estimated cost does not include removal of existing equipment.

ASBESTOS SUBSTITUTION OPTIONS

Two alternatives are considered for asbestos friction product plants: 1) conversion of existing equipment for use with nonasbestos materials, and 2) scrapping or reselling the existing equipment and purchasing new equipment. Converting the equipment or plant to produce something other than

* Personal communications from Mr. Leroy McDonald, Mead Corporation, South Lee, MA, October 7, 1986; Ms. Jan Morris, Raymark Corporation, Crawfordsville, IN, September 23, 1986; Mr. Steven Simon, Brassbestos Mfg. Corporation, Peterson, NJ, September 23, 1986; Mr. George Houser, Raymark Corporation, Manheim, PA, October 14, 1986.

† "Greenfield facilities" are entirely new facilities constructed in areas where no previous building has been constructed.

TABLE 3-3. ESTIMATED COST OF FRICTION PRODUCTS PLANT INSTALLATION
(December 1985 dollars)

Component	Percent of total capital investment	Cost of equipment, \$1000
Direct costs		
Purchased equipment	20	8,000
Purchased equipment installation	10	4,000
Instrumentation and controls (installed)	4	1,600
Piping (installed)	6	2,400
Electrical (installed)	2	800
Buildings (including services)	6	2,400
Yard improvements	2	800
Service facilities (installed)	10	4,000
Land	1	400
Total direct costs	61	24,400
Indirect costs		
Engineering and supervision	7	2,800
Construction expense	7	2,800
Contractor's fee	5	2,000
Contingency	5	2,000
Total indirect costs	24	9,600
Total fixed-capital investment	85	34,000
Working Capital	15	6,000
TOTAL CAPITAL INVESTMENT	100	40,000

TABLE 3-4. ESTIMATED COST OF FRICTION PRODUCTS MANUFACTURING EQUIPMENT INSTALLATION (December 1985 dollars)

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	25	3,000
Purchased equipment installation	10	1,200
Instrumentation and controls (installed)	5	600
Piping (installed)	10	1,200
Electrical (installed)	5	600
Buildings (including services)	0	0
Yard improvements	0	0
Service facilities (installed)	5	600
Land	0	0
Total direct costs	60	7,200
Indirect costs		
Engineering and supervision	10	1,200
Construction expense	10	1,200
Contractor's fee	5	600
Contingency	5	600
Total indirect costs	30	3,600
Total fixed-capital investment	90	10,800
Working Capital	10	1,200
TOTAL CAPITAL INVESTMENT	100	12,000

friction products was not considered because the equipment and support systems can be used to produce nonasbestos friction products, for which there will be a continued demand regardless of the formulations used in the industry.

CONVERSION COSTS

Converting existing equipment for use with nonasbestos materials would involve cleaning the existing equipment and the plant and changing the molds. The costs presented herein do not include the R&D costs to find a substitute material or the cost of the reported decrease in the plant's productivity when asbestos substitutes are used. The friction products plants contacted were developing their own substitute compositions, which would not be available to other producers. Finding a substitute material can reportedly involve as much as 4 or 5 years and the efforts of three or four full-time laboratory technicians or researchers.[*] The total cost for the time alone is estimated to be $200,000. This does not include the costs of testing new materials with the appropriate products. Engineering costs can be another $300,000 (e.g., equipment modifications and additional pollution controls).

Adding another 50 percent to the technician costs to cover supervision, other part-time researchers, and miscellaneous supplies would result in an estimated research cost of $300,000 to identify substitutes. Total costs for research and engineering are estimated to be $600,000.

Reported values for the resulting reduction in process operating rate when asbestos substitutes are used varied widely. One plant reported no reduction in production rate,[†] whereas others reported reductions of up to 40 percent.[**] Greater wear on the process equipment was also reported to result with asbestos substitutes. These higher material costs and reductions in production rate doubled operating costs.[††]

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[*] Personal communications from Mr. Leroy McDonald, Mead Corporation, South Lee, MA, October 7, 1986; Mr. Robert Tami, Motion Control Industries, Ridgeway, PA, October 23, 1986.

[†] Personal communication from Mr. George Houser, Raymark Corporation, Crawfordsville, IN, October 14, 1986.

[**] Personal communications from Mr. Delvin Foster, LS1-Certified Brakes, Danville, KY, September 23, 1986; Mr. Greg Beckett, Wheeling Brake Block Manufacturing, Bridgeport, CT, September 23, 1986.

[††] Personal communication from Mr. Greg Beckett (above).

Most producers of friction products currently appear to have converted at least part of their facilities to the use of nonasbestos materials and are looking for substitutes for most of their other products. The cost of converting the equipment for the typical facility described earlier is estimated to be $1,095,000. This includes $750,000 for equipment cleanup (25 percent of the cost of replacement equipment as presented in Table 4), $120,000 for general plant cleanup, and an estimated $225,000 for mold changes (assuming 50 molds per plant, 30 of which will need to be converted at a cost of $7500 per mold).* Again, the estimated $600,00 cost of the necessary research and engineering is not included. The equipment and plant cleanup may be less than estimated, depending on the regulatory requirements governing these activities. The estimates for equipment are based on taking the equipment apart, cleaning each piece, and then reassembling the equipment for use.† Plant cleanup costs are based on the reported cleanup costs of $30,000 (isolating the area and other stringent controls for asbestos dust were not required)** for a 100,000-square-foot facility. Based on PEI's asbestos cleanup experience, the cost of vacuuming and washing down walls is only about 25 percent of the total cost of a strictly-controlled cleanup. Other costs include preparing and isolating the cleanup area, handling and transfer of the collected asbestos dust, landfilling the wastes in an approved hazardous waste landfill facility, and demobilization. Including these costs would increase the plant cleanup costs to $120,000.

EQUIPMENT RESALE VALUE

The cost for reselling existing equipment and purchasing new all equipment that is directly involved with producing friction products (not including plant mobile equipment or other ancillary equipment) is estimated to be $4,320,000. This includes the purchase and installation of new equipment after cleanup ($750,000), resale ($750,000 or 25 percent of the purchased equipment cost),†† and cleanup of the plant ($120,000). This

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* Personal communication from Mr. Bill Outcalt, Aztec Industries, North Brookfield, MA, September 8, 1986.

† Personal communication from Mr. Jim Smith, Blackman-Mooring Steamatic Castrophe, Inc., Fort Worth, TX.

** Personal communication from Mr. George Houser, Raymark Corporation, Crawfordsville, IN, October 14, 1986.

†† Personal communication from Mr. Jim Mercer, J. Little Mercer Company, Inc., Rehoboth, MA, September 29, 1986.

estimate assumes that the new equipment goes in the same plant area as the removed equipment and that minimal wiring, piping, and other support equipment is required.

GENERAL COMMENTS

Some plants may be unable to find substitutes for asbestos, particularly those with no (or minimal) R&D capability. These plants will be required to shut down or to sell the plant to another friction product manufacturer.

The remaining useful life of equipment used for friction product manufacturing will vary. The average age of most of the existing equipment belonging to the manufacturers that were contacted was about 20 years, but equipment ages of as high as 40 years have been reported.

The loss in production efficiency due to the use of substitutes is primarily a result of the nature and use of the asbestos substitutes. Reasons for this reduction include longer mixing times, handling difficulties and additional maintenance due to the higher abrasiveness of the formulations, and longer finishing times. Based on reported losses in production efficiencies from 0 to 40 percent, an average loss of 20 percent is estimated.

SECTION 4

CONVERSION COSTS--PAPER AND FELTS INDUSTRY

Asbestos-containing papers and felts are used in a variety of industrial and consumer products. Asbestos paper is used in gaskets, filters, insulation papers, and similar products. Asbestos felt is used as backing material in various applications. Switching to asbestos-substitute materials in the papers and felts industry depends on finding suitable substitutes for the asbestos content in these products.

PRODUCTION EQUIPMENT

The production equipment at a papers and felts facility consists primarily of several mixing and holding chests, a jordan, steam-filled dryers, and winding and calender rolls. Each facility also needs a boiler to supply the steam for the dryers. The exact equipment at each facility varies with the products manufactured there.

ASBESTOS SUBSTITUTION OPTIONS

The conversion to asbestos substitutes in the papers and felts industry depends primarily on the industry's ability to find substitutes suitable for the users of the materials now produced with asbestos products. No major problems have been reported in converting the papers and felts equipment to asbestos-substitute materials. Most of it can be readily converted to asbestos-substitute products. One industry contact indicated, however, that the equipment would have to be cleaned thoroughly before it is converted for use with asbestos-substitute materials.

The one paper facility (Quin-T Corporation, Erie, Pennsylvania) that responded to PEI's request for information indicated it has two paper-making machines and produces 16 million pounds of paper annually. Sixty-five percent of this output contains asbestos; the remaining portion does not.

CONVERSION COSTS

In general, the costs of converting and cleaning this equipment are expected to be minimal. The responding facility (Quin-T Corporation, Erie, Pennsylvania) reported a minor modification expense of $7000 and equipment cleaning costs of $10,000 to $15,000. The facility further reported that the conversion would take 1 to 1.5 months to complete.

Table 4-1 shows the capital cost breakdown at a facility with a capacity of 8000 tons of paper per year. The costs are derived from the equipment cost data provided by the Quin-T Corporation and on recommended capital cost percentages.[3]

TABLE 4-1. ESTIMATED COST OF A NEW PAPER FACILITY WITH A CAPACITY OF 8000 TONS/YR

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	18.3	1,500
Equipment installation	11.0	900
Instrumentation and controls (installed)	3.1	258
Piping (installed)	1.5	120
Electrical (installed)	4.2	348
Buildings (including services)	4.4	360
Yard improvements	1.1	90
Service facilities (installed)	11.0	900
Land	0.7	60
Total direct costs	55.3	4,536
Indirect costs		
Engineering and supervision	9.5	780
Construction expense	10.6	870
Contractor's fee	3.7	300
Contingency	11.0	900
Total indirect costs	34.7	2,850
Total Fixed-Capital Investment	90.0	7,386
Working Capital	10.0	823
TOTAL CAPITAL INVESTMENT	100.0	8,209

EQUIPMENT RESALE VALUE

Although the equipment used in the papers and felts industry is similar to that used in industries that produce roofing felts and felt-backed vinyl sheet flooring, no active market is currently available for this equipment.

SECTION 5

CONVERSION STATUS--ROOFING FELTS INDUSTRY

The U.S. roofing felt industry manufactures saturated and unsaturated roofing felts. No information was available from this industry regarding the current status of asbestos use in the manufacture of roofing felts.

Most manufacturers of saturated roofing felt have discontinued the use of asbestos and now produce either organic or fiberglass felts. Only one company (Nicolet in Pennsylvania) is suspected of still manufacturing unsaturated roofing felt.[7] This company has confirmed that it sells unsaturated felt, but it will not reveal whether it produces the unsaturated felt at company-owned plants or purchases it from another firm.

SECTION 6

CONVERSION STATUS--VINYL-ASBESTOS FLOOR TILE INDUSTRY

Two floor tile facilities responded to PEI's request for information relating to equipment conversion to asbestos-substitute materials. The facilities indicated that a complete conversion to asbestos-substitute materials has been completed and that none of the operations at these facilities now use asbestos as a raw material.*

It is reported that all of the floor tile facilities in the United States now manufacture products containing no asbestos.[7]

* Personal communications from American Beltrite, Inc., Lawrenceville, NJ (October 9, 1986) and Armstrong World Industries, Inc., Lancaster, PA (September 30, 1986).

SECTION 7

CONVERSION STATUS--ASBESTOS FELT-BACKED VINYL SHEET FLOORING INDUSTRY

No data are available regarding the production of asbestos felt-backed vinyl sheet flooring in the United States. Most manufacturers of felt-backed vinyl sheet flooring have discontinued the use of asbestos and now manufacture products containing asbestos-substitute materials.[7]

SECTION 8

CONVERSION COSTS--ASBESTOS-CEMENT SHEET AND SHINGLE INDUSTRY

Asbestos-cement (A-C) sheets are used primarily in the construction industry--as wall lining in factories and agricultural buildings, as fire-resistant walls and curtain walls, and for other similar applications. Asbestos-cement shingles are used for siding and roofing on both residential and commercial buildings. Asbestos is used as a reinforcing material because of its high tensile strength, flexibility, thermal resistance, and corrosion resistance. Conversion to nonasbestos products in the A-C sheet and shingle industry depends on finding acceptable substitute materials and product formulations.

PRODUCTION EQUIPMENT

Formulations for A-C sheeting vary with the manufacturing process; however, the basic production process and composition are similar for all such products. The equipment at a sheeting facility consists primarily of various mixers and sheeter mills. In addition to the same equipment found at a sheet facility, a shingle facility also has a punch press and baking and finishing equipment, such as autoclaves, brushers, waxers, and paint machines.

ASBESTOS SUBSTITUTION OPTIONS

One sheet facility* and one shingle facility† responded to PEI's request for information. Both facilities indicated that specially designed equipment for asbestos substitute materials has not been developed. The sheeting

* Personal communication from the Victor Products Division of Dana Corporation, Robinson, IL, September 29, 1986.

† Personal communication from Supradur Manufacturing Corporation, Rye, NY, October 10, 1986.

facility further indicated that extensive research has not yet demonstrated that the products containing asbestos substitutes can be manufactured with the existing equipment.

The shingle facility does not have specific supporting information, but feels that asbestos substitute products will run much slower with the existing equipment. Based on the conversion impact data for other industries, a reduction in production efficiency of at least 20 percent is estimated.

The responding sheeting facility indicated that body mixers would have to be replaced and sheeter mills would require modification. This facility has four body mixers, nine sheeter mills, and an annual production rate of 3,000,000 square yards of sheeting. This facility further indicated that the equipment would have to be cleaned thoroughly before a switch is made to asbestos-substitute materials.*

Both facilities estimated that conversion would take about 2 years. The indicated duration is a rough estimate; the actual duration will depend upon the extent and nature of equipment modifications. The conversion duration is needed to allow time for developing product formulations, test runs, equipment modifications, and startup and commissioning with substitute materials. The actual downtime for conversion will be significantly lower than the conversion duration because the facilities will continue to manufacture asbestos-containing products until the conversion is completed.

CONVERSION COSTS

The facilities contacted by PEI indicated that conversion to asbestos-substitute materials would require significant expenditures. Replacement of body mixers and modifications of the sheeter mills are the two major cost-intensive items reported by the sheeting facility. The cost of replacing the existing four body mixers is estimated to be $720,000, and the cost of modifying the nine sheeter mills is estimated to be $180,000. An additional $50,000 expenditure was estimated for tearing down and cleaning the equipment. The total estimated conversion cost for a sheeting facility with a capacity of 3,000,000 square yards per year is about $1,000,000.*

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* Personal communication from the Victor Products Division of Dana Corporation, Robinson, IL, September 29, 1986.

Table 8-1 shows a cost breakdown for an A-C sheet facility with a capacity of 3,000,000 square yards/year. PEI developed this breakdown from purchased equipment cost data provided by a responding facility (Victor Products Division of Dana Corporation) and the use of current recommended percentages for cost components.[3]

Table 8-2 shows the estimated cost breakdown for installing an additional 3,000,000 square yards of sheeting per year at an existing plant. The cost assumes that the infrastructure (i.e., the underlying base, building, and basic support systems) is already in position. The purchased equipment cost is assumed to be 70 percent of the amount needed to set up a greenfield installation.

The shingle facility (Supradur Manufacturing Corporation of Rye, New York) indicated that extensive research has not yet demonstrated that the existing equipment can be used to make products containing asbestos substitutes. According to this facility, the most likely option for switching to asbestos-substitute products would be to construct an entirely new facility at a cost of about $8 to $10 million. This facility currently makes 21,500 tons of siding and roofing products per year.

EQUIPMENT RESALE VALUE

No resale market exists for the equipment used to make A-C sheets and shingles because of the limited number of facilities in the industry. The equiment can be sold as scrap, and such, is assumed to have zero net value; i.e., the credits generated from the sale of the scrap are assumed to equal the cost of equipment removal and transportation and the reconditioning of the area from which it was removed.

Waste disposal costs for an A-C sheet and shingle facilty are assumed to be similar to those for the A-C pipe industry and are calculated as a percentage of the capital cost of a new plant. The equipment disposal costs for the A-C pipe industry ranged from 1.4 to 2.8 percent of the capital cost. Based on this range, the disposal cost of $400,000 is estimated for equipment with a capacity of 3,000,000 square yards per year. The costs are based on disposing the plant equipment in a hazardous waste landfill. A significant part of the cost is for removing heavy equipment from the plant and hauling it to the landfill.

TABLE 8-1. ESTIMATED COST OF AN A-C SHEET FACILITY WITH A CAPACITY OF 3,000,000 SQUARE YARDS/YR

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	18.3	3,000
Equipment installation	11.0	1,800
Instrumentation and controls (installed)	3.1	516
Piping (installed)	1.5	240
Electrical (installed)	4.2	696
Buildings (including services)	4.4	720
Yard improvements	1.1	180
Service facilities (installed)	11.0	1,800
Land	0.7	120
Total direct costs	55.3	9,072
Indirect costs		
Engineering and supervision	9.5	1,560
Construction expense	10.6	1,740
Contractor's fee	3.7	600
Contingency	11.0	1,800
Total indirect costs	34.7	5,700
Total Fixed-Capital Investment	90.0	14,772
Working Capital	10.0	1,650
TOTAL CAPITAL INVESTMENT	100.0	16,422

TABLE 8-2. ESTIMATED COST OF A-C SHEET AND SHINGLE PRODUCTS EQUIPMENT INSTALLATION

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	26.7	2,100
Equipment installation	17.8	1,400
Instrumentation and controls (installed)	3.8	300
Piping (installed)	0.8	60
Electrical (installed)	5.1	400
Buildings (including services)	0.0	0
Yard improvements	0.0	0
Service facilities (installed)	6.4	500
Land	0.0	0
Total direct costs	60.6	4,760
Indirect costs		
Engineering and supervision	10.8	845
Construction expense	12.0	943
Contractor's fee	4.2	329
Contingency	12.5	979
Total indirect costs	39.4	3,096
Total Fixed-Capital Investment	100.0	7,856
Working Capital	0.0	0
TOTAL CAPITAL INVESTMENT	100.0	7,856

SECTION 9

CONVERSION COSTS--TEXTILES AND PACKING INDUSTRY

The textiles and packing industry produces asbestos-containing products for other industries to use as supplementary material in their products. A typical textiles and packing facility makes products in various forms such as lap, roving, wick, thread, yarn, rope, cord, packing, and cloth. The equipment at a particular facility depends on the products made there. The switch to asbestos-substitute materials in the textiles and packing industry depends on the ability to find suitable substitutes for these methods.

PRODUCTION EQUIPMENT

Although the production equipment at a textiles and packing facility depends on the products made at the plant, the front-end equipment, which performs the preliminary processing, is common to all the facilities. The preliminary processing generally includes operations such as fiber blending, packing and lap formation, carding, and drawing. The preliminary processing produces roving that can be further processed to produce wick by twisting the yarn or thread by spinning it. The yarn can be further processed to produce rope, cord, or packing. Rope and cord are made from yarn by additional twisting, whereas packing involves steps such as braiding, extrusion, molding, or laminating. Individual processing functions at the facility generally take place in separate equipment modules. A textiles and packing facility also requires a boiler to provide steam for various process operations.

ASBESTOS SUBSTITUTION OPTIONS

The conversion to asbestos substitutes in the textiles and packing industry depends primarily on the ability of ancillary industries to find substitutes for the materials currently being produced with asbestos-containing products from the textiles and packing industry. No major problems have been reported with regard to converting the textiles and packing equipment to use asbestos-substitute materials. Most of the equipment can be readily converted without the need for significant equipment cleaning.

Two textiles and packing facilities provided PEI with conversion-related data. One facility, which produces yarn for friction products, indicated that the carding equipment would have to be replaced if the plant were to convert to asbestos substitute materials. This facility has 18 cards with an annual yarn production rate of 3000 tons. Conversion is estimated to take 4 to 6 weeks per card and to entail an expenditure of $15,000 to $20,000 per card. The facility did not refer to any other conversion problems.*

A facility producing 250 tons of packing material reported that it recently converted its entire product line to asbestos-substitute materials. The facility is now using the same equipment without any additions or modifications, and no expenses were incurred in the conversion.†

CONVERSION COSTS

In general, no costs are associated with the conversion of a textiles and packing facility to nonasbestos-substitute materials. At some facilities, the compatibility of plant equipment with the available substitute materials may need to be studied. Although PEI is not aware of the reasons one facility needed to replace its carding equipment, this facility is believed to be an exception. The facility estimated the cost of replacing the carding equipment to be around $90 to $120 per ton-year of product. The replacement involved a total of 18 cards producing 3000 tons/year of yarn for friction products.

Equipment for producing asbestos-based products can be readily switched to asbestos-substitute materials without significant modifications. Although equipment cleaning is generally recommended, the cleaning costs are expected to be insignificant. If carding equipment must be replaced, the cost of such replacement at a 1000-ton/year facility is estimated to be between $90,000 and $120,000.

* Personal communication from Raymark Industrial Division, Marshville, NC, October 23, 1986.

† Personal communication from Garlock, Inc., Compression Packing Division of Colt Industries, Sodus, NY, September 24, 1986.

The capital cost breakdown of a textiles and packing facility with a capacity of 1000 tons/year is shown in Table 9-1. The costs are derived from equipment cost data provided by the textiles and packing facilities contacted by PEI and recommended capital cost percentages.[3] The equipment cost for this size facility was extrapolated from the equipment cost at a facility with a capacity of 250 tons/year and an equipment scale factor of 0.6 (i.e., the plant size ratio to the 0.6 power). The equipment cost data for the 250-ton/yr facility and the 3000-ton/yr facility gave a scale factor of 0.89. This factor was not used because it does not fall within the generally accepted scale factor range of 0.5 to 0.75.

EQUIPMENT RESALE VALUE

The textiles and packing industry equipment generally has no resale value; however, its scrap value is around $80/ton. The total weight of the equipment at a 1000-ton/year facility was calculated from the data for a 3000-ton/year capacity plant by using a 0.6 scale factor and roughly amounts to 60 tons. The scrap value of this equipment is estimated to be $4800.

TABLE 9-1. ESTIMATED COST OF A TEXTILES AND PACKING FACILITY WITH A CAPACITY OF 1000 TONS/YR

Component	Percent of fixed capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	18.3	1,068
Equipment installation	11.0	641
Instrumentation and controls (installed)	3.1	184
Piping (installed)	1.5	85
Electrical (installed)	4.2	248
Buildings (including services)	4.4	256
Yard improvements	1.1	64
Service facilities (installed)	11.0	641
Land	0.7	43
Total direct costs	55.3	3,230
Indirect costs		
Engineering and supervision	9.5	555
Construction expense	10.6	619
Contractor's fee	3.7	214
Contingency	11.0	641
Total indirect costs	34.7	2,029
Total Fixed-Capital Investment	90.0	5,259
Working Capital	10.0	586
TOTAL CAPITAL INVESTMENT	100.0	5,845

SECTION 10

CONVERSION COSTS--ASBESTOS SHEET GASKETING INDUSTRY

Asbestos is used as gasketing material because it is heat- and pressure-resistant, resiliant, strong, and relatively chemically inert. Gasket sheeting is produced by mixing the raw materials thoroughly and then compressing the mixture into sheets. The primary producers supply these compressed sheets to secondary producers/fabricators, who cut the sheets into gaskets according to customer specifications. Conversion to nonasbestos products in the gasketing industry depends on finding acceptable substitute materials and product formulations.

PRODUCTION EQUIPMENT

The equipment at a compressed sheet facility consists primarily of a material feed system, mixers, a drop mill, a sheeter/calender, and autoclaves. Raw materials, which typically include rubber, asbestos, and solvents, are fed through the feed system to the mixer for blending. The blended material is further processed in the drop mill before it is transferred to the sheeter machine. The sheets formed in the sheeter machine are then cured in an autoclave. Some facilities that produce gasket sheeting also have solvent recovery equipment to recover solvents that are liberated in the autoclaves.

ASBESTOS SUBSTITUTION OPTIONS*

The one sheet gasketing facility that responded to PEI's request for information indicated that finding the right substitute materials and formulations is the key to successful conversion and that no data regarding

* Personal communication from Special Paperboard Division of Boise Cascade, Beaver Falls, NY, October 3, 1986.

such substitute materials and product formulations are currently available. Extensive laboratory experimentation with substitute materials and formulations is required.

This facility also indicated that the expenditure for equipment modification would be significant; however, no specific data are currently available regarding the kinds of modification required for conversion to asbestos-substitute materials. Although the facility that responded to PEI's request has not conducted an investigation to generate such data, the spokesman indicated that the lack of successful development of substitute materials for many product areas precludes arriving at a good definition of equipment requirements. The facility further indicated that converting their equipment to asbestos-substitute materials would take about 3 years.

Because the facility has not collected specific conversion data, the indicated duration is a rough estimate. The conversion duration is needed for developing product formulations, test runs, equipment modifications, and startup and commissioning with the substitute materials. The actual downtime for conversion will be significantly less than the conversion duration. The facility will continue to manufacture asbestos-containing products until the conversion is completed.

CONVERSION COSTS

The facility that PEI contacted estimated a conversion cost of about $7.2 million; however, this estimate was made without itemizing any of the equipment modifications. An additional $200,000 expenditure was estimated for tearing down and cleaning the equipment.

Table 10-1 shows a cost breakdown for building a new sheet gasketing facility with a capacity of 28 tons/day. The cost breakdown was developed from the purchased equipment cost data received from the contacted facility* and recommended percentages for cost components.[3]

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* Personal communication from Special Paperboard Division of Boise Cascade, Beaver Falls, NY, October 3, 1986.

TABLE 10-1. ESTIMATED COST OF A NEW SHEET GASKETING FACILITY WITH A CAPACITY OF 28 TONS/DAY

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	18.3	12,000
Equipment installation	11.0	7,200
Instrumentation and controls (installed)	3.1	2,064
Piping (installed)	1.5	960
Electrical (installed)	4.2	2,784
Buildings (including services)	4.4	2,880
Yard improvements	1.1	720
Service facilities (installed)	11.0	7,200
Land	0.7	480
Total direct costs	55.3	36,288
Indirect costs		
Engineering and supervision	9.5	6,240
Construction expense	10.6	6,960
Contractor's fee	3.7	2,400
Contingency	11.0	7,200
Total indirect costs	34.7	22,800
Total Fixed-Capital Investment	90.0	59,088
Working Capital	10.0	6,600
TOTAL CAPITAL INVESTMENT	100.0	65,688

EQUIPMENT RESALE VALUE

The resale market for equipment used to produce sheet gasketing is limited; the resale value of the equipment at this 28-ton/day facility is estimated to be $50,000.

SECTION 11

CONVERSION COSTS--COATINGS AND SEALANTS INDUSTRY

Use of asbestos in the coatings and sealants industry has declined considerably in the past 5 years. Telephone conversations with the several producers of coatings and sealants in the United States indicate that most of them have switched to asbestos substitutes or are planning a switch in the near future.

PEI contacted various producers of coatings and sealants to obtain information on problems created by switching to asbestos substitutes and conversion-related costs. In general, no serious difficulties have occurred or are expected.

PRODUCTION EQUIPMENT

Coatings and sealants are batch-produced in kettles or tanks ranging in size from 50 to 6000 gallons. The batch time can vary from 4 to 10 hours depending on the product type. Common process industry equipment is used in the coatings and sealants industry and typically consists of the following: fluffers, conveyors, mixing tanks or kettles, and dispensers or blenders.

ASBESTOS-SUBSTITUTE OPTIONS

Our survey of the coatings and sealants industry indicated that no major equipment additions or modifications are needed to convert the plant equipment to asbestos-substitute products; however, finding the right substitute materials and formulations is a key to a successful conversion. Various coating and sealant products are produced by several manufacturers, and the product formulations are producer-specific and considered trade secrets. Thus, the manufacturers must develop their own formulations for the new materials. To effect a successful conversion requires extensive laboratory experimentation with asbestos-substitute materials and formulations. Once the right product formulations have been found, the switch to asbestos-substitute materials can be completed without incurring major expenditures. Thorough cleaning of the equipment is generally recommended before the switch is made to substitute materials; however, the cleaning costs are not reported to be significant.

A switch to asbestos substitutes generally requires the use of more than one substitute material because the properties offered by asbestos cannot be obtained from a single substitute material. The number and types of substitute materials required depend on the end products being manufactured. In general, the switch to asbestos substitutes adversely affects the production efficiency. Some substitutes require longer blending and mixing times. This, plus the need to handle more than one substitute material, results in lower production efficiency. Some facilities report that the production rate may be reduced by as much as 20 percent when substitute materials are used.* The facilities contacted by PEI did not report production equipment as having any effect on production efficiency.

The use of asbestos substitutes in the coatings and sealants industry can be accomplished without major problems. The majority of the producers have already voluntarily switched or are planning to switch to asbestos-substitute materials in the near future.

CONVERSION COSTS

The equipment used in the coatings and sealants industry is very simple and can generally be purchased off the shelf. Table 1 presents a cost breakdown for a coatings and sealants facility with a production capacity of 700 gallons/batch. This cost breakdown is based on purchased equipment cost data provided by one of the facilities PEI contacted† and on recommended percentages for cost components.[3] In general, the same equipment used to produce products containing asbestos can be used for products made with asbestos-substitute materials. Minor equipment variations may be necessary

* Personal communication from Mr. Allan Morris, Coopers Creek Chemical Corporation, West Conshohockten, PA, September 22, 1986.

† Personal communication from Mr. Donald Davis, American Tar Company, Seattle, WA, September 18, 1986.

in the material-handling area depending on the type and number of substitute materials required; however, these differences are not expected to affect the costs appreciably.

The 700-gallon batch capacity facility in Table 11-1 can typically produce 525,000 gallons of products per year. This output is based on a batch time of 8 hours and an operating schedule of 24 hours/day, 5 days/week, and 50 weeks/year. Batch time, which depends on product type, can vary from 4 to 10 hours.

Although no significant modifications to equipment is required, thorough cleaning is generally recommended before a switch is made to nonasbestos products. The costs of such cleaning are minimal (generally under $2000) and consist mainly of labor costs.*

Most of the conversion costs incurred as a result of switching to nonasbestos materials result from expenditure required for developing product formulations and finding suitable substitute materials. The laboratory costs, which depend on the product type, may run as high as $20,000 for complex formulations.† Finding the right formulations and substitute materials can take a year or longer.

EQUIPMENT RESALE VALUE

The resale market for most of the equipment used in the coatings and sealants industry is good because the mixers, conveyors, and other equipment used in this industry are also used in a wide variety of other industrial processes.** The facilities that PEI contacted indicate that resale value can range between 7 to 10 percent of new equipment costs, depending on the equipment age, condition, and general market conditions.†

GENERAL COMMENTS

The majority of the producers of coatings and sealants have already voluntarily switched to asbestos substitutes or are planning such a switch in the near future. The switch to nonasbestos materials does not present this

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* Personal communication from Mr. Donald Davis, American Tar Company, Seattle, WA, September 18, 1986.

† Personal communication from Mr. Bob Baker, Adhesive Engineering Company, San Carlos, CA, September 18, 1986.

** Personal communication from Mr. Bob Bair, National Varnish Company, Detroit, MI, September 23, 1986.

TABLE 11-1. ESTIMATED COST OF A NEW COATINGS AND SEALANTS FACILITY WITH A CAPACITY OF 700 GALLONS/BATCH (2100 GALLONS/DAY)

Component	Percent of total capital investment	Cost of equipment, $1000
Direct Costs		
Purchased equipment	18.3	30,000
Equipment installation	11.0	18,000
Instrumentation and controls (installed)	3.1	5,160
Piping (installed)	1.5	2,400
Electrical (installed)	4.2	6,960
Buildings (including services)	4.4	7,200
Yard improvements	1.1	1,800
Service facilities (installed)	11.0	18,000
Land	0.7	1,200
Total direct costs	55.3	90,720
Indirect costs		
Engineering and supervision	9.5	15,600
Construction expense	10.6	17,400
Contractor's fee	3.7	6,000
Contingency	11.0	18,000
Total indirect costs	34.7	57,000
Total Fixed-Capital Investment	90.0	147,720
Working Capital	10.0	16,500
TOTAL CAPITAL INVESTMENT	100.0	164,220

industry with any major problems. Depending on the product type, the production rate could be reduced by as much as 20 percent when substitute materials are used.

The conversion costs consist mainly of the laboratory research expenditures for finding new formulations that use substitute materials.

The resale market for the equipment used in this industry is generally good.

SECTION 12

EQUIPMENT CONVERSION COSTS--ASBESTOS-REINFORCED PLASTICS INDUSTRY

Asbestos is used as an additive in the plastics industry to impart stability to the plastics while they are in the thickened or fluid stages. The plastics containing asbestos can remain stable for up to a year. Although asbestos-substitute additives are available, the asbestos-reinforced plastics industry indicates that switching to these materials will require time and expenditure for developing product formulations that are compatible with the substitute materials.

PRODUCTION EQUIPMENT

Asbestos-reinforced plastics facilities use mixers to produce a thickened or liquid product. The process is a batch one, and batch time varies with the type of product. The thickened or liquid plastic product from the mixers is sent to downstream plant equipment for the production of the final products. This downstream equipment depends on the end products made by the facility; thus, it differs widely from facility to facility. The downstream equipment is not included in this analysis, however, because it is not affected by conversion to asbestos substitutes.

In addition to the mixer, the production of thickened or liquid plastic requires auxiliary items such as conveyors, bag-opening stations, and fabric filters to control emissions from the material-handling operations. The production equipment used in the asbestos-reinforced plastics industry is similar to that used in the coatings, sealants, and paint industries.

ASBESTOS SUBSTITUTION OPTIONS

PEI's survey of the asbestos-reinforced plastics industry indicated that no major equipment additions or modifications are needed to convert the plant equipment to products containing asbestos substitutes; however, finding the right substitute materials and formulations is the key to successful conversion. Extensive experimentation with substitute materials and formulations in the laboratory will be required to effect a successful conversion.

The thickened or liquid plastics produced at an asbestos-reinforced plastics facility are used by the downstream equipment at a later date; therefore, the shelf life of the thickened or liquid plastics (or their ability to remain stable for an extended period) is critical to the operation. In general, the desired shelf life is 1 year, which is attainable by plastics-containing asbestos. Industry contacts indicate that currently known likely substitutes for asbestos do not meet the shelf-life criteria. These contacts further indicate that when product formulations that meet the shelf-life criteria are found, the switch to asbestos-substitute materials can be made without incurring major expenses. One industry contact indicated a need for additional roll mills for a substitute with characteristics comparable to asbestos; however, this requirement appears to be an exception.*

A switch to asbestos-substitute materials generally requires the use of more than a single substitute material, as asbestos-reinforced plastics facilities make a variety of products and the properties offered by asbestos cannot be obtained from a single substitute material. The number and types of substitute materials required depend on the products manufactured. A switch to asbestos-substitute materials would also adversely affect the production rate due to the nature and use of multiple substrates. Some substitutes require a longer blending and mixing duration because of poor dispersion properties. Some product formulations may also require that heat be added to ensure proper mixing. The use of multiple substitute materials and added blending and mixing durations result in a loss of production efficiency. Some facilities report that the production rate may decrease by as much as 10 percent when substitute materials are used.†

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* Personal communication from Magnolia Plastics, Chamblee, GA, September 30, 1986.

† Personal communication from Resinold Plastics Company, Skokie, IL, September 24, 1986.

CONVERSION COSTS

The equipment used in the asbestos-reinforced plastics industry is very simple and can generally be purchased off the shelf. Table 12-1 presents a cost breakdown for an asbestos-reinforced plastics facility with a capacity of 4000 tons/year. This cost breakdown was developed from purchased equipment cost data provided by one of the facilities contacted by PEI* and recommended percentages for cost components.[3] In general, the same equipment can be used whether facilities use asbestos-containing materials or substitute materials. Minor variations may be required to the equipment in the material handling area depending on the type and number of substitute materials used; however, these differences are not expected to have an appreciable effect on the costs.

EQUIPMENT RESALE VALUE

The major costs involved with conversion to asbestos-substitute materials would be for developing product formulations and finding suitable substitute materials. Associated laboratory costs would depend on the type of product involved. Finding the right formulations and substitute materials could take as long as a year and cost as much as $30,000.*,†

Because a facility can continue to use the existing equipment after switching to asbestos substitute materials, no disposition of the existing equipment is involved. The equipment used in the asbestos-reinforced plastics industry also has a good resale market because the mixers and other equipment used in this industry are used in various other industries. Resale value, which can range between 8 and 20 percent of the new equipment cost, depends on the age and condition of the equipment and on general market conditions at the time of sale.**

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* Personal communication from Magnolia Plastics, Chamblee, GA, September 30, 1986.

† Personal communication from Resinold Plastics Company, Skokie, IL, September 24, 1986.

** Personal communication from Thermoset Plastics, Inc., Indianapolis, September 25, 1986.

TABLE 12-1. ESTIMATED COST OF AN ASBESTOS-REINFORCED PLASTICS FACILITY WITH A CAPACITY OF 4000 TONS/YR

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	18.3	85,000
Equipment installation	11.0	51,800
Instrumentation and controls (installed)	3.1	14,620
Piping (installed)	1.5	6,800
Electrical (installed)	4.2	19,720
Buildings (including services)	4.4	20,400
Yard improvements	1.1	5,100
Service facilities (installed)	11.0	51,000
Land	0.7	3,400
Total direct costs	55.3	257,040
Indirect costs		
Engineering and supervision	9.5	44,200
Construction expense	10.6	49,300
Contractor's fee	3.7	17,000
Contingency	11.0	51,000
Total indirect costs	34.7	161,500
Total Fixed-Capital Investment	90.0	418,540
Working Capital	10.0	46,750
TOTAL CAPITAL INVESTMENT	100.0	465,290

Although equipment used to produce asbestos-containing products can be used to make asbestos-substitute products without any significant modifications, some equipment cleaning may be required before switching to asbestos-substitute materials. Such cleaning costs would be minimal (generally under $4000)* and consist primarily of labor costs.

GENERAL COMMENTS

Switching to asbestos-substitute materials in the asbestos-reinforced plastics industry should not present any major problems. The primary expenditure would be for laboratory work to find suitable formulations and substitute materials. Also, the production rate could decrease as much as 10 percent with the use of substitute materials.

A good resale market generally exists for the equipment used in the industry.

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* Personal communication from Thermoset Plastics, Inc., Indianapolis, September 25, 1986.

SECTION 13

CONVERSION COSTS--MINING AND MILLING INDUSTRY

In the United States, open-pit mining is the primary technique used for asbestos. Milling of the ore takes place close to the mine site, and a dry process is generally used to separate the fiber from surrounding rock. Wet-milling and reprocessing of waste tailings have proven particularly useful in the production of short fibers, and these techniques generate fewer harmful dust emissions.

PRODUCTION EQUIPMENT

In general, the conventional mining equipment used in asbestos mining is similar to that used in other types of open-pit mining. This includes drilling equipment, trucks, front-end loaders, portable lighting, and generators. The milling equipment is unique to asbestos milling and thus not applicable to any other industry. This equipment consists primarily of vibrating screens and negative-air systems. Additional equipment at the facility includes crushers, dryers, conveyors, and air pollution control equipment. Support systems include utility systems and buildings.

ASBESTOS SUBSTITUTION OPTIONS

One asbestos mining and milling facility provided PEI with equipment and conversion data. PEI representatives visited this facility to view the operations and discuss conversion problems with the facility staff. The equipment used at asbestos mines can be used by other mining sectors without major modifications, the market for this equipment is practically nonexistent currently because the market for used mining equipment is depressed.

The equipment used in asbestos milling operations is unique to the asbestos industry and cannot be used in other industries. Also, this equipment must be decontaminated before being disposed of in a sanitary landfill.

CONVERSION COSTS

No expenditure would be required to convert the equipment used in the asbestos mines to other mining sectors. The equipment can be used in other mining sectors. The indicated resale value does not account for the cleanup considerations under RCRA. The cost of new mining equipment for a mining capacity of 34,000 tons/yr of asbestos is estimated at $6,000,000.[8]

Table 13-1 presents a cost breakdown for an asbestos milling facility with a capacity of 34,000 tons per year. This cost breakdown was developed from the purchased equipment cost data supplied by a responding facility and based on current recommended percentages for cost components.[3]

TABLE 13-1. ESTIMATED COST OF AN ASBESTOS MILLING FACILITY WITH A CAPACITY OF 34,000 TONS/YR

Component	Percent of total capital investment	Cost of equipment, $1000
Direct costs		
Purchased equipment	28.3	7,000
Equipment installation	6.1	1,500
Instrumentation and controls (installed)	1.7	430
Piping (installed)	0.8	200
Electrical (installed)	2.4	580
Buildings (including services)	24.3	6,000
Yard improvements	0.6	150
Service facilities (installed)	6.1	1,500
Land	0.4	100
Total direct costs	70.7	17,460
Indirect costs		
Engineering and supervision	5.3	1,300
Construction expense	5.9	1,450
Contractor's fee	2.0	500
Contingency	6.1	1,500
Total indirect costs	19.2	4,750
Total Fixed-Capital Investment	90.0	22,210
Working Capital	10.0	2,470
TOTAL CAPITAL INVESTMENT	100.0	24,680

EQUIPMENT RESALE VALUE

Although asbestos mining equipment can be used in other mining sectors, this equipment would have minimal salvage value or resale value because the used mining equipment market is depressed. This depression applies to the mining industry in general, including copper and lead mining, which use the same type of equipment. A current resale value of about 10 percent is reported for the mining equipment. The mining facility contacted by PEI indicates a resale value of $132,000 and an estimated scrap value of $282,000. The facility further indicates, however, that the equipment would have to be cleaned and decontaminated before its sale as used equipment or scrap. Although no cost estimates for cleanup and decontamination are available, the facility indicates that these costs would exceed the scrap or resale value by several million dollars.[8] Assuming that decontamination costs are 25 percent of the new equipment cost,* these costs would be approximately $1,800,000. This estimate, however, appears low based on the large size and the age of the equipment involved.

GENERAL COMMENTS

If an asbestos mine is required to shut down, the equipment probably would be left in place, as disposal requirements of State and Federal regulatory agencies with regard to existing asbestos mining equipment are uncertain as of this writing.

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* Personal communication from Jim Smith, Blackman-Mooring Steamatic Catastrophe, Inc., Fort Worth, TX.

SECTION 14

RETROFIT/CONVERSION COSTS--ASBESTOS DIAPHRAGM CELLS IN THE CHLOR-ALKALI INDUSTRY

The chlor-alkali industry in the United States mainly uses asbestos diaphragm based electrolytic cells for the production of chlorine and caustic soda. In 1983, the asbestos diaphragm cells accounted for 77.9 percent of the U.S. elemental chlorine capacity, mercury cells accounted for 16.6 percent, and membrane cells accounted for 0.6 percent. The remaining 5 percent of the chlorine was produced by various chemical processes, such as fused salt electrolysis and HCl oxidation from potassium chloride and nitric acid.[9]

The electrolytic cell is the only equipment at a chlor-alkali plant in which asbestos material is used. Asbestos consumption averages about 0.25 lb/ton of chlorine. For each unit of chlorine production, 1.1 units of sodium hydroxide are produced. The cell design and operation parameters are plant-specific and are considered proprietary. Many diaphragm plants have onsite cogeneration facilities to supply the large quantities of electricity and steam needed for chlor-alkali production.

Asbestos diaphragms are prepared on the plant site; they are not available as premanufactured products. In the diaphragm-forming process, a slurry of asbestos in water is drawn through a screen or perforated plate by vacuum techniques. Asbestos fibers are deposited on the screen, or plate, where they form a paper-like mat approximately 1/8 inch thick. This asbestos-coated screen is used as the cathode in electrolytic cells. Currently, the majority of U.S. diaphragm cells in the United States use modified asbestos (resin bound) diaphragms and have metal anodes; these cells consume 2300 kWh of power per ton of chlorine produced. The surface area of the diaphragm ranges from approximately 200 to 1000 square feet for a cell with a volume of 64 to 275 ft^3. Each diaphragm may use 60 to 200 pounds of asbestos fibers and have a service life of 3 months to more than 1 year.

ASBESTOS SUBSTITUTION OPTIONS

The asbestos substitution options for the chlor-alkali industry are based on the use of an ion-exchange (nonasbestos) membrane technology marketed by U.S. and Japanese vendors. Two options are available to accomplish the switch to a nonasbestos membrane technology: 1) retrofitting the existing cells with the nonasbestos membrane, and 2) conversion of the plant to accept new membrane cells. Regardless of the substitution option selected, additions and modifications are required to the plant's existing auxiliary systems to meet the operational requirements of the membrane technology. These additions and modifications are needed primarily in the brine-treatment, anolyte-dechlorination, and salt-evaporation areas.

In Japan, existing cells have been retrofitted to accept the nonasbestos membrane; however, no plants in the United States have attempted retrofitting. Because of physical limitations of the existing equipment, the retrofit option does not allow utilization of the full potential of the membrane technology. The chemical environment to which the membrane cell internals are subjected is much more severe than in the diaphragm cells. The internals of diaphragm cells are generally constructed of carbon steel materials, whereas the internals of membrane cells require the use of higher-quality materials such as nickel-based alloys. Thus, the retrofit option requires the upgrading of cell internals to withstand the operating environment created in the membrane cells. Nickel plating of selected cell internals was mentioned as an option to overcome this problem. However, the material upgrading measures cannot match the performance and life of the cells specifically designed for membrane technology. It is reported that the use of retrofitted diaphragm cells may necessitate a major modification of cell components within about 3 to 5 years after completion of retrofit because of the severe operating environment.*

The conversion option involves replacement of diaphragm cells with membrane electrolyzers that are designed to match existing electrical equipment. With this approach, the full potential of the membrane cell technology can be realized. Occidental Chemical Corporation has completed a

* Personal communication from Mr. Thomas J. Navin, OxyTech Systems, Chardon, OH, November 19, 1986.

partial conversion of its Taft, Louisiana, plant to membrane cell technology. This represents the only U.S. conversion to membrane cell technology. The total capacity of the Taft plant is 1650 tons/day; capacity converted to membrane cells is 400 tons/day. The plant has an onsite cogeneration facility. Brine is brought in from mines about 40 miles from the plant site. The diaphragm cell equipment that was converted to membrane cell technology was in poor operating condition, and the conversion to membrane cell technology provided energy savings as well as other advantages of membrane cell technology. The membrane part of the plant has been in operation since January 1986, and no major operating problems have been reported.*

The retrofit/conversion of a diaphragm cell plant to a membrane cell plant requires additional auxiliary systems, and modifications must be made to the existing systems. System additions, independent of the substitution option selected, are required in three plant processes: 1) brine treatment, 2) anolyte dechlorination, and 3) salt evaporation. Plants that are retrofitted/converted to the membrane cell technology must install a brine treatment facility to reduce brine hardness from the 2 to 5 parts per million allowed for diaphragm cells to 25 to 50 parts per billion. Ion-exchange fixed-bed columns can provide the required treatment. An anolyte dechlorination system is needed to remove chlorine from the depleted brine stream before resaturation. Salt evaporation is needed to provide solid salt for anolyte resaturation.

The existing electrical and process equipment at the diaphragm cell plant can be reused with minimal modifications by designing membrane equipment to match existing equipment.

The membrane technology has several advantages over the diaphragm technology, and membrane technology is considered a viable option when existing chlor-alkali plants are to be retired. These advantages will also make membrane technology the preferred choice at new grass-roots plants, which will not be faced with the site-specific factors that affect conversion of existing diaphragm plants. The current chlor-alkali production and consumption environment in the United States, however, is such that these

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* Personal communication from Mr. Tom Johnston of OxyChem Company, Taft, LA, November 29, 1986.

advantages alone do not provide adequate incentive for the industry to retire the existing diaphragm equipment and replace it with the membrane equipment. The following factors enter into the selection/conversion of equipment in the chlor-alkali industry:

- Availability of cogeneration equipment to generate the larger quantities of steam and electricity required by diaphragm equipment.
- Cost of conversion.
- Product quality.
- Useful life and condition of the existing equipment.
- Required raw materials.
- Supply/demand environment.

Significantly less energy is required at membrane plants than at diaphragm plants; however, energy consumption is currently not a significant factor at the chlor-alkali plants in the United States. Numerous chlor-alkali plants have a cogeneration facility on site that has been specifically designed to generate the steam and electricity needed for chlor-alkali production. Furthermore, the plants that have no cogeneration facilities have negotiated contracts to obtain electricity at low rates. The current low energy prices favor the continued operation of the diaphragm plants and offer little cost-saving incentive for conversion of these plants to the membrane technology. Should electricity rates rise significantly above these current levels, the existing diaphragm plants may seriously investigate possible conversion to membrane technology. Also, plants with a cogeneration facility could be faced with the following problems after conversion to membrane technology: 1) finding alternate uses for extra steam capacity, 2) the need to install additional power generation equipment at a significant cost, 3) inefficient operation of the boiler at significantly less than capacity, or 4) shirting down of the cogeneration facility.

Installing chlor-alkali plants (diaphragm or membrane) entails large capital expenditures. In general, the useful life of chlor-alkali plants has not been defined; historically, they are operated over a long period by performing both routine and major maintenance, as needed. Because conversion. costs are also significant, plants are expected to continue operating on a marginally cost-effective basis rather than giving consideration to converting to membrane technology.

The quality of the caustic produced by membrane cells is superior than that produced by diaphragm plants; however, the use of better-quality caustic has no advantages in the United States. The caustic-consuming processes in the United States are designed for the quality of the caustic produced by diaphragm plants, and in most cases, improving the quality will have no cost benefits. In Japan, on the other hand, industry is geared to the use of high-quality caustic because the chlor-alkali industry in Japan used mercury cells, which also produce higher-quality caustic, before converting first to diaphragm cells and then to membrane cells. Caustic quality is currently not a driving force for a change to membrane cells in the United States.

The most significant factor affecting the selection of membrane technology is the useful remaining life and condition of the existing diaphragm equipment. If the existing plant equipment is old and no longer cost-effective to operate and the plant must install new chlor-alkali production equipment, the membrane technology offers a viable option. The general trend in the industry, however, is to operate the existing plants as long as possible by regularly performing major equipment maintenance. Those plants that have very old equipment and inefficient diaphragm cells and are located in an area where electricity cost is high might find it advisable to convert to membrane technology.

The membrane technology requires ultrafine purified brine, whereas diaphragm plants can work with purified brine. The majority of the chlor-alkali plants on the Gulf Coast use well brine. Additional equipment would have to be installed to process the brine to make it acceptable for membrane plants. In addition, diaphragm plants are once-through plants, whereas membrane plants operate in a recirculating mode. If a plant is located some distance from the source of brine, additional costs would be incurred to transport the depleted brine to the original source. In the United States, most of the technical problems connected with the use of existing raw material sources at chlor-alkali plants having the membrane technology have already been solved.

The chlorine demand in the United States is on the decline, a trend that is expected to continue because of the regulation prohibiting the use of chlorine-derived products (e.g., chlorofluorocarbon). For this reason, some plants may just be retired when the existing equipment can no longer be operated cost-effectively.

In summary, the current chlor-alkali industry environment does not offer adequate incentive for all plants to convert to the membrane technology. Additional regulatory factors prohibiting the use of asbestos would be necessary to force the conversion. In the absence of such factors, it is likely that diaphragm-based chlor-alkali plants may continue to operate beyond the year 2000. Membrane technology is a viable option when existing plants can no longer operate cost-effectively and cost of electricity becomes a major factor.

CONVERSION COSTS

No plants in the United States have attempted to retrofit diaphragm cells to accept ion-exchange membranes. OxyTech, a U.S. supplier of the membrane cell technology, indicates a cost basis of $50,000 to $55,000 per metric-ton day of caustic capacity. This cost, which is based on OxyTech's experience with international plants, represents the turnkey cost and includes all the necessary modifications of diaphragm cells and auxiliary systems and the additional systems required for membrane technology.

OxyTech reported the costs of conversion options to be in the range of $85,000 to $90,000 per metric ton day of caustic capacity. This firm converted Occidential Chemical's plant in Taft, Louisiana, and was also involved in the addition of membrane cell capacity at the Vulcan Materials Wichita, Kansas plant. The reported costs include the costs of all system additions and modifications to the existing systems.

Table 14-1 shows a breakdown of membrane cell retrofit and conversion costs. PEI generated this cost breakdown by using published percentages[3] for the individual cost components and cost basis provided by OxyTech. The assumed percentages for individual cost components are also shown in the table. Costs shown are based on a per-ton day of chlorine.

Japanese vendors have indicated retrofit costs of around $35,000/ton-day of chlorine; however, this cost does not include the membrane cost, which Japanese vendors consider to be part of the operating costs. Because the membrane cost accounts for a significant part of the cost of a membrane cell plant, PEI believes the initial membrane cost should be included in the capital costs.

TABLE 14-1. MEMBRANE CELL RETROFIT/CONVERSION COSTS

	Percent of total	Cost, \$ x 1000	Percent of total	Cost, \$ x 1000
Direct Costs				
Purchased equipment	16.3	15,388	12.7	7,042
Equipment installation	13.0	12,310	22.5	12,500
Instrumentation and controls	2.8	2,647	1.9	1,056
Piping (installed)	7.8	7,386	4.4	2,465
Electrical (installed)	3.8	3,570	1.9	1,056
Buildings (including services)	3.9	3,694	1.3	704
Yard improvements	1.0	923	.3	176
Service facilities (installed)	9.8	9,232	6.3	3,521
Land	.7	615	0.0	0
Subtotal	59.0	55,765	51.3	28,520
Indirect Costs				
Engineering and supervision	8.5	8,001	12.7	7,043
Construction expense	9.4	8,925	11.4	6,338
Contractor's fee	3.3	3,077	3.2	1,761
Contingency	9.8	9,232	11.4	6,338
Subtotal	31.0	29,235	38.6	21,480
Total fixed-capital investment	90.0	85,000	90.0	50,000
Working capital	10.0	9,453	10.0	5,583
Total capital investment	100.0	94,453	100.0	55,583

Capacities of U.S. chlorine plants vary widely; installed capacity is generally a function of the onsite chlorine needs. Based on the costs shown in Table 14-1, retrofit and conversion costs of a 1000-ton/day plant will be 85 and 50 million dollars, respectively. Table 14-2 summarizes the costs of a 1000-ton/day chlorine plant.

Waste disposal costs for discarded diaphragm cell equipment can be significant. The dimensions of a 5-ton/day Hooker H-4 diaphragm cell are 10.2 ft wide by 18.5 long by 7 ft high for a volume of 22.5 yd^3.[10] Based on disposal costs of \$150/yd^3 at a hazardous waste landfill and assuming that the disposal cost accounts for only about 20 percent of the total cost of landfilling (the other 80 percent being for loading, transporting, and unloading the equipment), the total cost of diaphragm cell disposal would be \$3,400/ton per day of chlorine production capacity. Assuming a linear relationship between cell production capacity and the volume disposed of, disposal of equipment that produces 1000 tons/day would be \$3.4 million. The disposal of only the interal portion of these cells (for retrofitting to membrane technology) would cost about one-third of this amount, or \$1.1. million.

TABLE 14-2. INSTALLATION COSTS OF 1000 TONS/DAY CHLORINE PLANT (July 1986 dollars)

Option	Installation cost, million dollars
Diaphragm plant - greenfield installation[a]	350
Membrane plant - greenfield installation	300
Retrofitting of diaphragm plant to nonasbestos membrane plant	56
Conversion of diaphragm plant to nonasbestos membrane plant	94

[a] An entirely new plant.

EQUIPMENT RESALE VALUE*

The cost of a new diaphragm plant is reported to be around \$350,000/ton-day of chlorine for a greenfield installation. Chlorine plant equipment is custom- designed to meet the proprietary design specifications of individual companies. Individually, equipment items have no resale value because of their specialized design. The cost of converting a diaphragm plant to a membrane cell plant includes the costs of removing the old cell equipment and necessary preparations for the new equipment. Retrofitting diaphragm cells

* Personal communication from Mr. Thomas J. Navin, Oxytech Systems, Chardon, OH, December 5, 1986.

to membrane cells may require the cleaning of cell internals; however, these cleaning costs are not reported to be a major cost item. The conversion option would involve no asbestos cleanup because the complete cell assembly would be replaced.

The reported cost of a greenfield membrane plant ($300,000/ton-day of chlorine) is slightly lower than the cost of a diaphragm plant.

GENERAL COMMENTS

For U.S. plants the continued use of asbestos diaphragm cells appears to be the most practical alternative. If the use of asbestos diaphragms is banned, however, the conversion option is preferred over the retrofit option because this option permits full utilization of the membrane technology and will result in fewer cell material failures. Although initial costs of the retrofit option are lower than the conversion costs, the conversion option is expected to be cheaper in the long run.

Retrofitted/converted plants will be able to use the existing brine sources; however, additional brine treatment will be required.

The useful life of a diaphragm plant is reported to be in the range of 20 to 25 years. Membrane technology appears to be a viable option when existing capacity is to be replaced. Without external regulatory pressures, however, the existing chlor-alkali industry environment does not offer adequate incentives for switching from diaphragm plants to non-asbestos technologies. The membrane technology will be the preferred choice at new grass-roots plants because these plants will have the advantage of not having to face the site-specific factors that enter into the conversion of existing diaphragm plants.

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APPENDIX C: ECONOMIC IMPACTS ANALYSES

This appendix presents detailed analyses of the economic impacts of the regulatory options considered in the RIA. The specific areas of economic impacts examined are the impacts of the regulatory alternative on small business and the economic impacts on communities. Hence, this detailed analysis is organized into two sections. Section 1 presents a detailed analysis of the small business impacts and Section 2 reports a detailed assessment of the community impacts of the preferred regulatory alternative.

1. Small Business Impact Analysis for Primary Processors of Asbestos

1.1 Introduction

The impact on small business of the proposed rulemaking on asbestos uses in industrial and commercial applications must be analyzed pursuant to the Regulatory Flexibility Act. As stipulated in that act, a Regulatory Flexibility Analysis (RFA), including a Small Business Impact (SBI) Analysis, is required. The SBI Analysis is the subject of this appendix.

In order to assess the proportion of the costs of regulatory action associated with the ban and phasedown[1] of asbestos products absorbed by small businesses,[2] it is necessary to select an index with which to measure these impacts. For this analysis, the projected producer surplus loss has been selected as an indication of the costs of regulation borne by producers.

1.2 Methodology for Assessing the Impact of Asbestos Regulation on Small Business

The potential impact of regulation on small primary processors of asbestos can be estimated by examining the proportion of the producer surplus loss that can be attributed to small firms. The producer surplus losses used in this analysis are based on domestic production. These values are used to calculate total producer surplus loss and the portion attributable to small firms.

In 1985, there were 48 small primary processors of asbestos (See Appendix F), a decline of 59 percent from the 118 small processors that were involved in asbestos production in 1981 (RTI 1985). These 48 small firms were mostly in product categories 29 and 30, Roofing Coatings and Cements and Non-Roofing Coatings, Compounds, and Sealants.

In 1981, there were 26 product categories[3] that contained primary processors of asbestos defined as small businesses. By 1985, the number of categories potentially impacted had dropped to 15. Table C.1-1 identifies the categories that had small businesses in 1981, and the number of small businesses within each category for 1985.

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[1] The ban/phasedown combination used in this analysis was selected from six regulatory alternatives presented as models for asbestos regulation. The option selected, preferred section-B, is used in the Asbestos Regulatory Cost Model to generate the producer surplus losses used in this analysis.

[2] The Small Business Administration (SBA) defines small businesses as those that have fewer than a designated number of employees. The employee cut-off is established by Standard Industrial Classification (SIC) code and for the categories identified in this analysis is 750 employees, except for the categories 05, 27, 28, 29, and 30 that have a cut-off of 500 employees, and category 13 that has a cut-off of 1,000 employees.

[3] RTI identified 27 product categories with small firms potentially impacted by regulatory action. Due to realignment and redefinition of some product categories for the 1985 survey conducted by ICF, the number of categories and the products included in certain categories have changed.

Table C.1-1. Percentage of 1985 Asbestos Production Held by Small Firms

Product Number	Product Description	Number of Small Firms in 1985
03	Millboard	1
04	Pipeline Wrap	0
05	Beater-Add Gaskets	1
06	High-Grade Electrical Paper	1
07	Roofing Felt	0
08	Acetylene Cylinders	1
11	Specialty Paper	1
13	Diaphragms	0
14	Asbestos Cement Pipe	1
15	Asbestos Cement Flat Sheet	0
16	Asbestos Cement Corrugated Sheet	0
17	Asbestos Cement Shingles	1
18	Drum Brake Linings	3
19	Disc Brake Pads (LMV)	4
20	Disc Brake Pads (HV)	0
21	Brake Blocks	2
22	Clutch Facings	0
23	Automatic Transmission Components	0
24	Friction Materials	2
26	Asbestos Thread, Yarn, and Other Cloth	0
27	Sheet Gaskets	0
28	Asbestos Packings	0
29	Roofing Coatings and Cements	9
30	Non-Roofing Coatings, Compounds and Sealants	18
31	Asbestos-Reinforced Plastics	1
32	Missile Liner	0
33	Sealant Tape	2

Source: ICF 1986a - Appendix F of this RIA.

Once the percentage of product output attributable to small firms has been calculated, the share of the producer surplus losses borne by these small businesses can be determined. For this analysis it has been assumed that all firms, regardless of size, would incur producer surplus loss in proportion to their market shares. The producer surplus losses for small businesses are calculated by multiplying the producer surplus loss by the percentage of production held by small firms for each product category.[4]

1.3 Results

The total domestic non-mining and milling producer surplus losses for Regulatory Alternative G (immediate bans of all asbestos products) for each asbestos category assuming a three percent rate of discount and for low, moderate, and high rates of decline[5] for asbestos production are presented in Table C.1-2. Table C.1-3 presents the fraction of these total producer surplus losses that can be attributed to small firms using the same rates of decline for asbestos production identified above.

Of the 15 product categories identified as having small companies, only 13 were expected to incur impacts on small businesses as a result of asbestos regulation. The total producer surplus losses for all categories is less than $3 billion, and less than $30 million for the small businesses in product

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[4] It has been assumed that all firms all experience producer surplus losses in proportion to their market share (ICF 1987). Although it is possible that smaller firms are more efficient and therefore likely to incur proportionately smaller producer surplus losses, this analysis will assume that all firms have the same efficiency (this is consistent with previous analyses).

[5] The rates of decline used in this analysis are based on the following assumptions:

- high -- the rate of decline will be the same as the historical rate from 1981 to 1985 (assumes substitution will occur at the same rate as experienced between 1981 and 1985); and

- moderate -- the rate of decline will be 50 percent of the high level;

- low -- the rate of decline is assumed to have leveled off. Product output will, therefore, remain at current levels (assumes substitution has already occurred);

- the rate of decline for product categories 18 and 19, Drum Brake Linings and Disc Brake Pads (LMV), respectively, are calculated using the Brake's Model (ICF 1987) for high, moderate, and low rates of decline.

- the production for Categories 7 (Roofing Felt), 13 (Asbestos Diaphragms), 16 (Asbestos Cement Corrugated Sheet), 23 (Automatic Transmission Components), and 32 (Missile Liner) are assumed to be zero for all scenarios.

categories with small business impacts (assuming the largest impact scenario: low rate of decline and 3 percent discount rate). The majority of the small business portion of the producer surplus loss is attributable to product categories 14 and 17, Asbestos Cement Pipe and Asbestos Cement Shingles, respectively.

Table C.1-2

Total Producer Surplus Losses[a] for Asbestos Product Categories

Scenario	Producer Surplus Loss Assuming (3 Percent Discount Rate) ($1,000,000's)
Low Rate of Decline	$2,778.41
Moderate Rate of Decline	2,769.88
High Rate of Decline	2,762.04

[a]The total producer surplus losses for each asbestos product category are calculated by the Asbestos Regulatory Cost Model (ARCM).

Source: Appendix G of this RIA.

Table C.1-3

Total Producer Surplus Losses Attributable to Small Firms

Scenario	Producer Surplus Loss Assuming (3 Percent Discount Rate) ($1,000,000's)
Low Rate of Decline	29.57
Moderate Rate of Decline	26.70
High Rate of Decline	24.06

Source: Appendix G of this RIA.

2. Community Impacts

The proposed rule regulating the use and distribution of asbestos and asbestos products can take any one of three forms: a staged product ban, phase-down of asbestos fiber use, or a combination of the two. Any form of the rule has, besides the economic costs and benefits associated with it, implications for communities in which plants manufacturing asbestos products are located. The severity of the impact depends on the nature of the final rule; for instance, a product ban may prompt some firms to either lay off workers (if they manufacture a substitute product) or shut down the plant permanently (if they only manufacture the asbestos product), while a gradual phase-down or a delayed product ban may provide enough time for firms to adjust to the changing market realities without undertaking major changes that may severely affect the local communities.

For this analysis, we have assumed an immediate product ban will adversely impact a community in two different ways: direct income losses will be suffered by employees who would lose their jobs because of a plant shut down, and indirect income losses suffered by other members of the community because of the lost value of locally produced good and services no longer purchased by the laid-off employees. In contrast, a gradual phase-down of asbestos use or a rule that imposes product bans in 1990 or 1995 are not likely to impact a community adversely because these rules allow enough time for employees to find new jobs, obtain new skills, and permit employment levels of affected companies to be reduced through normal attrition.

Although EPA is evaluating different product ban scenarios based on the products and the timing of the ban, we have examined the community impact for a scenario in which eight products are banned immediately. The products that were proposed for an immediate ban under as least one of the options considered in the analysis are:

- Roofing Felt (Saturated and Unsaturated)*
- Flooring Felt (including Felt-backed Vinyl Sheet Flooring)*
- Floor Tile*
- Asbestos-Cement Pipe
- Asbestos-Cement Flat Sheet
- Asbestos-Cement Corrugated Sheet*
- Asbestos-Cement Shingles
- Cloth Used for Protective Clothing*

Five of these products, marked with an asterisk, are no longer produced in the United States.[1]

This analysis quantifies the income losses to workers (direct earnings losses) and to communities (indirect income losses) affected by immediate product bans. Direct earnings losses are calculated as the wages that would have been earned by the laid-off workers in the absence of the product bans minus the sum of the federal and state income taxes, and any unemployment compensation received. Indirect income losses are calculated by applying an economic multiplier to the before-tax earnings losses of the affected workers.

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[1] ICF Incorporated, 1986. "Survey of Primary and Secondary Processors of Asbestos." Washington, D.C.

Other losses, such as those attributable to a loss in human capital and non-pecuniary costs are recognized and the factors influencing these are discussed qualitatively, but these are not calculated quantitatively. The remainder of this analysis is organized into two major sections, followed by two appendices:

- <u>Section 2.1</u> identifies the plants affected by the immediate product bans and discusses the pecuniary and non-pecuniary factors contributing to the direct earnings losses incurred by employees laid off and presents the calculations for these losses.

- <u>Section 2.2</u> presents calculations of the indirect community income losses due to reduced purchases by the laid-off employees.

- <u>Attachment A</u> presents economic and demographic profiles of each community affected by the immediate product bans.

- <u>Attachment B</u> presents sample calculations of direct earnings losses to employees and indirect community income losses for a community affected by an immediate product ban.

2.1 Direct Earnings Losses of Employees

The proposed ban of three of the asbestos-containing products still produced in the United States will impose costs on the plant employees laid off permanently as a result of the plant's reaction to the ban. (Hereafter, these employees will be referred to as the plant employees.) The purpose of this section is to identify these costs, to review the factors that influence costs incurred, and to quantify costs wherever possible. Exhibit C.2-1 identifies the affected plants, their location, and the product they manufacture. A total of seven plants might be affected by the product bans, as shown in the exhibit. These seven plants are located in four states.

Costs incurred by plant employees as a result of the ban (private labor dislocation costs) include both pecuniary losses and non-pecuniary losses. Pecuniary costs are lost earnings and fringe benefits during the initial period of unemployment, and lost earnings thereafter attributable to a loss in human capital.[2] These costs are usually measured as the difference between what the plant employees would have earned in the absence of the product ban and what they will earn if the product bans are imposed. Lacking employee-specific data, it is possible to quantify only the earnings loss during the initial period of unemployment. Lost earnings thereafter attributable to a loss in human capital and non-pecuniary costs, frequently referred to as psychic costs, are only qualitatively assessed.

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[2] Plant employees who will be laid off as a result of the product ban might be unable to market their full range of skills to new employers and hence would receive lower wages in subsequent jobs. The difference in wages received is attributed to a "loss in human capital" and is discussed later in greater detail.

Exhibit C.2-1. Plants Affected by Immediate Product Bans

Company	Plant Location City	State	Product Manufactured
Capco Pipe Company	Van Buren	Arkansas	Asbestos-Cement Pipe
Certain-Teed Corporation	Riverside	California	Asbestos-Cement Pipe
J. M. Mfg. Corporation	Stockton	California	Asbestos-Cement Pipe
Nicolet, Inc.	Ambler	Pennsylvania	Asbestos-Cement Flat Sheet
Supradur Mfg. Corporation	Wind Gap	Pennsylvania	Asbestos-Cement Shingles
J. M. Mfg. Corporation	Denison	Texas	Asbestos-Cement Pipe
Certain-Teed Corporation	Hillsboro	Texas	Asbestos-Cement Pipe

Source: ICF Incorporated, 1986. "Survey of Primary and Secondary Processors of Asbestos." Washington, D.C, Appendix F of this RIA.

2.1.1 Loss in Earnings During Initial Period of Unemployment

Plant employees would suffer a loss in disposable income because they would lose their jobs following imposition of the product ban to the time when they would be reemployed or withdraw from the labor force (labor force withdrawal is discussed in detail below). This loss consists of wages (net of taxes) over the period of unemployment minus any transfer benefits received, such as union severance benefits, unemployment compensation, and welfare.

Lost gross wages consist of the wages the plant employees would have continued to receive over the period of unemployment if they had not been laid off. Because the wages of the individual plant employees are unknown, average weekly earnings for asbestos products (SIC 3292) employees are used as a proxy. It is assumed that the laid-off employees would have continued to earn this wage in the absence of the ban, i.e, no adjustments to this wage are incorporated in the calculations regardless of the unemployment duration. In 1985, average weekly earnings of production workers were obtained from the Supplement to Employment and Earnings and were estimated to be $420.85.[3] Supervisory and non-production worker (hereafter referred to as supervisory workers) wages in this SIC were not available from the same source, so they are estimated by using 1985 wages reported in the Annual Survey of Manufacturers and assuming that the ratio of supervisory to production worker wages are the same as in the other source.[4,5] The average weekly earnings for supervisory workers were estimated to be $596.57 in 1985.[6]

Average gross weekly wages that plant employees would have earned over the initial period of unemployment overstate actual losses; these earnings must be reduced by the amount of federal and state income taxes that would have been

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[3] U.S. Department of Labor, 1986. Supplement to Employment and Earnings, June 1986. Bureau of Labor Statistics. Washington, D.C.

[4] The Annual Survey of Manufacturers, 1985, published by the Bureau of Labor Statistics, U. S. Department of Labor, Washington, D.C., provides data on production workers and total employees. The data for supervisory and non-production workers are derived from this information. These two categories are combined and referred to as "supervisory workers" in this analysis since average earnings of all non-production workers (including supervisors) is derived using the information on total and production payrolls; total and production employees; and hours worked by production workers in SIC 3292.

[5] Plants already producing a substitute product are assumed not to shut down, but to lay off employees associated with the production of the banned asbestos product. Affected plants producing only the asbestos product are assumed to shut down and lay off all employees. In the latter case, the employees other than those in the production or supervisory categories are referred to as "non-production" workers and are treated identically to supervisory workers since an average wage for both is used.

[6] Including all non-production workers in the supervisory category is reasonable because the wages of this group are derived by dividing the total compensation of all non-production workers by the total amount of such workers. Hence, the wage figure used here is actually the weighted average wage of actual supervisory workers and other non-production workers.

paid had the plant employees not been laid off. Presumably, the plant employees would continue to pay local property tax and sales tax, although sales tax would be at lower levels.

1987 Federal tax tables are used to calculate the federal income taxes plant employees would have paid in the absence of the product ban. Exhibit C.2-2 summarizes the estimated income taxes paid by plant employees. Assuming the plant employees have unemployed spouses and two dependents, the average weekly federal tax paid by production workers is estimated to be $38.90 per week for an annual income of $21,884.20. For supervisory workers the figure is estimated to be $65.25 per week for an annual income of $31,021.64. Similar calculations of state income taxes paid by plant employees are done using 1986 state tax tables for the four states involved.

In addition, while unemployed, the plant employees would receive unemployment compensation and, in some cases, union severance benefits and welfare payments. Weekly unemployment compensation is calculated for each state where an affected plant is located. Given the level of the average annual salary, these employees would be eligible to receive maximum weekly benefits. Exhibit C.2-3 summarizes the relevant unemployment compensation data by state.[7]

Since no standard provisions exist for union severance benefits across industries, they are not incorporated in the estimate of lost earnings, nor are any welfare benefits. To the extent that the asbestos employees would receive these benefits, this analysis overstates earnings losses. On the other hand, this analysis also does not quantitatively account for losses in fringe benefits. This omission works in the other direction. Exhibit C.2-4 provides a summary of gross weekly earnings, weekly federal and state income taxes, and weekly unemployment compensation benefits for each state in which affected plants are located.

Employee income losses over the immediate period of unemployment depend on the duration of unemployment as well as on the reduction in disposable income. Despite the scarcity of data describing the personal characteristics of the plant employees, it is possible to draw general conclusions regarding the effect of demographic characteristics on the duration of unemployment. In general, young male employees with transferable skills find new employment more quickly than older male or female employees. Persons in the latter category are more likely to drop out of the labor force after an initial job search than persons in the former category.[8]

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[7] Unemployment compensation, or at least some portion of it, may be subject to income tax. However, this depends on the amount of benefits received and the total income in the tax year. Since the timing of the unemployment and the wages in the new jobs are not known, it is not feasible to make the relevant calculations. Furthermore, given the tax rates, the amount of tax, if any, is likely to be small.

[8] Jacobson,L. and Thomason, J., 1979. "Earnings Loss Due to Displacement." The Public Research Institute. Under contract to the U.S. Department of Labor, Washington, D.C. Contract J-9-M-9-0042.

Exhibit C.2-2. Summary Table for State and Federal Income Tax

States	Class	Annual[a] Wage (dollars)	Annual[b] Federal Tax (dollars)	Annual[c] State Tax (dollars)	Annual State and Federal Tax (dollars)	Weekly State and Federal Tax (dollars)
Arkansas	Production	21,884.20	2,022.80	846.04	2,868.84	55.17
	Supervisory	31,021.64	3,393.00	1,454.44	4,847.44	93.22
California	Production	21,884.20	2,022.80	279.24	2,302.04	44.27
	Supervisory	31,021.64	3,393.00	708.76	4,101.78	78.88
Pennsylvania	Production	21,884.20	2,022.80	481.52	2,504.32	48.16
	Supervisory	31,021.64	3,393.00	682.24	4,075.24	78.37
Texas	Production	21,884.20	2,022.80	n/a[d]	2,022.80	38.90
	Supervisory	31,021.64	3,393.00	n/a	3,393.00	65.25

[a] 1985 figures.

[b] Based on tax tables for 1987 and assumed that the plant employee is married and has an unemployed spouse and two dependent children. Personal deduction for each dependent is $1,900.

[c] State taxes are based on 1986 state tax tables.

[d] n/a : not applicable -- the State of Texas has no state income tax.

Source: Supplement to Employment and Earnings, June, 1986.

Exhibit C.2-3. Summary of Unemployment Compensation

State	Worker Class	Plant Employee Average Yearly Wage (dollars)	Average Weekly Benefits[a] (dollars)	Waiting Period[b]	Number of Weeks
Arkansas	Production	21,884.20	97.80	One Week	26 Weeks
	Supervisory	31,021.64			
California	Production	21,884.20	111.91	One Week	26 Weeks
	Supervisory	31,021.64			
Pennsylvania	Production	21,884.20	153.66[c]	One Week	26 Weeks
	Supervisory	31,021.64			
Texas	Production	21,884.20	139.31	One Week	26 Weeks
	Supervisory	31,021.64			

[a]It is assumed that worker's yearly wage is evenly distributed throughout the base period. Also, both production workers and the others are qualified for maximum weekly benefits based on their yearly wages. A worker is assumed to be married and have two children.

[b]This is the period between the laid-off workers applying for unemployment benefits and starting to receive them. It is assumed that workers will be compensated for the "waiting period", even though the benefits are delayed.

[c]This amount includes the maximum weekly benefit of $142.66 plus $5 allowance for dependent spouse and $3 for each dependent child.

Sources: Supplement to Employment and Earnings, June 1986. U.S. Department of Labor, Employment and Training Administration. Transcribed telephone conversation with Lynn Webb on February 5, 1987.

Exhibit C.2-4. Lost Weekly Earnings and Offsets of Plant Employees by State

State	Worker Class	Weekly Gross Earnings of SIC 3292 Employees	Applicable Weekly Federal and State Tax	Weekly Unemployment Compensation[a]
Arkansas	Production	420.85	55.17	97.80
	Supervisory	596.57	93.22	97.80
California	Production	420.85	44.27	111.91
	Supervisory	596.57	78.88	111.91
Pennsylvania	Production	420.85	48.16	153.66[b]
	Supervisory	596.57	78.37	153.66
Texas	Production	420.85	38.90	139.31
	Supervisory	596.57	65.25	139.31

[a]Weekly unemployment compensation is received for a maximum 26 weeks for the states listed above, and there is a one-week waiting period before benefits are received.

[b]This amount includes the maximum weekly benefit of $142.66 plus $5 allowance for dependent spouse and $3 for each dependent child.

Sources: Supplement to Employment and Earnings, June 1986. U.S. Department of Labor, Employment and Training Administration. Transcribed telephone conversation with Lynn Webb on February 5, 1987.

The duration of unemployment is a function of both the demographic characteristics of the plant employees and regional factors characterizing the communities in which the plants are located.[9] However, since data on average unemployment duration for each community are not available, a percentage distribution by unemployment duration of the unemployed labor force, for each state in which affected plants are located, is used (Exhibit C.2-5). The upper bound in each category is assumed to be the unemployment duration for that percentage of the production and supervisory workers.[10]

The final step in estimating the earnings lost by plant employees during the initial period of unemployment is to combine the data discussed to this point. Exhibit C.2-6 shows the anticipated number of employees laid off in each worker category because of an immediate product ban. The anticipated action by each plant is assumed to be "shut down" if they manufacture only the banned asbestos product, and "lay off" otherwise. In case of a "shut down", all employees at the plant are assumed to be laid off.[11] The actual distribution by unemployment duration of employees laid-off (based on the percentage distribution shown in Exhibit C.2-5) is shown in Exhibit C.2-7. The number of employees in each unemployment duration category is calculated by applying the relevant percentage to the anticipated lay-offs for each worker category (Exhibit C.2-6) and rounding off to the nearest whole number.[12]

Direct earnings losses by class of employee (supervisory or production) in each affected community are calculated by multiplying net weekly earnings (gross earnings minus state and federal taxes, and unemployment compensation for the appropriate duration) by the appropriate duration of unemployment, and then by the number of plant employees laid-off.[13] Total earnings losses are shown in Exhibit C.2-8, which indicates that direct earnings losses would average $331,599.33 per plant and $4,970.44 per employee.

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[9] Jacobson and Thomason, 1979, *op. cit.*

[10] The upper bound is used to account for the worst case, consistent with our worst case hypothesis. For the "> 27 weeks" category it is assumed to be 52 weeks.

[11] The non-production employees, i.e., the total number of employees at the plant minus the sum of production and supervisory workers for the asbestos product, are classified along with supervisory workers since an average wage for non-production and supervisory workers is used, as discussed in the text above.

[12] In cases where this results in a total different from the anticipated number of lay-offs in either worker category, the adjustment is made by allocating the difference to the "52 weeks" category (if the rounded-off total is less than the anticipated actual) or by taking the difference off the "5 weeks" category (if the rounded-off total is greater than the anticipated actual).

[13] A sample calculation is shown in Appendix B.

Exhibit C.2-5. Distribution of Unemployment Duration by State

State	Percentage Distribution of the Unemployed[a] Labor Force by Unemployment Duration			
	<5 Weeks	5-14 Weeks	15-27 Weeks	>27 Weeks
Arkansas	47.6	31.0	10.3	11.1
California	46.2	30.3	11.9	11.6
Pennsylvania	37.4	30.6	13.0	19.0
Texas	51.0	29.5	10.3	9.2

[a]The upper bound is used as the unemployment duration for all categories. For the "> 27 weeks" category the unemployment duration is assumed to be 52 weeks.

Source: U.S. Department of Labor, Geographical Profile of Employment and Unemployment, 1985.

Exhibit C.2-6. Summary of Employee Lay-Offs by Plant

Plant Location	Product	Total Employees at Plant	Total Production Workers at Plant	Production Workers for Asbestos Product	Supervisory Workers for Asbestos Product	Anticipated Action	Production Workers Laid-Off	Supervisory[a] Workers Laid-Off
Van Buren, AR	A-C Pipe	74	55	55	10	Shut Down	55	19
Riverside, CA	A-C Pipe	100	70	70	10	Shut Down	70	30
Stockton, CA	A-C Pipe	175	95	60	5	Lay Off[b]	60	5
Ambler, PA	A-C Flat Sheet	40	35	12	2	Lay Off[b]	12	2
Wind Gap, PA	A-C Shingles	101	85	85	16	Shut Down	85	16
Denison, TX	A-C Pipe	204	164	47	6	Lay Off[b]	47	6
Hillsboro, TX	A-C Pipe	60	39	39	6	Shut Down	39	21

[a] Includes non-production workers laid off when a plant shuts down.

[b] Plant does not shut down because it also manufactures substitute product.

Source: Transcribed telephone conversations and documented correspondence with company personnel.

Exhibit C.2-7. Distribution of Employees Laid-Off by Unemployment Duration[a]

Plant Location	Worker Type	Number of Employees by Duration of Unemployment			
		5 Weeks	14 Weeks	27 Weeks	52 Weeks
Van Buren, AR	Production	26	17	6	6
	Supervisory	9	6	2	2
Riverside, CA	Production	32	21	8	9
	Supervisory	14	9	4	3
Stockton, CA	Production	28	18	7	7
	Supervisory	2	1	1	1
Ambler, PA	Production	4	4	2	2
	Supervisory	1	1	0	0
Wind Gap, PA	Production	32	26	11	16
	Supervisory	6	5	2	3
Denison, TX	Production	24	14	5	4
	Supervisory	3	1	1	1
Hillsboro, TX	Production	20	11	4	4
	Supervisory	11	6	2	2

[a]The numbers presented in this table are rounded off to the nearest whole number. In cases where this results in a total different from the anticipated number of lay-offs in either worker category, the adjustment is made by allocating the difference to the "52 weeks" category (if the rounded-off total is less than the anticipated actual) or by taking the difference off the "5 weeks" category (if the rounded-off total is greater than the anticipated actual).

Exhibit C.2-8. Direct Earnings Losses of Employees

Type of Product	Number of Plants	Number of Production Workers	Number of Supervisory Workers[a]	Direct Earnings Losses of Employees (dollars)
Asbestos-Cement Pipe	5	271	81	1,701,748.75
Asbestos-Cement Flat Sheet	1	12	2	66,476.92[b]
Asbestos-Cement Shingles	1	85	16	552,969.61
Total	7	368	99	2,321,195.28

[a]This includes supervisory and non-production workers laid off.

[b]A sample calculation for this entry is presented in Attachment B.

2.1.2 Loss of Fringe Benefits

Although not usually included in employees' income, fringe benefits such as medical, dental, and life insurance, and pension benefits can be significant losses when employees are laid off permanently. The loss of fringe benefits to plant employees may be quantified as the difference between cost of these benefits to plant employees and the cost of these benefits to unemployed individuals.

The cost of insurance to employees is usually extremely small because of group rates. Hence, the cost of losing insurance coverage equals the difference in premiums paid by the worker when employed at the plant (usually negligible) and premium required to continue the same coverage when unemployed. However, the costs in terms of lost insurance coverage could be lower if the plant employees could be covered at no extra cost on their spouses' policies.

Finally, plant employees laid-off may also suffer losses of pension benefits. Older employees will suffer a disproportionate loss, especially under defined benefit pension plans. However, because of wide variations of pension plan provisions and lack of precise data, these are not quantified here.

2.1.3 Loss in Human Capital

Plant employees who would be laid-off as a result of the product ban are also likely to suffer a loss in human capital. Plant employees would be unable to market their full range of skills to new employers and hence would receive lower wages in subsequent jobs. Two factors are primarily responsible for any loss in human capital: low transferability of skills from asbestos production to other occupations and loss of union rent. Unions frequently are able to negotiate greater than competitive wages. The difference between these wages and competitive wages is termed union rent.[14] The impact of each of these factors on plant employees is discussed below.

While employed at asbestos plants, employees may have acquired skills valuable to employers. The more specific these skills are to the occupation, the more likely these employees are to earn higher wages. Following imposition of the ban, plant employees would be unable to find similar jobs because all such production in the U.S. would be prohibited. Hence, these workers would not be able to market their full range of skills and, as a result, would not command the same level of earnings until they were retrained in new occupations.

Such a loss in human capital is predominantly a function of age, when age is a proxy for tenure. Employee sex and race play lesser roles. Older workers would suffer the largest loss in human capital as, in general, they have acquired the greatest amount of occupation-specific skills. In contrast, young workers with low tenure have less to lose, and so the difference in earnings between their asbestos occupation and subsequent jobs is likely to be

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[14] Jacobson and Thomason 1979, *op. cit.*

very small. Transient workers who frequently change from one job to another would also suffer low losses in human capital as a result of the ban.[15]

This loss in human capital may be particularly severe in the asbestos industry not only because employees in this industry are older on average, but also because they have a relatively long tenure. Male employees in SIC 329 (stone, clay, and glass products) had an average tenure of 5.7 years on their current job in January 1981. This contrasts with the average tenure for men of 3.9 years in all non-agricultural industries. Female employees in SIC 329 had a relatively long tenure of 3.5 years in January 1981, compared to a non-agricultural industry average of 2.5 years for female employees.[16]

Loss of union rent is another factor which contributes to loss in human capital. According to available estimates, 82 percent of production workers in SIC 329 are represented by labor organizations.[17] However, only 61 percent of manufacturing employees as a whole are represented by labor organizations.[18] Those plant employees unable to obtain another unionized job would lose earnings and benefits above the competitive level obtained by unions.

Loss of human capital may also lead some employees to withdraw from the labor force. As plant employees search for other jobs following imposition of a product ban, they might find that wages in alternative jobs are lower than the value of leisure time or time spent otherwise occupied at home. In this case employees would be likely to withdraw from the labor force. This situation would be most likely to occur for older workers close to retirement age and for secondary earners having the option not to work for compensation. Although this analysis does not quantify the employees' loss of human capital, it is important to note how it should be measured for employees who may withdraw from the labor force. These employees would choose not to be employed in an alternative job because they would place a higher value on non-work related uses of their time. Hence, their earnings should not be measured as zero following imposition of the ban. Rather, their loss in human capital should be measured as the difference in wages they would have received in the absence of the product ban and wages they will receive in alternative employment.[19]

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[15] Holen, A., Jehn, C., and Trost, R.P., 1981. "Earnings Losses of Workers Displaced by Plant Closings." The Public Research Institute. Under contract to the Bureau of International Labor Affairs, U.S. Department of Labor, Washington, D.C. Contract J-9-K-6-0016.

[16] U.S. Department of Labor, 1983. Job Tenure and Occupational Change, 1981. Bureau of Labor Statistics. Washington, D.C.

[17] Freeman, R.B., and Medoff, J.L., 1979. "New Estimates of Private Sector Unionism in the United States." Industrial and Labor Relations Review, Vol. 32, No. 2, pp. 143-174.

[18] U.S. Department of Labor, 1981. Earnings and Other Characteristics of Organized Workers, May 1980. Bureau of Labor Statistics. Washington, D.C.

[19] Jacobson and Thomason 1979, *op. cit.*

2.1.4 Psychic Costs

Psychic costs include mental and physical suffering brought about by involuntary loss of employment. Psychic costs range from a dissatisfaction with having to leave familiar surroundings to find a new job, to severe mental and physical health problems. These costs are particularly severe for middle-aged men facing family responsibilities. According to Dr. M. Harvey Brennen of Johns Hopkins University, a one percent increase in unemployment directly accounts for a 4.3 percent increase in men and a 2.3 percent increase in women entering mental hospitals, a 4.1 percent increase in suicides, a 5.7 percent increase in murders, 4 percent increase in the population of state prisons, and, over a 6-year period, a 1.9 percent increase in the number of persons dying from stress-related illnesses such as heart disease and cirrhosis of the liver.[20]

2.2 Indirect Community Income Losses

This section addresses the potential economic effects of the proposed product ban on the communities in which the employees of the affected plants live and work. As was the case with direct earnings losses, additional losses due to the fiber cap are not expected to be significant and are not included in this analysis. For each affected community, two economic effects are assessed: (1) bans would affect local economies differently based on differences in their unemployment rates and industry mixes; and (2) indirect economic losses would be borne by each community as a result of the proposed bans (excluding lost earnings of plant employees) because of the lost value of locally-produced goods and services which employees would not buy after a product ban.

The significance to each community of a plant closing to the local economic base is a unique situation. A number of standard economic variables are available for defining a local economic base. General economic variables reviewed include geographic location, land area, population, population density, and local unemployment rates. Attachment A provides a description of each community in which a plant affected by the product bans is located. The names and locations of the affected plants are listed in Exhibit C.2-1.

The second group of economic effects would be indirect community income losses. This study made use of the economic multiplier furnished by the Department of Commerce to calculate the local indirect economic consequences of plant closings.[21] These consequences would include reduced sales by local businesses of locally-produced goods and services to workers and to the plant. On a national level, for every $1 of income lost to employees in SIC 3292, employees in other SIC codes lose $0.83 which would have been spent on U.S.

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[20] Batt, W.L., 1983. "Canada's Good Example with Displaced Workers". Harvard Business Review, vol. 4, pp. 6-22.

[21] Richard B. Miller, Regional Economic Analysis Division, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C. provided the multiplier, based on the Department's Regional Industrial Multiplier System (RIMS) input-output model, in a transcribed telephone conversation on March 3, 1987.

made food, clothing, services, and other goods. (Income losses suffered by employees in SIC 3292 are estimated above.)

Generally, losses would vary in proportion to the self-sufficiency of each community. A closed economy which depends heavily on purchases by local citizens of locally-produced products would suffer more from a plant closing than one which imports heavily from other areas. As a nation, the United States is a relatively closed economy. Communities are significantly less self-sufficient than the nation because many of the goods and services they purchase are produced elsewhere and little value is added locally. However, the national economic multiplier is used here as an upper bound. To determine the income loss in SIC codes other than 3292, the multiplier is applied to the before-tax earnings loss of asbestos employees laid-off as a result of the ban. (The multiplier incorporates tax and savings factors.) These earnings losses are calculated by multiplying the gross weekly wages minus the relevant unemployment compensation per employee times the number of employees laid-off and then times the number of weeks each individual is expected to be out of work. Indirect community income losses are shown in Exhibit C.2-9.[22]

Exhibit C.2-10 shows the total income losses attributable to immediate product bans. An estimated $4.6 million will be lost, in terms of direct and indirect income losses to the affected workers and communities, due to the immediate product bans.

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[22] A sample calculation is shown in Appendix B.

Exhibit C.2-9. Indirect Community Income Losses

Type of Plant (dollars)	Number of Plants	Indirect Community Income Losses
Asbestos-Cement Pipe	5	1,648,225.81
Asbestos-Cement Flat Sheet	1	65,765.37[a]
Asbestos-Cement Shingles	1	545,204.42
Total	7	2,259,195.60

[a]A sample calculation for this entry is presented in Attachment B.

Exhibit C.2-10. Total Income Losses Attributable to Immediate Product Bans

Product	Number of Plants	Direct Earnings Losses of Employees (dollars)	Community Income Losses (dollars)	Indirect Total Income Losses (dollars)
A-C Pipe	5	1,701,748.75	1,648,225.81	3,349,974.56
A-C Flat Sheet	1	66,476.92	65,765.37	132,242.29[a]
A-C Shingles	1	552,969.61	545,204.42	1,098,174.03
Total	7	2,321,195.28	2,259,195.60	4,580,390.88

[a]A sample calculation for this entry is presented in Attachment B.

REFERENCES

ICF Incorporated. 1986a (July-December). Survey of Primary and Secondary Processors of Asbestos-Reinforced Plastic. Washington, D.C. Appendix F for this RIA.

ICF Incorporated. 1987. Asbestos Regulatory Cost Model and Brakes Model. Washington, D.C. Appendix A of this RIA.

RTI. 1985. Regulatory Impact Analysis of Controls on Asbestos. Prepared for Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency. EPA CBI Document Control No. 20-8510620.

ATTACHMENT A: DESCRIPTIONS OF PLANTS AND COMMUNITIES WHICH MAY BE AFFECTED BY THE PRODUCT BAN

This attachment discusses the plants of domestic primary processors which would be affected by the proposed immediate product bans and the communities in which they are located. It does not describe other plants and communities which could be affected by the fiber cap, such as miners and millers, other primary processors (i.e., those not banned), secondary processors, and importers.

The basic units of analysis for this study are counties. The Bureau of the Census, Population Division, Journey-to-Work and Migration Statistics Branch provided unpublished 1980 census data listing the places of residence of persons who worked in the counties where the plants are located. The data include the total number of workers commuting to each county and the number of workers traveling there from each county of residence.

This study assumes that the commuting patterns of plant workers parallel those of the "average" worker in the plant county and that the impact of total or partial plant shutdowns would thus be felt in the counties from which at least 68.3 percent of all workers in the plant county traveled (one standard deviation from a normal distribution). In most cases, one or two counties alone accounted for far more than 68.3 percent of a county's workforce.

Exhibit C.A-1 lists the counties which comprise the communities which would be affected by the proposed ban. As Exhibit C.A-1 illustrates, the affected communities vary widely with respect to geographic location, land area, and population density. The following section of this chapter will provide additional details about these communities which illustrate the differences among them.

The following discussion of individual communities is divided into three groups. The first group consists of communities in which asbestos-cement pipe manufacturers are located. The second consists of communities in which asbestos-cement flat sheet manufacturers are located. The third group consists of communities in which manufacturers of asbestos-cement shingles are located.

The following is a brief description of the data sources for the discussion of communities. The statistics on population, land area, SIC industry breakdowns by community, and local payrolls are provided by the Bureau of the Census. Specifically:

- 1980 List of Workplaces and Residences: Unpublished Census Data.[23]

- Land Area: 1977 City and County Data Book.

[23] Transcribed telephone conversation with Gloria Swikowski of Journey-to-Work and Migration Statistics Branch, Population Division, Bureau of the Census, Washington, D.C., on February 11, 1987.

Exhibit C.A-1. Definition of Communities

Company	Plant County	Counties in Community Area	Land Area (Square Miles)	Population (1985)	Total Community Population
Asbestos-Cement Pipe Plants					
Capco Pipe Company Van Buren, AL	Crawford, AR	Crawford, AR	596	40,500	40,500
Certain-Teed Corporation Riverside, CA	Riverside, CA	Riverside, CA	7,176	820,600	820,600
J. M. Manufacturing Corporation Stockton, CA	San Joaquin, CA	San Joaquin, CA	1,412	418,300	418,300
J. M. Manufacturing Corporation Denison, TX	Grayson, TX	Grayson, TX	940	96,700	96,700
Certain-Teed Corporation Hillsboro, TX	Hill, TX	Hill, TX	1,010	27,400	27,400
Asbestos-Cement Flat Sheet Plants					
Nicolet, Incorporated Ambler, PA	Montgomery, PA	Montgomery, PA Philadelphia, PA	496 126	663,200 1,637,400	2,300,600
Asbestos-Cement Shingles Plants					
Suprador Manufacturing Corporation Wind Gap, PA	Northampton, PA	Northampton, PA	376	231,400	231,400

- 1985 Population: <u>1985 Estimates of County Population</u> and <u>U.S. Bureau of Census, County Division</u>.

- 1984 Employees and Establishments by SIC Code: <u>County Business Patterns</u>.

The number of employees by plant was obtained from ICF's 1986 Survey of Primary and Secondary Processors of Asbestos. Unemployment rates by county for October 1986 are provided by the Bureau of Labor Statistics, U.S. Department of Labor.[24]

1. <u>Communities with Asbestos-Cement Pipe Plants</u>

The following five community descriptions discuss areas where asbestos-cement pipe plants are located. One of the plants is located in Arkansas, two in California, and two in Texas.

a. <u>Van Buren, Arkansas</u>

The Capco Pipe Company plant in Van Buren, Arkansas is one of 46 manufacturing establishments in Crawford County. Crawford County is defined as a self-contained commuting area since about 77 percent of those who work in the county also live there.

Van Buren is a small town in western Arkansas and not within commuting distance of any major city. Crawford County's population in 1985 was 40,500 with a density of 68 people per square mile. As Exhibits C.A-2 and C.A-3 show, there were 2,971 manufacturing jobs in the county in 1984 with the largest manufacturing employees being the food processing; and stone, clay and glass industries. Unemployment in October 1986 was 7.1 percent.

Crawford County is a rural county where job opportunities are limited, manufacturing plants tend to be very small, and there are no major metropolitan areas within commuting distance. The number of plant employees laid off in Van Buren following imposition of the ban would be 74 lay-offs (2.5 percent of local manufacturing jobs). The total annual payroll of Crawford County was $81.1 million in 1984 according to U.S. Bureau of Census, County Business Patterns.

b. <u>Riverside, California</u>

Riverside is a relatively self-contained city and county about 50 miles southwest of Los Angeles. About 86 percent of the people who work in Riverside County (population 820,600) also live there. It is the home of a Certain-Teed Corporation plant included in this study, one of 746 manufacturing establishments in the county.

Riverside's population density is 114 people per square mile and the major employers are the retail trade and service industries. Within the manufacturing sector (see Exhibits C.A-4 and C.A-5), about one-third of the jobs are in the electric/electronic and transportation equipment industries.

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[24] Transcribed telephone conversation with Valerie Laedlein, U.S. Department of Labor, Washington, D.C., on February 1, 1987.

Exhibit C.A-2. Local Economic Base of Van Buren, Arkansas Commuting Area (1984)[a]

Sector	Number of Employees	Percent of Total Employees	Number of Establishments
Agricultural Services, Forestry, Fisheries	0-19	b	3
Mining	20-99	0.3-1.5	8
Contract Construction	227	3.4	53
Manufacturing	2,971	44.8	46
Transportation and Other Public Utilities	303	4.6	37
Wholesale Trade	461	7.0	36
Retail Trade	1,185	17.9	150
Finance, insurance, and Real Estate	189	2.9	25
Services	1,125	17.0	128
Nonclassifiable Establishments	114	1.7	61
TOTAL	6,630		547

[a] Percent in tha second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: <u>County Business Patterns</u>, U.S. Bureau of Census. 1984.

Exhibit C.A-3. The Manufacturing Sector of Van Buren, Arkansas Commuting Area (1984)[a]

SIC	Industry	Number of Employees	Percent of Total Manufacturing Employees	Number of Establishments
20	Food and Kindred Products	1,508	50.8	10
23	Apparel and Other Textiles Products	20-99	0.7-3.3	1
24	Lumber and Wood Products	100-249	3.4-8.4	6
25	Furniture and Fixtures	242	6.1	6
27	Printing and Publishing	20-99	0.7-3.3	4
32	Stone, Clay and Glass Products	250-499	8.4-16.6	2
33	Primary Metal Industries	100-249	3.4-8.4	1
34	Fabricated Metal Products	100-249	3.4-8.4	2
	TOTAL	2,971		46

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-4. Local Economic Base of Riverside, California Commuting Area (1984)[a]

Sector	Number of Employees	Percent of Total Employees	Number of Establishments
Agricultural Services, Forestry, Fisheries	4,030	2.3	355
Mining	254	b	22
Contract Construction	16,381	9.3	1,702
Manufacturing	27,550	15.7	746
Transportation and Other Public Utilities	9,124	5.2	528
Wholesale Trade	9,031	5.2	711
Retail Trade	50,277	28.7	4,212
Finance, Insurance, and Real Estate	10,281	5.9	1,299
Services	44,964	25.6	4,617
Nonclassifiable Establishments	3,418	1.9	1,307
TOTAL	175,310	1.9	15,499

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: <u>County Business Patterns</u>, U.S. Bureau of Census. 1984.

Exhibit C.A-5 . The Manufacturing Sector of Riverside, California Commuting Area (1984)[a]

SIC	Industry	Number of Employees	Percent of Total Manufacturing Employees	Number of Establishments
20	Food and Kindred Products	1,128	4.1	30
23	Apparel and Other Textiles Products	697	2.5	30
24	Lumber and Wood Products	2,108	7.7	60
25	Furniture and Fixtures	934	3.4	30
26	Paper and Allied Products	500-999	1.8-3.6	5
27	Printing and Publishing	2,498	9.1	119
28	Chemicals and Allied Products	383	1.4	16
30	Rubber and Miscellaneous Plastics Products	2,293	8.3	44
31	Leather and Leather Products	100-249	b	4
32	Stone, Clay and Glass Products	2,108	7.6	60
33	Primary Metal Industries	1,279	4.6	18
34	Fabricated Metal Products	2,019	7.3	77
35	Machinery, Except Electrical	1,425	5.2	113
36	Electric and Electronic Equipment	4,123	15.0	34
37	Transportation Equipment	4,674	17.0	48
38	Instruments and Related Products	118	b	17
39	Miscellaneous Manufacturing Industries	309	1.1	26
	TOTAL	27,550		746

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Riverside's unemployment rate in October 1986 was 7.8 percent. The community contains a range of manufacturing establishments from highly technical producers of instruments to chemical plants and lumber and wood product manufacturers. The number of plant employees laid off in Riverside following imposition of the ban would be 100 (0.4 percent of local manufacturing jobs). The 1984 annual payroll for the county was $2.7 billion.

c. Stockton, California

Stockton is the largest city in San Joaquin County, in the heart of one of the nation's most important agricultural areas. The biggest non-farm sector in San Joaquin County is the service sector (see Exhibits C.A-6 and C.A-7). Manufacturing provides about 20,000 jobs, one-third of which are in the food and kindred products industry. Almost 93 percent of the people who work in San Joaquin County also live there.

Unemployment in San Joaquin County was 10.2 percent in October 1986. The population of the county was 418,300 in 1985 with a density of 296 people per square mile.

The relatively high unemployment rate and the dominance of the food processing industry mean that employees of the J. M. Manufacturing Corporation plant in Stockton could have a difficult time finding new jobs in their home community. The ban would cost 65 jobs (0.3 percent of local manufacturing jobs). The 1984 annual payroll for San Joaquin County was $1.7 billion.

d. Denison, Texas

Denison , Texas is a small community in the rural county of Grayson, just south of the Oklahoma border. Grayson County's population in 1985 was 96,700, with a density of 103 people per square mile. About 90 percent of the people who work in Grayson County also live there.

The manufacturing sector provided about 11,000 jobs in Grayson County in 1984 (see Exhibits C.A-8 and C.A-9), and was thus by far the largest employer. Nearly half of these jobs were in four electric and electronic equipment establishments. Unemployment in Grayson County was 8.2 percent in October 1986. After the ban, Grayson County would lose 53 jobs (0.5 percent of local manufacturing jobs). The annual payroll for Grayson County in 1984 was $498 million.

e. Hillsboro, Texas

Hillsboro is a small community about 45 miles south of Fort Worth, in Hill County. The county is a sparsely-populated 1,010 square miles (27 people per square mile) and about 90 percent of the people who work there also reside in the county.

Unemployment in Hill County was 7.7 percent in October 1986, out of a total labor force of about 5,000. In 1984, there were 1,387 manufacturing jobs in the community in a total of 34 establishments (see Exhibits C.A-10 and C.A-11). The largest industry was the stone, clay, and glass products industry employing 339 workers. The Certain-Teed plant closing could have a noticeable impact on the local unemployment rate, raising it by 1.2 percent from plant lay-offs alone. Additional jobs could be lost in the community

Exhibit C.A-6. Local Economic Base of Stockton, California Commuting Area (1984)[a]

Sector	Number of Employees	Percent of Total Employees	Number of Establishments
Agricultural Services, Forestry, Fisheries	862	b	189
Mining	133	b	18
Contract Construction	7,425	7.7	791
Manufacturing	19,033	19.7	447
Transportation and Other Public Utilities	6,150	6.4	454
Wholesale Trade	7,741	8.0	551
Retail Trade	22,233	23.0	2,171
Finance, insurance, and Real Estate	8,427	8.7	747
Services	23,402	24.2	2,631
Nonclassifiable Establishments	1,315	1.4	574
TOTAL	96,721		8,573

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-7. The Manufacturing Sector of Stockton, California Commuting Area (1984)[a]

SIC	Industry	Number of Employees	Percent of Total Manufacturing Employees	Number of Establishments
20	Food and Kindred Products	6,479	34.0	77
23	Apparel and Other Textiles Products	285	1.5	10
24	Lumber and Wood Products	2,137	11.2	38
25	Furniture and Fixtures	460	2.4	15
26	Paper and Allied Products	768	4.0	8
27	Printing and Publishing	821	4.3	56
28	Chemicals and Allied Products	542	2.8	14
30	Rubber and Miscellaneous Plastics Products	610	3.2	20
32	Stone, Clay and Glass Products	1,292	6.8	26
33	Primary Metal Industries	280	1.5	9
34	Fabricated Metal Products	1,911	10.0	44
35	Machinery, Except Electrical	755	4.0	59
36	Electric and Electronic Equipment	1,773	9.3	16
37	Transportation Equipment	339	1.8	15
39	Miscellaneous Manufacturing Industries	299	1.6	17
	TOTAL	19,033		447

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

Source: <u>County Business Patterns</u>, U.S. Bureau of Census. 1984.

Exhibit C.A-8. Local Economic Base of Denison, Texas Commuting Area (1984)[a]

Sector	Number of Employees	Percent of Total Employees	Number of Establishments
Agricultural Services, Forestry, Fisheries	20-99	b	22
Mining	100-249	b	28
Contract Construction	1,533	5.1	198
Manufacturing	10,974	36.4	128
Transportation and Other Public Utilities	1,405	4.7	89
Wholesale Trade	1,312	4.4	164
Retail Trade	7,010	23.3	640
Finance, Insurance, and Real Estate	1,321	4.4	180
Services	5,886	19.5	686
Nonclassifiable Establishments	439	1.5	194
TOTAL	30,135		2,329

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-9. The Manufacturing Sector of Denison, Texas Commuting Area (1984)[a]

SIC	Industry	Number of Employees	Percent of Total Manufacturing Employees	Number of Establishments
20	Food and Kindred Products	1,841	16.8	14
22	Textile Mill Products	500-999	4.6-9.1	2
23	Apparel and Other Textiles Products	622	5.7	6
24	Lumber and Wood Products	307	2.8	9
25	Furniture and Fixtures	107	b	4
26	Paper and Allied Products	209	1.9	4
27	Printing and Publishing	281	2.6	15
31	Leather and Leather Products	65	b	4
32	Stone, Clay and Glass Products	500-999	4.6-9.1	4
33	Primary Metal Industries	872	7.9	5
34	Fabricated Metal Products	735	6.7	19
35	Machinery, Except Electrical	443	4.0	20
36	Electric and Electronic Equipment	2,500-4,999	22.8-45.6	4
37	Transportation Equipment	258	2.4	7
38	Instruments and Related Products	500-999	4.6-9.1	1
39	Miscellaneous Manufacturing Industries	66	b	6
	TOTAL	10,974		128

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-10. Local Economic Base of Hillsboro, Texas Commuting Area (1984)[a]

Sector	Number of Employees	Percent of Total Employees	Number of Establishments
Agricultural Services, Forestry, Fisheries	20-99	0.4-2.0	10
Mining	0-19	b	2
Contract Construction	379	7.6	38
Manufacturing	1,387	27.7	34
Transportation and Other Public Utilities	491	9.8	33
Wholesale Trade	137	2.7	32
Retail Trade	1,229	24.5	197
Finance, insurance, and Real Estate	253	5.0	51
Services	973	19.4	139
Nonclassifiable Establishments	130	2.6	60
TOTAL	5,012		596

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-11. The Manufacturing Sector of Hillsboro, Texas Commuting Area (1984)[a]

SIC	Industry	Number of Employees	Percent of Total Manufacturing Employees	Number of Establishments
23	Apparel and Other Textiles Products	235	16.9	4
24	Lumber and Wood Products	100-249	7.2-18.0	2
25	Furniture and Fixtures	100-249	7.2-18.0	2
32	Stone, Clay and Glass Products	339	24.4	6
33	Primary Metal Industries	100-249	7.2-18.0	1
35	Machinery, Except Electrical	63	4.5	6
36	Electric and Electronic Equipment	100-249	7.2-18.0	1
	TOTAL	1,387		34

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

through secondary effects of a reduced overall payroll and goods or services currently provided to the plant.

Hillsboro would lose 4.3 percent of all manufacturing jobs (60 jobs) if the product ban is imposed. Hill County's annual payroll in 1984 was $63.5 million.

2. Communities with Asbestos-Cement Flat Sheet Plants

In 1985, there was only one plant in the United States producing asbestos-cement flat sheet. This plant is located in Pennsylvania.

a. Ambler, Pennsylvania

The plant in Ambler is owned by Nicolet, Incorporated. Ambler is in Montgomery County, Pennsylvania, a largely suburban county located northwest of Philadelphia. Ambler's "community" is defined as not only including Montgomery County (1985 population 663,200), but also Philadelphia County (1985 population 1,637,400), thus the total community population in 1985 was 2,300,600 (with a density of 3,699 people per square mile). The unemployment rate of the two counties was 5.1 percent in October 1986. This area has a relatively low unemployment rate and a substantial manufacturing base of about 3,500 establishments, which employed about 210,000 workers in 1984 (see Exhibits C.A-12 and C.A-13). Given these conditions the layoff of 14 asbestos product workers (< 0.1 percent of manufacturing jobs) at the Nicolet plant would have a very minor impact on the community.

3. Communities with Asbestos-Cement Shingle Plants

In 1985 there was only one plant in the United States producing asbestos-cement shingles. This plant is located in Pennsylvania.

a. Wind Gap, Pennsylvania

The plant in Wind Gap is owned by Supradur Manufacturing Corporation. Wind Gap is located in Northampton County about 15 miles northeast of Allentown-Bethlehem, the closest urban center.

Northampton County's 1985 population was 231,400 with a density of 615 per square mile. Unemployment in October 1986 was a relatively low 5.5 percent. In 1984, manufacturing provided about 29,000 jobs in Northampton County (as shown in Exhibits C.A-14 and C.A-15) and was the most important sector of the local economy. Considering the low unemployment and size of the manufacturing sector and the proximity of an urban center, the 101 layoffs (0.35 percent of manufacturing jobs) expected as a result of the ban would not have a severe impact on the community.

Exhibit C.A-12. Local Economic Base of Ambler, Pennsylvania Commuting Area (1984)[a]

Sector	Number of Employees	Percent of Total Employees	Number of Establishments
Agricultural Services, Forestry, Fisheries	2,286	b	390
Mining	858	b	33
Contract Construction	38,314	4.0	2,871
Manufacturing	210,082	22.2	3,536
Transportation and Other Public Utilities	49,659	5.2	1,423
Wholesale Trade	64,827	6.8	4,218
Retail Trade	153,685	16.2	12,841
Finance, Insurance, and Real Estate	95,723	10.1	4,546
Services	325,704	35.4	16,923
Nonclassifiable Establishments	6,567	b	3,367
TOTAL	947,705		50,148

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-13. The Manufacturing Sector of Ambler, Pennsylvania Commuting Area (1984)[a]

SIC	Industry	Number of Employees	Percent of Total Manufacturing Employees	Number of Establishments
20	Food and Kindred Products	19,107	9.1	207
21	Tobacco Manufacturers	20-99	b	1
22	Textile Mill Products	1,409	b	41
23	Apparel and Other Textiles Products	20,618-23,117	9.8-11.0	321
24	Lumber and Wood Products	728	b	70
25	Furniture and Fixtures	5,439	2.6	121
26	Paper and Allied Products	7,029	3.3	106
27	Printing and Publishing	21,298	10.1	569
28	Chemicals and Allied Products	13,400	6.4	133
30	Rubber and Miscellaneous Plastics Products	1,841	b	24
31	Leather and Leather Products	4,635	2.2	116
32	Stone, Clay and Glass Products	626	b	25
33	Primary Metal Industries	4,582	2.2	69
34	Fabricated Metal Products	19,636	9.3	436
35	Machinery, Except Electrical	17,483	8.3	425
36	Electric and Electronic Equipment	18,010	8.6	197
37	Transportation Equipment	10,710	5.1	44
38	Instruments and Related Products	10,329	4.9	128
39	Miscellaneous Manufacturing Industries	2,986	1.4	185
	TOTAL	210,082		3,536

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-14. Local Economic Base of Wind Gap, Pennsylvania Commuting Area (1984)[a]

Sector	Number of Employees	Percent of Total Employees	Number of Establishments
Agricultural Services, Forestry, Fisheries	136	b	44
Mining	98	b	8
Contract Construction	1,797	2.6	419
Manufacturing	28,971	42.1	387
Transportation and Other Public Utilities	3,196	4.6	148
Wholesale Trade	2,560	3.7	233
Retail Trade	11,848	17.2	1,128
Finance, insurance, and Real Estate	3,366	4.9	309
Services	16,302	23.7	1,476
Nonclassifiable Establishments	618	b	336
TOTAL	68,892		4,488

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: County Business Patterns, U.S. Bureau of Census. 1984.

Exhibit C.A-15. The Manufacturing Sector of Wind Gap, Pennsylvania Commuting Area (1984)[a]

SIC	Industry	Number of Employees	Percent of Total Manufacturing Employees	Number of Establishments
20	Food and Kindred Products	1,063	3.7	18
22	Textile Mill Products	865	3.0	16
23	Apparel and Other Textiles Products	10,330	35.7	134
24	Lumber and Wood Products	201	b	11
25	Furniture and Fixtures	110	b	7
26	Paper and Allied Products	270	b	6
27	Printing and Publishing	1,869	8.5	35
28	Chemicals and Allied Products	517	1.8	11
30	Rubber and Miscellaneous Plastics Products	689	2.4	10
32	Stone, Clay and Glass Products	1,391	4.8	25
33	Primary Metal Industries	5,000-9,999	17.3-34.5	5
34	Fabricated Metal Products	1,094	3.8	33
35	Machinery, Except Electrical	1,462	5.0	32
36	Electric and Electronic Equipment	595	2.1	7
38	Instruments and Related Products	51	b	7
39	Miscellaneous Manufacturing Industries	500-999	1.7-3.4	10
	TOTAL	28,971		387

[a] Percent in the second column are calculated from U.S. Census Bureau totals for this community. These totals do not reflect 100 percent of industry employees in the community because of reporting methods. The figures and totals in the first and third columns were provided by the Census Bureau. These figures do not add up to the totals, nor do the individual percentage figures add up to 100 percent.

[b] Less than 1 percent of total.

Source: <u>County Business Patterns</u>, U.S. Bureau of Census. 1984.

ATTACHMENT B: <u>SAMPLE CALCULATION OF DIRECT EARNINGS AND INDIRECT INCOME LOSSES CAUSED BY AN IMMEDIATE PRODUCT BAN</u>

This appendix presents a sample calculation of direct earnings and indirect income losses caused by an immediate product ban (as shown in Exhibits C.2-8 and C.2-9). The sample calculation is based on an immediate ban of <u>asbestos-cement flat sheet</u>.

1. <u>Relevant Data for Sample Calculation</u>

As shown in Exhibit C.2-1, only one plant manufactures asbestos-cement flat sheet. This plant is located in Ambler, Pennsylvania, and employs a total of 40 employees of which 35 are production workers as shown in Exhibit 6. However, only 12 of these production workers are involved in the manufacture of asbestos-cement flat sheet. Therefore, this plant will not shut down, instead, will lay off the 12 production workers and the 2 supervisory workers associated with the production of asbestos-cement flat sheet (as shown in Exhibit C.2-6).

The text lists the sources from where data on employee earnings was obtained. Earnings for production workers were estimated as $420.85 per week or $21,884.20 annually. Earnings for supervisory workers were estimated as $596.57 per week or $31,021.64 annually. It is assumed that each worker has an unemployed spouse and two dependent children.

2. <u>Calculation of Offsets to Loss in Earnings</u>

<u>Federal Income Tax</u>: Based on 1987 Federal tax tables, the income tax paid annually by production and supervisory workers (Exhibit C.2-2) is calculated as:

Federal income tax paid
by a production worker = $3,000.00 * 0.11 + $11,284.20 * 0.15 = $2,022.80

Federal Income Tax paid
by a supervisory worker = $3,000.00 * 0.11 + $20,421.64 * 0.15 = $3,393.00

<u>State Income Tax</u>: Pennsylvania had a flat income tax rate of 2.2 percent for the 1986 tax year. Therefore, the state taxes paid annually by the workers (Exhibit C.2-2) are:

State Income Tax paid
by a production worker = $21,884.20 * 0.022 = $481.52

State Income tax paid
by a supervisory worker = $31,021.64 * 0.022 = $682.24

Therefore, weekly taxes (Exhibit C.2-2) paid by each:

Production worker = ($2,022.80 + $481.52)/52 = $48.16

Supervisory worker = ($3,393.00 + $682.24)/52 = $78.37

Unemployment Compensation: The average weekly benefits for unemployment compensation provided to each worker by the Pennsylvania is \$153.66 per week for a maximum of 26 weeks (as shown in Exhibit C.2-3).

Unemployment Duration: Exhibit C.2-5 shows the percentage distribution of the unemployed labor force by unemployment duration. This distribution is used to calculate the numbers presented in Exhibit C.2-7. The relevant sample calculation is shown below and the numbers are rounded off to the nearest whole number.

Number of production workers
unemployed for 5 weeks = 12 * 0.374 = 4.49 = 4

Number of production workers
unemployed for 14 weeks = 12 * 0.306 = 3.67 = 4

Number of production workers
unemployed for 27 weeks = 12 * 0.130 = 1.56 = 2

Number of production workers
unemployed for 52 weeks = 12 * 0.190 = 2.28 = 2

Number of supervisory workers
unemployed for 5 weeks = 2 * 0.374 = 0.75 = 1

Number of supervisory workers
unemployed for 14 weeks = 2 * 0.306 = 0.61 = 1

Number of supervisory workers
unemployed for 27 weeks = 2 * 0.130 = 0.26 = 0

Number of supervisory workers
unemployed for 52 weeks = 2 * 0.190 = 0.38 = 0

3. Calculation of Direct Earnings Losses of Employees

Given the weekly earnings and offsets, and the duration of unemployment, the direct earnings losses of employees can be calculated as:

After-tax earnings loss per week of unemployment for each:

Production worker = \$420.85 - \$48.16 = \$372.69
Supervisory worker = \$596.57 - \$78.37 = \$518.20

Direct earnings losses (including unemployment compensation as shown in Exhibit C.2-3) for all:

Production workers = ((\$372.69 - \$153.66) * (4 * 5 + 4 * 14 + 4 * 26))
+ (\$372.69 * (2 * (27 - 26) + 2 * (52 - 26))

= \$59,550.66

Supervisory workers = (($518.20 - $153.66) * (1 * 5 + 1 * 14 + 0 * 26)) + ($518.20 * (0 * (27 - 26) + 0 * (52 - 26))

= $6,926.26

All employees = $59,550.66 + $6,926.26 = **$66,476.92** (as shown in Exhibit C.2-8)

4. Calculation of Indirect Community Income Losses

Given the weekly earnings, the unemployment compensation, the duration of unemployment, and the economic multiplier (which is 0.83 and incorporates tax and saving factors) the indirect community income losses can be calculated as:

Indirect community income losses attributable to direct earnings losses by all:

Production workers = ((($420.85 - $153.66) * (4 * 5 + 4 * 14 + 4 * 26)) + ($420.85 * (2 * (27 - 26) + 2 * (52 - 26))) * 0.83

= $58,780.68

Supervisory workers = ((($596.57 - $153.66) * (1 * 5 + 1 * 14 + 0 * 26)) + ($596.57 * (0 * (27 - 26) + 0 * (52 - 26))) * 0.83

= $6,984.69

All employees = $58,780.68 + $6,984.69 = **$65,765.37** (as shown in Exhibit C.2-9)

5. Calculation of Total Income Losses

The total income losses attributable to immediate product bans is calculated as:

Total income loss = $66,476.92 + $65,765.37 = **$132,242.29** (as shown in Exhibit C.2-10)

APPENDIX D -- COST FOR ENGINEERING CONTROLS FOR BRAKE MAINTENANCE/REPAIR

This appendix contains information concerning the methods and data used to calculate the costs of engineering controls for reducing asbestos exposures during brake repair/replacement. Fist is a brief overview of the calculations performed to obtain these cost estimates. This is followed by a report by PEI Associates prepared for EPA concerning the costs of different engineering controls designed to reduce asbestos exposure in brake maintenance and repair. The information developed in this report provides the basic input data for the analysis of the costs of brake engineering controls relative to the costs of banning these products presented in the Sensitivity Results in Volume IV of this Regulatory Impact Analysis.

1. <u>Calculation of Per Unit Control Costs</u>

Four engineering control options were considered based on feasible engineering control systems identified by PEI: the Enclosure/HEPA Vacuum Filtered System, the HEPA Vacuum Filtered System, and the Wet Brush/Recycling Liquid System. These systems were used to define the following engineering control options:

1. Require use of Enclosure/HEPA Vacuum Filtered Systems.

2. Require use of <u>either</u> the Enclosure/HEPA or HEPA Filtered Vacuum Systems.

3. Require the use of Wet Brush/Recycling Liquid Systems.

4. Require the use of an Engineering Control System, Enclosure/HEPA, HEPA Vacuum Filtered Systems <u>or</u> Wet Brush/Recycling Liquid Systems.

The methodology used to evaluate the costs associated with requiring the use of engineering control systems consists of the following steps:

1. Using the number of asbestos brake jobs performed in shops, and the percentage of shops not using a particular system, the number of potential jobs to be performed with the system under consideration is determined. This number represents the number of jobs that would be performed if that particular system were required by regulation.

2. The number of potential shops that could use a particular system is multiplied by the total annualized acquisition cost (includes taxes, freight, management and supervision cost associated with the acquisition of equipment; a 7 percent discount rate and 10-year capitalization period were used to derive this number) to determine a stream of annual acquisition costs for the whole industry. Each shop is assumed to buy one piece of equipment every ten years.

3. Total annual variable costs are obtained by multiplying the number of asbestos brake jobs determined in step 1 by the sum of maintenance costs (filter replacement, detergent replacement and waste disposal) and loss of productivity costs (disc and drum) per brake job.

4. Total costs for the 20 year period are obtained by adding annual acquisition, maintenance, and loss of productivity costs.

5. The net present value associated with requiring the use of each of engineering control systems is obtained using a 7 percent discount rate to discount the stream of cash flows.

The assumptions and data used to develop these costs for Regulatory Alternative A are presented below for the HEPA Vacuum control system -- the type of system considered in one of the sensitivity analyses presented in Appendix G.

HEPA Vacuum System

Item	Amount
Acquisition Cost	$891.00
Taxes, Freight, Mgt, and Support	80.00
Total Acquisition Cost	971.00
Annualized Acquisition Cost	138.00
Operation and Filter Replacement (per brake job)	1.39
Per Brake Job Waste Disposal	0.56
Productivity Loss Per Brake Job	0.83

COST OF ENGINEERING CONTROLS FOR BRAKE MAINTENANCE/REPAIR

by

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Contract No. 68-02-4248
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Office of Pesticides and Toxic Substances
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

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CONTENTS

TABLES

SECTION 1

INTRODUCTION

1.1 BACKGROUND

In the past, asbestos has been widely used in motor vehicle brake materials. Recognition of the hazardous properties of asbestos has resulted in substitution of less toxic fibers for some brake materials in recent years. Because of the large number of vehicles still having brakes containing asbestos, however, there is still considerable potential for exposure, especially during the repair or replacement of such brake systems. The U.S. Environmental Protection Agency (EPA) has been examining alternative approaches to controlling exposures from certain asbestos-containing products, including brake materials, since proposing the "Asbestos Ban/Phasedown Rule" on January 29, 1986. In June, 1986 EPA issued, "Guidance for Preventing Asbestos Disease Among Auto Mechanics" to assist mechanics in lowering exposure.[1]

On June 20, 1986, the Occupational Safety and Health Administration (OSHA) issued guidance to employers regarding exposures to asbestos in all industries covered by the Occupational Safety and Health Act (51 FR 22733). Appendix F to the guidance described nonmandatory work practices and engineering controls that can be used to reduce asbestos exposures during automotive brake and clutch repair to levels below the present OSHA standard's action level of 0.1 f/cc, 8-hour, time-weighted average (the OSHA Permissible Exposure Limit (PEL) is 0.2f/cc 8-h TWA). To loosen asbestos-containing residue from brakes, the guidance recommends the use of either an enclosed cylinder/high-efficiency particulate air (HEPA)-filtered vacuum system, a compressed air/solvent system, or aerosol spray cans of solvent cleaner.

In a previous work assignment for the Office of Toxic Substances' Chemical Engineering Branch, PEI Associates (PEI) prepared a report entitled

"Asbestos Dust Control in Brake Maintenance" (September 1985). This report identified techniques and engineering controls that are available to reduce worker exposure to asbestos during brake repair. The purposes of the present work assignment were (1) to develop a new control technology baseline that will characterize current practices in brake repair shops, taking into account the recent OSHA guidelines; and (2) to update the information in the previous PEI report on enclosure/HEPA-filtered vacuum systems, HEPA-filtered vacuum systems, and wet brush/recirculating liquid systems.

1.2 APPROACH

The primary sources of information for this study were direct contact with vendors of control equipment, the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), literature supplied by the vendors, and the open literature. Other sources included trade associations such as the Motor Vehicle Manufacturers Association and trade publications such as <u>After Market Business</u>, <u>Brake and Front End</u>, <u>Tire Review</u>, and <u>Jobber and Warehouse Executive</u>.

1.3 ORGANIZATION AND CONTENTS

Section 2 presents descriptions of the enclosure/HEPA-filtered vacuum system, the HEPA-filtered vacuum system, and the wet brush/recirculating liquid system. Section 3 describes the four parameters that are used to define the industry baseline: (1) the number of brake facilities, (2) the number of control devices in use, (3) the number of do-it-yourself brake jobs, and (4) the impact of the OSHA guidelines. Section 4 presents the cost of the systems described in Section 2. Both capital cost and operation and maintenance costs are presented. Section 5 presents the conclusions of the study. Appendix A presents vendor literature on several of the control systems.

SECTION 2

DESCRIPTION OF SYSTEMS STUDIED

This project concentrated on three systems used to control exposure to asbestos dust during brake repair: (1) enclosure/HEPA-filtered vacuum systems, (2) HEPA-filtered vacuum systems, and (3) wet brush/recirculating liquid systems. This section first presents the general characteristics of a system type and then presents the specifications of models that are presently on the market. Vendor literature for many models are presented in the Appendix.

2.1 ENCLOSURE/HEPA-FILTERED VACUUM SYSTEM

An enclosure/HEPA-filtered vacuum system consists of an enclosure which is put around the hub assembly of the wheel prior to cleaning. The enclosure is fitted with a compressed air adapter which allows the mechanic to blow the brake area clean of accumulated dirt and brake dust. The resultant air and dust are drawn off through a vacuum which contains a HEPA filter. The recommended procedure for using these systems is to 1) turn the vacuum on and position the enclosure around the brake assembly, 2) remove the drum, 3) clean the brake area, and 4) remove the enclosure and proceed with the brake repair.[1] PEI identified five manufacturers of this type of system: Clayton Associates, Control Resource Systems, Hako, Nilfisk of America, and Pullman/Holt.

Clayton Associates, Inc.--

Clayton sells four enclosure/HEPA-filtered vacuum models: BCE-1000, BCE-1500, BCE-2000, and BCE-2500. Models BCE-1000, BCE-1500, and BCE-2000 are similar systems, each having a HEPA filter surface area of 7753 in.^{2}, two single-speed flow-through motors pulling 220 cfm, and a see-through shatterproof Lexan enclosure with neoprene gloves. The difference in the units is that the enclosures of the BCE-1500 and BCE-2000 are 2 inches and 4 inches higher respectively than that of the BCE-1000. The larger units are for shops that repair vehicles with larger wheels. The fourth model sold by Clayton is the BCF-2500 which differs from the other three models in that it has a smaller HEPA filter area (2080 $in.^2$), and a single flow-through motor pulling 110 cfm. All units are designed so that the filters are changed while the vacuum is in operation, thus drawing dust away from the worker during the operation. All units are equipped with a manometer. The manometer measures the pressure differential above and below the main filter. A drop in airflow indicates that dust must be shaken from the filters or that the vacuum must be emptied. NIOSH noted that mechanics using the Clayton system positioned the enclosure around the hub before removing the drum, as recommended by the vendor.[2]

Control Resource Systems, Inc. (CRSI)--

CRSI sells one enclosure/HEPA-filtered vacuum model, the 600B. The unit is constructed of 16-gauge sheet metal with a 1/8 inch-thick Plexiglas window on the front. The enclosure is vented to a 300-to-600 cfm HEPA filter. Hand access is from the sides through arm sleeves, but gloves are not included in the system. The enclosure is 21 inches high, 15 inches wide, and 15 inches deep. The enclosure can be adjusted to a working height ranging from 2 feet to 6 feet.

Hako--

Hako sells two basic enclosure/HEPA filtered vacuum models. The C80106-07 is used for cars and light trucks, while the C80106-09 is used for larger trucks and buses. The model C80106-07 consists of a vinyl brake drum hood for 7- to 12-inch diameter drums which is vented to a 6-gallon vacuum tank fitted with a 95-cfm fan and a 2226-$in.^2$ HEPA filter. The model C80106-09 is the same except that the enclosure is larger to allow it to be used on drums with 12- to 19-inch diameters. The stand for either unit adjusts to a working height from 1 to 5 feet. A larger 15-gallon vacuum tank is available with a HEPA filter area of 4,120 $in.^2$. A manometer and gloves are also optional. Hako offers other models but they are essentially only minor variations of these two models.

Nilfisk of America--

Nilfisk sells three enclosure/HEPA-filtered vacuum models: Asbesto-Clene 400, Asbesto-Clene 500, and Asbesto-Clene 600. The only difference between Systems 400 and 500 is that the 500 model includes a high lift stand for use when working on vehicles on hydraulic lifts. Both systems are used with brake drums from 7- to 12-inch diameters. The model 600 enclosure has a 12- to 19-inch diameter range and is used on larger commercial vehicles. Mechanic access to the brakes with Nilfisk systems is through a cotton sleeve. Visibility is through viewing windows. The enclosures can be vented to five vacuum systems: GS80i, GS81, GS82, and GS83, and GB733. The GS80i has a 2½-gallon capacity with an 87-cfm fan and a 1620-in.^{2} HEPA filter; the GS81 has a 4-gallon capacity with an 87-cfm fan and a 1744-in.^{2} HEPA filter; the GS82 has a 12-gallon capacity with a 191-cfm fan and a 3895-in.^{2} HEPA filter; the GS83 has an 18-gallon capacity with a 208-cfm fan and a 4703 in.^{2} HEPA filter; and the GB733 has an 18-gallon capacity with a 180-cfm fan and a 4077-in.^{2} HEPA filter. A manometer is optional on Models GS82, GS83, and GB733. The GS-83 vacuum system provides for enclosed mechanical agitation (cleaning) of the main filter and for negative pressure during collection bag change. NIOSH noted that mechanics using a Nilfisk system typically removed the brake drum before positioning the enclosure, contrary to recommended procedures.[2]

Pullman/Holt--

Pullman/Holt sells four enclosure/HEPA-filtered vacuum models: E2-86, E2-105, E3-86, and E3-102. These four models are combinations of two enclosures and two vacuums. The E2 enclosure is for cars and light duty trucks with 6- to 14-inch drum diameters. The enclosure is clear with a latex rear panel and latex gloves. The E3 enclosure is similar except it is for use with heavy duty trucks and buses with 8- to 22-inch drum diameters. The A86 vacuum has a 5-gallon tank and a 2-stage bypass motor with a 96-cfm fan. The A102 vacuum is similar but uses a larger motor with a 110-cfm fan. A manometer is standard on all models.

2.2 HEPA-FILTERED VACUUM SYSTEM

The HEPA-filtered vacuum system consists of a vacuum and HEPA filter without enclosure. With this system, brake dust containing asbestos is simply vacuumed away from the brake area by the mechanic at the start of the brake repair job. The asbestos in the collected brake dust is captured by the HEPA filter. There are approximately 10 to 15 vendors of HEPA-filtered vacuum cleaners.[3,4] A wide variety of HEPA-filtered vacuums are sold to collect toxic substances such as asbestos, beryllium, cotton dust, lead, mercury, or silica. PEI could not identify any that were presently being marketed to collect asbestos from brake maintenance without the use of an enclosure. The vendors of enclosure/HEPA-filtered vacuum systems, who could sell their systems either way, do not recommend use of such systems without the enclosure.[3,5,6,7] However, a brake repair facility contacted by PEI during the previous study for EPA was using the vacuum system without the enclosure and claimed that this approach was not only less cumbersome for the mechanic, but also lessened contamination due to buildups inside the enclosure. Although many companies manufacture HEPA-filtered vacuums, four companies that actively sell to both the asbestos and the brake mechanic markets were chosen as representative of the market: Hako, NFE International, Nilfisk of America, and Pullman/Holt.

Hako--

Hako has two basic HEPA-filtered vacuum models. The X-1000-6 is a 6-gallon vacuum tank filter with a 95-cfm fan and a 2226-in.^{2} HEPA filter. The C80315-03 is a 15-gallon vacuum tank fitted with a 95-cfm fan and a 4120-in.^{2} HEPA filter.

NFE International--

The NFE SAFE-T-VAC backpack is a 2.1-gallon vacuum with a 100-cfm fan. The vacuum straps onto the operator's back using a special carrying frame. Because the unit is carried by the worker, the unit requires only a short hose, thus providing greater suction at the nozzle for the same size vacuum. The unit has an automatic shutoff when the bag is full.

Nilfisk of America--

While any of Nilfisk's vacuum units could be used, because air blowing of the dust is not necessary the smallest unit is most likely to be chosen for brake repair (Model GS80i). It has a 2¼-gallon capacity with an 87-cfm fan and a 1620-in.^{2} HEPA filter.

Pullman/Holt--

While either of two Pullman/Holt vacuum units could be used, because air blowing of the dust is not necessary the smallest unit is most likely to be chosen for brake repair (Model A86). This unit has a 5-gallon tank with a 2-stage bypass motor and a 96-cfm fan.

2.3 WET BRUSH/RECIRCULATING LIQUID SYSTEM

In a wet brush/recirculating liquid system, amended water (i.e., water containing a surfactant) or organic solvent is washed over the brake parts to remove both the asbestos-containing dust and accumulated grease and dirt. The liquid is applied gently to the brake area through the bristles of a brush or as a light mist with a spray gun. The liquid is collected beneath the hub assembly and recirculated until it becomes too dirty for reuse. For a system to have a positive effect on asbestos exposure over time, the liquid must be collected and disposed of properly. Also, when the liquid is sprayed on the brakes, it should be applied with as little force as possible to minimize the possibility of the asbestos dust becoming airborne prior to wetting. Three vendors of this type of system were identified: Ammco, Kleer-Flo, and U.S. Sales.

Ammco--

The Ammco brake assembly washer Model 1250 consists of two pans mounted vertically and connected to a standard mechanic's compressed air gun. The top pan is perforated to allow fluid to flow through to the bottom pan, which acts as a sump. Liquid is siphoned from the lower pan into the air line at standard air gun line pressure. This lowers the pressure to 6 to 8 psi, emitting a light spray. The liquid runs off the part into the upper, perforated pan which catches parts and large debris. The liquid drains into the lower pan for recycle. Ammco recommends the use of amended water (i.e, water containing a surfactant) in the system and sells packets of surfactant concentrate for this purpose. Gasoline or flammable solvents are not recommended, but nonflammable solvents such as chlorinated degreasing solvents may be utilized. If nonflammable solvents are used in the system, they may or may not be reclaimed. The amended water is typically disposed of down a sanitary sewer.

Kleer-Flo--

The Kleer-Flo LW22 brake washer consists of an upper tray, a bottom tank with lid, and a flow-through brush for cleaning. The unit has a 6-gallon capacity and the liquid is recirculated by pump. The manufacturer recommends the use of Kleer-Flo Greasoff No. 19 cleaning compound in the system. The cleaning compound is sold in one-gallon containers and is mixed with 5 parts water to one part surfactant concentrate for use.

U.S. Sales--

The U.S. Sales "Bird Bath" brake washer consists of a pump circulated system fed through a flow-through brush. The cleaning solution is collected below the brake assembly for recirculation. Before recirculation, however, it passes through a paper filter which captures asbestos entrained in the solution. The vendor did not recommend a specific cleaning solution but said the type of cleaning solution used is up to the discretion of the customer. At this time, U.S. Sales is developing a water-based cleaning solution to offer their customers. They do not recommend use of a solvent-cleaning solution.

SECTION 3

INDUSTRY BASELINE

PEI estimated several parameters which EPA can use to define a baseline from which various control scenarios can be judged. These parameters are (1) the number of brake repair shops by type, (2) the number of control devices presently in use, (3) the number of do-it-yourself (DIY) brake jobs, and (4) the impact of the new OSHA guidelines.

3.1 NUMBER AND TYPE OF BRAKE SHOPS

An annual estimate of the number of brake facilities by type is contained in a Motor Vehicle Manufacturers Association publication, Motor Vehicle Facts and Figures, which references 1984 Service Job Analysis, published by Hunter Publishing Company. Table 3-1 presents this data for service stations, independent repair shops, new car/truck dealerships, and self-service fleet shops. Mr. Bruce Blackwelder of the Automotive Parts and Accessories Association indicated that the Service Job Analysis is the best source of information for this type of data.[8]

Mr. Darrell Wallace of Ammco stated that the vast majority of all four types of shops do brake work.[9] Some independent repair shops that exclusively perform engine overhauls, transmission, air conditioning, or radiator service would not do brake jobs.[9] Nilfisk estimates that there are 285,000 auto repair shops in the U.S. and 1,000,000 mechanics who are exposed to brake dust each year.[5] U.S. Sales estimates that there are between 150,000 and 200,000 service stations, fleet shops, and auto dealerships that do brake work in the United States.

Table 3-1 also includes information on the number of axle sets of drum brake shoes and disc brake pads installed by type of shop in 1984. Because brake shoe or pad replacement is the most common repair performed on brakes,

TABLE 3-1. NUMBER OF BRAKE REPAIR FACILITIES

Type of shop	Automotive repair outlets, 1984[10]		Brake drum shoes installed in 1984 (axle sets)[7]		Disc brake pads installed in 1984 (axle sets)[11]	
	Number	Percent	Number (1000's)	Percent	Numbers (1000's)	Percent
Service station	115,000	35.0	10,797	36.0	13,021	36.5
Independent repair shop	150,000	45.6	13,766	45.9	16,460	46.1
New car/truck dealership	25,000	7.6	3,809	12.7	5,314	14.9
Self service fleet shops	39,000	11.9	1,620	5.4	889	2.5
Total	329,000	100.0	29,992	100.0	35,684	100.0

The numbers represent a baseline estimate of the number of times mechanics are exposed to asbestos during routine brake maintenance. The fact that not all brake pads contain asbestos reduces actual exposures but exposures can also result when brakes are checked and not changed. Other operations that may be performed include drum turning, rotor resurfacing, or cylinder replacement. Because cost of parts is relatively small in the total cost of a brake job, brake shoes or disc brake pads are usually replaced when other brake work is done.

3.2 NUMBER OF CONTROL DEVICES IN USE

To estimate the number of control devices presently in use, PEI contacted vendors of the equipment. Table 3-2 presents the results of this survey. None of the vendors was able to give a breakdown of the number of units by type of shop. The vendors indicated that most shops had only one system, but it was not common to see two or three at larger facilities.

TABLE 3-2. NUMBER OF CONTROL SYSTEMS IN USE[3,5,6,7,9,12,13,14]

Vendor	Enclosure HEPA-filterd vacuum	HEPA-filtered vacuum	Wet brush/ recirculating liquid
Control Resource Systems	50	Nil	0
Nilfisk	6,000-7,000	Nil	0
Clayton Associates	450	Nil	0
Hako	<1,000[a]	Nil	0
Pullman Holt	200	2,000[b]	0
Kleer-Flo	0	0	c
U.S. Sales	0	0	3,000-4,000
Ammco	0	0	<10,000[d]
Total	<8,700	>2,000	<20,000[d]

a PEI estimate based on conversations with other vendors.
b Sold to automotive service shops.
c Would not divulge information.
d PEI estimate.

3.3 NUMBER OF DO-IT-YOURSELF BRAKE JOBS

After Market Business (formerly Home and Auto Magazine) estimates that there are 65 million DIY's in the United States.[16] The same source estimates that there are 20 million brake jobs (drum and disc axle sets) performed by DIY's annually.[16]

A Simmons Market Research Bureau survey in 1981 found that 42 percent of consumer brake jobs (i.e., excludes fleet and commercial vehicles) were performed by DIY's.[15] The same source estimates that there are approximately 43 million brake jobs (drum and disc axle sets) performed on consumer vehicles.[15] This yields an estimated 18 million brake jobs performed by DIY's annually.[15]

Both estimates are consistent. Because PEI obtained survey questions and breakdowns of replys for the Simmons Market Research Bureau survey, PEI believes the 18 million estimate to be the more accurate. Of total DIY's in 1985, 71 percent have done drum brake jobs and 69 percent have done disc brake overhauls.[16]

3.4 IMPACT OF OSHA GUIDLINES

It is assumed that each shop performing brake maintenance complies with OSHA "Work Practices and Engineering Controls for Automotive Brake Repair Operations - Nonmandatory" guidelines (29 CFR Section 1910.1001 - Asbestos, Tremolite, Anthophyllite, and Acitinolite, Appendix F) by using solvent spray from an aerosol can. Aerosol brake cleaners typically contain from 15 to 20 percent 1,1,1-trichloroethane and from 50-75 percent perchloroethylene.[17] In discussions with OSHA personnel involved with the cost impact analysis performed before their regulations and guidelines were promulgated, PEI learned that their basis for minimum control was a spray can filled with a solvent cleaner. They assumed one spray can would be used for each brake job (axle set). The cost impact to the industry was calculated by multiplying the number of brake jobs in a year times the cost of a solvent spray can.[18] During NIOSH's study of asbestos controls for brake maintenance, they noted the use of a product containing, 1,1,1-trichloroethane. An aerosol can of solvent spray costs about $1.75.[19] Because the OSHA regulations and guidelines are in place, a proper starting point (or baseline) from which to measure the impact of new regulations in this area is to assume that all shops which do not have one of the three control systems under consideration are currently using the solvent spray can method for control.

SECTION 4

ESTIMATED COST OF CONTROL SYSTEMS

This section presents the estimated costs of the purchase and use of each of the three asbestos control systems for brake maintenance. These costs were primarily developed from information provided by vendors. Where data gaps still existed, they were estimated using information from EPA reports, OSHA regulations, and PEI engineering judgment. Capital and operation and maintenance (O&M) costs were used to estimate the total annual cost of using each system. Tables 4-1 through 4-3 summarize the results.

Cost estimates are based on using one control unit in a shop performing 91 drum brake jobs (axle sets) and 109 disc brake jobs (axle sets) each year. This basis was arrived at by dividing the total number of each job performed by the total number of repair facilities in the U.S. given in Table 3-1.

4.1 CAPITAL COSTS

Total capital cost consists of direct purchase cost and indirect purchase costs such as taxes, freight, and management and supervision. This cost is then annualized by estimating the life of the equipment and the annual cost of capital.

4.4.1 Direct Costs

Direct costs for the control systems were obtained from vendors and their product literature. The costs are for standard equipment (no options) as offered by the manufacturer. All costs are in 1987 dollars.

For the enclosure/HEPA-filtered vacuum systems, direct costs for all models offered by Clayton, Control Resource Systems, Inc., and Pullman-Holt were included. Nilfisk and Hako offer a variety of interchangeable enclosures and vacuums. For those vendors, two systems which encompassed their

TABLE 4-1: ANNUAL COST OF ENCLOSURE/HEPA-FILTERED VACUUM CONTROL SYSTEMS (a)

Vendor	Model	Direct Cost	Taxes and Freight (b)	Management and Supervision (c)	Total Capital Cost	Expected Life, Years (d)	Annualized Capital Cost (e)	O&M Cost: Filter Replacement (f)	O&M Cost: Waste Disposal (g)	O&M Cost: Lost Productivity (h)	Total Annual Costs
CLAYTON ASSOC., INC.	BCE-1000 (one size fits all)	$3,495	$140	$175	$3,810	10	$620	$158	$63	$311	$1,152
	BCE-1500 (one size fits all)	$3,575	$143	$179	$3,897	10	$634	$158	$63	$311	$1,166
	BCE-2000 (one size fits all)	$3,630	$145	$182	$3,957	10	$644	$158	$63	$311	$1,176
	BCE-2500 (cars and light trucks)	$2,500	$100	$125	$2,725	10	$443	$158	$63	$311	$975
CONTROL RESOURCES SYSTEMS, INC.	BRAKEMASTER 600B (cars and light trucks)	$1,995	$80	$100	$2,175	10	$354	$156	$63	$311	$884
HAKO, INC.	C80106-07 (cars and light trucks)	$1,195	$48	$60	$1,303	10	$212	$120	$63	$311	$706
	C80106-09 (larger trucks and buses)	$1,321	$53	$66	$1,440	10	$234	$60	$63	$311	$668
NILFISK OF AMERICA, INC.	GS80i w/400 OR 500 ENCLOSURE (cars and light trucks)	$1,500	$60	$75	$1,635	10	$266	$194	$63	$311	$834
	GS82 w/600 ENCLOSURE (larger trucks and buses)	$2,500	$100	$125	$2,725	10	$443	$156	$63	$311	$973
PULLMAN-HOLT	E2-86 (cars and light trucks)	$1,040	$42	$52	$1,134	10	$184	$213	$63	$311	$771
	E2-102 (cars and light trucks)	$1,466	$59	$73	$1,598	10	$260	$194	$63	$311	$828
	E3-86 (larger trucks and buses)	$1,270	$51	$64	$1,384	10	$225	$213	$63	$311	$812
	E3-102 (larger trucks and buses)	$1,690	$68	$85	$1,842	10	$300	$194	$63	$311	$868

(a) Costs are for one system per shop performing 91 drum and 109 disc brake jobs (one axle) per year.
(b) Taxes = 3% and freight = 1% of direct cost.
(c) Management and supervision = 5% of direct cost.
(d) PEI estimate based on conversations with vendors.
(e) Assumes 10% interest over the expected life of the unit.
(f) Based on vacuum filter costs and changing frequency (provided by the vendors) for 91 drum and 109 disc brake jobs per year.
(g) Costs are based on proper disposal as recommended in "Asbestos Waste Management Guidance", EPA/530-SW-85-007, May 1985.
(h) Based on data from NIOSH on the extra time needed to clean the brake area of one wheel with this control system relative to the time necessary with a solvent spray can and assuming a burdened labor rate of $25.00 per hour at a shop performing 91 drum and 109 disc brake jobs per year.

TABLE 4-2: ANNUAL COST OF HEPA-FILTERED VACUUM CONTROL SYSTEMS (a)

Vendor	Model (b)	Direct Cost	Taxes and Freight (c)	Management and Supervision (d)	Total Capital Cost	Expected Life, Years (e)	Annualized Capital Cost (f)	O&M Cost: Filter Replacement (g)	O&M Cost: Waste Disposal (h)	O&M Cost: Lost Productivity (i)	Total Annual Costs
HAKO, INC.	X-1000-6	$999	$40	$50	$1,089	10	$177	$120	$63	$83	$443
	C80315-03	$1,245	$50	$62	$1,357	10	$221	$60	$63	$83	$427
NFE	SAFE-T-VAC "BACKPACK"	$595	$24	$30	$649	10	$106	$200	$63	$83	$452
NILFISK OF AMERICA, INC.	GS80i	$850	$34	$43	$927	10	$151	$194	$63	$83	$491
PULLMAN-HOLT	A-86	$764	$31	$38	$833	10	$136	$213	$63	$83	$495

(a) Costs are for one system per shop performing 91 drum and 109 disc brake jobs (one axle) per year.
(b) 80 to 110 cfm, approximately 1 hp HEPA-filtered vacuum system including attachment tools.
(c) Taxes = 3% and freight = 1% of direct cost.
(d) Management and supervision = 5% of direct cost.
(e) PEI estimate based on conversations with vendors.
(f) Assumes 10% interest over the expected life of the unit.
(g) Based on vacuum filter costs and changing frequency (provided by the vendors) for 91 drum and 109 disc brake jobs per year.
(h) Costs are based on proper disposal as recommended in "Asbestos Waste Management Guidance", EPA/530-SW-85-007, May 1985.
(i) Based on data from NIOSH on the extra time needed to clean the brake area of one wheel with this control system relative to the time necessary with a solvent spray can and assuming a burdened labor rate of $25.00 per hour at a shop performing 91 drum and 109 disc brake jobs per year.

TABLE 4-3: ANNUAL COST OF WET BRUSH/RECIRCULATING LIQUID CONTROL SYSTEMS (a)

Vendor	Model	Direct Cost	Taxes and Freight (b)	Management and Supervision (c)	Total Capital Cost	Expected Life, Years (d)	Annualized Capital Cost (e)	O&M Cost: Filter Replacement (f)	O&M Cost: Detergent (g)	O&M Cost: Waste Disposal (h)	O&M Cost: Lost Productivity (i)	Total Annual Costs
AMMCO	1250	$275	$11	$14	$300	10	$49	$0	$118	$0	$0	$167
KLEER-FLO	LW22	$879	$35	$44	$958	10	$156	$0	$118	$0	$0	$274
U.S SALES	"BIRD-BATH"	$425	$17	$21	$463	10	$75	$12	$118	$0	$0	$205

(a) Costs are for one system per shop performing 91 drum and 109 disc brake jobs (one axle) per year.
(b) Taxes = 3% and freight = 1% of direct cost.
(c) Management and supervision = 5% of direct cost.
(d) PEI estimate based on conversations with vendors.
(e) Assumes 10% interest over the expected life of the unit.
(f) Only the "Bird-Bath" system uses a filter. This value is based on the cost of a replacement filter, the frequency it would be changed, and 91 drum and 109 disc brake jobs (one axle) per year.
(g) Based on the cost of the vendor's detergent, the approximate number of brake jobs that could be performed with a unit of detergent, and 91 drum and 109 disc brake jobs (one axle) per year.
(h) Costs are based on proper disposal as recommended in "Asbestos Waste Management Guidance", EPA/530-SW-85-007, May 1985.
(i) Based on data from NIOSH on the extra time needed to clean the brake area of one wheel with this control system relative to the time necessary with a solvent spray can. For these types of controls, no extra time is involved.

respective costs ranges were used. For the HEPA-filtered vacuum systems, smaller sized vacuum equipment (approximately 100 cfm) were included. Accessory attachment tools were added to the basic vacuum cost. For the wet brush/recirculating liquid systems, each vendor offers only one model.

4.1.2 Indirect Costs

Indirect costs were calculated using factors from "Capital and Operating Cost of Selected Air Pollution Control Systems."[20] Freight and local sales taxes were estimated to be 1 percent and 3 percent, respectively, of the direct capital cost. Management and supervision (encompassing items such as system selection, purchasing, and training) were estimated as 5 percent of the direct capital cost. Total capital cost is the sum of the direct and indirect capital costs.

4.1.3 Expected Life and Total Annualized Cost

Vendor estimates for life expectancy ranged from 7 to 20 years for the enclosed/HEPA-filtered vacuum systems, 10 to 20 years for the HEPA-filtered vacuum systems, and 10 to 50 years for the wet brush/recirculating liquid systems. While some vendors tended to give long life expectancies, PEI feels a shorter life is more realistic for mechanical equipment. Because vendor estimates can tend to over estimate real useful life of a product, PEI adopted the conservative vendor estimates and assumed a 10 year useful life expectancy for the equipment. The annualized capital cost reflects the costs with capital recovery over the depreciable life of the equipment. A 10 percent rate was chosen to calculate the annualized capital cost as this is the discount rate presently recommended for use by the Office Management and Budget (OMB) in circular No. A-94 Revised. Using the 10-year life expectancy and assuming a 10 percent interest rate, annualized capital cost equals the total capital costs multipled by 0.16275.

4.2 OPERATION AND MAINTENANCE COSTS

O&M costs are those associated with the day-to-day use of the control systems. These items include (1) lost productivity, (2) filter replacement for the HEPA systems, (3) detergent or solvent for wet brush/recirculating liquid systems, and (4) asbestos waste disposal. To develop costs for these items, it was assumed that the control devices would be used per the vendors' instructions and in accordance with all EPA and OSHA regulations and guidelines.

4.2.1 Lost Productivity

Lost productivity costs are those associated with the extra time it takes to set-up and perform brake maintenance operations using the control systems. For the purposes of this study, the baseline from which to measure this extra time is the time it takes to perform brake cleaning using the "solvent spray can" asbestos control method, the least costly of the methods recommended by OSHA.

In the recent NIOSH field study of asbestos control systems for brake maintenance, operations performed by mechanics were timed. Data were generated for the three control systems plus the solvent spray can method. Lost productivity relative to the solvent spray can method was estimated by calculating the difference in these times. Table 4-4 presents this data from the NIOSH study along with the estimated lost productivity per wheel and per axle set.

NIOSH personnel who conducted the asbestos control study indicated to PEI that the usage time for the Nilfisk enclosure/HEPA-filtered vacuum system did not include the time involved in removing the brake drum from the wheel, as per recommended procedures. As such, when calculating lost productivity cost for all of the enclosure/HEPA-filtered vacuum systems, the lost time for the Clayton unit was used (7 minutes).

Lost productivity costs were calculated by multiplying the lost time per axle by the number of brake jobs (axle sets including drum and disc) performed in a year and a burdened labor cost of $25.00 per hour. This is a rounded estimate based on the latest Bureau of Labor Statistics wage rate for a Motor Vehicle Mechanic of $12.55 and administration and overhead costs of approximately 100 percent. When using the enclosure/HEPA-filtered vacuum systems, it is not necessary to use the enclosure for disc brake work. It is recommended that a crevice tool be attached to the vacuum hose of these systems and used as with the HEPA-filtered vacuum system. As such, the lost productivity time for the enclosure/ HEPA-filtered vacuum system was set equal to 1 minute per axle for disc brakes.

TABLE 4-4. NIOSH DATA ON BRAKE CLEANING TIMES

Control		Time to clean brake[18] (1 wheel)	Lost productivity per wheel	Lost productivity per axle
Enclosure/HEPA Vacuum System:	(Nilfisk)	1-5 min (typical[a] = 3 min)	1.5	3
	(Clayton)	3-9 min (avg. = 5 min)	3.5	7
HEPA Vacuum System:	(Nilfisk)	1.5-3 min (typical = 2 min)	0.5	1
Wet Brush/Recirculating Liquid System:	(Kleer-Flow)	1-2 min (typical = 1.5 min)	0	0
Solvent Spray Can Method		1-2 minutes (typical = 1.5 min)	-	-

[a] The typical time was provided by NIOSH as a good estimate of the time required to clean the wheel using the various systems. Where only a range of times was available from NIOSH an arithmetic average of the range was used.

4.2.2 Filter Replacement

For systems utilizing a HEPA filter, filters must be changed periodically as brake dust accumulates in the units. Typically, these vacuums contain a disposable vacuum collection bag, 1 to 3 prefilters, and a HEPA filter. Unit costs for replacement bags and filters were applied to their changing frequencies to estimate yearly replacement costs. For the HEPA filters and any prefilters, the changing frequency for a given vacuum model was provided by the vendor. Vendors provided an extremely wide range of estimates on the changing frequency of disposable collection bags, ranging on an equalized scale from 17 to 200 brake jobs per ft^3 of vacuum capacity. Based on 91 drum and 109 disc brake jobs per year and vendor estimates of changing frequency, PEI used a changing frequency of four times per year for vacuum units with under 1-ft^3 foot capacity and twice per year for systems with greater than 1-ft^3 capacity.

When changing any of the filters on an asbestos vacuum, the mechanic should wear a dual-cartridge, HEPA-filtered respirator and protective clothing at a minimum. The waste from the vacuum must be placed in a 6-mil polyethylene bag printed with the standard asbestos OSHA warning label. The bag should then be placed in a labeled, locked, 55-gallon drum. Costs for replacement filters, replacement respirator cartridges, Tyvek suit, gloves, and the labor time necessary for the filter replacement were included in the filter replacement costs.

4.2.3 Detergent

The wet brush/recirculating liquid control systems utilize a cleaning solution to expedite the brake cleaning process. Two of the vendors offer a detergent which the operator adds to water to form a cleaning solution. The third vendor (U.S. Sales) is developing a detergent for use with their system and now recommends that customers choose their own detergent. The average annual cost for detergent was calculated using the unit cost and vendor estimates of the number of brakes which could be cleaned with a batch of the detergent solution. The detergent cost for each vendor system was set equal to the average cost all vendors.

4.2.4 Asbestos Waste Disposal

Disposal of asbestos waste generated by the three control devices would generally not be regulated. National Emission Standards for Hazardous Air Pollutants (NESHAPS) applicable to asbestos (40 CFR Part 61, Subpart M) specifically exclude "Operations That Primarily Install Asbestos Friction Materials on Motor Vehicles" from emission and solid waste disposal standards which have been set for manufacturing, building abatement projects, demolition, and some other asbestos applications. Asbestos wastes are not listed as hazardous under the Resource Conservation and Recovery Act (RCRA), and thus are not subject to the expensive manifesting, transportation and disposal cost associated with these wastes. Some states do regulate asbestos wastes as hazardous wastes; however, it is doubtful that any garage would generate a sufficient quantity of waste in a month to qualify as a generator. Under RCRA, facilities which generate less than 100 kg of hazardous waste per month are termed "conditionally exempt small quantity generators" and can manage their waste as ordinary solid waste (i.e., disposal in a sanitary landfill is permitted). It is also doubtful that any garage would be subject to CERCLA requirements by releasing more than 1 pound of asbestos in a 24-hour period.

Although regulations may not apply to the disposal of asbestos waste from routine brake maintenance operations, the cost of disposing this waste in a responsible manner is included. Cost factors for disposal of asbestos waste from building abatement projects were used to estimate these costs.

For asbestos waste from vacuums, the amount of brake dust generated was estimated using the disposable collection bag changing frequency and capacity. Using these figures, the "average" shop would produce one 55-gallon drum of brake dust every 4 years. Including disposal of the prefilters and the HEPA filter would increase this figure to one 55-gallon drum generated every 2 years. Cost for disposal of this volume of waste included transportation (mileage and labor) and disposal at a landfill approved for asbestos waste disposal (which can be a sanitary landfill). Approval is contingent on special operating procedures with asbestos waste.

No cost is included for the disposal of the spent cleaning solutions from the wet brush/recirculating liquid system. Although at large asbestos abatement projects, it is considered good practice to filter the asbestos from wastewater before discharging, it would not be practical to use any of these units to filter the small quantities of water generated from brake maintenance. The U.S. Sales "Bird-Bath" has a paper filter to screen asbestos from the recirculating cleaning solution. No data was found on the effectiveness of the filter in capturing the asbestos fibers.

4.3 SENSITIVITY ANALYSIS

Annual costs were calculated based on a facility with one control performing 91 drum brake jobs and 109 disc brake jobs per year. Table 4-5 presents a sensitivity analysis showing how annual costs change as the number of brake jobs and number of control systems change. O&M costs account for the majority of the total annual cost of all three types of control systems. The proportional cost differences between the three types remain relatively constant with increases in either number of brake jobs or the number of control systems in use. Total annual costs can be as high as $8.16 per job for a shop with one HEPA-filtered vacuum system performing 50 brake jobs per year to as low as $0.69 per job for a shop with three wet brush/recirculating liquid systems performing 5,000 brake jobs per year.

TABLE 4-5: COST SENSITIVITY ANALYSIS

ENCLOSURE/HEPA-FILTERED VACUUM SENSITIVITY ANALYSIS RESULTS
(Total Annual Cost, dollars per year for the Nilfisk GS80i w/400 or 500 enclosure)

	Brake jobs per year (axle sets)					
	50	250	500	1250	2500	5000
# of units						
1	*$408*	*$976*	*$1,685*	*$3,814*		
2				*$4,080*	*$7,628*	
3					*$7,891*	*$15,001*

HEPA- FILTERED VACUUM SENSITIVITY ANALYSIS RESULTS
(Toatal Annualized Cost, dollars per year)

	Brake jobs per year (axle sets)					
	50	250	500	1250	2500	5000
# of units						
1	*$236*	*$576*	*$1,001*	*$2,277*		
2				*$2,428*	*$4,554*	
3					*$4,703*	*$8,963*

WET BRUSH/ RECIRCULATING LIQUID SENSITIVITY ANALYSIS RESULTS
(Total Annual Cost, dollars per year for the U.S. Sales "Bird-Bath")

	Brake jobs per year (axle sets)					
	50	250	500	1250	2500	5000
# of units						
1	*$108*	*$238*	*$400*	*$887*		
2				*$962*	*$1,773*	
3					*$1,848*	*$3,474*

SECTION 5

CONCLUSIONS

The following information was gathered through contact with vendors, NIOSH, OSHA, and trade associations:

- There are an estimated 329,000 brake repair facilities in the U.S. Only 2.6 percent of these currently use the enclosure/HEPA-filtered vacuum system, and less than 1 percent of the shops use a HEPA-filtered vacuum system. Approximately 6 percent of the shops use a brush/recirculating liquid system.

- Based on discussions with vendors and NIOSH, PEI estimates that while enclosures are always used during dust removal, often they are not put on the hub until after the brake drum has been removed. Brake shoes are normally repaired after the enclosure has been removed.

- An estimated 18 million brakes (disc and drum axle sets) are replaced by do-it-yourselfers annually.

- Based on the cost of use and discussions with OSHA, all the repair facilities that do not currently have a HEPA or wet collector method are assumed to use the aerosol spray method to comply with the new OSHA guidelines. This roughly represents approximately 90 percent of the brake repair facilities (about 300,000 shops).

- The direct cost of enclosure/HEPA-filtered vacuum systems ranges from $1,040 to $3,630, with $1,500 per unit as a reasonable estimate of the cost of a typical unit sold. The O&M costs for these units, which include filter replacement, waste disposal, and loss of productivity costs, are approximately $500 per year. A reasonable estimate of total annual cost for a "typical" shop performing 91 drum and 109 disc brake jobs per year is $800.

- The capital cost of HEPA-filtered vacuum systems range from $595 to $1,245, with a reasonable estimate of the cost of a typical unit of $850. Vendors estimated that the number of facilities using just the HEPA vacuum without enclosure is small. The O&M costs of these units, which include filter replacement, waste disposal, and loss of productivity costs, are approximately $300 per year. A reasonable estimate of total annual cost for a "typical" shop performing 91 drum and 109 disc brake jobs per year is $450.

- The capital cost of wet brush/recirculating liquid system ranges from $275 to $879 with $425 per unit as a reasonable estimate of the cost of a typical unit sold. The O&M costs of these units, which include filter replacment, detergent, and waste disposal, are approximately $120 per year. A reasonable estimate of total annual cost for a "typical" shop performing 91 drum and 109 disc brake jobs per year is $200.

- O&M costs account for the majority of the total annual cost of all three types of control systems. The proportional cost differences between the three types remain relatively constant with increases in either the number of brake jobs or number of control systems in use. Total annual costs can be as high as $8.16 per job for a shop with one HEPA-filtered vacuum system performing 50 brake jobs per year to as low as $0.69 per job for a shop with three wet brush/ recirculating liquid systems performing 5,000 brake jobs per year.

- The average life of all systems is 10 years.

- NIOSH estimates of loss of productivity from use of these systems to be seven minutes per axle for the enclosure/HEPA system, one minute per axle for the HEPA system, and no loss in productivity for the wet brush/recirculating system. For the average shop performing 91 drum brake jobs and 109 disc brake jobs per year, this translates to an annual cost of $311 for the enclosure/HEPA system and $83 for the HEPA filter system.

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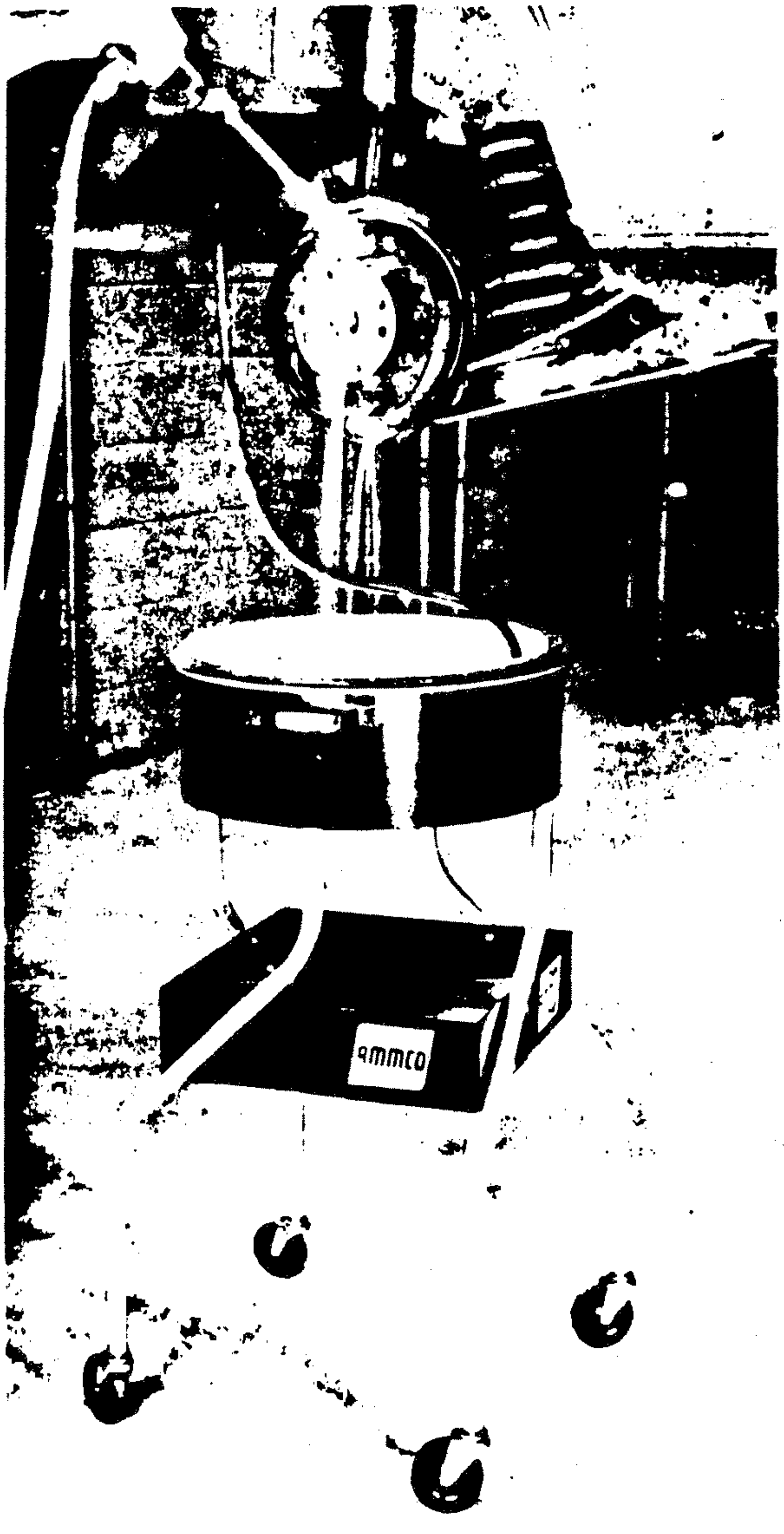
APPENDIX A

VENDOR LITERATURE

AMMCO

AMMCO Model 1250 Brake Assembly Washer



Meets Newest Federal OSHA Asbestos Standard 1910.1001

Washing brake assemblies before starting a brake job lets you work cleaner, easier, and safer. Model 1250 Washer and AMMCO 1256 Concentrate not only remove dirt, grease, and oil, but the liquid traps *dangerous* asbestos fibers before they become airborne, thus maintaining air cleanliness within OSHA Standards. Just roll the washer to the job, connect an air line and you're ready to wash and disassemble at the same time. Parts drop into pan. Specially designed Gun and Nozzle directs properly atomized stream of cleaning solution where you want it. Cleaning solution drains into the Sump through perforations in top pan for reuse. Parts Pan and Sump can be lifted from Portable Stand (left) and used wherever required (see reverse side). Unit does double duty as a mobile parts washer.

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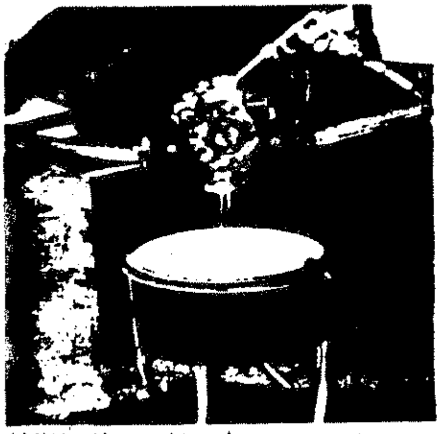
Combines Ease and Versatility

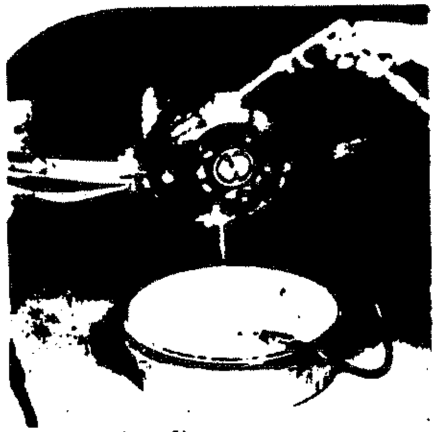
Simply add concentrate.

Pour 1 gallon (3.78 L) of water into the pan and dissolve a 1 oz. (28.3 g) packet of No. 1256 Brake Washer Concentrate.

Then, select the most convenient combination.


With the stand;


On the rack;


Or, on the floor.

SPECIFICATIONS

Height: 35" (889 mm)	**Capacity: 1 gal. (3.78 L)**
Wheelbase: 17.25" (438.15 mm)	**Pressure: 90-150 p.s.i. (620.5-1034 kPa)**
Hose Length: 36" (914.4 mm)	**Weight: 32 lbs. (14.5 Kg)**

Look to AMMCO for a complete line of Brake Lathes, Wheel Balancers, Tire Changers, Wheel Alignment Equipment, Engine Repair Tools, Hydraulic Presses, and every accessory you'll need to get the job done right and at the same time—reach your greatest profit potential.

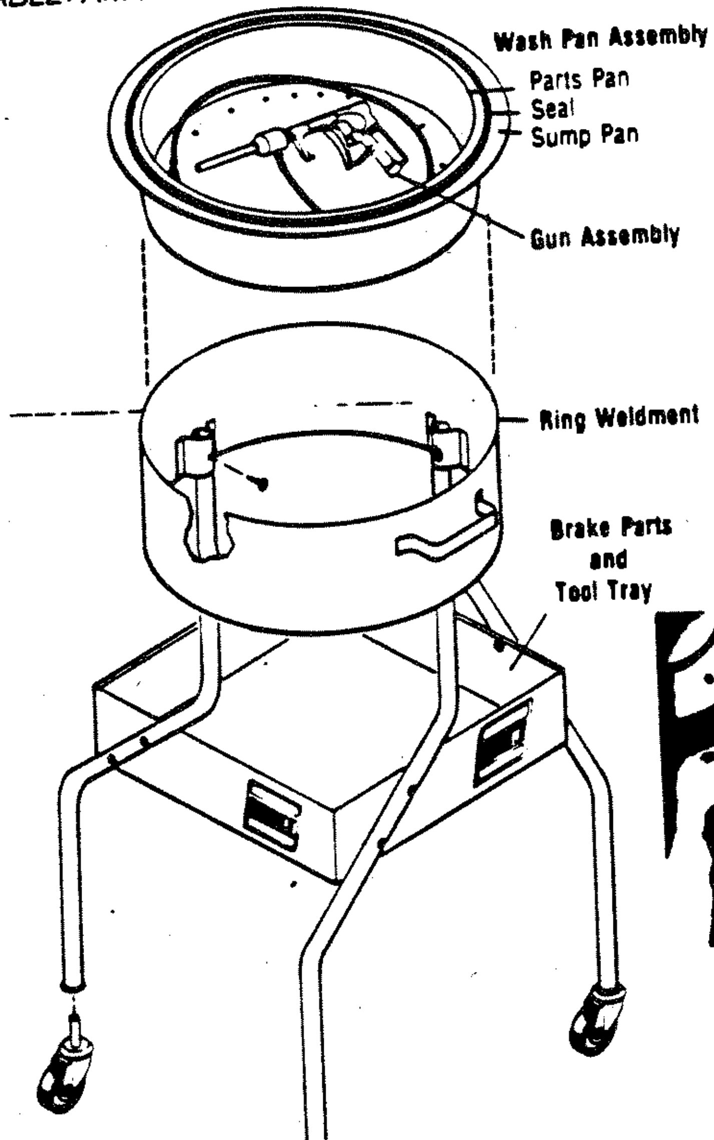
AMMCO
AMMCO TOOLS, INC.
WACKER PARK
NORTH CHICAGO, IL 60064 U.S.A.
(312) 689-1111 CABLE AMMCO EXP TELEX 378181

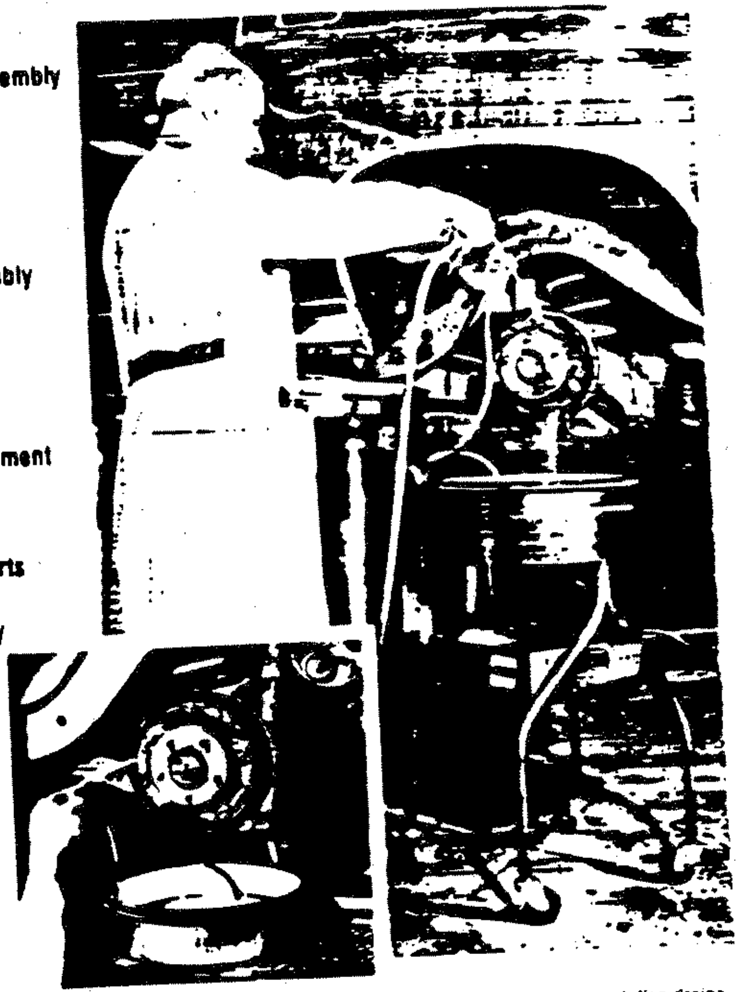
DISTRIBUTED BY:

A-747-1-87

BRAKE ASSEMBLY WASHER MODEL 1250

AMMCO TOOLS, INC. / WACKER PARK / NORTH CHICAGO, ILLINOIS 60064 U.S.A. / (312) 689-1111
CABLE: AMMCO EXP / TELEX: 254795





Washing brake assemblies is a quick, easy job. The washing solution drains into the Sump for recirculation.

Parts Pan and Sump Pan (Wash Pan Assembly) can be removed from the Washer Stand for close-quarters work. (Small photo)

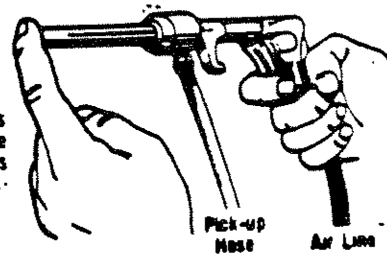
OPERATION

Wash the brake assembly as illustrated. Drop the parts into the Pan as the brakes are disassembled to prevent their loss.

When the Washer is not in use the fluid will drain into the Sump. To avoid blowing brake dust around the shop area start the pumping action first by aiming the Gun into the Pan and depressing the Trigger.

HOW TO UNCLOG GUN:

As Washing Solution becomes dirty, the Gun may clog. Place finger over Barrel and depress Trigger to back-flush the Pick-up Hose



Printed in U.S.A.

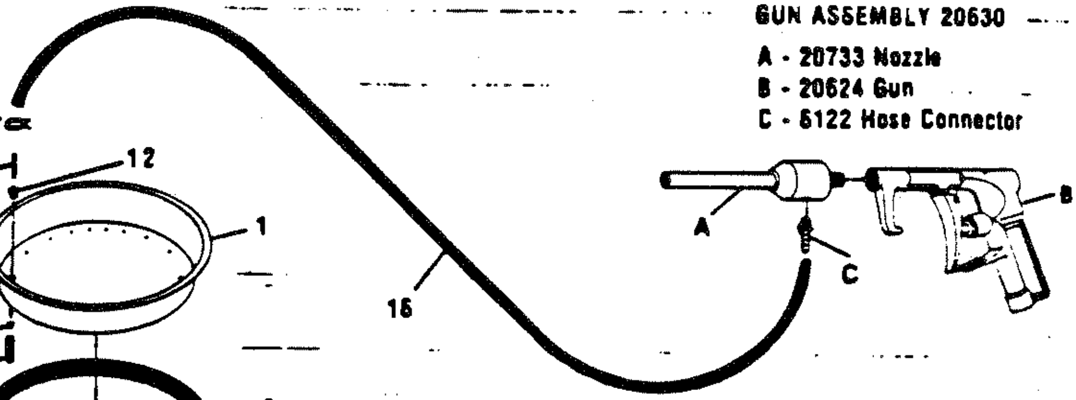
ASSEMBLY

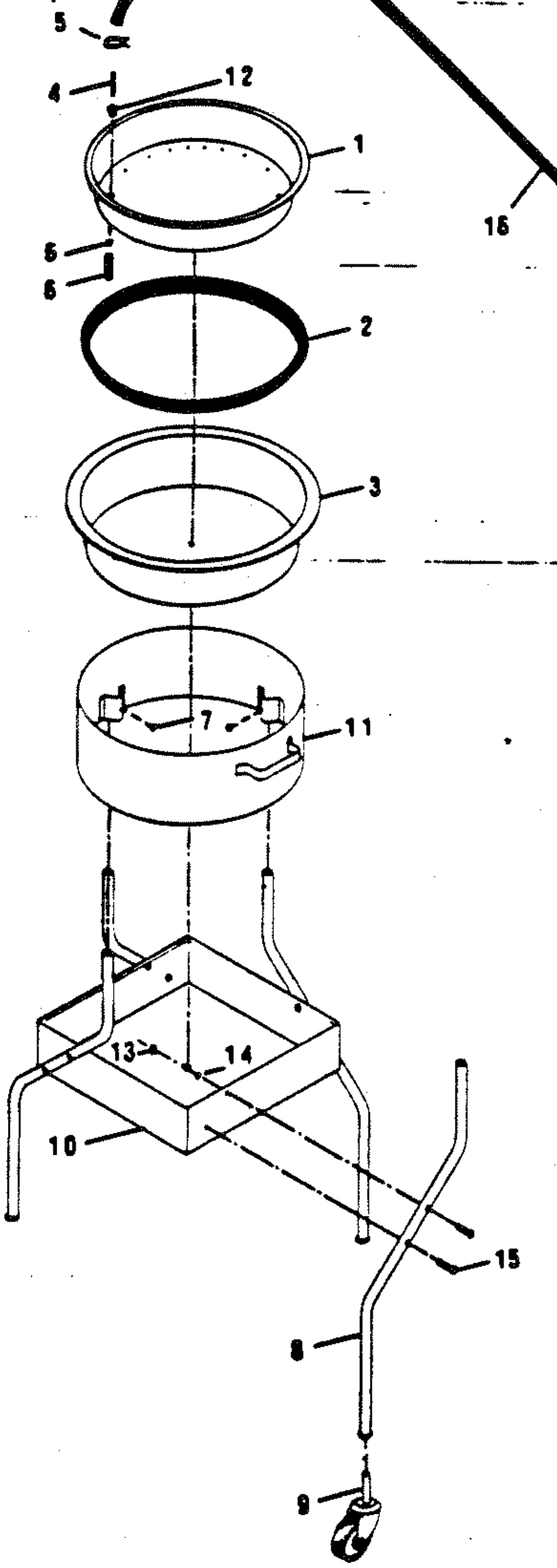
1. Install the Casters in the Grip Sleeves if the four Legs.
2. Bolt the Legs to the square Tool Tray keepingthe screw holes that are at the top of the Leg facing inward.
3. Stand this Leg and Tray assembly upright and slip the Ring Weldment over the Legs. Press and tap the Ring onto the Legs until the screw holes are aligned. Fasten Ring and Legs together with the four sheet metal screws.
4. Place the Wash Pan Assembly in the Ring and fill the Pan with one gallon of AMMCO No. 1256 safe Washing Solution.
5. Connect an air line to the base of the Gun Handle. **Maximum air pressure 150 PSI.**

20643-6-77

GUN ASSEMBLY 20630

A - 20733 Nozzle
B - 20624 Gun
C - 6122 Hose Connector





Item	Part No	Qty	Description
1	20634	1	Parts Pan
2	20631	1	Seal
3	20635	1	Sump Pan
4	20619	1	Tube
5	20644	2	Hose Clamp
6	20623	1	Hose, 2"
7	11088	4	Sheet Metal Screws
8	20629	4	Leg
9	20620	4	Caster
10	20636	1	Tool Tray
11	20633	1	Ring Weldment
12	20618	1	Snap Bushing
13	11213	8	Nut
14	5999	8	Lock Washer
15	20749	8	Round Hd. Screw
16	20622	1	Hose, 36"

AMMCO NO. 1256 safe washing solution is recommended for use in the Model 1250 Brake Assembly Washer. A carton of 20 - 1 oz. packets of Concentrate makes 20 gallons of washing solution.

DIRECTIONS: Pour one gallon of water into top Parts Pan of Brake Washer (it will drain into Sump). Add contents of one packet of No. 1256 Concentrate to top Parts Pan. Dissolve Concentrate by operating Gun and saturating the Concentrate with water from the Sump.

Because of AMMCO's constant program of improvement, specifications are subject to change without notice

CLAYTON ASSOCIATES, INC.

CLAYTON 201-938-6700
FARMINGDALE, NJ 07727-0589

PART II

A Presentation of CLAYTON'S Brake Cleaning Equipment

While other companies may offer vacuum enclosure equipment, none compare to **CLAYTON'S** for ***safety or ease of use.*** Brake Cleaning Equipment is our reason for being, not just an afterthought to sell a few more vacuum cleaners.

Our machines were born of a dedicated commitment to provide technicians and mechanics with a truly usable device to protect occupational health. Today that commitment continues as we introduce our new Pro-Line™ series Brake Cleaning Equipment and the nation's first Clutch Cleaning Enclosures and Tools.

Asbestos-caused diseases are a serious problem for mechanics and their families. Please take the time to understand the nature of this problem and carefully compare equipment before purchasing. Why spend over $1,000 on an ill-conceived device to be cast aside, when effective, easy-to-use Brake Cleaning Equipment is available at an affordable price.

James E. Clayton, President

CLAYTON BRAKE CLEANING EQUIPMENT

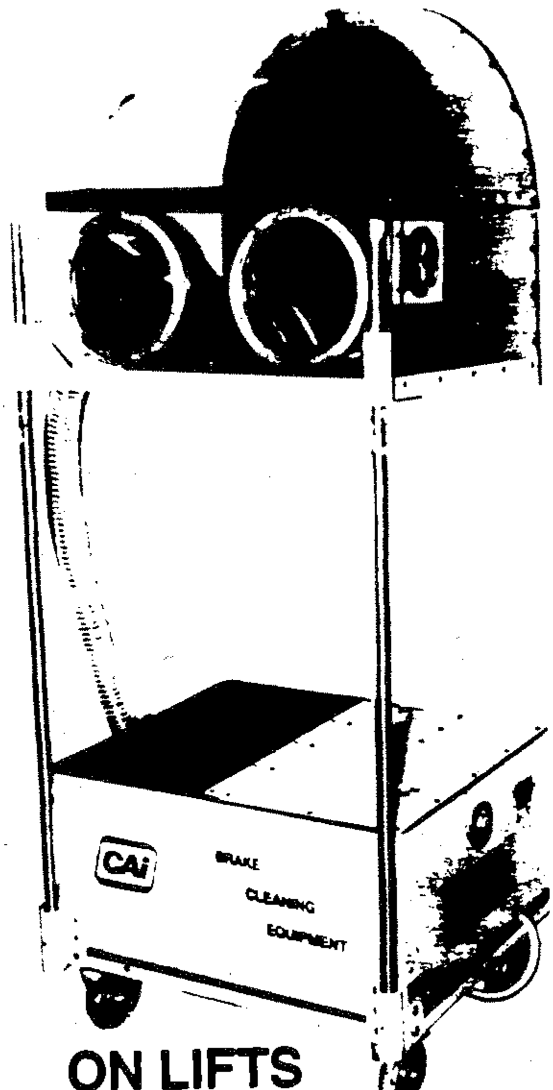
PURPOSE

Permits the mechanic to safely contain and collect deadly asbestos-ridden dust from vehicle brakes and clutches.

DESIGN

Self-contained compact machines consisting of:

1. An enclosure surrounding the brake assembly so the mechanic can safely blow dust from the brake shoes and backing plate.
2. A high performance, vacuum powered, filtration system designed to permit safe collection and disposal of hazardous asbestos dust removed from the enclosure.



6 → **AUTOMATIC LATCHING MECHANISM** prevents opening filter compartment unless motors are running.

SHATTERPROOF LEXAN enclosure is transparent providing light and excellent visibility for the operator.

1 → **NEOPRENE GLOVES** protect the mechanic from any hand or arm contact with dust.

2 → **REMOVE CAR & TRUCK DRUMS** (up to 1¼ ton capacity) within the enclosure.

SINGLE COMPACT UNIT for easy handling & storage.

5 → **MANOMETER** signals time for HEPA filter change.

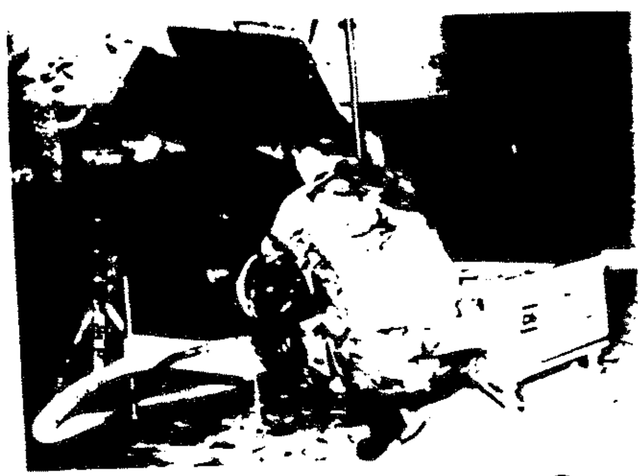
2 → **ONE SIZE FITS ALL** vehicles, compact cars to heavy duty trucks up to 20″ backing plate.

4 → **UNIQUE ELASTIC PANEL** automatically seals behind backing plate, about the axle, preventing dust from being blown out of the enclosure.

VACUUM RELIEF VALVE maintains minimum vacuum pressure to assure positive seal.

ON LIFTS

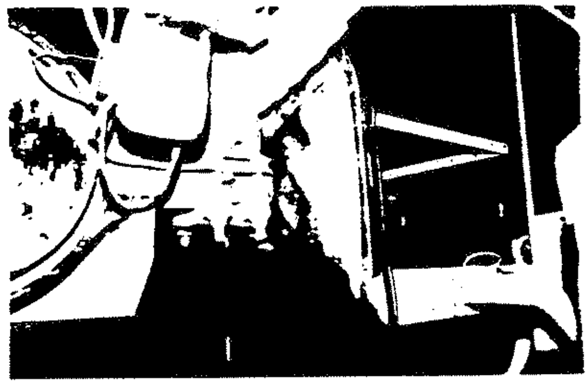
Readily adjusts to vehicles on lifts or safety stands; no attachments are required to achieve this versatility.



ON SAFETY STANDS

4 **Unique Auto-Seal™ panel automatically seals behind backing plate, about the axle, preventing dust from being blown out of the enclosure.**

Vacuum relief valve maintains minimum vacuum pressure to assure positive seal.



HEAVY-DUTY SERIES

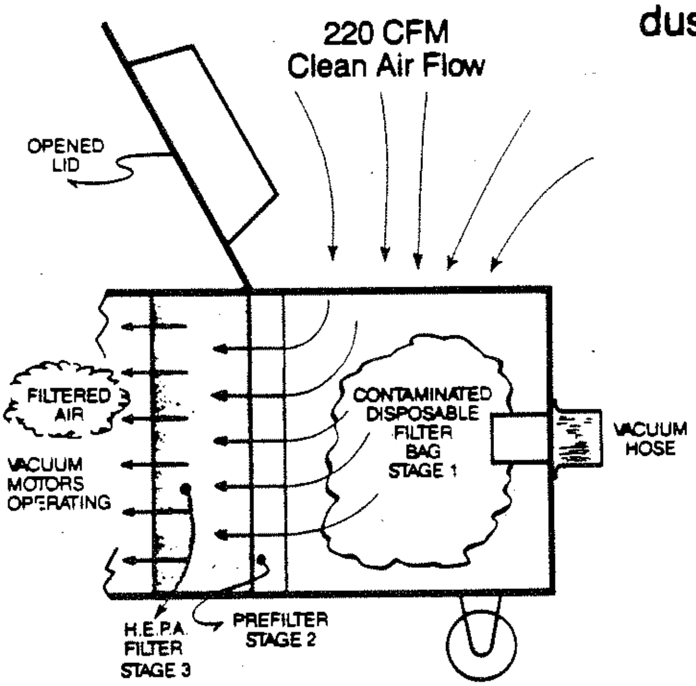
BCE-1000 Recommended for brake work which is generally performed on cars and light trucks serviced on lifts (suitable for occasional use on heavy duty trucks)

BCE-1500 Same as BCE-2000 except for having a 2″ shorter enclosure. Ideal for frequent service of cars and light trucks on lifts or safety stands. Also suitable for occasional servicing of heavy duty trucks.

BCE-2000 Slightly larger enclosure providing more room for heavy duty brakes and recommended for work which is generally performed on safety stands

6 SAFE-FILTER-CHANGE™

SAFE-FILTER-CHANGE™, a Clayton Associates' design exclusive, eliminates the substantial risk of exposure to hazardous dust and debris during routine filter change common to all other vacuum cleaners.



SAFE-FILTER-CHANGE™ permits operator to change the bag and pre-filter with vacuum motors running.

220 C.F.M. air flow into the filter compartment sweeps loose dust into HEPA filter preventing exposure to operator or to the environment.

WORLD'S MOST EFFICIENT HEPA FILTER: 99.999% on particles **0.12 MICRON** or larger.

EACH FINISHED MACHINE IS TESTED and certified to be **100% LEAK-FREE.**

AUTOMATIC LATCHING MECHANISM prevents opening filter compartment unless motors are operating.

SAFE-FILTER-CHANGE™ IS A SAFETY FEATURE OF ALL & BCE SERIES MACHINES

Refers to USEPA recommended features found on page 5.

CLAYTON

201-938-6700
FARMINGDALE, NJ 07727-0589

BRAKE CLEANING EQUIPMENT, HEAVY DUTY SERIES

BCE-1000 — Recommended for cars and light trucks (up to 1¼ ton capacity) frequently serviced on lifts. May be used occasionally to service vehicles on safety stands; for frequent service of light vehicles on safety stands model BCE-1500 is preferred. BCE-1000 is suitable for occasional service of heavy duty vehicles as well; for frequent service use model BCE-2000.

BCE-1500 — Same as BCE-2000 except for having a 2″ shorter enclosure. Ideal for frequent service of cars and light trucks on lifts or safety stands. Also suitable for occasional servicing of heavy duty trucks.

BCE-2000 — Designed for frequent service of light or heavy duty vehicles on lifts or safety stands. Enclosure is 4″ higher than model BCE-1000, 2″ higher than model BCE-1500 for greater ease in handling large brake assemblies.

SPECIFICATIONS

	BCE-1000	BCE-1500	BCE-2000
ACCOMODATES VEHICLES ON SAFETY STANDS OR LIFTS	Standard	Standard	Standard
AFE-FILTER-CHANGE™	″	″	″
ANOMETER	″	″	″
14 GAUGE STEEL CONSTRUCTION	″	″	″
N-SERVICE TRAINING	″	″	″
UTOMATIC LATCHING MECHANISM	″	″	″
IEPA FILTER EFFICIENCY: . . . .99.999% @ 0.12 micron	″	″	″
HEPA FILTER SURFACE AREA (SQ. IN.)	7753	7753	7753
IOTORS, SINGLE-SPEED, FLOW-THROUGH	2	2	2
OLTS	115	115	115
MPS (2 MOTORS RUNNING)	15	15	15
C.F.M. (AT INTAKE, 2 MOTORS RUNNING)	220	220	220
ORD AND LENGTH (FT.)	12/3,50	12/3,50	12/3,50
ILTERS	3	3	3
CAPACITY, DISPOSABLE PAPER FILTER (CU. FT.)	.82	.82	.82
LENGTH (IN.)	28	28	28
VIDTH (IN.)	23	23	23
VEIGHT (LBS.)	112	120	120
CASTER SIZE (IN.)	4	4	4
TTACHED IMPERMEABLE GLOVES, SIZE	10-½	11-½	11-½
APACITY, MAXIMUM BACKING PLATE DIAMETER (IN.)	20	20	20

ACCESSORIES INCLUDED

— BLOW GUN
— 5″ ROUND DUSTING BRUSH
— 1½″ DIAMETER VACUUM HOSE, 24″ LONG
— 2″ DIAMETER VACUUM HOSE 10′ LONG
— PREFILTERS, PACK OF 3
— DISPOSABLE PAPER BAGS, PACK OF 10
— 6 MIL OSHA-STANDARD PLASTIC BAGS, PACK OF 10

OPTIONAL ITEMS

— SIZE 11½ GLOVES
— STEEL CREVICE TOOL
— CLUTCH TOOLS, SEE SEPARATE LITERATURE
— FLOOR AND GENERAL PURPOSE TOOLS, SEE SEPARATE LITERATURE

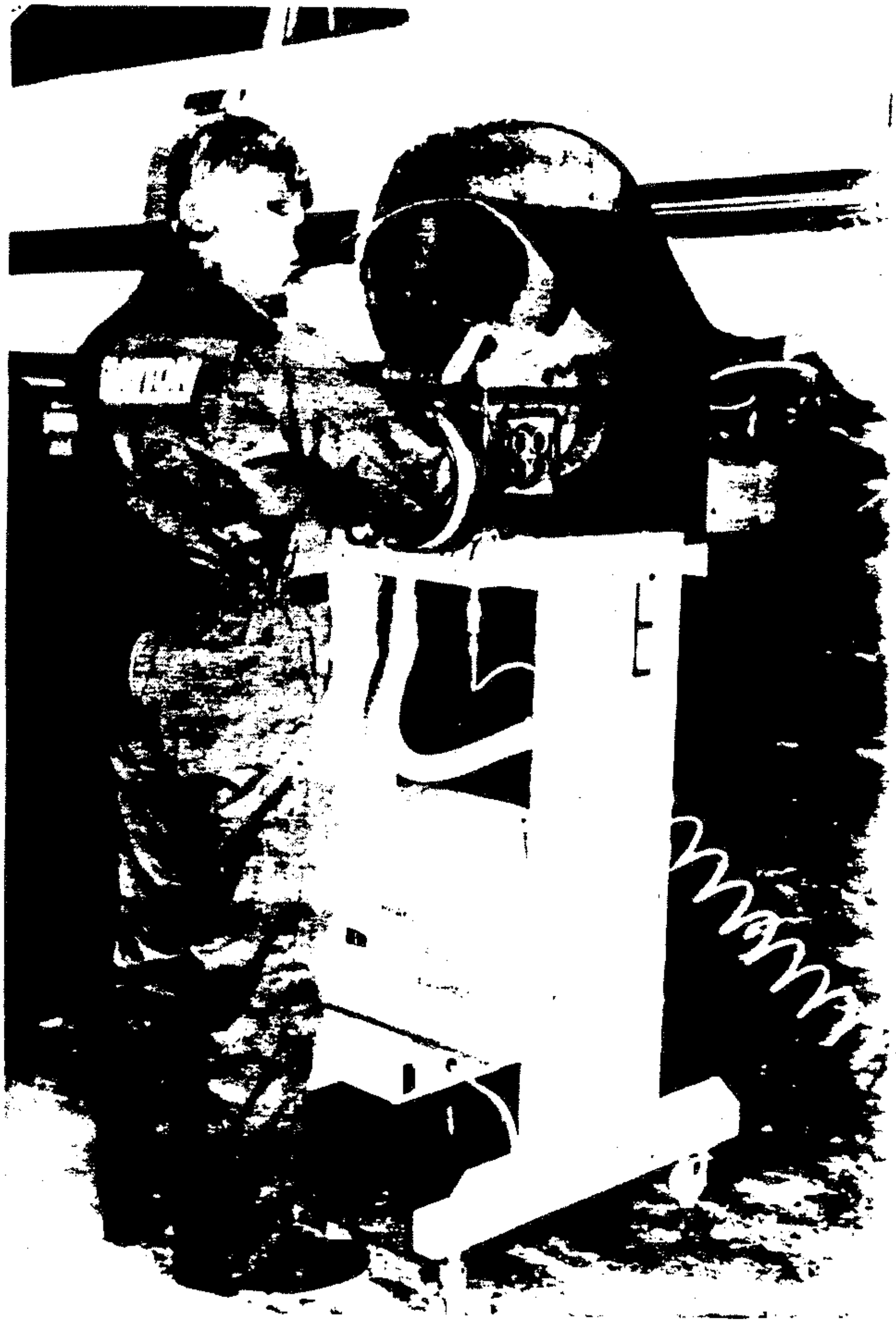
CLAYTON HEAVY DUTY SERIES
SPECIFICATIONS FOR AUTOMOTIVE BRAKE AND CLUTCH CLEANING EQUIPMENT

Brake cleaning equipment must meet or exceed specifications 1-11 as a **minimum** requirement.

1. Brake Cleaning Equipment shall be of modular design and construction consisting of a **single unit comprising both the Vacuum Collection System and the Brake Drum Enclosure.** The unit shall be on wheels and portable.
2. Two (2) single-speed thru-flow motors **creating 220 CFM air flow at the Vacuum Intake** providing maximum dust removal. **Motors shall be situated downstream from the H.E.P.A. filter, thereby preventing the motors from becoming contaminated.**
3. The vacuum collection device shall contain a manometer to **monitor the condition of the H.E.P.A. filter so as to signal time for H.E.P.A. filter replacement.**
4. **The Vacuum Collection System shall be designed so as to permit a single operator to remove the disposable filters and/or collected dust and debris while negative pressure from the vacuum motors draws or sweeps loose dust or particles away from the operator into the H.E.P.A. filter. Air sampling of operator's breathing zone must affirm zero asbestos exposure using transmission electron microscopy (T.E.M.) analysis.**
5. The Vacuum Collection System shall have a lockable filter compartment and shall have an **automatic locking mechanism (latch) to prevent access to disposable filters and/or collected dust and debris unless vacuum motor(s) is (are) operating.**
6. **Purchasers may, at their option, exchange any vacuum equipment purchased (excluding enclosure, hoses, and hand tools) for a like model or its' equivalent (new or remanufactured at the sellers option) containing a new H.E.P.A. filter, new motor brushes, covered by a full new equipment warranty, for a cost not more than $100 plus the cost of the H.E.P.A. filter(s) alone. This option may be exercised at any time within seven (7) years of original purchase.**
7. Filter system consisting of at least three (3) filters, including **one (1) H.E.P.A. (High Efficiency Particulate Air)** filter **having a minimum efficiency of 99.999% on particles 0.12 micron or greater in size.**
8. H.E.P.A. filter shall be tested by its manufacturer who will **list the test results** on each filter; furthermore, **each finished vacuum collection device shall be certified to be 100% leak-free according to a standard D.O.P. test protocol:** furthermore, each finished vacuum collection device must be designed to permit the end user to readily test filtration system using the same D.O.P. test protocol.
9. **A single enclosure shall be suitable for backing plates up to 20" in diameter. The enclosure design shall permit the operator to remove car and light truck brake drums within the confines of the enclosure. Enclosure shall be large enough and designed so as to enable the operator to use a hammer or other tools to loosen and remove drums from vehicle.**
10. **The face of the enclosure through which the axle is inserted shall be covered by overlapping impermeable panels which effectively seal about the axle preventing dust-laden air from escaping the enclosure during the cleaning process. These panels shall fully close the opening side when not in use to prevent release of dust into the atmosphere.**
11. **The enclosure shall contain a vacuum relief valve to automatically control the amount of vacuum pressure within the enclosure and assure proper seal about the axle (re: item 10).**
12. System design shall permit vehicles to be serviced on safety stands or lifts.
13. The Vacuum Collection System shall be constructed of 14 guage steel to withstand shop abuse and rough handling.
14. The H.E.P.A. filter must be recess mounted within the filter compartment to prevent accidental damage. **H.E.P.A. filter shall be positioned with sealing face gasket downstream of the air flow; it shall be rigidly held in place by solid brackets so as to prevent air from by-passing the filter.**
15. The enclosure shall be equipped with **attached impermeable gloves** which will **prevent operator exposure to hazardous substances within the enclosure.**
16. Brake enclosure shall be **made of Lexan or comperable shatterproof, fully transparent material,** on the top and three (3) sides, thereby, providing excellent visability for the operator.
17. In-service training shall be provided via V.C.R. video tape or live presentation upon installation of the equipment.
18. The equipment will be warranteed against defects for one (1) year following purchase. Parts and labor will be included under warranty. Labor to be provided at purchaser's site for the first 90 days at no charge. For the balance of the warranty period, labor will be free of charge on equipment returned to the vendor's factory.
19. The equipment shall be painted O.S.H.A. safety yellow to enhance visibility and promote safety consciousness.
20. The Brake Cleaning Equipment shall include the following, in addition to meeting or exceeding the aforementioned criteria: A blow-gun, a 5" round dusting brush, a 1½" vacuum hose assembly - 24" long, a 2" vacuum hose assembly - 10' long, 3 prefilters, 10 disposable filter bags, 10 six (6) mil. plastic bags.
21. Equipment shall be manufactured in the U.S.A.

CLAYTON
BRAKE CLEANING EQUIPMENT

PRO-LINE BCE-2500 for the BRAKE SPECIALIST



CLAYTON'S PROVEN QUALITY & SAFETY AT AN AFFORDABLE PRICE.

CLAYTON

PRO-LINE™ BRAKE CLEANING EQUIPMENT · BCE-2500

Recommended for cars and light trucks (up to 1¼ ton capacity) serviced on lifts. Suitable for occasional service of heavy duty vehicles if serviced on lifts. Optional "Free-Wheeler" dolly assembly (P.N. 625-330) needed to service vehicles on safety stands or lifts.

SPECIFICATIONS

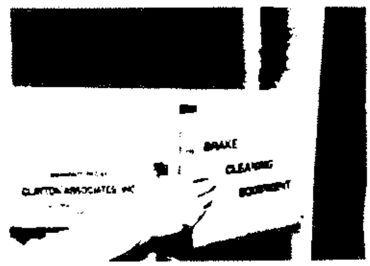
SAFE-FILTER-CHANGE™	Standard
MANOMETER (TO MEASURE HEPA FILTER AND PREFILTER)	"
AUTOMATIC LATCHING MECHANISM	"
LOCKABLE FILTER COMPARTMENT	"
MODULAR SINGLE UNIT CONSTRUCTION	"
TESTED 100% LEAK FREE	"
VACUUM RELIEF VALVE	"
MOTOR DOWN STREAM FROM HEPA FILTER	"
AUTOSEAL™ OVERLAPPING CLOSURE PANELS	"
SHATTERPROOF TRANSPARENT ENCLOSURE	"
PRINTED O.S.H.A. SAFETY YELLOW	"
HEPA FILTER EFFICIENCY 99.999% @ 0.12 MICRON	"
HEPA FILTER SURFACE AREA (SQ. IN)	2080
MOTOR, SINGLE SPEED THRU-FLOW	1
VOLTS	115
AMPS	7½
C.F.M. (AT INTAKE)	110
CORD LENGTH (IN.)	18
FILTERS	3
CAPACITY, DISPOSABLE PAPER FILTER (CU. FT.)	.82
WEIGHT (LBS.)	153
CASTER SIZE (IN.)	4
ATTACHED IMPERMEABLE GLOVES, SIZE	10½
CAPACITY, MAXIMUM BACKING PLATE DIAMETER (IN.)	20
1½" DIAMETER HOSE, 24" LONG	1
1½" DIAMETER HOSE, 36" LONG	1

P.O. BOX 589 • 30 SOUTHARD AVENUE • FARMINGDALE, N.J. 07727-0589
(201) 938-6700

SAFE-FILTER-CHANGE™ a CLAYTON exclusive

Heres How It Works:

1. Turn on motor.
2. Open filter compartment.
3. Incoming clean air prevents dust from exiting the compartment.
4. Wear gloves, remove filter bag from fill tube.
5. Pour approximately 1 pint of water into bag to wet contents.

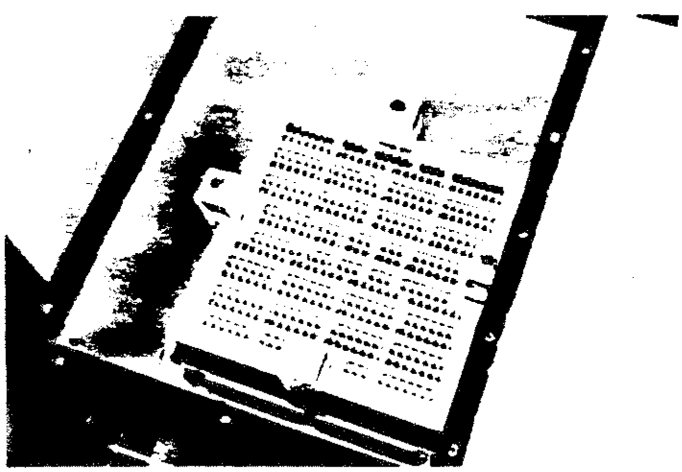


6. Filter bag is now ready for safe removal.
7. Turn a 6 mil poly bag inside out over hands and arms.
8. Reaching through the plastic bag, grasp the filter bag.
9. Fold the plastic bag around the filter bag and secure it for storage or disposal.

*During each step of **SAFE-FILTER-CHANGE™** clean air flowing into the compartment protects the workers and the environment from exposure to dust contained in the filter compartment.*

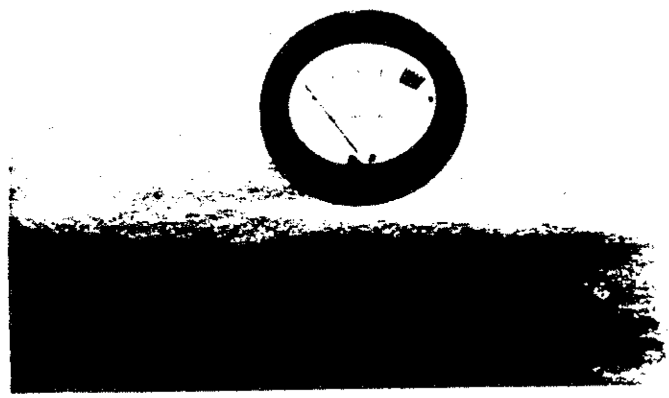
STATE-OF-THE-ART AIR FILTRATION

The world's most efficient HEPA (High Efficiency Particulate Air) filter, certified 99.999% efficient on particles 0.12 micron or greater, captures even the smallest of particles.
Unique filter locking fixture securely holds HEPA in place preventing any bypass of contaminated air around the filter. HEPA filter is situated upstream from the motor assuring that only PURE AIR passes through the motor - never a worry to the mechanic who may have to service the motor or switch.



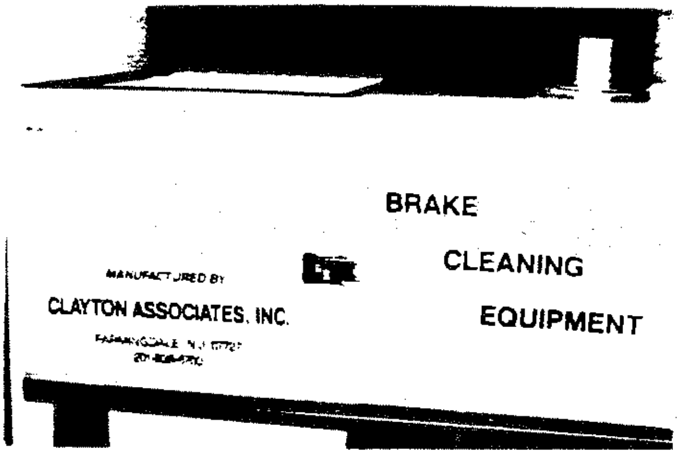
MANOMETER

Measures the condition of the HEPA filter so there's no guessing whether or not it should be changed.
With good preventive maintenance customers can expect 3-5 years of service between HEPA filter changes.



EQUIPMENT EXCHANGE PROGRAM

When its time to change the HEPA you may purchase a new one and replace it yourself or Clayton will send a new or reconditioned cabinet with a new HEPA filter installed, tested and certified 100% leak free. All for just a few dollars more than the cost of the HEPA filter.



AUTOMATIC LATCHING MECHANISM

- Prevents filter compartment door from opening unless vacuum motor is running.

LOCKABLE OUTER CABINET LATCH

- Prevents unauthorized access to filter compartment.

FINISHED EQUIPMENT TESTED & CERTIFIED 100% LEAK FREE

- What good is a HEPA filter vacuum if you can't be sure it's really capturing the small particles of hazardous dust?
- Each of Clayton's finished vacuum systems is tested by an independent contractor and certified to be **100% LEAK FREE**

AUTOSEAL™ PANEL

- Automatically seals around the axle to prevent dust from being blown out of the enclosure.
- Panel remains closed when not in use.

SHATTERPROOF, TRANSPARENT ENCLOSURE

- Excellent visibility for working.
- Polycarbonate is unaffected by brake fluids, grease, etc.

ONE SIZE FITS ALL VEHICLES

- Backing plates up to 20" diameter fit within this large enclosure. Any yet it works equally well on the smallest of cars too.

ATTACHED IMPERMEABLE GLOVES

- Prevent hand or arm exposure to dust.
- Two gloves make it easy for technician to use tools to loosen stubborn drums.

PULL DRUMS WITHIN THE ENCLOSURE

- Drums on vehicles up to 1¼ ton capacity are readily removed within the enclosure.
- Even large drums will fit inside the enclosure, however, they are generally too heavy for an individual to remove in this manner.

VACUUM RELIEF VALVE

- Maintains a uniform vacuum pressure within the enclosure to assure a tight seal around the axle.
- Opens on demand to allow incoming air to sweep dust and debris through the enclosure and into the vacuum collection system below.

PRO-LINE™ BCE-2500
SPECIFICATIONS FOR AUTOMOTIVE BRAKE AND CLUTCH CLEANING EQUIPMENT

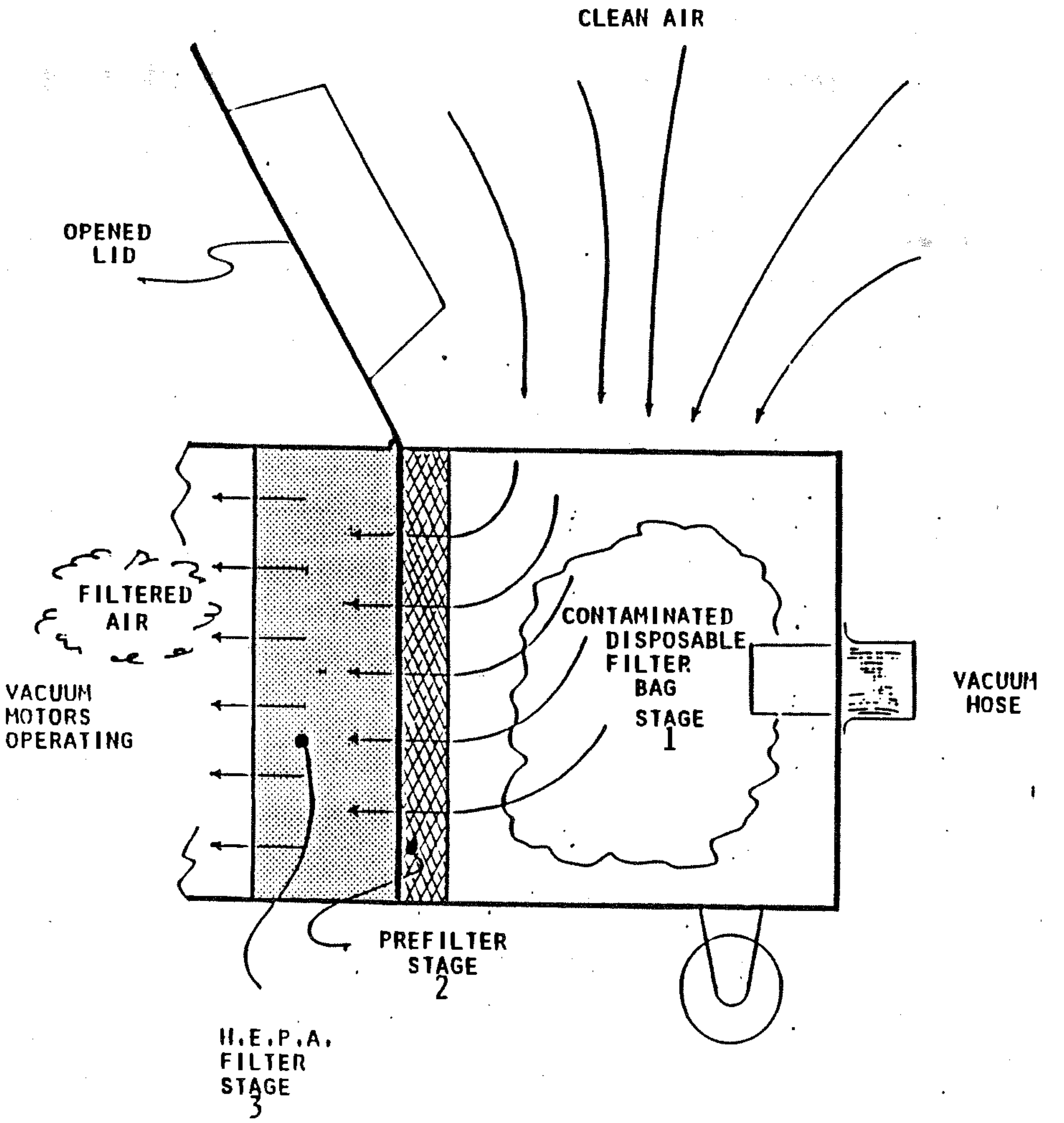
Brake Cleaning Equipment must meet or exceed specifications 1-11 as a **minimum** requirement.

---

1. Brake Cleaning Equipment shall be of modular design and construction consisting of a **single unit comprising both the Vacuum Collection System and the Brake Drum Enclosure.** The unit shall be on wheels and portable
2. One (1) single-speed thru-flow motor **creating 110 CFM air flow at the Vacuum Intake** providing maximum dust removal. **Motors shall be situated downstream from the H.E.P.A. filter, thereby preventing the motors from becoming contaminated.**
3. The vacuum collection device shall contain a manometer to **monitor the condition of the H.E.P.A. filter so as to signal time for H.E.P.A. filter replacement.**
4. **The Vacuum Collection System shall be designed so as to permit a single operator to remove the disposable filters and/or collected dust and debris while negative pressure from the vacuum motors draws or sweeps loose dust or particles away from the operator into the H.E.P.A. filter. Air sampling of operator's breathing zone must affirm zero asbestos exposure using transmission electron microscopy (T.E.M.) analysis.**
5. The Vacuum Collection System shall have a **lockable filter compartment and shall have an automatic locking mechanism (latch) to prevent access to disposable filters and/or collected dust and debris unless the vacuum motor is operating.**
6. **Purchasers may, at their option, exchange any vacuum equipment purchased (excluding enclosure, hoses, and hand tools) for a like model or its' equivalent (new or remanufactured at the sellers option) containing a new H.E.P.A. filter covered by a full new equipment warranty, for a cost not more than $100 plus the cost of the H.E.P.A. filter alone. This option may be exercised at any time within seven (7) years of original purchase.**
7. Filter system consisting of at least three (3) filters, including **one (1) H.E.P.A. (High Efficiency Particulate Air)** filter **having a minimum efficiency of 99.999% on particles 0.12 micron or greater in size.**
8. H.E.P.A. filter shall be tested by its manufacturer who will **list the test results** on each filter; furthermore, each **finished vacuum collection device shall be certified to be 100% leak-free according to a standard D.O.P. test protocol:** furthermore, each finished vacuum collection device must be designed to permit the end user to readily test filtration system using the same D.O.P. test protocol.
9. **A single enclosure shall be suitable for backing plates up to 20" in diameter. The enclosure design shall permit the operator to remove car and light truck brake drums within the confines of the enclosure. Enclosure shall be large enough and designed so as to enable the operator to use a hammer or other tools to loosen and remove drums from vehicle.**
10. **The face of the enclosure through which the axle is inserted shall be covered by overlapping impermeable panels which effectively seal about the axle preventing dust-laden air from escaping the enclosure during the cleaning process. These panels shall fully close the opening side when not in use to prevent release of dust into the atmosphere.**
11. **The enclosure shall contain a vacuum relief valve to automatically control the amount of vacuum pressure within the enclosure and assure proper seal about the axle (re: item 10).**
12. System design shall permit vehicles to be serviced on safety stands or lifts.
13. The H.E.P.A. filter must be recess mounting within the filter compartment to prevent accidental damage. **H.E.P.A. filter shall be positioned with sealing face gasket downstream of the air flow; it shall be rigidly held in place by solid brackets so as to prevent air from by-passing the filter.**
14. The enclosure shall be equipped with **attached impermeable gloves** which will **prevent operator exposure to hazardous substances within the enclosure.**
15. Brake enclosure shall be **made of Lexan or comparable shatterproof, fully transparent material,** on the top and three (3) sides, thereby providing excellent visability for the operator.
16. In-service training shall be provided via V.C.R. video tape or live presentation upon installation of the equipment.
17. The equipment will be warranteed against defects for one (1) year following purchase. Parts and labor will be included under warranty. Labor to be provided at purchaser's site for the first 90 days at no charge. For the balance of the warranty period, labor will be free of charge on equipment returned to the vendor's factory.
18. The equipment shall be painted O.S.H.A. safety yellow to enhance visibility and promote safety consciousness.
19. The Brake Cleaning Equipment shall include the following, in addition to meeting or exceeding the aforementioned criteria: A blow-gun, a 5" round dusting brush, a 1½" vacuum hose assembly - 24" long, a 1½" vacuum hose assembly 3' long, 1 prefilter, 1 disposable filter bag.
20. Equipment shall be manufactured in the U.S.A.

Safe Filter Change™

PATENT PENDING



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COLLECTION & DISPOSAL SYSTEMS FOR ASBESTOS AND OTHER HAZARDOUS SUBSTANCES

CONTROL RESOURCE SYSTEMS, INC.

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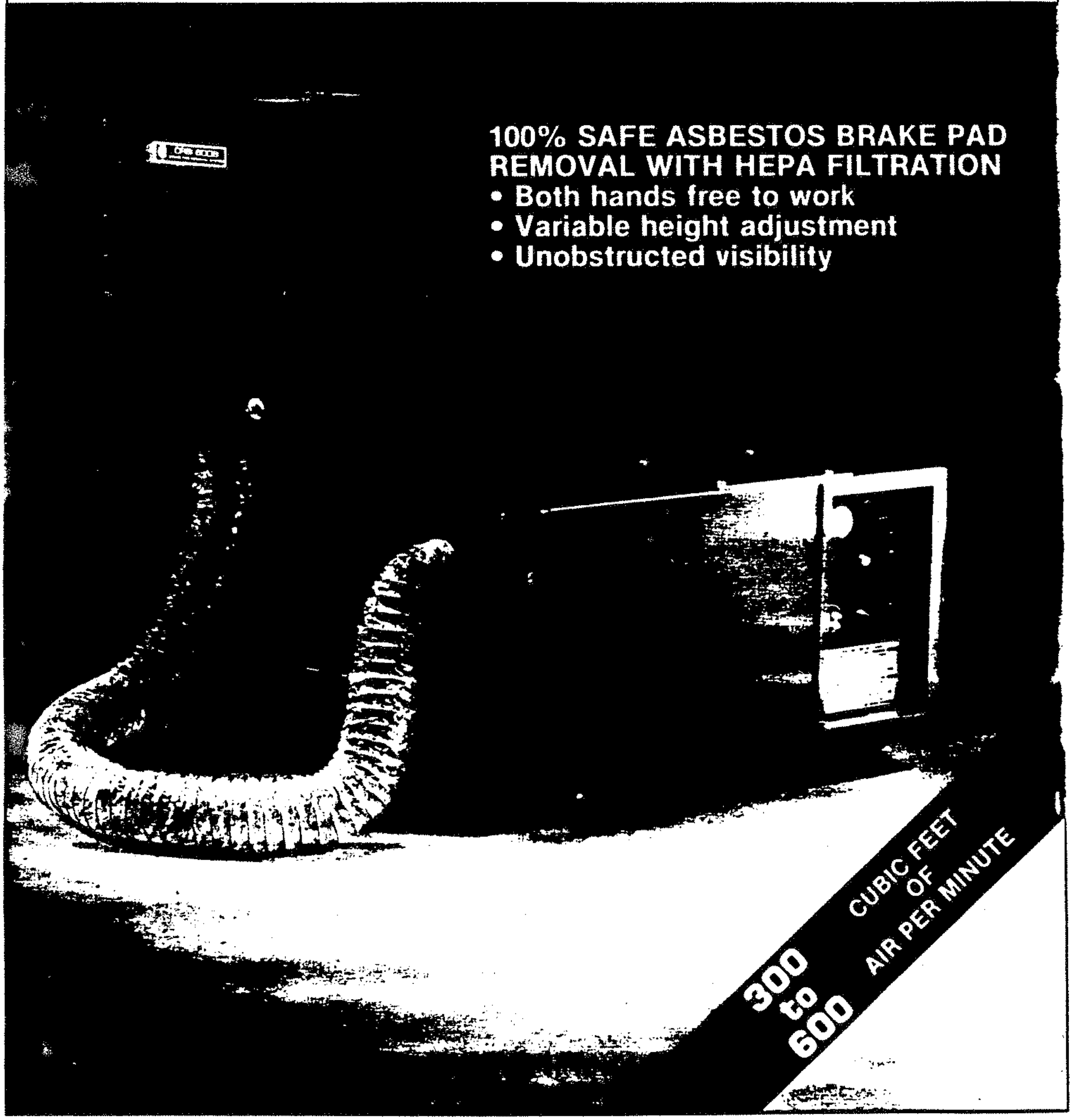
A REVOLUTION IN
ASBESTOS BRAKE
PAD REMOVAL

CRSI™
600B
Patent Pending

100% SAFE ASBESTOS BRAKE PAD REMOVAL WITH HEPA FILTRATION
- Both hands free to work
- Variable height adjustment
- Unobstructed visibility



Environmental Systems
That Help You Breathe Easy,
By the Architects of Clean Air

CRSI 600B™
BRAKE PAD REMOVAL SYSTEM

Brakemaster Specifications

- Dimensions: (Cabinet)
  Height 21" Width 15" Depth 15"
- Weight: 50 lbs.
- Construction: 16 GA Sheet Metal Cabinet
  14 GA Structural Tubing Stand
- ⅛" Thick Plexiglass Window
- Height Adjustment:
  2'0" to 6'0"

BRAKEMASTER UNIT INCLUDES:

- 1 Unit with adjustable base on 4 heavy duty casters. (Filtration unit sold separately).
- Standard air hose connection
- Air gun with hose
- 2 hand sleeves
- 1 axle sleeve
- 25 feet-4" dia. flex hose

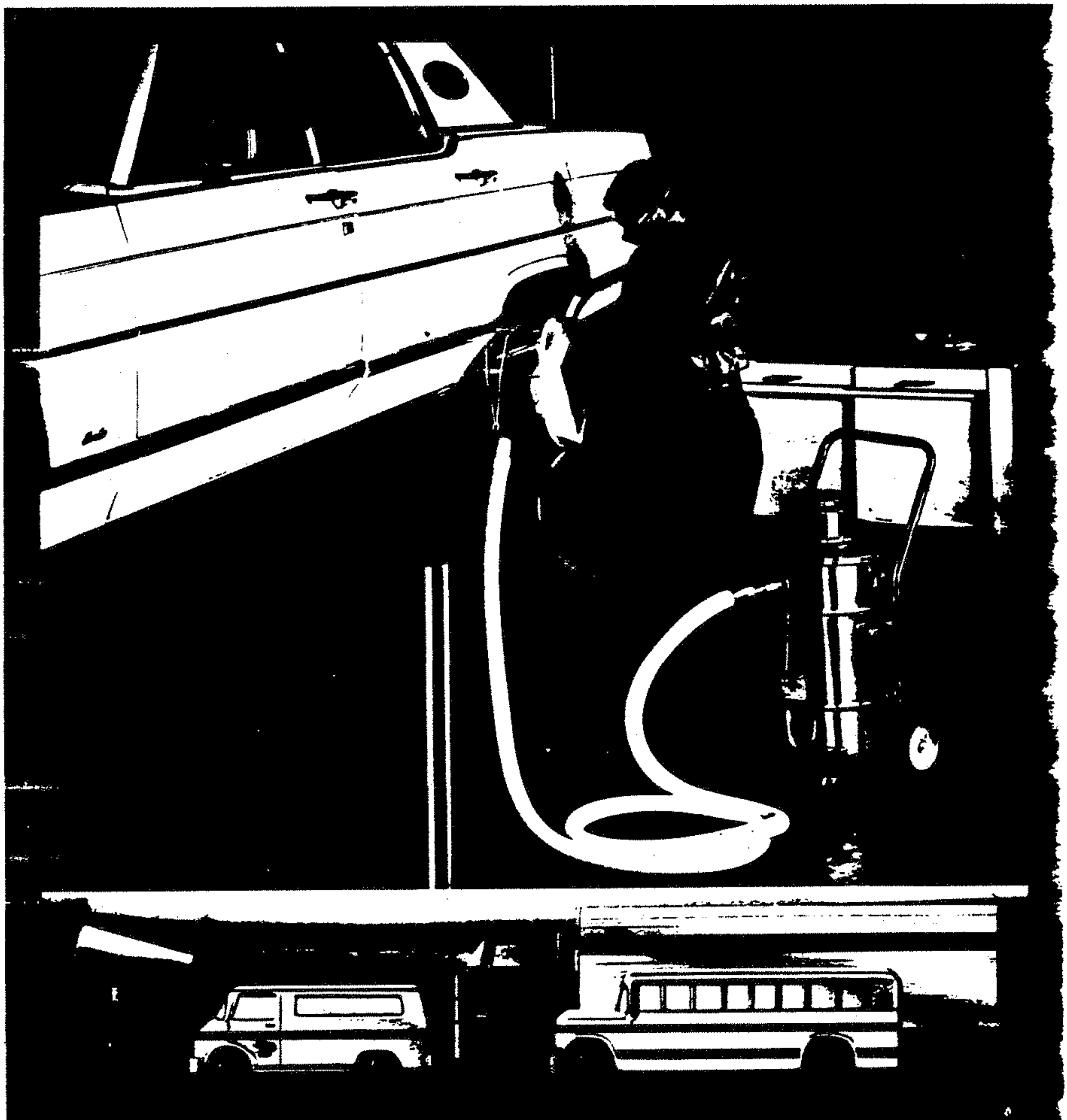
Manufactured & Distributed by:
Control Resource Systems, Inc.
670 Mariner Drive, Michigan City, Indiana 46360
"Toll Free" 1-800-272-3786 • (219) 872-5591 • Telex No 753007

CRSI™

HAKO

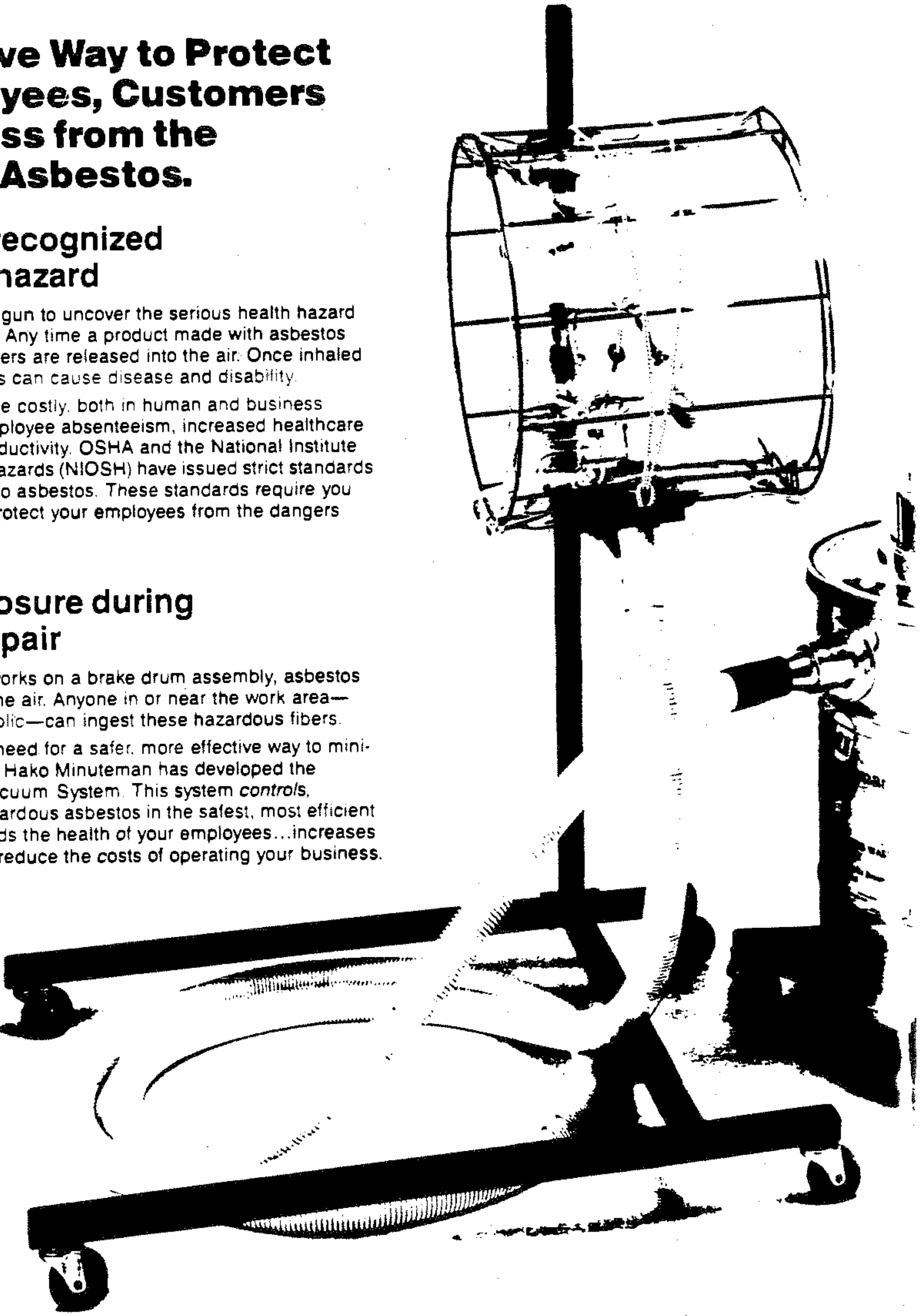
Hako
Minuteman
Asbestos Brake Drum Vacuum System
Featuring Hako's exclusive Clear-View* Heavy Duty Vinyl Hood

*Patent Pending



The Safest and Most Effective Way to Control and Remove Asbestos Dust from Brake Drums

Take a look at Hako Minuteman



The Effective Way to Protect your Employees, Customers and Business from the Hazards of Asbestos.

Asbestos—a recognized public health hazard

Reseachers have only begun to uncover the serious health hazard represented by asbestos. Any time a product made with asbestos is disturbed, asbestos fibers are released into the air. Once inhaled or swallowed, these fibers can cause disease and disability.

Asbestos exposure can be costly, both in human and business terms. It can result in employee absenteeism, increased healthcare costs and decreased productivity. OSHA and the National Institute of Occupational Safety Hazards (NIOSH) have issued strict standards to limit worker exposure to asbestos. These standards require you to take certain steps to protect your employees from the dangers of asbestos exposure.

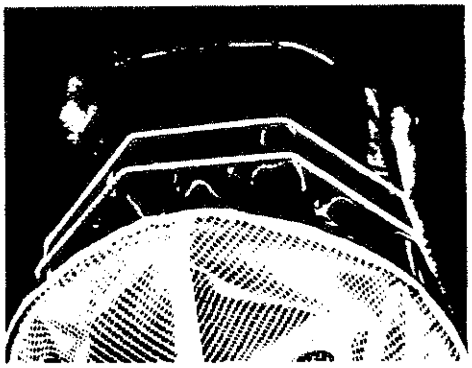
Asbestos exposure during brake drum repair

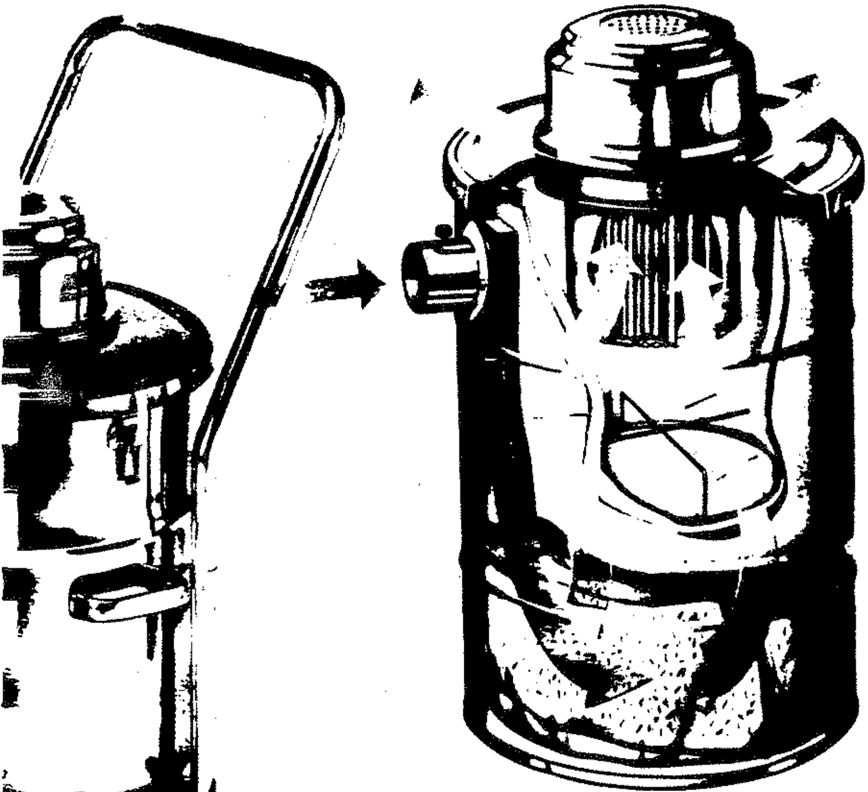
Every time a mechanic works on a brake drum assembly, asbestos fibers are released into the air. Anyone in or near the work area—including the general public—can ingest these hazardous fibers.

Recognizing the critical need for a safer, more effective way to minimize asbestos exposure, Hako Minuteman has developed the Asbestos Brake Drum Vacuum System. This system *controls*, *isolates* and *contains* hazardous asbestos in the safest, most efficient way possible. It safeguards the health of your employees...increases productivity...and helps reduce the costs of operating your business.

* INDEPENDENT LABORATORY TEST RESULTS SHOW HAKO MINUTEMAN'S ASBESTOS BRAKE DRUM VACU

Asbestos Brake Drum Vacuum System





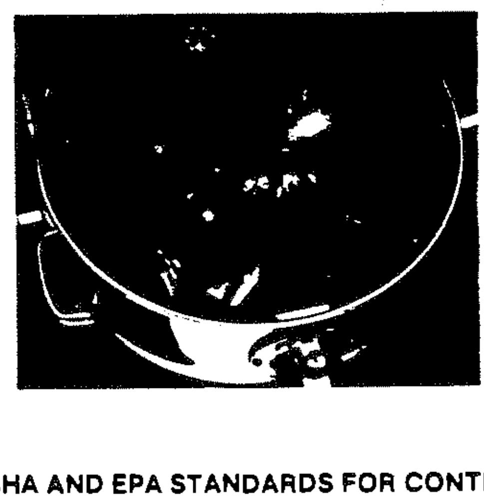
How Hako gives you three levels of protection:

1. Controls

Hako's exclusive Clear-View heavy duty vinyl brake drum hood covers the entire brake drum assembly to trap and contain loose asbestos. Provides *total* visibility during cleaning operations for increased safety and control. Built-in air blowing nozzle dislodges loose asbestos fibers from deep inside brake shoe lining quickly and efficiently. Protects mechanic from asbestos exposure—prevents fibers from spreading to other areas

2. Isolates

Once asbestos fibers are trapped within the hood, they are safely vacuumed through the exclusive Hako 5-stage, high efficiency filtration medium. This filtration system, designed specifically for the handling of asbestos, isolates the fibers for added safety and protection. A key component in the isolation of asbestos is a DOP, (smoke) tested and registered H.E.P.A. (high efficiency particulate air) filter with a minimum efficiency of 99.97% on particles of 0.3 micrometers. Both the operator and the motor assembly are protected since all air going through the vacuum is H.E.P.A. filtered before being exhausted into the environment



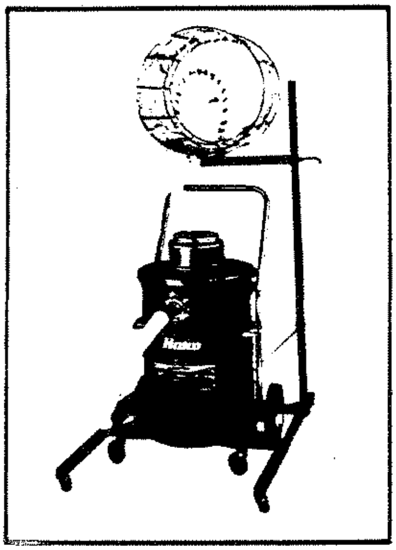
3. Contains

Hako provides an extra measure of operator protection in the handling and disposal of hazardous asbestos. Asbestos fibers are collected in a disposable filter bag which is surrounded by a heavy duty plastic tank liner. This liner is marked "Contains Asbestos Fibers," complying with Federal regulations. The operator simply closes the top of the plastic liner and lifts it—with the filter bag safely inside—out of the tank for safe and easy disposal.

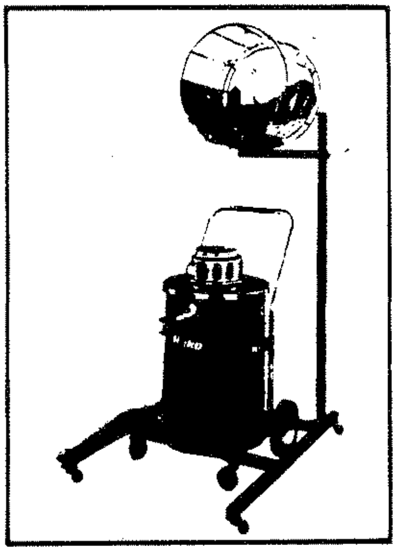
'STEM WILL EXCEED ALL OSHA AND EPA STANDARDS FOR CONTROLLING & ELIMINATING ASBESTOS DUST

A versatile, portable system that's easy to operate

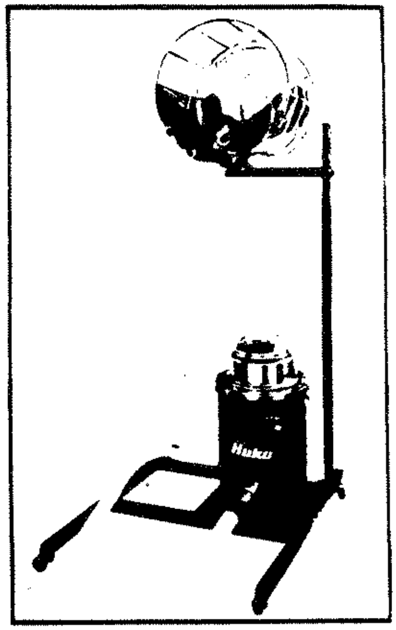
Also available with 2 non-permeable gloves



15 gallon—Standard



15 gallon with gloves



6 gallon with gloves

Product Features:

Asbestos Vacuum
- Your choice of 6 or 15 gallon asbestos vacuum.
- All asbestos-laden air is H.E.P.A.* filtered before release into the environment
- Hako Minuteman critical filter vacuums are easily adapted for wet recovery.
- A full range of tools and attachments available.

Exclusive Clear-View Heavy Duty Vinyl Hood
- Allows total operator visibility during cleaning operation.
- Covers entire brake assembly to contain asbestos.
- Built-in air blowing nozzle firmly secured to hood to prevent accidental removal.
- Mounts to Dolly Stand for total mobility and easy access to different working heights and vehicles.
- Available in two standard sizes for cars (adjustable from 7" to 12" in diameter), trucks, buses (adjustable from 12" to 19" in diameter) ... even aircraft.

* Videotape operating instructions available (VHS format).

Dolly Stand
- Mounts to Brake Drum Hood to form a complete, portable cleaning unit.
- Constructed of rugged structural steel for long-term durability.
- Fitted with casters for total mobility.
- Allows adjustment of Hako Brake Drum Hood to working heights of up to 5 feet.

If you repair brakes, you need the Hako Asbestos Brake Drum Vacuum System

Ideal for:
- Auto Dealers.
- National Chain Automotive Service Centers.
- Independent Repair Shops.
- Truck Fleet Operators.
- Public and School Bus Systems.
- Car and Truck Rental Companies.
- Municipal and Industrial Fleets.
- Aircraft Repair Operations.

* Independent laboratory test results show Hako Minuteman's Asbestos Brake Drum Vacuum System will exceed all OSHA and EPA standards for controlling and eliminating asbestos dust.

Specifications

	Asbestos -6	Asbestos -15
Static Lift (Inches Water	88	88
Air Flow (C.F.M.)	95	95
Power (Watts)	930	930
Cord & Length	16-3/50	16-3/50
Wet Capacity (gallons)	N/A	Optional
Dry Capacity (cu. ft.)	21	82
Filter Area (Total Square Inches)	2,226	4,120
Overall Height	25"	36
Width	14"	21"
Volts— Standard Optional	115 220	115 220
Wheels	Optional	Yes
Wheel Size— Front Rear	3" 6	3 8
Wet/Dry	N/A	Optional
Dry Only	Yes	Yes
Weight (Pounds)	24.5	51

Specifications subject to change without notice

Meets Federal Asbestos Pick-Up and Removal Requirements.
CM. 1-C.24593LSH H.E.P.A. (High Efficiency Particulate Air) Filters are **99.99%** effective at 0.12 micrometers H.E.P.A. Filter meets or exceeds the following military and government specifications:

Mil-F-51079A
U/L Std. 586 listed
Mil-F-510680
U/L Class 1 listed
OSHA 3095
A.E.C - Regulatory Guide #1.51
EPA-560-OPTS-86-002
EPA-560-OPTS-86-003

Hako Minuteman

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THE FULL LINE • Industrial/Commercial/Institutional and Critical Filter Vacs • Sweepers • Scrubbers • Floor/Carpet Machines

Hako

Minuteman

Series 800 Asbestos Vacuum Systems

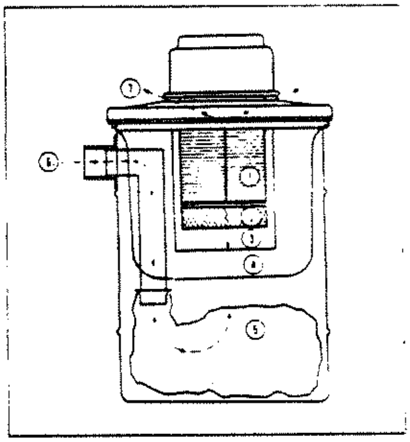
For On-Going Removal of Asbestos and Other Toxic Dusts

Operation

A dry vacuum, each Asbestos Vac utilizes five filters to capture sub-micron particles...a disposable paper filter protector, primary paper cloth filter, impaction pre-filter and a H.E.P.A. final filter. A disposable paper collector bag is included on the 6 and 15 gallon models. A heavy gauge plastic drum liner may be used on the 30 and 55 gallon sizes for safe removal of large volume pick-ups.

Each unit features a 2 stage by-pass electric motor.

1. H.E.P.A. Filter (99.97% efficient at .3 micrometers)
2. Impact Filter
3. Cloth Filter
4. Filter Protector
5. Disposable Bag
6. Intake
7. Exhaust

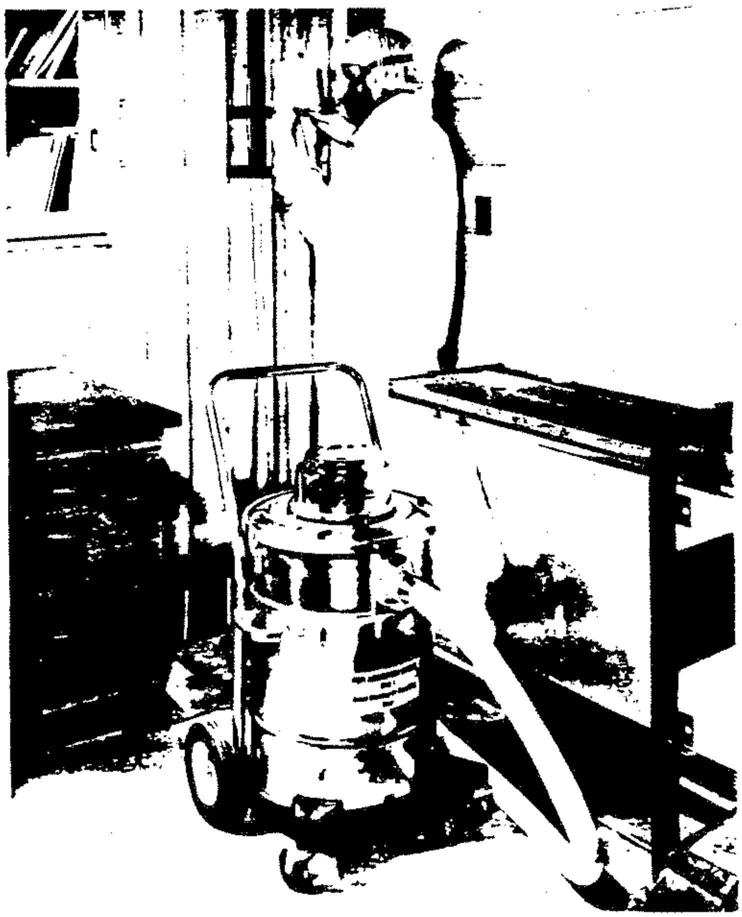


Application

For use in schools, offices, industrial and shipboard cleaning operations. With an efficiency rating of 99.97% on particles of .3 micrometers, the Asbestos Vac is particularly useful for cleaning up after insulation operations on pipes, in removing asbestos-covered ceiling dust to prevent "snowing" and for vehicle maintenance procedures involving asbestos coated material such as brakes.

This vacuum is highly effective in filtering airborne pollutants such as:

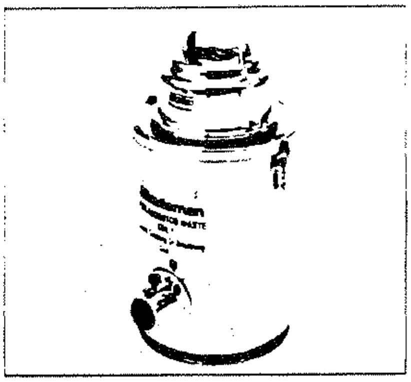
- Aluminum
- Arsenic
- Arsenite
- Barium
- Bentomite
- Beryllium
- Cement
- Cerium
- Chromium
- Coal
- Diatonite
- Fertilizer
- Foundry Dusts
- Fullers Earth
- Fumigants
- Fungicides
- Graphite
- Hematite
- Herbicides
- Insecticides
- Iron
- Kaolin
- Kiln
- Lead Arsenate
- Lime
- Mica
- Nickel
- Nicotine
- Pesticides
- Pyrethrum
- Rodenticides
- Rotenone
- Silica
- Sillimanite
- Talc
- Tin
- Titanium
- Tripoli
- Tungsten Carbide
- Vinyl Chloride
- Wood



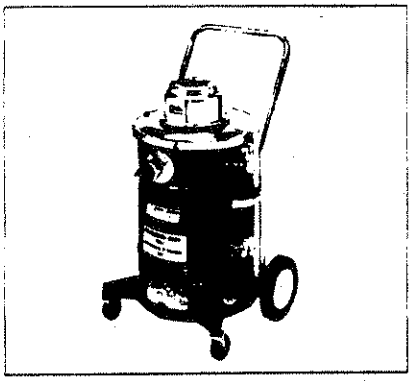
Easily Meets Federal Asbestos Pick-Up and Removal Requirements. Mil-C-24593(SH)

Selection

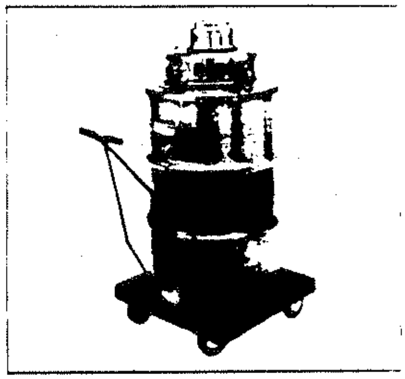
Hako-Minuteman Asbestos Vacuums are available in a variety of models and sizes from 6 to 55 gallon capacities. They can be easily modified for wet pick-up applications when equipped with a water shut-off module and a 1:1 tank/lid adapter. Most Asbestos Vacs are available with painted or stainless steel drums.



Model C-80106
Available in painted or stainless steel. 115/220V equipped with easily disposed of paper collection bag. A convenient easy-to-carry size (6 gallon). A wheel bracket is optional. Weight: 24½ lbs.



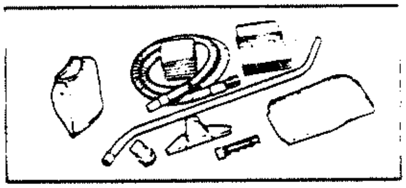
Model C-80315
Available in painted or stainless steel 15 gallon drums with 115V or 220V AC/DC motors. Each unit includes front casters, 8" rear wheels and a carriage handle. Weight: 51 lbs.



Model C-80330, C-80355
Available with 30 or 55 gallon painted drums with 115V or 220V AC/DC motors. Each unit is equipped with a dolly cart and handle for easy maneuverability. Weight: 30 Gallon size — 121 lbs., 55 gallon size — 138 lbs.

Options

Hako-Minuteman Asbestos Vacuums can accommodate various options such as water shut-off modules and tank/lid adapters for wet pick-up applications. The optional starter tool kit at right is recommended for each new unit. (C-80559-00)



Specifications

The following Series 800 Asbestos Vacuum specifications provide the practical information to allow specific comparisons between sizes ranging from 6 to 55 gallons.

Please note that these vacuums are shown as dry only. Wet/dry capability can be added by obtaining the optional equipment indicated above.

H.E.P.A. (High Efficiency Particulate Air) Filters are 99.97% effective at .3 microns.

H.E.P.A. filter meets or exceeds the following military and government specifications.
Mil-F-51079A
Mil-F-51068D
U.L. Class 1 listed
U.L. Std. 586 listed
A.E.C. — Regulatory Guide #1.51

Specifications subject to change without notice

		Asbestos -6	Asbestos -15	Asbestos -30	Asbestos -55
Static Lift (inches water)		88	88	88	88
Air Flow (C.F.M.)		95	95	95	95
Power (watts)		930	930	930	930
Cord & Length		16-3'50	16-3/50'	16-3/50'	16-3/50'
Wet Capacity (gallons)		NA	Opt	Opt	Opt
Dry Capacity (cu.ft.)		.21	.82	4.36	7.15
Filter Area Total Square Inches		2226	4120	4120	4120
Overall Height		25"	36"	48"	54"
Width		14"	21"	25"	25"
Volts	Standard	115	115	115	115
	Optional	220	220	220	220
Wheels		Opt	Yes	Yes	Yes
Wheel Size	Front	3"	3"	5"	5"
	Rear	6"	8"	5"	5"
Wet/Dry		—	Opt.	Opt	Opt
Dry Only		Yes	Yes	Yes	Yes
Weight (pounds)		24½	51	121	138

We offer a complete line of attachments, special tools and accessories for all Hako-Minuteman Asbestos Vacs.

See tools, parts and accessories catalog.

Hako Minuteman

THE FULL LINE OF • Industrial/Commercial/Institutional and Critical Filter Vacs • Sweepers • Scrubbers • Floor/Carpet Machines.

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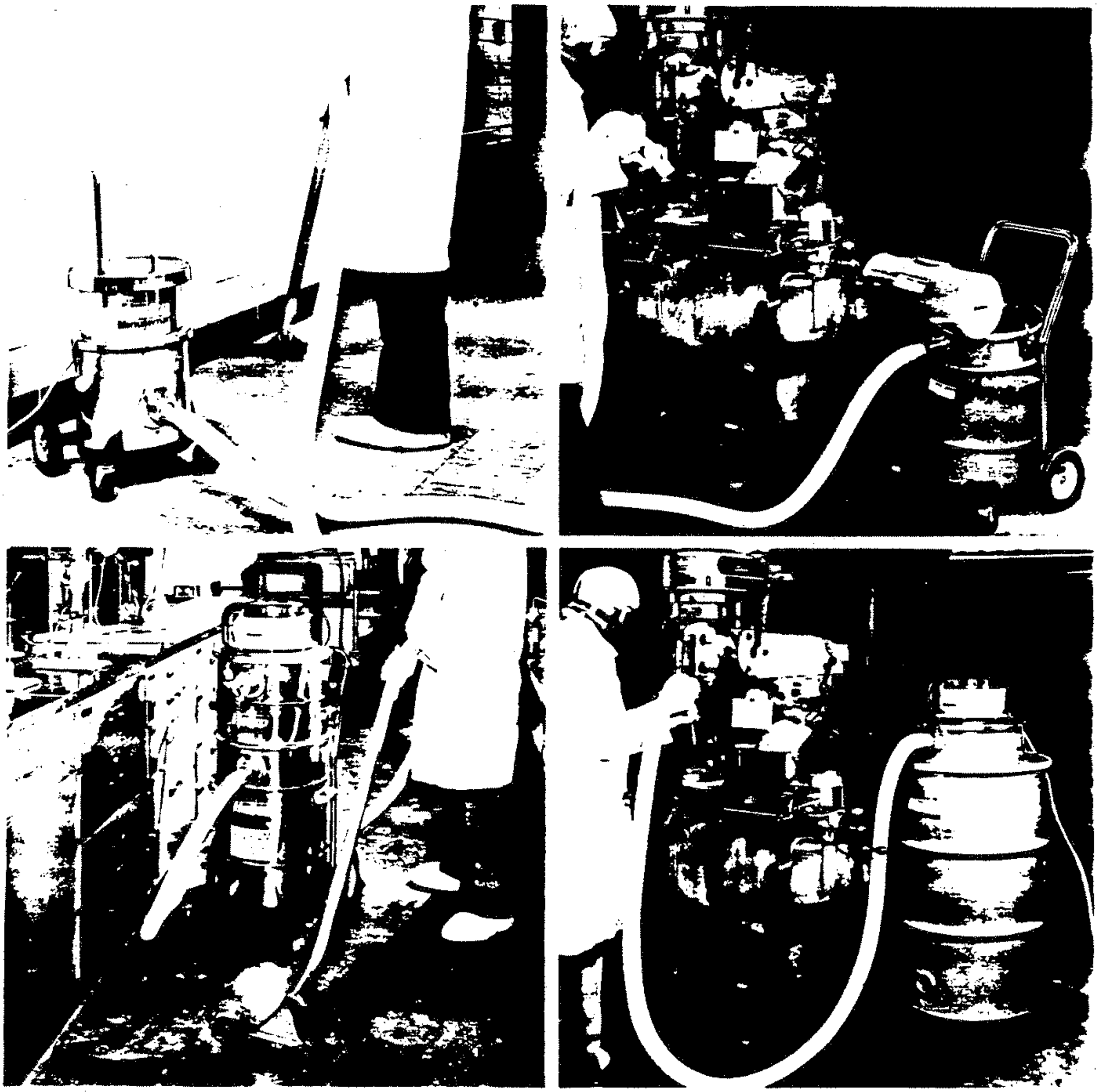
Hako
Minuteman

Series 800 Critical Filter Vacuum Systems

For Efficient Pick-Up of Hazardous Wastes



Wet/Dry or Dry Only–H.E.P.A. Filter Systems

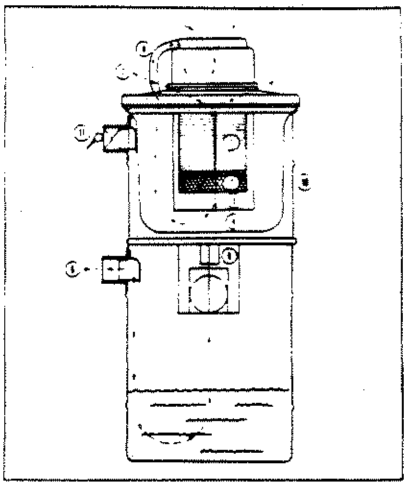
Operation

All Hako-Minuteman X-100. X-1000 and MX-1000 vacuums feature quiet operating lid assemblies and are equipped with an exclusive 3 stage by-pass motor. Motor Cooling Air Recirculation device standard on X-100. X-1000. and MX-1000 vacuums. This device assures that all air going through the vacuum has been H.E.P.A. filtered before it is exhausted back into the environment. All motor cooling air is exhausted without turbulence. The X-1700 and X-700 models are compressed air operated critical filter vacuums. The use of transfer lids allows for quick tank changes during emergency cleaning. Details on the operation of air vacs is contained in the Hako-Minuteman Series 700 literature.

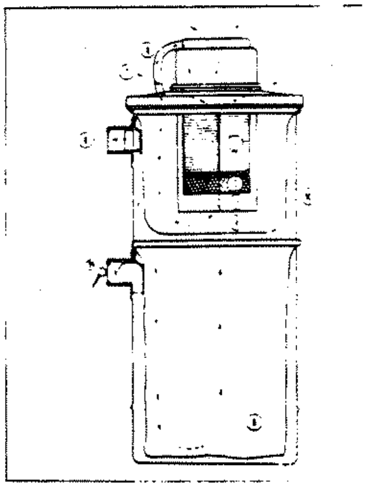
When used for dry pick-up, four filters, H.E.P.A. filter, impact filter, cloth bag and filter protector bag, trap any contaminated material that enters the tank and filters all air that flows through the vacuum.

On X-100 models the external filter box allows quick and easy changing of the impaction pre-filter and H.E.P.A. filter.

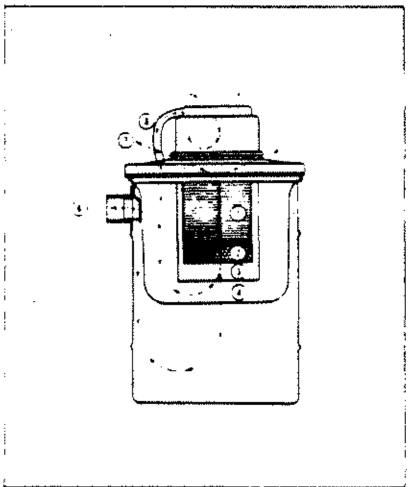
1. H.E.P.A. Filter
2. Impact Filter
3. Cloth Filter
4. Filter Protector
5. Disposable Bag
6. Intake
7. Exhaust
8. Motor Cooling Air Recirculation
9. X-100 and MX-1000/Water Shut-Off
   MX-1000 Dry Only/Plastic Bag
   X-1000-30/55-Dry Only/Plastic Bag
10. 1:1 Adapter
11. Plug
    Water Shut-Off Module



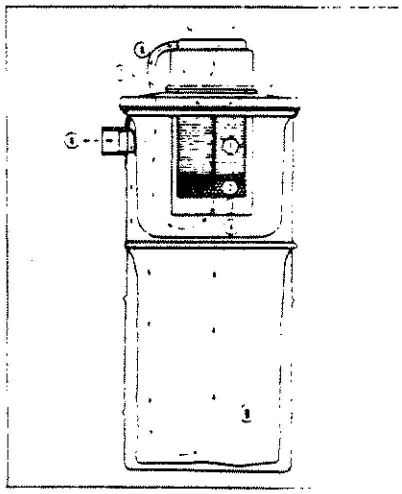
MX-1000-Wet



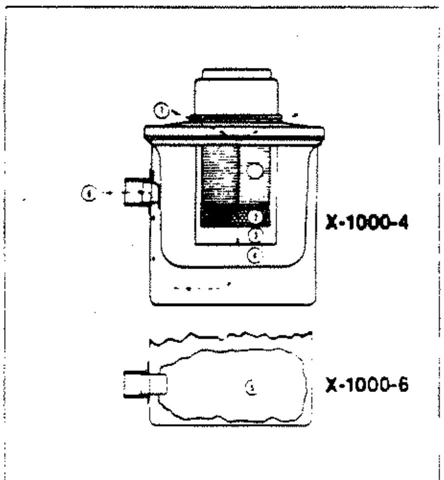
MX-1000-Dry



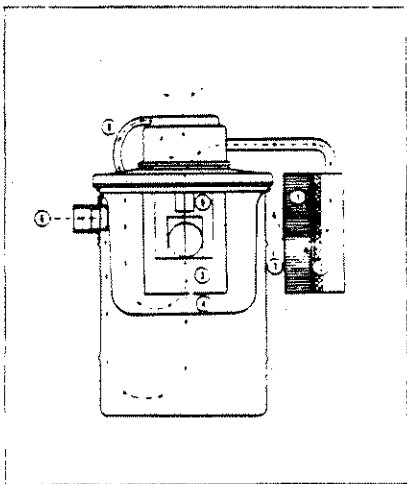
X-1000-15



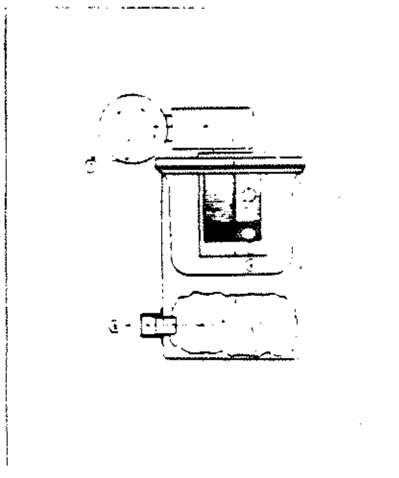
X-1000-30/55



X-1000-4/6



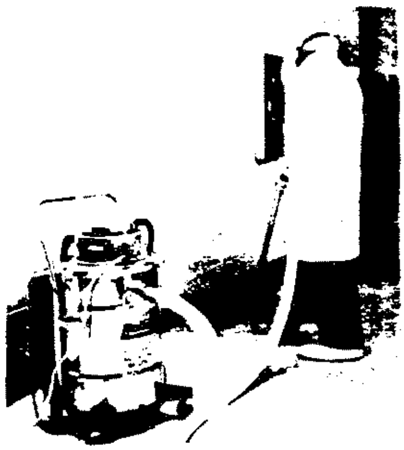
X-100-15



X-1700-6

Application

American Cleaning Equipment Corporation offers many sizes and configurations of the Hako-Minuteman Critical Filter Vacuums for safely trapping and containing nuclear, mercury, chemical, asbestos and other hazardous materials. Minuteman Critical Filters Vacuum Systems are the safest and most reliable way to collect contaminates, because each model contains a high density "impact" type filter with 90 to 95% efficiency as measured by the "D.O.P." test and a H.E.P.A. (High Efficiency Particulate Air) filter 99.97% effective at 0.3 microns minimum effectiveness. The Critical Filter Vacuums are approved for use in hospitals, "white rooms", electronic assembly areas, testing labs and nuclear plants — or wherever there is a need to remove hazardous material and prevent its escape into the air. Almost any size — from 4 to 475 gallons — and any configuration — wet, dry or both — can be adapted to your particular needs. Options include extra-large-volume water pick-up paper or plastic filter bags, lightweight (24 lb.) models, and 95 c.f.m. to 300 c.f.m. power.

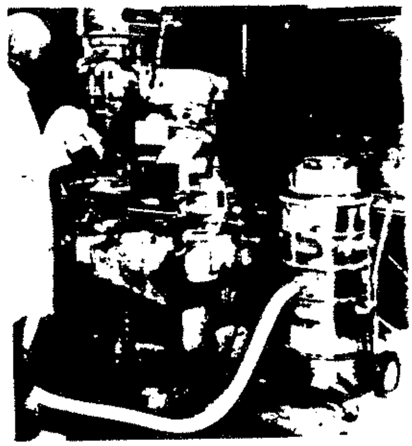


X-100 Vacuums

This H.E.P.A. filter vacuum meets the requirements of the U.S. Nuclear Regulatory Agency and the Army Chemical Warfare Service for use in areas with radioactive liquid or dry contamination. It also is ideally suited for use in hospitals, testing labs and industrial "white rooms" in both wet and dry applications.

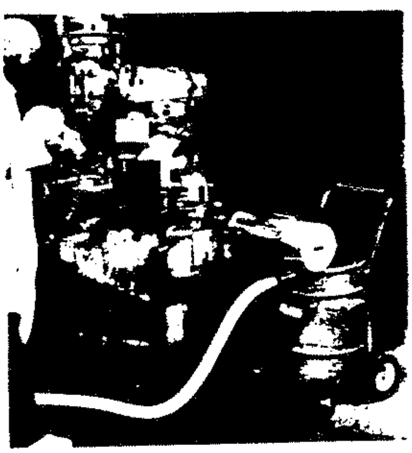
X-1000 Vacuums

Low noise level makes these vacuums ideally suited for dry only use in class 100 "white rooms", "clean rooms" and laboratories and in pharmaceutical and biological research labs. May be converted to wet pick by using optional water shut-off module and 1:1 adapter.



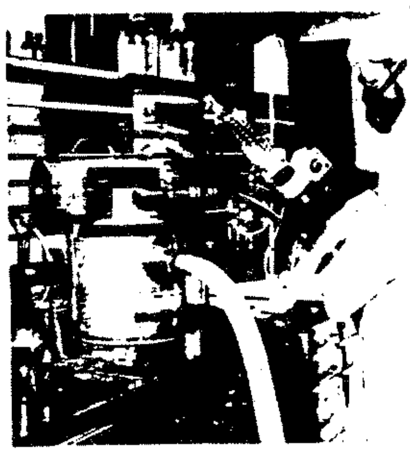
MX-1000 Vacuums

These wet/dry versions of the X-1000 series are for use in nuclear plants' hot cells, hospital critical cleaning, class 100 "white rooms", "clean rooms" and biological and pharmaceutical labs.



X-1700 Air Vacs

H.E.P.A. filtered air operated vacuums are designed for use in either laboratory or industrial settings. Any of these models may be used as remote vacuum sources for transfer systems providing fast recovery of large quantities of spilled material.



X-1700-4

Air operated vacuums are also recommended for the recovery of potentially explosive material when proper electrical grounding precautions are taken. Please contact the factory for more information.

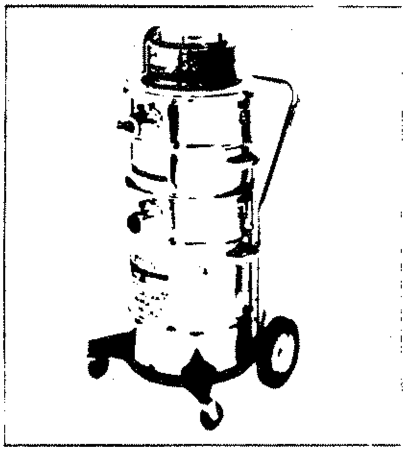
X-1000-4/6

One of the smallest available H.E.P.A. filter vacuums. Perfect for use in tight quarters such as on board ships and under lab benches.

Selection

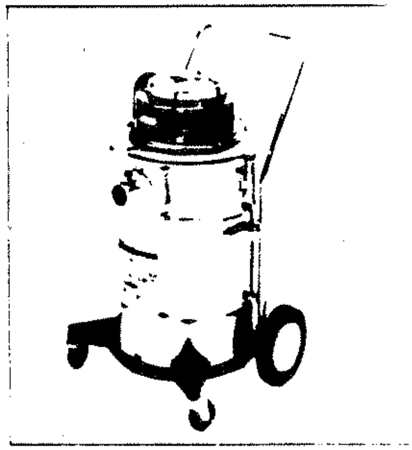
Hako-Minuteman critical filter vacs offer a selection of models and sizes to fit any specific hazardous waste cleaning application.

Series 800 vacuums are available in wet/dry and dry only models ranging in size from 4 to 55 gallon tanks. Special application arrangements are available for the 475 gallon range. All models incorporate the individually tested and certified H.E.P.A. filter for complete filtering of vacuum air. Most units are available with painted or stainless steel tanks in a variety of filter configurations. 115V or 220V AC/DC motors are available except on air operated vacuums.

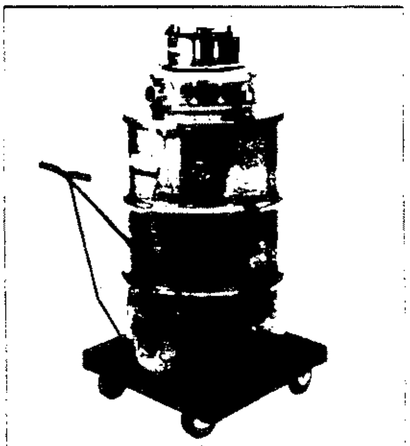


Model MX-1000
Available in wet/dry or dry models. Features a dual intake system, water shut-off module and disposable plastic bags inside. The powerful motor with a multi-stage impeller is whisper quiet but achieves extra high suction and static water lift. Weight: wet/dry 86 lbs. - Dry 83 lbs.

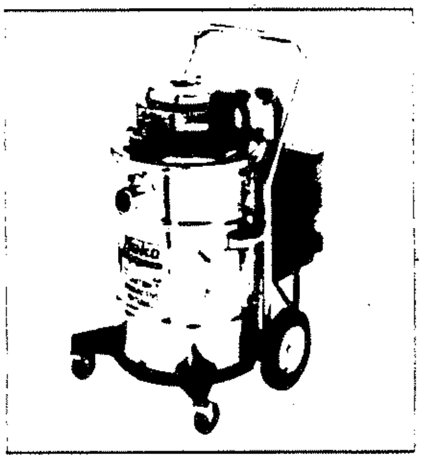
Model X-1000-4/6
To recover small quantities in tight places this 6 gallon vacuum is lightweight and portable. Heavy duty by-pass motor, paper bag, handle and cable are standard. Also available in 4 gallon model. Weight: 4 gallon 22¼ lbs. - 6 Gallon 24½ lbs



Model X-1000-15
3 stage by-pass motor and 4 stage filtering system purifies all vacuum and motor-cooling air of carbon dust and copper particles. Low noise level makes it ideal for dry only use in class 100 "white rooms". Carriage handle, casters and wheels standard. Weight: 69 lbs.



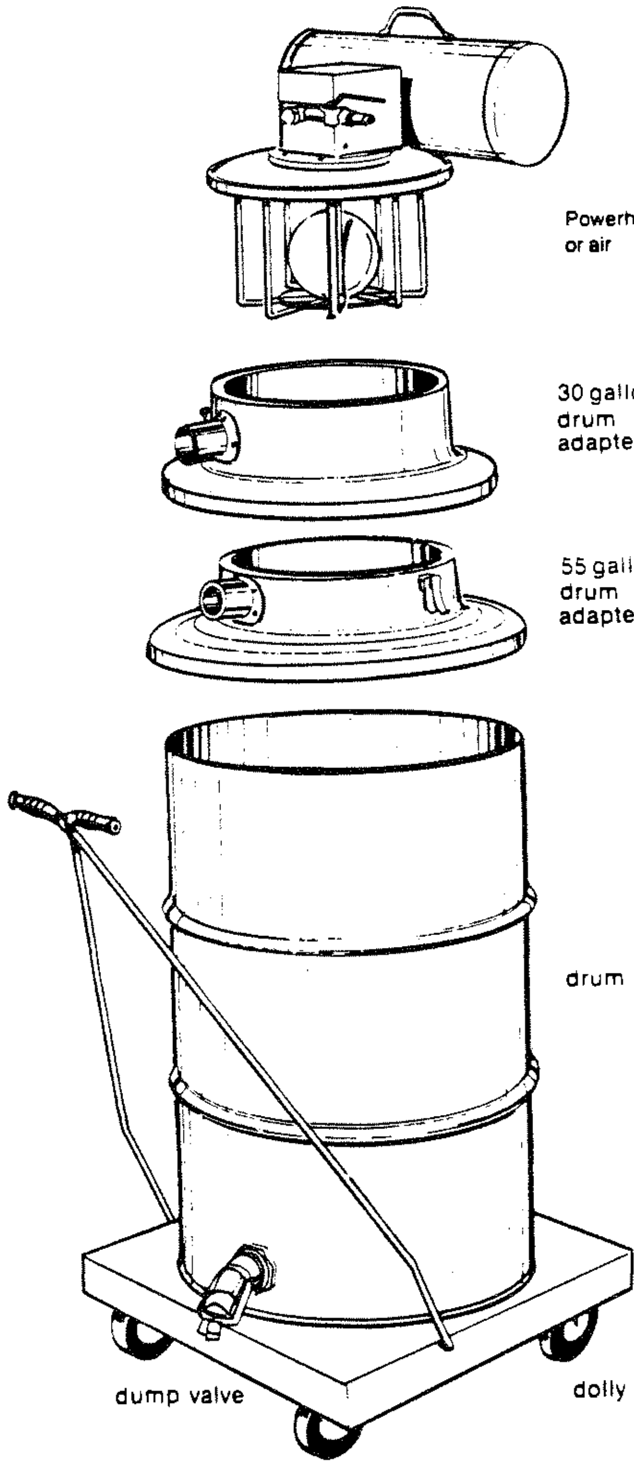
Model X-1000-30/55
May be used with disposable plastic bags for ultra safe handling of contaminates. Same features and applications as the model X-1000-15 but in 30 gallon and 55 gallon size. Weight. 30 gallon 107 lbs -55 gallon 122 lbs.



Model X-100
This wet/dry 15 gallon system features a filtered 3 stage by-pass motor that cools and circulates air with 99.97% efficiency to .3 microns. External filter box allows quick and easy cleaning of the H.E.P.A. filter. Also available in a 30 gallon capacity model. Weight: 15 gallon 87½ lbs. - 30 gallon 127 lbs.

Model X-1700-4/6
This lightweight, 4 gallon portable air-powered vacuum is so powerful it can be used as an emergency pump or power head vacuum with 55 gallon transfer drum/lid system when recovering large quantities. Requires ½" air line. Also available in 6 gallon size. Weight: 4 gallon 23 lbs. - 6 gallon 24 lbs

Options



Series 800 Critical Filter Vacs can accommodate numerous options to further expand the capabilities of each machine Drum adapters are available to enable the use of 15 gallon lids on both 30 and 55 gallon drums. When using a lid adapter, the position of the vacuum intake is in the adapter rather than on the side of the tank as it is on some models. This allows use of a disposable plastic liner bag which can be easily and quickly removed for disposal of picked up materials

Also, a disposable paper filter protector can be used on the 15 gallon lid. With this lid and appropriate adapters, both the plastic bag and filter protector can simplify waste disposal and extend filter life. When the cleaning job is finished the filter protector is dropped into the plastic bag to be discarded with waste material.

The absolute filter is adaptable to any of these configurations for the exhaust of pure air.

Also, please note the partial list of applications and materials which can be picked up by Series 800 Critical Filter Vacuums.

Applications:

- Nuclear Plants
- Hot Cells
- Hospital Critical Cleaning
- Biological Research Labs
- Pharmaceutical Research Labs
- White, Clean Rooms
- Industrial Lab White Rooms
- Convalescent Homes
- Instrument Manufacturing
- Pharmaceutical Manufacturing
- Battery Manufacturing
- Onboard Nuclear-Powered Ships

Specifications

These Hako-Minuteman 800 Series specifications provide the practical information to allow specific comparisons between models and sizes ranging from 4 to 55 gallons.

Please note on air vac specs that C.F.M. represents cubic feet per minute and P.S.I. represents pounds per square inch.

These figures are average only. Maximum allowable, pressure is 150 P.S.I.

Please note also that more detailed information on air vacuums is contained in Series 700 air vac literature.

H.E.P.A. (High Efficiency Particulate Air) filters are 99.97% effective at .3 microns.

H.E.P.A. filter meets or exceeds the following military and government specifications.
Mil-F-51079A
Mil-F-51068D
U0L Class 1 listed
U0L Std. 586 listed
A.E.C.—Regulatory Guide #1.51

Specifications subject to change without notice

	X-100 -15	X-100 -30	X-1700 -4	X-1700 -6	X-703 -15	X-703 -30	X-703 -55	X-1000 -4	X-1000 -6	X-1000 -15	X-1000 -30	X-1000 -55	MX-1000 Wet/Dry	MX-1000 Dry
Static Lift (Inches water)	88	88	218	218	218	218	218	88	88	88	88	88	88	88
Air Flow (C.F.M.)	128	128	166	166	166	166	166	95	95	128	128	128	128	128
Power (watts)	1180	1180	—	—	—	—	—	930	930	1180	1180	1180	1180	1180
Cord & Length	16-3/50'	16-3/50'	—	—	—	—	—	16-3/50'	16-3/50'	16-3/50'	16-3/50'	16-3/50'	16-3/50'	16-3/50'
Wet Capacity (gallons)	12	25	—	—	—	—	—	—	—	—	—	—	12	—
Dry Capacity (cu. ft.)	1.87	4.36	.21	1.56	.82	4.36	7.15	.21	.62	1.87	4.36	7.85	2.07	2.07
Filter Area Total Square Inches	5332	5332	2226	2300	4120	4120	4120	1769	2226	20582	20582	20582	20582	20582
Overall Height	35"	48"	19"	24"	33"	45"	51"		25"	35"	47"	53"	93"	93"
Width	21"	24"	14"	14"	21"	25"	25"	14"	14"	21"	25"	25"	21"	21"
Volts Standard/Optional	115/220	115/220	—	—	—	—	—	115/220	115/220	115/220	115/220	115/220	115/220	115/220
Wheels	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Wheel Size Front/Rear	3"/8"	5"/5"	—	—	3"/8"	5"/5"	5"/5"	—	—	3"/8"	5"/5"	5"/5"	3"/8"	3"/8"
Wet/Dry	Yes	Yes	—	—	—	—	—	—	—	—	—	—	Yes	Opt.
Dry Only	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	Yes
Weight (pounds)	87½	127	23	24	51	98	113	22¼	24½	69	107	122	86	83
Air Pressure — P.S.I.	—	—	90	90	90	90	90	—	—	—	—	—	—	—
Compressed Air Flow — S.C.F.M.	—	—	42	42	42	42	42	—	—	—	—	—	—	—

We offer a complete line of attachments, special tools and accessories for all Hako-Minuteman vacuums. See tools, parts and accessories catalog.

Hako Minuteman

111 South Route 53, Addison, Illinois 60101 • Phone (312) 627-6900

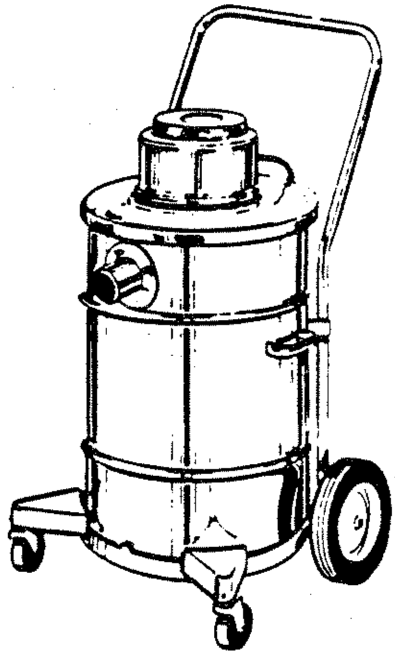
THE FULL LINE OF • Industrial/Commercial/Institutional and Critical Filter Vacs • Sweepers • Scrubbers • Floor/Carpet Machines

Printed in U.S.A. 12-83-30M

Series 800 Critical Filter Vacuums

Asbestos Vac 15

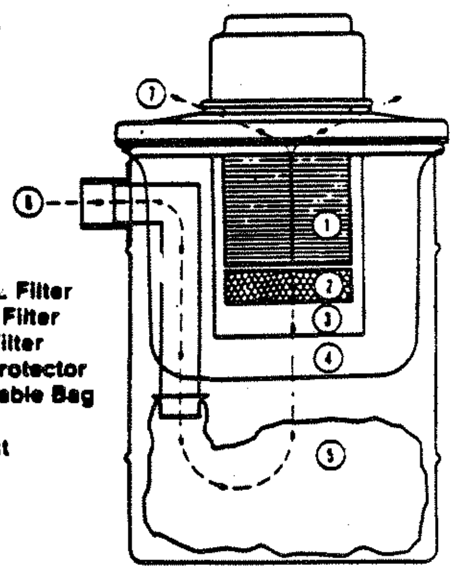
Order No.	General Description	Price
C80315-01	Minuteman Asbestos Vac — H.E.P.A. Filter Vacuum (115V 15 Gal. Stainless Steel, Dry Only) Includes 750219—Lid Assembly (115V) w/H.E.P.A. Filter 805015—Cloth Filter 750221—Tank Assembly Stainless Steel 15 gal. 380049PLT—Bag frame 110121PKG—Impact filters (12) 805038PKG—Filter Protectors (12) 760598PKG—Disposable Bags (10) 761042PKG—Plastic Bags (50)	
	110010—H.E.P.A. (Replacement)	
C80315-02	Minuteman Asbestos Vac — H.E.P.A. Filter Vacuum (220V 15 Gal. Stainless Steel, Dry Only) Same as (C-80030-01) except 750188 lid assembly (220V)	
C80315-03	Minuteman Asbestos Vac — H.E.P.A. Filter Vacuum (115V 15 Gal. Painted, Dry Only) Includes 750219—Lid Assembly (115V) w/H.E.P.A. filter 805015—Cloth Filter 750220—Tank Assembly Painted, 15 gal. 380049PLT—Bag Frame 110121PKG—Impact filter (12) 805038PKG—Filter Protectors (12) 760598PKG—Disposable Bags (10) 761042PKG—Plastic Bags (50)	
	110010—H.E.P.A. (Replacement)	
C80315-04	Minuteman Asbestos Vac — H.E.P.A. Filter Vacuum (220V. 15 Gal.. Painted, Dry Only) Same as (C80030-01) except 760188 lid assembly (220V)	



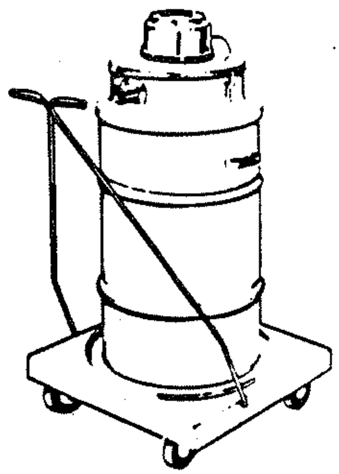
ASBESTOS VACUUMS

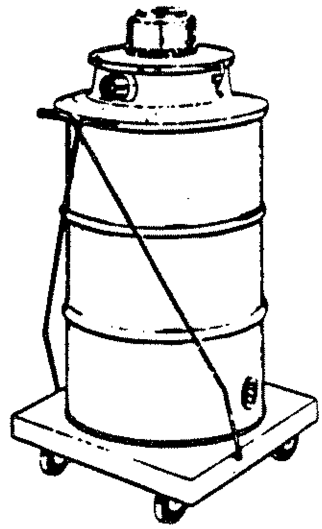
Because it meets or exceeds OSHA requirements for cleaning the air of asbestos and other toxic and noxious dusts, this dry-only vacuum can be used in offices, schools and industrial areas where daily or weekly removal of sub-micron particles is necessary. Each Minuteman Asbestos Vacuum contains 5 different filters: disposable paper bag coarse filter (standard in 15 gal. models) for the bulk of the particles, impact filter, H.E.P.A. filter, primary cloth filter and paper filter protector. Heavy-gauge plastic drum-liner bags may be used in the 30 and 55 gallon models to safely remove large-volume pick-ups. While specifically designed for asbestos particles, this vacuum is also effective in filtering other airborne pollutants such as cement, foundry and lime kiln dusts, insecticides, fertilizer dusts, coal dust, limestone dusts, and many others. With an efficiency rating of 99.999% on particles of 5 micrometers, the Asbestos Vacuum is particularly useful for cleaning up after insulation operations in pipes, in removing asbestos-covered ceiling dust to prevent "snowing" and for vehicle maintenance procedures involving brakes, clutches and other asbestos-loaded material. Each unit features a 2 stage by-pass motor, front casters, 8" rear wheels and a carriage handle. An optional filter tool kit is recommended for each unit.

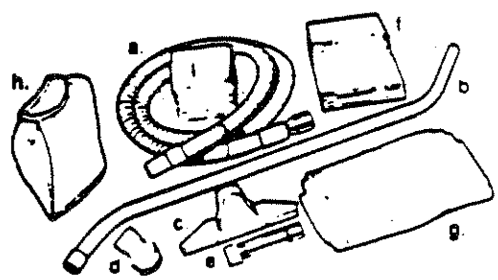
1. H.E.P.A. Filter
2. Impact Filter
3. Cloth Filter
4. Filter Protector
5. Disposable Bag
6. Intake
7. Exhaust



Order No.	General Description	Price
	Vacuum Accessories Use for liquid pick-up 110902—Adapter (Painted) 110901—Adapter (Stainless Steel) 110406—Water Shut-Off	
C80330-01	Minuteman Asbestos Vac—H.E.P.A. Filter Vacuum (115V, 30 Gal. Painted, Dry Only) Includes: 750219—Lid Assembly (115V) w/H.E.P.A. Filter 805047—Cloth Filter C80601-70—Adapter Ring (30 gal.) C90007-80—Tank Assembly Painted, 30 gal. 900048—Dolly Car 110121PKG—Impact filter (12) 805038PKG—Filter Protectors (12) 805037PKG—Plastic Drum liners (12)	
	110010—H.E.P.A. filter (Replacement)	
C80380-02	Minuteman Asbestos Vac — H.E.P.A. Filter Vacuum (220V, 30 Gal., Painted, Dry Only) Same as (C-80030-01) except 750188 lid assembly (220V)	
C80355-01	Minuteman Asbestos Vac — H.E.P.A. Filter Vacuum (115V, 55 Gal., Painted, Dry Only) Includes: 750219—Lid Assembly (115V) w/H.E.P.A. filter 805047—Cloth Filter C80601-80—Adapter Ring (55 gal.) 900015PTD—Tank Assembly Painted, 55 gal. 900048—Dolly Cart 110121PKG—Impact filters (12) 805038PKG—Filter Protectors (12) 805048PKG—Plastic Drum liners (12)	
	110010—H.E.P.A. (Replacement)	
C80355-02	Minuteman Asbestos Vac — H.E.P.A. Filter Vacuum (220V, 55 Gal., Painted, Dry Only) Same as (C80355-01) except 750188 lid assembly (220V)	
805580	#7a Tool Kit For Asbestos Vac (1½", Dry only) Includes: a. 801010—10' x 1½" Hose b. 800015—1½" Wand (Operator's handle) c. 800070—Gulper Tool d. 800024—3" Round Brush e. 800116—1½" x 8" Swivel Connector f. 760598PKG—10 Disposable Paper Bags g. 761042PKG—50 Plastic Bags h. 805038PKG—12 Filter Protectors i. 110121PKG—12 Impaction Pre-Filters *No substitution of tools*	



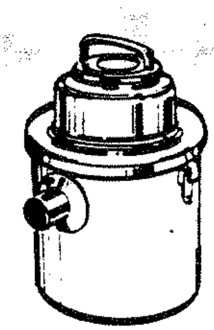




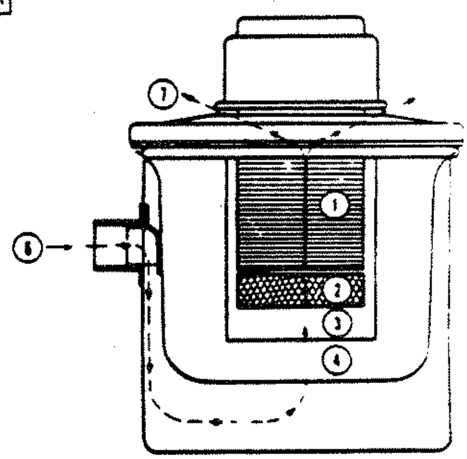
Series 800 Critical Filter Vacuums (Dry Only)

Order No	General Description	Price	X-1000-4 STAINLESS TANK 115V	X-1000-4 STAINLESS TANK 220V	X-1000-4 PAINTED TANK 115V	X-1000-4 PAINTED TANK 220V
C80104-01	(X-1000-4) — (115V, **Stainless Steel**, 4 Gal., Dry Only)		✓			
C80104-02	(X-1000-4) — (220V, **Stainless Steel**, 4 Gal., Dry Only)			✓		
C80104-03	(X-1000-4) — (115V, **Painted**, 4 Gal., Dry Only)				✓	
C80104-04	(X-1000-4) — (220V, **Painted**, 4 Gal., Dry Only)					✓
	Includes: 387000—Lid Assembly (115V) with H.E.P.A. Filter		Yes	—	Yes	—
	387220—Lid Assembly (220V) with H.E.P.A. Filter		—	Yes	—	Yes
	110010—H.E.P.A. Filter		*(Replacement)*			
	110121PKG—Impact Filter (Pkg. 12)		Yes	Yes	Yes	Yes
	908001—Tank Assembly—Stainless Steel, 4 Gal.		Yes	Yes	—	—
	908002—Tank Assembly — Painted, 4 Gal.		—	—	Yes	Yes
	805044—Cloth Filter		Yes	Yes	Yes	Yes
	761177PKG—Filter Protectors (Pkg. 12)		Yes	Yes	Yes	Yes
	384009PLT—Bag frame		Yes	Yes	Yes	Yes
	804000—Hose 1¼" x 10'		Yes	Yes	Yes	Yes
	804005—Crevice Tool		Yes	Yes	Yes	Yes
	804006—3" Round Dusting Brush		Yes	Yes	Yes	Yes
	804015—5" Upholstery Tool		Yes	Yes	Yes	Yes
	804008—Plastic Tool Adapter		Yes	Yes	Yes	Yes
	750003—Wheel Bracket		Opt	Opt	Opt	Opt

Yes = Standard. Opt. = Optional



MODEL X-1000-4
To recover small quantities in tight places, this 4 gal. critical filter vacuum is lightweight, portable. Contains H.E.P.A. filter, cloth filter bag and heavy-duty by-pass motor. Fits 1¼" and 1½" tools. Handle and 50 ft. 16-3 cable are standard.



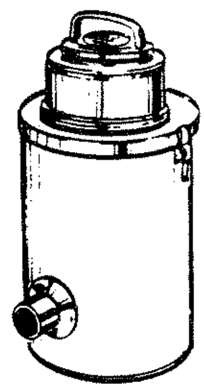
① **H.E.P.A. Filter**
② **Impact Filter**
③ **Cloth Filter**
④ **Filter Protector**
⑥ **Intake**
⑦ **Exhaust**

Series 800 Critical Filter Vacuums (Dry Only)

X-1000-6

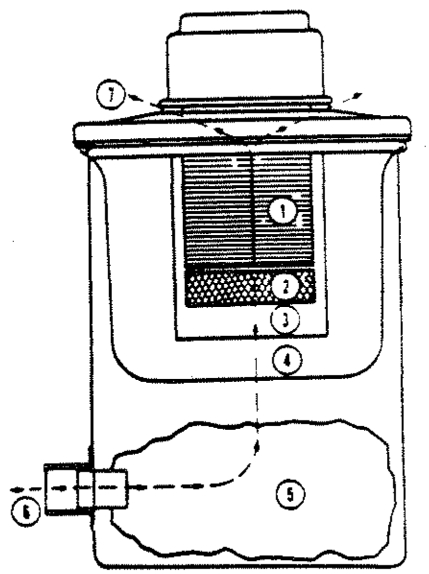
Order No	General Description	Price	X-1000-6 STAINLESS TANK 115V	X-1000-6 STAINLESS TANK 220V	X-1000-6 PAINTED TANK 115V	X-1000-6 PAINTED TANK 220V
C80106-01	(X-1000-6) — (115V, **Stainless Steel**, 6 Gal., Dry Only, w/paper bags)		✓			
C80106-02	(X-1000-6) — (220V, **Stainless Steel**, 6 Gal., Dry Only, w/paper bags)			✓		
C80106-03	(X-1000-6) — (115V, **Painted**, 6 Gal., Dry Only, w/paper bags)				✓	
C80106-04	(X-1000-6) — (220V, **Painted**, 6 Gal., Dry Only, w/paper bags)					✓
	Includes: 387000—Lid Assembly (115V) with H.E.P.A. Filter		Yes	—	Yes	—
	387220—Lid Assembly (220V) with H.E.P.A. Filter		—	Yes	—	Yes
	110010—H.E.P.A. Filter		*(Replacement)*			
	110121PKG—Impact Filter (Pkg. 12)		Yes	Yes	Yes	Yes
	907003—Tank Assembly—Stainless Steel 6 Gal.		Yes	Yes	—	—
	907004—Tank Assembly—Painted, 6 Gal.		—	—	Yes	Yes
	805041—Cloth Filter		Yes	Yes	Yes	Yes
	761177PKG—Filter Protectors (Pkg. 12)		Yes	Yes	Yes	Yes
	384003PKG—Disposable Bag (Pkg. 10)		Yes	Yes	Yes	Yes
	380049PLT—Bag frame		Yes	Yes	Yes	Yes
	804000—Hose 1¼" x 10'		Yes	Yes	Yes	Yes
	804005—Crevice Tool		Yes	Yes	Yes	Yes
	804006—3" Round Dusting Brush		Yes	Yes	Yes	Yes
	804015—5" Upholstery Tool		Yes	Yes	Yes	Yes
	804008—Plastic Tool Adapter		Yes	Yes	Yes	Yes
	750003—Wheel Bracket		Opt	Opt	Opt	Opt

Yes = Standard. Opt. = Optional



MODEL X-1000-6

Lightweight portable vacuum with 6 gallon tank and many of the same features as X-1000-4. Additional equipment includes 5" taller size and disposable paper bag inside which traps material for testing or safe disposal.



1. **H.E.P.A. Filter**
2. **Impact Filter**
3. **Cloth Filter**
4. **Filter Protector**
5. **Disposable Bag**
6. **Intake**
7. **Exhaust**

Minuteman

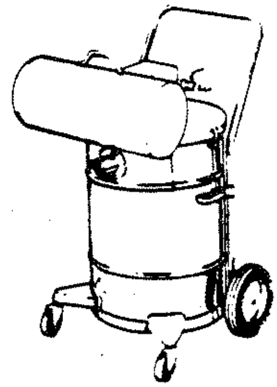
Effective 5/1/84

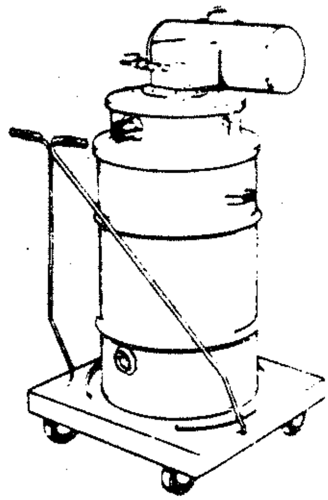
See Vacuum Tools and Attachments for accessories

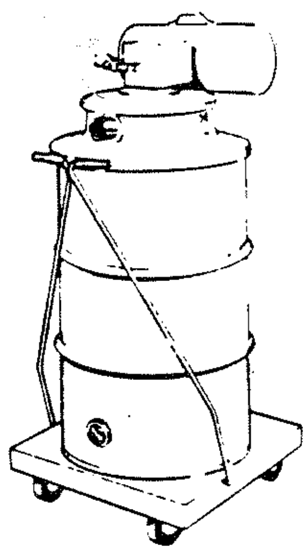
Series 800 Critical Filter Vacuums (Air Operated)

X-703-15/30/55

Order No	General Description	Price
C87015-01	**(X-703-15) Air-Vac — H.E.P.A. Filter Vacuum** (Air Powered, 15 Gal., **Stainless Steel**, Dry Only) Includes: **750300—Lid Assembly** **805047—Cloth Filter** **750382—Tank Assembly Stainless Steel, 15 gal.** **750604—H.E.P.A. Filter Assembly**	
	110001—H.E.P.A. (Replacement)	
	703007PKG—Pre-filter (Replacement Pkg. 12)	
C87015-02	**(X-703-15) Air-Vac — H.E.P.A. Filter Vacuum** (Air Powered, 15 Gal., **Painted**, Dry Only) **Same as (C87015-01) except** **750381 tank assembly Painted**	
C87030-01	**(X-703-30) Air-Vac — H.E.P.A. Filter Vacuum** (Air Powered, 30 Gal., **Painted**, Dry Only) Includes: **750300—Lid Assembly** **805047—Cloth Filter** **750604—H.E.P.A. Filter Assembly** **C80601-70—Adapter Ring (30 gal.)** **C90007-80—Tank (30 gal.)** **900048—Dolly Cart**	
	110001—H.E.P.A. (Replacement)	
	703007PKG—Pre-filter (Replacement Pkg. 12)	
C87055-01	**(X-703-55) Air-Vac — H.E.P.A. Filter Vacuum** (Air Powered, 55 Gal., **Painted**, Dry Only) Includes **750300—Lid Assembly** **805047—Cloth Filter** **750604—H.E.P.A. Filter Assembly** **C80601-80—Adapter Ring (55 gal.)** **900015PTD—Tank (55 gal.)** **900048—Dolly Cart**	
	110001—H.E.P.A. (Replacement)	
	703007PKG—Pre-filter (Replacement Pkg. 12)	







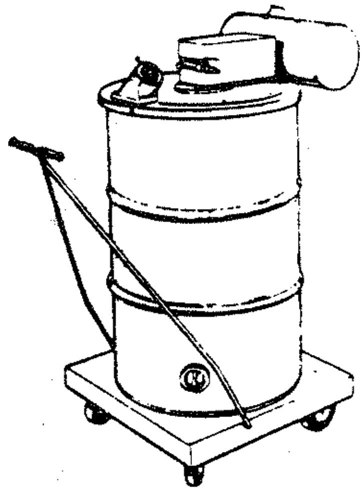
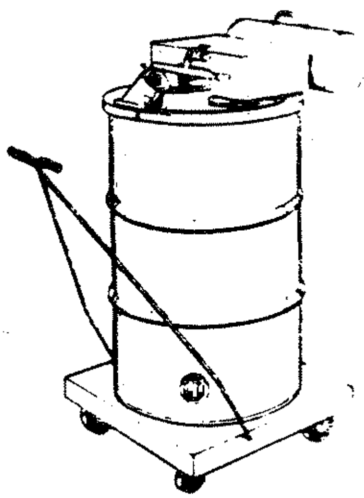
Prices and specifications subject to change without notice.

Prices F.O.B. Addison, IL

Printed in U.S.A.

Series 800 Critical Filter Vacuums (Air Operated)

X-701/X-702/55

Order No	General Description	Price	
C87155-01	Minuteman-Air-Vac (Model X-701) (55 Gal., Painted, Dry Only) Includes: 701100—Lid Assembly with Silencer/H.E.P.A. filter 805024—Filter 900015PTD—Tank (55 Gal.) 900048—Dolly Cart		
	110001—H.E.P.A. (replacement)		
C87255-01	Minuteman-Air-Vac (Model X-702) (55 Gal., Painted, Dry Only) Includes: 702112—Lid Assembly with Silencer/H.E.P.A. filter 805024—Filter 900015PTD—Tank (55 Gal.) 900048—Dolly Cart		
	110001—H.E.P.A. (replacement)		

Safe-T-Vac VACUUM CLEANER

Makes hazardous cleanup faster, safer, and less costly than ordinary HEPA-filtered vacuum cleaners.

You won't find another hazardous material vacuum cleaner like the SAFE-T-VAC.™ Anywhere. At any price.

A vacuum with an automatic filter cleaning system that keeps it operating at near 100% efficiency. One that conveys all material directly into a plastic disposal bag so workers can't be exposed to stray toxic dust. A vacuum that sucks excess air out of the bag before it's sealed so you can haul away more bags in fewer trips.

Check the SAFE-T-VAC's™ long list of exclusive features. Then check the competition. You'll find the SAFE-T-VAC™ is more flexible, provides a greater margin of safety, and costs less to operate.

Modular design for extra convenience

The SAFE-T-VAC™ is a powerful, twin-motor vacuum with 80″ H_2O suction and 200 cfm air flow. It rolls easily to the cleanup site and plugs into any 110V outlet.

The SAFE-T-VAC™ also mates with a companion back pack vacuum (see back page) that's perfect for close-up cleaning in hard to reach areas where long hose runs would cause excessive suction loss.

Each unit can be purchased separately, or combined for a total cleaning system. Both are available with or without HEPA filtration for use with hazardous materials.

Sealed system for maximum safety

Other vacuum cleaners, even high-priced HEPA units, potentially expose the worker to harmful dust when they're emptied. But the SAFE-T-VAC™ is a completely closed system. Once material is sucked into the hose, it's never seen again. Everything is collected in a thick, non-porous polyethylene bag. When it's ready for removal, excess air is sucked out of the bag and the operator seals the neck shut. The bag slides off the filler tube without exposing the worker to any hazardous materials.

Even the back pack unit empties safely and conveniently. When full, it plugs into a special inlet on the SAFE-T-VAC™ and it's vacuumed clean. No bags to remove. No chance for dust to escape.

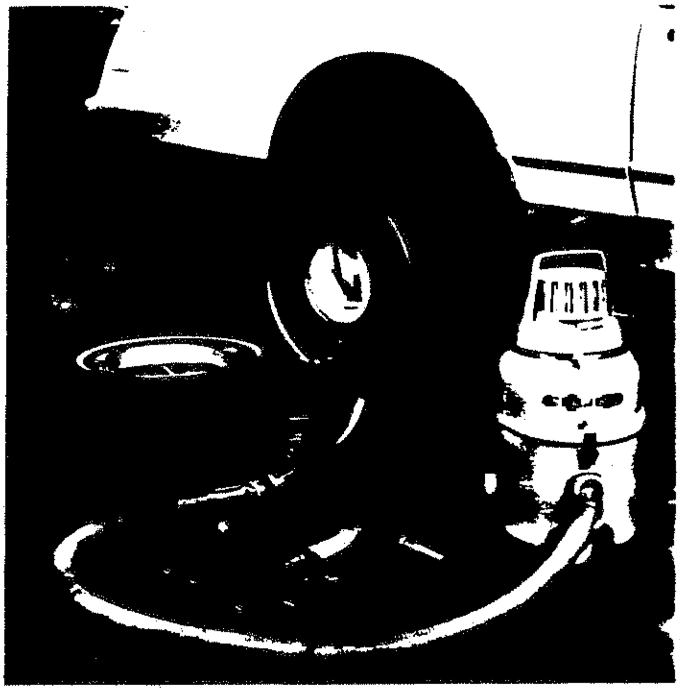
Patented "pulser" keeps filters clean and reduces downtime

Very fine dust quickly clogs ordinary vacuum cleaner filters. It reduces their suction and requires frequent shutdowns for filter cleaning or replacement.

But the SAFE-T-VAC™ uses a patented "pulser" system that blasts reverse air back through the primary filter, knocking trapped particles into the collection bag. The process is completely automatic. And it lets the SAFE-T-VAC™ run at near 100% efficiency and maintain its high air flow for longer periods of time.

All collected material, including dust from the filters, collects in a 6 mil polyethylene bag. During removal, excess air is sucked out of the bag while it's being tied off at the neck. Only then is it slipped off the filler tube, eliminating the chance of the operator coming in contact with any hazardous dust or material.

NILFISK OF AMERICA, INC.

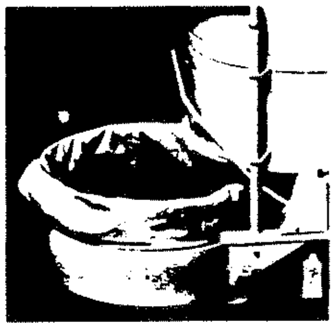


Asbesto-Clene System 400. Recommended with vacuum Model GS 81 wherever volume passenger car/light truck brake lining work is done. Comes with stand for use with low jacks

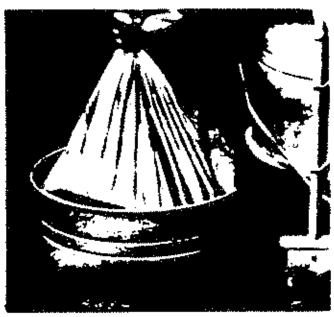
Asbesto-Clene System 600. Recommended with vacuum Model GS 83 wherever volume brake lining work is done on large commercial vehicles. Comes with stand for use with low jacks

Easy disposal of asbestos dust

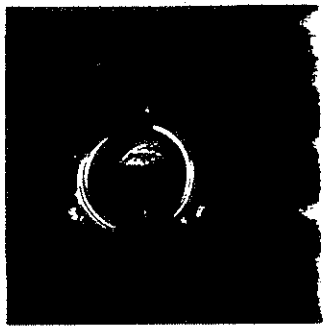
1. External shaking handle releases all debris from filter. Dust collects in enclosed container.



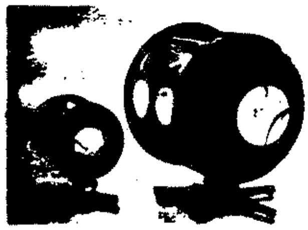
2. Lower the container which holds either polyliners or disposable bags



3. Seal polyliner or bag for safe disposal



Optional Manometer (on Models GS 82 and GS 83) alerts mechanic when filter needs to be shaken. Cleaning the filter regularly maintains high suction and filtration efficiency and extends filter service life.



Customized encapsulators, for oversize or off-the-road vehicles, are available by special order.

ASBESTO-CLENE® COMPONENTS	Heavy Duty Systems			Light Duty Systems		
	System 400	System 500	System 600	System 400(80i)	System 500(80i)	System 600(82)
Model GS 80i Vacuum, 2½ gal. capacity						
Model GS 81 Vacuum, 4 gal. capacity						
Model GS 82 Vacuum, 12 gal. capacity						
Model GS 83 Vacuum, 18 gal. capacity						
No. 400 Encapsulator						
No. 600 Encapsulator						
Low Stand						
High Lift Stand						
Microfilters						
HEPA or Super-HEPA Filters						
10' Hose, 1½" ID						
10' Hose, 2" ID						
Disposable Filter Bags						
Sealable Polyliners						
Manometer (Optional)						

Other vacuum cleaner attachments available for routine cleanup applications

HEPA or Super-HEPA Filtration.

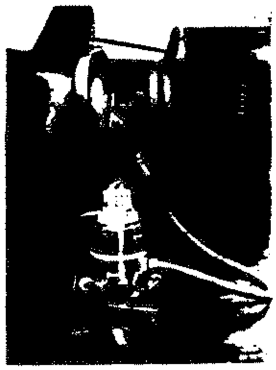
Nilfisk offers a choice of HEPA filters. Our standard HEPA filter retains 99.97% of all particles down to and including 0.3 microns in size. Our Super-HEPA, the ultimate in filtration efficiency, retains 99.9995% of all particles 0.12 microns or larger. Both filters meet and exceed the new OSHA standard for the control of asbestos dust in brake repair and maintenance operations (29 CFR 1910.1001 Appendix F).

National Representatives.

Nilfisk has a nationwide network of representatives, all thoroughly familiar with government codes and regulations dealing with the safe cleanup of asbestos dust. For more information or to contact your nearest Nilfisk representative for specific recommendations, call or write: Nilfisk of America, Inc., 300 Technology Drive, Malvern, PA 19355. (215) 647-6420.

Other Nilfisk Asbesto-Clene Systems for Light Duty

Asbesto-Clene System 400(80i). Recommended with vacuum Model GS 80i for use in garages where only occasional brake lining work is done. Comes with stand for use with low jacks.



Asbesto-Clene System 500(80i). Same as system 400 (80i) except encapsulator stand is for vehicles up on hydraulic lifts.

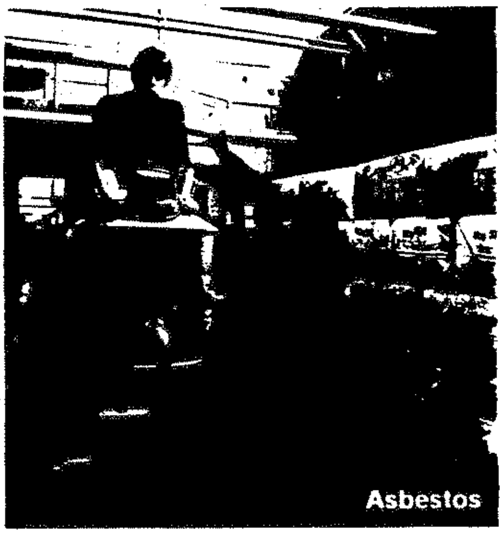
Asbesto-Clene System 600(82). Recommended for garages where only occasional brake lining work is done on large commercial vehicles with brake drums in the 10 to 19 diameter range double wheel assemblies. Comes with stand for use with low jacks.

Dust Collection Specialists Since [illegible]

Nilfisk simplifies the safe collection and disposal of toxic, hazardous, and nuisance waste materials.

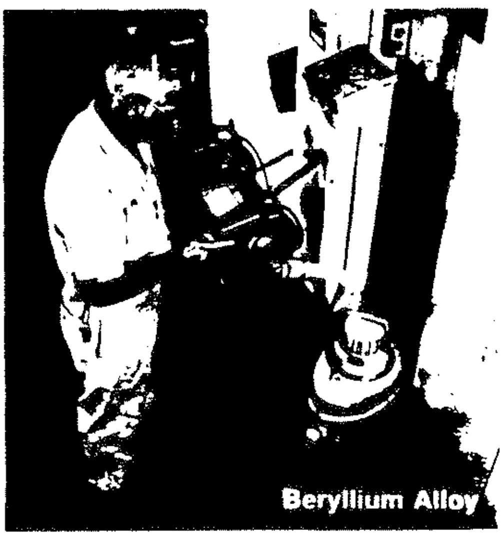
Unique absolute [illegible] system meets [illegible] OSHA safety stand[illegible] fo[illegible] materials a[illegible] asbestos, silica, [illegible] beryllium all[illegible] cotton du[illegible] health endang[illegible]

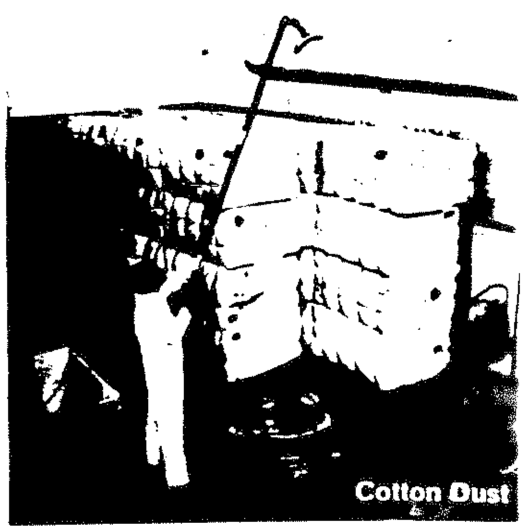

Lead


Asbestos

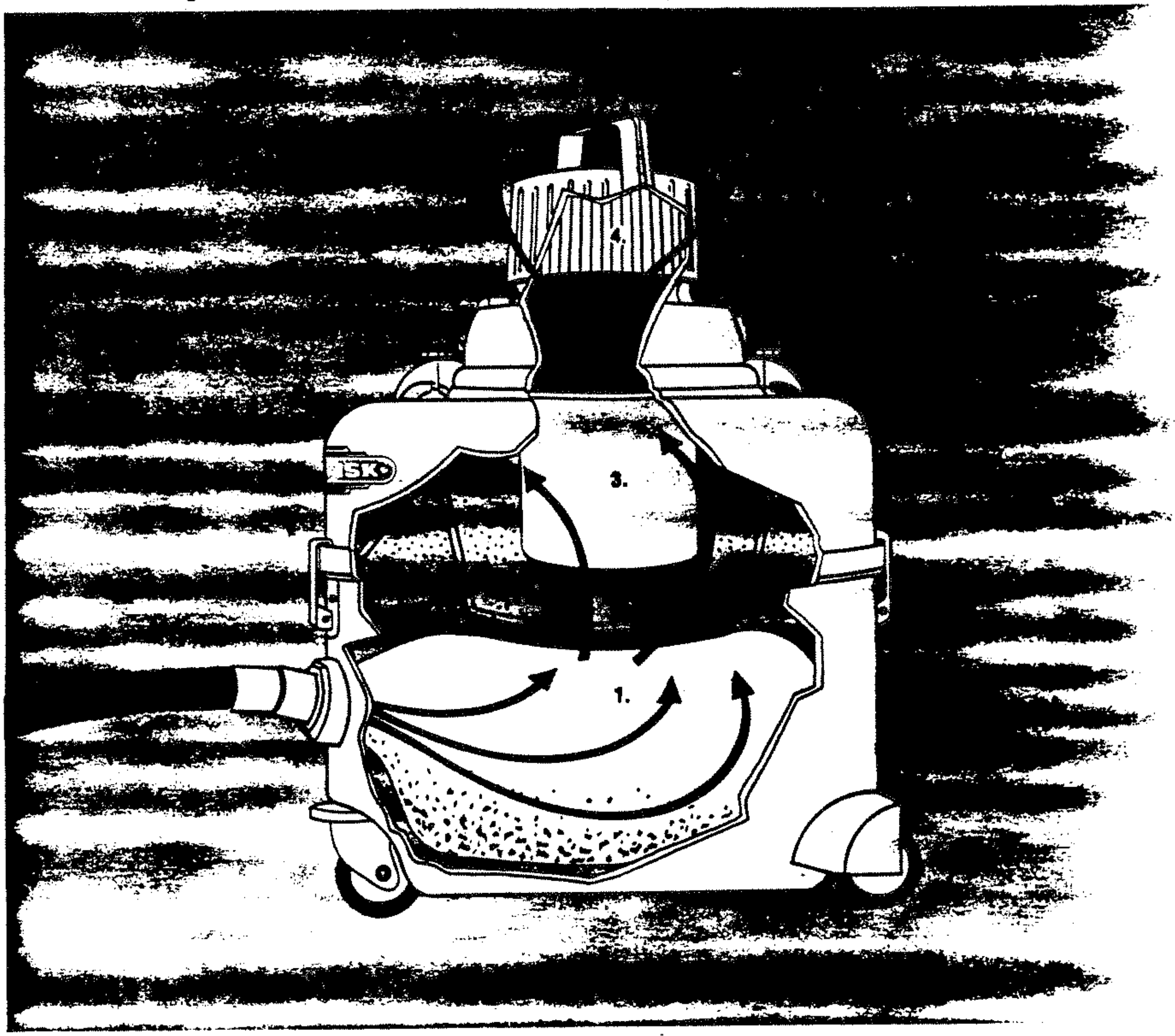

Silica


Mercury


Beryllium Alloy


Cotton Dust

Nilfisk Filtering System traps toxic and hazardous dust with up to 99.9995% retention efficiency down to 0.12 microns.



Nilfisk portable dust collectors / industrial vacuums deliver this absolute filtration with minimal loss of suction and without the risk of motor burn-out. They trap even ultra-fine dusts and return "absolutely" clean air to the work environment. Here's how the absolute filtering system works:

1. First Stage Separation — The centrifugal or "cyclonic" airflow pattern of the cleaner aerodynamically separates heavier dust from collected fines.

2. Main Filter — Powerful suction coupled with extra-large filtering surfaces ensures a steady, even airflow which prolongs filter life and eliminates premature clogging. Optional manometer on larger models detects build-up of dust and alerts the operator to shake the main filter. Exclusive external handle allows the operator to purge the filter without the danger of secondary exposure to collected dust since the cleaner remains sealed.

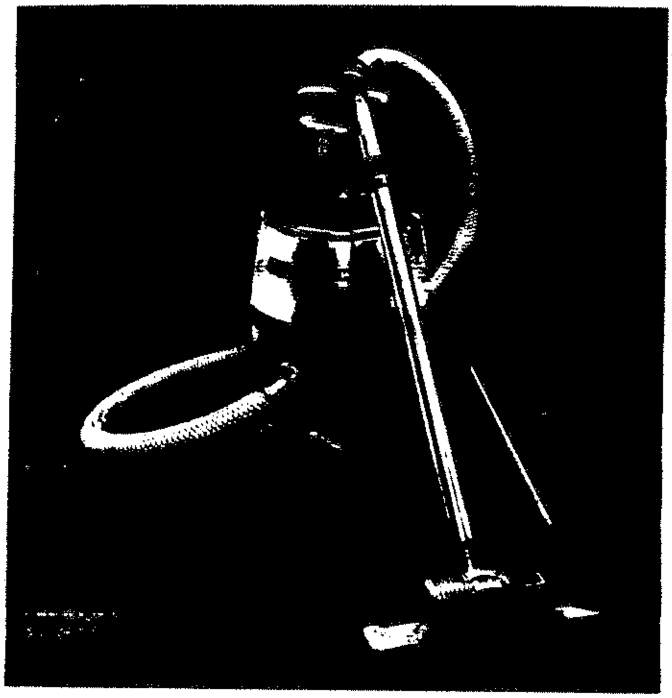
3. Microfilter — Final pre-filtering protection for the motor is provided by a microfilter with a retention efficiency of 99.5% at 2 microns.

4. "Absolute" Exhaust Filters—Nilfisk High Efficiency Particulate Air (HEPA*) or Super HEPA (ULPA-Ultra Low Penetration Air) filters further increase retention efficiencies to absolute standards of up to 99.9995% at 0.12 microns. The dust is collected in sealable bags for safe disposal.

Nilfisk portable dust collectors have design advantages that make them ideal for the safe collection and disposal of toxic, hazardous, and nuisance waste materials in any work environment — from laboratories and clean rooms to manufacturing and processing facilities. These design advantages include:

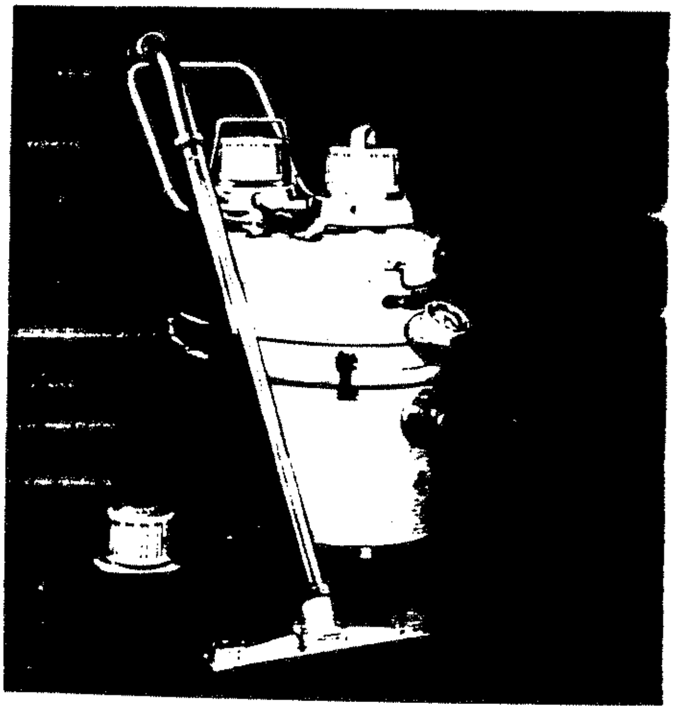
- clog resistance
- absolute filtering
- dust-free disposal
- powerful suction
- large recovery capacity
- low noise level

 *Retention efficiency 99.97% at 0.3 microns or larger

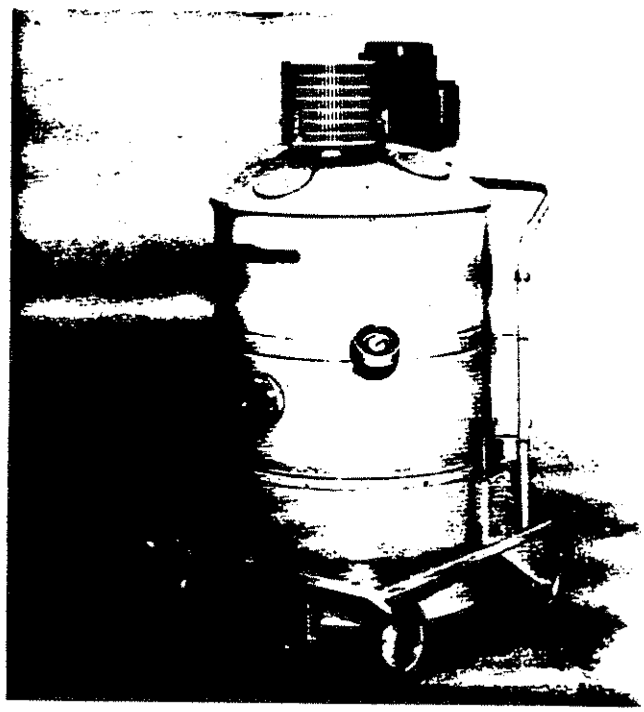


Handy small-sized unit with big-power cleanup. The GS 80 goes anywhere for fast, safe cleanup. Ideal for use at individual work stations. Has a disposable bag capacity of 2¼ gallons dry-bulk.

Greater capacity with greater durability. The GS 81 is a larger, heavy-duty unit that is easily maneuvered even where space is restricted. Has a disposable bag capacity of 4 gallons dry-bulk.

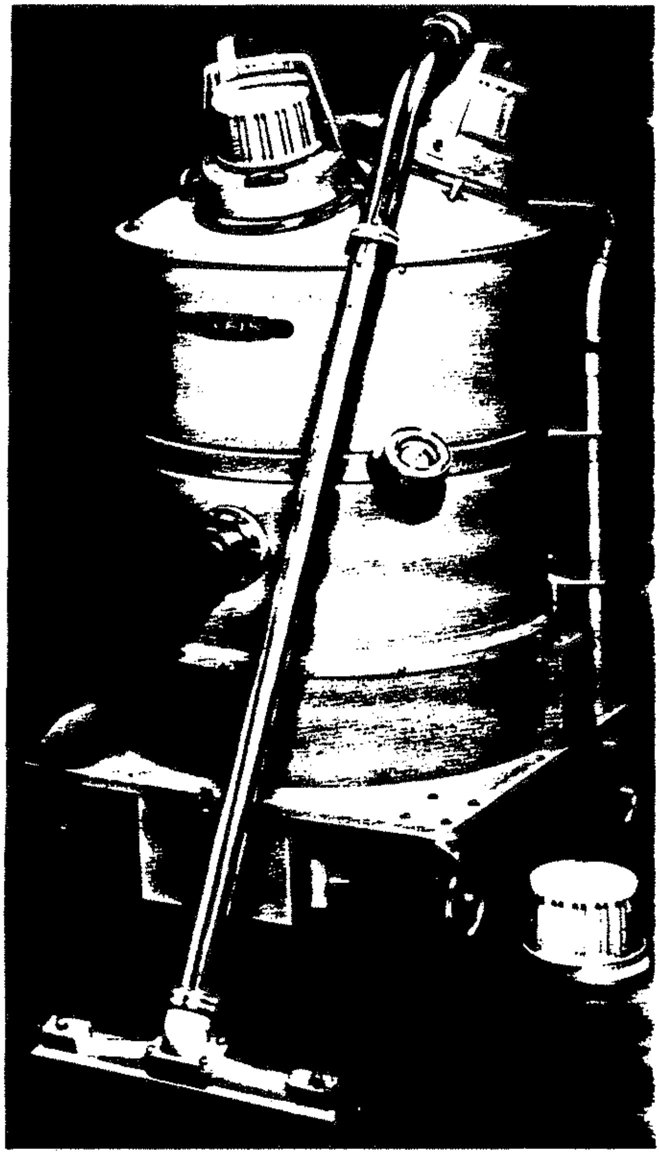


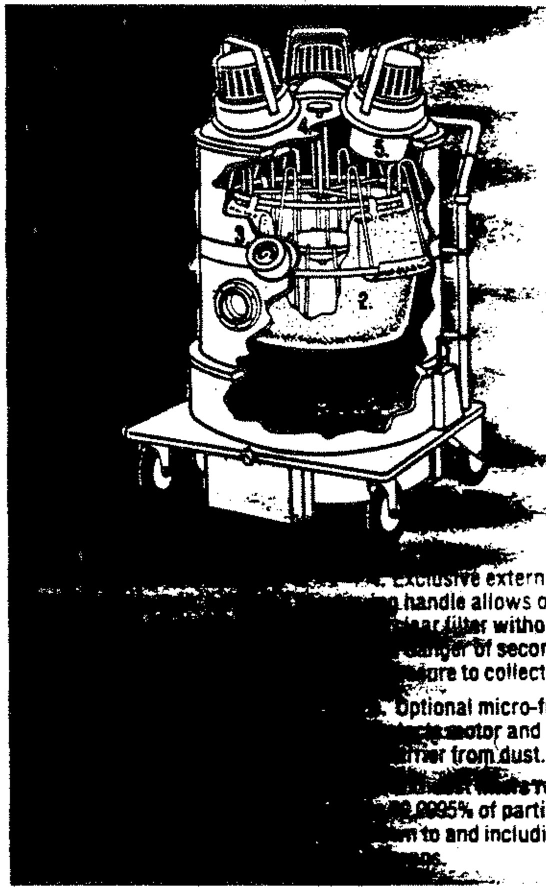
Ruggedness and versatility in a medium-sized unit. The GS 82 has the suction capacity to handle a wide range of tough cleanup assignments. Delivers a capacity of 12 gallons dry-bulk.



Heavy-duty, performance. The GB 733 has the power and capacity to handle any cleanup assignment. Three-phase induction motor permits continuous recovery of dusts in either built-in or mobile applications. Disposable bag capacity of 18 gallons dry-bulk.

NILFISK
GS 83





Big performance and capacity with ease of handling. The GS 83 brings big performance and capacity to toxic waste cleanup. Practical design ensures ease of handling. Powerful centrifugal airflow maintains optimum suction for continuous operating efficiency — either as a portable cleaning system or as a fixed dust collector. Has a disposable bag capacity of 18 gallons dry-bulk.

Optional Manometer

(On models GS82 & GS83) Alerts operator when filter needs to be shaken. Cleaning the filter regularly maintains high suction and filtration efficiency and extends filter service life.

Easy, dust-free disposal of debris

1. Use external agitator handle to shake all debris off filter into sealed container.

2. Lower the container (bottom of vacuum) to floor. Disposable polyliners are available to fit container.

3. Debris is now captured in the easily sealed heavy-gauge polyliner.

Nilfisk
Mercury Vacuum Cleaner

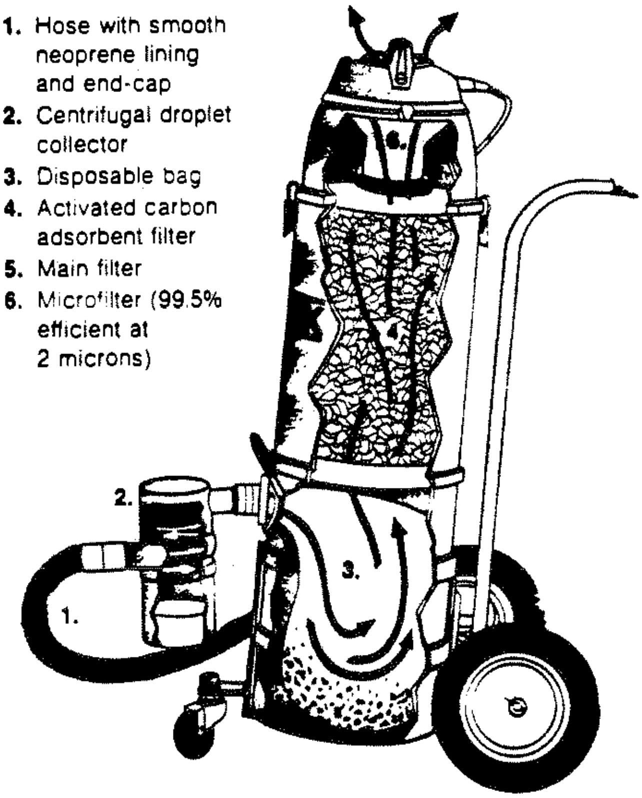
Nilfisk has developed a completely portable mercury recovery system to eliminate the hazards of mercury spills in laboratories and manufacturing facilities.

The system handles both liquid mercury and mercury compounds. Powerful suction capacity and well engineered cleaning tools ensure quick cleanup of spills even in hard-to-reach places. The centrifugal droplet separator has been designed to collect liquid mercury in an unbreakable plastic bottle for future re-use or disposal. An airtight cover for sealing a filled recovery bottle is also supplied. Smooth neoprene hose-lining reduces droplet residue in the hose.

Large five-gallon stainless steel container with disposable bag provides additional recovery capacity for large spills, dust and debris. A thirty-pound charge of specially activated carbon effectively eliminates harmful mercury vapor from the vacuum exhaust. Generally, a carbon cartridge charge will last for two years before needing replacement.

The Nilfisk mercury recovery system meets or exceeds OSHA standards for inorganic mercury. Optional high efficiency particulate air (HEPA) filters ensure "absolute" retention of mercury compound dusts and other contaminants. [illegible] particulate and vapor filters are easily replaced.

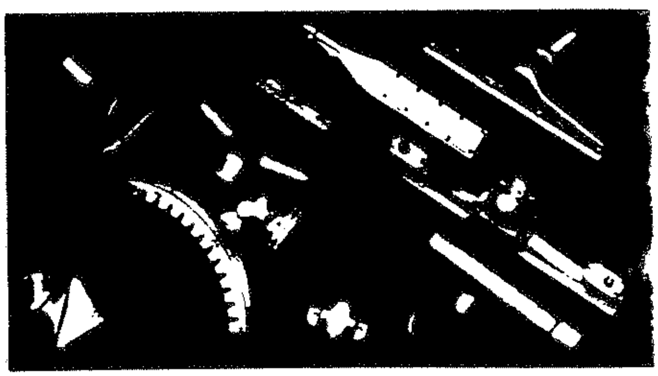
1. Hose with smooth neoprene lining and end-cap
2. Centrifugal droplet collector
3. Disposable bag
4. Activated carbon adsorbent filter
5. Main filter
6. Microfilter (99.5% efficient at 2 microns)



Complete line of accessories

Nilfisk portable dust collectors can be fitted with a complete line of accessories to handle practically any kind of cleaning situation. Special accessories include attachments for floors, machinery, equipment, overhead pipes, walls, shelving, and just about anything or anyplace where dust collects.

All Nilfisk nozzles are engineered to deliver optimum suction power at the pickup point. All hose-ends have swiveling ball-joint couplings to permit full freedom of movement. The couplings also help to prolong hose life by reducing knots and kinks that can develop during heavy use.

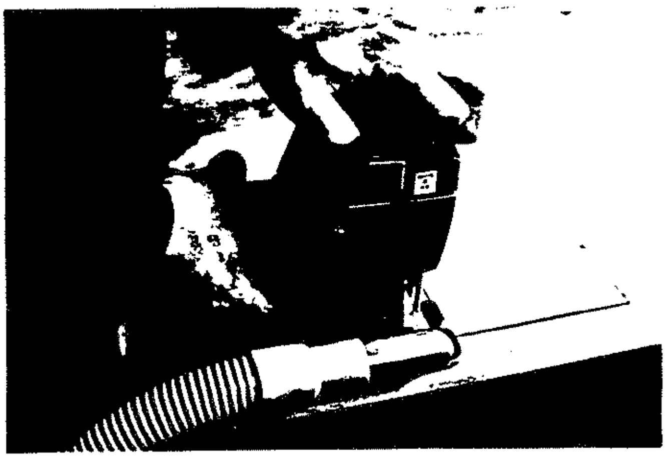


Nilfisk Asbestos Removal Systems

Nilfisk asbestos removal systems meet or exceed OSHA safety standards for the collection of asbestos dust.

Our filtering system ensures up to 99.9995% retention efficiency at 0.12 microns. It traps ultrafine dust and returns "absolutely" clean air to the work environment. Nilfisk has applied this filtering system to a number of specific asbestos cleanup problems as indicated below.

Removing sprayed-on asbestos insulation. Nilfisk has developed a complete system for the quick, safe removal of sprayed-on asbestos insulation. Oversize main filters eliminate premature clogging. HEPA FILTERS meet OSHA 29 CFR 1910.1001. Separator top fits standard 30- or 55-gallon drums lined with heavy-gauge polyliners to trap the bulk of the loosened asbestos insulation in sealable bags. Unique scraping nozzle loosens wetted asbestos in most cases and sucks it directly into the enclosed system. This reduces the amount of asbestos that falls to the floor. Lightweight extension wands can eliminate the need for scaffolding, allow the operator to get to hard-to-reach areas. Fixed floor nozzle permits fast cleanup of large open spaces.



Controlling asbestos dust. Nilfisk offers shielded hand tool and sander systems to control toxic or nuisance dust created in the fabrication of materials. All systems consistently meet or exceed OSHA standards for control of toxic dusts. Each system consists of a HEPA or Super HEPA-filtered vacuum cleaner and a safely enclosed hand tool—such as a saber saw, drill and oscillating saw—or dust control sanders. Static pressure and airflow have been skillfully combined to overcome the unusually high escape velocity of asbestos fibers and other toxic dusts. Nilfisk vacuum cleaners have been in regular use for years in manufacturing facilities.

Collecting automotive brake lining dust. Nilfisk Asbesto-Clene® Systems have been totally engineered to contain and collect asbestos dust which is liberated when automotive brake linings are replaced. Each system consists of a HEPA-filtered dust collector and a brake encapsulation cylinder. When the cylinder is in position, the entire brake assembly is enclosed by a segmented diaphragm which forms a dust seal. Clear shatterproof windows permit continuous viewing of the cleaning process. Compressed air directed by the mechanic dislodges even inaccessible asbestos dust from the exposed brake mechanism. The loosened dust within the cylinder is sucked directly into the Nilfisk collector and trapped in disposable bags. During the entire operation, the mechanic is safe from asbestos dust exposure. The systems require little maintenance. All steel construction resists abuse. Available in three models: System 400 for vehicles with drum brakes in the 7" to 12" diameter range; System 500 is a System 400 fitted to a highlift jack, and 600 for commercial vehicles with drums in the 12" to 19" diameter range. System 600 will accomodate double wheel assemblies.

National representatives. Nilfisk has a nationwide network of regional representatives to help you manage your toxic waste cleanup problems. They are thoroughly familiar with governmental codes and regulations dealing with the safe cleanup of toxic and hazardous waste materials. The Nilfisk representative in your area will gladly survey your workplace and make recommendations at no cost.

For more information. If you would like more information on Nilfisk portable dust collectors, call or write Customer Service Department, Nilfisk of America, Inc., 300 Technology Drive, Malvern, PA 19355 1 (800) NIL-FISK.

Printed in U.S.A. NIL1400C 15M 11-86

NILFISK SPECIFICATIONS AT-A-GLANCE

		GS 80 GS 80I	GS 81	GS 82	GS 83	GB 733	Mercury Vacuum
Capacity							
Tank	Gallons Dry Bulk	3.25	5.25	12	18	18	5.25
Disposable Bag*	Gallons Dry Bulk	2.25	4	12	18	18	4
Droplet Bottle**	Liters (Quarts)	--	--	--	--	--	1 (1.057)
Waterlift	Inches	75	75	75	59/75	59	75
Air Flow	Cubic Feet/Minute	87	87	191	208	180	87
Energy Use							
Voltage	Volts	115/220	115/220	115/220	115/220	220 or 440†	115/220
Current Draw	Amps	7.8/3.9	7.8/3.9	12/12	14/12	8.6	7.8/3.9
Watts Consumed	Watts	700	700	1400	1500/2100	1900	700
Filter Area	Square Inches ††	1620	1744	3895	4703	4077	326
Dimensions							
Height, Alone	Inches	16	19	30.5	43.2	49.4	45
Width	Inches	12	12.5	18.5	28.4	28.8	19.5
Length	Inches	--	18.3	27.5	31.1	31.6	30
Weight, Alone	Pounds	13.2	23	65	123	163	87
Sound Level***	dB(A)	67	67	70	72	79	67
Motor Type, 115V (Number of Motors)		GSD (1)	GSD (1)	GSD (2)	GSE (3)	--	GSJF (1)
Motor Type, 220V (Number of Motors)		GSJ (1)	GSJ (1)	GSJ (2)	GSJ (3)	3ϕ(1)	GSJF (1)
Cooling		Primary	Primary	Primary	Primary	Secondary	Primary
External Filter Agitator		N/A	N/A	Standard	Standard	Standard	N/A
Option Availability							
HEPA Filter		Yes	Yes	Yes	Yes	Yes	Yes
ULPA Filter		Yes	Yes	Yes	Yes	No	Yes
Manometer		No	No	Yes	Yes	Yes	No
Sound Suppressor		Yes	Yes	Yes	Yes	No	Yes
Blower Adapter		Yes	Yes	Yes (220V Only)	Yes (220V Only)	Yes	Yes
Disposable Bags		Yes	Yes	Yes	Yes	Yes	Yes

Special Notes:

Power Cord Length	Models 80, 81: 23 Feet Standard, 33 Feet Optional. Models GS 82, 83, and 733: 33 Feet Standard. Mercury Vacuum 33 Feet Standard
Filter Types	Cotton Standard, Acid-resistant Dralon Optional, Gore-Tex® Optional
Accessories	More than 100 specialized hoses, wands and nozzles are available. Please ask for our special descriptive list
Sound Suppressor	Reduces motor noise an additional 10 dB(A)

* Where disposable bag is used inside tank
** Pertains only to Nilfisk Mercury Vacuums
*** Sound level is measured at 6 feet from operator
† 3-phase power required
N/A Not Available

Since these product features are continually being improved, these specifications may change without notice

†† Models GS80, 80I, 81, and 82 include paper bag, main filter, microfilter, HEPA. Model GS83 includes main filter, microfilter, HEPA. Model GB733 includes main filter, HEPA. Mercury Vacuum includes main filter only

DEMONSTRABLY BETTER

NILFISK FEATURES

GS-Series Motors
Exclusively Nilfisk: Long-lasting, powerful motors are standard. Built entirely by Nilfisk, these are the most refined industrial vacuum cleaner motors in the world. They are superior to anything else now available. For instance, Nilfisk carbon brushes outlast those in most ordinary industrial vacuums almost two to one. And every Nilfisk motor is dynamically balanced, extending its service life by preventing premature wear. Vibration-free performance, even at 19,000 rpm, keeps operating noise levels in the low 70 dB(A) range.

A patented thermo-valve prevents overheating caused by neglecting filters or by an accidental blockage in a nozzle or hose. It "whistles," telling the operator there's a potential problem somewhere.

All Nilfisk motors have the power to generate a cyclone within the vacuum cleaner. This centrifugal airflow forces collected debris directly down into the container or, in some models, a sealable plastic bag. This prevents the main filter from clogging quickly and assures that Nilfisk vacuums maintain maximum efficiency until almost full.

Exclusive Nilfisk thermistors diminish the amperage surge at start-up. Carbon brush life is extended and circuit breaker overloading is reduced. Built-in condensers eliminate static interference with sensitive electronic equipment.

Planned to the last detail, Nilfisk motors are supplied either grounded or double-insulated. On top of all this, Nilfisk stocks motor replacement parts for 20 years to assure quick repairs if necessary.

Manometer
The Nilfisk manometer, another exclusive: The optional manometer measures the pressure differential above and below the main filter and tells the operator at a glance whether the Nilfisk cleaner is operating at peak efficiency. It indicates when the vacuum cleaner is creating maximum airflow, when dust must be shaken from filters, and when the vacuum must be emptied. All this without opening the container and exposing the operator to collected dust or debris.

Along with assuring better vacuuming results, the Nilfisk manometer increases filter and motor life and keeps downtime to a minimum.

Nilfisk manometers are available for models GS 82, GS 83, and GB 733.

External Filter Agitator Handle
Another Nilfisk plus: the filter agitator. Shaking this external handle keeps the main filter inside the vacuum cleaner free of clogging dust. It maintains the vacuum's maximum suction and filtration efficiency, protects motors against superfine dust, prolongs filter life, and thus saves employees from exposure to collected toxic or hazardous dust.

Nilfisk filter agitators are standard on models GS 82, GS 83 and GB 733.

HEPA and ULPA Filters
Nilfisk HEPA filters (optional): Of all the fiberglass HEPA filter cartridges available, this is the easiest to remove intact, and change, without particulates escaping into the air—or getting on hands and clothes.

This critical filter in Nilfisk's graduated filtration system assures that 99.97% of all ultrafine particulates, toxic and nuisance, are captured. Down to and including 0.3 microns.

Nilfisk ULPA filters (optional): The laser tested ULPA filters have a retention efficiency of 99.9995% at 0.12 microns.

All Nilfisk HEPA and ULPA filters are individually DOP-tested and certified. They meet ANSI Z9.2-1971.

Nilfisk HEPA and ULPA filters available to fit most Nilfisk vacuum cleaners.

Blower Attachment
More Nilfisk versatility: blower attachments (optional). Special blower adapter replaces a motor's exhaust diffuser and converts the powerful vacuum motor into an equally powerful blower.

Blower adapters are available for Nilfisk models GS 80, GS 801, GS 81, GS 82 and GS 83.

Sound Suppressor
Nilfisk sound suppressors (optional): When exceptionally low noise levels are critical, Nilfisk sound suppressors quiet motors an additional 10 dB(A) to the even more silent low 60's range.

Most Nilfisk models can be equipped with sound suppressors.

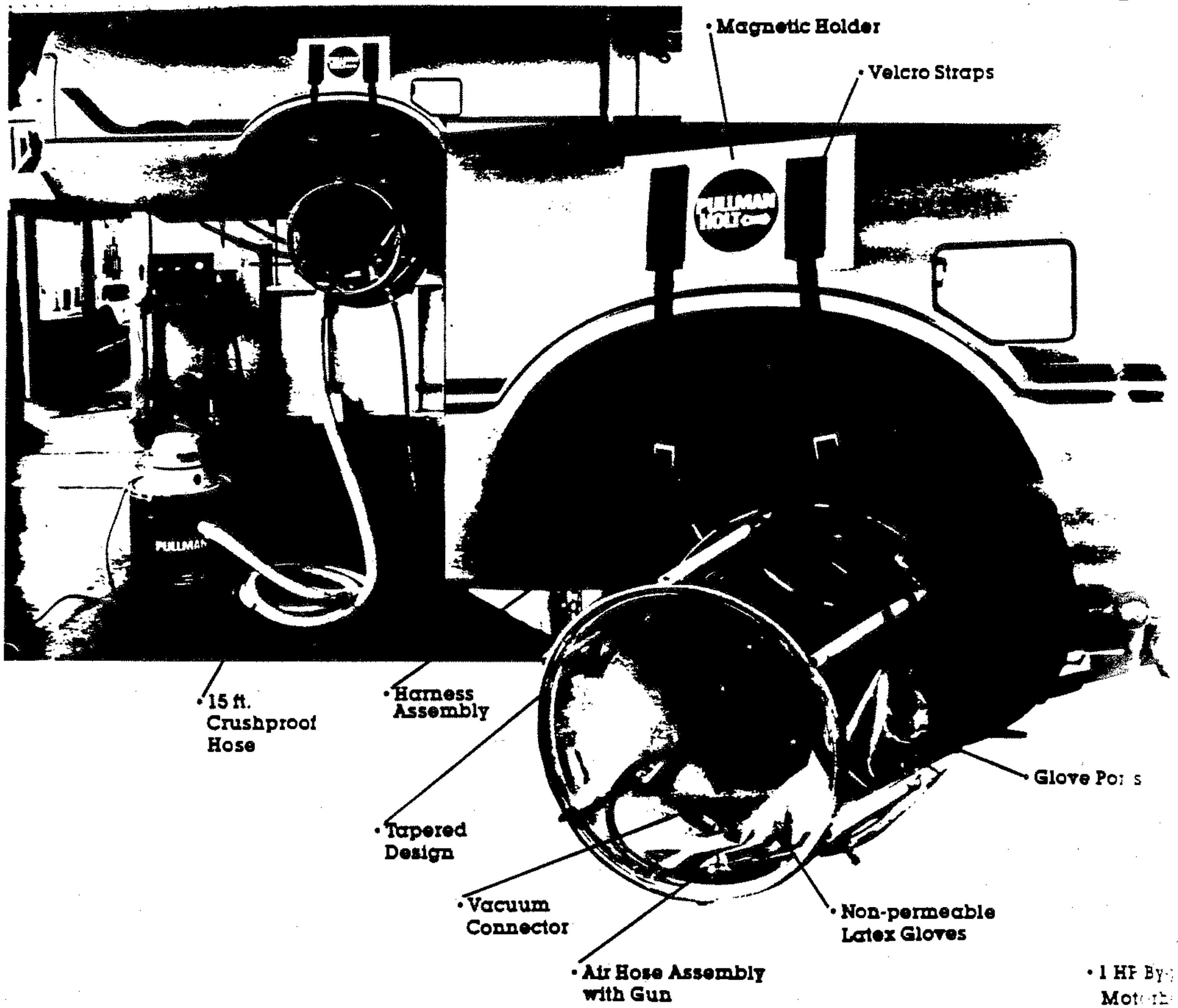
DEMONSTRABLY BETTER

PULLMAN/HOLT

STOP

Put the Brakes On SAFELY

WHITE



The "Brake Bubble"

The "Brake Bubble" was designed and developed in the Nuclear Industry with state of the art material to meet the changing OSHA and EPA requirements in today's brake industry. Pullman/Holt now offers a vacuum system for safe, efficient and complete removal of asbestos dust during brake drum repair. Protect your business, employees, and customers from the dangers of asbestos.

for Safe Removal

Brake Bubble* Features:

Lightweight—Complete unit weighs less than 10 lbs.

Visibility—The brake drum is clearly visible from any angle.

Tapered Design—Allows easy access to glove ports with operator efficiency in mind.

Non-Permeable Latex Gloves—Attached to "Brake Bubble," providing operator with total protection from exposure to asbestos dust.

Air-Blower and Vacuum Connector—Permanently built into the unit and sealed for safe hook-up of air-compressor and HEPA Vacuum.

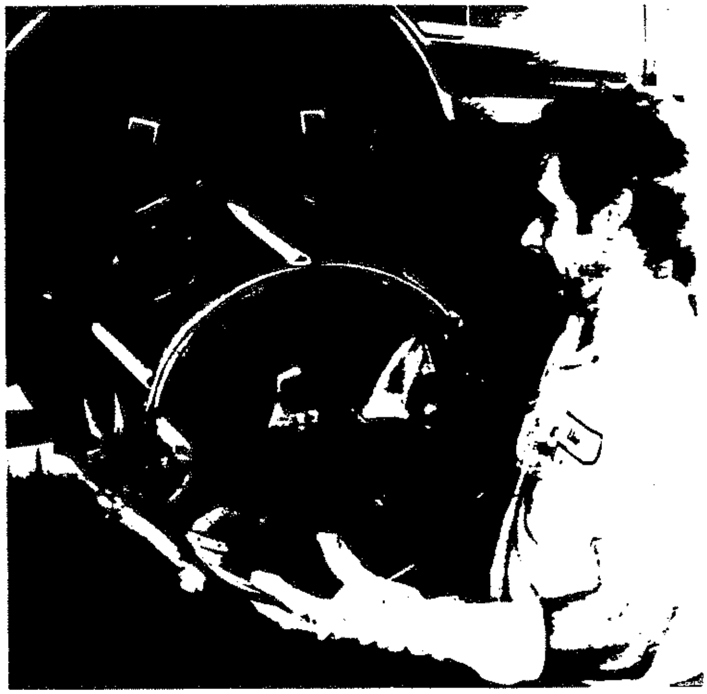
Installation—Brake drum slides through a button hole type opening in rear panel enclosing it in the "Brake Bubble."

*Magnetic Holder** with Velcro Straps—Attaches to vehicle's fenders holding the "Brake Bubble" in place and straps adjust unit to proper height for operator comfort.

Latex Rear Panel—Enables operator to hammer from the rear of the unit to remove brake drum.

Optional Telescoping Stand—Use to support the "Brake Bubble" when working on vehicles with non-metallic surfaces.

*Patent Pending



Asbestos Brake Vacuum

Pullman/Holt's asbestos vacuum exceeds all EPA and OSHA filtration standards to prevent recontamination of air in the work place. This unit connects to the "Brake Bubble" providing total protection necessary for containing and removal of asbestos dust.

Asbestos Vacuum Features:

Filter System—includes primary Nuclear Grade HEPA filter, fiberglass prefilter and paper filter bag for triple filtration.

Unit Comes With—6 prefilters, 3 paper collector filter bags, and 3 poly bags imprinted with asbestos warning for proper disposal.

5 Gallon Tank—Baked enamel painted magenta for high visibility.

Equipped With—4 casters and 15 ft. crushproof hose.

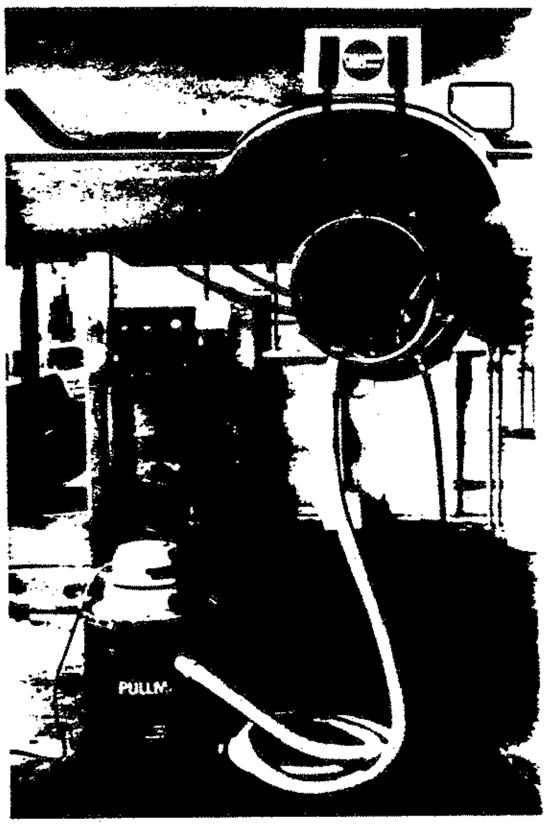
Powerful Motorhead—2 stage, 1 HP By-pass motor, delivers 85" waterlift, 96 CFM for superior efficiency.

Manometer—a testing gauge to determine the efficiency level of the HEPA filter.

HEPA Filter – Rated efficiency is 99.99% at .3 microns; D.O.P. method.

Asbestos Dust

Comes with E2 Brake Bubble Enclosure (B526487) and A86 Asbestos Vacuum (B526488).
The complete system necessary for removal of asbestos dust. (B526485)



Model E2 Brake Bubble Enclosure Only

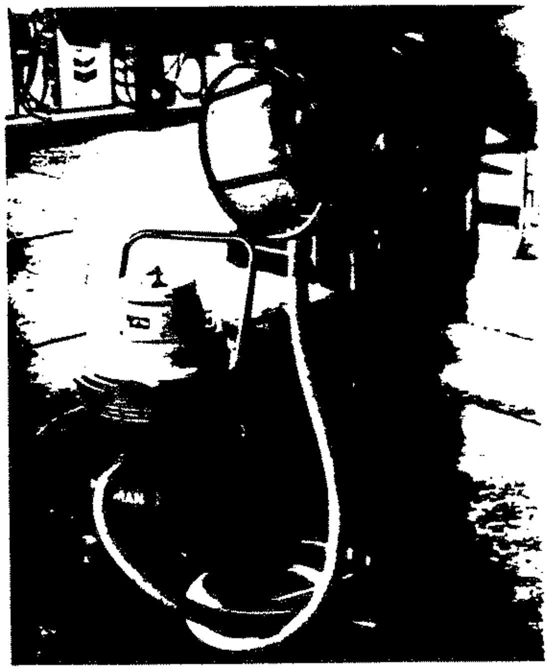
Comes equipped with magnetic holder, harness assembly, velcro straps, 1 pair non-permeable latex gloves, 2 pair absorbtex glove liners, air hose assembly with gun, and connector for telescoping stand. (B526487)

Model A86 Asbestos Vacuum

Comes with Nuclear Grade HEPA filter with prefilter, 15 ft. crush proof hose, manometer, 3 paper and 3 poly bags. (B526488)

Telescoping Stand

The metal adjustable stand attaches at the bottom of the "Brake Bubble." It is used to support the unit when working on the vehicles with non-metallic surfaces. (B526486)



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APPENDIX E -- WELFARE EFFECTS OF ASBESTOS REGULATION UNDER NONCOMPETITIVE FIBER SUPPLY

1. Introduction

The Asbestos Regulatory Cost Model (ARCM) estimates the costs of a variety of regulatory alternatives for banning and/or phasing down asbestos use over time. Underlying this model is a framework in which all relevant economic actors are assumed to participate in competitive markets for both their products and the factors of production they require. Such a framework is legitimate for modeling the impacts of regulations on most industries because most are sufficiently competitive to make the predictions of models based on competition reasonably accurate.

The asbestos mining industry, however, might not be competitive, so it is worth investigating the extent to which the predictions of the ARCM are sensitive to the assumption that the asbestos fiber industry is competitive. In particular, the ARCM predicts that during a phase-down of fiber usage, both foreign and domestic miners and millers of asbestos fiber will be made worse off (because the net price they receive from selling fiber falls) and that the value of permits to mine and to import fiber and asbestos products will be positive (so that distributing them or selling them produces gains to either the government or to the parties who receive the permits). These conclusions may not be correct, however, if the foreign asbestos fiber producers do not constitute a competitive industry.

This brief paper qualitatively analyzes the implications for the welfare predictions of the ARCM of assuming that miners and millers are not a competitive industry. Quantitative predictions of the precise welfare effects that result from these regulatory alternatives under the assumption that the asbestos fiber industry is not competitive are not possible without detailed empirical and modeling efforts (modeling a cartel's supply behavior would require different techniques and data than currently employed in the ARCM). Nevertheless, the qualitative results offered here can be combined with the existing predictions of the ARCM (which assume a competitive fiber industry) to obtain some indication of whether and how changes in welfare caused by the regulatory alternatives would differ depending on the underlying industry structure assumed.

The remainder of this paper is organized as follows:

- Section 2 presents a graphical analysis of the welfare effects of product bans under alternative assumptions concerning the competitiveness of the fiber industry;

- Section 3 presents a graphical analysis of the welfare effects of a fiber phase-down under alternative assumptions concerning the competitiveness of the fiber industry;

- Section 4 performs the same welfare analysis for policies that combine a fiber phase down and product bans; and

- Section 5 summarizes the major conclusions.

2. Product Bans, Welfare Effects, and Industry Structure

One of the regulatory alternatives considered for controlling asbestos calls for "staged bans" of asbestos-using products. Certain groups of products would be banned at several points in time. The welfare effects that result from banning these products are fairly intuitive and can be estimated using the ARCM. Briefly, product bans cause domestic consumer and producer welfare to decline among those parties that use or manufacture the banned products. These welfare effects are easy to understand -- consumers may be made worse off because substituting alternative products for the banned ones involves costs (consisting, in general, of both direct monetary costs associated with using substitutes, and less tangible, but no less real, reductions in welfare due to the potentially reduced utility or productivity achievable with these substitutes). Producers of these products, on the other hand, also could be made worse off if the capital they use to produce the products declines in value after the bans (because the capital is less valuable in other uses or cannot be economically transferred to other uses).

In addition to declines in the welfare of domestic producers and consumers of banned products, other ramifications on the world market for asbestos could flow from banning domestic manufacture or sale of these asbestos products. In particular, if the quantity of asbestos embodied in the banned products is substantial relative to the rest of the world's consumption of asbestos, then it is possible that the world price of asbestos fiber will fall after the product bans. This effect mirrors the standard conclusion that if the demand for a good falls significantly, and the supply of the good is not perfectly elastic (i.e., the supply function slopes upward), then a price reduction for the good will occur. Two consequences result. First, the world's suppliers of asbestos fiber will be made worse off because the price at which they sell fiber falls.[1] Second, demanders of fiber in the rest of the world are made better off, again because of the lower asbestos fiber price.

The ARCM calculates these welfare effects under the assumption that the asbestos fiber industry is competitive. Output tables are produced by the model listing the declines in the welfare of domestic producers and consumers of asbestos products and the net change in the welfare of foreign entities (including both foreign miners and millers of asbestos, foreign producers of products that use asbestos fiber, and foreign consumers of asbestos products). However, the model does not explicitly separate the gross changes in the welfare of foreign miners and millers of fiber and foreign consumers of asbestos products. Because the subject of this paper is the impact of altering an assumption about the market behavior of one of these groups (the foreign miners and millers of asbestos fiber), it is worth examining somewhat more closely how the ARCM is able to measure the effects of the product bans on foreign market participants.

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[1] These include both domestic and foreign suppliers of asbestos, but for ease of exposition, the remainder of this paper assumes that only foreigners supply asbestos fiber -- an approximation that is very close to reality.

2.1 Measuring Welfare Effects on Foreign Entities

The ARCM can measure the net welfare impact on foreign miners and millers of asbestos fiber and foreign consumers of asbestos products because of the economic construction of the supply of asbestos fiber to the U.S. In Exhibit 1, the top panel shows an equilibrium in the U.S. asbestos fiber market (with no controls or other distortions). The ARCM models various combinations of bans and phase-downs and calculates foreign welfare losses as declines in the areas bounded below by the supply function and above by the price of fiber. As drawn, the diagram assumes that all asbestos products in the U.S. are banned (so that the demand for fiber from domestic producers of asbestos goods falls to zero), so that the entire area above the supply function and below the baseline price (P^0) is shaded indicating the loss of foreign welfare (again, in this paper, all fiber mining and milling is assumed to be undertaken by foreigners).

The bottom panel of Exhibit E-1 shows the world market conditions that correspond to the initial equilibrium and the ban scenario described in the top panel for the U.S. market. Note that the baseline demand for asbestos fiber in the world includes the demand for fiber by U.S. producers and that the price of fiber in the world and in the U.S. are equal in the baseline. After the total U.S. product ban, the world demand for fiber falls, as indicated in the exhibit, and the price of fiber falls to P^1, which also corresponds to the vertical-axis intercept of the supply of fiber to the U.S.

Exhibit E-1 makes clear why the area of "producer surplus" associated with the supply of asbestos fiber to the U.S. market is, in reality, the net of world miner and miller welfare losses and foreign producer and consumer welfare gains.[2] In the bottom panel, as the price of asbestos fiber falls, foreign consumers of fiber are made better off while the producers of fiber are made worse off. Indeed, as the diagram is drawn, the majority of the losses of foreign fiber producers is offset by the gains in welfare of foreign consumers of fiber. It is the difference between the losses of foreign producers and the gains of foreign consumers that appears as the area of producer surplus loss associated with the supply of fiber to the U.S. market (i.e., the shaded areas in the two panels of the exhibit are equal).

2.2 Welfare Effects under Competitive Fiber Supply

Given this understanding of the analytical mechanism by which foreign welfare changes (at least on net) can be measured in the framework of the ARCM, it is possible to investigate the qualitative differences between the welfare effects on all parties due to product bans in the U.S. under alternative assumptions concerning the competitiveness of foreign asbestos fiber supply.

Exhibit E-2 (top panel) graphically shows how the ARCM identifies and measures the welfare effects of banning asbestos products. The diagram

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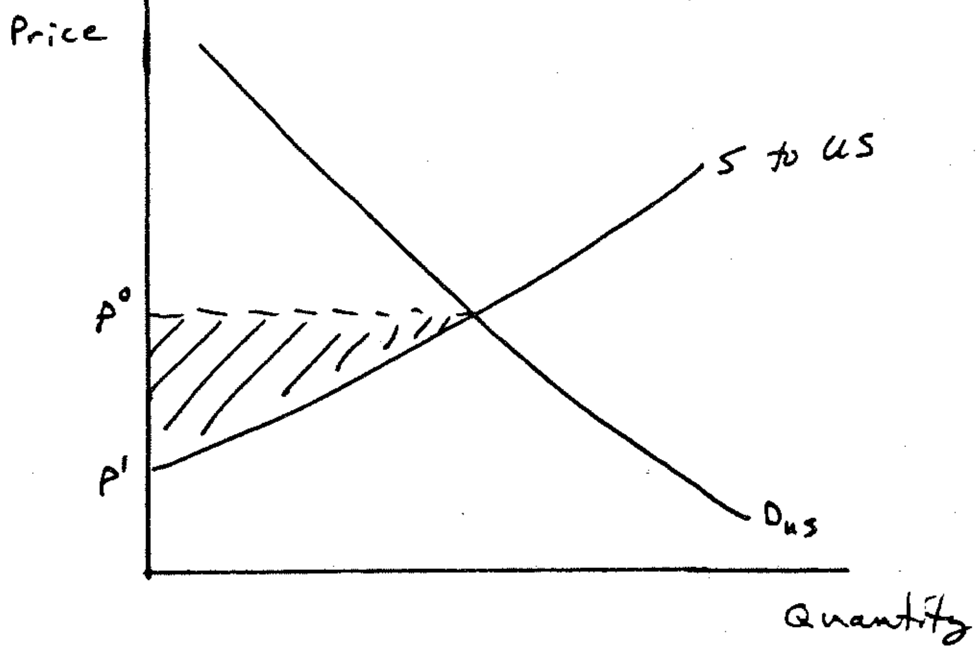
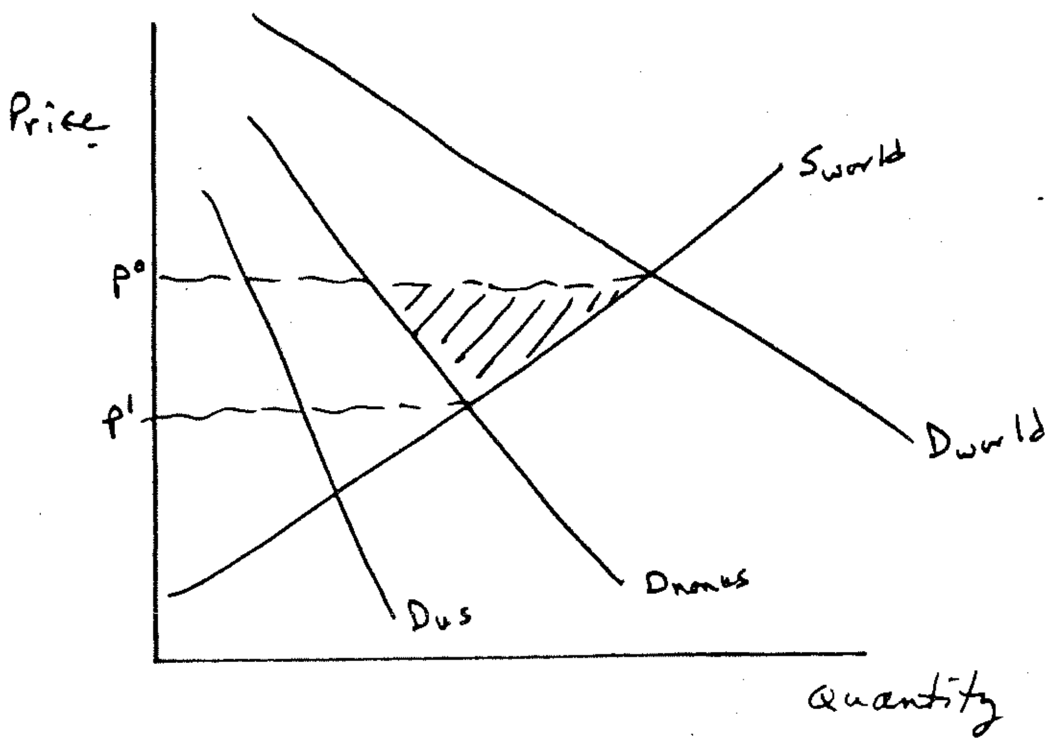
[2] Strictly speaking, entities "downstream" from the asbestos fiber market include all producers, associated factors of production, and consumers. However, for ease of exposition, these entities will be referred to as foreign "consumers" of asbestos fiber from this point forward.

Exhibit E-1

FOREIGN WELFARE EFFECTS OF ASBESTOS REGULATIONS
MEASURED BY THE ARCM



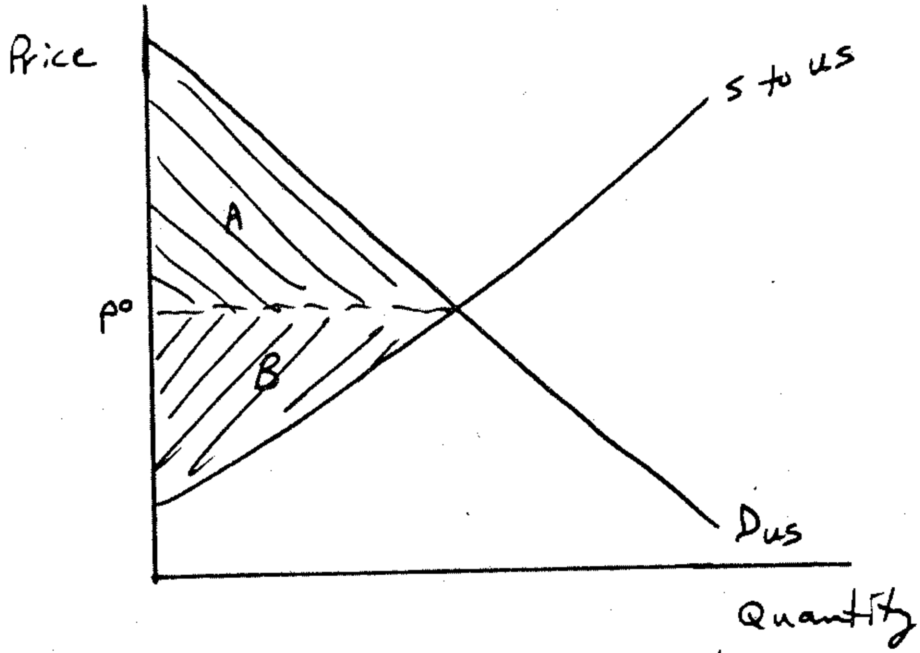
U.S. Fiber Market



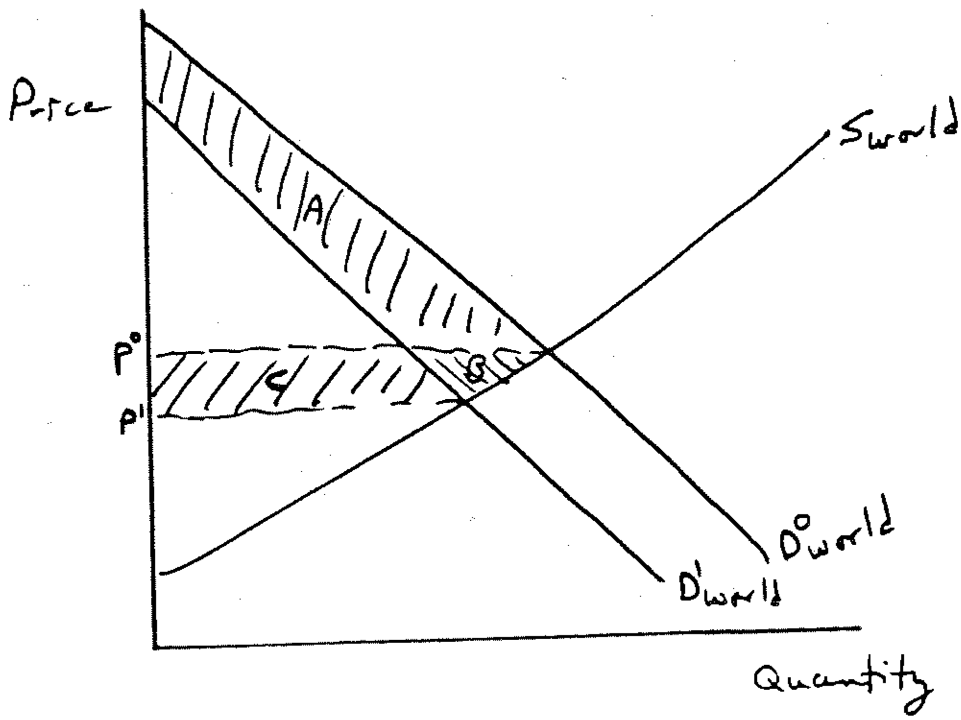
World Fiber Market

EXHIBIT E-2

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PRODUCT BANS
UNDER COMPETITIVE FIBER SUPPLY



U.S. Fiber Market



World Fiber Market

assumes that all asbestos products have been banned, so that the demand for asbestos fiber for the U.S. is zero after the bans. Area A in the diagram represents the loss of U.S. consumer and producer welfare in all of the banned markets. Area B, on the other hand, represents the net loss of foreign producer and consumer surplus (assuming that all fiber is imported to the U.S.). Thus, under competition, areas associated with the supply and demand for asbestos fiber, as represented in the U.S. market, measure changes in domestic and foreign welfare.

The bottom panel of Exhibit E-2 shows how these same welfare effects could be measured in a diagram depicting the supply and demand for asbestos fiber in the world. This diagram reproduces the bottom panel of Exhibit E-1, except that some shading has been added to facilitate the discussion. As explained before, the inward shift of the demand function for fiber in the world market represents the effect of U.S. bans of asbestos products. An equivalent measure of the welfare losses of U.S. producers and consumers is Area A in the bottom panel which is the shaded area between the two demand functions down to the original price, P^0. Thus, Area A in the bottom panel corresponds to Area A as measured in the top panel. Similarly, as discussed above, Area B in the top panel equals Area B in the bottom panel. Finally, Area C in the bottom panel measures the transfer from foreign producers of fiber to foreign consumers of asbestos fiber. Hence, Area B plus Area C equals the gross loss of foreign fiber producer welfare, of which Area C is transferred to foreign consumers, which measures their gain from the U.S. regulation.

2.3 Welfare Effects Under A Fiber Cartel

Two alternative assumptions concerning the structure of the asbestos fiber industry are worth considering. First, one could assume that prior to the promulgation of U.S. bans on asbestos products, the fiber producers were (and continue to be after the bans) a cartel, operating as if it were a monopolist. The alternative is to assume that, for some reason or another, the promulgation of the U.S. regulations concerning asbestos encourages the establishment of a cartel among the miners and millers of asbestos. Although these two situations are indistinguishable <u>after</u> the promulgation of the U.S. regulations, they nevertheless result in slightly different conclusions concerning welfare <u>changes</u> relative to the initial unregulated situation.

Consider first the welfare effects, both domestic and foreign, associated with banning all U.S. sale and consumption of asbestos products under the assumption that the mining and milling of asbestos in the world is a cartel prior to and after the regulations are imposed. In the top panel of Exhibit E-3, the derived demand for fiber in the U.S. is shown with the baseline price of P^0, which is observed in the world.[3] The loss in domestic producer and consumer surplus associated with the product bans is simply the shaded area under the demand function and above the baseline price. Note, however, that the supply of fiber to the domestic market is not drawn in this top panel. This is because, strictly speaking, monopolists do not have supply functions.

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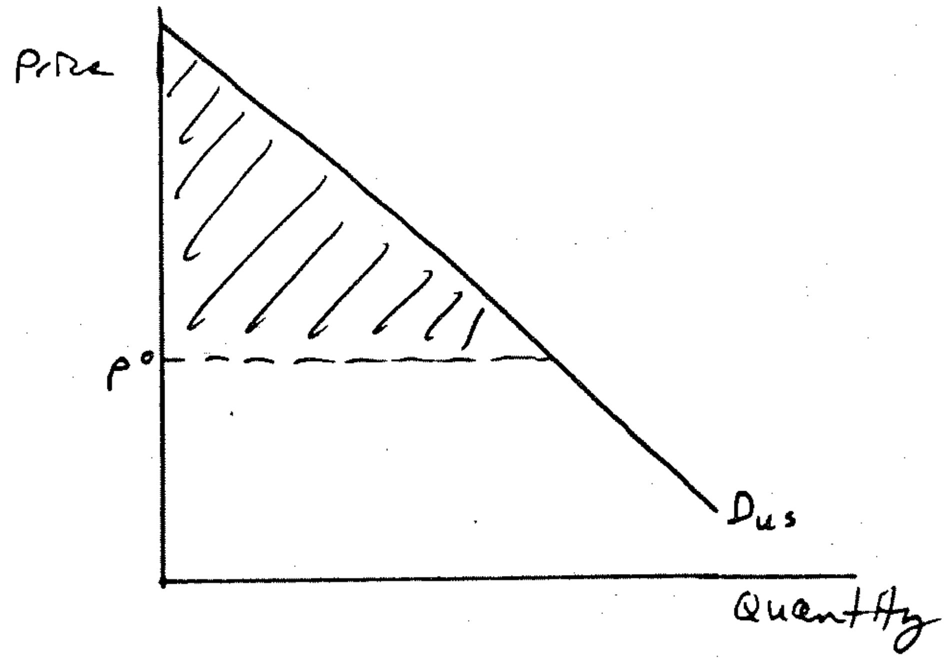
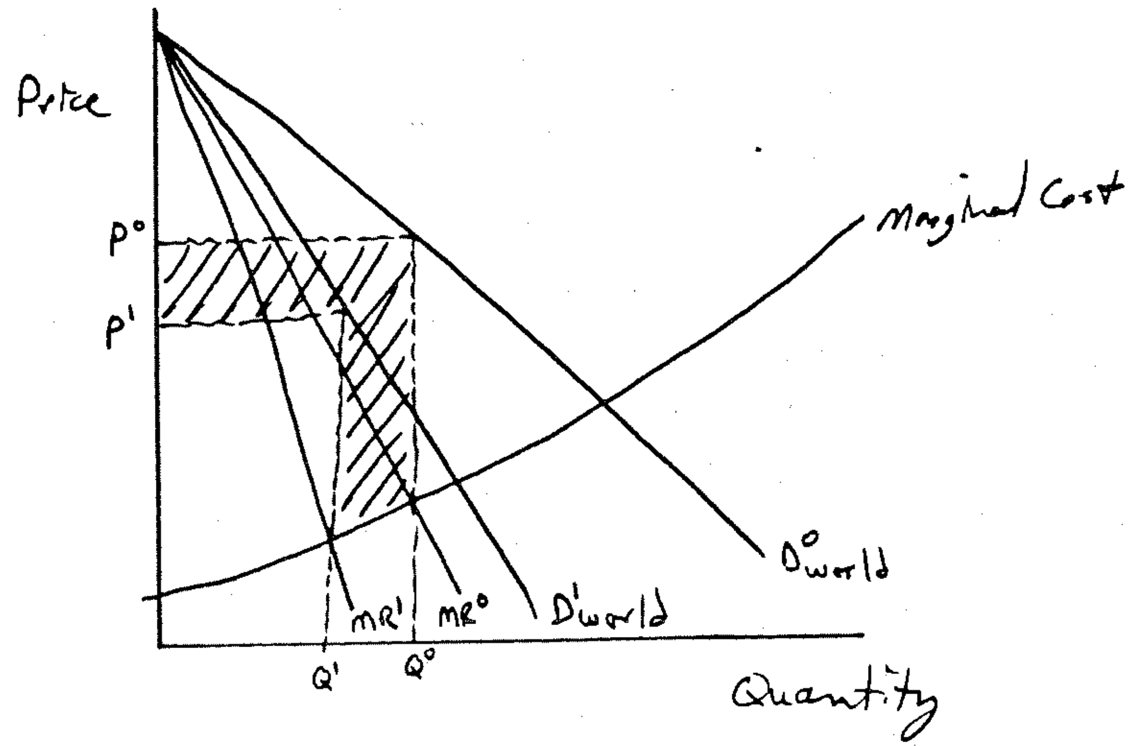
[3] The change of assumptions regarding the underlying structure of the asbestos fiber market, of course, does not change the observed price of fiber, only the welfare interpretation of the baseline conditions.

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PRODUCT BANS
UNDER A PREEXISTING CARTEL -- PRICE DECREASE



U.S. Fiber Market



World Fiber Market

They make supply decisions based on demand and cost conditions, but in a behaviorally quite different way than do competitive suppliers of goods.

To understand the international welfare ramifications of the U.S. product bans, one must examine the effects of the bans on the world market for asbestos fiber. In the bottom panel of Exhibit E-3, the world market for asbestos fiber is shown assuming that the market is monopolized both before and after the U.S. product bans. The world demand for fiber in the absence of the U.S. product bans is shown as D^0, and the monopolist supplies Q^0 to the market at a price of P^0 (which matches the price of P^0 in the top panel), based on the intersection of the initial marginal revenue function and the long run marginal cost of production (shown in the diagram to be coincident with the original supply function). After the product bans, the world demand for fiber falls as indicated in the diagram, producing a new marginal revenue function relative to which the monopolist again considers production costs to determine the price and quantity in the market after the bans.

As the diagram is drawn, the world price of fiber falls after the product bans and, of course, the quantity sold falls as well. As a result of this, foreign asbestos fiber suppliers lose the shaded area in the bottom panel of the exhibit relative to the pre-ban situation. On the other hand, foreign consumers of fiber are made better off as a result of the fall in the price of asbestos fiber. However, as the price of fiber falls, foreign consumers of asbestos are made better off only to the degree that they receive transfers form foreign miners and millers of fiber. Thus, foreign entities taken as a whole must be made worse off due to the product bans in the U.S.

It is conceivable that the price of fiber could rise after the product bans if the remaining world demand for fiber is sufficiently inelastic. Although the welfare implications of the product bans for U.S. entities are the same irrespective of the post-ban fiber price, the implications for the welfare of foreign entities are slightly different if the price of fiber rises after the product bans. Exhibit E-4 shows this case. The top panel shows the U.S. fiber market as in Exhibit E-3. The bottom panel shows the world fiber market and is drawn so that the post-ban fiber price exceeds the pre-ban price. In this event, foreign consumers of asbestos fiber are made worse off, rather than better off, by the U.S. policy. This same price rise serves to mitigate the profit reduction of the cartel, but not enough to make the cartel better off under the ban than otherwise. This conclusion is clear since it is always better for a monopolist to face a larger demand than a smaller one.[4] Hence, when the demand for fiber falls due to the U.S. product market bans, the cartel will be made worse off relative to the pre-ban situation.

Although the implications for the price of fiber are unclear and depend ultimately on empirical issues, most of the basic conclusions derived in the competitive case for welfare changes in the rest of the world remain true in this case. First of all, domestic consumers and producers are made worse off due to the bans, just as before. Second, foreign entities taken as a whole are made worse off due the product bans regardless of the impact on the price

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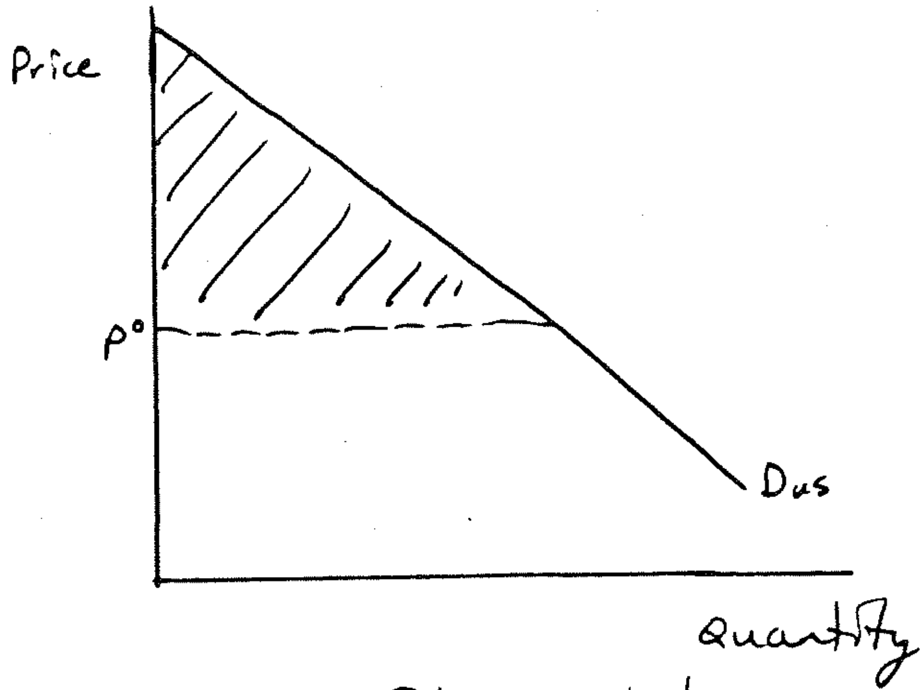
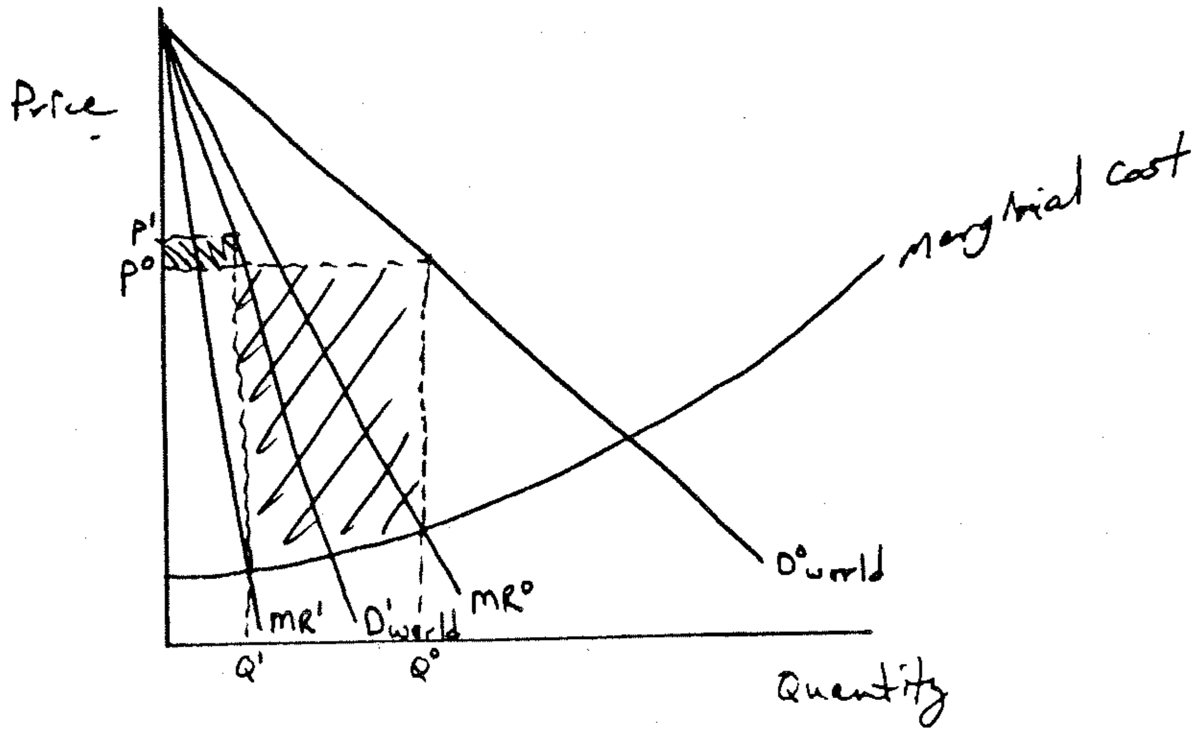
[4] The monopolist could always have set the quantity of fiber at Q^1 prior to the U.S. regulation and would have received at least P^1 Thus, the monopolist must clearly be worse off under the U.S. policy.

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PRODUCT BEANS
UNDER A PREEXISTING CARTEL -- PRICE INCREASE



U.S. Fiber Market



World Fiber Market

of fiber, although the conclusion from the competitive model of fiber supply that foreign consumers of asbestos fiber will be made better off is not necessarily true in this case. The price of fiber could either rise or fall after the product bans, so the welfare of these foreign consumers depends upon the movement of the fiber price. Nevertheless, although the welfare implications for foreign consumers *per se* are ambiguous, foreigners taken as a whole clearly must be worse off after the bans than before because the only way for foreign consumers to be better off is to gain from a possible transfer from foreign fiber suppliers. Thus, most of the competitive model's qualitative conclusions hold for the case of a preexisting monopoly in the asbestos fiber market.

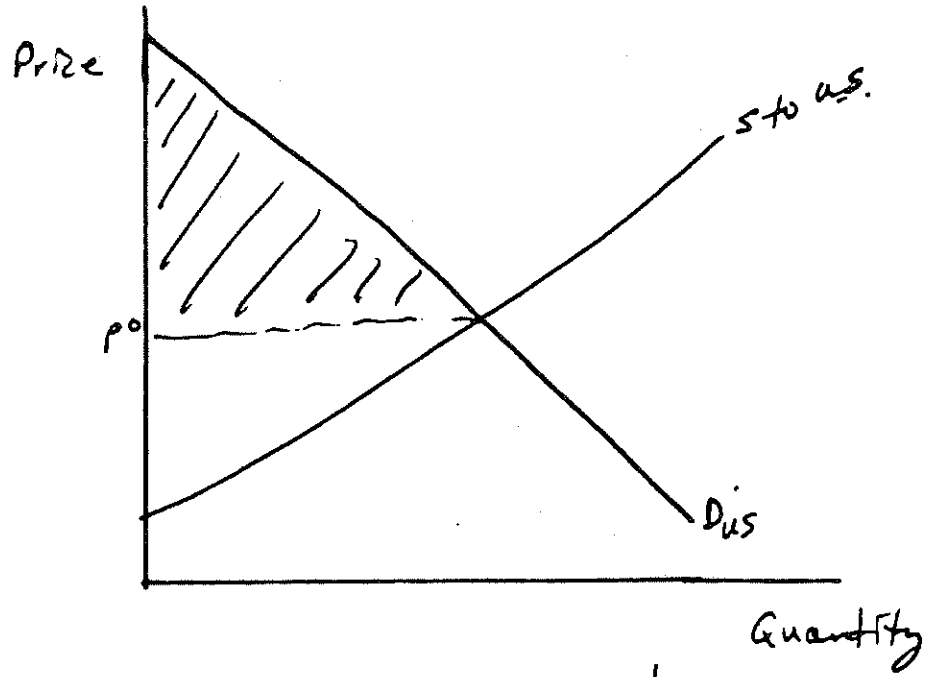
Now consider the situation in which it is the promulgation of the U.S. product bans that causes the world asbestos industry to form a cartel and to begin operating as a monopolist. Again, the top panel of Exhibit E-5 shows the domestic market for fiber with the pre-ban price of P^0, the demand for fiber, and the supply function for fiber to the U.S. market. In this case, it is perfectly legitimate to draw the pre-ban supply of fiber to the U.S. market because it is only after the imposition of the bans that the cartel forms and it becomes impossible to define a meaningful supply function for the industry.

Clearly, the loss of U.S. producer and consumer surplus equals the area under the U.S. demand function down to the baseline price of P^0. To examine the welfare effects of the product bans on foreign fiber suppliers and demanders, it is again necessary to diagram the world market for fiber, as shown in the bottom panel of Exhibit E-5. The diagram shows the pre-ban equilibrium in the world fiber market at P^0. Thus, in the pre-ban situation, producer surplus equal to the area above the world fiber supply function and below the baseline price of P^0 is enjoyed by the fiber suppliers. However, after the bans are promulgated, two opposite forces act on the welfare of fiber suppliers. First, the inward shift the demand for fiber tends to make them worse off (because less fiber can be sold at all prices). On the other hand, at the same time that the demand for fiber declines, the industry is assumed to form a cartel and to act as a monopolist would. This operates in the other direction. Whether the cartel is better off after both the decrease in demand and the cartelization depends on first, whether the price of fiber rises after the cartelization, and second, if the price does increase, whether the price increases by enough to offset the reduction in quantity associated with the decline in demand.

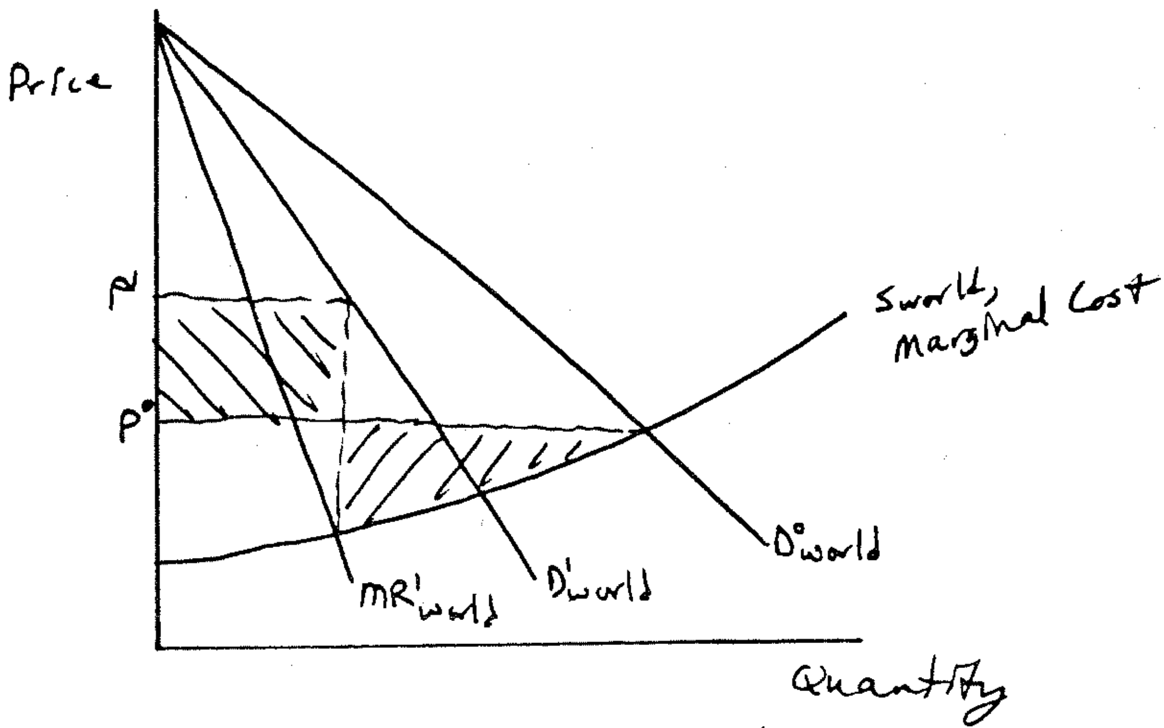
Graphically, these two influences on the profits of the world's asbestos fiber suppliers can be seen in Exhibit E-5 as (1) the loss of producer surplus due to the demand reduction -- the triangular shaded area above the supply function bounded by the baseline price, the supply function, and the new quantity supplied, and (2) the gain from a price rise -- the shaded box above the baseline price. If the latter exceeds the former, then the world's fiber suppliers will be better off after the bans than before. If, on the other hand, the price of fiber does not rise by enough, then the fiber producers will be worse off than before the bans (although they will be better off as a cartel than as a competitive industry given the regulation).

The price of fiber could fall, however, after both the imposition of the product bans and the cartelization, as shown in Exhibit E-6. The U.S. market drawn in the top panel is the same as in Exhibit E-5, but the world market shown in the bottom panel is not. In this case, the price of fiber falls

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PRODUCT BANS
UNDER A CONCOMITANT CARTEL -- PRICE INCREASE

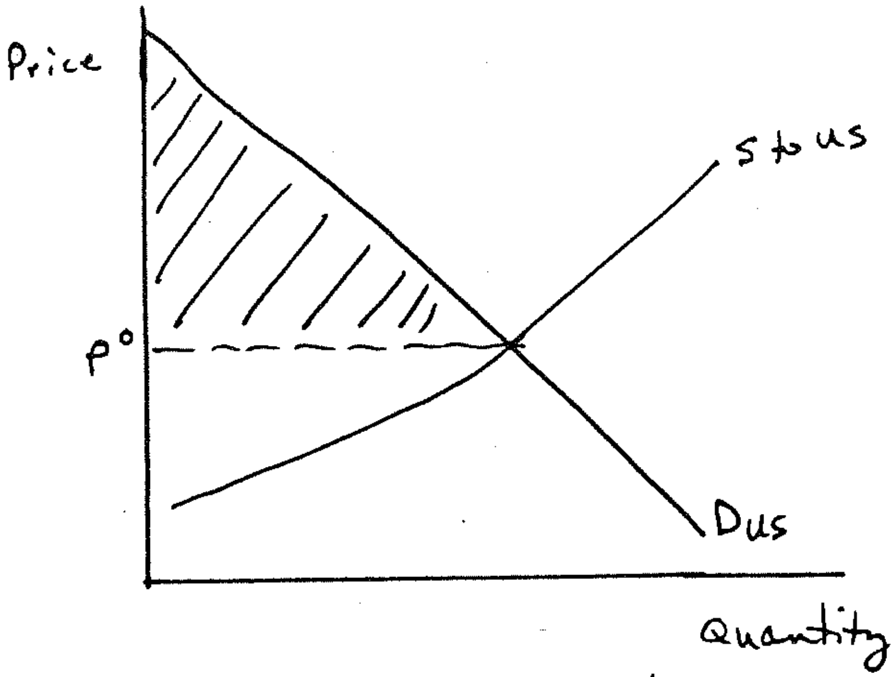


U.S. Fiber Market

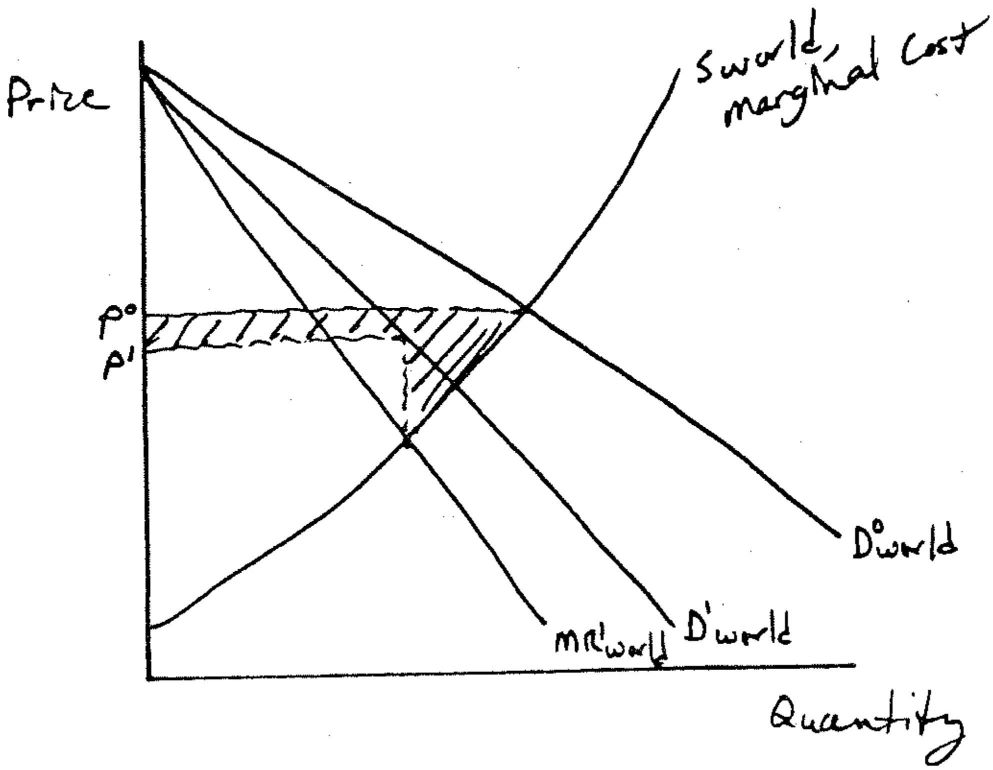


World Fiber Market

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PRODUCT BANS
UNDER CONCOMITANT CARTEL -- PRICE DECREASE



U.S. Fiber Market



World Fiber Market

after the product bans, making foreign asbestos purchasers better off and clearly reducing the welfare of foreign asbestos suppliers. Thus, in this case the welfare conclusions for all affected entities are qualitatively identical to those derived in the competitive case.

This discussion makes clear that the welfare of foreign consumers of asbestos fiber may either rise or fall depending on whether the fiber price falls or rises after the bans. Either case is a possibility, so no a priori prediction is possible. As a consequence, if the world asbestos industry becomes a cartel at the same time that the U.S. product bans are promulgated, the welfare changes induced could differ from those that would result if the industry is competitive after the bans. Although U.S. producers and consumers are still worse off by precisely the same amount as predicted by the ARCM under competitive assumptions, the welfare of foreign producers of asbestos fiber could either rise or fall depending on empirical issues. Similarly, the welfare of foreign consumers could rise or fall. However, if foreign consumers are made better off, then foreign fiber producers must be worse off, again because the welfare of foreign consumers can only be improved through transfers from foreign fiber producers and because the foreigners taken as a whole must be worse off after the bans regardless of the cartelization of the industry. In other words, no matter what happens to the price of fiber under the product bans, foreign entities taken as a whole must be worse off. Certain groups could experience welfare gains, but this can only occur because of transfers from other groups of foreign market participants. The cartelization serves to make foreign market participants collectively even worse off, but redistributes some of the surplus associated with asbestos fiber.

To summarize the conclusions of the analysis of product bans and alternative fiber market competitive assumptions, the findings of the ARCM are robust to changes in such assumptions in terms of the predictions it yields for the welfare changes of U.S. market participants and for the net impact on the welfare of foreign market participants. However, the decomposition of welfare changes for these foreign producers and consumers can differ dramatically depending on both the assumptions made concerning the competitive conditions of fiber supply before and after the bans and a variety of empirical magnitudes. If the foreign demand for fiber is very inelastic, then the fiber price is likely to rise under the product bans. If, on the other hand, the foreign demand is very elastic, then the price is likely to fall, producing the same qualitative conclusions generated by the ARCM.

3. Fiber Phase-Down, Welfare Effects, and Industry Structure

This section analyzes the welfare effects on the various parties modeled in the ARCM due to the other form of asbestos regulation, a fiber phase-down. Again, the focus is on how these welfare effects might be different if alternative assumptions are made concerning the competitiveness of the foreign asbestos fiber market. As in the previous section, three alternative assumptions are analyzed: a competitive industry (as currently modeled in the ARCM), a preexisting cartel that operates as a monopolist, and a similar cartel that comes into existence at the time that the phase-down regulation is promulgated.

3.1 Welfare Effects Under Competitive Fiber Supply

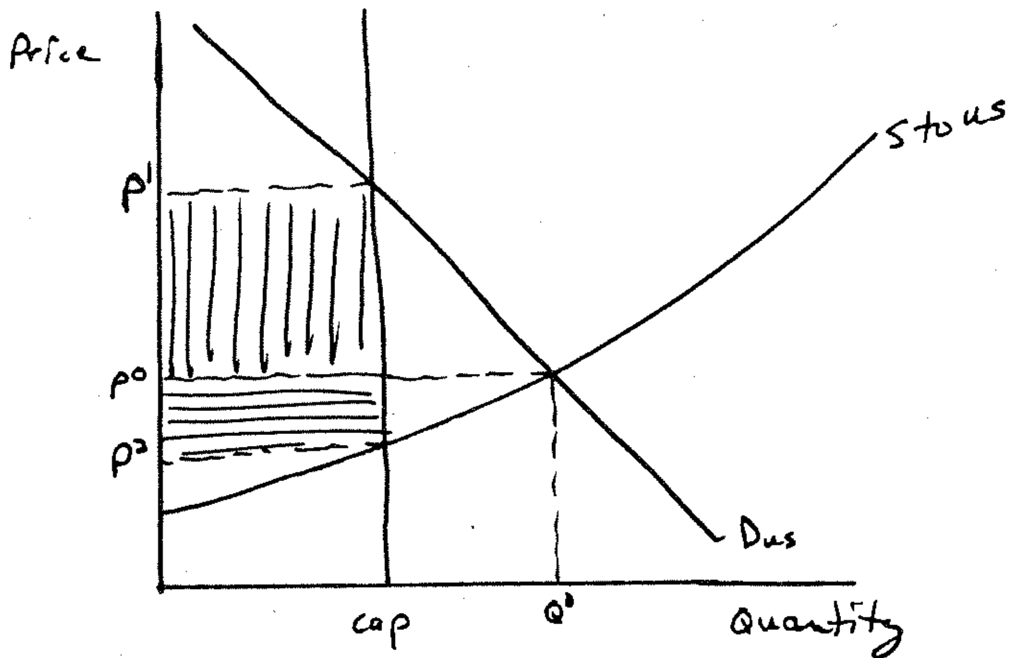
Consider first the welfare effects predicted by the ARCM under the assumption that the foreign fiber market is competitive. Following the convention established in the previous section, the top panel of Exhibit E-7 shows what happens in the U.S. asbestos fiber market when the phase-down is promulgated. This diagram shows one of the years during which the fiber phase-down occurs, so that the cap on fiber usage is still positive, but less than the amount of fiber that would have been sold in the U.S. in the absence of the phase-down regulation. Graphically, the top panel shows that the baseline fiber sold in the U.S. would have been Q^0 and the price P^0 in the absence of the phase-down (the intersection of the U.S. demand for fiber and the supply of fiber to the U.S. from the rest of the world).

Assuming competition in the foreign fiber market, the welfare effects in this year of the phase-down can be seen as follows. First, downstream producer and consumer surplus is lost because the price of fiber to U.S. customers rises to P^1, reflecting both the cost of fiber and the value of permits to purchase fiber that must be held in order to purchase the fiber (the permits, of course, are the mechanism that allocates the limited supply of fiber to competing customers). This lost downstream producer and consumer surplus is equal to the vertically-shaded area above the original price, P^0, up to the new higher "full" fiber price, P^1, and over to the cap amount, Q^1, plus the triangular area to the right of the cap amount out to the demand function. Foreign market participants -- miners and millers of asbestos fiber and consumers of asbestos products -- on <u>net</u> lose the horizontally-shaded area above the supply function from the new, lower price received by fiber producers, P^2, up to the original price and out to the cap amount, plus the triangular area to the right of this rectangle out to the supply function and below the original price. Finally, permit owners (those to whom the permits were allocated or to whom they were sold) gain the two shaded areas in the diagram precisely because the permits are valuable.

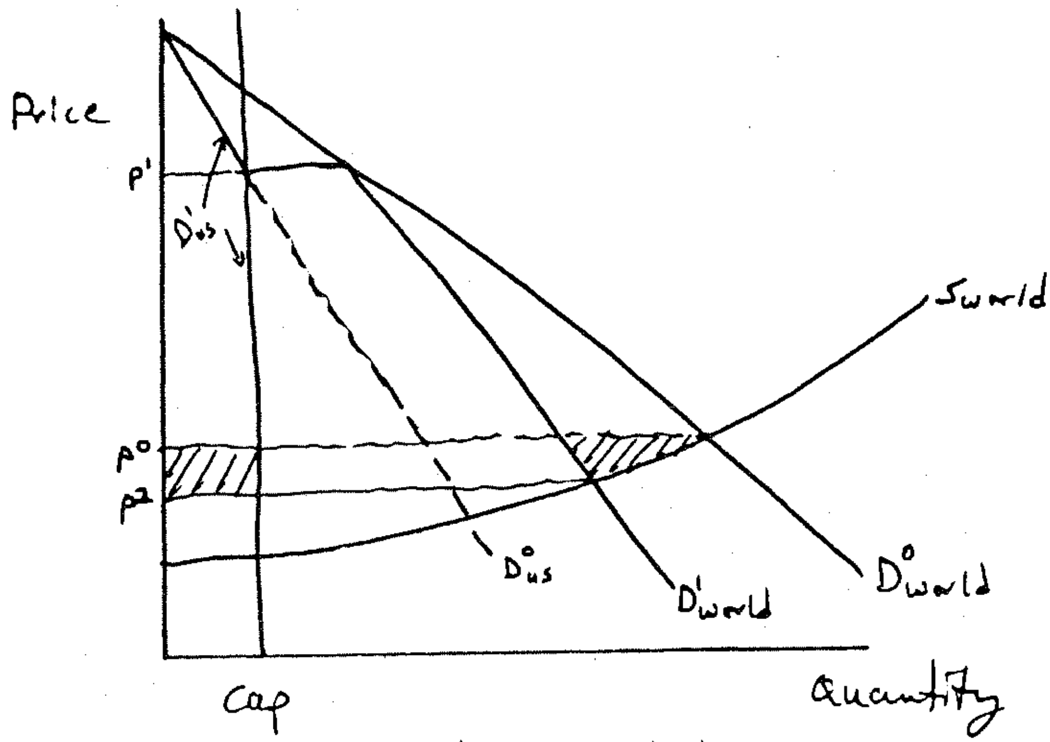
The domestic-foreign welfare impacts are, perhaps, more interesting in the case of a fiber phase-down because, at least in the competitive model of fiber supply, part of the value of permits arises because some of the lost foreign welfare is transferred to U.S. market participants in the form of permit allocations (the bottom of the permit value rectangle is this transfer). This occurs because of the drop in the international price of asbestos fiber, which is produced in very much the same way that it occurs in the competitive model with product bans analyzed in the previous section. The bottom panel of the exhibit shows the world market for asbestos fiber. Again, the supply function can be drawn because the world market for asbestos fiber is assumed to be competitive.

World demand for fiber in the absence of the phase-down cap is shown as D^0. With the phase-down cap, the demand becomes the kinked demand function, D^1. The kink occurs because at the point of the kink, the fiber demand from U.S. customers falls vertically, rather than continuing in the classical downward-sloping fashion. Combining this with a standard downward-sloping demand function from non-U.S. purchasers of asbestos results in the kink. The U.S. fiber demand <u>effective</u> in the world market is shown to the left in the diagram as a demand function that starts out from the vertical axis and then becomes vertical at the price P^1, which corresponds to the price of asbestos fiber at which the phase-down cap just becomes binding. In the absence of the

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PHASE DOWN
UNDER COMPETITIVE FIBER SUPPLY



U.S. Fiber Market



World Fiber Market

phase-down cap, the demand function would have continued in the classical downward-sloping fashion, as indicated by the dashed continuation of the downward-sloping portion of the U.S. demand function with the phase-down cap.[5]

Given this kinked demand function for fiber in the world market, the new competitive price for fiber is established after the phase-down cap is imposed at P^2, corresponding to the fiber price P^2 shown in the top panel of the exhibit. As in the case of product bans, the net loss of foreign welfare shown in the top panel can be identified in the diagram in the bottom panel. The producers of fiber lose the entire area between the new and baseline prices of fiber out to the supply function. Foreign consumers, on the other hand, gain the area to the left of their demand function between the two prices of fiber over to the vertical segment of the U.S. demand function. The shaded area between the two fiber prices and the vertical segment of the U.S. demand, of course, is identical to the horizontally-shaded area in the top panel. Hence, the net loss to foreign market participants equals the two shaded areas in the diagram. In this case, a price drop that makes foreign producers of fiber worse off and foreign consumers of fiber better off is unambiguous, hence the changes in welfare for these entities are also unambiguous.

3.2 Welfare Effects Under a Fiber Cartel

As in the previous section, two assumptions are made concerning the cartelization of the world asbestos fiber industry, i.e., that the industry is a preexisting cartel and, alternatively, that the industry becomes a cartel at the time that the phase-down regulation is promulgated. In this subsection, the welfare effects under each of these assumptions are addressed in turn.

Consider first the situation of a preexisting cartel in the fiber industry. The top panel of Exhibit E-8 shows the U.S. fiber market in a given year of the phase-down with and without the phase-down cap on fiber purchases. This diagram shows the U.S. demand for fiber, but does not present a supply function for asbestos fiber, again because cartels do not have conventional supply curves. The baseline price of fiber is P^0, the "full" price of fiber (including the value of the permits required to trade the fiber) under the phase-down is P^1, and the price of fiber received by producers under the phase-down is shown as P^2.

According to this diagram, the world price of fiber falls, just as in the competitive case. If the fiber price does fall, the welfare results for a fiber cartel under the phase-down regulation are qualitatively identical to those derived assuming competitive supply of fiber. However, the world fiber price need not necessarily fall under the phase-down caps, so whether or not the welfare effects under the phase-down regulation and a fiber cartel mirror those of the competitive case hinges on the factors that determine the direction of movement of the fiber price. Exhibit E-8 shows the situation in

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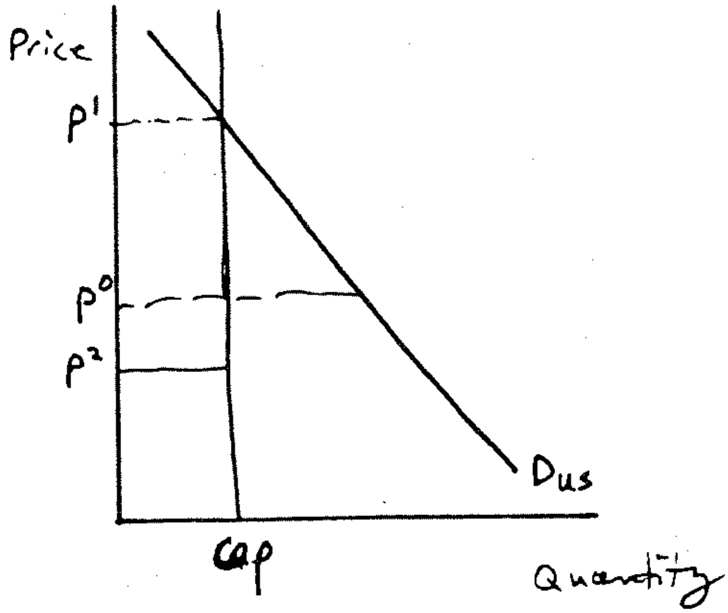
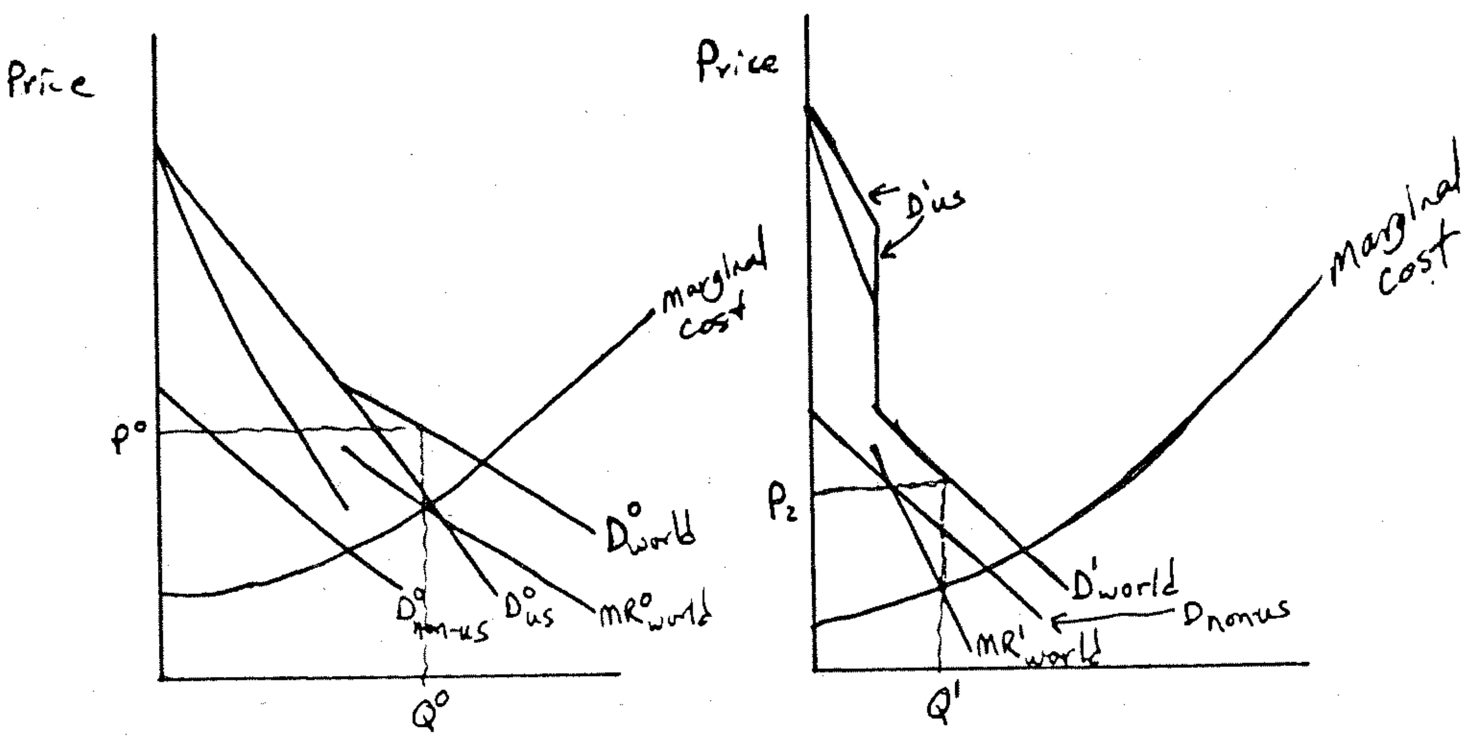
[5] Constructing the U.S. demand under the phase-down cap as this vertical demand at P1 should accord with intuition: if the price of asbestos fiber were to rise to anything above P1, less than the cap amount would be demanded. On the other hand, if the price of fiber is less than P1, only the phase-down quantity of fiber can be purchased by U.S. entities regardless of how low the price becomes.

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PHASE DOWN
UNDER A PREEXISTING CARTEL -- PRICE DECREASE



U.S. Fiber Market



World Fiber Market

which the price of fiber falls after the imposition of the phase-down cap. The alternative outcome is examined in Exhibit E-9.

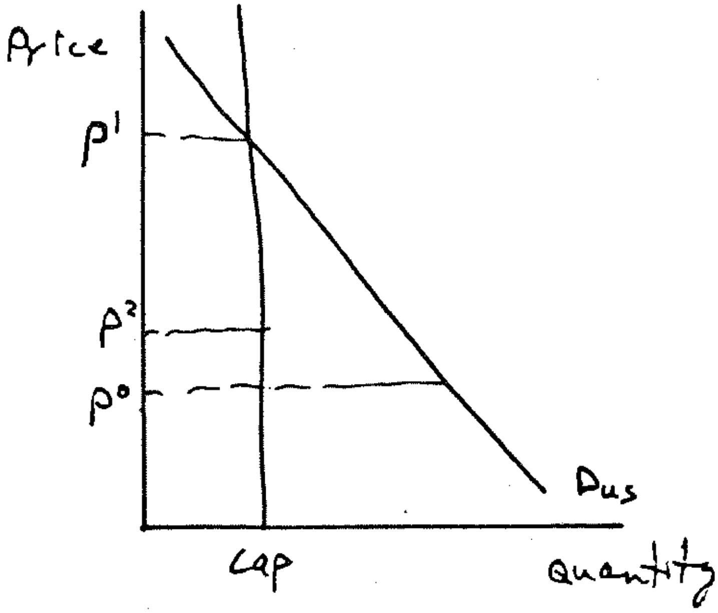
The bottom panel of Exhibit E-8 contains two diagrams, the left-hand depicting the world fiber market in the baseline, i.e., with no fiber cap but with the cartel, and the right-hand showing the same market, but with the phase-down cap. These diagrams are drawn in such a way that the fiber price falls under the phase-down cap. These are fairly complicated diagrams, so some detailed explanation is required. First of all, the total world demand for fiber in the absence of the phase-down cap is derived in the left-hand diagram by horizontally summing the U.S. fiber demand (the without-phase down baseline demand function) and the rest-of-the-world demand for fiber. This yields the outward-kinked demand function for the world, as shown in the left-hand diagram. The marginal revenue function for this baseline world demand relative to which the cartel maximizes its profit is shown in the diagram as the line starting in the vertical axis at the intersection of the world demand for fiber and the vertical axis which falls until the point of the kink in the world demand, and then discontinuously jumps up at that point to continue its descent as shown.

The discontinuity in the marginal revenue function occurs because of the kink in the demand function and is not central to the argument advanced here. However, because kinks in the demand functions inevitably will materialize under the phase-down cap, it seems worthwhile to introduce kinks and discontinuities at the outset.

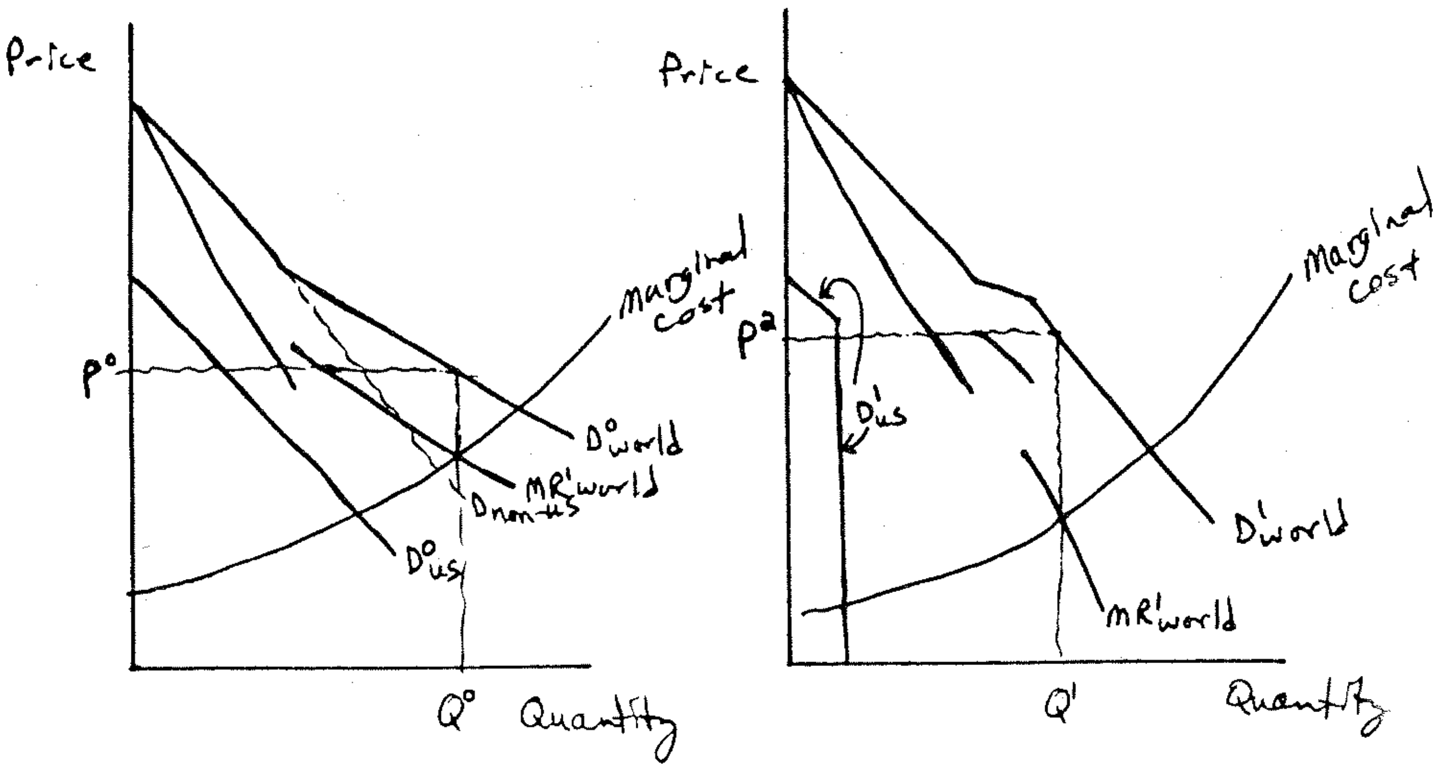
In the absence of the phase-down cap, the cartel would have produced Q^0 and charged a price of P^0, as shown in the diagram. With the phase-down cap, however, matters are quite different. To see what happens, first construct the new world demand function in the right-hand diagram as the horizontal summation of the U.S. demand for fiber under the phase-down cap (the mostly vertical demand function near the vertical axis in the diagram), and the unchanged foreign demand for fiber. This produces the quite peculiar initially downward sloping, then vertical, then downward-sloping demand function as labeled in the right-hand diagram. Next, the marginal schedule for this new demand function can be derived as consisting at first of the small segment of the original marginal revenue schedule near the top of the vertical axis. The marginal revenue schedule then drops vertically until it finally becomes downward-sloping as indicated. The vertical segment of the marginal revenue schedule reflects the fact that the price of fiber must drop substantially before any units in excess of the phase-down cap can be sold to foreign consumers. Of course, the shape and position of the marginal revenue schedule under the phase-down depends critically on the assumptions made concerning the shapes and positions of the demand functions, but the task at this point is simply to indicate that a fall in the price of fiber is possible.

The right-hand diagram shows the new profit-maximizing price and quantity for the cartel as P^2 and Q^1. Note that P^2 in the right-hand diagram (which corresponds with P^2 in the top panel) is less than P^0 in the left-hand diagram. Clearly, the quantity sold in the market declines relative to the baseline, but the price does as well. Qualitatively speaking, these conclusions are perfectly consistent with those that result assuming competitive supply of fiber -- the price falls, output of fiber declines,

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PHASE DOWN
UNDER PREEXISTING CARTEL -- PRICE INCREASE



U.S. Fiber market



World Fiber Market

foreign fiber producers are made worse off, and foreign consumers are made better off.

Although Exhibit E-8 concludes that a price decline for fiber may occur due to the phase-down cap, it is also possible for the price of fiber to rise. Exhibit E-9 examines this case. In the top panel, once again, the U.S. market for fiber is shown, but with a price rise for fiber under the phase-down cap. In this case, if the price of fiber rises, not only do foreign fiber producers not contribute to the value of permits, they actually acquire some of the value of the permits relative to the competitive situation. That is, the value of permits is given by the rectangle bounded by the new "full" price of fiber, P^1, by the new higher producer-price of fiber, P^2, and the phase-down cap. Because P^2 in this case is higher than P^0, permits clearly are worth less than under the competitive scenario.

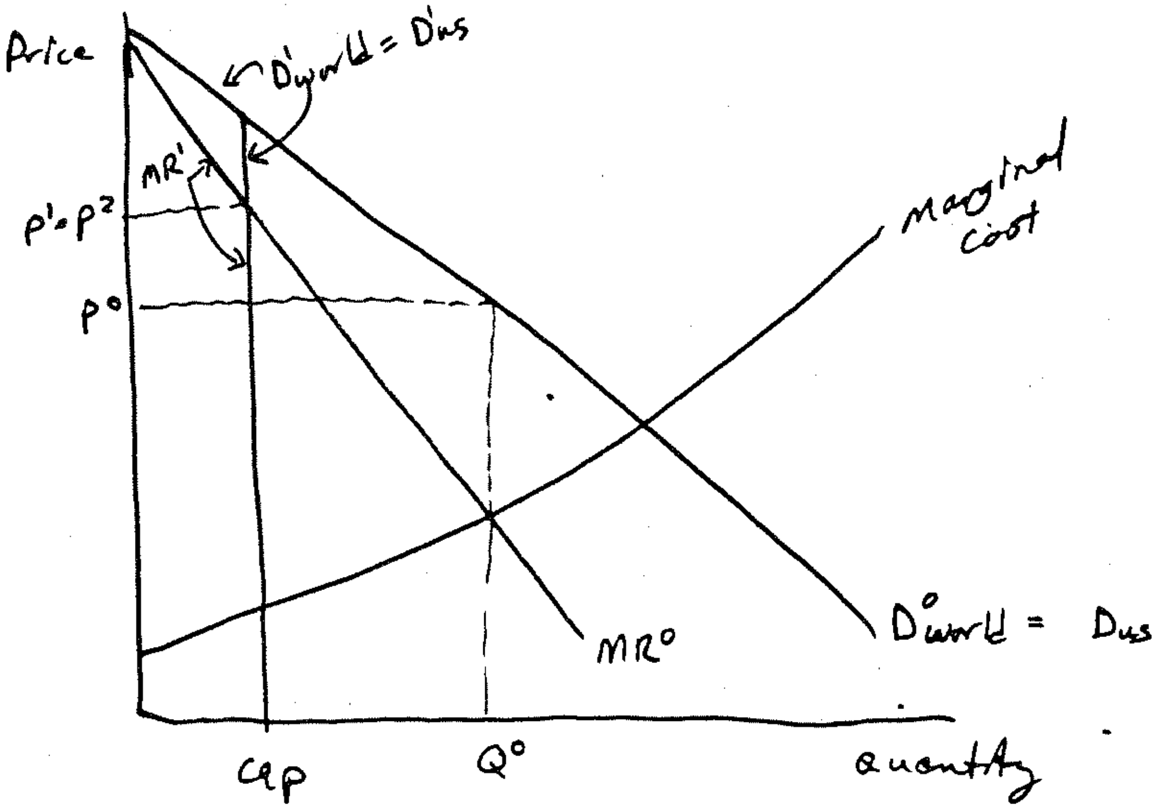
To see how a price rise might occur, consider the bottom panel of Exhibit E-9. Here, the relative sizes of the non-U.S. and the U.S. demands in the absence of the phase-down cap have been reversed, but otherwise the construction of the world fiber demand and the associated marginal revenue schedules are the same as in the previous example. Following the reasoning in the previous example, the equilibrium price and quantity in the fiber market in the absence of the phase-down cap are found as P^0 and Q^0 in the left-hand diagram. The fiber phase-down cap again makes the bulk of the U.S. demand function for fiber (expressed as an effective demand in the world market) vertical, as shown in the right-hand diagram. Once again, the new world fiber demand can be constructed by summing the two relevant demand functions horizontally to yield the new world demand shown as D^1 in the right-hand diagram. Finally, the associated marginal revenue schedule for this new demand function can be derived in the same fashion as in the previous example.

The bottom-panel diagrams show that by drawing the demand and cost functions appropriately, the new equilibrium price of fiber can be higher than before, although the quantity supplied to the market, of course, still falls. In the event that the price of fiber does rise, almost all of the welfare conclusions of the competitive case must be qualified. It remains true that U.S. producers and consumers are worse off and that foreign entities as a whole are also worse off, but the welfare of foreign consumers declines in this case as well. Because the price of fiber rises, no benefits are conferred on any foreign parties, contrary to the conclusion reached in the competitive case. Furthermore, the value of permits is reduced by the increased price of fiber, rather than augmented by a decline in that price. Indeed, the larger the price increase for fiber, the smaller the permit values, so that if the U.S. were the only market for asbestos fiber, the entire value of permits measured in the competitive model for fiber supply would accrue to the foreign cartel.

This last conclusion is worth examining somewhat more closely. Exhibit E-10 shows the world fiber market under the assumption that the U.S. is the only market for asbestos fiber. Consequently, the world and U.S. demands are coincident in both the baseline and phase-down situations. For the baseline situation, the marginal revenue and cost schedules yield the indicated values for the equilibrium price and quantity, P^0 and Q^0. Under the phase-down, the marginal revenue schedule never resumes its downward slope after becoming vertical at the fiber cap. This makes sense because, by hypothesis, at no price will any additional demand for fiber materialize due to the phase-down

Exhibit E-10

POSSIBLE EXTRACTION OF PERMIT VALUES UNDER A PHASE DOWN



World Fiber Market

cap. Therefore, marginal revenue in this case equals marginal cost at precisely the amount of the phase-down cap, which implies that the price of fiber rises under the phase-down cap to exactly P^1. In this event, all of the permit values are appropriated by the cartel since what has to this time been called P^2 now equals P^1, the "full" price of fiber. Thus, in this extreme case, permits will have no value at all.

Even in this scenario, however, some of the conclusions of the competitive model remain true in a qualitative sense. U.S. consumers and producers are worse off (although more so because of the zero value of permits), and foreign fiber producers are worse off as well because even though they appropriate all of the permit values, the level of their profits must fall relative to the baseline because the cartel could have set output at the phase-down cap, but elected not to. Clearly, profits must be lower at the constrained level.

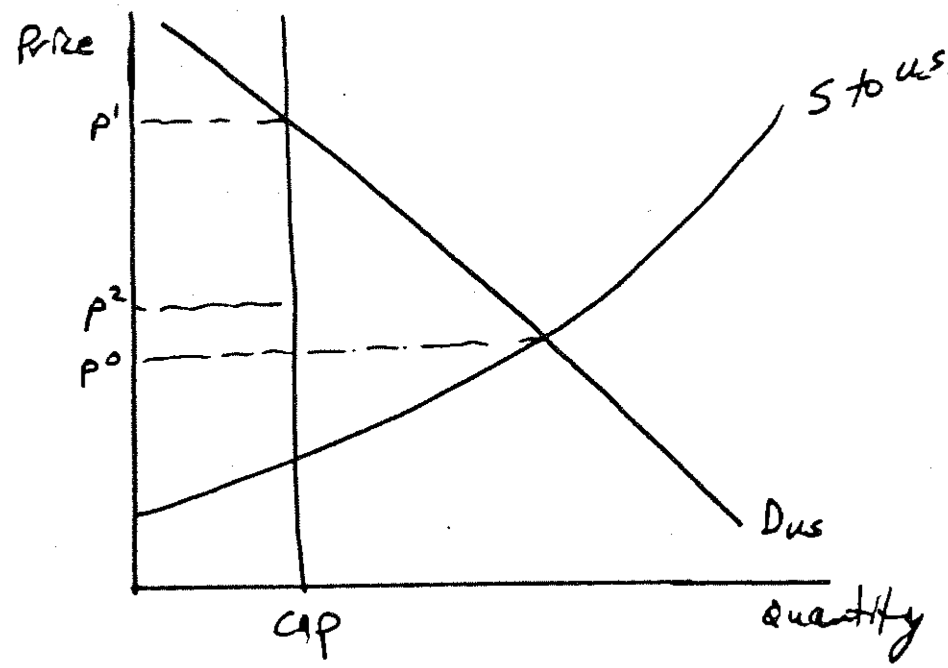
Finally, there is yet another case in which the cartel could appropriate the entire permit value under the phase-down cap. This is if the cartel can segregate the foreign and U.S. markets for fiber, charging different prices to each. In this case, the cartel separately sets marginal revenue in each market equal to marginal cost, thereby producing (in general) unequal prices for each market. In this case, under the phase-down, the U.S. marginal revenue schedule displays the vertical segment down to the horizontal axis, indicating again that the price in the U.S. market should rise to the point at which the phase-down cap is on the margin of being binding, i.e., set the U.S. submarket fiber price equal to P^1. Thus, in this case as well, the foreign fiber cartel could appropriate all of the permits' value, thus leading to qualitatively different conclusions under the cartel than under competition in the fiber industry.

The second alternative assumption concerning the competitiveness of the fiber industry is that the industry becomes a cartel at the time that the phase-down regulation is promulgated. In this case, as was shown in the case of product bans, changes in welfare occur for two reasons -- the phase-down cap on U.S. fiber purchases and the shift from competitive pricing of fiber to monopoly pricing.

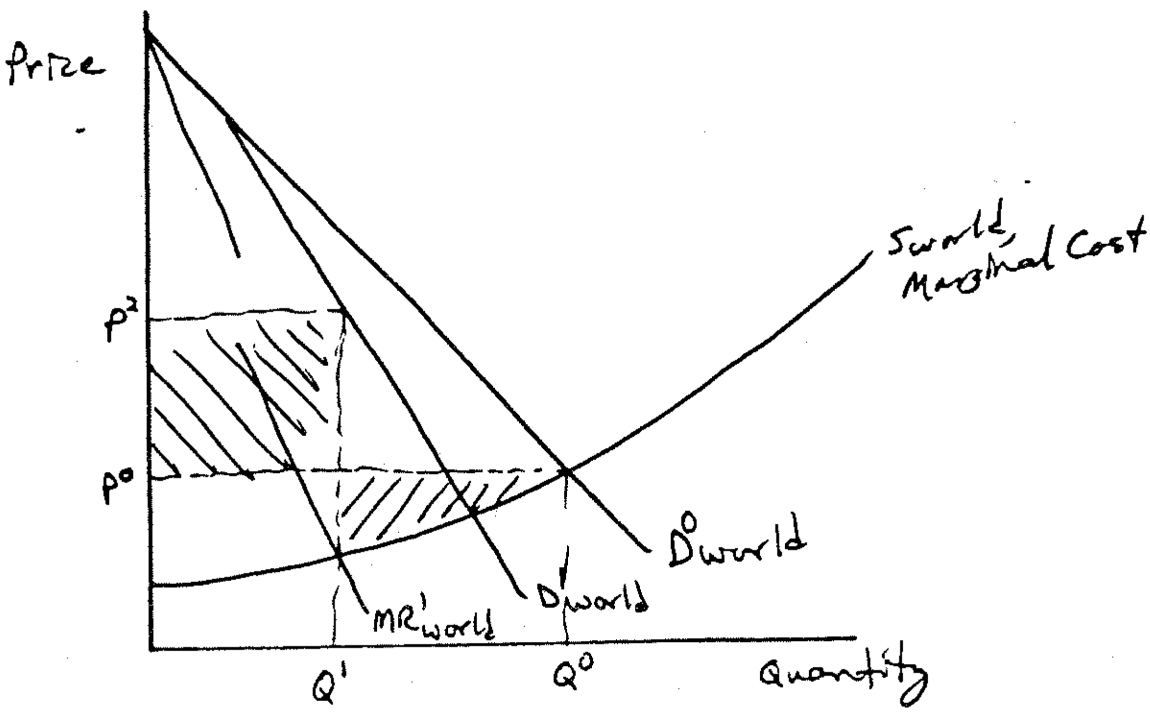
Intuitively, one might expect the price of fiber to rise after the cartel is formed, but, as in the case of a preexisting cartel, whether the price of fiber rises or falls after the cartelization of the industry and the promulgation of the phase-down regulation depends on empirical issues and is therefore ambiguous. Exhibit E-11 shows the case in which the price of fiber rises under the phase-down regulation. The top panel shows the now familiar U.S. market for asbestos fiber, with the baseline supply of fiber (which exists because the industry is not yet cartelized) and the U.S. demand for fiber. Under the phase-down, the fiber price rises to P^2 in this diagram, resulting in reduced permit values relative to the competitive situation.

The bottom panel of the exhibit shows the conditions in the world market corresponding to those in the top panel. World demand in the absence of the phase-down is shown as D^0 which, together with the competitive supply of fiber, yields the baseline price and quantity of fiber as shown. Under the phase-down regulation, the U.S. demand for fiber again takes on the vertical properties outlined above, producing a discontinuous marginal revenue schedule. The now-cartelized industry maximizes its profits given the cost function (which was previously the supply schedule) and the marginal revenue

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PHASE DOWN
UNDER CONCOMITANT CARTEL -- PRICE INCREASE



U.S. Fiber Market



World Fiber Market

schedule, producing a reduced quantity and charging the higher price indicated.

In this case, as the diagram shows, the price rises under the phase-down regulation relative to the baseline. As a consequence, some of the welfare conclusions reached by the ARCM assuming a competitive supply of fiber are not consistent with this scenario. Although U.S. producers and consumers are still made worse off by the regulation, they are even worse off if the fiber suppliers become a cartel at the same time. Second, foreign consumers of asbestos are worse off, rather than better off, because the fiber price rises rather than falls. Finally, the welfare of foreign fiber producers need not necessarily fall due to the phase-down regulation. As was the case under the product bans, it is possible for the price of fiber to rise by enough to more than compensate for the lost fiber producer surplus due to reduced production levels. In the diagram, the rectangular shaded area between the baseline and phase-down prices, P^0 and P^2, must be larger than the triangular shaded area above the cost (supply) function for foreign fiber producers to be made better off. Clearly, this is a possibility, but whether it would be a reality is an empirical issue.

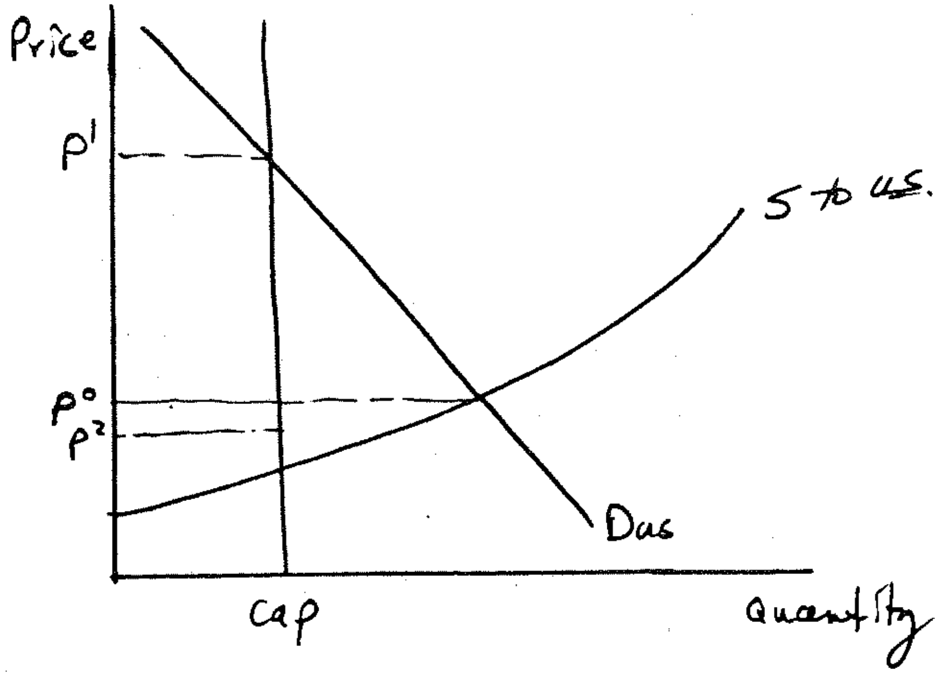
The possibility that the price of fiber could fall after both the imposition of the phase-down regulation and the cartelization of the fiber industry is shown in Exhibit E-12. The top panel shows the U.S. market for asbestos fiber assuming that the fiber price falls, showing the permit values as the difference between the full fiber price, P^1, and the phase-down fiber price, P^2, just as in the competitive fiber supply case. Thus, in this case, the welfare conclusions reached are qualitatively similar to those of the competitive case: part of the value of permits is contributed by transfers from foreign fiber suppliers (through the drop in the price of fiber), domestic producers and consumers are worse off, foreign consumers are better off, and foreign fiber suppliers are worse off.

The corresponding world market conditions are shown in the bottom panel of Exhibit E-12. The baseline price and quantity are produced by the intersection of the competitive supply function and the baseline world demand. Under the phase-down, the U.S. demand again becomes vertical at the phase-down cap, which alters the world demand function as shown. The new marginal revenue schedule shown in the exhibit and the cost function (which was the supply function in the baseline situation) determine the new price, which in this case is lower than the baseline price. Thus, a price reduction in these circumstances is possible even though the cartel forms only upon the promulgation of the regulation. If this were to occur, then the welfare conclusions would be qualitatively the same as those reached by the ARCM assuming competitive supply of fiber.

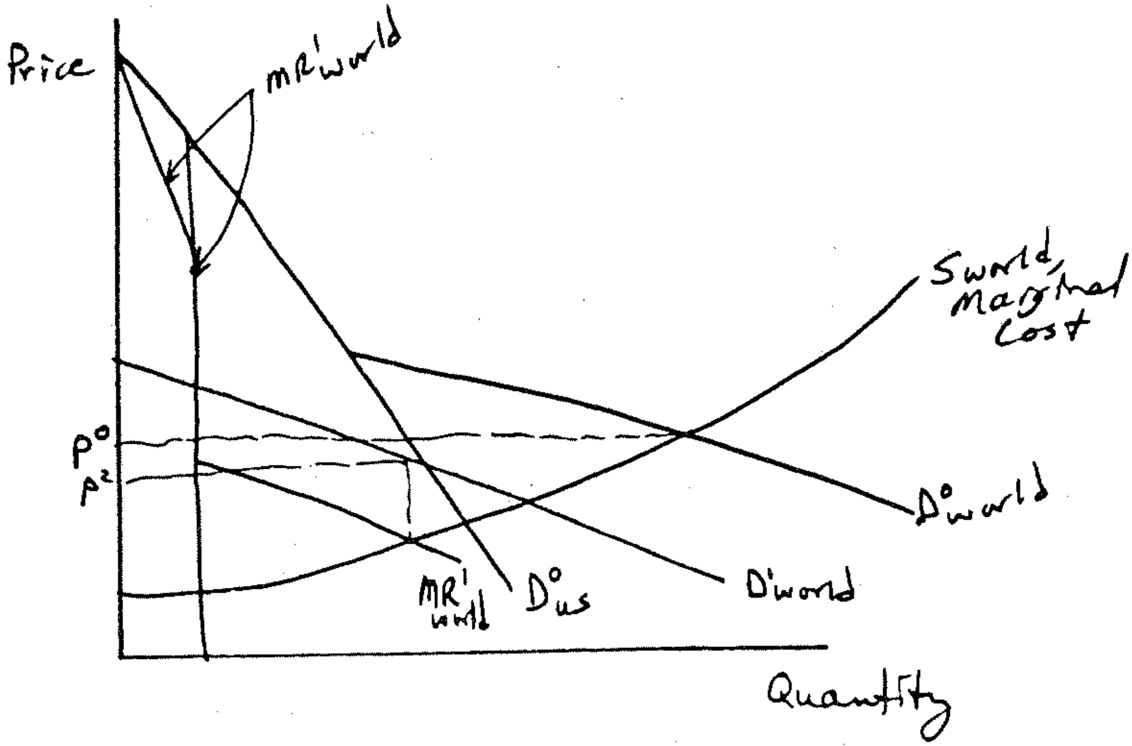
Ultimately, whether the welfare effects under a cartelized fiber industry and the fiber phase-down are qualitatively the same as under a competitive fiber industry depends on two empirical issues. The first is whether a foreign fiber cartel can segregate the fiber market into the U.S. submarket and the foreign submarket. If so, then the welfare conclusions would be quite different from those generated by the ARCM. Indeed, all of the value of permits for fiber would disappear and accrue instead to the overseas cartel. On the other hand, if the foreign cartel cannot segregate the market into the two submarkets, then whether the welfare effects under the fiber phase-down qualitatively match those generated by the ARCM depends on what happens to the

EXHIBIT E-12

DOMESTIC AND FOREIGN WELFARE EFFECTS OF PHASE DOWN
UNDER CONCOMITANT CARTEL -- PRICE DECREASE



U.S. Fiber Market



World Fiber Market

world price of fiber after the imposition of the regulation. If the price rises (because foreign demand is inelastic relative to the combined U.S. and non-U.S. demand), then the welfare conclusions would be different in that the price rise would decrease the value of permits. If the price falls (because foreign demand is large and elastic relative to U.S. demand), then the welfare effects would be qualitatively the same as those generated by the ARCM.

4. Combination Regulations, Welfare Effects, and Industry Structure

The proposed regulations on asbestos call for both staged bans (bans on different products that occur at different points in time) and a general phase down of fiber consumption over time. Thus, the actual welfare effects simulated by the ARCM under competitive conditions in the fiber market reflect both forms of regulation. Hence, it is worth completing the analysis of this paper by examining the qualitative similarities and differences between the welfare effects of these combination regulations under alternative assumptions concerning the structure of the world asbestos fiber market.

4.1 Welfare Effects Under Competitive Fiber Supply

First, consider the welfare effects of both a phase down and product bans calculated by the ARCM assuming that the fiber market is competitive. Exhibit E-13 shows the U.S. and world fiber markets for one year in which some (but not all) products that use asbestos are banned in the U.S. and in which a binding fiber cap exists. The top panel shows the U.S. producer and consumer surplus losses associated with the product bans as the area between the pre- and post-ban derived demand curves for fiber down to the baseline price, P^0. The top panel also shows the price of fiber dropping from P^0 to P^1. This drop in the price of fiber makes sense since in a competitive market with an upward-sloping supply of fiber, reduced demand results in a lower price.

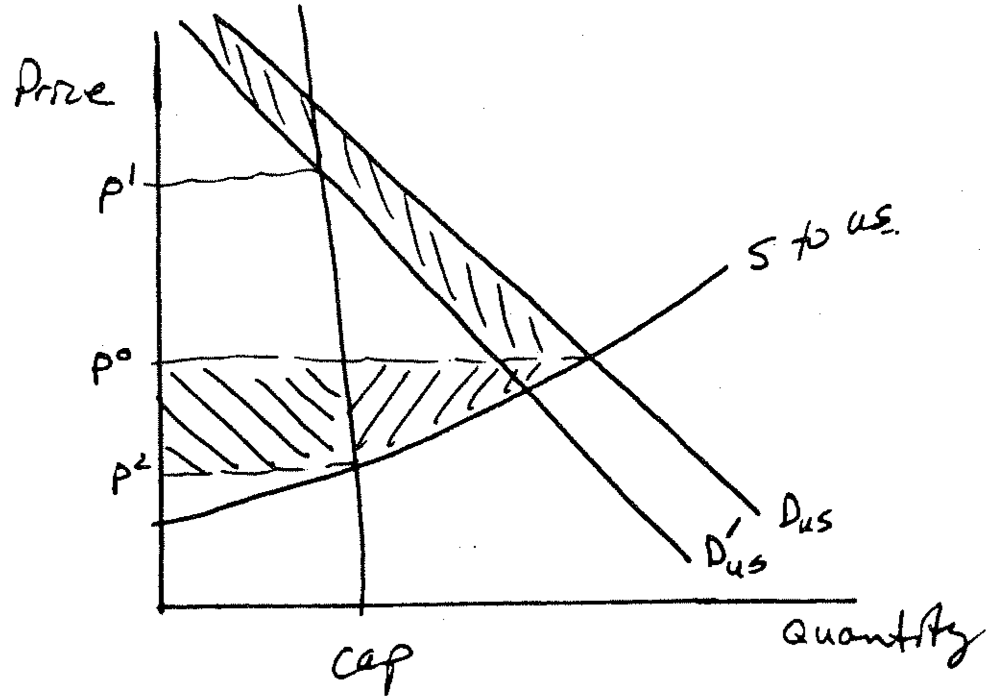
The bottom panel of the exhibit shows the situation in the world market for fiber before and after the bans and phase-down cap are imposed. The inward shift of the demand function for fiber reflects both the product bans and the phase-down cap in the U.S., producing an inward-shifted and kinked demand for fiber, labeled D^1. This drop in demand causes the price of fiber to fall from P^0 to P^2, consistent with the top panel of the exhibit.

Under competitive conditions, the welfare effects of combination regulations are fairly intuitive. Clearly, the drop in the price of fiber makes foreign suppliers of fiber worse off while, at the same time, making foreign purchasers of fiber better off, In the U.S., producers and consumers of banned products are clearly worse off as are the producers and consumers of products that have not been banned (due to the higher "full" price of fiber). However, owners of permits gain the area between the full price of fiber, P^1, and the lower price of fiber on the world market, P^2. Thus, some of the value of permits is contributed by foreign suppliers of fiber through the price reduction.

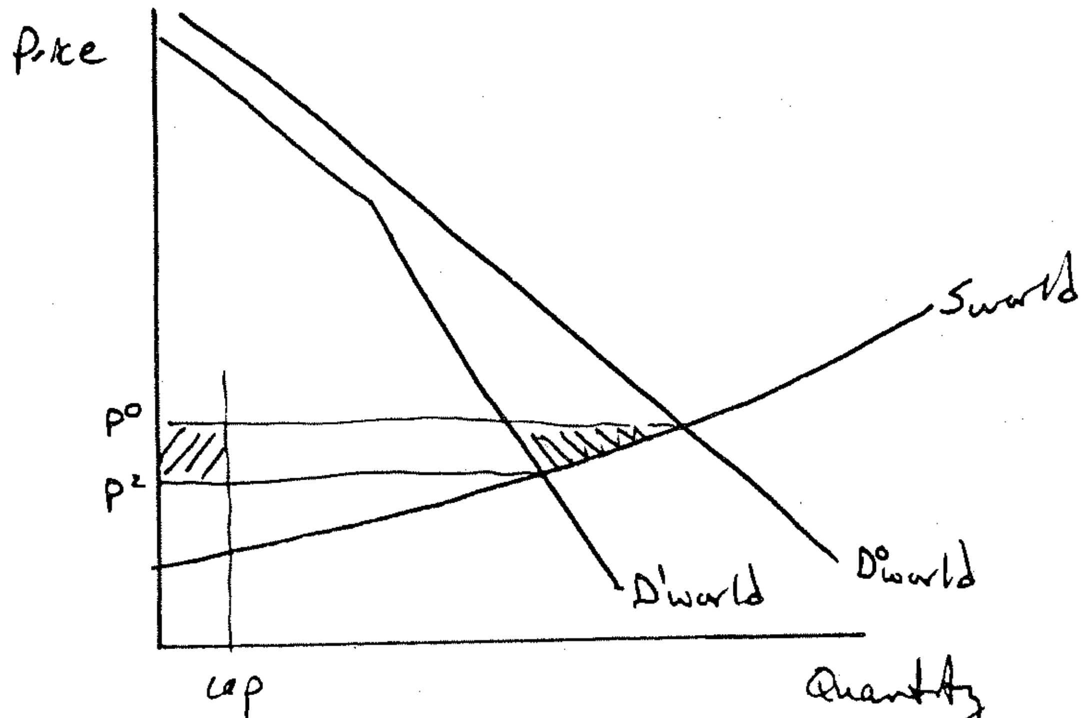
4.2 Welfare Effects under a Fiber Cartel

One alternative assumption concerning the structure of the world fiber market is that it is a cartel acting as a monopolist. Under these conditions, the welfare effects domestically and internationally of the phase down and bans could be qualitatively different in several ways.

DOMESTIC AND FOREIGN WELFARE EFFECTS OF BANS AND PHASE DOWN
UNDER COMPETITIVE FIBER SUPPLY



US Fiber Market



World Fiber Market

Exhibit E-14 shows the U.S. fiber market and the world fiber market in a year in which some products have been banned and in which a binding fiber cap exists. In the top panel, the inward shift of the derived demand for fiber in the U.S. market reflects the product bans, as before. Just as in the competitive case, the decreased welfare of U.S. producers and consumer of banned products can be measured by the area between the pre- and post-ban demands. Finally, in this diagram, the world price of fiber is assumed to fall, making the welfare conclusions in this case qualitatively similar to those derived assuming a competitive world fiber supply.

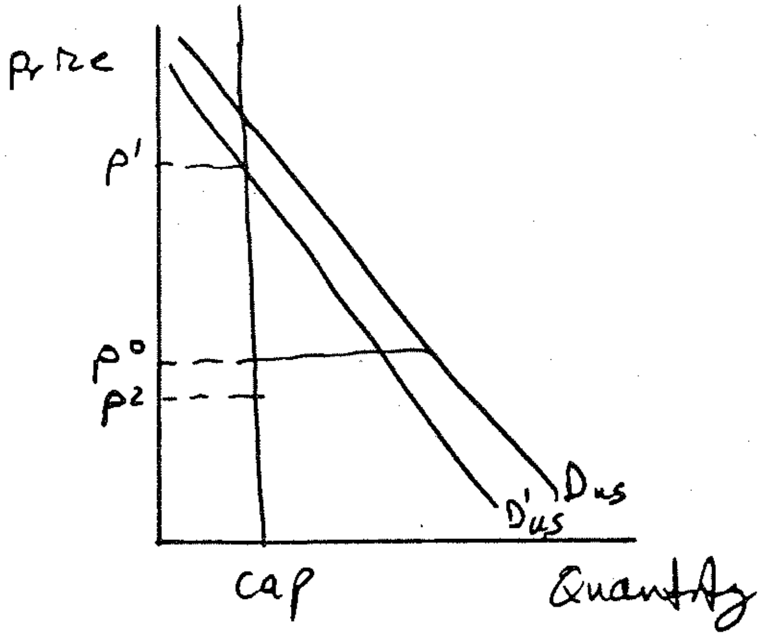
The bottom panels of the exhibit show the corresponding world fiber market conditions. The left diagram shows the baseline situation that would have existed had the bans and phase-down cap not been imposed. In this diagram, the world demand for fiber is shown as D^0, and the corresponding marginal revenue function is drawn as MR^0. Combined with the marginal cost function, the baseline price for fiber is P^0.

The right-hand diagram shows the situation after imposing the bans and phase-down cap. Again, the world demand shifts inward due to the bans and has a kink and vertical segment due to the phase-down cap. The corresponding marginal revenue function is labeled as MR^1 and has a discontinuity due to the kinked nature of the demand function. Given the way that these functions are drawn, the price of fiber falls after imposing the phase-down cap and the product bans. In this event, the welfare of foreign fiber suppliers falls and that of foreign consumers of fiber rises, both as a consequence of the decline in the price of fiber. Qualitatively, these welfare effects match those that result from the same regulations assuming competitive fiber supply.

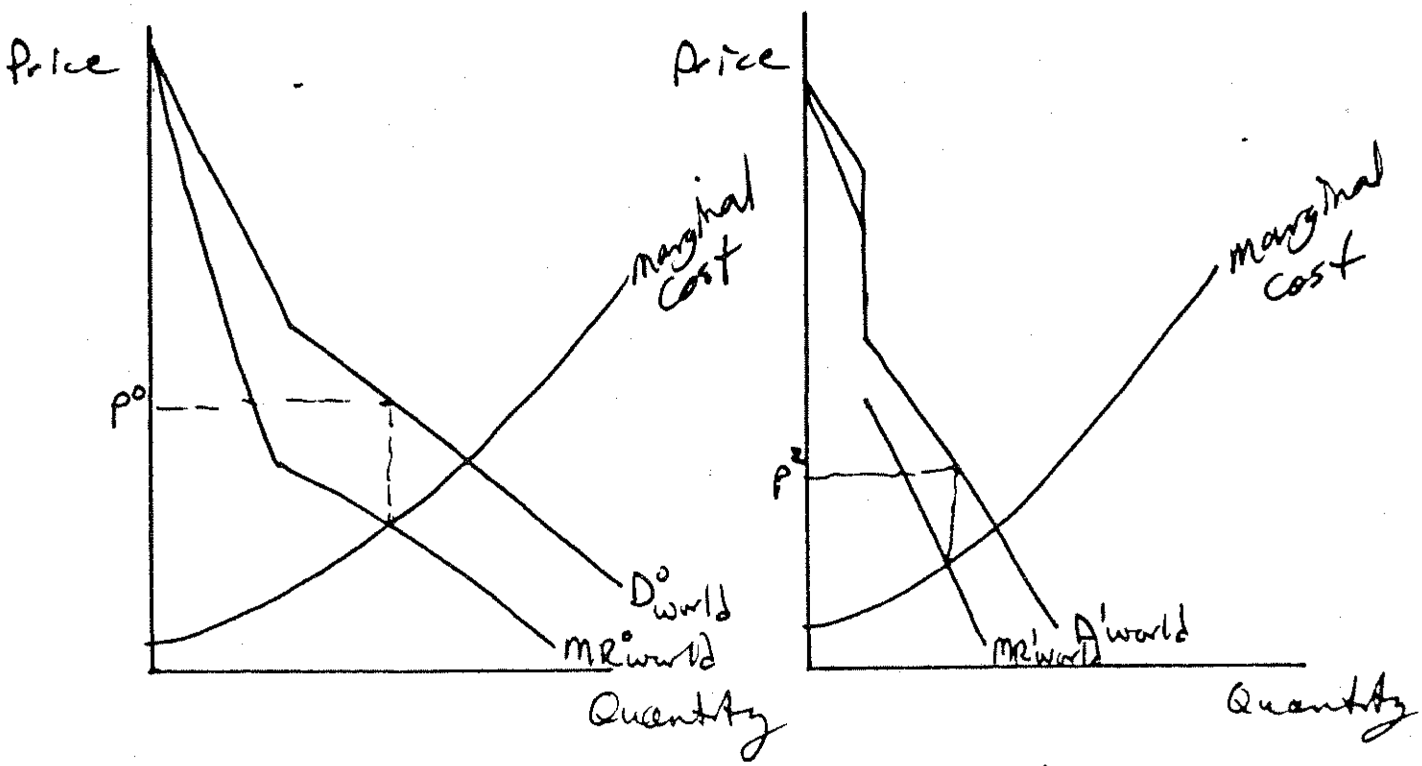
The price of fiber, however, does not necessarily fall relative the baseline price after imposing the phase-down cap and product bans. Exhibit E-15 shows the case in which the price of fiber rises after the imposition of these U.S. regulations. Again, the top panel shows the U.S. market for fiber with the pre- and post-ban derived demands for fiber as before. However, in this case, the price of fiber rises from P^0 to P^2.

The bottom panel of the exhibit shows the world market conditions that correspond to the conditions shown in the top panel. Again, the left-hand diagram shows the baseline situation in which the cartel maximizes profits by setting marginal cost equal to marginal revenue, as indicated, producing a baseline price of P^0. The right-hand diagram shows the post-regulatory situation in which the demand for fiber has shifted inward and has a kink associated with the phase-down cap. In this case, the price of fiber rises relative the baseline so that foreign purchasers of fiber are made worse off, rather than better off, by the U.S. regulations. However, as outlined in previous sections, the rise in the price of fiber cannot fully offset the reduced profits from smaller sales of the cartel. If the price rise was large enough, the cartel would have produced the new equilibrium quantity in the first place and gained even more profit. Thus, the rise in the price of fiber cannot fully restore the profit position of the cartel, so foreign producers of asbestos fiber must be worse off under the regulations. Nevertheless, if the price of fiber rises, the value of permits to mine or import asbestos to the U.S. will be worth less than otherwise, so there are differences in the domestic welfare implications of the regulations if the fiber market is not competitive.

DOMESTIC AND FOREIGN WELFARE EFFECTS OF BANS AND PHASE DOWN
UNDER PREEXISTING CARTEL -- PRICE DECREASE

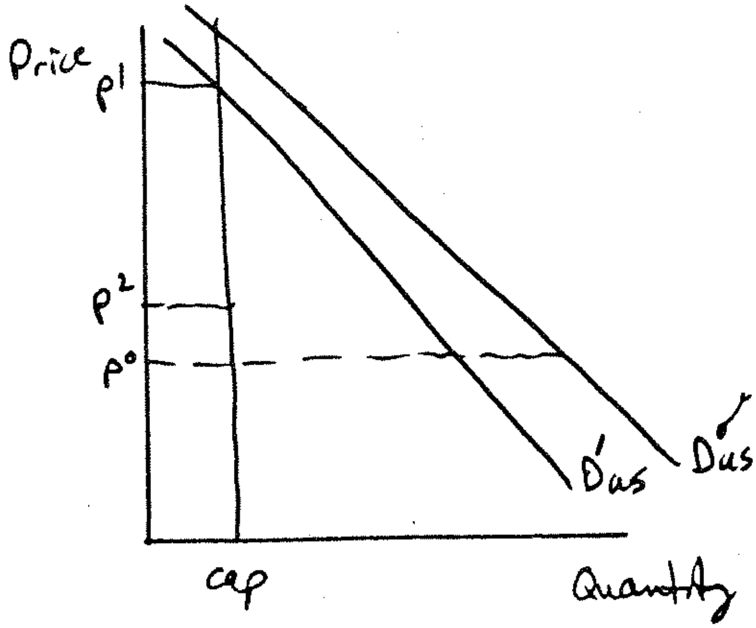


U.S. Fiber Market

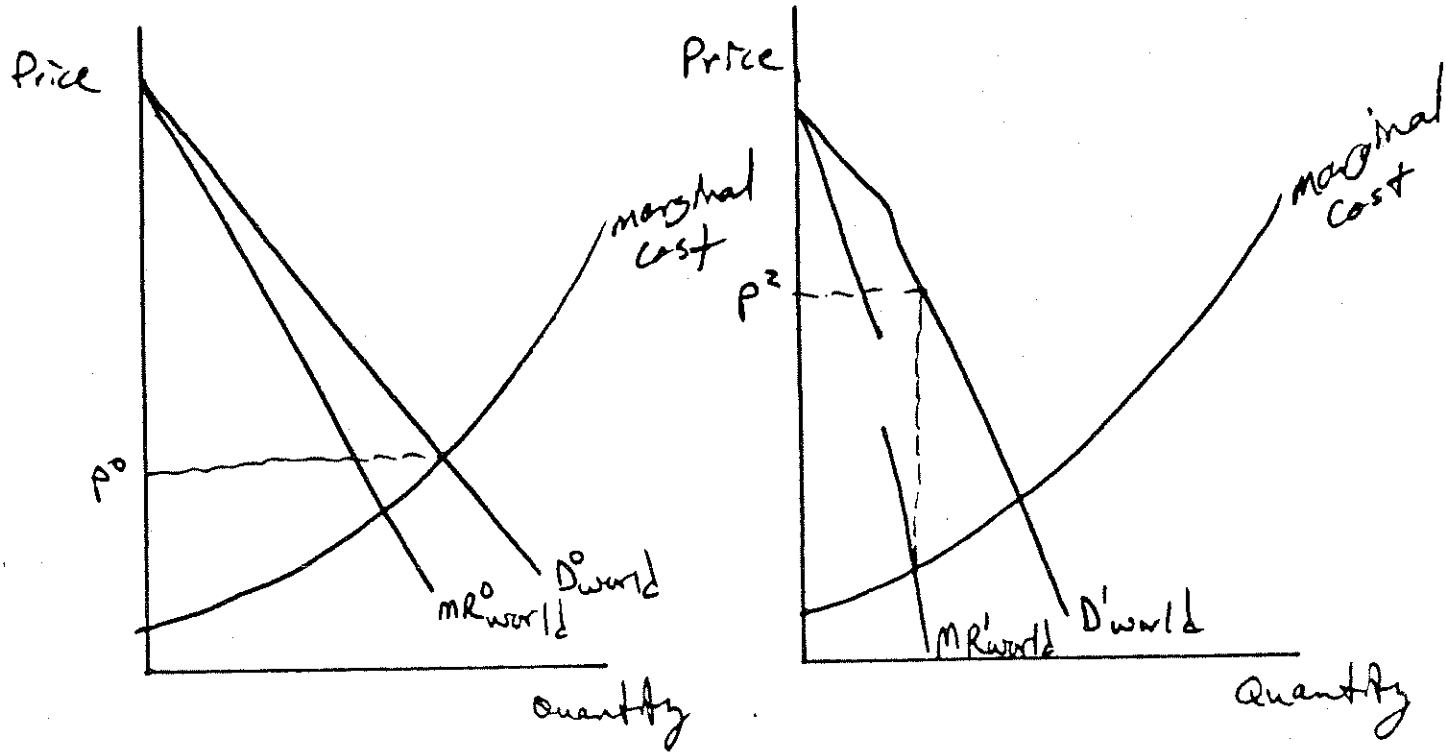


World Fiber Market

DOMESTIC AND FOREIGN WELFARE EFFECTS OF BANS AND PHASE DOWN
UNDER PREEXISTING CARTEL -- PRICE INCREASE



U.S. Fiber Market



World Fiber Market

Most of the qualitative conclusions reached assuming that the world fiber market is competitive are still true even if the world fiber market currently is a profit-maximizing cartel. U.S. producers and consumers of banned and non-banned products are still worse off due to the bans and the higher "full" price of asbestos fiber, and foreign fiber suppliers are worse off. The only difference from a qualitative perspective is whether the price of fiber rises or falls. In the former case, foreign purchasers of asbestos fiber are made better off by the regulations and permit values in the U.S. decline relative to the competitive case.

An alternative assumption concerning the structure of the world asbestos fiber market is that the industry is a competitive one until the U.S. regulations cause firms to collude, resulting in monopolistic pricing. In this case, the qualitative predictions of the welfare consequences associated with imposing both product bans and a fiber phase-down cap at the same time can be somewhat different from those reached assuming competition. Once again, the issue hinges on whether the post-regulation price of fiber rises or falls relative the baseline

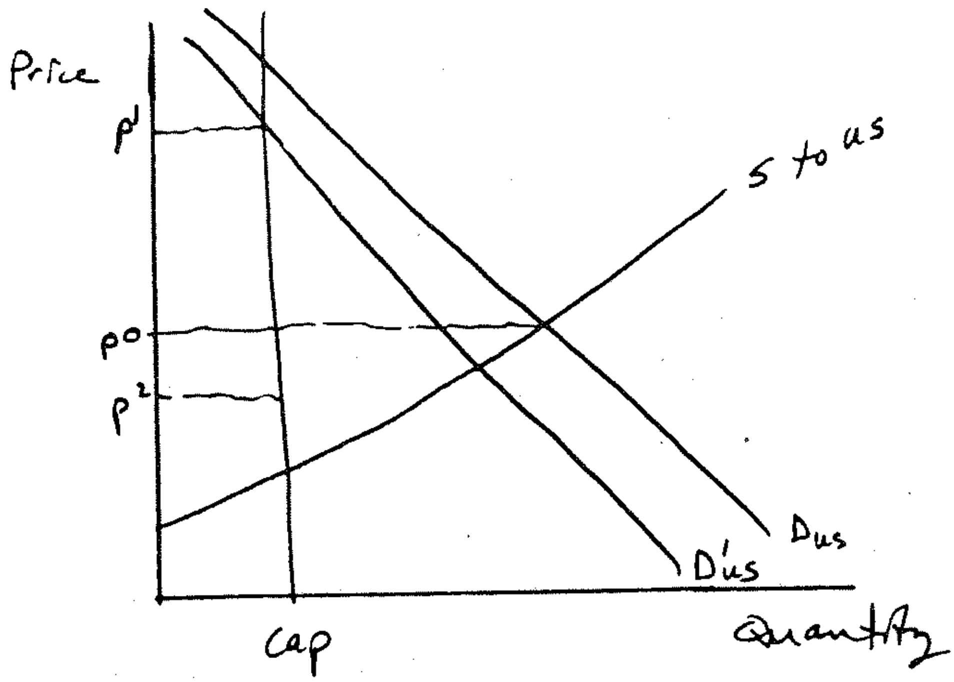
Exhibit E-16 shows the case in which the price of fiber falls relative the baseline. The top panel shows the U.S. fiber market and the fall in the price of fiber. The pre- and post-ban derived demand functions for fiber have the same interpretation as above as do the areas reflecting downstream producer and consumer surplus losses and the value of fiber permits. The bottom panel of the exhibit shows the world fiber market. The pre-regulation demand curve for fiber and the supply function determine the baseline price of fiber, P^0. After the regulations are imposed, the demand function shifts inward and develops kinks and vertical segments due to the product bans and the phase-down cap.

In this case, the resulting marginal revenue function and the marginal cost schedule indicate that the price of fiber falls relative the baseline. In this event, the qualitative welfare conclusions reached assuming competitive fiber supply hold here as well. Domestic producers and consumers of asbestos products are worse off, part of the value of permits reflects transfers from foreign fiber suppliers (the drop in the price of fiber from P^0 to P^2), foreign consumers of asbestos fiber are better off, and foreign producers of fiber are worse off.

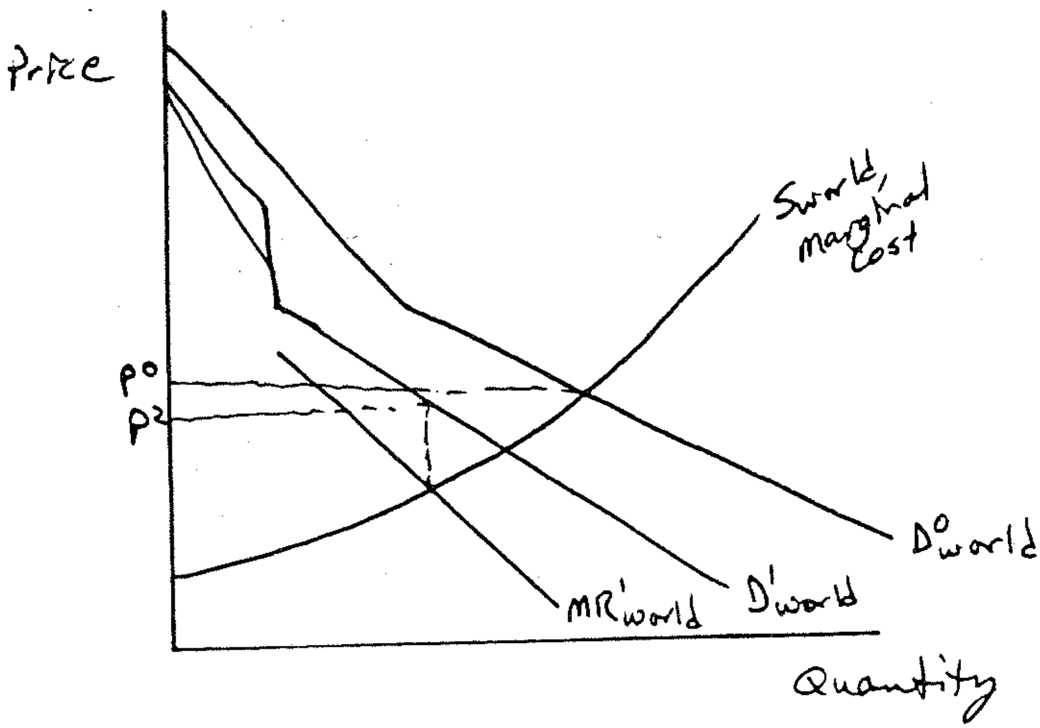
However, the price of fiber could rise after the product bans and phase-down cap are imposed. Exhibit E-17 shows this case. Again, the top panel shows the U.S. fiber market, all of which is the same as in the previous diagram except that the price of fiber is higher, rather than lower, relative to the baseline. Thus, if the price of fiber rises, then the value of permits is reduced (and could conceivably be entirely eliminated in extreme circumstances). The bottom panel shows the corresponding world market conditions. As these functions are drawn, the inward shift of the demand for fiber due to the product bans and the kinks and vertical segment caused by the phase-down cap result in a higher price for fiber.

If the price of fiber rises relative to the baseline, then the welfare effects of the regulations may be qualitatively different than under a competitive structure of the fiber industry. Indeed, it is possible that by cartelizing the industry, the foreign producers of fiber could be better off after the imposition of the regulations than before (although it is the

DOMESTIC AND FOREIGN WELFARE EFFECTS OF BANS AND PHASE DOWN UNDER CONCOMITANT CARTEL -- PRICE DECREASE

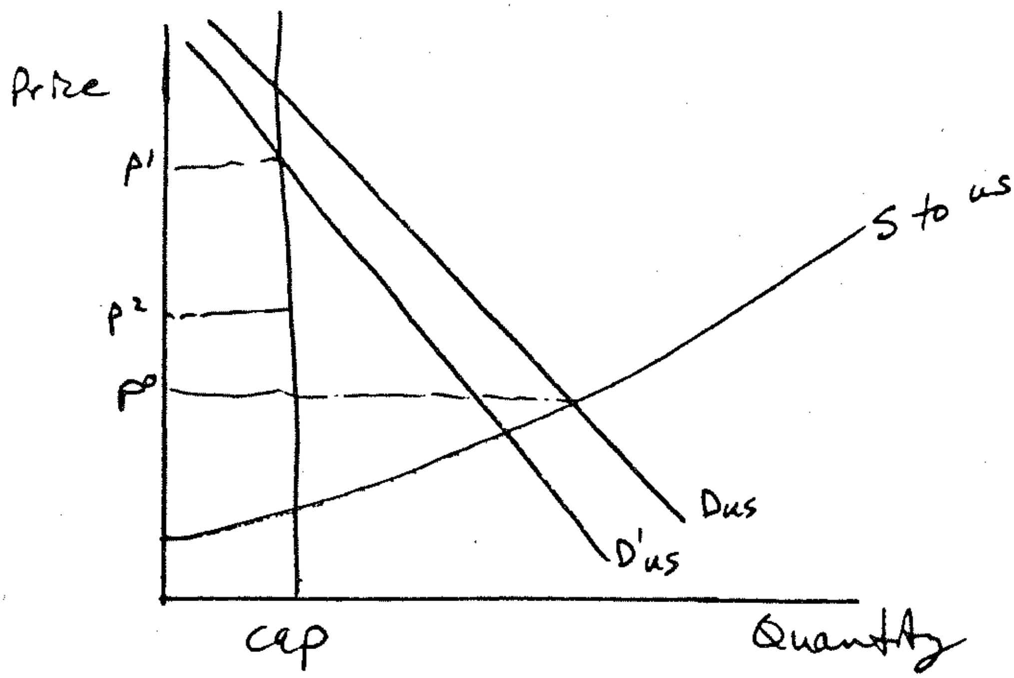


U.S. Fiber Market

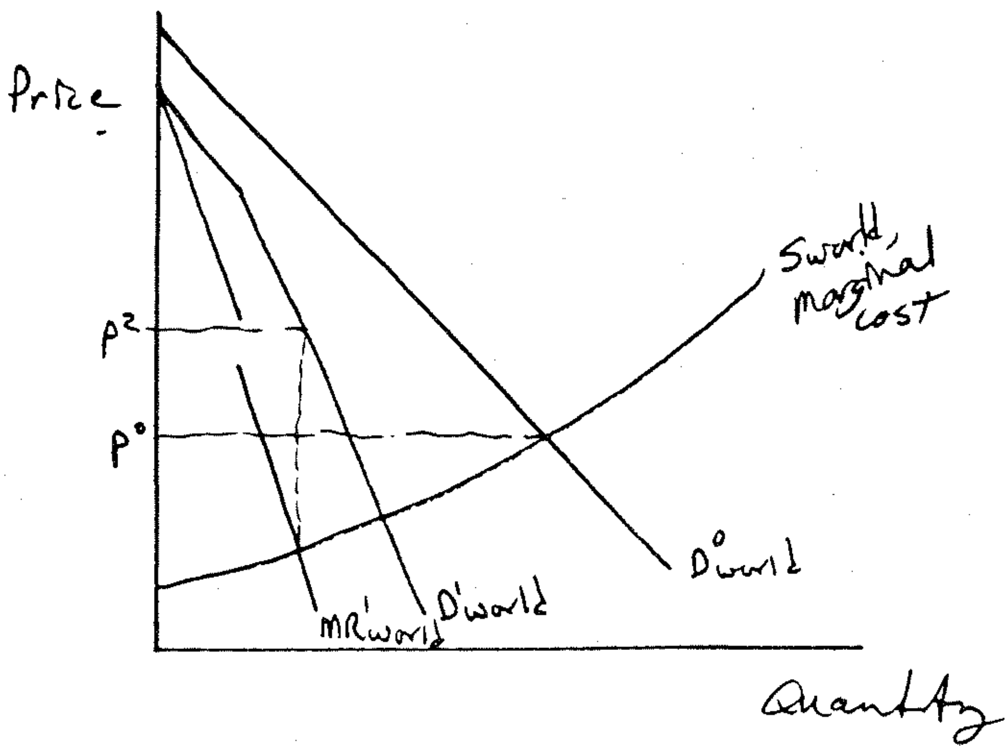


World Fiber Market

DOMESTIC AND FOREIGN WELFARE EFFECTS OF BANS AND PHASE DOWN UNDER CONCOMITANT CARTEL -- PRICE INCREASE



U.S. Fiber market



World Fiber Market

cartelization that drives this, not the regulations <u>per se</u>). Furthermore, foreign consumers of fiber will be worse off, rather than better off, if the price of fiber rises and the value of permits to mine or import fiber will be lower than otherwise.

In sum, if the fiber industry is not competitive, the welfare effects of combining a fiber phase down and product bans could be qualitatively different from those predicted under the assumption that the world fiber industry is competitive. However, from a qualitative perspective, any differences between the welfare predictions of the competitive model and the cartel models are driven by the direction of change of the price of asbestos fiber. If the price falls, then the qualitative predictions of all model are similar. If the price rises, then the predictions for foreign consumers of fiber will be reversed, the prediction for foreign producers of fiber <u>might</u> be reversed, and the value of permits to mine or import fiber will be reduced relative to the competitive case.

5. <u>Conclusions</u>

A summary of the welfare predictions developed in this paper concerning the effects of the proposed regulations on asbestos under alternative assumptions about the structure of the world asbestos fiber market appears in Exhibit E-18. The top of the exhibit lists the economic entities which may be affected by the regulations. Down the left-hand side of the exhibit appear alternative sets of assumptions concerning the structure of the world fiber market and the type of regulation under consideration. The entries in the exhibit are either "+", "-", or "?" indicating the predicted direction of welfare changes for each affected set of economic entities. The entries for "Permit Holders" indicate whether foreign entities contribute to or detract from the value of permits, as described above.

This summary table shows that many of the conclusions reached assuming a competitive supply of asbestos fiber are robust to alternative assumptions concerning the structure of the world fiber market. Others, however, are not. The analysis suggests that there is some ambiguity concerning even the qualitative conclusions one can draw concerning some of the welfare effects of the regulations, although some of the conclusions are unambiguous. For example, U.S. producers and consumers are always worse off in their roles as producers and consumers under the product bans or phase-down alternatives. Furthermore, the quantity of fiber sold world-wide always falls regardless of whether the fiber market is competitive or cartelized.

Other conclusions from the competitive framework are not as robust to the assumption one makes concerning the competitiveness of fiber supply. For example, the price of fiber in the world may either rise or fall if the supply of fiber is not competitive under either regulation or a combination of regulations. This contrasts with the findings of the competitive model in which the fiber price always falls under either the product bans or the phase-down cap. Because of this ambiguity concerning the direction of movement of the asbestos fiber price under the cartel rather than a competitive industry, the welfare conclusions for foreign entities as well as the value of the permits under the phase-down are ambiguous. If the fiber price falls in the cartel situations, then matters qualitatively resemble the conclusions reached by the ARCM assuming competitive supply of fiber. On the other hand, if the fiber price rises under the product bans, the phase-down

Exhibit E-18. Summary of Welfare Effects Under Alternative Fiber Industry Structures

Regulation/ Industry Structure	Economic Entity: Domestic Producers/Consumers	Permit Holders*	Foreign Fiber Producers	Foreign Consumers
Bans Only:				
Competitive	-	N/A	-	+
Preexisting Cartel				
Price Decrease	-	N/A	-	+
Price Increase	-	N/A	-	-
Concomitant Cartel				
Price Decrease	-	N/A	-	+
Price Increase	-	N/A	?	-
Phase Down:				
Competitive	-	N/A	-	+
Preexisting Cartel				
Price Decrease	-	+	-	+
Price Increase	-	-	-	-
Concomitant Cartel				
Price Decrease	-	+	-	+
Price Increase	-	-	?	-
Bans and Phase Down:				
Competitive	-	N/A	-	+
Preexisting Cartel				
Price Decrease	-	+	-	+
Price Increase	-	-	-	-
Concomitant Cartel				
Price Decrease	-	+	-	+
Price Increase	-	-	?	-

N/A = Not Applicable.

*Entries for Permit Holders refer to whether foreign entities contribute or detract from permit values as the policy is implemented relative to the competitive case.

caps, or under both policies, then the value of permits will be reduced (in the phase-down cases) and the welfare of foreign consumers will fall. Moreover, the welfare of foreign fiber producers could even <u>rise</u> if they organized their cartel at the same time that the regulations are promulgated.

REGULATORY IMPACT ANALYSIS OF CONTROLS ON ASBESTOS AND ASBESTOS PRODUCTS

FINAL REPORT

VOLUME III
APPENDIX F

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TABLE OF CONTENTS

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,

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* 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.

<u>ATTACHMENT</u>

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

[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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VI. HIGH-GRADE ELECTRICAL PAPER

A. Product Description

Classification of asbestos paper products into specific categories is difficult. Similar products may be classified differently by two manufacturers due to their differing end applications. Also, manufacturers may place all of their products into the category for which most of the material is used, or they may divide the products into each end application. Our division of paper products into different categories is based on the information obtained from both the manufacturers and users of these products.

Asbestos is used in electrical paper insulation because of its high thermal and electrical resistance that permit the paper to act effectively as an insulator and to protect the conductor from fire at the same time. Asbestos electrical insulation is composed of 80 to 85 percent asbestos fiber encapsulated in high temperature organic binders. It is formed on conventional papermaking machines and may be obtained in rolls, sheets, and semi-rigid boards (ICF 1986).

The major use of asbestos electrical paper is insulation for high temperature, low voltage applications such as in motors, generators, transformers, switch gears, and other heavy electrical apparatuses. Typically, operating temperatures are 250°F to 450°F (ICF 1986).

B. Producers of High-Grade Electrical Paper

At present, asbestos paper for electrical insulation is manufactured by only one firm, the Quin-T Corporation in Tilton, New Hampshire. A previous survey failed to identify any 1981 importers of asbestos electrical insulating paper, and the asbestos processor surveyed in 1986 was not aware of any such imports (ICF 1984, ICF 1986).

C. Trends

The production volumes and fiber consumption for electrical paper for

1985 are presented in Table 1. Production decreased by 20 percent between 1981 and 1985, from 841 short tons to 698 short tons (ICF 1986) (TSCA 1982a). Domestic fiber consumption declined between 1981 and 1985 by 11.5 percent, from 841 short tons to 744 short tons[1] (ICF 1986).

The only two secondary processors of high-grade electrical paper for insulation purposes have ceased manufacturing asbestos containing materials. In 1981, the Square D company, having plants in Clearwater, Florida and Milwaukee, Wisconsin, stopped processing. In 1985, Power Magnetics ceased all production of asbestos containing products (ICF 1986).

The sole manufacturer of asbestos electrical insulation estimates that asbestos products hold 10 percent of the total market. Their share of the market in high temperature applications may be as high as 75 to 80 percent (ICF 1986). The use of asbestos electrical paper in typical applications appears to be declining, as asbestos is being phased out in various applications. One manufacturer of transformers believes that the use of asbestos has been completely eliminated for this product (Square D 1986).

D. Substitutes

Asbestos is unique among raw minerals because it is a chemically inert and nearly indestructible mineral that can be processed into fiber. Asbestos

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[1]Although the consumption value for electrical paper from the ICF 1986 survey indicates that the finished product is more than 100 percent asbestos, it is likely that some of the fiber consumption was in fact, inventory. The submitter could not be reached, however, for corroboration.

Table 1. Production of High-Grade Electrical Paper and Asbestos Fiber Consumption

	1985 Fiber Consumption (short tons)	1985 Production (short tons)	Reference
Total	744	698	ICF (1986a)

fibers partially adsorb the binder with which they are mixed during processing; they are then intertwined, and become the strengthening matrix of the product. By formulating the product with 85 percent asbestos fibers, manufacturers are also employing it as a filler. The remaining 15 percent 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 the numerous qualities of the mineral. Hence, manufacturers have been forced to replace the asbestos fiber with a combination of substitute materials, including aramid and ceramic. The formulations of the substitute products most often include a combination of more than one type of substitute fiber and more than one filler in order to reproduce the properties of asbestos necessary for that application. Formulation of substitute products is done on an application-by-application basis by each manufacturer (ICF 1986).

The substitute products can be grouped into two major categories according to the type of asbestos substitute fiber used: aramid or ceramic (ICF 1986). Table 2 shows a comparison of these substitutes. The current market share of the different substitute formulations is presently unknown and our attempt to project the market shares in the event of an asbestos ban relies more on the informed judgement of industry rather than on specific data. It is evident from the survey that the market share of asbestos free electrical paper is increasing rapidly, as more companies replace asbestos (ICF 1986).

1. Aramid Paper

A typical aramid-based paper product, Nomex (R), the tradename for a substitute paper manufactured by Dupont, is made with an aromatic polyamide. It is thermally stable to 400°F and flame resistant. Quin-T Corporation in Tilton, NH, cites this substitute as performing better than asbestos paper in

Table 2. Substitutes for Asbestos High-Grade Electrical Paper

Paper Product	Manufacturer	Advantages	Disadvantages	Remarks	Reference
Aramid	Dupont	Performance is better. Thermal stability. Flame resistant.	Premium price. Low temperature range.	Aromatic polyamide paper.	ICF (1986a) ICF (1984a)
Ceramic	Carborundum Corp.	Good dielectric properties temperature resistance up to 2000°F. Easily handled. Easily cut.	Stiff. Expensive.	Ceramic paper.	ICF (1986a) ICF (1984a)

some situations. It is very expensive, however, and has a price of $10.48 per pound (five times that of the asbestos product). Quin-T indicated that this material would capture 80 percent of the asbestos market in the event of an asbestos ban (ICF 1986). The disadvantages of Nomex (R) are that it does not have the high temperature limits of asbestos and may not have the same range of applicability that asbestos has (DuPont 1980).

2. Ceramic Paper

Fiberfrax (R) is the name of a ceramic paper made by the Carborundum Corporation and is representative of other ceramic papers available. It has good dielectric properties as well as a temperature resistance up to 2000°F. Two advantages of this paper relative to asbestos are that it is easier to handle and easier to cut. Quin-T Corporation has indicated that this material will take 20 percent of the asbestos electrical paper market in the event of a ban of asbestos. The product is three times as expensive as the asbestos paper, and costs $7.04 per pound (ICF 1986).

Some of the drawbacks of ceramic paper products include the loss of tensile strength after exposure over extended periods, stiffness during use, and slightly more permeability than asbestos at low temperatures (Carborundum 1986).

E. Summary

It appears that substitutes for asbestos electrical paper currently exist. However, these products cost more to produce and may not perform as well. Asbestos is unique among known raw minerals because of its combination of strength, heat resistance, and low price. Since no across the board substitute fiber exists for the mineral, the manufacturer has been forced to replace asbestos with a combination of substitute materials, including aramid- and ceramic-based papers. The substitute materials are a combination of fibers and fillers designed with proprietary formulations.

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 3 summarizes the findings of this analysis, and presents the data inputs for the Asbestos Regulatory Cost Model.

Table 3. Data Inputs for Asbestos Regulatory Cost Model
(006) High-Grade Electrical Paper

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	Reference
Asbestos Electrical Paper	698 tons	1.07 tons/ton	1	$2.53/lb.	3 years	$2.53/lb.	N/A	ICF (1986a)
Aramid Electrical Paper	N/A	N/A	N/A	$10.48/lb.	3 years	$10.48/lb.	80%	ICF (1986a), ICF (1984a)
Ceramic Electrical Paper	N/A	N/A	N/A	$7.04/lb.	3 years	$7.04/lb.	20%	ICF (1986a), ICF (1984a)

N/A: Not Applicable.

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VII. ROOFING FELT

A. Product Description

Asbestos roofing felt is made in two separate stages. In the first stage, asbestos fiber, cellulose fiber, and various fillers are combined to produce unsaturated roofing felt. The second stage involves saturating this felt by coating it with either coal tar or asphalt to produce the final product -- saturated roofing felt.

Unsaturated roofing felt is a paper product composed of 85 to 87 percent asbestos fiber (usually grades 6 or 7 chrysotile fiber), 8 to 12 percent cellulosic fibers, 3.5 percent starch fibers, and small amounts of fillers such as wet and dry strength polymers, kraft fibers,[1] fibrous glass, and mineral wool. The product is manufactured on conventional paper machines. The ingredients are combined and mixed with water and then fed through a series of machines that apply heat and rollers to produce a felt with uniform thickness. The felt can be either single- or multi-layered grade. For the multi-layered grade fiberglass filaments or wire strands may be embedded between the paper layers for reinforcement (Krusell and Cogley 1982).

These steps comprise the primary processing stage of production; the product is now considered an unsaturated felt and is ready to be coated. It can be coated at either the main plant, or it can be coated at geographical locations nearer to demand if lower transportation costs justify it.[2] The felt is coated by pulling it through a bath of hot asphalt or coal tar until it is thoroughly saturated. The paper then passes over a series of hot rollers so that the asphalt or coal tar is properly set. It may be coated with extra surface layers of asphalt or coal tar depending on the intended

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[1]Kraft fibers consist of a blend of cellulose and wood pulp fibers.

[2]It is less expensive to ship unsaturated felt because it weighs much less.

application. After saturation and coating, the roofing felt passes over a series of cooling rollers that reduce its temperature and provide a smooth surface finish. The felt is then air-dried, rolled, and packaged for marketing as saturated roofing felt (Krusell and Cogley 1982).

Asbestos roofing felt is used for built-up roofing. There are two types of built-up roofing systems -- hot roof systems and cold roof systems. The hot roof system is the more common; it involves the application of several plys or layers of roofing felt alternating with hot asphalt or tar, often with a top layer of gravel imbedded in the asphalt. The layers used may be fiberglass felts, organic felts, or asbestos felts.

The other system is a cold roof system. It does not require the application of hot tar or asphalt, instead, adhesive tars or roof coatings are used to bond the layers together. The layers used may be single-ply membrane, fiberglass felts, organic felts, or asbestos felts.

Asbestos is used in roofing felts because of its dimensional stability and resistance to rot, fire, and heat. Dimensional stability, which refers to the product's ability to expand and contract with changes in temperature, is important because roofs are exposed to wide temperature fluctuations that may cause the roof to actually crack, allowing water to penetrate and settle. Because this water may remain trapped for long periods of time, rot resistance becomes crucial. In addition, rot resistance is important because flat roofs (on which built-up roofing is typically used) tend to have poor drainage and do not allow water to run off (ICF 1985).

B. <u>Producers and Importers of Asbestos Roofing Felt</u>

There were three primary processors and three secondary processors of asbestos roofing felt in 1981. The primary processors were Nicolet, Inc., Celotex Corporation, and Johns-Manville Corporation[3] (TSCA 1982a). However, no primary processors produced any asbestos felt in 1985 and none are currently producing asbestos roofing felt (ICF 1986).

The secondary processors in 1981 were B.F. Goodrich Corporation, Mineral Fiber Manufacturing Corporation, and Southern Roofing & Metal Company (TSCA 1982b). Southern Roofing & Metal Company stopped processing asbestos roofing felt in 1982. B.F. Goodrich Corporation processed imported asbestos roofing felt in part of 1985, but has now stopped. Mineral Fiber Manufacturing Corporation is the only domestic company which still processes asbestos roofing felt (ICF 1986).

Mineral Fiber Manufacturing Corporation does not purchase[4] asbestos roofing felt. They simply receive unsaturated roofing felt, coat and saturate it with asphalt, and return the saturated roofing felt to their supplier, a Canadian firm called Cascades, Inc. Cascades, Inc. then sells this product in the U.S. through Power Marketing Group, a distributor that does not process any asbestos itself. Power Marketing Group believes they are the only company selling this product in the U.S., and no other processors or importers of asbestos roofing felt were identified (Power 1987b, ICF 1984, ICF 1986).

C. <u>Trends</u>

The three primary processors produced approximately 3,107,538 squares of asbestos roofing felt in 1981 (TSCA 1982a), and they had all ceased production of this product in 1985. Information on imports by Power Marketing Groups and other companies in 1981 is not available, but Power Marketing Group believes it is the only importer of this product in 1985. Thus, we see that both

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[3]Johns-Manville Corporation has changed its name to Manville Sales Corporation.

[4]The company insists that it does not purchase or process any roofing felt. They provide the service of coating the felt and charge a fee for their service.

production and consumption of asbestos roofing felt have declined significantly in the U.S.

D. Substitutes

There are currently four products which have served or may serve as substitutes for asbestos roofing felt -- fiberglass felt, organic felt, modified bitumen, and single-ply membrane. A discussion of each one will be presented separately.

1. Organic Felt

Organic felt is the oldest roofing felt, and it had dominated the market until recently because it was very economical. It is composed primarily of wood pulp or cellulosic fiber, and this makes it susceptible to rotting. Although asbestos felt could not compete with organic felt on price, it was able to outperform it because of its heat, fire, and rot resistance. These resistance properties were particularly important because they allowed commercial users to save on their insurance premiums (Manville 1986). The recent substitution away from asbestos roofing felt has resulted in some increased market share for organic felt, but the primary beneficiary has been fiberglass felt. The current producers of organic felt include: Manville Sales, Celotex, Koppers, and Certainteed (Washington Roofing 1986).

2. Fiberglass Felt

Fiberglass roofing felt is made of glass or refractory silicate mixed with a binder. The exact composition is not available. Owens-Corning Corporation invented the continuous filament manufacturing process in 1964. The introduction of fiberglass felt drastically changed the market because it took virtually the entire market share of asbestos roofing felt and now has a major share of the roofing felt market. Fiberglass felt was able to do this because it possesses the same heat, fire, and rot resistant qualities of asbestos felt, but it is much less expensive and may require fewer layers.

Most of the recent substitution away from asbestos roofing felt was achieved through the use of fiberglass felt. The current producers of fiberglass felt include: Owens-Corning, Manville Sales, Tamco, and GAF (Washington Roofing 1986).

3. Modified Bitumen

Power Marketing Group states that the asbestos felt they sell is used almost exclusively in flashing applications. This refers to the process of waterproofing roof valleys or the area around any object which protrudes from the roof. Asbestos felt is used in these applications because fiberglass felt has a tendency to pull away when it is applied vertically as is often the case in flashing applications (Power 1986). Organic felt is not suitable for such applications because it is susceptible to rotting.[5] Power Marketing Group believes the only effective substitute is modified bitumen. However, it costs 10-15 percent more than asbestos roofing felt, and it also presents a fire risk because it must be applied with a torch (Power 1986).

4. Single-Ply Membrane

Single-ply membrane is a cold roof system. The product itself is a laminate (roll of bonded or impregnated layers) of modified bitumen and polymeric materials. For example, Koppers KMM(R) system is a 160 mil, five layer laminate composed of a thick plastic core protected on each surface by a layer of modified bitumen and an outer film of polyethylene.

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[5]The view expressed by Power Marketing Group concerning the usefulness of asbestos are not shared by members of the industry. The National Roofing Contractors Association does not recommend the use of asbestos felt, and most roof suppliers do not carry the product (National Roofing Contractors 1986; Washington Roofing 1986). One roofing contractor claimed that using fiberglass felt for virtually an entire job and then using asbestos felt for only the flashing applications would not be practical because it would cause unnecessary delay and confusion while conferring limited benefits (Johnny B. Quick 1986).

A single-ply membrane is typically loosely laid (i.e. without layers of tar) with a covering of loose gravel. If more than one sheet of membrane is required to cover an area, the edges of the sheets are sealed together by ironing them together or through the application of a coal adhesive (Krusell and Cogley 1982).

The fact that single-ply membrane roofing can be applied cold to the roof deck is an important advantage when city ordinances or other considerations prohibit hot tar because of the dangers associated with tar kettles. At temperatures ranging between 650°F and 750°F, the tar or asphalt mixture will burn and has, in some instances, exploded and caused damage to property and pedestrians. As a result, some communities do not allow the use of hot tar or asphalt (Krusell and Cogley 1982). Manufacturers of single-ply membrane roofing systems include: Carlisle Syntex, Plymouth Rubber, Gates Engineering, and Koppers (Washington Roofing 1986).

Table 1 presents the advantages and the disadvantages of asbestos roofing felt and its substitutes, and Table 2 presents the inputs for the Regulatory Cost Model. Because asbestos felt is now used primarily in flashing applications, the projected market shares of the substitutes are based on their ability to substitute for asbestos felt in this particular application.

E. <u>Summary</u>

Asbestos roofing felt is no longer produced in the U.S. It is only distributed by Power Marketing Group, a company that imports the asbestos product from Canada. Total U.S. consumption of this product was 283,200 squares in 1985.

There appears to be some disagreement between representatives of Power Marketing Group and other industry sources on the likely substitutes of asbestos roofing felt in the case of an asbestos ban. Our estimated market shares are an attempt to reconcile these two views. Modified bitumen is

Table 1. Substitutes for Asbestos High-Grade Electrical Paper

Product	Manufacturer	Advantages	Disadvantages	References
Asbestos Felt	Cascades, Inc. Kingsley Falls, Quebec	Dimensional stability. Rot, fire, and heat resistance. Effective in flashing applications.	Potential environmental and occupational health problems.	ICF (1986) Krusell and Cogley (1982)
Organic Felt	Manville Sales Corp. Celotex Corp. Koppers Co. Certainteed Corp.	Low cost.	Low durability. Low strength. Low rot resistance.	ICF (1986)
Fiberglass Felt	Owens-Corning Corp. GAF Corp. Tamco, Inc. Manville Sales Corp.	Rot, fire, and heat resistance. Dimensional stability Requires less asphalt saturation.	Less effective in flashing applications.	ICF (1986)
Modified Bitumen	Many	Effective in flashing applications.	Can only be applied with a torch.	Power (1986)
Single-Ply Membrane	Carlisle Syntex, Inc. Plymouth Rubber Corp. Koppers Co. Gates Engineering Co. Firestone Corp. Goodyear, Inc. Manville Sales Corp.	Can be applied cold. Rot, fire, and heat resistant. Dimensional stability. Effective in flashing applications.	High cost.	ICF (1986)

Table 2. Data Inputs for Asbestos Regulatory Cost Model

Product	Imports[a]	Product Asbestos Coefficient	Consumption/ Production Ratio	Price	Useful Life	Equivalent Price	Market Share	References
Asbestos Felt	283,200 squares[b]	0.0045 tons/square[b]	N/A	$6.65/square[b]	18 years	$6.65/square	N/A	ICF (1984) Power (1987a)
Fiberglass Felt	N/A	N/A	N/A	$3.85/square	18 years	$3.85/square	40%[b]	Washington Roofing (1986)
Modified Bitumen	N/A	N/A	N/A	$7.48/square[b]	18 years	$7.48 square	50%[b]	Power (1986)
Single-Ply Membrane	N/A	N/A	N/A	$29.26/square	18 years	$29.26/square	10%[b]	Washington Roofing (1986)

N/A: Not Applicable.

[a]This table is slightly different from the other data input tables. The heading for the second column is usually output and this refers only to domestic production. This number is then multiplied by the consumption production ratio to compute total domestic consumption. Because domestic production for this production is zero, we have provided the amount of roofing felt imported. The consumption production ratio is not computed because it is infinite.

[b]See Attachment for explanations.

projected to capture 50 percent of the market at a price of $7.48/square, fiberglass felt is projected to capture 40 percent of the market at a price of $3.85/square, and single-ply membrane is projected to capture 10 percent of the market at $29.26/square (see Attachment).

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ATTACHMENT

Because the information about substitutes obtained from various sources is somewhat contradictory, the projected market shares are based on a synthesis of the various opinions expressed. Thus, they are not attributable to any specific source, but they are the results of conversations with various industry members. It has been assumed that organic felt cannot be used in flashing applications due to its susceptibility to rotting.

Power Marketing Group believes that modified bitumen is the only effective substitute for asbestos felt and that its share should be 100 percent. Several industry sources (Washington Roofing 1986, Johnny B. Quick 1986) and the National Roofing Contractors Association (National Roofing Contractors Association 1986) believe that asbestos felt would be replaced with more conventional roofing materials. They estimate that fiberglass felt will take 80 percent of the market and single-ply membrane will take the remaining 20 percent. We have computed our market shares by weighting both of these opinions equally. Therefore, we estimate the following market shares: modified bitumen -- 50 percent, fiberglass felt -- 40 percent, and single-ply membrane -- 10 percent.

VIII. FILLER FOR ACETYLENE CYLINDERS

A. Product Description

Asbestos is used to produce a sponge-like filler that is placed in acetylene cylinders. The filler holds the liquified acetylene gas (acetone) in suspension in the steel cylinder and pulls the acetone up through the tank as the gas is released through the oxyacetylene torch. The torch is used to weld or cut metal and is sometimes used as an illuminant gas. The filler also acts as an insulator that offers fire protection in case the oxidation of the acetylene becomes uncontrollable. The desirable properties of asbestos in this function include its porosity, heat resistance, anti-corrosiveness and its strength as a binding agent (ICF 1986).

B. Producers and Importers of Filler for Acetylene Cylinders

Currently, there are three primary processors of asbestos filler for acetylene cylinders in the United States. The amount of fiber consumed and the number of cylinders produced in 1985 are listed in Table 1. There were no secondary processors of the filler in 1985 (ICF 1986). There were no acetylene cylinders imported to the U.S. in 1985. (NI Industries 1986).

C. Trends

Since 1981, domestic production of acetylene cylinders has decreased. The decrease is attributed to the severity of the last recession that contributed to the closing of the Los Angeles plant of NI Industries (NI Industries 1986). Recently, the market for acetylene cylinders has been stable and is expected to remain so for the foreseeable future (ICF 1986). Table 2 lists the fiber consumed and the cylinders produced in 1981 and 1985.

Table 1. Fiber Use and Production of Asbestos Filler -- 1985

	Asbestos Fiber Consumed (short tons)	Asbestos-Containing Acetylene Cylinders Produced	Reference
Total	584.1	392,121	ICF (1986)

Table 2. Acetylene Cylinder Market 1981-1985

Year	Asbestos Fiber Consumed (short tons)	Asbestos-Containing Acetylene Cylinders Produced	Reference
1981	863.0	528,432	ICF (1986)
1985	584.1	392,121	ICF (1986)

D. Substitutes

Currently, only one of the filler processors is producing a substitute filler. NI Industries processes a filler that contains glass fiber and the company reports that the glass filler performs as well as the asbestos filler. The only disadvantage that NI Industries cites is that the non-asbestos cylinder costs about 3 percent more than the asbestos cylinder. NI Industries also reports that it is attempting to gain the right to use a Union Carbide developed graphite filler. In addition, NI Industries plans to stop processing asbestos within the next year (NI Industries 1986). The other processors gave no indication about their plans for substituting asbestos in the manufacture of acetylene cylinder filler (ICF 1986). Table 3 summarizes the findings of this analysis, and presents the data inputs for the Asbestos Regulatory Cost Model.

E. Summary

Asbestos is used to produce a sponge-like filler that is placed in acetylene cylinders. Currently, there are three primary processors or importers. The market for acetylene cylinders is relatively stable and is expected to remain so for the foreseeable future. One of the processors, NI Industries, is producing a substitute glass filler that performs as well as the asbestos filler and costs about 3 percent more that the asbestos filler.

Table 3. Data Inputs for Asbestos Regulatory Cost Model
(008) Acetylene Cylinders

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	Reference
Acetylene Cylinders w/ asbestos filler	392,121 pieces	0.0014896 tons/piece	1.0	$90.00/piece	1 use	$90.00/piece	N/A	ICF (1986)
Acetylene Cylinders w/ glass filler	N/A	N/A	N/A	$93.00/piece	1 use	$93.00/piece	100%	ICF (1986)

N/A: Not Applicable.

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IX. FLOORING FELT

A. Product Description

Asbestos flooring felt is a paper product which is used as a backing for vinyl sheet floor products. It consists of approximately 85 percent asbestos and 15 percent latex binder by weight. Short fiber chrysotile asbestos (usually grades 5 through 7) is used and is generally obtained from Canada (Krusell and Cogley 1982). The latex binder is usually a styrene-butadiene type, although acrylic latexes can be used.

Asbestos flooring felt is manufactured on conventional papermaking machines. The ingredients are mixed together and combined with water. This mixture is then placed on a belt and forced through a series of machines which remove some of the water by applying heat and by suction. The next step is to force the mixture through rollers in order to produce a flat and uniform paper product. The felt is then allowed to cool before being rolled and wrapped.

These felt rolls are then used in producing vinyl sheet flooring. They are fed into coating machines where they are coated with vinyl and possibly decorated through various printing techniques. At this point, the product is considered a vinyl plastisol, and it may be colored by various additives or techniques. This printed sheet then goes through a fusion step where it is coated with a final layer of material called the "wear layer." The wear layer is a homogeneous polymer application that provides an impervious surface for the finished floor product.

Asbestos flooring felt has a number of desirable qualities. These include dimensional stability as well as high moisture, rot, and heat resistance.[1] The flooring is able to withstand these conditions without cracking, warping, or otherwise deteriorating. Asbestos flooring felt is also particularly

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[1]Dimensional stability refers to the product's ability to stretch and contract with temperature changes and "settling" of the floor deck.

useful in prolonging floor life when moisture from below the surface is a problem (Krusell and Cogley 1982).

B. Producers and Importers of Asbestos Flooring Felt

There were four domestic primary processors of this product in 1981: Armstrong World Industries, Congoleum Corporation, Nicolet, Inc., and Tarkett, Inc. (TSCA 1982a). There were no secondary processors of asbestos flooring felt in 1981 (TSCA 1982b). In addition, two importers of asbestos flooring felt were identified in 1981 -- Biscayne Decorative Products Division of National Gypsum Company and Armstrong World Industries (ICF 1984). Since that time, all four primary processors have ceased production of asbestos flooring felt, and both importers have stopped importing asbestos flooring felt (ICF 1986). Because none of the other respondents to our survey indicated that they had begun production of asbestos flooring since the 1981 survey or were aware of any other producers or importers of asbestos flooring felt, we have concluded that there are currently no domestic producers or consumers of this product (ICF 1986).

C. Trends

1981 production of asbestos flooring felt was 127,403 tons (TSCA 1982a). Because all four producers have since stopped processing asbestos, production declined to 0 tons in 1985. There is no information on 1981 or 1985 imports of asbestos flooring felt.

D. Substitutes

As previously discussed, the key advantages of asbestos flooring felt were its dimensional stability and high heat, moisture, and rot resistance. Substitutes fall into two categories -- raw materials which can be used to produce a non-asbestos flooring felt and products which replace flooring felt itself. The substitutes for asbestos in the production of flooring felt include fiberglass, Pulpex(R), ceramic fiber, clay, and Bontex 148(R). The substitutes for flooring felt include foam cushioned backings and backless sheet vinyl. Tables 1 and 2 list the various substitutes and their advantages and disadvantages.

All of the substitutes are purchased as raw materials to be used in the production of flooring felt which is then used to produce vinyl sheet flooring. As a result, there is no observable flooring felt market. Furthermore, flooring felt producers would not reveal how much of the substitute is required or what other ingredients are required to produce their particular non-asbestos felt. Fortunately, cost estimates are not needed since asbestos flooring felt is no longer produced or sold in the U.S. and is therefore not being modeled.

Fiberglass flooring felt is a product which shares all of the advantages of asbestos flooring felt. It possesses dimensional stability, and is resistant to heat, rot, and moisture. Furthermore, it we look at roofing felt, a very similar product, we see that the fiberglass felt is much less expensive than the asbestos felt. Although the roofing application is somewhat different, the result in the flooring felt market is probably analogous.

Hercules, Inc. has developed the product Pulpex(R) to replace asbestos in flooring felt. Pulpex(R) is a fibrillated polyolefin pulp and comes in two forms -- Pulpex E (composed of polyethylene) and Pulpex P (composed of polypropylene). Pulpex(R) is sold to four North American producers of flooring felt and to six flooring felt producers worldwide. It has been commercially available since 1981. Pulpex(R) shares many of the advantages of asbestos, but it has a lower tensile strength and is less heat resistent (Hercules 1986).

Tarkett, Inc. produces a flooring felt in-house which uses a clay product to substitute for asbestos. The company claims that there are no advantages

Table 1. Substitutes for Asbestos in Flooring Felt

Product	Manufacturer	Advantages	Disadvantages	References
Asbestos Felt	None	Dimensional stability. Moisture, rot, and heat resistance.	Potential environmental and occupational health hazards.	Krusell and Cogley (1982) ICF (1986)
Fiberglass	Many	Dimensional stability. Moisture, rot, and heat resistance.	None.	Krusell and Cogley (1982)
Pulpex(R)	Hercules Corp. Wilmington, DE	Dimensional stability. Moisture and rot resistance.	Low tensile strength.	Hercules (1986)
Bontex 148(R)	Georgia Bonded Fibers, Inc. Newark, NJ	Heat resistance.	High cost.	Georgia Bonded Fibers (1986)
Clay	Many	Dimensional stability. Moisture, rot, and heat resistance.	None.	Tarkett (1986)

Table 2. Substitutes for Asbestos Flooring Felt

Product	Manufacturer	Advantages	Disadvantages	References
Foam-Cushioned Backing	Many	Dimensional stability. Moisture resistance.	High cost.	Krusell and Cogley (1982)
"Backless" Vinyl	Many	Easy to install. Excellent elastic properties. Moisture resistance.	High cost.	Krusell and Cogley (1982)

or disadvantages relative to asbestos in making this change (Tarkett 1986). it is not known if any other producers are using clay to substitute for asbestos in flooring felt.

Georgia Bonded Fibers has developed the product Bontex 148(R) which can be used in producing a flooring underlay. Bontex 148(R) is composed of synthetic fibers and cellulose. Product samples have been sent to all major producers of flooring felt, but its use is still limited to experimental applications in this country. It has been used in flooring felt in Europe, but the major drawback in the U.S. appears to be price. The main advantage of this substitute is that it has high heat resistance (Georgia Bonded Fibers 1986).

In addition to substitutes for asbestos <u>in</u> flooring felt, it is also possible to substitute other products directly for the flooring felt. "Backless" sheet vinyl is a sheet flooring material with a special vinyl backing. This backing has excellent elastic properties which allow the flooring to stretch and contract under the most severe applications. In addition, this backless vinyl is easier and faster to install than asbestos felt-backed vinyl. It requires a minimum of adhesive deck bonding, usually only around the edges, and can be stapled into place (Krusell and Cogley 1982).

Another substitute for flooring felt is foam-cushioned backing. Foam-cushioned backing is formed by attaching a cellulosic foam layer to vinyl sheet. This product has very good dimensional stability and moisture resistance. Backless vinyl and foam-cushioned backings appear to be good, commercially available alternatives to felt-backed vinyl flooring (Krusell and Cogley 1982).

The durability of felt backing is not a factor in the service life of the vinyl sheet product. The service life is primarily a function of wear layer thickness, traffic, and maintenance. In addition, the cost of the felt backing is a very small percentage of the total cost of the vinyl sheet product. Because the costs of most substitute backings were likely to have been comparable to the cost of asbestos felt backing, user cost was probably not a significant obstacle to eliminating asbestos in flooring felt.

E. Summary

In 1981 there were four primary processors of asbestos flooring felt in the U.S. By 1985 they had all stopped using asbestos in the production of flooring felt. There are a number of different substitutes for asbestos in flooring felts such as fiberglass, Pulpex(R), ceramic fiber, clay, and Bontex 148(R). Because the cost of the felt backing is only a small portion of the total cost of the vinyl floor product, the removal of asbestos has had very little impact on this industry.

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X. CORRUGATED PAPER

A. Product Description

Corrugated paper is a type of commercial paper that is corrugated and cemented to a flat paper backing and is sometimes laminated with aluminum foil. It is manufactured with a high asbestos content (95 to 98 percent by weight) and a starch binder (2 to 5 percent) (Krusell and Cogley 1982).

The manufacturing of corrugated paper uses conventional paper making equipment in addition to a corrugation machine that produces the corrugated molding on the surface of the paper.

Corrugated asbestos paper is used as thermal insulation for pipe coverings and as block insulation. The paper can be used as an insulator in appliance, hot-water and low-pressure steam pipes, and process lines.

B. Producers of Corrugated Paper

At present, asbestos corrugated paper is no longer manufactured in the United States (ICF 1986a). In 1981 there were three producers of asbestos corrugated paper: Celotex Corporation, Johns-Manville Corporation, and Nicolet Industries (TSCA 1982). All three companies had ceased production by 1982 (ICF 1986a).

C. Trends

Production of asbestos corrugated paper fell from 46 tons in 1981 to 0 tons in 1985 (ICF 1985, ICF 1986a). A recent survey failed to identify any 1981 importers of asbestos corrugated paper (ICF 1984). In addition, none of the firms surveyed in 1986 are aware of any importers of asbestos corrugated paper (ICF 1986a).

D. Substitutes

Asbestos was used in corrugated paper primarily because it had heat and corrosion resistance, high tensile strength, and durability. It has been replaced by non-corrugated, asbestos-free commercial paper. The three main types of paper currently used for pipe and block insulation are ceramic fiber paper, calcium silicate, and fiberglass paper (ICF 1985).

Table 1 presents a summary of substitutes for asbestos corrugated paper. Ceramic fiber paper is used for both pipe and block insulation. It is heat resistant, resilient, has high tensile strength, low thermal conductivity, and low heat storage. Babcock & Wilcox produces a ceramic fiber pipe insulation blanket and a block insulation material. The raw material used is kaolin, a high purity alumina-silica fireclay. It has a melting point of 3200°F and a normal use limit of 2300°F, but it can be used at higher temperatures in specific applications.

Certain-Teed, Owens-Corning, and Knauf Corporation produce a fiberglass product that can be used up to 850°F. Fiberglass pipe insulation is also used at very low temperatures, (it can operate at temperatures as low as -50°F).

Calcium silicate pipe covering is produced by Owens-Corning under two brand names Kaylo(R), and Papco(R). These products are heat resistant and can be used in temperature applications from 1200°F to 1500°F. Calcium silicate is less efficient at low temperatures than fiberglass. Asbestos fiber previously was used in calcium silicate pipe covering for its strength, but it has been replaced with organic fiber.

No comparison of costs has been made between the asbestos and non-asbestos products because the asbestos product is no longer produced domestically and will not be a separate category in the cost model (ICF 1985).

E. Summary

Asbestos corrugated paper is no longer produced in the United States. In 1981, there had been a small amount left in inventory, but it has since been sold. Asbestos had been used in corrugated paper because of its high temperature resistance and its durability. Substitutes include ceramic fibers, fibrous glass, and calcium silicate fibers in conjunction with various

Table 1. Substitutes for Asbestos Corrugated Paper

Product	Manufacturer	Advantages	Disadvantages
Ceramic Block and Pipe Insulation Material	Babcock & Wilcox	Heat resistant, can operate up to 2300°F. High tensile strength. Low thermal conductivity.	Expensive. Not as strong as asbestos.
Calcium Silicate Pipe Insulation Material	Owens-Corning (Kaylo)	Heat resistant, can operate up to 1500°F. Easy application. Low thermal conductivity.	Expensive.
Fiberglass Block and Pipe Insulation Paper	Owens-Corning Certain-Teed	Used for both hot and cold temperatures. High insulating. Easy application.	Not as heat resistant as other substitutes. Not as strong as asbestos.

fillers. The entire market has already been substituted therefore market shares and price comparisons are not available.

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XI. SPECIALTY PAPERS

Asbestos is used in papers primarily due to its chemical and heat resistant properties. Two types of asbestos specialty papers that are covered in this section include beverage and pharmaceutical filters and cooling tower fill. However, since the asbestos fill product is no longer processed in the United States, cooling tower fill is only briefly discussed below. Asbestos diaphragms for electrolytic cells, which were previously treated as specialty papers, are presented separately in Section XIII.

A. Cooling Tower Fill

Cooling towers are used to air-cool liquids from industrial processes or air conditioning systems. The hot liquid is passed over sheets of material (the cooling tower fill) in order to provide maximum exposure to air. Sheets of asbestos paper impregnated with melamine and neoprene may be used as fill for applications requiring high temperatures or where a fire hazard may exist. Cooling tower sheets are manufactured in various sizes, with typical sheets being 18 inches by 6 feet and 0.015 to 0.020 inches thick (ICF 1985). The composition of cooling tower fill includes a blend of two grades of chrysotile asbestos bound with neoprene latex. The asbestos content is 90 to 91 percent, the remaining 9 to 10 percent consisting of a binder material (Krusell and Cogley 1982).

The major use of asbestos fill has been cooling tower applications where high heat resistance was necessary. Due to the availability of good and inexpensive substitute products, however, asbestos fill has been forced out of the market. As a result, the 1981 producers of asbestos fill, Marley Cooling Tower Co. and Munters Corp., are no longer manufacturing asbestos fill in the United States (Krusell and Cogley 1982, Marley Cooling Tower 1986).

A wide variety of substitute materials are currently available for cooling tower fill including polyvinyl chloride (PVC), wood, stainless steel mesh, and polypropylene. Each of these substitutes is manufactured by Munters Corporation (ICF 1986). The PVC plastic is the primary asbestos fill substitute because it is, by far, the most cost-effective product, with high durability and modest cost. One industry source stated that PVC has actually increased the market for cooling tower fill (Munters 1986). Other products available as asbestos fill substitutes have limited application due to specific disadvantages. For example, it is not economically feasible to manufacture wood into the forms (e.g., sheet materials) required for cooling tower fill; and stainless steel, although more durable than PVC, is too expensive for extensive use (Marley Cooling Tower 1986). Portland cement reinforced with such fibers as mineral and cellulose is presently under development as a substitute for asbestos fill. Although not presently marketed, this substitute's use is restricted due to its availability only in limited shapes and at a high cost (Marley Cooling Tower 1986).

B. Beverage and Pharmaceutical Filters

1. Product Description

Asbestos has been used in filters for the purification and clarification of liquids because it offers an exceptionally large surface area per unit of weight and has a natural positive electrical charge which is very useful for removing negatively charged particles found in beverages (Krusell and Cogley 1982). Asbestos filter paper is made on a conventional cylinder or Fourdrinier papermaking machine but, due to the very low demand for the asbestos filters, these machines are primarily used to produce more popular paper products, such as the non-asbestos filter substitutes (i.e., diatomaceous earth and cellulose fiber product and loose cellulose fiber products) (Krusell and Cogley 1982). Asbestos filters may contain, in addition to asbestos, cellulose fibers, various types of latex resins, and occasionally, diatomaceous earth (Krusell and Cogley 1982). The asbestos content of beverage filters ranges from 5 percent, for rough filtering applications, to 50 percent, for very fine filtering. In general, as the asbestos content of the filter increases, the filtering qualities improve (Krusell and Cogley 1982).

Applications of asbestos filter paper are found primarily in the beer, wine, and liquor distilling industries where they are used to remove yeast cells and other microorganisms from liquids. Asbestos filters are also used for filtration of some fruit juices (e.g., apple juice) and for special applications in the cosmetics and pharmaceuticals industries (Krusell and Cogley 1982).

2. Producers of Beverage and Pharmaceutical Filters

In 1981 there were four companies manufacturing asbestos filters:

- Alsop Engineering, NY;
- Beaver Industries, NY;
- Cellulo Company, CA; and
- Ertel Engineering, NY.

In 1985, two companies, Cellulo and Ertel, discontinued the use of asbestos in the production of filters (Ertel Engineering 1986). The primary substitute materials used consisted of either diatomaceous earth and cellulose fibers, or loose cellulose fibers (ICF 1986). The other two companies, Alsop Engineering and Beaver Industries, refused to respond to the ICF survey. As a result, production estimates for these companies were estimated based on the methodology presented in Appendix A.

3. Trends

For many years the use of asbestos in filters has been declining. Nearly 1000 short tons of asbestos fiber were consumed per year for the production of filters in the late 1960s and early 1970s. In 1985, however, only about 300 short tons of asbestos fiber were used for the production of asbestos filters (ICF 1986).

4. Substitutes

The primary reason for the use of asbestos filters is their ability to remove haze from liquids. Asbestos filters absorb less liquid than non-asbestos filters due to the low porosity of asbestos fiber. Filters containing asbestos are also more compressible than non-asbestos filters, making it easier to fit them into filter equipment thereby reducing the chances of developing leaks (Krusell and Cogley 1982).

Filter papers manufactured with cellulose fibers and diatomaceous earth and those made with loose cellulose fibers are available as substitutes for asbestos beverage filters. Both substitute products are comparable in performance to the asbestos product, although they are more difficult to handle and more expensive (Cellulo 1986). In addition, the all cellulose filter product cannot be made in grades high enough for very fine filtration and, therefore, "filter aids", consisting of chemically treated cellulose fibers or diatomaceous earth, may be added to all cellulose filters to improve their performance. Table 1 presents the advantages and disadvantages of each substitutes compared to the asbestos filter product, while Table 2 presents the data inputs for the Asbestos Regulatory Cost Model. Non-asbestos substitute filters can be used almost interchangeably with asbestos filters in most applications because, like asbestos filters, they have high wet strength and can clarify, polish, and sterilize a wide variety of liquids (e.g., acids, alkalis, antiseptics, beer, wine, fruit juices) (Krusell and Cogley 1982). The non-asbestos substitutes were reported to have comparable service life when used in similar applications. These two substitutes are expected to each take over about half of the filter market.

5. Summary

Asbestos filter papers are used for the purification and clarification of liquids in the beer, wine and liquor distilling industries. The trends

Table 1. Advantages/Disadvantages of Non-Asbestos Filter Substitute Products

Substitute Products for Asbestos Beverage and Pharmaceutical Filters	Price ($/lb.)	Advantages	Disadvantages	References
Diatomaceous Earth and Cellulose Fiber	2.00	Generally same performance as asbestos product	More difficult to handle for end-user vs. asbestos product.	Cellulo Co. (1986)
			More costly than asbestos product.	Cellulo Co. (1986)
Loose Cellulose Fiber	1.00	Generally same performance as asbestos product.	More difficult to handle for end-user.	Cellulo Co. (1986)
			More costly than asbestos product.	Cellulo Co. (1986)
			Not made with grades high enough for very fine filtering.	ICF (1984)
			Many need "filter aid"-chemically treated cellulose fiber for a positive charge -- to improve performance.	ICF (1984)

Table 2. Data Inputs for Asbestos Regulatory Cost Model

Product	Output[a]	Product Asbestos Coefficient[b]	Consumption Production Ratio	Price[c]	Useful Life[d]	Equivalent Price	Market Share	Reference
Asbestos Filter Paper	434 tons	0.212	1.0	$4,300/ton[e]	1 use	$4,300/ton	N/A	TSCA (1982a), ICF (1984a), Cellulo (1986)
Diatomaceous Earth and Cellulose Filter Paper	N/A	N/A	N/A	$4,000/ton	1 use	$4,000/ton	50%	Cellulo (1986)
Loose Cellulose Fiber Filter Paper	N/A	N/A	N/A	$2,000/ton	1 use	$2,000/ton	50%	Cellulo (1986)

[a] The two producers of this asbestos product both refused to respond to our survey. We have assumed that their 1985 output is equal to their 1981 output.

[b] The two producers of this product both refused to respond to our survey. We have assumed the product asbestos coefficient is the same as the value used by RTI in the Regulatory Impact Analysis (RTI 1985).

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

[d] The product's useful life is typically 1 use, but some filters may have a longer life.

[e] The two producers of this product both refused to respond to our survey. We have assumed that the ratio between the price of asbestos filter paper and diatomaceous earth and cellulose filter paper is still the same as that reported in 1981 (ICF 1985).

show a definite decline in the use of asbestos fiber in filter production. Of the four companies producing asbestos filters in 1981, two (Alsop Engineering and Beaver Industries) have been assumed to still be producing in 1985 because they refused to respond to the ICF survey. The 1985 asbestos filter production was assumed to be 434 tons; 92 tons of asbestos fiber were consumed in this production. One reason for this decline is that the non-asbestos substitute products, which include diatomaceous earth and loose cellulose fibers, have been found to be comparable in performance to the asbestos product for most applications. These non-asbestos products are, however, more expensive.

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XII. VINYL-ASBESTOS FLOOR TILE

A. Product Description

Vinyl-asbestos floor tiles are manufactured from polyvinyl chloride polymers or copolymers and are usually produced in squares 12 inches by 12 inches. They are commonly sold in thicknesses of 1/16, 3/32, and 1/8 of an inch.

The exact composition of vinyl-asbestos floor tile varies by manufacturer. Typical ranges for the percentage of each constituent are:

- asbestos : 5-25 percent,
- binder : 15-20 percent,
- limestone : 53-73 percent,
- plasticizer: 5 percent,
- stabilizer : 1-2 percent, and
- pigment : 0.5-5 percent.

Although each company has its own specific process for manufacturing vinyl-asbestos floor tile, the basic steps are very similar. Raw asbestos fiber, pigment, and filler are mixed dry to form a cohesive mass to which liquid constituents are added if required. Although the mixture is exothermic (it generates heat during mixing), it may need to be heated further in order to reach a temperature of at least 300°F at which point it is fed into a two-roll mil where it is pressed into a slab or desired thickness. The slab is then passed through calenders, machines with rollers, where it acquires a uniform finished thickness (Krusell and Cogley 1982). Embossing, pigmenting, and other surface decoration is done while the material is still soft. The tile is then cooled using one of three processes: immersion in water, spraying with water, or placing in a refrigeration unit. In order to minimize shrinkage after cutting, the tile is allowed to air cool before it is cut into squares and waxed (Krusell and Cogley 1982).

Vinyl-asbestos floor tile can be used in commercial, residential, and institutional buildings. It is often used in heavy traffic areas such as supermarkets, department stores, commercial plants, kitchens, and "pivot points" -- entry ways and areas around elevators. The tile is also suitable for radiant-heated floors as long as temperatures do not exceed 100°F. The tile may be installed on concrete, prepared wood floors, or old tile floors (Floor Covering Weekly 1980).

B. Producers and Importers of Vinyl-Asbestos Floor Tile

There were six primary processors of this asbestos product in 1981: Amtico Division of American Biltrite, Armstrong World Industries, Azrock Industries, Congoleum Corp., Kentile Floors, Inc., and Tarkett, Inc. (TSCA 1982a). There were no secondary processors of vinyl-asbestos floor tile, and a survey of importers failed to identify any importers of vinyl-asbestos floor tile (TSCA 1982b, ICF 1984). All six primary processors have stopped using asbestos since that time. Tarkett, Inc. and Azrock Industries were the first companies to eliminate the use of asbestos in vinyl floor tiles. Armstrong World Industries had eliminated asbestos by the end of 1983, and Congoleum Corp. had eliminated it in 1984. Amtico Division of American Biltrite phased out asbestos in 1985, and Kentile Floors, Inc. phased out the use of asbestos in 1986. Because none of the other respondents to our survey indicated that they had begun production of vinyl-asbestos floor tile or were aware of any other producers or importers of vinyl-asbestos floor tile, we have concluded that there are currently no domestic producers or consumers of this product (ICF 1986).

C. Trends

1981 production of vinyl-asbestos floor tile was 58,352,864 square yards. In 1985, only one company was still processing asbestos in order to make floor tile and its production was 18,300,000 square yards. This represents a decline of almost 70 percent. In addition, Kentile Floors phased out asbestos use in 1986 and current production of vinyl-asbestos floor tiles is 0.

D. Substitutes

The use of asbestos in the production of vinyl composition floor tile conferred a number of advantages to consumers in its end use as well as to producers in its manufacturing process. Asbestos fiber imparted the following properties in its use in floor tile: abrasion and indentation resistance, dimensional stability, durability, flexibility, and resistance to moisture, heat, oil, grease, acids, and alkalis. The heat resistance and dimensional stability of asbestos are important in the manufacturing process. The ability to withstand high temperature prevents possible cracking. Dimensional stability prevents shrinkage or expansion during production and helps manufacturers meet their tolerance limits.

The major substitute for vinyl-asbestos floor tile is asbestos-free vinyl composition tile. Manufacturers have reformulated their mixtures using a combination of synthetic fibers, fillers, binders, resins, and glass. The binders and fillers include limestone, clay, and talc. The fiber substitutes include fiberglass, polyester, Pulpex(R), Santoweb WB(R), and Microfibers(R). The substitutes for asbestos in vinyl floor tiles and their characteristics are summarized in Table 1.

Fiberglass floor tile is produced by many manufacturers and has many of the same properties as asbestos fiber. It is used in floor tile primarily for its dimensional stability under wet conditions. Since fiberglass does not absorb moisture, the tile is prevented from shrinking. In addition, fiberglass is heat resistant and can withstand temperatures as high as 800°F without softening (Krusell and Cogley 1982).

Polyester fiber is produced by many manufacturers. When it is used in combination with other binders and fillers, it is able to achieve many of the

Table 1. Substitutes for Asbestos in Vinyl Floor Tile

Product	Manufacturer	Advantages	Disadvantages	References
Asbestos	None	Heat resistance during manufacture. Indentation resistance. Flexibility. Abrasion resistance. Moisture resistance. Chemical resistance. Fungal resistance. Dimensional stability.	Environmental and occupational health problems.	Krusell and Cogley (1982) ICF (1986)
Pulpex(R) (Polyolefin Pulp)	Hercules, Inc. Wilmington, DE	Dimensional stability. Moisture resistance. Rot resistance.	Low tensile strength. Low heat resistance.	Hercules (1986)
Santoweb WB(R) (Hardwood Fiber)	Monsanto Corp. St. Louis, MO	Impact resistance. Heat resistance.	Absorbs water when large amounts are used.	Monsanto (1986)
Microfibers(R) (Polyester and Cellulose Fibers)	Microfibers, Inc. Pawtucket, RI	Dimensional stability. Thickening properties.		Microfibers (1986)
Fiberglass	Many	Dimensional stability Moisture resistance. Rot resistance.	Lower strength. More brittle.	Krusell and Cogley (1982)
Polyester	Many	Dimensional stability. Moisture resistance.	Less flexible. Subject to bacterial attack.	Krusell and Cogley (1982)

characteristics of asbestos. The major drawbacks are that the tiles are less flexible and that the tiles are subject to bacterial attack (Krusell and Cogley 1982).

Pulpex(R) is a fibrillated polyolefin pulp made by Hercules, Inc. It also has many of the same characteristics as asbestos when used in combination with other fillers and binders, but it cannot be used at extremely high temperatures. Pulpex(R) has been commercially available in the U.S. since 1981. Although its primary use in the U.S. has been in flooring felt, it has been used in vinyl tile as an asbestos substitute in Europe (Hercules 1986).

Santoweb WB(R) is a hardwood fiber and has been on the market for 10 years. It is produced by Monsanto Corporation. Its major strengths are its high impact resistance and its high heat resistance. It can withstand temperatures of at least 300°F during calendaring. In addition, it is less brittle than fiberglass and more cost-effective than chopped polyester. The Santoweb WB(R) composition of floor tile is ideally 1.5 percent and the upper limit is 2.5 percent beyond which the floor tile will absorb too much water (Monsanto 1986).

Microfibers(R) are reinforcing fibers which consist of a combination of polyester, cotton, nylon, and cellulose fibers. Microfibers(R) are made by the Microfibers Corporation. Their primary advantages are their dimensional stability as well as their ability to serve as a thickener (Microfibers 1986).

Several non-asbestos blends use larger amounts of resins, binders, and fillers in place of asbestos. One producer of asbestos-free vinyl composition tile uses increased amounts of limestone and resin. These new vinyl composition tiles appear to share many of the qualities of vinyl-asbestos floor tile, but they have three drawbacks. They do not wear as well, they have reduced dimensional stability, and they are more expensive to produce (ICF 1986).

In addition to the new vinyl composition tiles being produced, substitutes for vinyl-asbestos floor tile include solid vinyl tile, rubber tile, ceramic tile, linoleum, wood, and carpet. However, these floor coverings lack many of the qualities of vinyl-asbestos floor tile. For example, solid vinyl is not as abrasion resistant as vinyl-asbestos tile and has a low resistance to solvent-based cleaning materials. Rubber tile is also susceptible to deterioration from certain cleaning compounds, is not grease resistant, and is more difficult to maintain. Carpet is less durable in most uses, and it is more difficult to keep clean. In addition to these drawbacks, all these substitutes are more expensive than vinyl-asbestos floor tile.

On the whole, vinyl composition tiles are the best substitute for vinyl-asbestos tiles in terms of prices and performance. Distributors claim that consumers of vinyl composition tile are almost never concerned about whether or not asbestos fibers are used. They believe that the most important considerations in choosing vinyl tile are color, style, and price and that there have been no difficulties in switching from vinyl-asbestos floor tile to vinyl composition tile (John Ligon, Inc. 1986, H&M Tile & Linoleum Co. 1986).

E. <u>Summary</u>

Asbestos fiber was used in the production of vinyl floor tiles because it imparted the following characteristics to the tile: abrasion and indentation resistance, dimensional stability, flexibility, and resistance to moisture, heat, oil, grease, acids, and alkalis. However, producers have been able to generate these characteristics by reformulating their mixtures using a combination of synthetic fibers, fillers, binders, resin, and glass. (A more complete description is not possible because floor tile producers consider these formulations to be proprietary.) This reformulation appears to have been successful because there are currently no domestic processors of vinyl-asbestos floor tile.

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XIII. ASBESTOS DIAPHRAGMS

Asbestos Diaphragms are employed in the chlor-alkali industry for the production of chlorine and other primary products such as caustic soda. There are presently three types of electrolytic cells in commercial use: asbestos diaphragm cells, mercury cells, and membrane cells (Kirk-Othmer 1985). All electrolytic cells operate on the same principle -- an electric current decomposes a solution of brine into (1) chlorine, liberated at the anode (positive electrode) and (2) caustic soda and hydrogen, liberated at the cathode (negative electrode). The ratio of chlorine to caustic soda produced during the process is 1:1.1 by weight (Chemical Week 1982). Most of the chlorine produced in the United States is made using electrolytic cells (Kirk-Othmer 1985).

Asbestos diaphragm and mercury cells account for over 90 percent of domestic chlorine production; electrolytic cells using asbestos diaphragms accounted for 76.7 percent of the chlorine production capacity as of January 1, 1986, while mercury cell technology accounted for 16.5 percent (Chlorine Institute 1986b). In the past few years, a new technology, known as membrane cell technology, has been developed to replace diaphragm cells in the chlorine production process. As reported by the Chlorine Institute, membrane cell technology accounted for 2.4 percent of the total chlorine production capacity as of January 1, 1986 (Chlorine Institute 1986b).

In Sections A, B, and C of this paper, each of the cell technologies is discussed individually; Section D compares some salient characteristics of the three technologies, while Section E discusses market trends for the chorine production industry.

A. Asbestos Diaphragm Technology

In this chlor-alkali production process, an asbestos diaphragm is used to physically separate chlorine produced at the anode from caustic soda and hydrogen produced at the cathode; the diaphragm thus, acts as a mechanical barrier between the two chambers (Kirk-Othmer 1985).

Diaphragm cells are especially appropriate where salt (the raw material for chlorine production) is present at the plant site in underground formation. The salt can be solution-mined[1] with water, treated, and sent to the chlorine cells for decomposition into chlorine and caustic soda (Chlorine Institute 1986a). The diaphragm material is critical to the proper operation of a diaphragm cell and some of the properties that are necessary for proper cell operation are as follows (Chlorine Institute 1986a):

- sufficient mechanical strength;
- high chemical resistance to acids and alkalies;
- optimum electrical energy efficiency;
- easy to deposit on the cathode with uniform thickness and without voids;
- appropriate physical structure to permit percolation of depleted brine with minimum back-migration; and
- acceptable service life.

Asbestos is uniquely qualified as a diaphragm material, exhibiting the most favorable combination of these properties (Chlorine Institute 1986a). This has resulted in widespread use of asbestos made diaphragms throughout the chlorine production industry.

Asbestos diaphragms are prepared at the chlorine plant site itself and are not available as pre-manufactured products ready for use. In the diaphragm forming process, a slurry of asbestos in water is drawn through a screen or perforated plate by vacuum techniques. Asbestos fibers are deposited on the screen, or plate, forming a paper-like mat approximately an eighth of an inch

[1] Water is pumped into the salt mine, a salt solution is then pumped out.

thick (Coats 1983). This asbestos-coated screen is used as the cathode in electrolytic cells. In the past twenty years, many advances have been made in the design of asbestos diaphragms and in the design of the cell itself. These have included the introduction of dimensionally stable metal anodes[2] as a replacement for graphite anodes and the development of the modified asbestos (resin bound) diaphragms which consist of chrysotile and polymeric powders of fibers stabilized at high temperatures before use (Chlorine Institute 1986a). Today, the majority of U.S. diaphragm cells utilize modified asbestos diaphragms and have metal anodes; they consume 2,300 KWH of power per ton of chlorine produced (Chlorine Institute 1986a, Chemical Week 1982).

The surface area of the diaphragm is quite large, ranging from approximately 200 to 1,000 square feet for a cell with a volume of 64 to 275 cu ft (Coats 1983). Each diaphragm may use 60 to 200 pounds of asbestos fiber and have a service life of three months to over one year (three months for plants where graphite anodes are still in use; 6 to 15 months for plants using resin bound asbestos diaphragms) (Chlorine Institute 1986b). Using modified asbestos diaphragm technology, production of 1000 tons of chlorine and co-products requires about 250 pounds or 0.125 ton of asbestos (Chlorine Institute 1986b). The only major disadvantage of using asbestos diaphragm cells is the weak concentration of the caustic soda produced by the cell (usually about 10 percent by weight) because of the permeability of the cell to both brine and water (Chemical Week 1981). This necessitates further processing for concentrating the caustic to the industry standard, typically 50 percent, using multiple-effect evaporators and large amounts of steam. Removing the excess salt involves crystallization and, possibly, ammonia extraction, both of which add to the cost of production (Chemical Week 1982).

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[2] Dimensionally stable anodes consist of a coating of ruthenium dioxide and titanium applied to an expanded titanium metal base (Kirk-Othmer 1983).

1. Producers of Asbestos Diaphragms

Asbestos diaphragms are not marketed; the chlorine producers purchase asbestos fiber and manufacture and install the diaphragm themselves. Table 1 provides a list of chlorine manufacturers (SRI 1984, Verbanic 1985). In 1985, 28 manufacturers were operating 57 chlorine plants in 26 states throughout the U.S. with an estimated total annual capacity of 13.2 million tons (Chlorine Institute 1986b), a reduction from previous years when annual capacity had reached almost 15 million tons (Verbanic 1985). The largest of these chlorine producers was Dow Chemical, with a combined annual capacity of 3,750,000 tons, approximately 28.5 percent of the total U.S. chlor-alkali capacity followed by PPG Industries and Diamond Shamrock, each accounting for about 10 percent of the chlorine production capacity (Verbanic 1985). Chlorine production and asbestos fiber consumption information for the period 1983-1985 is presented in Table 2. Based on this information, about 975 metric tons of asbestos fibers were estimated to have been consumed by the chlorine industry in the production of approximately 10 million tons of chlorine during 1985. According to a separate estimate given by the Chlorine Institute, 900 metric tons of asbestos had been consumed during this period.

2. Substitutes for Asbestos Diaphragms

No other substance has been found to be suitable for replacing asbestos diaphragms in electrolytic cells. This has resulted in the development of alternative cell technologies that require either the building of new chlorine plants or the retrofitting of existing plants. Among the new technologies, the most significant one that is steadily gaining acceptance in the U.S. is the membrane cell technology (Chemical Business 1985).

Table 1. Producers of Chlorine

Company[a]	Plant	Remarks
AMAX Inc.		
AMAX Specialty Metals Corp, Subsidiary		
Magnesium Division	Rowley, Utah	
Brunswick Pulp and Paper Company		
Brunswick Chemical Company, Division	Brunswick, GA	
Champion International Corporation		
Wood Chemicals and Associated Products Division	Caston, NC	
Diamond Shamrock Corporation		
Diamond Shamrock Chemicals Company	Battleground, TX	
Chlor-Alkali Division	Deer Park, TX	
	Delaware City, DE	
	La Porte, TX	
	Mobile, AL	
	Muscle Shoals, AL	146,000 tons/annum mercury-cell plant switching to membrane cells of the company's own design.[c]
Dow Chemical U.S.A.	Oyster Creek, TX	Combined capacity is 4,100,000. 2,000 tons/day on standby.[b]
	Pittsburg, CA	
	Plaquemine, LA	
	Freeport, TX	456,250 tons/annum of chlorine capacity has been shutdown -- about 10% of Dow's chlorine capacity on the Gulf Coast.[e]
E.I. duPont de Nemours & Co., Inc.	Niagara Falls, NY	
Chemicals and Pigment Department		
Petrochemicals Department	Corpus Christi, TX	
Freon Products Division		
FMC Corp., Industrial Chemical Group	South Charleston, WV	To close end of 1985.[b]
Formosa Plastics Corporation, U.S.A.	Baton Rouge, LA	
Fort Howard Paper Company	Green Bay, WI	
	Muskogee, OK	Membrane cell technology.
General Electric Company	Mount Vernon, IN	
Plastics Business Operations		
Georgia-Pacific Company	Bellingham, WA	
Chemical Division		
Georgia-Gulf Corporation	Plaquemine, LA	

Table 1 (Continued)

Company[a]	Plant	Remarks
The B.F. Goodrich Company	Clavert City, KY	Plant for sale.[b]
Convent Chemical Corporation, Subsidiary	Convent, LA	
Kaiser Aluminum and Chemical Corporation Kaiser Industrial Chemicals Division	Gramercy, LA	
LCP Chemicals and Plastics, Inc. LCP Chemicals Divisions	Acme, NC Ashtabula, OH Brunswick, GA Linden, NJ Syracuse, NY Orrington, ME Moundsville, WV	
Mobay Chemical Corporation Inorganic Chemicals Division	Baytown, Texas	
Monsanto Company Monsanto Industrial Chemicals Company	Sauget, IL	
Niacor	Niagara Falls, NY	Due to begin production in 1987. 50/50 joint venture between Olin and DuPont; will use membrane cell technology.[b]
Occidental Petroleum Corporation Occidental Chemical Corporation, Subsidiary Hooker Industrial and Specialty Chemicals	Niagara Falls, NY	
	Taft, LA	Membrane cell unit of 146,000 tons on stream in 1986.[b]
	Tacoma, WA	Includes membrane cell units.[c]
Olin Corporation Olins Chemicals Group	August, GA Charleston, TN Niagara Falls, NY	
Oregon Metallurgical Corporation	Albany, OR	
Pennwalt Corporation Chemicals Group Inorganic Chemicals Division	Portland, OR	
	Tacoma, WA	Membrane cell technology.[b]
	Wyandotte, MI	
PPG Industries	Lake Charles, LA Natrium, WV	

Table 1 (Continued)

Company[a]	Plant	Remarks
RMI Company	Ashtabula, OH	
Stauffer Chemical Company		
Chlor-Alkali Products Division	Henderson, NV	
	Le Moyne, AL	
	St. Gabriel, LA	
Titanium Metals Corporation of America		
TIMET Division	Henderson, NV	
Vertac Chemical Corporation	Vicksburg, MS	
Vulcan Materials Company		
Vulcan Chemicals, Division	Port Edward, WI	Approximately 75% of caustic/chlorine is produced via the asbestos diaphragm cell process.[d]
	Geismar, LA	
	Wichita, KS	
	Denver City, TX	Includes 73,000 tons of membrane technology.[b]
Weyerhaeuser	Longview, WA	

Sources:

[a] SRI 1984.

[b] Verbanic C. 1985.

[c] Chemical Engineering 1976. Cell employs modified Nafion perfluorosulfonic-acid membranes which separate the anode and cathode halves in the same manner as conventional asbestos diaphragms.

[d] Vulcan Chemicals 1986.

[e] Chemical Week 1986c.

Table 2. Chlorine Production/Asbestos Fiber Consumption

(1) Year	(2) Annual Capacity (millions of tons)[b]	(3) Utilization Rate (on average)[b]	(4) Production (millions of tons)[b] (2 x 3)	(5) Percentage of Production Using Asbestos A Diaphragms	(6) Consumption of Asbestos Fiber (tons)
1981	14.8	72%	10.7	75.0	1,004
1985	13.2	77%	10.2	76.7	977

Sources:

[a] Chlorine Institute 1986b.

[b] Chemical Week 1985 (February 1).

[c] Coats V. 1983.

B. Membrane Cells

Although diaphragms and membranes each serve a similar function of physically separating the two electrodes in an electrolytic cell, the mechanisms by which they operate are entirely different. In the diaphragm cell, brine flows through the asbestos diaphragm at a carefully controlled rate such that no back flow of hydroxyl ions occurs. In the membrane cell, a cation exchange membrane is used instead of a diaphragm, utilizing solid salt as opposed to brine. The cation exchange membrane permits the passage of sodium ions into the cathode compartment, but rejects the passage of chloride ions. Chlorine is formed on the anode side; hydrogen and caustic soda are formed on the cathode side. Because the membrane is very thin, some chloride or hydroxyl ion transfer occurs; however, pure water may be added to the cathode compartment to maintain a constant sodium hydroxide concentration (Kirk-Othmer 1985). As a result, membrane cells can produce caustic soda of high concentration (30-35 percent) with a low salt content (0.02-0.2 percent).

The most prominent advantages offered by the membrane cell technology are the reduced energy consumption, improved product quality, less frequent cell maintenance, and increased flexibility in plant operation (Chemical Marketing Reporter 1983). Worldwide, there are 70 plants that have opted for membrane technology, more than half of them being in Japan (Chemical Week 1986a). Outside Japan, the membrane process has been installed in 5 plants in the United States, 7 in Europe, 4 in Latin America, and 20 in other parts of the world (Chemical Week 1986a). Membrane cell technology is offered by firms such as Diamond Shamrock and Hooker Chemical, Japan's Asahi Chemical, Asahi Glass, and Tokuyama Soda, and Italy's Oronzio de Nora (Chemical Week 1981). Dow Chemical may now be added to this list. In July, 1986, Dow joined Italy's Oronzio de Nora in a new 50-50 joint venture to license technology and equipment. They will operate globally under the name, Oronzio de Nora

Technologies (Chemical Week 1986a).

The first large-scale membrane cell installation in the U.S. came on stream in late 1983 at a 73,000 ton/year facility of Vulcan Chemicals Division at Wichita, Kansas (Verbanic 1985). Other membrane facilities are presently being created either through retrofits of existing asbestos diaphragm cells to accept an ion-exchange membrane or through conversions (cell replacement) which require replacement of the diaphragm cells with membrane electrolyzers. Both retrofits and conversions require additions and modifications to existing ancillary equipment. Conversions have been occurring in the U.S. for several years but no commercial retrofits have been attempted in the U.S. to date.

It has been found that retrofits are not only costly but do not achieve the energy savings that total cell replacement (conversion) provides. Moreover, in some cases retrofitting is not even an option due to either the incompatibility of the available salt source and the available membrane materials, or the complexity of the diaphragm cell geometry. The cost of conversion varies widely, depending on cell size and type. An April 1986 Chlorine Institute survey of diaphragm cell producer members projected the membrane replacement cost of the current total chlorine production capacity of the industry to be $2.1 billion (1986 dollars) -- or about $75,600 per daily ton (Chlorine Institute 1986b).

Table 3 provides a list of manufacturers employing the membrane cell technology. Those facilities presently on stream have chlorine production capability from 12 to 400 tons/day each, for a combined capacity of less than 900 tons/day or approximately 328,000 tons per annum -- less than 2.5 percent of the total industry capacity (Chlorine Institute 1986b). By 1987 another 366,000 tons are expected to be added (i.e. Occidental, Niacor), creating a

Table 3. Chlorine Producers Using Membrane Cell Technology

Company	Plant Location	Annual Capacity (metric tons/ year)	Year Due on Stream
Fort Howard Paper Company[a]	Muskogee, OK	N/A[c]	N/A
P&G Paper Products Co.[a]	Green Bay, WI	N/A	N/A
Vulcan Chemicals Division[a]	Wichita, KS	73,000	1983
Pennwalt Corporation[a]	Tacoma, WA	91,000	1985
Occidental Chemical Corp.[a]	Taft, LA	146,000	1986
Niacor[b]	Niagara Falls, NY	220,000	1987

Source: [a] Chemical Week 1986a.
[b] Verbanic 1985.
[c] N.A. -- Not Available.

projected total annual capacity of approximately 542,000 tons/year employing membrane technology.

The cost of the high performance membrane materials which are being used in the newer cell installations are estimated to be in the order of 60 to 75 dollars per square foot of surface area (Coats 1983). Some cells may use membranes with an area of less than 10 square feet, while others may use membranes of over 50 square feet. Associated costs, such as installation and regasketing, are not well known due to the limited number of plants presently operating with the membrane cell technology (Chlorine Institute 1986b). However, the labor required to make a membrane for retrofit purposes is substantially greater than that required to prepare an asbestos diaphragm. In addition, the cost of making shaped membranes, necessary for optimal power efficiency for retrofit purposes, adds significantly to the cost (PPG Industries 1986).

Although the service life of a membrane cell is generally estimated at about 2 years (Chlorine Institute 1986b), it is possible to routinely achieve a three-year membrane life (Chemical Week 1986a). At typical operating conditions, about 85 tons of chlorine would be produced per square meter of membrane during a 2 year membrane life (Chlorine Institute 1986b).

C. Mercury Cells

Mercury cell technology involves a chemical process to separate the chlorine from the caustic soda and hydrogen as opposed to the physical processes of the diaphragm and membrane cells. The mercury cell process involves two subcells: (1) the brine (electrolyzer) subcell, and (2) the denuder or soda (decomposer) subcell.

The cathode in the mercury cell is a thin layer of mercury which is in contact with the brine. Closely spaced above the cathode is the anode. The anode is a suspended, horizontal assembly of blocks of graphite or dimensionally stable (titanium-base) anodes (Kirk-Othmer 1983). Purified, saturated brine containing approximately 25.5 percent by weight sodium chloride is decomposed as it passes between the cathode and anode in the primary brine cell. Chlorine gas is liberated at the anode and is then discharged to the purification process while sodium metal is liberated at the cathode. A low concentration amalgam, containing 0.25-0.5 percent by weight of sodium, is formed in the mercury cell (Kirk-Othmer 1985).

A second reaction is carried out in a separate device, the denuder subcell, where the dilute amalgam is fed and then reacted with water. The dilute amalgam is converted directly into 50 or 73 percent caustic that contains very little salt. A significant amount of electricity is involved in this reaction (Kirk-Othmer 1985).

Mercury cells must operate with solid salt in order to maintain a water balance. Unique to the operation of mercury cells is the total salt resaturation which occurs after the brine has passed through the primary brine subcell. At this point, a portion (or in some cases, all) of the depleted brine is dechlorinated, resaturated with solid salt, and returned to the cell-brine feed (Kirk-Othmer 1983).

Many of the mercury cells presently in operation have been in service for at least 20 years. During that period, some cell modifications have been made including the substitution of metal anodes for graphite anodes. Due to the wide difference in cell design, chlorine produced per mercury cell could vary from 1 ton/day to 7 or 8 tons/day. In addition, energy consumption varies. Total energy consumption using the mercury cell process could be less than that for using the diaphragm cell production process; while, in many cases, the disparity between technologies could be little or none (Chlorine Institute 1986b).

Mercury cells once accounted for a major part of the world's chlor-alkali capacity. However, in recent years, this technology has been steadily replaced by the asbestos diaphragm cell due primarily to the environmental and industrial hygiene concerns associated with mercury. The first major industrialized country to complete the process switchover was Japan, having eliminated the use of mercury cells in chlor-alkali production in 1986 (Chemical Week 1986b). In the United States, only 16.5 percent of chlorine is produced using mercury cell technology. No new mercury cell construction has occurred in the United States since 1970, and none is likely to in the future (Chlorine Institute 1986b).

D. Comparison of the Three Cells' Characteristics

The three cell technologies (asbestos diaphragm, membrane and mercury) each have distinct price, performance, and market characteristics as indicated in Table 4.

1. Cost of Cell Technology

Diaphragm cell technology is the most used technology for chlorine production in the United States, accounting for 76.7 percent of U.S.installed chlorine production capacity (Chlorine Institute 1986b). There are many different sizes and designs of asbestos diaphragm cells presently used in the industry. Hence, the costs of an asbestos diaphragm varies considerably, ranging from $250 to $2,000. Actual asbestos cost may represent only 10 to 20 percent of the total diaphragm replacement cost (Chlorine Institute 1986b). Other costs associated with the diaphragm include the cost of resin binders and the labor involved for removal and reinstallation of the cell (Chlorine Institute 1986b).

The membrane cell, which accounts for 2.4 percent of the present U.S. chlorine capacity, have estimated costs in the area of $60 to $75 per square foot (Chlorine Institute 1986b). Cells may use membranes with an area of less than 10 square feet, while others may use membranes of over 50 square feet.

Table 4. Comparison of Electrolytic Cell Technologies

	Asbestos Diaphragm	Membrane Cell	Mercury Cell
Price			
o Purchase Cost[j]	\$250-\$2,000[a]	\$600-\$3,750[b]	Not Available
o Other[j]	Other costs include cost of resin binders; labor removal and reinstallation of cell[a]	Associated costs of installation, regasketing, etc. not well known	Not Available
Performance			
o Service Life[j]	3 months to 15 months	2 years	20 years or more[d]
o Energy consumption[k] (KWH/metric ton of chlorinated produced)	2,800-3,000 (average) 2,300 (Best Available Technology)[c]	2,100-2,300[c]	2,900 (average)
o Purity of caustic soda[g] produced (alkali)	10-15% caustic, 1.0-1.2% salt content	30-35% caustic, 0.02-0.2% salt content	50% caustic with low salt content
Market Share[j]	76.7%	2.4%	16.5%

[a] The cost of asbestos for a diaphragm could range from \$50-\$250; actual asbestos cost may account for only 10-20 percent of the total diaphragm replacement cost (Chlorine Institute 1986b). The surface area of the diaphragm ranges from approximately 200 to 1,000 sq ft for a cell with a volume of 64 to 275 cu ft (Coats 1983).

[b] Some cells use membranes with an area of less than 10 square feet, while others use membranes of over 50 square feet.

[c] 20-30 percent less energy than mercury cell or asbestos diaphragm technology.

[d] During this 20 year period some cell modifications have been made (i.e., substitution of metal anodes for graphite anodes).

[e] N/A = Not Available.

[f] Rizzo 1983 (August).

[g] Chemical Week 1981 (May 27).

[h] Chemical Week 1982 (November 17).

[i] Chemical Week 1984 (February 1).

[j] Chlorine Institute 1986b.

[k] Verbanic 1985.

Hence, the purchase cost of materials for membrane cells may range from $600 to $3,750. Since only a few U.S. plants are operating with membrane cells, the associated costs of installation, regasketing, etc. are not well known (Chlorine Institute 1986b). However, the labor costs involved in making a membrane for retrofitting purposes is significantly more expensive than that required for preparing an asbestos diaphragm.

The mercury cell accounts for 16.5 percent of the U.S. chlorine production capacity; however, it is steadily being replaced by both the membrane cell and the asbestos diaphragm cell technologies. Price information for the mercury cell is not available.

2. Useful Service Life

The life of a membrane cell is about two years, while an asbestos diaphragm is expected to

last from three to 15 months. The modified (resin bound) asbestos diaphragm, which is most often employed in chlorine plants, lasts 6 to 15 months (Chlorine Institute 1986b).

Most of the mercury cells in operation today have been in service for 20 years or more, although during this period some cell modifications have been made such as the replacement of metal anodes for graphite anodes (Chlorine Institute 1986b).

3. Energy Consumption

In comparing the three cell technologies in terms of energy consumption, the membrane cell is generally the lowest consumer at 2,100 to 2,300 KWH per metric ton of chlorine produced (Verbanic 1985). In some instances total energy consumption via the mercury cell route may be less than that for the diaphragm cell, but typically, the disparity is marginal. On average, both technologies consume 2,800 to 3,000 KWH per metric ton of chlorine (Verbanic 1985).

4. Purity of Product

Lastly, a primary advantage the membrane cell has over the asbestos diaphragm is the quality of caustic soda produced. Membrane cells produce a stronger caustic solution, 30 to 35 percent, compared to the diaphragm's 10 to 15 percent (Chemical Week 1981). The caustic soda product produced via the mercury cell is more pure than that produced via the asbestos diaphragm cell.

E. Market Trends for the Chlorine Industry

Slow growth and overcapacity have characterized the industry since the early 1970s (Verbanic 1985). During these years of increasing environmental awareness, chlorine growth slowed to only 2 to 3 percent per year (Verbanic 1985). With the imposition of new regulations on several end-use markets (e.g., chlorinated pesticides and solvents, chlorofluorocarbons as aerosol propellants, etc.), demand for chlorine was reduced by several million tons by mid-1970 (Verbanic 1985). However, this drastic reduction in demand was not immediately recognized by producers, and installation of additional capacity continued throughout the 1970s. Consequently, operating rates in the chlor-alkali industry have been low since 1974, remaining below the 80 percent level except for 1979, when the high of 84 percent was achieved (Verbanic 1985). Operating rates have been improving for the industry as the economy has recovered from the 1982 recession (Verbanic 1985). Estimates for 1985 capacity utilization rates have been as high as 84 percent, while most estimates have remained in the area of 75-80 percent (Verbanic 1985). One source forecasts the 1986 average operating rate to be 87 percent, a definite gain over the 1985 average (Chemical Week 1985). The recent improvement stems from both a reduction in annual production capacity of more than 1 million tons and the departure by several well-known producers from the chlor-alkali industry (Verbanic 1985). Since 1980, some 23 chlor-alkali production facilities have been completely or partially closed, involving about 2,740,000 tons of annual production capacity (Chlorine Institute 1986a).

The chlor-alkali business is now a slow-growing, mature business with a long-term growth trend of 1.5 percent (Verbanic 1985). However, general gains may be expected in the 1986 chlor-alkali market, stemming from a 2 to 3 percent boost in industrial and chemical demand and a relative 8 percent decline in the trade-weighted value of the dollar, increasing the demand for chlorine products overseas (Chemical Week 1985).

As a result of slow-growth in demand, few, if any, new chlor-alkali plants are expected to open in the U.S. Rather than building new plants, existing firms are switching over from asbestos diaphragm and mercury cells to membrane cell technology because of the many advantages the membrane technology offers. The future of membrane cell technology in the chlor-alkali industry seems certain; it's not a question of whether U.S. producers will switch to membranes, but when and where (Chemical Week 1984).

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XIV. ASBESTOS-CEMENT PIPE AND FITTINGS

A. Product Description

This 1988 report on asbestos-cement pipe has been updated from the 1986 report to account for the increased acceptance of polyvinyl chloride (PVC) pipe over the past two years. Sussex Plastics Engineering was hired to conduct a survey of the present status of standards for plastic pipe products suitable to replacing asbestos-cement pipe in potable water and sewer applications. This survey was intended to update the information of the Malcolm Pirnie (1983) report because plastic pipe standards have been extended to larger diameters and new products have been developed since 1986 (Sussex Plastics Engineering 1988a).

Asbestos-cement pipe is made of a mixture of Portland cement (42 to 53 percent by weight), asbestos fibers (15 to 25 percent by weight), and silica (34 to 40 percent by weight). These materials are combined with water and processed into a pliable mass that is wound around a steel cylinder and then compressed and cut into 10 or 13-foot lengths. The product then goes through a curing process, known as autoclaving, that involves immersion in water or pressurized steam to enhance corrosion resistance to high sulfate soils and waters. Cured pipes then undergo a finishing process that includes machining the ends and, optionally, lining the pipe with gilsonite coatings, asphalt-based coatings, or other coatings to protect the pipe from acidic or corrosive fluids (ICF 1985).

According to the Bureau of Mines, approximately 18 percent of the total asbestos fiber consumed in the U.S., or 30,871, tons was used in the production of asbestos-cement pipe in 1985 (Bureau of Mines 1986a, Bureau of Mines 1986b). Applications for asbestos-cement pipe may be divided into pressure pipe (water mains) and non-pressure pipe (sewer line) applications. The pressure pipe applications include conveyance of potable water, force main sewers, industrial process lines, and industrial fire protection systems (Association of Asbestos Cement Pipe Producers 1986b). Non-pressure pipe applications include use in storm drain pipes and sewer pipes, although these uses constitute only a small portion of present asbestos-cement pipe production. Asbestos-cement pipe is especially widespread throughout the Southeast, Mountain, and Pacific regions (Association of Asbestos Cement Pipe Producers 1986b).

Approximately 22 million linear feet, or 4,167 miles, of asbestos-cement pipe are installed annually in the U.S. (Association of Asbestos Cement Pipe Producers 1986a). As of 1986 it is roughly estimated that 400,000 miles of asbestos-cement pipe have been installed in the U.S., over 325,000 miles of which is asbestos-cement water pipe (Association of Asbestos Cement Pipe Producers 1986b; American Waterworks Association 1986). A small but unknown amount of asbestos-cement pipe is also used as conduits for electrical and telephone cables and for laterals from street mains to consumers (Krusell and Cogley 1982).

Asbestos-cement pipe comes in a variety of diameters, formulations, and weights designed for different applications. In the past, diameters ranged from 4 inches through 42 inches, however, current production of asbestos-cement pipe larger than 24 inches in diameter was not reported by any domestic manufacturer (Certain-Teed 1986c, JM Manufacturing 1986a, Capco 1986a, Capco 1986b). Standard lengths are 10 and 13 feet. Among the many factors that are important in selecting pipe for pressure (water mains) and non-pressure applications (sewer mains) the major ones are:

- Fluid conveyed;
- Flow capacity;
- Depth of cover/external loads;
- Soil characteristics;
- Flexibility;
- Bedding requirements; and
- Connections.

Other factors used in selecting pipe include cost, availability, useful life, and the experience of the engineer, contractor, or utility director (Malcolm Pirnie 1983).[1]

For the purpose of this discussion, the enormously complex asbestos-cement pipe market has been divided into 10 submarkets which are shown in Table 1. (These asbestos-cement submarkets were originally derived by Malcolm Pirnie (1983). Table 1 also shows, in addition to the 10 submarkets, the 1981 relative market share of each asbestos-cement pipe submarket by linear foot of asbestos-cement pipe (see Attachment, Item 1).[2]

In 1981, according to Table 1, by linear feet, approximately 83 percent of the asbestos-cement pipe produced was used in pressure applications and 17 percent was used in non-pressure applications. The relative market shares by weight of pressure and non-pressure asbestos-cement pipe shipments from 1980 to 1985 are presented in Table 2. Pressure pipe has taken a larger share of the asbestos-cement pipe shipments since 1980, comprising 89 percent of all asbestos-cement pipe shipments by 1985.

B. Producers and Importers of Asbestos-Cement Pipe

The number of plants producing asbestos-cement pipe was reduced from 9 to 5 between 1981 and 1983. All of those five are still operating today (ICF 1985, ICF 1986). Plants were closed or dismantled in response to several

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[1] For a more detailed description of the significance of each factor and how asbestos-cement pipe's performance relates to it, refer to Malcolm Pirnie (1983).

[2] 1981 data is used because this is the most recent year for which production of asbestos-cement pipe in each of the 10 submarkets chosen by Malcolm Pirnie (1983) are available. Note that in 1981 there were 5 additional submarkets of pipe >24" in diameter, one for each of the two operating pressure classes and one for each of the three depth of cover classes. Since asbestos-cement pipe is no longer produced over 24" in diameter these 5 submarkets have been deleted. Thus, the markets shares shown in Table 1 are derived only for asbestos-cement pipe 24" in diameter based upon 1981 production in each of the 10 submarkets (see Attachment, Item 1 and Malcolm Pirnie 1983).

Table 1. Asbestos-Cement Pipe Submarkets in the United States

Asbestos-Cement Pipe Application	Specifications	Share of Asbestos-Cement Pipe Market (by linear feet) Consumed in 1981
Pressure Flow Water Pipe	0-150 psi, 4"-12" diameter	59.52
Pressure Flow Water Pipe	>150 psi, 4"-12" diameter	5.33
Pressure Flow Water Pipe	0-150 psi, 12"-24" diameter	16.39
Pressure Flow Water Pipe	>150 psi, 12"-24" diameter	1.72
Total Pressure	82.96	
Non-Pressure Gravity Sewers	0'-8' deep, 4"-12" diameter	7.04
Non-Pressure Gravity Sewers	0'-8' deep, 12"-24" diameter	6.86
Non-Pressure Gravity Sewers	8'-16' deep, 4"-12" diameter	1.35
Non-Pressure Gravity Sewers	8'-16' deep, 12"-24" diameter	1.47
Non-Pressure Gravity Sewers	>16' deep, 4"-12" diameter	0.15
Non-Pressure Gravity Sewers	>16' deep, 12"-24" diameter	0.17
Total Non-Pressure	17.04	
Total Pressure and Non-Pressure		100.00

See Attachment, Item 1 for sources and calculations.

Table 2. Market Share of Domestic Asbestos-Cement Shipments by Weight

Year	Pressure Flow Water Pipe (percent)	Non-Pressure Flow Gravity Sewers (percent)
1980	73	27
1981	76	24
1982	85	15
1983	86	14
1984	89	11
1985	89	11

Source: Association of Asbestos Cement Pipe Producers 1986a.

factors. Among these were competition from substitute pipe (especially polyvinyl chloride), the drop in sewer system construction since EPA grant cutbacks in 1978, and the drop in housing starts in prior years (U.S. Industrial Outlook 1983). Table 3 lists these remaining domestic producers of asbestos-cement pipe. The locations of the remaining producers confirm the fact that the asbestos-cement pipe market is primarily in the southwestern part of the nation.

All companies which produce asbestos-cement pipe also produce PVC pipe (Association of Asbestos Cement Pipe Producers 1986a). There appears to be a greater demand for pressure pipe as is shown by Certain-Teed's Riverside, CA plant which produces only pressure pipe and is currently operating at 95 percent of capacity, while Certain-Teed's Hillsboro, TX plant, which produces both pressure and non-pressure asbestos-cement pipe, is operating at only 60 percent of capacity (Industrial Minerals 1986). No importers of asbestos-cement pipe were identified, although according to the U.S. Bureau of the Census a very small amount (relative to domestic production) of pipe was imported in 1985 (see Trends) (U.S. Dep. Com. 1986).

C. Trends

Domestic asbestos-cement pipe shipments from 1980 through 1985 are presented in Table 4. As Table 4 indicates domestic asbestos-cement pipe shipments have decreased by about 42 percent since 1980, with a 78 percent decline in non-pressure pipe shipments and a smaller decline (28 percent) in pressure pipe shipments (see Attachment, Item 2). Table 5 presents 1985 production of asbestos-cement pipe and asbestos consumption. There were 216,903 tons (15,062,708 feet) of asbestos-cement pipe, valued at about $110 million, produced in 1985 (ICF 1986, Association of Asbestos Cement Pipe Producers 1986b, see Attachment, Item 10).

Table 3. Producers of Asbestos-Cement Pipe

Company	Plant	Product Lines: Asbestos-Cement	Product Lines: PVC
Capco Inc.	Van Buren, AR	X	X
Certain-Teed Corp.	Riverside, CA Hillsboro, TX	X	X
JM Manufacturing Corp.	Stockton, CA	X	X
	Denison, TX	X	X

Table 4. Domestic asbestos-cement Pipe Shipments[a]

Year	Total Shipments (tons)	Pressure Pipe Shipments (tons)	Non-Pressure Pipe Shipments (tons)
1980	417,816	302,928	114,888
1981	346,678	265,147	81,531
1982	286,555	242,453	44,102
1983	288,671	248,863	39,808
1984	296,450	262,527	33,923
1985	243,873	218,191	25,682
Totals	1,880,043	1,540,109	339,934

[a]Association of Asbestos Cement Pipe Producers 1986a.

Table 5. 1985 Production of Asbestos-Cement Pipe

	Tons of Asbestos Consumed	Production (tons)
Total[a]	32,690.8	216,903

[a]One company refused to provide production and fiber consumption data for their asbestos-cement pipe plant (ICF 1986). Their production and fiber consumption have been estimated using a method described in Appendix A of this RIA.

Source: ICF 1986.

Imports of asbestos-cement pipe are insignificant. In 1984 they were about 4,191 tons, or equal to 1.4 percent, by weight, of domestic shipments and in 1985 they dropped to about 2,790 tons, or 1.1 percent, by weight, of domestic shipments (U.S. Dep. Comm. 1986).

The growth of the pipe industry, including asbestos-cement pipe, will be largely determined by trends in the sewer and waterworks construction industry. The value of sewer system construction, which accounts for 11 percent of the asbestos-cement pipe market in 1985, increased by about 5 percent in 1985 and is expected to increase further in 1986. In the longer term, sewer system construction may decline slightly due to less federal spending and the projected eventual leveling of housing starts at a relatively high level (U.S. Industrial Outlook 1986). Waterworks construction, accounting for about 89 percent of asbestos-cement pipe use, increased sharply in 1984 and 1985, recovering from a slump in the early 1980's. The increased level of housing starts and the record amounts of municipal bonds issued for waterworks systems were two important factors responsible for this change (U.S. Industrial Outlook 1986). For the longer term outlook, waterworks construction is predicted to be one of the fastest growing segments of public construction. Growth will come from two sources: the high level of housing starts, and the need to replace old waterworks in cities (engineers recommend that this should be done every 50 years) (U.S. Industrial Outlook 1986). The new demand in asbestos-cement pipe's largest market could have a positive impact on the demand for asbestos-cement pipe, although detailed forecasts are not available.

Potential growth in asbestos-cement pipe demand will be limited by the availability of satisfactory substitutes (discussed below). In some instances, notably PVC pipe, costs are approaching those of asbestos-cement pipe, especially large diameter pipes (ICF 1985).

D. Substitutes

As Table 1 indicates, there are many submarkets within the asbestos-cement pipe market. In reality, this exhibit provides only a broad aggregate of pipe submarkets because every site has unique characteristics in which price and performance tradeoffs among different types of pipe must be made.

For all 10 submarkets of asbestos-cement pipe, Malcolm Pirnie (1983) found two main substitutes: polyvinyl chloride (PVC) and ductile iron pipe. The major factors Malcolm Pirnie (1983) considered in determining substitutes in the non-pressure submarkets were pipe diameter, depth of cover, and soil characteristics and for pressure submarkets the major factors were pipe diameter, operating pressure, fluid characteristics and soil characteristics (Malcolm Pirnie 1983). (For a more in-depth discussion of how these substitutes were determined see Malcolm Pirnie 1983.)

The following paragraphs describe the two substitutes and discuss two other products that have already replaced asbestos-cement in the over 24 inch diameter submarkets. It should be noted that the substitutes discussed here are the ones most likely to replace asbestos-cement pipe because of their price and performance characteristics, but are not the only ones available (Malcom Pirnie 1983).

1. Polyvinyl Chloride Pipe (PVC)

PVC pipe is produced by more than 13 U.S. companies including the three producers of asbestos-cement pipe (ICF 1985). The advantages of PVC pipe include the following:

- Lightweight;
- Long laying lengths; and
- Ease of installation (Malcolm Pirnie 1983).

Industry representatives report that PVC can be joined to existing asbestos-cement pipe when repairs in water or sewer mains are required (ICF 1985). Disadvantages of PVC include:

- Subject to attack by certain organic chemicals.
- Subject to excessive deflection when improperly installed.
- Limited range of diameters are available.
- Subject to surface changes caused by long term ultra-violet exposure (Malcolm Pirnie 1983).

In addition it cannot withstand high temperatures as well as asbestos-cement pipe or some other substitutes (ICF 1985).

PVC is the most important substitute for asbestos-cement pipe because it could fill much of the asbestos-cement pipe market if asbestos were banned (American Concrete Pressure Pipe Association 1986, Industrial Minerals 1986), especially in the following applications (Malcolm Pirnie 1983):[3]

- pressure pipe, 0-150 psi, 4"-12" diameter
- pressure pipe, 0-150 psi, 12"-24" diameter
- non-pressure, 0'-16' deep, 4"-24" diameter

Thus PVC is the most probable substitute for the "small" end of the asbestos-cement pressure pipe market (small diameter pipe under low pressure), and for all diameter pipes (at relative shallow depths) in the non-pressure market. PVC has largely taken over the sewer market (Industrial Minerals 1986, Sussex Plastics Engineering 1988a and b, JM Manufacturing 1988).

2. Ductile Iron (DI) Pipe

Ductile iron pipe is manufactured by at least six companies, including the Jim Walter Corporation (the parent company of U.S. Pipe and Foundry), American Cast Iron Pipe Company, McWane Cast Iron Pipe Company, Pacific Cast

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[3] In the 1986 report, ductile iron was the pipe chosen to replace asbestos-cement in the pressure pipe, 0-150 psi, 12"-24" diameter category. Based on the updated Sussex Plastics Engineering (1988) survey of PVC pipe standards and availability, PVC is the most likely substitute for asbestos is this submarket (Sussex Plastics Engineering 1988a and b and ICF estimate).

In 1988, PVC has also taken over the 4"-12" non-pressure (sewer/gravity) pipe market and might therefore also take away the >16' deep, 4"-12" diameter market from the other major substitute, ductile iron (JM Manufacturing 1988). However, because this submarket represents only 0.15 percent of the entire asbestos-cement pipe market, it was considered insignificant and has been left as a ductile iron submarket in this analysis.

Iron Company, the Clow Company, and Atlantic States Cast Iron Company. Clow, Atlantic States, and Pacific States are all owned by McWane Cast Iron Pipe Company. U.S. Pipe and Foundry and American Cast Iron Pipe Company are the largest producers (Ductile Iron Pipe Research Association 1986b).

Ductile iron is produced by adding magnesium to molten iron and then casting the materials centrifugally to control pipe thickness. The pipe is lined with cement mortar and often encased in plastic to prevent internal and external corrosion. The pipe is usually cut into 18 or 20 foot lengths.

The major advantages of ductile iron pipe include:

- Long laying lengths;
- Not brittle;
- High internal pressure and load bearing capacity; and
- High beam and impact strength (Malcolm Pirnie 1983).

Ductile iron is very strong, can handle stress from water hammer and highway traffic, and is more flexible and less brittle than cement-based pipes. Major disadvantages of ductile iron are:

- Subject to corrosion where acids are present;
- Subject to chemical attack in corrosive soils; and
- High weight (Malcolm Pirnie 1983).

However, DI is usually lined and sometimes encased to prevent corrosion and rusting.

Ductile iron pipe is a direct competitor with asbestos-cement pipe in several submarkets, most importantly in parts of the pressure pipe (water main) submarket. In this study, DI has been chosen as the probable substitute for asbestos-cement pipe in the following submarkets (Malcolm Pirnie 1983):

- pressure pipe, >150 psi, 4"-24" diameter
- non-pressure pipe, >16' deep, 4"-24" diameter

Table 6 shows the costs of asbestos-cement pipe and its two major substitutes, PVC and ductile iron.[4] F.O.B. plant prices are based on weighted averages of several companies' prices (see Attachment, Items 4-7). Installation costs were derived from Means Guide to Building Construction Costs (1986) (see Attachment, Item 8). In 1986, industry representatives reported that the price of PVC had come down as the market for it had grown and possibly because of falling oil and natural gas prices (Industrial Minerals 1986). Since 1986, the price of PVC pipe has increased approximately 50 percent due to a temporary shortage of resin, which is one of the primary ingredients in the manufacture of PVC pipe. When the supply of resin increases, the price of PVC pipe should decline (see Attachment, Items 5a-b) (JM Manufacturing 1988, Sussex Plastics Engineering 1988a). DI is overall the most expensive substitute.

The following concrete substitutes have already replaced asbestos-cement pipe in the over 24 inch diameter submarkets; asbestos-cement pipe is no longer made in diameters greater than 24 inches.

a. Prestressed Concrete Pipe (PCP)

Prestressed concrete pipe is the most probable substitute for asbestos-cement pipe in large water mains (greater than 24" diameter). PCP is all pressure pipe. It ranges from 16 to 252 inches in diameter. It is less expensive, less brittle, and comes in longer lengths, 20 feet or longer, than asbestos-cement pipe (American Concrete Pressure Pipe Association 1986).

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[4] There is some uncertainty about the comparative installation costs of asbestos-cement and DI pipes. Estimates given by industry representatives indicated that ductile iron is sometimes more expensive to install than asbestos-cement pipe because its flexibility demands some compacting of the soil around the pipe. Yet engineers also say that DI is easier to install because it is less brittle and comes in longer lengths, normally 18 feet sections as opposed to asbestos-cement which is 10 and 13 feet (Ductile Iron Pipe Research Association 1986a).

Table 6. Cost of Asbestos-Cement Pipe and Substitutes

	Asbestos-Cement Pipe	PVC Pipe	Ductile Iron Pipe	References
FOB Plant Cost[a] ($/foot)	6.74	6.84	10.01	Certain-Teed 1986, JM Manufacturing 1986b, McWane 1986, U.S. Pipe 1986, Atlantic Cast Iron Pipe 1986.
Installation Cost[b] ($/foot)	2.20	4.24	5.86	Means 1985.
Total Cost ($/foot)	8.94	11.08	15.87	
Operating Life[c] (years)	50	50	50	ICF 1985.
Present Value[d] ($/foot)	8.94	11.08	15.87	

[a]See Attachment, Items 4-7 for calculations.

[b]Derived from Means 1985. See Attachment, Item 8 for calculations.

[c]Operating life estimates for pipe vary from 35 to 1,000,000 years. Operating life depends on many factors, including the appropriateness of the pipe for a specific site and application. The 50 years estimated here is a reasonable estimate for the useful life of pipe (ICF 1985).

[d]Present values equal total cost because operating life is the same for asbestos-cement pipe and its substitutes.

PCP is made of sand, gravel, and cement cast into various thicknesses and lengths. Steel wire under tension is wound around the outside of the pipe core before a mortar coating is applied. The wire adds to the pipe's ability to withstand the forces of water flowing through it under pressure. Another type of concrete pipe which is very similar to PCP is pretensioned concrete pipe. It is made the same way as PCP except that a rod, as opposed to a wire, is wrapped around the pipe before the last mortar coat. This rod enables one to use less steel for the interior cylinder than for PCP (U.S. Concrete Pipe 1986). PCP and other types of concrete pipe are produced by many manufacturers who can use readily-available local materials and produce customized shapes and lengths to meet local specifications.

b. Reinforced Concrete Pipe (RCP)

Reinforced concrete pipe and other pipes have already substituted for asbestos-cement pipe in storm drains and sewer lines which require diameters greater than 24 inches.

RCP is made of sand, gravel, and cement reinforced with steel bars and/or welded wire mesh (ICF 1985). It differs from PCP and pretensioned concrete pipe in that RCP has steel bars or a wire cage for a core instead of a steel cylinder and it does not have a wire or rod wrapped around it before the final mortar coat. The lack of a steel cylinder core makes it more permeable than the previously mentioned concrete pipes. Therefore it is used for nuisance runoff, sewer and storm drain pipe (U.S. Concrete Pipe 1986). At large diameters, it was less expensive than asbestos-cement pipe. The price factor explains why over 60 percent of U.S. sewer lines of greater than 24" diameter are made of reinforced concrete. The second most important material used in this submarket (greater than 24" diameter) is vitrified clay pipe, which accounts for 15 percent of the in-place pipe. In 1981, asbestos-cement pipe occupied fifth place in this market, accounting for 0.5 percent of it (Krusell and Cogley 1982).

Reinforced concrete pipe is produced by many manufacturers in the United States, in contrast to asbestos-cement pipe, which is produced at only a few plants. The disappearance of asbestos-cement pipe from the market has had no noticeable impact on the submarkets in which reinforced concrete pipe already dominated.

If asbestos-cement pipe were not available, based on the 1981 submarket shares, it is estimated that by weight of asbestos-cement pipe, 91.16 percent would shift to PVC and 8.84 percent to ductile iron (see Attachment, Item 9). By linear foot, 92.63 of the previous purchasers of asbestos-cement pipe would purchase PVC and 7.37 percent would use ductile iron (see Attachment, Item 1). Table 7 presents the data for the asbestos regulatory cost model and summarizes the findings of this analysis. Data inputs for the Asbestos Regulatory Cost Model are presented in units of linear feet because prices of asbestos-cement pipe and its substitutes are only available in cost per linear foot.

E. Summary

There are two types of asbestos-cement pipe; pressure pipe which comprises 89 percent of the asbestos-cement pipe market and non-pressure pipe which comprises about 11 percent of the market (Association of Asbestos Cement Pipe Producers 1986a). Pressure pipe applications include conveyance of potable water, force main sewers, industrial process lines, and industrial fire-protection systems. Non-pressure pipe applications include use in storm drains and sewers (Association of Asbestos Cement Pipe Producers 1986b).

Three companies, with a total of five plants, are still producing asbestos-cement pipe. In 1981, there had been nine plants operating (ICF 1985, ICF 1986). From 1980 through 1985 domestic pipe shipments have declined

Table 7. Data Inputs for Asbestos Regulatory Cost Model[a]

Product	Output (ft.)	Product Asbestos Coefficient	Consumption Production Ratio	Price ($/ft.)	Useful Life	Equivalent Price ($/ft.)	Market Share	Reference
Asbestos-Cement Pipe	15,062,708	0.0022	1.0128	8.94	50 years	8.94	N/A	See Attachment
PVC Pipe	N/A	N/A	N/A	11.08	50 years	11.08	92.63%	See Attachment
Ductile Iron Pipe	N/A	N/A	N/A	15.87	50 years	15.87	7.37%	See Attachment

N/A: Not Applicable.

[a]See Attachment, Items 1, 3-8, and 10-12 for explanation.

42 percent, with a 78 percent decline in non-pressure pipe shipments and a 28 percent decline in pressure pipe shipments (Association of Asbestos Cement Pipe Producers 1986a). Imports in 1985, about 1 percent of domestic shipments, were insignificant (U.S. Dep. Com. 1986). The two major substitutes are PVC and ductile iron pipe. If asbestos were no longer available it is estimated (by linear foot) that PVC would take 92.63 and ductile iron 7.37 of the asbestos-cement pipe market. PVC costs slightly more than asbestos-cement pipe and ductile iron costs almost twice as much as asbestos-cement pipe.

ATTACHMENT

(1) Calculations to derive each submarket's share, by linear feet, of the entire asbestos-cement pipe market.

In order to determine the market share by linear feet of each of the ten asbestos-cement pipe submarkets shown in Table 1, it is necessary to convert the amount of tons of asbestos-cement pipe produced in each submarket into linear feet of asbestos-cement pipe. First the average weight per foot of asbestos-cement pipe is calculated for each submarket. This weight per foot for each submarket is then multiplied by the tons of asbestos-cement pipe produced in 1981 in each submarket, giving linear feet produced in each submarket (As stated in the text, 1981 production data is the most recent available that is broken down into the ten submarkets). The calculations are shown in the following subsections a and b.

(a) Calculation of the weight per foot of asbestos-cement pipe in each submarket.

For the 0-150 pressure pipe submarkets an average was taken of Class 100 and 150 pipe. For the 0-8 feet depth non-pressure pipe submarkets Class 2400 pipe was used. For the 8-16 feet depth an average of Class 2400 and 3300 were used. For the >150 psi pressure pipe submarkets, an average was taken of Class 150 and 200 pipe and for >16 feet depth submarkets Class 3300 was used.

Submarkets taken by PVC as determined by Malcolm Pirnie (1983), Sussex Plastics Engineering (1988a), and ICF estimate.

0-150 psi, 4"-12" diameter

	Class 100 (lb/ft)	Class 150 (lb/ft)	
4"	7.2	7.9	
6"	10.6	11.9	
8"	16.0	18.3	Average for this submarket is 19.51 lb/ft.
10"	23.5	30.0	
12"	30.6	39.1	

0-150 psi, 12"-24" diameter

	Class 100 (lb/ft)	Class 150 (lb/ft)	
12"	30.6	39.1	
14"	36.3	51.8	
16"	46.6	65.9	
18"	63.8	91.3	Average for this submarket is 73.53 lb/ft.
20"	77.0	111.0	
24"	109.0	160.0	

0-8' deep, 4"-12" diameter

	Class 2400 (lb/ft)	
4"	5.3	
6"	9.1	
8"	12.8	Average for this submarket is 13.61 lb/ft.
10"	17.5	
12"	23.3	

0-8' deep, 12"-24" diameter

	Class 2400 (lb/ft)	
12"	23.3	
14"	27.1	
15"	30.0	
16"	33.2	Average for this submarket is 40.74 lb/ft.
18"	43.2	
20"	48.9	
21"	54.1	
24"	66.1	

8-16' deep, 4"-12" diameter

	Class 2400 (lb/ft)	Class 3300 (lb/ft)	
4"	5.3	6.6	
6"	9.1	10.7	
8"	12.8	14.9	Average for this submarket is 14.75 lb/ft.
10"	17.5	20.2	
12"	23.3	27.1	

8-16' deep, 12"-24" diameter

	Class 2400 (lb/ft)	Class 3300 (lb/ft)	
12"	23.3	27.1	
14"	27.1	31.2	
15"	30.0	34.8	
16"	33.2	37.7	Average for this submarket is 43.50 lb/ft.
18"	43.2	48.2	
20"	48.9	54.9	
21"	54.1	62.3	
24"	66.1	73.9	

Submarkets taken by Ductile Iron (DI) as determined by Malcolm Pirnie (1983), Sussex Plastics Engineering (1988a) and ICF estimate.

<u>≥150 psi, 4"-12" diameter</u>

	Class 100 (lb/ft)	Class 150 (lb/ft)	
4"	7.9	9.2	
6"	11.9	15.6	
8"	18.3	23.1	Average for this submarket is 23.94 lb/ft.
10"	30.0	35.4	
12"	39.1	48.9	

<u>≥150 psi, 12"-24"</u>

	Class 150 (lb/ft)	Class 200 (lb/ft)	
12"	39.1	48.9	
14"	51.8	61.8	
16"	65.9	79.9	
18"	91.3	--	Average for this submarket is 78.86 lb/ft.[5]
20"	111.0	--	
24"	160.0	--	

<u>≥16' deep, 4"-12" diameter</u>

	Class 3300 (lb/ft)	
4"	6.6	
6"	10.7	
8"	14.9	Average for this submarket is 15.90 lb/ft.
10"	20.2	
12"	27.1	

[5] Weights were not found for all sizes, so this is an average of only the weights shown. The reader may note that later, for calculating ductile iron prices, averages were taken across rows for pipe of the same class, however, because the pipes in the above case are of different classes we did not feel this method was appropriate.

≥16' deep, 12"-24" diameter.

	Class 3300 (lb/ft)
12"	27.1
14"	31.2
15"	34.8
16"	37.7
18"	48.2
20"	54.9
21"	62.3
24"	73.9

Average for this submarket is 46.26 lb/ft.

Source: Certain-Teed 1986c.

(b) Calculations to convert ton production for each submarket into each submarket's share by linear feet of the entire asbestos-cement pipe market.

	Tons Produced in 1981 for 24" Diameter	Multiplication Factors to Convert to Linear Feet	Linear Feet of Pipe Per Submarket	Submarket Share
		PVC Submarkets		
0-150 psi, 4"-12"[a]	108,843	x 2,000 lb/ton x 1 ft/19.51 =	11,157,662.737	59.52%
0-150 psi, 12"-24"[a]	112,957	x 2,000 lb/ton x 1 ft/73.53 =	3,072,405.821	16.39%
0-8' deep, 4"-12"	8,977	x 2,000 lb/ton x 1 ft/13.61 =	1,319,177.076	7.04%
0-8' deep, 12-24"	26,182	x 2,000 lb/ton x 1 ft/40.74 =	1,285,321.551	6.86%
8-16' deep, 4"-12"	1,870	x 2,000 lb/ton x 1 ft/14.75 =	253,559.322	1.35%
8-16' deep, 12"-24"	5,984	x 2,000 lb/ton x 1 ft/43.50 =	275,126.437	1.47%
				92.63%

	Tons Produced in 1981 for 24" Diameter	Multiplication Factors to Convert to Linear Feet	Linear Feet of Pipe Per Submarket	Submarket Share
		DI Submarkets		
>150 psi, 4"-12"[a]	11,969	x 2,000 lb/ton x 1 ft/23.94 =	999,916.458	5.33%
>150 psi, 12"-24"[a]	12,717	x 2,000 lb/ton x 1 ft/78.86 =	322,520.923	1.72%
>16' deep, 4"-12"	224	x 2,000 lb/ton x 1 ft/15.90 =	28,176.101	0.15%
>16' deep, 12-24"	748	x 2,000 lb/ton x 1 ft/46.26 =	32,338.954	0.17%
				7.37%
		Total	18,746,205.379	100.00%

Total market shares held by pressure and non-pressure pipe.

Pressure Pipe : 82.96%
Non-Pressure Pipe: 17.04%

Total market shares of the asbestos-cement replacement market that will be taken by PVC and Ductile Iron Pipe.

PVC Pipe : 92.63%
Ductile Iron Pipe: 7.37%

[a]These are pressure pipe submarkets.

The source for the 1981 tonnage is ICF 1985. The weight per ton came from Attachment, Item 1a.

(2) Calculation of the decline of asbestos-cement shipments, in tons, since 1980, based on Table 4.

All Pipe

(1980-1985)/1980 x 100 = (417,816-243,873)/417,816 x 100 = 42%

Pressure Pipe

(1980-1985)/1980 x 100 = (302,928-218,191)/302,928 x 100 = 28%

Non-pressure Pipe

(1980-1985)/1980 x 100 = (114,888-25,682)/114,888 x 100 = 78%

Source: Association of Asbestos Cement Pipe Producers 1986a.

(3) <u>Prices for asbestos-cement pressure and non-pressure pipe in each submarket</u>

For the 0-150 pressure pipe submarkets an average was taken of Class 100 and 150 pipe.

For the 0-8 feet depth non-pressure pipe submarkets Class 2400 pipe was used.

For the 8-16 feet depth non-pressure pipe submarkets an average of Class 2400 and 3300 were used.

For the >150 psi pressure pipe submarkets an average was taken of Class 150 and 200 pipe (when prices for Class 200 are not available on average of Class 150 is taken), and for >16 feet depth submarkets Class 3300 was used.

Submarkets taken by PVC as determined by Malcolm Pirnie (1983), Sussex Plastics Engineering (1988a) and ICF estimate.

<u>0-150 psi, 4"-12" diameter</u>

	Class 100 ($/ft)	Class 150 ($/ft)	
4"	2.05	2.16	
6"	2.66	3.01	
8"	3.95	4.46	Average for this submarket is $4.46/ft.
10"	4.96	6.51	
12"	6.53	8.30	

<u>0-150 psi, 12"-24" diameter</u>

	Class 100 ($/ft)	Class 150 ($/ft)	
12"	6.53	8.30	
14"	7.92	10.11	
16"	10.14	12.49	
18"	15.31	18.31	Average for this submarket is $15.43/ft.
20"	17.53	22.27	
24"	25.15	31.05	

0-8' deep, 4"-12" diameter

	Class 2400 ($/ft)	
4"	1.15	
6"	1.65	
8"	2.40	Average for this submarket is $2.87/ft.
10"	4.00	
12"	5.15	

0-8' deep, 12"-24" diameter

	Class 2400 ($/ft)	
12"	5.15	
14"	6.21	
15"	8.40	
16"	8.83	Average for this submarket is $11.14/ft.
18"	11.38	
20"	14.11	
21"	14.36	
24"	20.67	

8-16' deep, 4"-12" diameter

	Class 2400 ($/ft)	Class 3300 ($/ft)	
4"	1.15	1.31	
6"	1.65	1.88	
8"	2.40	2.57	Average for this submarket is $3.02/ft.
10"	4.00	4.39	
12"	5.15	5.73	

8-16' deep, 12"-24" diameter

	Class 2400 ($/ft)	Class 3300 ($/ft)	
12"	5.15	5.73	
14"	6.21	7.85	
15"	8.40	9.07	
16"	8.83	9.61	Average for this submarket is $11.62/ft.
18"	11.38	12.38	
20"	14.11	15.39	
21"	14.36	15.80	
24"	20.67	20.96	

Submarkets taken by Ductile Iron (DI) as determined by Malcolm Pirnie (1983), Sussex Plastics Engineering (1988a) and ICF estimate.

<u>≥150 psi, 4"-12" diameter</u>

	Class 150 ($/ft)	Class 200 ($/ft)	
4"	2.16	2.36	
6"	3.01	3.41	
8"	4.46	4.78	Average for this submarket is $5.23/ft.
10"	6.51	7.50	
12"	8.30	9.77	

<u>≥150 psi, 12"-24" diameter</u>

	Class 150 ($/ft)	
12"	8.30	
14"	10.11	
16"	12.49	
18"	18.31	Average for this submarket is $17.09/ft
20"	22.27	
24"	31.05	

<u>≥16' deep, 4"-12" diameter</u>

	Class 3300 ($/ft)	
4"	1.31	
6"	1.88	
8"	2.57	Average for this submarket is $3.18/ft.
10"	4.39	
12"	5.73	

>16' deep, 12"-24" diameter.

	Class 3300 (\$/ft)	
12"	5.73	
14"	7.85	
15"	9.07	
16"	9.61	Average for this submarket is \$12.10/ft.
18"	12.38	
20"	15.39	
21"	15.80	
24"	20.96	

Source: Certain-Teed 1986c.

(4) Weighted average calculation of F.O.B. plant price for A/C pipe

Submarket	Submarket's Share of Overall PVC Market (by Linear Foot)	x	Price/Foot	=	Submarket's Weighted Price Per Foot
0-150 psi, 4"-12" diameter	0.5952	x	\$ 4.46	=	\$2.65
0-150 psi, 12"-24" diameter	0.1639	x	\$15.43	=	\$2.53
0-8' deep, 4"-12" diameter	0.0704	x	\$ 2.87	=	\$0.20
0-8' deep, 12"-24" diameter	0.0686	x	\$11.14	=	\$0.76
8-16' deep, 4"-12" diameter	0.0135	x	\$ 3.02	=	\$0.04
8-16' deep, 12"-24" diameter	0.0147	x	\$11.62	=	\$0.17
>=50 psi, 4"-12" diameter	0.0533	x	\$ 5.23	=	\$0.28
>=150 psi, 12"-14" diameter	0.0172	x	\$17.09	=	\$0.29
>+16' deep, 4"-12" diameter	0.0015	x	\$ 3.18	=	\$0.00
>+16' deep, 12"-14" diameter	0.0017	x	\$12.10	=	\$0.02
		Total Weighted Price			\$6.94

However, according to Certain-Teed (1986), these prices are 3 percent above plant F.O.B. cost.

Therefore, the actual price is: \$6.94/1.03 = \$6.74

Source: Certain-Teed 1986, ICF 1985.

(5a) <u>Calculations of PVC Pipe prices for PVC Submarkets</u>
(Source: JM Manufacturing 1986b)

<u>0-150 psi, 4"-12" diameter</u>

	Class 150 (\$/ft)	
4"	1.20	
6"	2.20	
8"	3.80	Average for this submarket is \$4.19/ft.
10"	5.75	
12"	8.00	

<u>0-150 psi, 4"-12" diameter</u>

See Items 5b and c. Average for this submarket is \$17.19.

	Sewer Pipe (\$/ft)	
4"	0.45	
6"	1.00	
8"	1.85	Average for this submarket is \$2.06/ft.
10"	2.90	
12"	4.10	

<u>0-8' deep, 12"-24" diameter</u>

	Sewer Pipe (\$/ft)	
12"	4.10	
15"	5.90	
18"	9.85	Average for this submarket is \$10.29/ft.
21"	13.72	
24"	17.87	

<u>8-16' deep, 4"-12" diameter</u>

	Sewer Pipe (\$/ft)	
4"	0.45	
6"	1.00	
8"	1.85	Average for this submarket is \$2.06/ft.
10"	2.90	
12"	4.10	

8-16' deep, 12"-24" diameter

	Sewer Pipe ($/ft)	
12"	4.10	
15"	5.90	
18"	9.85	Average for this submarket is $10.29/ft.
21"	13.72	
24"	17.87	

(5b) Calculation of 1988 PVC Pipe Prices for Updated PVC Submarkets

0-150 psi, 4"-12" diameter, Water or Pressure Pipe

	Extrusion (DR 18)	JM Manufacturing (DR 18)	Row Average	
4"	$ 1.85	$ 2.00	$ 1.93	
6"	$ 3.50	$ 3.60	$ 3.55	Average price for this submarket is: $6.68
8"	$ 5.90	$ 6.20	$ 6.05	
10"	$ 8.90	$ 9.20	$ 9.05	
12"	$12.60	$13.00	$12.80	

0-150 psi, 12"-24" diameter, Water or Pressure Pipe
(New PVC submarket, formerly a Ductile Iron submarket)

	Extrusion* (DR 18, 25)	JM Manufacturing* (DR 18, 25)	Row Average	
12"	$12.60	$13.00	$12.80	
14"	$12.50	$12.50	$12.50	Average price for this submarket is: $26.04
16"	$16.00	$15.80	$15.90	
18"	$22.10	$19.80	$20.95	
20"	$27.50	$24.40	$25.95	
24"	$39.50	$33.75	$36.63	

* In diameters of 14"-24", DR 25 is the type of pressure pipe usually used. DR 18, which is more expensive and stronger than DR 25, is the type of PVC pipe usually used for diameters of ≤12" (JM Manufacturing 1988).

0-8' deep, 4"-12" diameter, Sewer or Gravity Pipe

	Extrusion	JM Manufacturing	Certain-Teed	Row Average	
4"	$ 0.75	$ 0.75	$ 0.75	$ 0.75	
6"	$ 1.60	$ 1.60	$ 1.50	$ 1.57	Average price for this submarket is: $3.16
8"	$ 2.80	$ 2.90	$ 2.75	$ 2.82	
10"	$ 4.50	$ 4.50	$ 4.30	$ 4.43	
12"	$ 6.20	$ 6.40	$ 6.05	$ 6.22	

0-8' deep, 12"-24" diameter, Sewer or Gravity Pipe

	Extrusion	JM Manufacturing	Certain-Teed	Row Average	
12"	$ 6.20	$ 6.40	$ 6.05	$ 6.22	
15"	$ 9.20	$ 9.50	$ 9.25	$ 9.32	Average price for
18"	$14.50	$15.10	$14.50	$14.70	this submarket
21"	$21.00	$21.00	$19.75	$20.58	is: $15.01
24"	$27.00	$27.45	$25.50	$26.65	

8-16' deep, 4"-12" diameter, Sewer or Gravity Pipe

	Extrusion	JM Manufacturing	Certain-Teed	Row Average	
4"	$ 0.75	$ 0.75	$ 0.75	$ 0.75	
6"	$ 1.60	$ 1.60	$ 1.50	$ 1.57	Average price for
8"	$ 2.80	$ 2.90	$ 2.75	$ 2.82	this submarket
10"	$ 4.50	$ 4.50	$ 4.30	$ 4.43	is: $3.16
12"	$ 6.20	$ 6.40	$ 6.05	$ 6.22	

8-16' deep, 12"-24" diameter, Sewer or Gravity Pipe

	Extrusion	JM Manufacturing	Certain-Teed	Row Average	
12"	$ 6.20	$ 6.40	$ 6.05	$ 6.22	
15"	$ 9.20	$ 9.50	$ 9.25	$ 9.32	Average price for
18"	$14.50	$15.10	$14.50	$14.70	this submarket
21"	$21.00	$21.00	$19.75	$20.58	is: $15.01
24"	$27.00	$27.45	$25.50	$26.65	

(Sources: Extrusion 1988, JM Manufacturing 1988, and Certain-Teed 1988.)

(5c) Calculation of 1986 price of the new PVC submarket (0-150 psi, 12"-24")

The 1988 price of PVC is approximately 51 percent higher than the 1986 price due to a temporary nationwide shortage of resin, one of the primary ingredients in the manufacture of PVC pipe. Because of this temporary increase in price, the 1986 prices of PVC probably are more reflective of the long range price of PVC than are the 1988 prices. In order to determine what the 1986 price of the new PVC submarket (0-150 psi, 12"-24" diameter) would be, an average percent increase in price for all the 1986 submarkets of PVC pipe was calculated and this percent was then subtracted from the 1988 price of the new PVC submarket. These calculations are shown below.

Average Increase from 1986 PVC Prices to 1988 Prices
Taken from 5a and 5b Above

	1986 Price	1988 Price	Percent Increase
0-150 psi, 4"-12" diameter	$ 4.19	$ 6.68	59.31
0-8' deep, 4"-12" diameter	$ 2.06	$ 3.16	53.24
0-8' deep, 12"-24" diameter	$10.29	$15.01	45.87
8-16' deep, 4"-12" diameter	$ 2.06	$ 3.16	53.24
8-16' deep, 12"-24" diameter	$10.29	$15.01	45.87
Average Percent Price Increase			51.50

The price for the new PVC category is a 1988 price and thus reflects the temporary increase due to the resin shortage in the U.S. Deducting this percent increase of 51.50 percent from the 1988 price, we can derive a 1986 price for this new category.

$$\$26.04/1.5150 = \$17.19$$

(6) Calculations of Ductile Iron Pipe Prices ($/ft) for Ductile Iron Submarkets

All prices are for Class 50 pipe, except for the last Ductile Iron submarket. Each average submarket price is derived from the average price for each diameter within the submarket.

$\geq$ 150 psi, 4"-12" diameter

	McWane	U.S. Pipe	Atlantic	Class 50 Average
4"	-	-	4.33	4.33
6"	-	-	4.78	4.78
8"	6.03	6.28	6.58	6.30
10"	-	-	8.70	8.70
12"	10.70	10.61	11.13	10.81

Average for this submarket is $6.98/ft.

$\geq$150 psi, 12"-24" diameter

12"	10.70	10.61	11.13	10.81
14"	-	-	14.45	14.45
16"	15.68	16.28	16.93	16.30
18"	-	-	19.58	19.58
20"	-	-	22.39	22.39
24"	26.06	27.06	28.25	27.12

Average for this submarket is $18.44/ft.

>= 16' deep, 4"-12" diameter

4"	-	-	4.33	4.33
6"	-	-	4.78	4.78
8"	6.03	6.28	6.58	6.30
10"	-	-	8.70	8.70
12"	10.70	10.61	11.13	10.81

Average for this submarket is $6.98/ft.

	Class	U.S. Pipe	Atlantic	Class 50 Average
12"	50	10.61	11.13	10.87
14"	52	-	16.67	16.67
16"	52	18.70	19.46	19.08
18"	54	-	25.19	25.19
20"	54	-	28.56	28.56
24"	54	34.21	35.62	34.92

Average for this submarket is $22.55/ft.

Sources: McWane 1986; U.S. Pipe 1986; Atlantic Cast Iron Pipe 1986.

(7) Determination of average prices for PVC and Ductile Iron

Since PVC is 92.63 percent of the substitute market, we must determine a weighted market price.

PVC

Submarket	Submarket's Share of Overall PVC Market (by linear foot)	x	Price/Foot	=	Submarket's Weighted Price ($/ft.)
0-150 psi, 4"-12" diameter	59.52/92.63	x	$ 4.19	=	$2.69
0-150 psi, 12"-24" diameter	16.39/92.63	x	$17.19	=	$3.04
0-8' deep, 4"-12" diameter	7.04/92.63	x	$ 2.06	=	$0.16
0-8' deep, 12"-24" diameter	6.86/92.63	x	$10.29	=	$0.76
8'-16' deep, 4"-12" diameter	1.35/92.63	x	$ 2.06	=	$0.03
8'-16' deep, 12"-24" diameter	1.47/92.63	x	$10.29	=	$0.16
			Total Weighted PVC Price:		$6.84

Since Ductile Iron is 7.37 percent of the substitute market, we must determine a weighted market price.

Ductile Iron (DI)

Submarket	Submarket's Share of Overall DI Market (by linear foot)	x	Price/Foot	=	Submarket's Weighted Price ($/ft.)
>=150 psi, 4"-12" diameter	5.33/7.37	x	$ 6.98	=	$ 5.05
>=150 psi, 12"-24" diameter	1.72/7.37	x	$18.44	=	$ 4.30
>=16' deep, 4"-12" diameter	0.15/7.37	x	$ 6.98	=	$ 0.14
>=16' deep, 12"-24" diameter	0.17/7.37	x	$22.55	=	$ 0.52
			Total Weighted DI Price:		$10.01

(8) Calculations for Installation Costs ($/foot)

Costs are derived using an average of Means 1985 prices for 4"-12" diameter water distribution pipe. Piping excavation and backfill are excluded.

	A/C Pressure (150 psi)	PVC Pressure (Class 150, SDR 18)	DI, Class 250 Water Pipe		
			Mechanical Joint		
				4"	$3.50
				6"	$4.00
				8"	$6.30
4"	$1.68	$2.52		10"	$7.55
6"	$1.74	$2.80		12"	$9.40
8"	$2.34	$4.24			
10"	$2.51	$4.85	Tyson Joint		
12"	$2.71	$6.80		4"	$3.19
				6"	$3.65
				8"	$5.75
				10"	$6.80
				12"	$8.50
Average Total:	$2.20	$4.24	Average Total for Tyson and Mechanical:		$5.86

Source: Means 1985.

(9) <u>Determination of Submarket Share by Weight Based on 1981 Production</u>[a]

PVC

Submarket	1981 Tons Produced <=24" Diameter	1981 Market Share by Weight (percent)
0-150 psi, 4"-12" diameter	108,843	37.47
0-150 psi, 12"-24" diameter	112,957	38.89
0-8' deep, 4"-12" diameter	8,977	3.09
0-8' deep, 12"-24" diameter	26,182	9.01
8-16' deep, 4"-12" diameter	1,870	0.64
8-16' deep, 12"-24" diameter	5,894	2.06
	264,813	91.16
Ductile Iron (DI)		
>=150 psi, 4"-12" diameter	11,969	4.12
>=150 psi, 12"-24" diameter	12,717	4.38
>=16' deep, 4"-12" diameter	224	0.08
>=16' deep, 12"-24" diameter	748	0.26
	25,658	8.84
Total 1981 Production	290,471	100.00

[a]See text for explanation of why 1981 production data is used.

Source: ICF 1985.

(10) <u>Calculations for conversion of 1985 asbestos-cement pipe production from tons to feet</u>.

216,903 tons of asbestos-cement pipe were produced in 1985 (ICF 1986). According to the Association of Asbestos Cement Pipe Producers (1986a), approximately 16,899,000 feet, or 243,873 tons, of asbestos-cement pressure pipe were shipped in the U.S. in 1985. Dividing tons by feet gives 0.0144 tons/feet of asbestos-cement pressure pipe.[6]

216,903 tons/(0.0144 tons/feet) = 15,062,708 feet of asbestos-cement pipe produced in 1985.

[6] Even though this ratio is derived for pressure pipe, because pressure pipe is about 90 percent of all asbestos-cement pipe shipments, we apply it to our ton figure above, which includes both pressure and non-pressure asbestos-cement pipe. Comparable figures of the length of non-pressure pipe tonnage were not available.

(11) <u>Calculations for product asbestos coefficient for asbestos regulatory cost model</u>.

In 1985, 32,690.7 tons of asbestos were consumed in the production of asbestos-cement pipe (ICF 1986).

32,690.7 tons of asbestos/15,062,708 feet of asbestos-cement pipe
= 0.0022 tons/feet.

(12) <u>Calculations for consumption production ratio for asbestos regulatory cost model</u>.

In 1985, 2790.4065 tons of asbestos-cement pipe were imported into the U.S. (U.S. Dep. Comm 1986). This ton figure is converted to linear feet using the 0.0144 tons/linear foot figure derived previously.

2790.4065 tons/(0.0144 tons/feet)
= 193,778 feet of asbestos-cement pipe were imported in 1985.

The consumption production ratio is:

(domestic production + imports)/(domestic production)
= (15,062,708 + 193,778)/15,062,708
= 1.0129.

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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. <u>Trends</u>

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
Non-Calcium Silicate Product Substitutes					
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. <u>Cost and Market Shares for Construction/Utility Sheets</u>

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. <u>Laboratory Work Surface Substitutes</u>

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. Cost and Market Shares for Laboratory Work Surface Sheet

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]

[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. <u>Summary</u>

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) <u>Calculation of cost of substitutes for flat asbestos-cement construction/utility sheet</u>.

Flat Sheet Product	Thickness	F.O.B. Plant Price/ Thickness	Comments	Source
Asbestos-Cement Sheet	1/2"	$1.81		Nicolet 1986a
<u>Calcium Silicates</u>				
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
<u>Non-Calcium Silicates</u>				
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) Calculating to determine weighted average cost of substitutes for flat asbestos-cement laboratory work sheets to be used in asbestos regulatory cost model.

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) <u>Calculation of product asbestos coefficient for asbestos-cement sheet for asbestos regulatory cost model</u>.

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) <u>Calculation for consumption/production ratio for asbestos regulatory cost model</u>.

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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XVII. ASBESTOS-CEMENT SHINGLES

A. Product Description

All asbestos-cement siding and roofing shingles are made from the same materials; a mixture of Portland cement, asbestos fiber, ground silica, and sometimes an additional fraction of finely ground inert filler and pigment (Supradur 1986a and b, Krusell and Cogley 1982). Domestically produced shingles now contain 18 percent asbestos, while imported shingles have 13 percent asbestos by weight (PEI 1986, ICF 1986, Atlas 1986c, see Attachment, Item 1).

In manufacturing asbestos-cement shingles, the raw materials are mixed either in a dry or wet state. The mixture is then placed on a moving conveyor belt, adding water if the mixture is dry. The mixture proceeds through a series of press rolls and is then textured with a high pressure grain roll. The shingles are then cured, cut to size, punched, or otherwise molded. Further processing may include autoclaving, coating, shaping or further compression (AIA/NA and AI 1986, Supradur 1986c).

Asbestos-cement siding shingles usually resemble shakes or machine-grooved shingles, and asbestos-cement roofing shingles generally resemble either shakes or slate (Supradur 1985). The slate style is the most popular asbestos-cement roofing shingle. Most of the siding products are thinner than asbestos-cement roofing shingles and have a painted finish (Supradur 1986b). It is estimated that 77 percent of the asbestos shingle market is siding shingles and 23 percent is roofing shingles (PEI 1986, see Attachment, Item 1).

Asbestos-cement roofing and siding shingles have been used primarily on residential properties, although some applications have also been found in schools, churches, and historical restoration projects (Supradur 1986a, Raleigh 1986). In rural areas they are often found in agricultural buildings and farm houses and are used to prevent fire or water damage because of their resistance to both (National Tile Roofing Manufacturer's Association 1986, Raleigh 1986). Currently, asbestos-cement roofing shingles have relatively no use in new construction (Atlas 1986b) and are principally being used for replacement and maintenance in luxury homes, schools, churches, and historical restorations (Atlas 1986b, Supradur 1986a). For historical restoration they could be used either to preserve the historical integrity of a landmark that originally had asbestos-cement shingles, or to replace real slate with a variety of asbestos-cement shingles that resemble slate (Atlas 1986b; National Roofing Contractor's Association 1986). Asbestos-cement shingles are used mostly in the Northeast and the Midwest and are generally not found in the West or South (National Tile Roofing Manufacturer's Association 1986).

B. Producers and Importers of Asbestos-Cement Shingles

In 1981, there were three producers of asbestos-cement shingles: International Building Products, National Gypsum, and Supradur Manufacturing. National Gypsum stopped production prior to 1982 (TSCA 1982, ICF 1984). International Building Products closed their asbestos operations completely in March 1986, however it is not known when they last produced asbestos-cement shingles (Atlas 1986a). Table 1 presents production data for the only remaining domestic producer of asbestos-cement roofing and siding shingles.

The only known importer of asbestos-cement shingles is Atlas International Building Products (AIBP) in Montreal, Quebec, Canada (Atlas 1986a and 1986b, Eternit 1986).

C. Trends

Domestic production of asbestos-cement shingles for 1981 and 1985 are presented in Table 2. While total domestic production of asbestos-cement

Table 1. Production of Asbestos-Cement Shingles

	1985 Asbestos Consumption (tons)	1985 Asbestos-Cement Shingle Production (squares)
Total	3,893	176,643

Source: ICF 1986.

Table 2. Production of Asbestos-Cement Shingles

Year	Number of Producers	Output (squares)
1981	3	266,670
1985	1	176,643

Sources: ICF 1986, TSCA 1982.

shingles has declined 34 percent since 1981, Supradur's production has increased 15 percent during this period (see Attachment, Item 3).

It is not know how many asbestos-cement shingles are imported in the U.S. According to the Bureau of the Census, 10,416.3785 tons of asbestos-cement 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. Dept. Comm. 1986a, 1986b). This number most likely includes flat and corrugated asbestos-cement sheet and asbestos-cement shingles. AIBP, the only importer of these products from Canada roughly estimated that 80 percent of their U.S. shipments are asbestos-cement shingles (Atlas 1986a, Atlas 1987). Eighty percent of Canadian shipments, or 6,791 tons, converts to 64,654 squares of asbestos-cement shingles imported in 1985.

D. Substitutes

Table 3 summarizes the primary substitutes for asbestos-cement siding and roofing shingles. There are no substitutes for asbestos-cement shingles in the maintenance and repair market because there are no substitute products that resemble the asbestos-cement product closely enough to be able to replace it in parts (National Roofing Contractor's Association 1986, Supradur 1986b). Slate is the only shingle that would be close in appearance to some asbestos-cement shingles, but it is much thicker and far more expensive (Supradur 1986b). For our study, we will consider substitutes that can be used instead of asbestos-cement shingles for complete remodeling or new construction. The following section presents separate discussions of substitutes for asbestos-cement siding shingles and asbestos-cement roofing shingles.

1. Asbestos-Cement Siding Shingle Substitutes

The three primary substitutes for asbestos-cement siding shingles are wood, aluminum, and vinyl siding. Wood siding includes hardboard siding and

Table 3. Product Substitutes for Asbestos-Cement Shingles

Product Substitute	Manufacturer	Advantages	Disadvantages	Availability	References
<u>Siding Substitutes</u>					
Red Cedar Shingles and Handsplit Shakes	Over 450 in U.S. and Canada.	Relatively high strength/weight ratio. Effective insulator. Rigid. Wind resistant. Attractive.	Non fire-resistant. Usually requires stain or protective coating.	National	Red Cedar Shingles and Handsplit Shake Bureau 1986b, Chemco 1986b
Hardboard Siding	U.S. Plywood, Stamford, CT; Weyerhaueser, Tacoma, WA; and more than 10 others	More insulative than vinyl and aluminum. Doesn't dent easily as aluminum. Not as noisy as aluminum. Doesn't expand and contract like vinyl. Doesn't have knots like cedar wood.	Absorbs moisture. Requires protective paint. Doesn't have longevity of vinyl and aluminum. More expensive to install.	National	Weyerhaeuser 1986, American Home Improvement 1986
Vinyl Siding	Certain-Teed, Valley Forge, PA; Vipco, Columbus, OH; and several others	Easy to cut and handle. Won't peel, flake, blister or corrode. Inexpensive. No maintenance required.	Can be dented, but not as easily as aluminum. Can't be painted. Color may fade over time. Expands and contracts with temperature change. Can be brittle in cold weather. Available only in light colors. Flexible.	National	Certain-Teed 1986, Commonwealth Aluminum 1986, Alcoa 1986a, b
Aluminum Siding	Alcan Aluminum, Warren, OH; Alcoa Building Products, Sidney, OH; and several others	Several colors. Lightweight. Corrosion resistant. Holds color well. No maintenance required. Stiffer than vinyl.	Can be dented. Cannot be painted. More expensive than vinyl.	National	Alcoa 1986a, b, Commonwealth Aluminum 1986

Table 3 (Continued)

Product Substitute	Manufacturer	Advantages	Disadvantages	Availability	References
Roofing Substitutes					
Asphalt Fiberglass and Organic	Manville Sales, Denver,CO; Owens-Corning, Toledo, OH; GAF, NY, NY; Georgia Pacific, Atlanta, GA; and several others	Fire resistant. Weather resistant. Wind resistant. Low cost. Easy application. Lightweight	Fiberglass shingles. May be brittle. Shorter life. Tendency to conform.	National	Asphalt Roofing Manufacturer's Association 1981, National Roofing Contractor's Association 1986, ICF 1984
Cedar Wood Shingles and Shakes	American Wood Treating, Mission, B.C., Canada and over 450 other mills in B.C., WA, OR and ID	Relatively high strength/weight ratio. Effective insulator. Rigid. Wind resistant. Attractive.	Not as fire resistant as other products.	National	Red Cedar Shingle and Handsplit Shake Bureau 1985
Tire, Concrete and Clay	Monier, Orange, CA; Ludowici-Celadon, New Lexington, OH; U.S. Tile, Corona, CA; and several others	Durable. Wind and weather resistant. Incombustible. Insulative.	Heavy. Expensive to install.	National	National Tile Roofing Manufacturer's Association (n.d.), Means 1986

red cedar shakes and shingles[1] with a small amount of redwood or cedar paneling. Hardboard is the most common wood siding product, comprising 69 percent of the wood siding category (American Hardboard Association 1986a, Red Cedar Shingle & Handsplit Shake Bureau 1986b, see Attachment, Item 4). Hardboard is made by mixing wood fiber (90 percent) with phenolic resin (10 percent) and compressing them under high pressure. Usually a wood grain is embossed onto the board to make it resemble redwood or cedar; it can also have a stucco or shake appearance. Hardboard comes in two main sizes: lap panels which are 1 foot by 16 feet and boards which are 4 by 8 feet. Both come in thicknesses varying from 7/16 to 1/4 inch. Hardboard has a national market, although in the South and the Southwest brick and stucco, respectively, are preferred (Weyerhaeuser 1986). There are about 10 major manufacturers of hardboard siding including U.S. Plywood, Stamford, CT; Weyerhaueser, Kalamath Falls, OR; Masonite, Laurel, MS; and Georgia-Pacific, Atlanta, GA (Weyerhaueser 1986).

Red cedar siding shakes and shingles comprise the remaining 31 percent of the wood siding category (American Hardboard Association 1986a, Red Cedar Shingle & Handsplit Shake Bureau 1986b, see Attachment, Item 4). Over 90 percent of cedar siding is used in the Northeast, particularly New England. Red cedar is an effective insulator because its cellular structure retards the passage of heat and cold through the wood (Red Cedar Shingle & Handsplit Shake Bureau 1986b). Cedar siding is usually stained by users although the stains are usually flammable and make the product much less flame resistant.

Vinyl siding has been one of the largest growing siding products and can especially substitute for asbestos-cement shingles in residential areas. It

[1] Shingles are sawed on both surfaces, whereas shakes have at least one split surface and thus present a rugged, irregular texture (Red Cedar Shingle and Handsplit Shake Bureau 1986a).

competes mostly with aluminum siding. Vinyl has taken a larger share of the siding market in the past few years, thereby reducing aluminum's share. Both aluminum and vinyl siding often have a simulated wood-grain finish and are available in several colors. One major problem with vinyl is its tendency to expand and contract with changes in temperature. In hot weather vinyl siding may expand and come loose from the exterior wall. In order to minimize this expansion problem, vinyl siding is only available in light colors that do not absorb as much heat (Alcoa 1986b, Commonwealth Aluminum 1986). Major producers of vinyl siding include Certain-Teed, Valley Forge, PA; Vipco Inc., Columbus, OH; Mastic Corp., South Bend, IN; Wolverine, Lincoln Park, MI; Bird Inc., Bardstown, KY; Alcoa Building Products, Sidney, OH; and Alside, a division of USX Corporation (Certain-Teed 1986).

Aluminum is a proven product and has been available for over 30 years, longer than vinyl siding. While aluminum is more temperature resistant than vinyl, it dents much more easily than other siding products (Commonwealth Aluminum 1986, Certain-Teed 1986). Though metal, aluminum siding resists rusting by forming a protective oxide coating (Commonwealth Aluminum 1986). Three major producers of aluminum siding are Alcan Aluminum in Warren, OH, Alcoa Building Products in Sidney, OH, and Reynolds in Richmond, VA. Both Reynolds and Alcoa also produce vinyl siding.

Painted steel, stucco, masonry, brick, and concrete blocks may also be used as siding, but they will not be significant substitutes for asbestos-cement siding shingles (Commonwealth Aluminum 1986, Krusell and Cogley 1982, American Hardboard Association 1986b).

2. Asbestos-Cement Roofing Shingle Substitutes

The primary substitutes for asbestos-cement roofing shingles are asphalt shingles (fiberglass or organic), cedar wood shingles, and tile (concrete or clay). Asphalt shingles are the most competitive asbestos-cement roofing shingles substitute, even though they have a shorter service life than other substitutes (National Roofing Contractor's Association 1986). Before 1960, most asphalt shingles had an organic or wood-pulp base. Today, however, 83 percent of standard strip asphalt shingles have a fiberglass base. All asphalt shingles are fire resistant (fiberglass-asphalt shingles have a Class A fire rating, the highest fire rating available; organic-asphalt shingles have a Class C fire rating, which is a lower rating than Class A, but still somewhat fire resistant). Fiberglass-asphalt have slightly less bulk and are lighter weight than the organic-asphalt shingles (Asphalt Roofing Manufacturer's Association 1984). Some contractor's prefer the organic- asphalt because they have a longer proven track record than fiberglass-asphalt shingles and some of the very light weight and cheaper fiberglass-based shingles are very brittle; however, many feel that this problem has been resolved by the manufacturers (Qualified Remodeler Magazine 1986, RSI 1986a). There are over 20 domestic manufacturers of asphalt shingles including Owens-Corning Fiberglas, GAF, Georgia Pacific, and Lunday-Thagard (Owens-Corning Fiberglas 1986, Asphalt Roofing Manufacturer's Association 1981).

Although not as fire resistant, red cedar wood shingles and shakes are popular roofing substitutes. Cedar shingles are made in the Northwest and in British Columbia, Canada by over 450 mills; however, some of these are virtually one man operations (Red Cedar Shingle & Handsplit Shake Bureau 1985). Ninety-five percent of Canadian production is shipped to the U.S. and accounts for 70 percent of U.S. domestic consumption (Red Cedar Shingle & Handsplit Shake Bureau 1986a). Red cedar shingles and shakes are distributed across the U.S., the highest concentration being in California, Washington, Oregon, and Texas (Red Cedar Shingle & Handsplit Shake Bureau 1986b). Only 15 to 30 percent of cedar roofing shingles and shakes are fire resistant, with a fire rating of either Class B or Class C. Because of the fire hazard posed by non-fire resistant cedar roofing shingles, some California towns have outlawed their use (RSI 1986b, American Wood Treating 1986, Chemco 1986a and b). Approximately 72,000,000 squares of asphalt fiberglass and organic strip shingles were produced in 1985 (Asphalt Roofing Manufacturer's Association 1986, see Attachment, Item 6).

The tile roofing market is about the same size as the cedar roofing market, each of which are less than one-tenth the size of the asphalt roofing shingle market (National Tile Roofing Manufacturers Association 1986, Red Cedar Shingle and Handsplit Shake bureau 1986a, Asphalt Roofing Manufacturers Association 1986). Concrete comprises 90 percent of the tile market and clay holds the remaining 10 percent (National Tile Roofing Manufacturer's Association 1986). Tile is used primarily in the Sunbelt -- Florida, California, and the South (Raleigh 1986, National Tile Roofing Manufacturer's Association 1986). It is very insulative because the air space between the tile and the underlayment creates a heat flow barrier (National Tile Roofing Manufacturer's Association (n.d.)). Tile is available in three main styles: s-tile, mission, and flat (shakes or slate-like). There are more than 13 U.S. concrete tile manufacturers; the largest in the U.S. and the world is Monier Roof Tile in Orange, CA (Monier 1986a, National Tile Roofing Manufacturer's Association (n.d.)). The four clay roof tile manufacturer's, all located near clay deposits, are Ludowici-Celadon, New Lexington, OH,; U.S. Tile, San Valle, and MCA in Corona, CA (National Tile Roofing Manufacturer's Association 1986). Slate is very expensive and has a very small share of the roofing market. It is primarily used in the Vermont and New York area, the two states where it is quarried.

The cost of asbestos-cement shingles and substitute roofing and siding products are compared in Table 4.

Table 4. Cost of A/C Shingles and Substitutes[a]

	A/C Shingles	Vinyl Siding	Aluminum Siding	Asphalt Roofing Shingles	Tile Roofing	Wood Siding and Roofing[b,c]
FOB Plant Cost ($/square)	65	50	65	19	63	53
Installation Cost ($/square)	48	63	63	30	110	109
Total Cost ($/square)	113	113	128	49	173	162
Operating Life (years)	40	50	50	20	50	30
Present Value ($/square)	113	106	120	67	163	181

[a]See Attachment, Items 8-13 for equations used to determine costs.

[b]Wood siding includes hardboard and cedar shingles and shakes (see text). Wood roofing includes only cedar shingles and shakes (see text).

[c]In order to simplify the number of inputs for the asbestos regulatory cost model, wood siding and wood roofing are combined into one wood roofing/siding category for which price and market share are determined (see Attachment, Item 11 for calculations).

Siding. Wood siding is the most expensive asbestos-cement siding substitute overall.[2] Asbestos-cement shingles, vinyl siding, and aluminum siding are close in overall price.

The substitute market for asbestos-cement siding shingles is divided among wood (hardboard and cedar shakes and shingles), 40 percent; vinyl, 35 percent; and aluminum, 25 percent (see Attachment, Items 4-5).

Roofing. Table 4 shows that asphalt roofing shingles, the most popular substitute for asbestos-cement roofing shingles, are also the least expensive overall, even though they have half the service life. Both tile and cedar shingles and shake roofing are more than double the cost of asphalt roofing (see Attachment, Items 11-14).

The current market share for substitute roofing shingles, based on 1985 production, is asphalt shingles (primarily asphalt-fiberglass), 86 percent, with tile (primarily concrete) and cedar wood shingles each taking 7 percent (see Attachment, Item 6). Asphalt-fiberglass shingles has been and continues to be the fastest growing segment of the roofing market, while cedar roofing shingle and shake production has declined since 1983 (Red Cedar Shingle & Handsplit Shake Bureau 1986b).

Because the domestic asbestos-cement shingle market is 77 percent siding and 23 percent roofing (PEI 1986), the combined roofing and siding replacement market for asbestos-cement shingles would probably breakdown as follows (see Attachment, Items 4-7):

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[2] For the asbestos regulatory cost model, in order to simplify the number of inputs, wood siding and wood roofing are combined into one wood roofing/siding category for which price and market share are determined (see Attachment, Item 4-7, 11).

	Projected Market Share (percent)
Wood	32
Vinyl	27
Asphalt	20
Aluminum	19
Tile	2
Total	100

Table 5 presents the data for the asbestos regulatory cost model and summarizes the findings of this analysis.

E. Summary

Asbestos-cement siding shingles resemble shakes or machine-grooved shingles and asbestos-cement roofing shingles generally resemble either shakes or slate (Supradur 1985). They are primarily being used for replacement and maintenance in luxury homes, schools, churches, and historical restoration projects (Atlas 1986b, Supradur 1986a). Of three domestic producers in 1981, only one, Supradur, remains in 1986. Production has declined 34 percent from 266,670 squares in 1981 to 176,643 squares in 1985 (ICF 1986, TSCA 1982). Only one company, Atlas International Building Products (AIBP) of Montreal, Quebec, Canada is known to import asbestos-cement shingles into the U.S. (Atlas 1986a, Atlas 1986c).

There are no substitutes for asbestos-cement shingles for maintenance and repair applications because no substitute products resemble the asbestos product closely enough to replace it in part (National Roofing Contractor's Association 1986, Supradur 1986b). However, there are many adequate substitutes that can be used for complete replacement, remodeling or in new construction. The replacement market is as follows: wood siding and roofing,

Table 5. Data Inputs for Asbestos Regulatory Cost Model[a]

Product	Output (squares)	Product Asbestos Coefficient	Consumption Production Ratio	Price ($/square)	Useful Life	Equivalent Price ($/square)	Market Share	Reference
Asbestos-Cement Shingles	176,643	0.022	1.37	$113.00	40 years	$113.00	N/A	See Attachment
Wood Siding and Roofing	N/A	N/A	N/A	$162.00	30 years	$174.05	32%	See Attachment
Vinyl Siding	N/A	N/A	N/A	$113.00	50 years	$109.16	27%	See Attachment
Asphalt Roofing Shingles	N/A	N/A	N/A	$ 49.00	20 years	$ 61.66	20%	See Attachment
Aluminum Siding	N/A	N/A	N/A	$128.00	50 years	$123.65	19%	See Attachment
Tile Roofing	N/A	N/A	N/A	$173.00	50 years	$167.12	2%	See Attachment

N/A: Not Applicable.

[a]See Attachment, Items 4-16 for explanation and calculations.

32 percent; vinyl siding, 27 percent; asphalt-based roofing, 20 percent; aluminum siding, 19 percent; and tile roofing, 2 percent. Vinyl and aluminum siding cost about the same as the asbestos product. Asphalt-based roofing shingles are about half the cost, and tile roofing and wood siding and roofing are 45-60 percent more expensive than asbestos-cement shingles.

ATTACHMENT

(1) Calculation of percent of asbestos in domestic asbestos-cement shingles.

One domestic producer has a production capacity of 134,800 squares or 12,000 tons for siding shingles and 40,000 squares or 9,500 tons for roofing shingles (PEI 1986). This gives an average weight of 178 lbs./square ((12,000 tons x 2,000 lbs./ton)/(134,800 squares)) for siding shingles and 475 lbs./square ((9,500 tons x 2,000 lbs./ton)/(40,000 squares)) for roofing shingles. This yields a roofing and siding shingle weighted average weight of 246 lbs./square ((134,800 squares x 178 lbs./square + 40,000 squares x 475 lbs./ square)/174,800 squares). The domestic producer's shingles have an average of 44 lbs. of asbestos per square. Therefore, ((44 lbs. of asbestos/square)/246 lbs./square) x 100 = 17.89 percent or 18 percent asbestos by weight in asbestos-cement domestic shingles.

From the production capacities in squares shown above, it is estimated that 77 percent of the asbestos-cement shingle market is siding and 23 percent is roofing.

(2) Calculation for imports of asbestos-cement shingles.

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 was from Canada. Atlas International Building Products (AIBP), the only importer of these products from Canada estimates that 80 percent of their imports is asbestos-cement shingles (Atlas 1986a). Ten percent equals 6,791 tons or 13,582,000 lbs. of asbestos-cement shingles.

AIBP estimates that 60 percent of the asbestos-cement shingles imports are siding and 40 percent are roofing shingles:

Siding = 0.6 x (6,791 tons) = 4,075 tons = 8,150,000 lbs.
Roofing = 0.4 x (6,791 tons) = 2,716 tons = 5,432,960 lbs.

AIBP's siding and roofing shingles weigh 155 lbs./square and 450 lbs./square, respectively.

Siding Shingles = (8,150,000 lbs.)/(455 lbs./square)
= 52,581 squares

Roofing Shingles = (5,432,960 lbs.)/(450 lbs./square)
= 12,073 squares

Total Imports = 64,654 squares

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. These imports from other countries may possibly include some flat asbestos-cement shingles (U.S. Dep. Comm. 1986a, 1986b).

(3) Calculations for changes in production of asbestos-cement shingles between 1981 and 1985 (TSCA 1982, ICF 1986).

(1985 production - 1981 production/1981 production) * 100
= (176,643 squares - 266,670 squares/266,670 squares) * 100
= -33.8% = -34%.

Domestic production has changed as follows:

(1985 production - 1981 production/1981 production) * 100
= (176,643 squares - 153,603 squares/153,603 squares) * 100
= 15%.

(4) Calculations for the share of cedar shingle and hardboard in the wood siding market.

Members of the Red Cedar Shingle and Handsplit Shake bureau produced 355,825 squares in 1985. Since this association accounts for only 70 percent of the cedar shingle and shake market, 355,825/0.70, or 508,321 red cedar shingles and shakes were produced in 1985 (Red Cedar Shingle and Handsplit Shake Bureau 1986a and b). This combined with 1,128,992 squares of hardboard siding produced in 1985 makes for a total of 1,637,313 squares (American Hardboard Association 1986a and 1986b).

(508,321/1,637,313) * 100 = 31% red cedar siding
(1,128,992/1,637,313) * 100 = 69% hardboard siding

(5) Estimates of the projected market share for wood, vinyl, and aluminum in the siding market were based on estimates from the following references: Qualified Remodeler Magazine 1986; Alcoa 1986a and b; Contractor's Guide 1986.

(6) Calculations of projected market shares in the asbestos-cement shingles replacement roofing market.

Asphalt fiberglass and organic standard strip shingles produced in 1985 = 71,766,672 (Asphalt Roofing Manufacturer's Association 1986b).

Members of the Red Cedar Shingle and Handsplit Shake Bureau produced 3,885,174 squares of roofing shingles and shakes in 1985. Since this association accounts for only 70 percent of the cedar shingle and shake market, 3,885,174/0.70, or 5,550,249 squares of red cedar shingles and shakes for roofing were produced in 1985 (Red Cedar Shingle and Handsplit Shake Bureau 1986a and b).

About 6,000,000 squares of tile roofing were produced in 1985 (National Tile Roofing Manufacturer's Association 1986).

This makes a total of 83,316,921 squares consisting of 86.1 percent asphalt shingles, 6.7 percent wood, and 7.2 percent tile.

(7) Calculation of total replacement market shares.

The following calculations are based on the fact that 77 percent of the asbestos-cement shingle market is siding, and 23 percent is roofing (PEI 1986).

Wood roofing	6.7% (0.23) +			
and siding	40.0% (0.77)	=	32.34% =	32%
Vinyl	35.0% (0.77)	=	26.95% =	27%
Asphalt	86.1% (0.23)	=	19.80% =	20%
Aluminum	25.0% (0.77)	=	19.25% =	19%
Tile	7.2% (0.23)	=	1.66% =	2%

(8) Calculation of costs for asbestos-cement roofing and siding shingles.

The asbestos-cement shingle F.O.B. plant cost is based on Supradur's average price according to an ICF survey (ICF 1986). The asbestos-cement shingle installation cost is a weighted average for 325 lb./square and 500 lb./square roofing shingles and 167 lb./square siding shingles (Means 1986a).

Roofing asbestos-cement shingle cost

325 lb. $40/square
500 lb. $73/square
Average $56.50

Siding asbestos-cement shingle cost $46/square for 167 lb./square (Means 1986).

Because 77 percent of asbestos-cement shingle market is siding and 23 percent roofing,

(56.50/square * 0.23) + ($46/square * 0.77) = $48.42
= $48 for installation of asbestos-cement shingles.

(9) Cost of vinyl siding.

The F.O.B. plant cost for vinyl siding is based on the following references: Alcoa 1986a and b; Certain-Teed 1986.

The installation cost is for solid PVC panels 8"-10" wide, plain or insulated (Means 1986).

(10) Cost of aluminum siding.

The F.O.B. plant cost for aluminum siding is based on the following references: Alcoa 1986a and b; Certain-Teed 1986.

The installation cost for aluminum siding is the same as for PVC siding (American Home Improvement 1986; Wages and Evans 1986; Johnny B. Quick 1986).

(11) Cost of wood siding and roofing.

To determine the cost of wood siding and roofing, costs are first derived separately for wood siding alone and wood roofing alone. These costs are then multiplied by their share of the asbestos-cement shingle replacement market to give a weighted average cost for wood roofing and siding.

(a) Cost of wood siding.

The F.O.B. plant price of cedar siding shingles and shakes is $80/square (American Wood Treating 1986). The F.O.B. plant price for hardboard wood siding is $40/square (Weyerhaeuser 1986, U.S. Plywood 1986).

Since the 69 percent of the wood siding replacement market for asbestos-cement shingles is hardboard and 31 percent is cedar shakes and shingles (see previous calculations), the average cost for all wood siding will be

($80/square x 0.31) + ($40/square x 0.69) = $52.40/square for wood siding

The installation costs for cedar wood siding shingles and shakes are averaged from Means 1986.

16" long with 7-1/2" exposure = $78/square
18" long with 7-1/2" exposure = $71/square
18" long with 8-1/2" exposure = $80/square
Average of these three = $76.33 or $76/square

The installation costs for hardboard siding was estimated to be double that for aluminum and PVC, or $126/square. Even if this estimate is a bit high, it will include the cost for painting that hardboard siding requires (American Home Improvement 1986, Moon Sidings 1986, National Home Improvement Co. 1986).

The weighted average cost for all wood siding is based on 69 percent of the replacement market being hardboard and 31 percent cedar siding (see previous calculations).

($126/square x 0.69) + ($76/square x 0.31) = $110.50 or $111/square is the average installation cost for wood siding.

The operational life for wood siding is determined by taking a weighted average of that for hardboard and for cedar wood.

Hardboard life = 25 years (American Hardboard Association 1985, Weyerhaeuser 1986).

Cedar life = 40 years (ICF 1985).

(40 years x 0.31) + (25 years x 0.69) = 29.65 years = 30 years

(b) Cost of wood roofing.

The average estimated F.O.B. plant cost for non-fire treated cedar roofing shingles is \$68/square (American Wood Treating 1986, RSI 1986, Chemco 1986a).

The installation cost is an average of 16" and 18" roofing shingles.

16" = \$64/square
18" = \$58/square
Average = \$61/square

(c) Cost of wood siding and roofing

The wood roofing market represents 1.54 percent of the entire asbestos-cement shingle replacement market. The wood siding market represents 30.80 percent of the entire asbestos-cement shingle replacement market for a total market share of 32.34 percent for wood (see previous market share calculations). Therefore, roofing is ((1.54/32.34) x 100), or 4.8 percent of the wood replacement market and siding is ((30.80/32.34) x 100), or 95.2 percent of the wood replacement market.

Thus the weighted average F.O.B. plant cost for wood is:

(\$52/square x 0.952) + (\$68 x 0.048) = \$52.77/square = \$53/square

The weighted average cost for installation of wood roofing and siding is:

(\$111/square x 0.952) + (\$61/square + 0.048) = \$108.60 = \$109/square

The total cost for wood is:

\$52.77 + \$108.60 = \$161.37/square or
(\$163/square x 0.952) + (\$129/square x 0.048) = \$167.37/square

The average weighted operating life for wood roofing and siding is:

(30 years x 0.952) + (40 years x 0.048) = 30.48 years = 30 years

(12) Cost for asphalt standard strip shingles.

The F.O.B. plant cost for asphalt shingles is a weighted average of asphalt fiberglass, 83 percent, and asphalt organic, 17 percent, shingles (Asphalt Roofing Manufacturer's Association 1986).

Average price for fiberglass shingles = \$18.50/square (Owens-Corning 1986).

Average for organic shingles = \$20/square (Owens-Corning 1986).

(\$18.50/square x 0.83) = (\$20/square x 0.17) = \$18.75
= \$19/square is the cost for asphalt shingles.

Installation cost is also a weighted average of standard strip organic, 235-240 lb./square, and fiberglass, 210-235 lb./square shingles.

Installation cost for fiberglass = \$30/square (Means 1986)
Installation cost for organic = \$27/square (Means 1986)

(\$30/square x 0.83) + (\$27/square x 0.17) = \$29.50
= \$30/square is the average cost for installation of asphalt shingles.

(13) <u>Cost of roofing tile</u>.

The tile market is about 10 percent clay tile and 90 percent concrete tile (National Tile Roofing Manufacturer's Association 1986).

The F.O.B. plant cost for clay tile is an average of four companies, San Valle, U.S. Tile, MCA, and Ludowici-Celadon's prices for Mission, S, and Flat tile. S-tile was weighted 65 percent while the Mission and Flat were each weighted 17.5 percent. Ludowici's average price was weighted 30 percent, while the other three companies were each weighted 23.33 percent (U.S. Tile 1986, MCA 1986, San Valle 1986, Ludowici-Celadon 1986). This gave a clay tile price of \$134/square.

((0.30 (0.65 * 250.00 + 0.175 * 310.00 + 0.175 * 310.00)) +
(0.233 (0.65 * 70.40 + 0.175 * 97.20 + 0.175 * 114.75)) +
(0.233 (0.65 * 55.00 + 0.175 * 106.00 + 0.175 * 106.00)) +
(0.233 (0.65 * 58.50 + 0.175 * 90.40 + 0.175 * 100.57))).

The national average F.O.B. plant cost for concrete tile is \$55/square (Monier Roofing Tile Company 1986a and b).

Using the above tile market shares an average weighted price was derived: (\$55/square x 0.90) + (\$134/square x 0.10) = \$62.90 = \$63/square for tile roofing, F.O.B. plant.

Installation cost for clay was based on an average of S and Mission tile:

Mission = \$84/square (Means 1986)
<u>S-Tile = \$130/square (Means 1986)</u>
Average cost = \$107 for clay tile installation

Installation for concrete tile is based on the S-tile and corrugated tile = \$110/square (Means 1986).

Total installation cost for tile, concrete (90 percent) and clay (10 percent), is: (\$110/square x 0.90) + (\$107/square x 0.10) = \$109.7 = \$110/square.

(14) <u>Present value calculations for substitutes</u>.

N_a = life of asbestos product
N_b = life of substitute product

TC = total cost of product

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

$a = (1.05)^{N_a}$
$b = (1.05)^{N_b}$

$N_a = 40$ years
$a = (1.05)^{40} = 7.0400$

(a) <u>Vinyl siding</u>

$TC = \$113$/square
$N_b = 50$ years
$b = (1.05)^{50} = 11.4674$

$PV = \$113 \text{ square} \times (11.4674/7.0400) \times (7.0400 - 1)/(11.4674 - 1)$
$= \$106.21 = \$106$/square

(b) <u>Aluminum siding</u>

$TC = \$128$/square
$N_b = 50$ years
$b = (1.05)^{50} = 11.4674$

$PV = \$128 \text{ square} \times (11.4674/7.0400) \times (7.0400 - 1)/(11.6674 - 1)$
$= \$120.31 = \$120$/square

(c) <u>Wood siding</u>

$TC = \$163$/square
$N_b = 30$ years
$b = (1.05)^{30} = 4.3219$

$PV = \$163 \text{ square} \times (4.3219/7.0400) \times (7.0400 - 1)/(4.3219 - 1)$
$= \$181.95 = \$182$/square

(d) <u>Wood roofing</u>

$N_a = N_b = 40$ years

Therefore $PV = TC$

(e) <u>Wood siding and roofing</u>

$TC = \$162$/square
$N_b = 30$ years
$b = (1.05)^{30} = 4.3219$

$PV = \$162 \text{ square} \times (4.3219/7.0400) \times (7.0400 - 1)/(4.3219 - 1)$
$= \$180.83 = \$181$/square

(f) <u>Asphalt roofing</u>

$TC = \$49$/square
$N_b = 20$ years
$b = (1.05)^{20} = 2.6533$

PV = \$49 square x (2.6533/7.0400) x (7.0400 - 1)/(2.6533 - 1)
= \$67.47 = \$67/square

(g) Tile roofing

TC = \$173/square
N_b = 50 years
B = $(1.05)^{50}$ = 11.4674

PV = \$173 square x (11.4674/7.0400) x (7.0400 - 1)/(11.4674 - 1)
= \$162.61 = \$162/square

(15) Calculations for product asbestos coefficient for Asbestos Regulatory Cost Model.

Tons of asbestos used per unit of output

= 3,893 tons/176,643 squares
= 0.0220 tons/square

(16) Calculations for consumption-production ratio for Asbestos Regulatory Cost Model.

(Domestic production + Imports)/Domestic production

(176,643 squares + 64,654 squares)/(176,643 squares) = 1.37

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XVIII. DRUM BRAKE LININGS

A. Product Description

Most new light and medium vehicles, i.e., passenger cars and light trucks, are equipped with drum brakes on the rear wheels (and disc brakes on the front). A drum brake consists of a metal drum within which there are two curved metal "shoes," lined on the outside with molded friction material, called drum brake linings. When the brakes are applied, the curved shoes are pressed out against a metal drum that is connected to the wheels of the vehicle. The pressure of the shoes against the drum stops the turning of the wheels. There are two drum linings (one for each brake shoe) for each wheel (GM 1986a, ICF 1985).

In light and medium vehicles, the lining segments are usually a third of an inch thick or less. In heavy vehicles (i.e., heavy trucks and off-road vehicles), the segments are at least three-quarters of an inch thick and are called brake blocks, instead of drum brake linings (Allied Automotive 1986).

Asbestos-based drum brake linings contain approximately 0.38 lbs.[1] of asbestos fiber per lining on average (ICF 1986a). Asbestos is used because of its thermal stability, reinforcing properties, flexibility, resistance to wear, and relatively low cost (Krusell and Cogley 1982).

The primary production process for drum brake linings is a wet-mix process in which asbestos is combined with resins, fillers, and other product modifiers and the mixture is then extruded into flat, pliable sheets. The sheets are cut, formed into a curved shape, and then molded for 4 to 8 hours under moderate heat and pressure. After grinding, the linings are bonded (glued) or riveted to the brake shoe (ICF 1985). While bonded brake linings

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[1] See Attachment, Item 1.

have greater frictional surface area, riveted linings are quieter (Allied Automotive 1986).

Secondary processing of drum linings may be of several types. Some processors install new brake linings into brake assemblies for vehicles. Others repackage linings for sale as replacement parts in the aftermarket. Neither of these secondary processes involve grinding, drilling, or any other treatment of the brake linings that is performed by the primary processors. Another distinct type of secondary processing is automotive rebuilding. Rebuilders receive used, worn brake linings attached to the shoes. The old linings are removed from the shoes, the shoes are cleaned by abrasion, and new linings are attached. The rebuilt shoes with linings are then packaged and sold for the aftermarket (ICF 1985, Krusell and Cogley 1982).

B. Producers and Importers of Drum Brake Linings

Table 1 lists the thirteen primary processors of drum brake linings in 1985. All produced an asbestos-based product. Nine of the processors also produced substitutes (ICF 1986a).

Changes in primary processors from 1981 to 1985 include Friction Division Product's purchase of Thiokol's Trenton, NJ, plant and Brake System Inc.'s purchase of one of Raymark's Stratford, CT, plants (Friction Division Products 1986; Brake Systems 1986). Brassbestos of Paterson, NJ, went out of business in August, 1985 (ICF 1986a) and H.K. Porter of Huntington, IN, discontinued production of drum brake linings in 1986 (PEI Associates 1986). Thus, eleven companies continue to produce asbestos drum brake linings.

Table 2 lists the five current secondary processors of drum brake linings. The Standard Motor Products plant was formerly owned by the EIS division of Parker-Hannifan (ICF 1986a). At Echlin's Dallas, TX, plant, which was formerly owned by Raymark, linings are attached to brake shoes without any

Table 1. 1985 Primary Processors of Drum Brake Linings

Company	Plant Location(s)	Product: Asbestos	Product: Non-Asbestos	References
Allied Automotive	Cleveland, TN Green Island, NY	X X	X X	ICF 1986a, Allied Automotive 1986, TSCA 1982a
General Motors, Inland Division	Dayton, OH	X	X	ICF 1986a, TSCA 1982a
LSI-Certified Brakes (Division of Lear-Siegler)	Danville, KY	X		ICF 1986a, TSCA 1982a
Abex	Winchester, VA	X	X	Abex 1986, TSCA 1982a
Nuturn	Smithville, TN	X	X	ICF 1986a, TSCA 1982a
Virginia Friction Products	Walkerton, VA	X	X	ICF 1986a, TSCA 1982a
Chrysler	Wayne, MI	X	X	ICF 1986a, TSCA 1982a
U.S. Automotive Manufacturing	Tappahannock, VA	X		ICF 1986a, TSCA 1982a
Friction Division Products (plant formerly owned by Thiokol)	Trenton, NJ	X		ICF 1986a, TSCA 1982a
Carlisle, Motion Control Industries Div.	Ridgway, PA	X	X	ICF 1986a, TSCA 1982a
H.K. Porter[a]	Huntington, IN	X	X	ICF 1986a, TSCA 1982a
Brassbestos[b]	Paterson, NJ	X		ICF 1986a, TSCA 1982a
Brake Systems Inc. (Division of Echlin) (plant formerly owned by Raymark)	Stratford, CT	X	X	Brake Systems 1986, TSCA 1982a

[a]H.K. Porter stopped production of asbestos and semi-metallic drum brake linings in 1986 (PEI Associates 1986).

[b]Brassbestos went out of business in August 1985 (ICF 1986a). It is assumed that they produced asbestos-based on drum brake linings in 1985.

Table 2. 1985 Secondary Processors of Drum Brake Linings

Company	Plant Location	Product: Asbestos	Product: Non-Asbestos	References
Cali-Blok, EIS Div. of Parker-Hannifan	Gardena, CA	X	X	ICF 1986b, TSCA 1982b
Standard Motor Products	West Bend, WI	X		ICF 1986b, TSCA 1982b
Wagner	Parsippany, NJ	X	N/A	ICF 1986b, ICF 1985
Allied Automotive*	South Bend, IN	N/A	N/A	TSCA 1982b
Echlin	Dallas, TX	X	N/A	Brake Systems 1986, TSCA 1982b

NA: Information not available.

* Did not participate in 1986 ICF Survey.

Table 3 (Continued)

Company	Location	References
American Isuzu Motor Inc.	Whittier, CA	Automobile Importers of America 1986
Nissan Motor Corp.	Gardena, CA	Automobile Importers of America 1986
Porsche Cars North America	Reno, NV	Automobile Importers of America 1986
Renault USA, Inc.	New York, New York	Automobile Importers of America 1986
Rolls-Royce Motors, Inc.	Lyndhurst, NJ	Automobile Importers of America 1986
Subaru of America Inc.	Pennsauken, NJ	Automobile Importers of America 1986
Volvo Cars of North America	Rockleigh, NJ	Automobile Importers of America 1986
Hyundai Motor America	Garden Grove, CA	Automobile Importers of America 1986
Original Quality, Inc.	Jacksonville, FA	Automobile Importers of America 1986

Table 3. Importers of Asbestos-Based Drum Brake Linings

Company	Location	References
Guardian Corp. (Division of Wagner)	Parsippany, NJ	Wagner 1986a, ICF 1984
LSI-Certified Brakes (Division of Lear-Siegler)	Danville, KY	ICF 1986a, ICF 1984
Abex	Winchester, VA	ICF 1984
Toyota Motor Sales, U.S.A	Torrence, CA	ICF 1986a, ICF 1984
Mercedes-Benz of North America	Montvale, NJ	ICF 1984
Saab-Scania of America	Orange, CT	ICF 1986a, ICF 1984
Volkswagen of America	Troy, MI	ICF 1986a, ICF 1984
BMW of North America	Montvale, NJ	ICF 1984
Western Automotive Warehouse Distributors	Los Angeles, CA	ICF 1984
U.S. Suzuki Motor Corporation	Brea, CA	ICF 1986a, ICF 1984
Hawthorne Bonded Brake Co.	Los Angeles, CA	ICF 1986a, ICF 1984
Peugeot Motors of America	Lyndhurst, NJ	ICF 1984
General Motors	Dayton, OH	ICF 1984
J.I. Case Company	Racine, WI	ICF 1984
Alfa Romeo	Englewood Cliffs, NJ	Automobile Importers of America 1986
Fiat	Dearborn, MI	Automobile Importers of America 1986
Jaguar	Leonia, NJ	Automobile Importers of America 1986
Lotus Performance Cars	Norwood, NJ	Automobile Importers of America 1986
Mazda (North America) Inc.	Irvine, CA	Automobile Importers of America 1986
Mitsubishi Motors Corp. Services, Inc.	Southfield, MA	Automobile Importers of America 1986
American Honda Motor Co.	Gardena, CA	Automobile Importers of America 1986

Table 3. Importers of Asbestos-Based Drum Brake Linings

Company	Location	References
Wagner	Parsippany, NJ	Wagner 1986a, Wagner 1986b
Toyota Motor Sales, U.S.A	Torrence, CA	ICF 1986a, ICF 1984
U.S. Suzuki Motor Corp.	Brea, CA	ICF 1986a, ICF 1984
Mercedes-Benz of North America	Montvale, NJ	ICF 1984
Abex	Winchester, VA	ICF 1984
Kawasaki Motors Corp. U.S.A	Santa Ana, CA	ICF 1986a, ICF 1984
General Motors	Dayton, OH	ICF 1984
Volkswagen of America, Inc.	Troy, MI	ICF 1986a, 1986b
Western Automotive Warehouse Distributors	Los Angeles, CA	ICF 1984
J.I. Case Co.	Racine, WI	ICF 1984
Peugeot Motors of America, Inc.	Lyndhust, NJ	ICF 1984
Climax Molybdenum	Golden, Co.	ICF 1984
Original Quality Inc.	Jacksonville, FL	Original Quality 1986
Fiat	Dearborn, MI	Automobile Importers of America 1986
American Honda Motor Co.	Gardena, CA	Automobile Importers of America 1986
American Isuzu Motor Inc.	Whittier, CA	Automobile Importers of America 1986
Mazda (North America) Inc.	Irvine, CA	Automobile Importers of America 1986
Mitsubishi Motors Corp. Services	Southfield, MI	Automobile Importers of America 1986
Nissan Motor Corp.	Gardena, CA	Automobile Importers of America 1986
Renault USA, Inc.	New York, NY	Automobile Importers of America 1986
Subaru of America, Inc.	Pennsauken, NJ	Automobile Importers of America 1986
Hyundai Motor America	Garden Grove, CA	Automobile Importers of America 1986

[a]Volkswagen stated that in the 1987 model year, all vehicles will be fitted with only non-asbestos brake linings (ICF 1986a).

additional processing (Brake Systems 1986). Similarly, Wagner installs brake linings with no additional processing (Wagner 1986a).

Table 3 lists the twenty-one importers of asbestos-based drum brake linings.

C. Trends

Table 4 gives the production of asbestos-based drum brake linings and the corresponding consumption of asbestos fiber. From 1981 to 1985 there was a 19.6 percent decline in production of asbestos drum brake linings. This is probably due to substitution of asbestos in the OEM, and the fact that certain luxury and high-performance cars, that currently account for roughly 5 percent of OEM light/medium vehicles, are now equipped with four disc brakes (e.g., Cadillac Seville and El Dorado, Corvette, Pontiac STE and Fiero, and high-performance Camaros and Firebirds) (GM 1986a).[2]

In addition, it should be noted that some luxury imports, e.g., Mercedes, BMW, and Saab, use disc brakes on all four wheels (GM 1986a, Saab-Scania of America 1986). New Saab cars, in fact, use non-asbestos semi-metallic disc brake pads on all four wheels (Saab-Scania of America 1986). Information was not available on whether all four disc brakes in Mercedes and BMW cars were also non-asbestos-based. Nonetheless, the great majority of imported vehicles are still equipped with asbestos-based rear drum brakes (Ford 1986a, Abex 1986, MIT 1986).

Producers and purchasers of drum brake linings indicated that as of the 1986 model year, asbestos linings still account for 90-95 percent of the original equipment market (OEM) and virtually 100 percent of the aftermarket (GM 1986a, GM 1986c, Chrysler 1986, Allied Automotive 1986, Wagner 1986b, Ford 1986a). However, producers and users agreed that adequate substitutes have

[2] Disc brakes are a higher-performance brake. Applications of drum and disc brakes are discussed in further detail later in this section.

(ICF 1986a). Wagner installs asbestos and non-asbestos brake pads with no additional processing (Wagner 1986a).

Table 3 lists the 1981 and 1985 importers of asbestos-based disc brake pads.

C. Trends

Table 4 gives the production of asbestos-based disc brake pads (light/medium vehicles) and the corresponding consumption of asbestos fiber. The percent change in production and fiber consumption from 1981 to 1985 are -30.2 percent and -25.3 percent, respectively.

It should be noted that some luxury import cars are now equipped with four semi-metallic disc brakes (Allied Automotive 1986). Saab is one such example (Saab-Scania of America 1986). However, the great majority of imported cars still have asbestos-based rear drum brakes (Ford 1986a, Abex 1986, MIT 1986).

A survey of producers, purchasers, and other sources revealed that currently asbestos probably holds no more than 15 percent of the OEM for disc brake pads (light/medium vehicles) (ICF 1986a, GM 1986a, Ford 1986b, Chrysler 1986, Chilton's Motor Age 1986, Allied Automotive 1986, DuPont 1986).[4] The share, however, is significantly higher for the aftermarket, though probably not a majority (GM 1986a).[5]

Allied Automotive stated that by 1990 asbestos would be replaced by nearly 100 percent in the OEM (Allied Automotive 1986). One source stated that by 1990, 90 percent of OEM light/medium vehicles are projected to be front-wheel drive, requiring semi-metallic disc brakes in the front (Chilton's Motor Age 1986). Given the above two projections and the current trends of GM, Ford, and Chrysler, it is clear that by 1990 asbestos-based pads will be almost

[4] See Attachment, Item 2.

[5] See Attachment, Item 2.

Table 4. Production and Fiber Consumption for Asbestos-Based Drum Brake Linings

	1981	1985	References
Production (pieces)	160,470,368	129,042,578[a]	ICF 1986a, TSCA 1982a
Asbestos Fiber Consumption (tons)	23,878.0	24,691.8[b]	ICF 1986a, TSCA 1982a

[a] Abex, Allied Automotive (both plants), Brake Systems, and Brassbestos did not provide production information. Brassbestos went out of business in August, 1985; it is assumed that they produced asbestos-based drum brake linings in 1985 (ICF 1986a). Production was estimated for these four companies using a method described in the Appendix A of this RIA.

[b] Abex, Allied Automotive (both plants), Brake Systems, and Brassbestos did not provide fiber consumption information. Brassbestos went out of business in August, 1985; however, it is assumed that they consumed asbestos fiber for the production of asbestos-based drum brake linings in 1985 (ICF 1986a). Fiber consumption for these four companies was estimated using a method described in Appendix A of this RIA.

been developed for many, if not most, OEM drum brake lining applications (Abex 1986, GM 1986c, Ford 1986a).[3] A report by the American Society of Mechanical Engineers concluded that automobile and most trucks could have completely non-asbestos friction systems by 1992 (ASME 1987). Producers and users stated that time is required to gear up commercial production of the substitute linings, redesign brake systems to accommodate the particular coefficient of friction of the substitute material (where required), and to conduct field tests in order to gain the acceptance of lining producers, vehicle and brake system manufacturers, and consumers (GM 1986c, Ford 1986a, Abex 1986).

With the exception of Allied Automotive and Abex, producers are apparently not yet producing substitute drum brake linings in sizeable quantities (ICF 1986a).[4] Estimates for the time required to develop adequate production capacity for substitutes were not available; however, this time period is likely to be linked to vehicle manufacturers' approval of new substitutes.

Unlike disc brakes pads, in which a superior substitute has been available for the last fifteen years (i.e., semi-metallic pads), non-asbestos drum brake linings are relatively new (Abex 1986, Ford 1986a). Both producers and users of brake linings are highly averse to the risk that could be associated with the use of new materials. The risk is magnified, furthermore, when a major brake system redesign is required for a substitute lining (Abex 1986, Ford

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[3] Representatives from Ford and GM agreed there were adequate substitutes for many light/medium vehicle applications (cars and light trucks), but there were problems with finding good substitutes for large cars and medium-sized trucks (e.g., 2 1/2-ton delivery trucks) (Ford 1986a, GM 1986c). A representative from Abex, however, firmly believed that adequate substitutes have been developed for all drum brake lining applications (Abex 1986).

[4] As indicated earlier, Allied Automotive estimates that 18 percent of its 1986 drum brake lining production will be non-asbestos (Allied Automotive 1986). Abex did not provide an estimate of the current share of its OEM drum brake linings that are non-asbestos, but did indicate that a significant percentage was non-asbestos (Abex 1986).

1986a, GM 1986c, Allied Automotive 1986, Wagner 1986b).[5] This risk translates into stringent and lengthy testing processes required by both government and automobile and brake lining manufacturers before acceptance of new friction materials and brake systems.

Sufficient laboratory and vehicle testing has been conducted for the substitute drum brake linings in order to certify that they comply with federal performance and safety regulations (Abex 1986, Ford 1986a, GM 1986c).[6] However, vehicle manufacturers also require, on average, a total of one million miles of field testing in a variety of geographic locations, and under a variety of road conditions, before a new brake lining material or brake system design will be incorporated into OEM vehicles. Brake lining producers and vehicle manufacturers agreed that this field testing has only begun (Abex 1986, Ford 1986a, GM 1986c).

According to Ford, a potential alternative for asbestos in drum brake linings would be to make light/medium vehicles with four non-asbestos (semi-metallic) disc brakes (Ford 1986a).[7] However, brake lining producers

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[5] Producers and users stated that there are two general types of substitute linings -- those that require only minor modifications of brake systems and those that require major modifications or total brake system redesigns (Ford 1986a, Abex 1986).

[6] Compliance with federal performance and safety regulations -- Federal Motor Vehicle Safety Standards (FMVSS) 105, 121, and the proposed 135 -- can be certified at the testing facilities of OEM brake lining producers. At these facilities, producers always employ, at a minimum, dynamometer testing (recognized in the industry to be the most reliable and accurate laboratory testing method) and vehicle testing in a controlled environment (i.e., race track) (Abex 1986, Ford 1986a, GM 1986c).

[7] Semi-metallic disc brakes are already used on the front wheels of 85 percent of all new light/medium vehicles (Allied Automotive 1986), and certain domestic luxury and high-performance cars are now equipped with four non-asbestos disc brakes (GM 1986a). Disc brakes, particularly semi-metallic disc brakes, have higher performance than drum brakes because they have longer service life and are generally better at removing heat quickly (GM 1986a). Perhaps even more important for automakers, disc brakes have a very strong marketing advantage: disc brakes make cars sell. They are an important selling point with consumers (Ford 1986a, GM 1986a, Abex 1986).

and vehicle manufacturers agreed that there currently is not a significant trend towards four disc brakes in light/medium vehicles, nor is there likely to be in the near future, because of important performance and economic factors (Abex 1986, GM 1986a, GM 1986c, GMI 1986, Ford 1986a). First drum brakes make superior parking brakes (GM 1986a, Ford 1986a, Abex 1986).[8] Disc brakes, furthermore, reduce fuel economy because of "parasitic drag" and are much higher in cost than drum brakes because of the mechanical system required for disc brakes (Ford 1986a, GM 1986a). Because drum brakes are significantly cheaper and are a lower performance brake, they are used for the rear wheels, with disc brakes in the front, in the vast majority of the light/medium vehicle OEM (95 percent) (GM 1986a).[9] In most light/medium vehicles, particularly those with front-wheel drive, there is significantly less brake load or brake force in the rear than in the front.[10] Therefore, the cheaper lower-performance drum brakes are used in the rear since the rear brakes do not have to do much work (GM 1986a).[11] A final key factor that would stall a significant switch-over to four-disc-brake cars is the enormous equipment redesign that would be required (GMI 1986). Therefore, for the above-mentioned reasons, drum brake linings, at least in the near future, will continue to be produced for the light/medium vehicle OEM at roughly a 1:1 ratio with disc brakes.

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[8] The parking brake either utilizes the existing rear drum brakes (service brakes), is a separate rear drum brake, or is a separate front disc brake (front parking brake) (GM 1986a).

[9] The remaining 5 percent are the luxury and high performance cars equipped with four disc brakes (GM 1986a).

[10] In front-wheel drive cars, the brake load is 85 percent in the front and in rear-wheel drive cars, about 70 percent of the load is in the front (Ford 1986a, Design News 1984).

[11] In most cars, in fact, rear drum brakes would have the same service life as rear disc brakes because of the light brake load (GM 1986a).

D. Substitutes

As indicated earlier, primary processors and vehicle manufacturers agree that acceptable drum brake lining formulations have been developed for many, if not most, drum brake lining applications. Although these substitutes do not have the same performance characteristics as asbestos-based linings (no substitute currently provides all the advantages that asbestos linings do), they are "acceptable" from the standpoint of vehicle drivers: drivers will accept changes in performance, as long as there are no "surprises" while driving that reduce safety (Abex 1986, Ford 1986a, GM 1986c, MIT 1986). Non-asbestos organics (NAOs) are acceptable substitutes that have been developed for the OEM. Lining producers and vehicle manufacturers agree that NAOs would take the majority of the asbestos-based OEM in the event of a ban (GM 1986c, Abex 1986, Ford 1986a, Carlisle 1986).

NAO drum brake lining formulations, in general, include the following: fiberglass and/or Kevlar(R), mineral fibers,[12] occasionally some steel wool, and fillers and resins (Ford 1986a). Fiberglass and Kevlar(R), however, usually account for only a small percentage of the total formulation. For example, a representative from Ford stated that the optimal level of Kevlar(R) in drum brake lining formulations is usually about 3 percent by weight (Ford 1986a). Thus, labelling substitute drum brake linings as Kevlar(R)-based or fiberglass-based (producers tend to do this for marketing reasons) is misleading (Abex 1986, Ford 1986a, GM 1986c).

Of the thirteen primary processors of drum brake linings in 1985, at least eight currently produce NAO linings. These firms are: Allied Automotive, General Motors Inland Division, Abex, Nuturn, Virginia Friction Products,

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[12] Mineral fibers commonly used by producers include: wollastonite, phosphate fiber, aluminum silicate fiber, Franklin fiber, mineral wool, and PMF (processed mineral fiber) (ICF 1986a).

Chrysler, Carlisle, and Brake Systems Inc. (ICF 1986a). Although, the producers did not reveal the exact formulations of their NAO linings, they provided partial lists of the ingredients in their mixtures (ICF 1986a).

Five of the primary processors also produce a semi-metallic drum brake lining. These firms are: Abex, Allied Automotive, Carlisle, General Motors Inland Division, and H.K. Porter (Abex 1986, Allied Automotive 1986, ICF 1986a). Lining producers and vehicle manufacturers generally agree, however, that there are serious production and performance problems with semi-metallic drum brake linings (Abex 1986, GM 1986c, Ford 1986a, Carlisle 1986). H.K. Porter, in fact, discontinued its semi-metallic (and asbestos) drum brake lining operations in 1986; the firm stated that it was unable to find adequate substitute linings (PEI Associates 1986). Representatives from Abex and Ford stated that semi-metallics are very difficult to process into the required thin arc-shaped lining segments and are, thus, very prone to crack (Abex 1986, Ford 1986a).[13] These representatives also stated there were unacceptable performance problems, including "morning sickness," which involves moisture getting into the lining overnight, rendering the product useless until it heats up and dries out (Abex 1986, Ford 1986a). For the above reasons, lining producers and vehicle manufacturers agreed that semi-metallics would not take much of a share of the asbestos-based OEM in the event of a ban (Abex 1986, GM 1986c, Ford 1986a, Carlisle 1986).

Primary processors and vehicle manufacturers agree that there is adequate dynamometer and vehicle-testing capacity among the OEM producers to develop substitutes for the remaining OEM drum brake lining applications, i.e. medium-sized trucks with four-drum-brake systems. The difficulty in

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[13] Semi-metallics can, however, be successfully manufactured for very heavy brake block applications, where the arc of the segments is much wider than in drum brake linings (because of the larger drum) and the segments are considerably thicker (Abex 1986).

developing acceptable substitute linings for medium-sized trucks results from the more severe braking requirements for the rear drum brakes of these vehicles than for the majority of light/medium vehicles and the fact that the drum brake linings for medium-sized trucks must be riveted, not bonded, to the brake shoe. Thus, an acceptable substitute lining must have structural strength around the rivet area (Batelle 1987). Nevertheless, given enough time substitute linings for medium-sized trucks will be developed, particularly since brake systems can always be redesigned by including servo mechanical systems to amplify or modify the braking ability of a particular substitute lining in order to achieve the desired performance (Ford 1986a, Abex 1986, GM 1986c, MIT 1986).

Replacement of asbestos-based drum brake linings in the aftermarket, however, may be much more difficult. Most asbestos-based drum brake linings producers and auto manufacturers agree that brake systems designed for asbestos linings should continue to use asbestos linings. The parties maintain a position that substitute lining formulations that were designed for the OEM, when used to replace worn asbestos linings, do not perform as well as asbestos, and could jeopardize brake safety (Allied Automotive 1986, GM 1986b, GM 1986c, Wagner 1986b, Ford 1986a, Ford 1986b). Abex, however, indicated that it is selling its OEM non-asbestos organic drum brake linings for the aftermarket and reports that they are performing well (Abex 1986).

In general there are three important reasons for little or no development of substitute formulations engineered for aftermarket brake systems designed for asbestos:

- Considerable technical difficulties with developing adequate substitutes for a system designed specifically for asbestos;

- No federal safety and performance standards for brakes for the aftermarket;[14] and,
- High cost of producing and testing substitute formulations (Ford 1986a, Wagner 1986b, Abex 1986).

Aftermarket producers, except for those who also produce for the OEM, are generally small and almost totally lacking in testing equipment (Ford 1986a). Two firms stated that if some of these firms devoted substantial resources to testing and research and development, they would be out of business (Ford 1986a, Abex 1986). As long as there are asbestos drum brakes sold in the aftermarket, there will be little, if any, economic incentive to develop retrofit substitutes (LBJ Space Center 1986). However, even with a ban on asbestos linings for the aftermarket, the cost of substitutes designed for the aftermarket are likely to be prohibitive, given the technical difficulties (LBJ Space Center 1986).

Table 5 provides the data for the regulatory cost model. The substitute linings in the table are an NAO lining produced by Abex and a semi-metallic lining made by General Motors Inland Division. It is assumed that semi-metallic drum brake linings will account for a negligible share of the market. Note that the equivalent price of the NAO lining given in Table 5 is close to the asbestos lining price because of the longer service life.

E. Summary

Asbestos drum brakes are found on the rear wheels of most new light and medium vehicles, i.e., passenger cars and light trucks (GM 1986a). Thirteen companies produced asbestos drum brake linings in 1985 and by the end of 1986 only eleven continued to produce the asbestos product (ICF 1986a, PEI Associates 1986). In 1985, these producers consumed 24,691.8 tons of asbestos to produce 129,042,578 asbestos drum brake linings. Between 1981 and 1985,

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[14] By contrast, OEM brakes must meet federal regulatory standards -- FMVSS 105 and 121 (and, in the future, the proposed 135).

Table 5. Data Inputs on Drum Brake Linings for Asbestos Regulatory Cost Model[a]

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	Reference
Asbestos Mixture	129,042,578 pieces[b]	0.00019 tons/piece	1.15	$0.63/piece	4 years	$0.63/piece	N/A	ICF 1986a, ICF 1985
NAO	N/A	N/A	N/A	$0.79/piece	5 years	$0.65/piece	99%	Abex 1986, Ford 1986a, Carlisle 1986
Semi-Metallic	N/A	N/A	N/A	$1.09/piece	4 years	$1.09/piece	1%	ICF 1986a, Abex 1986, Ford 1986a, Carlisle 1986

N/A: Not Applicable.

[a] See Attachment, Items 3-5.

[b] The output for drum brake linings is split into OEM brakes (34,713,675 pieces) and aftermarket brakes (94,328,903 pieces) based on the ratio of OEM and replacement sales shown in Appendix A.

production of the asbestos linings declined 19.6 percent (ICF 1986a). However, asbestos linings still accounted for 90-95 percent of the OEM and virtually 100 percent of the aftermarket (GM 1986a, GM 1986c, Chrysler 1986, Allied Automotive 1986, Wagner 1986b, Ford 1986a). Acceptable substitutes have been developed for many, if not most, drum brake lining applications. For the OEM, NAOs are expected to take 99 percent and semi-metallics 1 percent of the asbestos drum brake lining market if asbestos were not available. NAOs cost the same as asbestos linings, while semi-metallics cost 73 percent more than the asbestos-based product. Developing adequate substitutes for the aftermarket will be difficult due to technical difficulties and economic factors.

ATTACHMENT

1. The asbestos fiber content per lining was calculated by dividing the 1985 asbestos fiber consumption for drum brake linings by the 1985 production of drum brake linings for producers for which both fiber consumption and production data were available: 24,691.8 tons (49,383,600 lbs.) divided by 129,042,578 pieces, or 0.38 lbs per piece.

2. A large producer of asbestos-based drum brake linings in 1981, stated that the share held by asbestos in its OEM linings was 97 percent in 1983, 96 percent in 1984, 91 percent in 1985, and is estimated to be 82 percent in 1986. One automobile manufacturer stated that currently 95 percent of its OEM drum brake linings were asbestos-based (GM 1986a). A second automobile manufacturer stated that currently 98.5 percent of its OEM linings were asbestos-based (Chrysler 1986). On the basis of these figures, it is assumed that asbestos holds roughly 90-95 percent of the OEM for drum brake linings. Two major producers of brake systems for the automobile and truck aftermarkets stated that 100 percent of the aftermarket was still asbestos-based.

3. The product asbestos coefficient is the same value calculated in Item 1 above, converted into tons per piece.

4. The consumption production ratio was calculated using 19,580,493 pieces as the value for the 1985 U.S. imports. (Total 1985 production is 129,042,078 pieces.) This value, however, only includes imports for the firms who provided information (see Table 4).

5. The asbestos product price is a weighted average (by production) of prices for producers who provided information. The useful life of the asbestos product was assumed to be the same as that reported in 1984 in Appendix A (ICF 1985). The two substitute lining prices were calculated by increasing the weighted average asbestos product price by what Abex and GM, respectively, reported as the percentage price increase for their substitute product over their asbestos product. One company indicated that its NAO lining cost 25 percent more than its asbestos-based lining; another company stated its semi-metallic lining was approximately 73 percent higher than its asbestos lining. While the first company did not indicate the service life of its NAO lining compared to its asbestos product, another manufacturer of NAO drum brake linings, reported that NAO linings had the same or up to 50 percent longer service life. Thus, a service life increase of 25 percent over the life of the asbestos product (that was given in Appendix H) is used in Table 5. It was not clear whether semi-metallic linings had longer or shorter service life than asbestos linings; therefore, the same service life as the asbestos product is used.

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XIX. DISC BRAKE PADS (LIGHT/MEDIUM VEHICLES)

A. Product Description

Disc brakes are used on the front wheels of virtually all (95 percent) light and medium vehicles (cars and light trucks) (GM 1986a). Approximately 5 percent of light/medium vehicles, certain luxury and high-performance cars (e.g., Cadillac Seville and El Dorado, Corvette, Pontiac STE and Fiero, high-performance Camaro and Firebird), have disc brakes on all four wheels (GM 1986a). A disc brake consists of a caliper to which are attached two steel plates, each lined with a molded friction material called a disc brake pad. The two disc brake pads straddle the rotor, or disc, that is in the center of a vehicle's wheel. Friction between the disc and the brake pad stops the vehicle when the brakes are applied (ICF 1985, Krusell and Cogley 1982).

Asbestos-based disc brake pads, like drum brake linings, are molded products containing asbestos fiber, fillers, additives, and resins. A dry-mix process is usually used in their manufacture; the basic steps in this process are as follows:

- Mixing of fibers, dry resins, and property modifiers;
- Molding and curing using heat and pressure; and
- Finishing by grinding and drilling.

The degree of automation of these steps may vary considerably among manufacturers, but once the finishing is completed, the pads are either bonded (glued) or riveted to the steel plates (ICF 1985, Krusell and Cogley 1982, Allied Automotive 1986).[1] The approximate asbestos fiber content per pad is 0.22 lbs. (ICF 1986a).[2]

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[1] While bonded brake pads have greater frictional surface, riveted pads are quieter (Allied Automotive 1986).

[2] See Attachment, Item 1.

Secondary processing of disc brake pads includes installation of pads into new brake assemblies, repackaging for sale to the aftermarket, and retrofitting worn brake pads with new pads for resale (ICF 1985, Krusell and Cogley 1982).

In addition to asbestos-based disc brake pads, there are semi-metallics. Semi-metallics pads have been in the domestic market for the last 15 years (Abex 1986). These pads are molded products containing chopped steel wool, sponge iron, graphite powder, fillers, and resins (Allied Automotive 1986, Ford 1986a). Some semi-metallic pads contain a very thin asbestos-containing backing, or underlayer, between the plate and pad. Other semi-metallic pads have no underlayer or have one made of a non-asbestos material. The underlayer acts as a thermal barrier between the pad and plate, and helps to bond the pad to the plate (Allied Automotive 1986). Producers generally do not consider semi-metallic pads with the asbestos underlayer to be asbestos pads since the lining itself contains no asbestos and the underlayer is only a very small percentage of the total content of the pad (Allied Automotive 1986).

Disc brake pads are used in the front of light/medium vehicles, whether rear-wheel or front-wheel drive, because of the heavier brake load or brake force in the front of vehicles (GM 1986a).[3] Disc brakes have higher performance than drum brakes, which are usually used in the rear, because they have longer service life and are generally more efficient at dissipating (GM 1986a). Front-wheel drive vehicles, which have greater brake load in the front (and, thus, generate more brake heat in the front) than rear-wheel drive vehicles, use semi-metallic disc brakes in the front, exclusively (Allied

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[3] In front-wheel drive cars the brake load is 85 percent in the front and in rear-wheel drive cars, about 70 percent of the load is in the front (Ford 1986a, Design News 1984).

Automotive 1986, Chilton's Motor Age 1986). Semi-metallic disc brakes perform better at higher temperatures than asbestos-based disc brakes and have a longer service life (Allied Automotive 1986, GM 1986a). Rear-wheel drive vehicles generally use asbestos-based disc brake pads in the front, though some also use semi-metallic front disc brakes (e.g., Ford Mustang) (Ford 1986b, GM 1986a). In general, at lower temperatures, asbestos-based disc brakes perform better than semi-metallics, and are quieter (GM 1986a, Allied Automotive 1986).

B. Producers and Importers of Disc Brake Pads (Light/Medium Vehicles)

Table 1 lists the fourteen 1985 primary processors of disc brake pads (asbestos and non-asbestos) for light/medium vehicles. Thirteen of the processors produced asbestos-based pads in 1985 and, currently, twelve are still producing. Twelve of the producers also produced a non-asbestos pad (Brake Systems 1986, ICF 1986a). Friction Division Products only produces non-asbestos pads (ICF 1986a).

Changes in primary processors from 1981 to 1985 include Friction Division Product's purchase of Thiokol's Trenton, NJ, plant and Brake Systems Inc.'s purchase of one of Raymark's Stratford, CT, plants (ICF 1986a, Brake Systems 1986). Brassbestos of Paterson, NJ, went out of business in August, 1985 (ICF 1986a). H.K. Porter of Huntington, IN (not listed in Table 1), stopped producing disc brake pads altogether prior to 1985 (ICF 1986a).

Table 2 lists the 1985 secondary processors of disc brake pads. The Standard Motor Products plant, formerly owned by the EIS Division of Parker-Hannifin, no longer is involved in secondary processing of asbestos-based pads

Table 1. 1985 Primary Processors of Disc Brake Pads
(Light and Medium Vehicles)

Company	Plant Location(s)	Product: Asbestos	Product: Non-Asbestos	References
Brake Systems Inc. (Division of Echlin) (plant formerly owned by Raymark)	Stratford, CT	X	X	Brake Systems 1986, TSCA 1982a
Delco Moraine Division, General Motors	Dayton, OH	X	X	GM 1986a, TSCA 1982a
Abex	Winchester, VA	X	X	Abex 1986, TSCA 1982a
Allied Automotive	Green Island, NY Cleveland, TN	X X	X X	Allied Automotive 1986, TSCA 1982a
Nuturn	Smithville, TN	X	X	ICF 1986a, TSCA 1982a
Auto Specialties Manufacturing Company	St. Joseph, MI	X	X	ICF 1986a, TSCA 1982a
LSI-Certified Brakes (Division of Lear-Siegler)	Danville, KY	X	X	ICF 1986a, TSCA 1982a
Brassbestos	Paterson, NJ	X[a]		ICF 1986a, TSCA 1982a
Friction Division Products (plant formerly owned by Thiokol)	Trenton, NJ		X	ICF 1986a, TSCA 1982a
U.S. Automotive Manufacturing	Tappahannock, VA	X		ICF 1986a, TSCA 1982a
Virginia Friction Products	Walkerton, VA	X	X	ICF 1986a, TSCA 1982a
H. Krasne Manufacturing	Los Angeles, CA	X	X	ICF 1986a, TSCA 1982a
Chrysler	Wayne, MI	X	X	ICF 1986a, TSCA 1982a
Auto Friction Corp.	Lawrence, MA	X	X	ICF 1986a, TSCA 1982a

[a] Brassbestos went out of business in August 1985. However, it is assumed that they produced asbestos-based disc brake pads in 1985.

Table 2. 1985 Secondary Processors of Disc Brakes Pads
(Light and Medium Vehicles)

Company	Plant Location	Product: Asbestos	Product: Non-Asbestos	References
Standard Motor Products (plants formerly owned by EIS Division of Parker-Hannifin)	West Bend, WI		N/A	ICF 1986b, TSCA 1982b
Wagner	Parsippany, NJ	X	N/A	ICF 1986b, ICF 1985
Cali-Blok (EIS Division of Parker-Hannifin)	Gardena, CA	X	X	ICF 1986b, TSCA 1982b

N/A: Information not available.

Table 4. Production and Fiber Consumption for Asbestos-Based Disc Brake Pads (Light and Medium Vehicles)

	1981	1985	Percent Change (%)	References
Production (pieces)	94,409,007	65,869,172[a]	-30.2	ICF 1986a, TSCA 1982a
Asbestos Fiber Consumption (tons)	9,525.9	7,119.2[b]	-25.3	ICF 1986a, TSCA 1982a

[a]Allied Automotive, Abex, Brassbestos, and Brake Systems Inc. did not provide 1985 asbestos disc brake pad production data. Their production was estimated using a method described in the Appendix A of this RIA.

[b]Abex, Brassbestos, and Brake Systems Inc. did not provide 1985 fiber consumption data. Their fiber consumption was estimated using a method described in the Appendix A of this RIA.

completely replaced in the OEM.[6] Although asbestos is still contained in the underlayer of some semi-metallic pads, the trend is, also, towards complete replacement.[7]

D. Substitutes

Semi-metallics are the only major substitute for asbestos-based disc brake pads (light/medium vehicles). GM, Ford, and Chrysler indicated that essentially all of their non-asbestos disc brake pads were semi-metallic (GM 1986a, Ford 1986b, Chrysler 1986). Nine of the fourteen producers of disc brake pads make a semi-metallic product: Allied Automotive, Nuturn, Friction Division Products, GM, Virginia Friction Products, H. Krasne Manufacturing Co., Chrysler, Abex, and LSI-Certified Brakes (ICF 1986a, Allied Automotive 1986, Abex 1986). Nuturn and Virginia Friction Products stated that Kevlar was also contained in their semi-metallic pads (ICF 1986a). A representative from GM stated that non-semi-metallic non-asbestos pads had a very small share of the OEM (GM 1986a). The other class of non-semi-metallic substitute pads are the non-asbestos organic (NAO) pads. Two producers, Brake Systems Inc. and Auto Friction Corp., were found to make these pads, but neither indicated whether they produced them in sizeable quantities (ICF 1986a).

As indicated earlier, asbestos holds only 15 percent of OEM disc brake pads (light/medium vehicles). Thus, the balance of 85 percent is nearly all semi-metallics (Allied Automotive 1986). Given the trend towards 100 percent front-wheel drive light/medium vehicles, it is clear that semi-metallics will replace most if not all asbestos pads in the near future (Chilton's Motor Age 1986, Allied Automotive 1986).

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[6] See Attachment, Item 2, for the current trends of GM, Ford, and Chrysler.

[7] See Attachment, Item 3.

Substitutes for the thin asbestos underlayer in some semi-metallic pads include either no underlayer or a chopped fiberglass or Kevlar(R) underlayer, depending upon the application (Allied Automotive 1986). Allied Automotive stated that the substitutes for the asbestos underlayer performed just as well (Allied Automotive 1986).

Replacement of asbestos pads with substitutes in the aftermarket, however, is much more difficult. Most producers and users agreed that brake systems designed for asbestos pads should continue to use asbestos. Semi-metallic pads which were designed for the OEM, when used to replace worn asbestos pads, do not perform as well as asbestos, and could jeopardize brake safety (Allied Automotive 1986, GM 1986b, Wagner 1986b, Ford 1986c). A much higher percentage of vehicles in the aftermarket, furthermore, are rear-wheel drive, most of which were designed to have asbestos front disc brakes (Chilton's Motor Age 1986).

In general, there are three important reasons for little or no development of substitutes engineered for aftermarket brake systems that were designed for asbestos:

- Considerable technical difficulties with developing adequate substitutes for a system designed specifically for asbestos;
- No federal safety and performance standards for brakes for the aftermarket;[8] and,
- High cost of producing and testing substitute formulations (Allied Automotive 1986, GM 1986c, Ford 1986a, Ford 1986b, Wagner 1986b, Abex 1986).

Aftermarket producers, except for those who also produce for the OEM, are generally small and almost totally lacking in testing equipment (Ford 1986a). If any of these firms devoted substantial resources to testing

[8] By contrast, OEM brakes must meet certain regulatory standards, Federal Motor Vehicle Safety Standards (FMVSS) 105 and 121 (and, in the future, the proposed 135) (Ford 1986a, Abex 1986).

and research and development, they would be out of business (Ford 1986a, Abex 1986). As long as there are asbestos disc brakes sold in the aftermarket, there will be little, if any, economic incentive to develop retrofit substitutes (LBJ Space Center 1986). However, even with a ban on asbestos pads for the aftermarket, the cost of substitutes designed for the aftermarket are likely to be prohibitive, given the technical difficulties (LBJ Space Center 1986).

Table 5 provides the data for the regulatory cost model. The substitute is the semi-metallic disc brake pad. Price and performance data were not available for NAO pads either because companies would not provide information or production was in very limited quantities (ICF 1986a). It is assumed, however, that NAO pads would account for a negligible share of the market. Note that the equivalent price of the semi-metallic pad is slightly less than the asbestos pad price because of the significantly longer service life.

E. Summary

Disc brakes are used on the front wheels of virtually all (95 percent) light and medium vehicles (cars and light trucks). Approximately 5 percent of all light/medium vehicles have disc brakes on all four wheels (GM 1986a). Thirteen companies consumed 7,119.2 tons of asbestos to produce 65,869,172 asbestos disc brake pads in 1985. Twelve companies are still producing. Between 1981 and 1985, production of asbestos disc brake pads declined approximately 30 percent (ICF 1986a, TSCA 1982a). Currently, asbestos only comprises 15 percent of the OEM for disc brake pads; the balance of 85 percent is held by semi-metallics (Allied Automotive 1986). If asbestos were no longer available it is predicted that semi-metallics would take 100 percent of the asbestos market. The

Table 5. Data Inputs on Disc Brake Pads (LMV) for Asbestos Regulatory Cost Model[a]

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	Reference
Asbestos Mixture	65,869,172 pieces[b]	0.00011 tons/piece	1.19	$0.42/piece	4 years	$0.42/piece	N/A	ICF 1986a, ICF 1985
Semi-Metallic	N/A	N/A	N/A	$0.67/piece	7.4 years	$0.40/piece	100%	ICF 1986a, H. Krasne 1986, Cali-Blok 1986

N/A: Not Applicable.

[a] See Attachment, Items 4-6.

[b] The output for disc brake pads (light and medium motor vehicles) is split into OEM brakes (10,077,464 pieces) and aftermarket brakes (55,791,708 pieces) based on the ratio of OEM and replacement sales shown in Appendix A.

equivalent price of semi-metallic disc brake pads is slightly less than the price of asbestos disc brake pads (ICF 1986a).

ATTACHMENT

1. The asbestos fiber content per pad was calculated by dividing the 1985 asbestos fiber consumption for disc brake pads by the 1985 production for producers for which both fiber consumption and production were available: 7,119.2 tons (14,238,400 lbs.) divided by 65,869,172 pieces, or 0.22 lbs. per piece.

2. GM, Ford, and Chrysler, the three largest U.S. automakers, and thus, probably the three largest consumers of OEM disc brake pads for light/ medium vehicles, were asked for the share asbestos held in their OEM pads. One company stated that currently only 5 percent of the OEM pads it consumes were asbestos-based. The second company stated in its 1986 model year the share was 6.9 percent, and projected it to be 3.9 percent in the 1987 model year. The third company stated asbestos held 40 percent of its OEM pads in the 1986 model year, but projected the share to be 10 percent in the 1987 model year (Ford 1986b). An editor from Chilton's Motor Age, an important trade publication, stated that currently 75 percent of domestic OEM light/medium vehicles were front-wheel drive (Chilton's Motor Age 1986). Because front-wheel drive vehicles use semi-metallic pads, the asbestos share of OEM pads could not be more than 25 percent, and probably somewhat less, given the fact that some rear-wheel drive cars use semi-metallic pads (e.g., Ford Mustang) (Chilton's Motor Age 1986). A large producer of asbestos-based pads in 1981 and a major supplier of materials for friction products both agree that the asbestos share of OEM pads for light/medium vehicles is 15 percent. Therefore, 15 percent would be a good estimate for the current share.

3. A large producer of semi-metallic pads, stated that in the 1986 vehicle model year, 50 percent of both its OEM and aftermarket semi-metallic pads contained an asbestos underlayer, but by January 1987, 90 percent of both its OEM and aftermarket pads would use either no underlayer or one made of a non-asbestos material. An automobile manufacturer stated that in its 1986 model year, 12.7 percent of its semi-metallic pads contained an asbestos underlayer, all of which were purchased from a single source. The rest of its pads contained no underlayer at all. The second automobile manufacturer estimated the OEM share that contained an asbestos underlayer to be currently 10 percent. The third automobile manufacturer stated that in the 1986 model year, 99.65 percent of its semi-metallic pads had an asbestos underlayer, and the share would be 91.75 percent in the 1987 model year. Nonetheless, the overall trend is towards complete replacement.

4. The product asbestos coefficient is the same value calculated in Item 1 above, converted into tons per piece.

5. The consumption production ratio was calculated using 12,589,555 pieces as the value for the 1985 U.S. imports. (Total 1985 production is 65,898,172 pieces.) This value, however, only includes imports for the firms who provided information (see Table 4).

6. The asbestos product price is a weighted average (by production) of prices for producers who provided information. The useful life of the asbestos product was assumed to be the same as that reported in 1984 in Appendix H (ICF 1985). The price of the semi-metallic pad was computed by increasing the weighted average asbestos product price by what GM stated was the percentage price increase of its semi-metallic product over its asbestos product (60.2 percent). The useful life of the semi-metallic pad was computed by taking the average of what two companies stated to be the percent increase in useful life of their semi-metallic pads over their asbestos pads (the straight average of 100 percent and 71 percent, or 85.5 percent), and then increasing the useful life of the asbestos product (given in Appendix H) by this value (85.5 percent) (ICF 1986a, 1986b). (Note: GM did not provide information on the useful life.)

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XX. DISC BRAKE PADS (HEAVY VEHICLES)

A. Product Description

Disc brake pads (both asbestos and non-asbestos) for heavy vehicles are a small and relatively new market (Allied Automotive 1986, Carlisle 1986). Although disc brake pads were small percentage of heavy vehicle brakes in the past, these systems are increasingly common for these vehicles. Except for the larger size, the pads are similar to those described for light and medium vehicles (Allied Automotive 1986). Disc brake pads for heavy vehicles, to date, are only used on the front wheels of certain intermediate-sized trucks (12,000-22,000 lbs. per axle) (Allied Automotive 1986). One producer, Allied Automotive, stated that disc brakes could never be used for the heaviest trucks, while another producer, Carlisle, indicated that, in perhaps five years, disc brakes will be developed for large trucks such as tractor trailers (Allied Automotive 1986, Carlisle 1986).

Although non-asbestos semi-metallic pads have nearly always been used for disc brakes for heavy vehicles in small proportions (Allied Automotive 1986, Carlisle 1986), in the past, asbestos-based pads were used to a greater extent. Asbestos disc brakes for heavy vehicles are now apparently only used to replace worn asbestos pads in the aftermarket (ICF 1986a, ICF 1985, Allied Automotive 1986, Carlisle 1986). The switch to semi-metallic pads from asbestos pads is due to the high braking temperatures generated in this vehicle application; semi-metallic pads, in general, have superior performance and service life at high temperatures (Allied Automotive 1986).

Semi-metallic pads are molded products containing chopped steel wool, sponge iron, graphite powder, fillers, and resins (Allied Automotive 1986, Ford 1986). Some semi-metallic pads for heavy vehicles may contain a very thin asbestos-containing backing, or underlayer, between the pad and the steel plate to which it is attached.[1] Other semi-metallic pads have no underlayer or have one made of chopped Kevlar or fiberglass (Allied Automotive 1986). The underlayer acts as a thermal barrier between the pad and plate and helps to bond the pad to the plate (Allied Automotive 1986). Producers generally do not consider semi-metallic pads with asbestos underlayers to be asbestos pads since the lining itself contains no asbestos and the underlayer accounts for only a very small percentage of the total content of the pad (Allied Automotive 1986).

Primary and secondary processing of asbestos-based pads is the same as that described for light and medium vehicles. According to Carlisle, the approximate asbestos fiber content per pad is 1.5 lbs. (ICF 1986a).

B. Producers and Importers of Disc Brake Pads (Heavy Vehicles)

Table 1 lists the four producers of (asbestos and non-asbestos) disc brake pads for heavy vehicles in 1985. Carlisle, and possibly Allied Automotive, produced asbestos-based pads in 1985. However, an Allied Automotive representative stated that the firm currently manufactures only semi-metallic pads (Allied Automotive 1986). Brake Systems and Raymark, only manufacture semi-metallic pads (Brake Systems 1986, ICF 1986a, Design News 1984).

Table 2 lists the sole secondary processor of disc brake pads for heavy vehicles in 1985. The firm, Hall Brake Supply, was also the only secondary processor in 1981 (TSCA 1982b). The pads produced by the firm are all asbestos-based (ICF 1986b).

There were no importers of asbestos disc brake pads for heavy vehicles in 1985 (ICF 1986a).

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[1] Information is not available on the percentage of semi-metallic pads that possibly contain an asbestos underlayer. Brake Systems, Inc. makes semi-metallic disc brake pads for heavy vehicles with an asbestos underlayer (Brake Systems 1986). Information was not available for the other producers.

Table 1. 1985 Primary Processors of Disc Brake Pads
(Heavy Vehicles)

Company	Plant Location	Product: Asbestos	Product: Non-Asbestos	References
Carlisle, Motion Control Industries Division	Ridgway, PA	X	X	ICF 1986a, TSCA 1982a
Allied Automotive	Green Island, NY	N/A[a]	X	Allied Automotive 1986, TSCA 1982a
Brake Systems	Stratford, CT		X[b]	Brake Systems 1986
Raymark	N/A[c]		X	Design News 1984

N/A = Information not available.

[a]Allied Automotive refused to respond to our survey. It was assumed that they produced asbestos-based disc brake pads in 1985, however they currently only produce semi-metallic pads (Allied Automotive 1986).

[b]Brake Systems produces semi-metallic pads with a very small asbestos underlayer; this is not considered an asbestos disc brake pad (Brake Systems 1986).

[c]Raymark, itself, did not provide information on its disc brake pad production. They only produce semi-metallic pads (ICF 1986a, Design News 1984).

Table 2. 1985 Secondary Processors of Disc Brake Pads
(Heavy Vehicles)

Company	Plant Location	Product: Asbestos	Product: Non-Asbestos	References
Hall Brake Supply	Phoenix, AZ	X		ICF 1986b, TSCA 1982b

C. Trends

Table 3 gives the production of asbestos-based disc brake pads for heavy vehicles and the corresponding consumption of asbestos fiber.

As previously mentioned, there were no importers of asbestos-based disc brake pads for heavy vehicles in 1985 (ICF 1986a). Hall Brake Supply was the sole importer in 1981. (ICF 1984).

According to Carlisle, the market for heavy-vehicle disc brakes is growing. The firm predicts that the switch to front disc brakes that occurred in cars and light trucks will also happen in intermediate- and large-sized trucks (Carlisle 1986).

D. Substitutes

According to Allied Automotive and Carlisle, 100 percent of the original equipment market (OEM) and most of the aftermarket is held by the semi-metallic pads (Allied Automotive 1986, Carlisle 1986). It is assumed that the 100 percent of the aftermarket will also become semi-metallic as aftermarket vehicles are scrapped and/or switch over to semi-metallic pads.[2]

Table 4 provides data inputs for the regulatory cost model.

E. Summary

Asbestos disc brake pads for heavy vehicles are used only on the front wheels of certain intermediate-sized trucks (12,000-22,000 lbs. per axle) (Allied Automotive 1986). Two producers, in 1985, consumed 117.6 tons of asbestos to produce 156,280 disc brake pads (heavy vehicles). Only one, Carlisle-Motion Control Industries, currently produces the asbestos disc brake pad for heavy vehicles (Allied Automotive 1986, Carlisle 1986, ICF 1986a).

[2] Allied Automotive also reports that non-asbestos underlayers, which are made of either chopped fiberglass or Kevlar(R), perform just as well as asbestos underlayers (Allied Automotive 1986).

Table 3. Production and Fiber Consumption for Asbestos-Based Disc Brake Pads (Heavy Vehicles)

	1981		1985		
	Production (pieces)	Asbestos Fiber Consumption (tons)	Production (pieces)	Asbestos Fiber Consumption (tons)	References
Total	385,496	44.6	156,820[a]	117.6[a]	ICF 1986a, TSCA 1982a

[a]One company refused to provide production and fiber consumption data for their asbestos-based disc pads (heavy vehicles). Its production and fiber consumption have been estimated using a method described in Appendix A of this RIA.

Table 4. Data Inputs on Disc Brake Pads (HV) for Asbestos Regulatory Cost Model[a]

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	References
Asbestos Mixture	156,820 pieces	0.00075 tons/piece	1.0	$10.00/piece	0.5 years	$10.00/piece	N/A	ICF 1986a, ICF 1985, Carlisle 1986
Semi-Metallic	N/A	N/A	N/A	$12.50/piece	0.75 years	$8.40/piece	100%	Allied Automotive 1986, Carlisle 1986

N/A: Not Applicable.

[a]See Attachment, Items 1-2.

Asbestos-based pads are now only used to replace worn asbestos pads in the aftermarket. For OEM, semi-metallic pads are used rather than asbestos pads because of the high braking temperatures generated in this application. If asbestos were no longer available, it is estimated that 100 percent of the aftermarket would become semi-metallic. Semi-metallic disc brake pads (heavy vehicles) cost approximately 20 percent less than asbestos disc brake pads for heavy vehicles.

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1. The product asbestos coefficient, as well as the asbestos and semi-metallic pad prices were provided by Carlisle.

2. The useful life of the asbestos pad was assumed to be the same as that reported in 1984 in Appendix H (ICF 1985). Carlisle stated that semi-metallic pads have 50 percent longer service life than asbestos pads; thus, the useful life of the semi-metallic pad given in the table is 1.5 times the asbestos pad life.

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XXI. BRAKE BLOCKS

A. Product Description

Brake blocks are brake linings used on the drum brakes of heavy vehicles -- heavy trucks, buses, and heavy off-road vehicles.[1] The comparable components on light/medium vehicles (cars and light trucks) are drum brake linings, which are discussed in Section XVIII. The heavy-vehicle drum brake consists of two curved metal "shoes" to which brake blocks are attached. When the brakes are applied, the curved shoes are pressed out against a metal drum that is connected to the wheels of the vehicle.[2] The pressure of the shoes against the drum stops the turning of the wheels (ICF 1985).

Each shoe has two blocks, a longer one (the anchor) and a shorter one (the cam), resulting in a total of four blocks per wheel. Each block is at least three-quarters of an inch thick and covers 50° to 60° of the arc around the wheel (Allied Automotive 1986, ICF 1985).

Asbestos-based brake blocks contain approximately 1.16 lbs.[3] of asbestos fiber per block on average (ICF 1986a). Asbestos is used because of its thermal stability, reinforcing properties, flexibility, resistance to wear, and relatively low cost (Krusell and Cogley 1982).

Brake blocks are usually manufactured by a dry mix process in which asbestos fiber is combined with a powdered binder (usually an epoxy novolac resin) to form briquets under pressure of 1,500 to 2,500 psi and temperature

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[1] Heavy trucks range from moderately heavy, 12-22,000 lbs. per axle, to very heavy, i.e., tractor trailers and logging and mining trucks (Allied Automotive 1986). Examples of heavy off-road vehicles include agricultural tractors and earth-moving equipment.

[2] Drum brakes for heavy vehicles are either air- or hydraulic-activated, depending upon the application. Tractor trailers, for example, would always use air brakes, while medium-sized trucks would normally use hydraulic brakes (Allied Automotive 1986).

[3] See Attachment, Item 1.

of 1985°F.[4] The briquets are then formed into blocks at 265°F to 300°F under additional pressure (2,000 to 3,000 psi) for 10 to 30 minutes. The blocks are then cut and ground to shape. After curing, grinding, drilling, and chamfering (cutting grooves), the block is finished (ICF 1985). The finished block is then riveted to the brake shoe (Allied Automotive 1986).

Secondary processing of brake blocks is similar to that of drum brake linings. Some processors install new brake blocks into brake assemblies for new vehicles. Others may repackage blocks for sale as replacement parts in the aftermarket. None of these secondary processes involve any grinding, drilling, or other treatment of the brake block. Another distinct type of secondary processing is brake rebuilding. Rebuilders receive used, worn blocks attached to the shoes. The old blocks are removed from the shoes, the shoes are cleaned by abrasion, and new blocks are attached. The rebuilt shoes with blocks are then packaged and sold for the aftermarket (ICF 1985, Krusell and Cogley 1982).

B. Producers and Importers of Brake Blocks

Table 1 lists the twelve primary processors of brake blocks in 1985. At least eight of these firms produced an asbestos-based product; Raymark did not provide information. Allied Automotive is a relatively small manufacturer of brake blocks, producing only for the severe braking applications segment of the market (i.e., logging and mining trucks) (Allied Automotive 1986). At least eleven of the processors also currently produce substitute products (ICF 1986a, Design News 1984).

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[4] Brake blocks may also be woven from asbestos yarn; however, the woven block is an older and far less common technology (Carlisle 1986a). Raymark and Standco Industries are, apparently, the only two producers who still make woven brake blocks (ICF 1986a).

Table 1. 1985 Primary Processors of Brake Blocks

Company	Plant Location(s)	Product: Asbestos	Product: Non-Asbestos	References
Carlisle, Motion Control Industries Division	Ridgway, PA	X	X	ICF 1986a, TSCA 1982a
Abex	Salisbury, NC Winchester, VA	X X	X X	Abex 1986, TSCA 1982a
Nuturn	New Castle, IN	X	X	ICF 1986a, TSCA 1982a
Allied Automotive	Cleveland, TN	X	X	Allied Automotive 1986, TSCA 1982a
Raymark	Crawfordsville, IN	N/A[a]	X	Design News 1984, TSCA 1982a
Standco Industries	Houston, TX	X		ICF 1986a, TSCA 1982a
H.K. Porter	Huntington, IN	X[b]	X	ICF 1986a, TSCA 1982a
Brake Systems Inc. (Division of Echlin) (plant formerly owned by Molded Industrial Friction Co.)	Prattville, AL		X	ICF 1986a, TSCA 1982a
Palmer Products Corp.	Louisville, KY	X	X	ICF 1986a, TSCA 1982a
Friction Products	Medina, OH		X	Friction Products 1986
Scan Pac	Menomomee Falls, WI		X	ICF 1986a, TSCA 1982a
Wheeling Brake Block	Bridgeport, CT	X[c]	X	ICF 1986a, ICF 1985

N/A = Information not available.

[a]Raymark refused to provide production information. However, it was assumed that they produced asbestos brake blocks in 1985.

[b]H.K. Porter stated that it would phase out its production of asbestos brake blocks by the end of 1986 (PEI Associates 1986).

[c]Wheeling Brake Block of Bridgeport, CT phased out its production of asbestos brake blocks in 1985 (Wheeling Brake Block 1986).

Changes in primary processors from 1981 to 1985 include Brake Systems Inc.'s purchase of Molded Industrial Friction Co.'s plant in Prattville, AL. The Brake Systems plant phased out asbestos-based blocks prior to 1985, and now produces only a non-asbestos product (ICF 1986a). Wheeling Brake Block of Bridgeport, CT, phased out its asbestos-based brake block operations in 1986. The firm currently manufactures a non-asbestos product (Wheeling Brake Block 1986). H.K. Porter stated it would phase out production of asbestos-based blocks by the end of 1986 (PEI Associates 1986).

Table 2 lists the three current secondary processors of brake blocks. Freightliner Corporation of Portland, OR, is essentially Mercedes-Benz's U.S. truck operations (Freightliner 1986). Information was not available on the type of secondary processing in which these firms were involved.

Table 3 lists the importers of asbestos-based brake blocks. There were four importers in 1981. Hall Brake Supply, one of the 1981 importers, did not import in 1985. Navistar International and Abex did not provide information on their imports, therefore the total 1985 imports could not be determined.

C. Trends

Table 4 gives the production of asbestos-based brake blocks and the corresponding consumption of asbestos fiber. Although, producers and purchasers of brake blocks did not provide current market shares, they indicated that the majority of the original equipment market (OEM) and aftermarket is probably still asbestos-based (Abex 1986, Ford 1986a, DuPont

Table 2. 1985 Secondary Processors of Brake Blocks

Company	Plant Location	Product: Asbestos	Product: Non-Asbestos	References
Hall Brake Supply	Phoenix, AZ	X	N/A	ICF 1986b, TSCA 1982b
FMC Corporation	Cedar Rapids, IA	X		ICF 1986b, TSCA 1982b
Freightliner Corporation	Portland, OR	X	N/A	ICF 1986b, TSCA 1982b

N/A = Information not available.

Table 3. Imports of Asbestos-Based Brake Blocks

	1981 Quantity Imported (pieces)	1985 Quantity Imported (pieces)	References
Total	182,809	N/A	ICF 1984

N/A = Information not available.

Table 4. Production and Fiber Consumption for Asbestos-Based Brake Blocks

	1981	1985	References
Production (pieces)	18,457,840	4,570,266[a]	ICF 1986a, TSCA 1982a
Asbestos Fiber Consumption (tons)	12,992.5	2,643.6[b]	ICF 1986a, TSCA 1982a

[a]Allied Automotive, Abex, Raymark, and Wheeling Brake Block refused to provide production data for their asbestos-based brake blocks. Data on production for Allied Automotive, Abex and Raymark was estimated using a method described in the Appendix A to this RIA. Data for Wheeling Brake Block is not included. They did not make asbestos brake blocks in 1981 and they have stopped production of asbestos brake blocks in 1986. We, therefore, assume that their 1985 production is small.

[b]Abex, Raymark, and Wheeling Brake Block refused to provide fiber consumption data for their asbestos-based brake blocks. Data on fiber consumption for Abex and Raymark was estimated using a method described in the Appendix A to this RIA. Data for Wheeling Brake Block is not included. They did not make the asbestos product in 1981 and they have stopped production in 1986. Therefore, we assume their 1985 fiber consumption is small.

1986).[5] Representatives from Ford and Abex agreed that good substitutes have been developed for a range of brake block applications; however, some heavy truck and heavy vehicle applications (which they did not specify) do not yet have substitutes (Ford 1986a, Abex 1986). Ford also indicated that while substitutes have been developed, many may not be near the point of large-scale commercial production (Ford 1986a). DuPont, a major supplier of materials for friction products, e.g., Kevlar(R), estimated that currently 75 percent of OEM brake blocks are still asbestos-based (DuPont 1986). Thus, 75 percent is assumed to be the asbestos-based OEM share, as it is the only available figure and it is not out of line with the comments of Ford and Abex. All firms, however, agreed that substantial progress is being made towards the replacement of asbestos blocks in the OEM (Abex 1986, Ford 1986a, DuPont 1986).

D. <u>Substitutes</u>

For the vast majority of applications, i.e. heavy trucks and off-road vehicles, excluding the super-heavy applications (logging and mining trucks), the major group of substitutes are the non-asbestos organics (NAOs) (Carlisle 1986a, DuPont 1986, Allied Automotive 1986). In fact, 65 percent of Nuturn's brake block production is currently NAO blocks (ICF 1986a). The major substitute for the super-heavy braking applications (logging and mining trucks), which represent a very small share of the total market, is the full-metallic block (Carlisle 1986a, Allied Automotive 1986).

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[5] 100 percent of railroad car brake blocks are non-asbestos (Ford 1986a, Abex 1986); and probably 100 percent of aircraft brake blocks are also non-asbestos (Krusell and Cogley 1982). These types of brake blocks have been non-asbestos for the last several years, and it is likely that asbestos-based blocks were never used to any great extent (if at all) for these markets (Krusell and Cogley 1982). Therefore, for the purposes of defining the asbestos-based brake block market, railroad car and aircraft brake blocks will be excluded.

NAO formulations generally contain the following ingredients: Kevlar(R) and/or fiberglass and/or mineral fibers,[6] perhaps some steel wool and/or other fibers, and fillers and resins (ICF 1986a). Fiberglass and Kevlar(R) usually account for only a small percentage of the total formulation. For example, a representative from DuPont stated that the optimal level of Kevlar(R) in brake block formulations is usually only 5 percent by weight (DuPont 1986). Thus, labelling substitute brake blocks as Kevlar(R)-based or fiberglass-based (producers tend to do this for marketing reasons) is misleading (Carlisle 1986b, Abex 1986, Ford 1986a). Of the twelve primary processors of brake blocks in 1985, at least eight currently produce NAO blocks. These firms are: Carlisle, Abex, Nuturn, H.K. Porter, Brake Systems Inc., Palmer Products, Scan Pac, and Wheeling Brake Block (Abex 1986, Wheeling Brake Block 1986, ICF 1986a).[7]

Producers generally agree that NAO brake blocks have the same or better performance than asbestos-based blocks, as well as improved service life (ICF 1986a, Allied Automotive 1986, Carlisle 1986a). A representative from Carlisle, the largest producer of brake blocks in 1981 (with approximately 36.6 percent of the market), stated that, on average, NAO blocks had 30 percent greater service life than asbestos blocks. (Nuturn, another major producer, claimed its NAO blocks had 100 percent greater service life (ICF 1986a).) NAO blocks are priced 30-50 percent higher than asbestos blocks, according to Carlisle (Carlisle 1986a).

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[6] Mineral fibers commonly used by producers include: wollastonite, phosphate fiber, aluminum silicate fiber, Franklin fiber, mineral wool, and PMF (processed mineral fiber) (ICF 1986a).

[7] Raymark did not provide information; Allied Automotive is in the process of developing a non-asbestos, non-full-metallic block (Allied Automotive 1986).

Full-metallic blocks are molded from sintered steel wool and sponge iron, and contain no resin (Ford 1986a). Producers of full-metallic blocks include Allied Automotive and Wheeling Brake Block (Allied Automotive 1986, Wheeling Brake Block 1986).[8] Allied Automotive stated that these substitutes had improved performance over asbestos for extremely high temperature ranges (Allied Automotive 1986). By contrast, Wheeling Brake Block, which manufactures full-metallic blocks in only limited quantities, stated that in the past its product generally had poor performance compared to asbestos blocks, however they have been improving this product recently (Wheeling Brake Block 1986, 1987). Allied Automotive indicated that the full-metallic blocks have up to two times longer service life than asbestos blocks, while Wheeling Brake Block felt their product had the same life as asbestos blocks (Allied Automotive 1987, Wheeling Brake Block 1987). Carlisle, which used to make the full-metallic brake block, but no longer does so, also stated that full-metallics had about the same life as asbestos brake blocks (Carlisle 1987). For the purposes of the asbestos regulatory cost model the useful life of the full metallic brake block has been assumed to be the same as for the asbestos block.[9]

Full-metallic brake blocks on average are 20 percent more expensive per component than asbestos brake blocks, assuming the useful lives are the same. The computation for the price of the full metallic brake block price does include an adjustment for the longer life of Allied Automotive's product.[10]

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[8] S.K. Wellman of Toronto, Ontario, Canada also produces a full-metallic brake block. They are specialty items, however, and are not carried in stock (S.K. Wellman 1987).

[9] See Attachment, Item 4.

[10] See Attachment, Item 4.

A potential substitute for brake blocks in the future may be carbon fiber and carbon/carbon fiber composite brake blocks (Ashland Petroleum 1986). Up to the present time, carbon fiber and carbon/carbon fiber composite blocks have been so expensive that they have only been used in very demanding applications such as high-performance military aircraft and large commercial airline applications (Ashland Petroleum 1986). These carbon-based blocks are used because of their high thermal stability and low weight (Krusell and Cogley 1982). The Ashland Carbon Fibers Division of Ashland Petroleum, however, has recently developed a low cost carbon fiber and carbon pitch product (which is used in combination with the carbon fiber for the carbon/carbon fiber composite) for use in carbon-based brake blocks. The firm believes that carbon blocks will now be manufactured more widely for the commercial and industrial brake block markets (Ashland Petroleum 1986).

Given the current OEM market shares, however, it is clear that in the near-term NAO brake blocks will capture the majority of the asbestos-based OEM in the event of a ban (Carlisle 1986a, Allied Automotive 1986). A representative from Carlisle stated that 75-80 percent of the OEM would likely be NAO blocks, with only 0.5 percent being full-metallic; the balance being substitutes not yet developed (Carlisle 1986a).[11]

Choice of replacement of asbestos-based brake blocks in the aftermarket, however, is more difficult to estimate. Many producers and users agreed that brake systems designed for asbestos brake blocks should continue to use asbestos. Substitute linings which were designed for the OEM, when used to replace worn blocks, do not perform as well as asbestos, and could jeopardize brake safety (Allied Automotive 1986, Ford 1986b). Abex, however, indicated

[11] Until other replacements can be found for the remaining 19.5-24.5 percent of asbestos-based applications, it is assumed for the present that the NAO substitute will replace 99.5 percent of the asbestos market if asbestos were no longer available. See Attachment, Item 5.

that it is selling its OEM non-asbestos-organic blocks for the aftermarket, and reports that they are performing well (Abex 1986). Given this evidence, we have concluded that the aftermarket shares would be identical to the OEM shares.

Table 5 provides data for the regulatory cost model. The substitutes are the NAO and full-metallic blocks. Note that the equivalent price of the NAO block given in the table is close to the asbestos block price because of the longer service life.

E. <u>Summary</u>

Brake blocks are brake linings used in drum brakes of heavy vehicles such as heavy trucks, buses, and heavy off-road vehicles (ICF 1985). There were nine producers of asbestos-based brake blocks in 1985. These companies consumed 2,643.6 tons of asbestos and produced 4,570,266 pieces of brake blocks. Since 1985, H.K. Porter and Wheeling Brake Block have stopped processing asbestos. This leaves seven current producers of asbestos brake blocks (ICF 1986a).

A majority of the OEM (about 75 percent) and the aftermarket is still asbestos-based (Abex 1986, Ford 1986a, DuPont 1986). The major group of substitutes for most applications are the non-asbestos organics (NAOs). It is projected that they would capture 99.5 percent of the asbestos brake block market if asbestos were not available. Full metallic brakes are a major substitute in super-heavy braking applications and they are projected to capture the remaining 0.5 percent of the asbestos market.

Table 5. Data Inputs on Brake Blocks for Asbestos Regulatory Cost Model[a]

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	References
Asbestos Mixture	4,570,266 pieces	0.00058 tons/piece	1.01	$5.74/piece	0.5 years	$5.74/piece	N/A	ICF 1986a, ICF 1985,
NAO	N/A	N/A	N/A	$8.04/piece	0.65 years	$6.22/piece	99.5%	Carlisle 1986a
Full-Metallic	N/A	N/A	N/A	$6.89/piece	0.5 years	$6.89/piece	0.5%	Allied Automotive 1986, Wheeling Brake Block 1986, Carlisle 1986a

N/A: Not Applicable.

[a]See Attachment, Items 2-5.

ATTACHMENT

1. The asbestos fiber content per block was calculated by dividing the 1985 asbestos fiber consumption for brake blocks by the 1985 asbestos brake block production: 2,643.6 tons (5,287,200 lbs.) divided by 4,570,266 pieces, or 1.16 lbs. per piece.

2. The product asbestos coefficient is the same value calculated in Item 1 above, converted into tons per piece.

3. The consumption production ratio was calculated using 41,808 pieces as the value for 1985 U.S. imports. (Total 1985 production is 4,570,266 pieces.) This value, however, only includes imports for the firms who provided information (see Table 4).

4. The asbestos product price is a weighted average (by production) of prices for producers who provided both price and production information for 1985. The useful life of the asbestos product was assumed to be the same as that reported in 1984 in Appendix H (ICF 1985).

   The price and useful life of the NAO block was calculated by multiplying what Carlisle reported as the average percent increase in price and useful life, respectively, of an NAO block over an average asbestos block by the (weighted average) asbestos product price and useful life, respectively. As mentioned in the text, Carlisle stated that NAO blocks are 30-50 percent higher in price (thus, 40 percent is used as the price increase) and have 30 percent longer useful life.

   The price and useful life of full-metallic brake blocks was computed based on information from three firms. Wheeling Brake Block claims their full-metallic brake block has the same useful life as asbestos brake blocks, but is 10-15 percent (12.5 percent average) more expensive (Wheeling Brake Block 1987). Carlisle, which no longer makes the full-metallic product but is familiar with the market, stated that full-metallic brake blocks have the same life as asbestos brake blocks, but are approximately 25 percent more expensive (Carlisle 1987). A third firm, Allied Automotive, claims their full metallic brake block have up to double the useful life (we assumed 50 percent on average), but is 83 percent more expensive than their premium asbestos product (Allied Automotive 1987). In order to average the estimates for these three firms, an equivalent price for the Allied Product had to be computed. (The equivalent price is a present value calculation that determines the price a product would have if it had the same useful life as asbestos.) This calculation showed Allied Automotive's full-metallic product to be 22.65 percent more expensive than asbestos blocks. The average cost of the full-metallic brake block is therefore 20.05 percent more expensive than asbestos brake blocks.

5. The market shares for the substitutes are provided by Carlisle. Carlisle stated the super-heavy applications (logging and mining trucks), for which full-metallic blocks would be used, represent only 0.5 percent of the market. Seventy-five to 80 percent of the market, stated Carlisle, would be captured by NAO blocks and the rest of the market would be taken by substitutes not yet developed. However, until other replacements can be found for the remaining 19.5-24.5 percent of asbestos-based applications, it is assumed that for the present that NAO blocks will replace 99.5 percent of the asbestos market if asbestos were no longer available.

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XXII. CLUTCH FACINGS

A. Product Description

Clutch facings are friction materials attached to both sides of the steel disc in the clutch mechanism of manual-transmission vehicles. Two metal pressure plates flanking the disc are pressed against the clutch facings by springs when the clutch is engaged. This pressure keeps the gears of the vehicle in position by means of a metal component that extends between the disc and the gears. When the driver steps on the clutch pedal to change gears, the springs pressing the plates against the clutch facings are pulled back, releasing the pressure that holds the gears in position (ICF 1985).

Clutch facings are made of molded or woven friction materials. Molded facings are used more widely than the woven (H.K. Porter 1986, ICF 1985). Woven clutch facings are a premium product. They have longer service life and engage gears better than molded facings; however, they cost substantially more (H.K. Porter 1986, ICF 1985). Woven clutch facings are, therefore, used in luxury automobiles (e.g., Mercedes-Benz) and high-performance vehicles. They may also be used in off-road vehicles, such as agricultural tractors and earth-moving equipment, where improved service life is important (H.K. Porter 1986, Deere and Co. 1986).[1]

Molded and woven clutch facings for the automotive markets are usually made of asbestos or fiberglass (ICF 1985).[2] The molded products are usually

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[1] The service life of these off-road vehicles ranges from 20 to 35 years, or roughly five times the life of an automobile. Clutch facings for these vehicles must last the lifetime of the vehicle, as the typical cost of opening up the transmission to replace a worn facing is on the order of $10,000 (Deere and Co. 1986).

[2] In heavy trucks and heavy earth-moving equipment, the clutch facings are replaced by buttons which can withstand greater pressure but are heavier, noisier, and cost more than materials used in automobiles. The buttons are made of sintered metal (bonded metal particles). Asbestos has almost never been used for these clutch applications (S.K. Wellman 1986). Thus, for the purpose of defining the asbestos-based clutch facing market, heavy vehicle clutch components will be excluded.

made by a dry mix process, as described for disc brake pads. Asbestos fiber or fiberglass is combined with binders in the molding process, during which wires are run through the component to give it shape. The final product is then pressed, cured, and ground to its final shape. Woven clutch facings are made by running asbestos or fiberglass yarn or cord through a wet mix to pick up the wet mixture. The yarn or cord is then woven after drying. The woven product is then hot-pressed, cured, and ground, as other wet-mix friction products (e.g., drum brake linings for light/medium vehicles) (ICF 1985, Krusell and Cogley 1982).

Secondary processing of clutch facings is similar to the secondary processing of automotive friction products previously discussed. Woven clutch facings may be rebuilt, as described for other automotive products (ICF 1985, Krusell and Cogley 1982). Repair of clutches is similar to repair of drum and disc brakes, as described earlier (ICF 1985, Krusell and Cogley 1982).

Asbestos-based molded clutch facings currently produced contain approximately 0.26 lbs. of asbestos fiber per piece (ICF 1986a).[3] (Data was not available on the asbestos fiber content per piece for woven facings.) Asbestos fiber is used to impart stability under friction, good wear up to 480°F, quietness, and very high tensile strength of 10,000 psi (ICF 1985).

B. Producers and Importers of Clutch Facings

Table 1 lists the three primary processors of clutch facings in 1985.[4] All three produce for the automobile, truck, and off-road vehicle markets; and, all firms make asbestos as well as non-asbestos facings (ICF 1986a). Raymark manufactures woven and, probably, molded facings (ICF 1986a, H.K. Porter 1986). H.K. Porter manufactures only woven facings; the firm stated

[3] See Attachment, Item 1.

[4] Producers of clutch buttons (which are non-asbestos) for heavy trucks and off-road vehicles are not included.

Table 1. 1985 Primary Processors of Clutch Facings

Company	Plant Location(s)	Product		References
		Asbestos	Non-Asbestos	
Raymark	Manheim, PA	X	X	ICF 1986a, TSCA 1982a
	Stratford, CT[a]	N/A	N/A	TSCA 1982a
	Crawfordsville, IN[a]	N/A	N/A	PEI Associates 1986
H.K. Porter	Huntington, IN	X	X	ICF 1986a, TSCA 1982a
Futurn	Smithville, TN	X	X	ICF 1986a, TSCA 1982

N/A = Information not available.

[a]This plant refused to respond to our survey. It is assumed that they are still producing asbestos clutch facings.

that it and Raymark are probably the only two current producers of woven facings (H.K. Porter 1986). H.K. Porter stated, however, that it would completely replace production of asbestos-based clutch facings with non-asbestos substitutes by the end of 1986 (PEI Associates 1986). Standco Industries of Houston, TX, (not listed in Table 1) ceased production of asbestos clutch facings prior to 1985; information was not available on whether it produced a non-asbestos product (ICF 1986a).

Table 2 lists the six current secondary processors of clutch facings. Freightliner Corporation of Portland, OR, is essentially Mercedes-Benz's U.S. truck operations (Freightliner 1986). Information was not available on the type of secondary processing in which these firms were involved (ICF 1986b).

Table 3 lists the 27 current importers of asbestos-based clutch facings. According to DuPont, non-asbestos clutch facings are used extensively in European cars; most new German cars, in fact, are equipped with non-asbestos facings (DuPont 1986). Nuturn of Smithville, TN, (not listed in Table 3) stopped importing asbestos-based clutch facings prior to 1985 (Nuturn 1986). Saab-Scania of America (Orange, CT; not listed in Table 3) reported that Saab cars are equipped with non-asbestos clutch facings; the firm stopped importing asbestos facings prior to 1985 (Saab-Scania of America 1986). New Mercedes-Benz automobiles are also equipped with non-asbestos clutch facings (DuPont 1986b).

C. Trends

Table 4 gives the production of asbestos-based clutch facings and the corresponding consumption of asbestos fiber. The 1985 values for production and fiber consumption do not include Raymark's Crawfordsville, IN, plant. Information on the size of the clutch facings production at the Crawfordsville plant was not available (ICF 1986a).

Table 2. 1985 Secondary Processors of Clutch Facings

Company	Plant Location(s)	Product		References
		Asbestos	Non-Asbestos	
Stanhope	Brookville, OH	X	N/A	ICF 1986b, TSCA 1982b
Comdaco	Kansas City, MO	X	N/A	ICF 1986b, TSCA 1982b
Freightliner Corp.	Portland, OR	X	N/A	ICF 1986b, TSCA 1982b
Hall Brake Supply	Phoenix, AZ	X	N/A	ICF 1986b, TSCA 1982b
Borg and Beck Clutch	Chicago, IL	N/A	N/A	TSCA 1982b
Dana Corp.	Wichita Falls, TX	N/A	N/A	TSCA 1982b

N/A = Information not available.

Table 3. Importers of Asbestos-Based Clutch Facings

Company	Location	References
U.S. Suzuki Motor Corp.	Brea, CA	ICF 1986a, ICF 1984
Toyota Motor Sales, USA	Torrence, CA	ICF 1986a, ICF 1984
Western Automotive Warehouse Distributors	Los Angeles, CA	ICF 1984
Kawasaki Motors Corp.	Santa Ana, CA	ICF 1986a, ICF 1984
J.I. Case	Racine, WI	ICF 1984
General Motors	Dayton, OH	ICF 1984
BMW of North America	Montvale, NJ	ICF 1984
Mercedes-Benz of North America	Montvale, NJ	ICF 1984
Volkswagen of America	Troy, MI	ICF 1986a, ICF 1984
Peugeot Motors of America	Lyndhurst, NJ	ICF 1984
Freightliner Corp.	Portland, OR	ICF 1986a, ICF 1984
Original Quality Inc.	Jacksonville, FL	Original Quality 1986
Alfa Romeo	Englewood Cliffs, NJ	Automobile Importers of America 1986
Fiat	Dearborn, MI	Automobile Importers of America 1986
American Honda Motor Company	Gardena, CA	Automobile Importers of America 1986
American Isuzu Motor, Inc.	Whittier, CA	Automobile Importers of America 1986
Jaguar	Leonia, NJ	Automobile Importers of America 1986
Lotus Performance Cars	Norwood, NJ	Automobile Importers of America 1986
Mazda (North America) Inc.	Irvine, CA	Automobile Importers of America 1986
Mitsubishi Motors Corp. Services, Inc.	Southfield, MA	Automobile Importers of America 1986
Nissan Motor Corp.	Gardena, CA	Automobile Importers of America 1986
Porsche Cars North America	Reno, NV	Automobile Importers of America 1986
Renault USA, Inc.	New York, NY	Automobile Importers of America 1986

Table 3 (Continued)

Company	Location	References
Rolls-Royce Motors, Inc.	Lyndhurst, NJ	Automobile Importers of America 1986
Subaru of America, Inc.	Pennsauken, NJ	Automobile Importers of America 1986
Volvo Cars of North America	Rockleigh, NJ	Automobile Importers of America 1986
Hyundai Motor America	Garden Grove, CA	Automobile Importers of America 1986

Table 4. Production and Fiber Consumption for
Asbestos-Based Clutch Facings

	1981	1985	References
Production (pieces)	7,478,934	7,237,112[a]	ICF 1986a, TSCA 1982a
Asbestos Fiber Consumption (tons)	1,120.5	993.5[b]	ICF 1986a, TSCA 1982a

[a]Raymark's Crawfordsville, IN and Stratford, CT plant refused to provide production data. Raymark's Stratford, CT production was estimated using a method described in the Appendix A of this RIA. The Crawfordsville, IN plant's production could not be estimated because they did respond to the 1981 TSCA Section 8(a) data request regarding this product and thus no previous production data were available to use for an estimate of 1985 production. Therefore, the number for total production does not include the production volume of Raymark's Crawfordsville, IN plant.

[b]Raymark's Crawfordsville, IN and Stratford, CT plant refused to provide fiber consumption data. Raymark's Stratford, CT plant fiber consumption was estimated using a method described in the Appendix A of this RIA. The Crawfordsville, IN plant's fiber consumption data could not be estimated because they did not respond to the 1981 TSCA Section 8(a) data request regarding this product and thus no previous fiber consumption data were available to use for an estimate of 1985 consumption. Therefore, the total fiber consumption number does not include asbestos fiber consumption of Raymark's Crawfordsville, IN plant.

The production of asbestos-based facings remained fairly level from 1981 to 1985. While the overall size of the clutch facings market (asbestos and non-asbestos substitutes) is not known, the asbestos-based share of the market may have declined somewhat. The vast majority of the clutch facings market is for light/medium vehicles, i.e., cars and light trucks (Ford 1986, Abex 1986). Currently, 15 percent of light/medium vehicles have manual transmissions (and, thus, use clutch facings), but this percentage has been steadily increasing (Ford 1986). Therefore, since the asbestos-based production remained fairly constant from 1981 to 1985, the non-asbestos-based share of the overall market may have increased.

D. Substitutes

All three primary processors of clutch facings produce a non-asbestos product; however, none of the producers would give estimates for the current shares the substitutes hold in the original equipment market (OEM) or aftermarket (ICF 1986a). U.S. automakers frequently import non-asbestos clutch facings from Europe, where they are used extensively. According to DuPont, the European woven clutch facings contain fiberglass, acrylic, and other fibers and are made primarily by Valeo, a French manufacturer (DuPont 1986 and 1987). Price and performance data for the European woven clutches were not available.

Raymark and H.K. Porter also produce non-asbestos fiberglass-based woven clutch facings (H.K. Porter 1986, DuPont 1987). While Raymark would not provide information, H.K. Porter stated that its fiberglass[5] woven facing has the same or improved performance and service life over asbestos-based woven facings, and that it is priced the same as its asbestos product. While the fiberglass product is more difficult to process, the same processing equipment can be used. Because woven clutch facings cost substantially more than molded

[5] The product also contains a smaller proportion of other fibers, which H.K. Porter did not specify (ICF 1986a).

products, however, H.K. Porter did not believe that woven fiberglass facings could capture the majority of the asbestos-based market in the event of a ban (ICF 1986a, H.K. Porter 1986).

Raymark and Nuturn manufacture non-asbestos molded clutch facings (ICF 1986a). Raymark's facing is fiberglass-based; the firm, however, would not provide price or performance information, nor would it estimate the expected market share in the event of a ban (ICF 1986a). Nuturn's facing contains aramid fiber, cellulose fiber, fiberglass, and ceramic fiber (ICF 1986a). Nuturn indicated that its non-asbestos product was priced 49 percent higher than its asbestos-based facing, but it had the same or up to 50 percent longer service life. This non-asbestos facing, however, would not be structurally stable in higher-temperature applications. Nuturn could not estimate the expected share of the market in the event of a ban (ICF 1986a).

Table 5 provides the data for the regulatory cost model. The substitute clutch facings included in the table are the European woven fiberglass facing, the molded fiberglass facing, Nuturn's molded product, and the woven fiberglass facing made by U.S. producers. Because price and useful life were not available for the European woven fiberglass clutch facing or Raymark's molded fiberglass facings, for the asbestos regulatory cost model it was assumed that the European product had the same price and longevity as the woven fiberglass facings produced by the U.S. firms Raymark and H.K. Porter, and that Raymark's molded fiberglass facing had the same life and price as Nuturn's aramid and fiberglass molded facing.

It should be noted that the asbestos substitute clutch facing market has been changing rapidly as substitutes improve. The market shares and prices shown in Table 5 are 1986 estimates; as of July, 1987 some of this information is already outdated and the market is still changing. This change is primarily due to U.S. firms improving their woven substitute facings (DuPont 1987).

Table 5. Data Inputs on Clutch Facings for Asbestos Regulatory Cost Model[a]

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	References
Asbestos mixture	7,237,112 pieces	0.00014 tons/piece	1.12	$1.71/piece	5 years	$1.71/piece	N/A	ICF 1986a, ICF 1985, b
Woven fiberglass (European product)	N/A	N/A	N/A	$2.92/piece	7.5 years	$2.11/piece	50%	DuPont 1986
Woven figerglass (U.S. Product)	N/A	N/A	N/A	$2.92/piece	7.5 years	$2.11/piece	30%	ICF 1986a
Molded aramid fiber, fiberglass, cellulose and ceramic fiber (Nuturn's product)	N/A	N/A	N/A	$2.55/piece	6.25 years	$2.12/piece	10%	ICF 1986a
Molded fiberglass	N/A	N/A	N/A	$2.55/piece	6.25 years	$2.12/piece	10%	ICF 1986a

N/A: Not Applicable.

[a]See Attachment, Items 2-7.

E. Summary

Clutch facings are friction materials attached to both sides of the steel disk in the clutch mechanism of manual transmission vehicles. Clutch facings are made of molded or woven friction materials; molded facings are used more widely than woven facings (ICF 1985, H.K. Porter 1986). In 1985, three producers consumed 993.5 tons of asbestos to produce 7,237,112 asbestos clutch facings. All three firms also make non-asbestos facings (ICF 1986a). The production of asbestos-based clutch facings remained fairly level from 1981 to 1985. The four major substitutes for the asbestos clutch facings are: European facings which contain fiberglass and other fibers; molded fiberglass-based facings produced by Raymark; a Nuturn molded facing containing aramid fiber, cellulose fiber, fiberglass and ceramic fiber; and fiberglass-based woven facing made by both Raymark and H.K. Porter (DuPont 1986 1987). Equivalents costs for the substitutes were 20-25 percent higher than for the asbestos product. If asbestos were not available it is estimated that the European substitute will take 50 percent, woven fiberglass 30 percent, molded fiberglass 10 percent and Nuturn's product 10 percent of the asbestos-based clutch facing market.

ATTACHMENT

1. The asbestos fiber content per piece was calculated by dividing the 1985 asbestos fiber consumption for molded asbestos clutch facings 993.5 tons or 1,987,000 lbs. by the 1985 production of molded asbestos clutch facings (7,237,112 pieces).

2. The product asbestos coefficient is the same value calculated in Item 1 above, converted into tons per piece.

3. The consumption production ratio was calculated using 885,947 pieces as the value for 1985 U.S. imports. (Total 1985 production of asbestos clutch facings is 7,237,112 pieces.) This value, however, only includes imports for the firms who provided information (see Table 4).

4. The asbestos mixture price is the price given by Nuturn for its molded asbestos product. The woven fiberglass mixture price is the price given by H.K. Porter for its woven fiberglass product.

5. The useful life of the asbestos mixture is assumed to be the same as that reported in 1984 in Appendix H (ICF 1985). The useful life of the woven fiberglass facing produced by U.S. firms is assumed to be 50 percent greater than the molded asbestos product, or 7.5 years. H.K. Porter stated the woven facing is a "premium" product with significantly longer service life than molded products (H.K. Porter 1986). Nuturn stated its substitute had the same or up to 50 percent increased service life (ICF 1986a). Thus, a 25 percent service life increase is assumed, which gives the Nuturn product a life of 6.25 years. Because price and useful life were not available for the European woven fiberglass clutch facing or Raymark's molded fiberglass facings, for the asbestos regulatory cost model it was assumed that the European product had the same price and longevity as the woven fiberglass facings produced by the U.S. firms Raymark and H.K. Porter, and that Raymark's molded fiberglass facing had the same life and price as Nuturn's aramid and fiberglass molded facing.

6. Based upon DuPont's statement that the European clutch facings are frequently used by U.S. automakers, a 50 percent share is assumed for the European facings. H.K. Porter stated that 30 percent of the market would be captured by the fiberglass woven facings. The remaining share is split equally between the molded fiberglass facings and Nuturn's product.

7. It should be noted that the asbestos substitute clutch facing market has been changing rapidly as substitutes improve. The market shares and prices shown in Table 5 are 1986 estimates; as of July, 1987 some of this information is already outdated and the market is still changing. This change is primarily due to U.S. firms improving their woven substitute facings (DuPont 1987).

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XXIII. AUTOMATIC TRANSMISSION FRICTION COMPONENTS

A. Product Description

An automatic transmission consists of 5 to 15 small metal rings called friction clutches, which are housed, along with gears, in a metal band called the transmission band. Each friction clutch is covered with a thin friction clutch plate which is made from a friction paper that contains asbestos or some other friction material. In addition, a lining, also made from this friction paper, is bonded to the inside of the transmission band (Mead 1986, Borg-Warner 1986). These automatic transmission friction components -- friction clutch plates and transmission band linings -- are immersed in a fluid environment which dissipates much of the heat generated when gears are changed. Asbestos-based automatic transmission friction components made by S.K. Wellman for medium trucks, for example, are 1/16 of an inch thick and may contain approximately 0.11 lbs. of asbestos per component (15 percent asbestos by weight) (S.K. Wellman 1986).[1]

Paper for automatic transmission components is manufactured by conventional paper-making processes; i.e., raw materials (the chosen friction material, fillers, and resins) are pulped and fed into a continuous papermaking machine. Finished paper is then removed from the machine (ICF 1985). Automatic transmission friction components are then cut from the paper, and after they are pressed and shaped, grooves (these can vary in design) are either cut or stamped into the components (ICF 1985).[2]

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[1] Raymark, another U.S. producer of asbestos-based automatic transmission friction components for automobiles, refused to provide information.

[2] Cut grooves are preferred over the stamped ones because they last longer (ICF 1985).

Two producers, Borg-Warner[3] and S.K. Wellman, purchase their friction paper. Information was not available on whether the other producer, Raymark, manufactures or purchases its friction paper. Armstrong World Industries (Fulton, NY) and Mead Corporation (South Lee, MA) produce friction paper for sale to the producers of automatic transmission components (ICF 1986a).[4]

Automobiles, light/medium trucks, and off-road vehicles use components made from friction paper (Borg-Warner 1986, S.K. Wellman 1986, Deere and Co. 1986). Friction components for the transmissions of heavy trucks, such as eighteen-wheel tractor trailers and logging and mining trucks, and certain off-road vehicles (heavy tractors and earth-moving equipment), however, are usually made from sintered metal that is molded into the desired shapes (S.K. Wellman 1986).

B. Producers and Importers of Automatic Transmission Friction Components

Table 1 lists the three current producers of (asbestos and non-asbestos) automatic transmission friction components. Borg-Warner produces only non-asbestos components (it did not produce asbestos-based components in 1981 either) (ICF 1986a). The other two manufacturers produced both asbestos and non-asbestos components in 1985 (S.K. Wellman 1986, Raymark 1986).[5] Borg-Warner produces transmission components for automobiles and trucks (ICF 1986a). S.K. Wellman produces components only for off-road vehicles and medium and heavy trucks (S.K. Wellman 1986). The third producer, Raymark,

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[3] Borg-Warner only uses non-asbestos-based friction paper (ICF 1986a).

[4] Armstrong World Industries makes both asbestos and non-asbestos friction paper; Mead Corporation only makes a non-asbestos variety. The latter company discontinued production of asbestos-based paper in December, 1983 (ICF 1986a).

[5] S.K. Wellman stopped producing asbestos-based automatic transmission friction components in March, 1987 (S.K. Wellman 1986).

Table 1. Producers of Automatic Transmission Friction Components

Company	Plant Location	Product: Asbestos	Product: Non-Asbestos	Market	References
S.K. Wellman	LaVergne, TN	X[a]	X	Medium and heavy trucks, off-road vehicles[a]	S.K. Wellman 1986, ICF 1984
Raymark	Stratford, CT Crawfordsville, IN	X N/A	X N/A	Autos, trucks, off-road vehicles[b]	ICF 1986a, ICF 1984, TSCA 1982a, Deere and Co. 1986
Borg-Warner	Frankfort, IL		X	Autos, trucks	ICF 1986a, TSCA 1982b

N/A = Information not available.

[a]S.K. Wellman stopped the production of asbestos-based automatic transmission friction components in March, 1987 (S.K. Wellman 1986).

[b]Off-road vehicles include tractors and earth-moving equipment.

makes components for automobiles, trucks, and off-road vehicles (Raymark 1986, S.K. Wellman 1986, Deere and Co. 1986).

There were no secondary processors of automatic transmission friction components in 1985 or in 1981 (ICF 1986b, 1985).

Table 2 lists the importers of asbestos-based components.

C. Trends

In 1981, the industry was slowly moving away from asbestos in automatic transmission components, and by 1985 substitution had increased rapidly (Borg-Warner 1986, ICF 1985). It is estimated that approximately 25 percent of the original equipment market (OEM) is still asbestos-based.[6] Data were not available for the percent share for the aftermarket, although it is likely to be higher than in the OEM.

Table 3 gives the production and fiber consumption of asbestos-based components. Because of the lack of available data, it is difficult to determine the actual decline in production from 1981 to 1985; however, sources generally agree that the substitution of asbestos in automatic transmission components will be complete, in at least new vehicles, in the near future (Borg-Warner 1986, S.K. Wellman 1986, DuPont 1986, Mead 1986).

D. Substitutes

Automatic transmission components made from cellulose-based friction paper are currently the main substitute for asbestos-based components (DuPont 1986, Mead 1986). Borg-Warner is the leading producer of cellulose-based components (Borg-Warner 1986). The chief cellulose material in its components is cotton fiber (Borg-Warner 1986). Cellulose-based components can also contain other fibers in smaller proportions. Mead Corporation produces friction paper containing greater than 50 percent cotton fibers with varying amounts of

[6] See Attachment, Item 1.

Table 2. Imports of Asbestos-Based Automatic Transmission Friction Components

Company	Location	References
Volkswagen of America	Troy, MI	ICF 1984
Toyota Motor Sales, USA	Torrence, CA	ICF 1984
Mercedes-Benz of North America	Montvale, NJ	ICF 1984
Western Automotive Warehouse Distributors	Los Angeles, CA	ICF 1984
Raymark, via their Japanese subsidiary, Daikin	Trumbull, CT[a]	ICF 1984
American Honda Motor Company	Gardena, CA	Automobile Importers of America 1986
American Isuzu Motor, Inc.	Whittier, CA	Automobile Importers of America 1986
Jaguar	Leonia, NJ	Automobile Importers of America 1986
Mazda (North America) Inc.	Irvine, CA	Automobile Importers of America 1986
Mitsubishi Motors Corp. Services, Inc.	Southfield, MA	Automobile Importers of America 1986
Nissan Motor Corp.	Gardena, CA	Automobile Importers of America 1986
Renault USA, Inc.	New York, NY	Automobile Importers of America 1986
Rolls-Royce Motors, Inc.	Lyndhurst, NJ	Automobile Importers of America 1986
Subaru of America, Inc.	Pennsauken, NJ	Automobile Importers of America 1986
Alfa Romeo	Englewood Cliffs, NJ	Automobile Importers of America 1986
Fiat	Dearborn, MI	Automobile Importers of America 1986
Lotus Performance Cars	Norwood, NJ	Automobile Importers of America 1986
Porsche Cars North America	Reno, NV	Automobile Importers of America 1986
Hyundai Motor America	Garden Grove, CA	Automobile Importers of America 1986
Volvo Cars of North America	Rockleigh, NJ	Automobile Importers of America 1986

N/A = Information not available.

[a]Since Raymark refused to provide information, Raymark's corporate headquarters is given as the location.

Table 3. Production and Fiber Consumption for
Asbestos-Based Automatic Transmission Friction Components

	1981		1985		
	Production (pieces)	Asbestos Fiber Consumption (tons)	Production (pieces)	Asbestos Fiber Consumption (tons)	References
Total	N/A	N/A	585,500[a]	2.5[a]	TSCA 1982b ICF 1986a

N/A = Information not available.

[a] Raymark Corp. refused to provide production and fiber consumption data. This data has, therefore, been estimated using a method described in the Appendix A to this RIA.

fiberglass and/or aramid fiber and/or carbon or graphite filler, depending on the application (ICF 1986a).[7] S.K. Wellman, Borg-Warner, and Raymark produce cellulose-based automatic transmission components for agricultural tractors containing either:

- Cotton fiber, with carbon fiber, cellulite, graphite filler, and phenolic resin; or
- Cellulose fiber, with cellulite and phenolic resin (Deere and Co. 1986).

Industry experts agree that if asbestos were no longer available, the original equipment market (OEM) would switch entirely to cellulose-based components (ICF 1986a, DuPont 1986, Mead 1986). Borg-Warner stated, and repair shops (previously interviewed by ICF in 1983) agreed, that cellulose-based components are also entirely interchangeable in the automobile aftermarket with no loss of performance (Borg-Warner 1986, ICF 1985). Deere and Company, a major manufacturer of tractors, indicated that cellulose-based components were not interchangeable with asbestos components in the tractor aftermarket because these transmissions were designed for the particular coefficient of friction of the asbestos components. Deere and Company has redesigned transmission systems specifically for cellulose-based components. The company stated that it was unlikely that suppliers would develop substitutes in the tractor aftermarket because of the relatively low volume of the market (which is also diminishing) and the extreme technical difficulty of engineering a substitute for a transmission system that was designed specifically for asbestos components (Deere and Co. 1986).

Table 4 provides the data for the regulatory cost model.

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[7] Armstrong World Industries stated its non-asbestos friction paper contained cellulose fibers and inorganic fillers; it did not indicate any additional fibers (ICF 1986a).

Table 4. Data Inputs on Automatic Transmission Friction Components for Asbestos Regulatory Cost Model

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	References
Asbestos Mixture	585,500 pieces	0.0000043 tons/piece	1.0	$1.60/piece	4-7 years	$1.60/piece	N/A	ICF 1986a, ICF 1985
Cellulose	N/A	N/A	N/A	$2.00/piece	4-7 years	$2.00/piece	100%	ICF 1986a, DuPont 1986, Mead 1986

N/A: Not Applicable.

[a]See Attachment, Items 2-4.

E. Summary

Automatic transmission friction components are either friction clutch plates or transmission band linings. Friction clutch plates are made from thin pieces of friction paper and cover friction clutches which are small metal rings found in each automatic transmission. A transmission band is a metal band that houses the gears and friction clutches; a lining made of friction paper is bonded to the inside of the transmission band (Mead 1986, Borg-Warner 1986).

Two companies consumed 2.5 tons of asbestos to produce 585,500 pieces of automatic transmission friction components in 1985 (ICF 1986a). In March, 1987 one of these companies ceased production of asbestos-based automatic transmission friction components, leaving one remaining U.S. producer (ICF 1986a). There are more than 14 companies importing asbestos-based components (ICF 1984, Automobile Importers of America 1986). Approximately 25 percent of the OEM for automatic transmission friction components is still asbestos based. The major substitute for asbestos-based components are made from cellulose-based friction paper, which contains cotton and possibly other fibers in smaller proportions (Mead 1986). If asbestos were no longer available, the OEM would switch entirely to cellulose-based components. There is disagreement as to whether asbestos-based automatic transmission friction components are completely interchangeable with cellulose-based components for all vehicle types in the replacement/repair market.

ATTACHMENT

1. According to a representative from Borg-Warner, the largest producer of automatic transmission friction components (all non-asbestos), asbestos-based components now account for roughly 50 percent of the OEM, but this share is rapidly declining (Borg-Warner 1986). Representatives from DuPont and Mead Corporation both stated that replacement of asbestos-based components in the OEM is now nearly 100 percent (DuPont 1986, Mead 1986). Using an average of the above estimates, and the fact that Borg-Warner is the largest producer, it is assumed that approximately 25 percent of the OEM is still asbestos-based.

2. The product asbestos coefficient was determined by dividing the total tons of asbestos fiber consumed by the number of pieces of components produced shown in Table 2.

3. The consumption production ratio was calculated assuming no imports for 1985. Importers did not provide information for 1985.

4. Since Raymark, the only remaining U.S. producer of asbestos-based components, did not provide information, the asbestos product price and useful life is assumed to be the same as that reported in 1984 in Appendix H (ICF 1985). Borg-Warner stated the purchase price of cellulose-based components was 25 percent higher than the asbestos product, thus the cellulose product price in the table is 1.25 times the asbestos product price. Borg-Warner also indicated that the useful life of the cellulose components was the same as the asbestos product (Borg-Warner 1986).

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XXIV. FRICTION MATERIALS

A. Product Description

Friction materials are used as braking and gear-changing (clutch) components in a variety of industrial and commercial machinery.[1] Applications include agricultural equipment such as combines, mining and oil-well-drilling equipment, construction equipment such as cranes and hoists, heavy equipment used in various manufacturing industries (e.g., machine tools and presses), military equipment, marine engine transmissions, elevators, chain saws, and consumer appliances such as lawn mowers, washing machines, and vacuum cleaners (Raymark 1986b, Design News 1984, ICF 1986a, 1985).

Friction materials are either molded or woven products for use in wet or dry friction systems (Design News 1984, ICF 1985, DuPont 1986, Deere and Co. 1986, Krusell and Cogley 1982).[2] Molded products include thin segments, blocks, and other components used as brake linings, as well as rings[3] and other molded components used as clutches (H.K. Porter 1986, Design News 1984). Brake linings may also be woven bands (Design News 1984, Krusell and Cogley 1982). Band applications range from large band brakes for oil-well-drilling equipment, cranes, and hoists, to light-duty general-purpose bands for a variety of commercial and industrial machines (Design News 1984).

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[1] This product category includes all brake and clutch applications other than automobiles, trucks, and off-road vehicles (including tractors and earth-moving equipment).

[2] Heavy industrial equipment often use oil-cooled clutches and brakes, sometimes referred to as wet friction products, because of severe operating conditions and design considerations. Fluids facilitate the transfer of heat away from the working surface of the friction material providing superior durability and resulting in longer life between major overhauls and replacement. Large band brakes for oil-well drilling equipment, cranes, and hoists require a special fluid system (Design News 1984). Wet friction systems may also be used in other lighter-duty commercial and industrial applications (DuPont 1986).

[3] One producer, H.K. Porter, considers these molded rings to be washers (ICF 1986a).

Asbestos is used in friction materials for the following reasons:

- Stable friction properties under heat;
- Strength;
- Wear resistance;
- Flexibility (asbestos-based materials can be shaped or bent easily); and
- Relatively low cost (ICF 1985, Raymark 1986b).

Asbestos-based friction materials contain an average 0.37 lbs. of asbestos fiber per piece (ICF 1986a).[4]

Manufacturing methods for friction materials vary depending on the type and application of the material. For example, woven asbestos band-brakes for heavy-duty uses are produced by passing asbestos cord, possibly reinforced with wire, through a wet-mix to pick up resin and modifiers. The saturated cord is then woven into tapes. The tapes are heated to partially cure the resin, and then may be further cured to form flexible bands or rigid segments (Krusell and Cogley 1982). Information on secondary processing, as well as rebuilding and repair of worn friction materials, was not available.

B. Producers and Importers of Friction Materials

Table 1 lists the seven producers of (asbestos and non-asbestos) friction materials in 1985. All producers, except for Scan Pac, produced an asbestos product in 1985 (ICF 1986a, PEI Associates 1986). All firms except Virginia Friction Products currently produce non-asbestos-based materials (ICF 1986a, PEI Associates 1986). Gatke Corporation is a relatively small producer, making asbestos products for cranes, hoists, and oil-well-drilling equipment

[4] See Attachment, Item 1.

Table 1. 1985 Primary Processors of Friction Materials

Company	Plant Location(s)	Product: Asbestos	Product: Non-Asbestos	References
Raymark	Manheim, PA	X	X	ICF 1986a, TSCA 1982a
	Stratford, CT[a]	N/A	N/A	
National Friction Products	Logansport, IN	X	X	ICF 1986a, TSCA 1982a
Virginia Friction Products	Houston, TX	X		PEI Associates 1986
Gatke Corp.	Warsaw, IN	X	X	ICF 1986a, TSCA 1982a
Wheeling Brake Block	Bridgeport, CT	X[b]	X	ICF 1986a, TSCA 1982a
H.K. Porter	Huntington, IN	X[c]	X	ICF 1986a, TSCA 1982a
Scan Pac	Menomonee Falls, WI		X	ICF 1986a, ICF 1985

N/A = Information not available.

[a]This plant refused to respond to our survey. It is assumed that they made asbestos friction materials in 1985.

[b]Wheeling Brake Block completely replaced its asbestos-based friction materials with non-asbestos products in 1986 (Wheeling Brake Block 1986).

[c]H.K. Porter stated it would phase out its asbestos-based friction materials by the end of 1986 (ICF 1986a, PEI Associates 1986).

(ICF 1986a, PEI Associates 1986). Information was not available on the size of Virginia Friction Products' production volume; however, the firm only makes asbestos-based friction materials for oil-well rigs and giant cranes (PEI Associates 1986). Wheeling Brake Block indicated it completely replaced its asbestos-based friction materials with non-asbestos products in 1986 (Wheeling Brake Block 1986). H.K. Porter stated it would phase out its asbestos-based friction-materials by the end of 1986, making only non-asbestos materials (ICF 1986a, PEI Associates 1986).

Table 2 lists the two secondary processors of friction materials in 1985. Hoover Company stopped consuming asbestos-based friction materials in 1986. The firm had purchased, and possibly further processed, asbestos brake linings for use in its vacuum cleaners (ICF 1986b).[5] Information is not available on the type of secondary processing in which Western Gasket Packing Company is involved.[6] Gasko Fabricated Products of Medina, OH (not listed in Table 2), discontinued secondary processing of its asbestos-based product prior to 1985 (ICF 1986b).[7]

There were no imports of asbestos-based friction materials in 1985 or in 1981 (ICF 1986a, 1986b, 1984).

C. Trends

Table 3 gives the production of asbestos-based friction materials and the corresponding consumption of asbestos fiber. The 1985 production value is 51

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[5] Information is not available on the non-asbestos brake lining used by Hoover Co.

[6] Information is also not available on whether Western Gasket Packing Co. processes a non-asbestos product.

[7] The asbestos-based product was a vacuum cleaner control disc; information is not available on whether the firm consumes a non-asbestos product (TSCA 1982b).

Table 2. 1985 Secondary Processors of Friction Materials

Company	Plant Location	Product: Asbestos	Product: Non-Asbestos	References
Hoover Co.	North Canton, OH	X	X	ICF 1986b, TSCA 1982b
Western Gasket Packing Co.	Los Angeles, CA	X	N/A	ICF 1986b, TSCA 1982b

N/A = Information not available.

Table 3. Production and Fiber Consumption of Asbestos-Based Friction Materials

	1981	1985	References
Production (pieces)	17,604,160	8,719,541[a]	ICF 1986a, TSCA 1982a
Asbestos Fiber Consumption (tons)	2,461.1	1,602.5[b]	ICF 1986a, TSCA 1982a

[a] Does not include production volume of Virginia Friction Products' Houston, TX, plant. Raymark's Stratford, CT plant and Wheeling Brake Block's Bridgeport, CT plant refused to provide production data for their asbestos friction materials. Data for these Raymark and Wheeling Brake Block plants were estimated using method described in Appendix A of this RIA.

[b] Does not include asbestos fiber consumption of Virginia Friction Products' Houston, TX, plant. Raymark's Stratford, CT plant and Wheeling Brake Block's Bridgeport, CT plant refused to provide fiber consumption data for their asbestos friction materials. Data for these Raymark and Wheeling Brake Block plants were estimated using the method described in Appendix A of this RIA.

percent less than that of 1981. The 1985 value does not include Virginia Friction Products' Houston, TX, plant; however, the production volume of this plant is probably small. The 1985 value for fiber consumption is 45 percent less than that of 1981; however, the 1985 value does not include consumption for Virginia Friction Products' plant.

Raymark, probably the largest producer of friction materials (asbestos and non-asbestos products combined)[8] stated that non-asbestos substitutes have been developed for most industrial applications, but not all of these substitutes are yet produced in sizeable quantities. Many of these substitutes must still undergo extensive field testing before they are accepted by customers (Raymark 1986b).

Other sources indicate that substitutes have been developed for many commercial and consumer applications, such as machine tools, chain saws, lawn mowers, washing machines, and vacuum cleaners (Design News 1984, Hoover 1986). DuPont, a major supplier of materials for friction products, e.g., Kevlar(R), stated that most friction materials are now non-asbestos (DuPont 1986). Thus, the current asbestos-based share of the total friction materials market is estimated to be 30 percent.[9]

D. Substitutes

Because of the large variety of friction material applications and the reluctance on the part of producers to reveal much more than one or two ingredients in their substitute formulations, it is very difficult to make price and performance comparisons between specific substitute and asbestos-based products, or to estimate market shares for specific substitutes

[8] Raymark, which produces mostly friction materials, stated that 40 percent of all of its friction products are now non-asbestos (Raymark 1986b). (Raymark also manufactures clutch facings, automatic transmission friction components, and brake blocks (ICF 1986a).)

[9] See Attachment, Item 2 for a full explanation of this estimate.

(ICF 1986a).[10] Nevertheless, all producers of substitute friction materials, except for Gatke Corporation,[11] indicated that their non-asbestos formulations contained fiberglass, Kevlar(R), or both, and other fibers (often mineral fibers) (ICF 1986a).[12] National Friction Products, which manufactures a broad range of friction materials, stated that these combinations would capture 80-85 percent of the friction materials market in the event of an asbestos ban. The remaining 15-20 percent of asbestos-based applications (application areas not specified) could not be replaced immediately (ICF 1986a).[13]

One example of a combination substitute product is Raymark's fiberglass and Kevlar(R) brake block used in large cranes and oil-well drilling equipment. The block is priced the same as its asbestos-based product and has the same service life, but does not perform as well at high temperatures (Raymark 1986a). H.K. Porter manufactures heavy-duty clutch components made of fiberglass and Nydag wollastonite board. These components, which are used for hoists, agricultural equipment, and large marine motors, are priced the same as asbestos-based clutches and have improved wear (ICF 1986a).

Gatke Corporation manufactures molded clutch facings, made chiefly from fiberglass, for use in cranes, hoists, and oil-well drilling equipment (ICF 1986a, PEI Associates 1986). The firm, however, considers these products to

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[10] Producers often would not elaborate on the friction materials they produced, and often were vague or uncertain about the performance of their substitutes compared to asbestos-based products (ICF 1986a).

[11] Gatke produces clutch components chiefly made of fiberglass for use in heavy machinery (ICF 1986a).

[12] These formulations may be similar to formulations used in clutch facings for automotive and off-road vehicles, and similar to the non-asbestos-organic (NAO) compounds used in automotive drum brake linings and brake blocks for heavy trucks and off-road vehicles.

[13] Until other replacements can be found for the remaining 15-20 percent of asbestos-based applications, it is assumed that for the present that the Kevlar(R) and fiberglass combination substitute will replace 100 percent of the asbestos market if asbestos were no longer available.

be inferior. The facings are less heat-resistant, more expensive, and heavier than asbestos-based facings. Furthermore, the fiberglass facings are abrasive to the transmission systems, and they are difficult to manufacture (ICF 1986a).

DuPont indicated that brake and clutch components made chiefly from fiberglass would not be used in wet friction systems because the glass fibers tend to break loose, travelling through the fluid-filled environment and causing abrasion (DuPont 1986).

Table 4 provides the data for the regulatory cost model. The substitute product is a general mixture containing fiberglass and/or Kevlar(R) in combination with other fibers. It is assumed that the market share for friction materials made chiefly from fiberglass will be negligible.

E. Summary

Asbestos friction materials are used as braking and gear-changing (clutch) components in a variety of industrial and commercial machinery (ICF 1985). There were six primary processors of asbestos friction materials in 1985 which consumed 1,602.5 tons of asbestos to produce 8,719,541 pieces of asbestos friction material. Since 1985, Wheeling Brake Block and H.K. Porter have stopped producing asbestos friction materials, leaving four remaining producers of the asbestos product (ICF 1986a). The primary substitute is a Kevlar(R) and fiberglass combination which is projected to take 100 percent of if the asbestos products were no longer available. The Kevlar(R) and fiberglass combination substitute costs the same as asbestos friction materials (ICF 1986a).

Table 4. Data Inputs on Friction Materials for Asbestos Regulatory Cost Model[a]

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	References
Asbestos Mixture	8,719,541 pieces	0.00018 tons/piece	1.0	$34.65/piece	0.5 years	$34.65/piece	N/A	ICF 1986a, ICF 1985 Raymark 1986a
Fiberglass and Kevlar(R)	N/A	N/A	N/A	$34.65/piece	0.5 years	$34.65/piece	100%	Raymark 1986a, National Friction Products 1986

N/A: Not Applicable.

[a]See Attachment, Items 3-6.

ATTACHMENT

1. The value for asbestos fiber per piece was determined by dividing the total asbestos fiber consumption, 1,602.5 tons, by total pieces produced, 8,719,541 pieces. This equals 0.000184 tons/piece or 0.37 lbs./piece.

2. A conservative estimate for the asbestos-based share of the market in 1981 would be 95 percent (non-asbestos substitutes were, in fact, available in 1981 for various applications) (ICF 1985). If it is also assumed that the overall friction materials market (asbestos and non-asbestos) remained constant from 1981 to 1985, then since the decline in asbestos-based production of friction materials was approximately 51 percent from 1981 to 1985, the 1985 asbestos-based share of the total market would have been 49 percent of 95 percent, or 47 percent. H.K. Porter, furthermore, stated that by the end of 1986 it should have completely replaced its asbestos-based materials with non-asbestos substitutes. H.K. Porter's approximate share of the asbestos-based market in 1985 was 11 percent (the production volume of Virginia Friction Products' plant is not available; however, it is probably small) (ICF 1986a). Thus, if it is assumed that the total friction materials market remained constant from the end of 1985 to the end of 1986, then perhaps another 10 percent can be subtracted from the asbestos-based share of the market, to account for the loss of H.K. Porter's asbestos-based production. This would make the asbestos-based share of the market as of January 1, 1987, 37 percent. Finally, taking into account Raymark's statement that substitutes have been developed for most industrial applications and DuPont's statement that most friction materials are not non-asbestos, it is reasonable to assume the present asbestos-based share is even smaller than 37 percent. A share of 30 percent is thus assumed.

3. The product asbestos coefficient is the same number given in Item 1 above, shown in tons per piece.

4. Given the variety of friction material applications, it is very difficult to compute a weighted average asbestos product price or a substitute product price. The asbestos and substitute mixture prices are for Raymark's brake blocks used in large cranes and oil-well drilling equipment (stated in the text).

5. The useful life of the asbestos mixture is assumed to be the same as that reported in 1984 (in Appendix H) for an asbestos friction block (ICF 1985). The useful life of the substitute mixture is assumed to be the same as the asbestos mixture, since Raymark stated its substitute friction block had the same service life as its asbestos product.

6. A market share of the Kevlar(R) and fiberglass combination substitute of 80-85 percent is given by National Friction Products (stated in the text). However, until other replacements can be found for the remaining 15-20 percent of the market it is assumed that for now the Kevlar(R) and fiberglass combination substitute will replace 100 percent of the asbestos market.

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XXV. ASBESTOS PROTECTIVE CLOTHING

A. Introduction

This chapter describes the uses and applications for asbestos protective clothing, the producers of these garments and the fibers that can substitute for asbestos in the production of alternative protective clothing.

B. Product Description

Asbestos clothing is formed by sewing asbestos cloth with asbestos thread. The asbestos cloth consists of any of the standard ASTM textile grades available (varying between 75 and 100 percent asbestos), that may contain wire, organic, or inorganic reinforcing strands (ATI 1967).

Asbestos cloth is woven from plied, twisted, and metallic yarns. Depending on the type of yarns used, asbestos cloth of five basic types is available. The classes of asbestos cloth are (ATI 1967):

- Class A -- cloth constructed of asbestos yarns containing no reinforcing strands;
- Class B -- cloth constructed of asbestos yarns containing wire reinforcing strands;
- Class C -- cloth constructed of asbestos yarns containing organic reinforcing strands;
- Class D -- cloth constructed of asbestos yarns containing non-metallic, inorganic reinforcing strands; and
- Class E -- cloth constructed of two or more of the yarns used i cloth Classes A through D.

The most widely used asbestos fabrics are woven from Class A and Class B yarns.

The asbestos thread that is used to sew the various grades of asbestos cloth can be either wire-inserted or non-metallic. Depending on the tensile strength and thermal stability requirements, asbestos thread is available in different grades, although the majority is 80-85 percent asbestos. These threads are often coated with an acrylic or wax coating to increase its strength and to facilitate the sewing of asbestos fabrics.

Traditionally, asbestos protective clothing has been used to ensure the health and safety of workers exposed to very high temperatures, molten metal splash, or the presence of fire. The use of asbestos gloves and mittens as well as coats and overalls has been widespread in laboratories, steel mills, and glass blowing and welding shops where these hazards are likely to be encountered (Utex 1986). In addition, there are other areas where fully-covering asbestos suits have been used to protect workers in very hazardous environments. Some examples of these more exotic job descriptions are oil-well firemen, steel furnace workers, race care drivers, military aircraft pilots, and astronauts (Garlock 1986).

C. Producers

The 1982 TSCA Section 8(a) survey of asbestos processors identified one company as a secondary processor (there were no primary processors) of asbestos textiles used as protective clothing. This company, A-Best Products Company, located in Cleveland, Ohio was involved in the manufacture of asbestos-containing safety clothing (TSCA 1982). A-Best Products Company manufactured gloves, mittens, coats, and coveralls by sewing asbestos cloth with asbestos thread (A-Best 1986). They ceased production of asbestos-containing protective clothing at the end of 1984 and since that time have used substitute fibers in the production of protective clothing (ICF 1986a).

Small quantities of asbestos gloves and mittens have been and continue to be imported from foreign countries such as Taiwan, South Korea, and Mexico (Aztec 1986), but no specific data could be identified.

D. Substitutes

The substitute materials that can replace asbestos fiber in protective clothing are: ceramics, fiberglass, carbon, aramid, and polybenzinidazole

(PBI) fibers. These fibers are used alone or in blends depending on the specific requirements of each application. Although fiberglass and ceramic fibers have very high temperature use ranges, the inflexibility of these materials make them unsuitable for protective clothing if abrasion resistance, durability, or flexibility are important characteristics. As higher temperatures are reached and the need for flexibility and integrity of the material increases (e.g., space suits, and fire-fighting equipment) it becomes necessary to blend these fibers with other more expensive, but more resilient fibers. Blends of ceramic or fiberglass with carbon, aramid, and PBI fibers can be formulated that meet or exceed the performance of any existing asbestos product, although the cost may be significantly higher (Utex 1986). In many applications, however, the added cost is insignificant when weighted against other costs. For example, the cost of a space suit, of any type, is insignificant in comparison to the cost of a space vehicle.

E. Summary

There are currently no domestic processors of asbestos-containing protective clothing, although some finished articles (e.g., gloves and mittens) continue to be imported in small quantities. Substitute fiber blends can be used to produce alternate protective clothing that meets or exceeds the quality standards required for asbestos protective clothing. To a large extent this replacement has already occurred in the protective clothing market. The demand for asbestos in this market is, therefore, negligible.

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XXVI. ASBESTOS TEXTILES

A. Product Description

Asbestos textiles are produced by standard textile production techniques involving carding, combing, and spinning of the asbestos fibers. Asbestos fibers can be blended with other types of fibers to give the resulting textile products added tensile strength. The manner in which asbestos fibers are processed into asbestos yarn and cloth products is illustrated in Figure 1.

There are two basic processes employed in asbestos textile manufacturing: the conventional and wet processes. Although most textiles are manufactured by the conventional process, each of these methods will be described.

1. Conventional Processing of Asbestos Fibers to Form Textile Products

In the conventional process, raw asbestos fibers of various grades are blended and mixed according to the fiber characteristics, manufacturing and finished product requirements, and intended use. The different grades of asbestos fiber received are placed in the fiber blender where they are mixed according to the requirements specified for the finished product. The selected fibers are then fed into a hopper where they are blended. Finally, the blended material is sent to the carding operation.

In the carding operation, asbestos fibers are combed into a relatively parallel arrangement called a fiber mat. This mat is pressed and layered into a lap consisting of alternating perpendicular arrangements of fiber mats. The lap is then slit into thin, continuous ribbons called roving. Cotton, rayon or other material may be added at this stage to strengthen the roving.

Roving, which has been mechanically twisted and spun to give it greater tensile strength, forms a single yarn. This yarn may be twisted with other single yarns, wire or other material to produce plied yarn that can be coated to produce thread or treated yarns. Plied yarns may be woven to produce

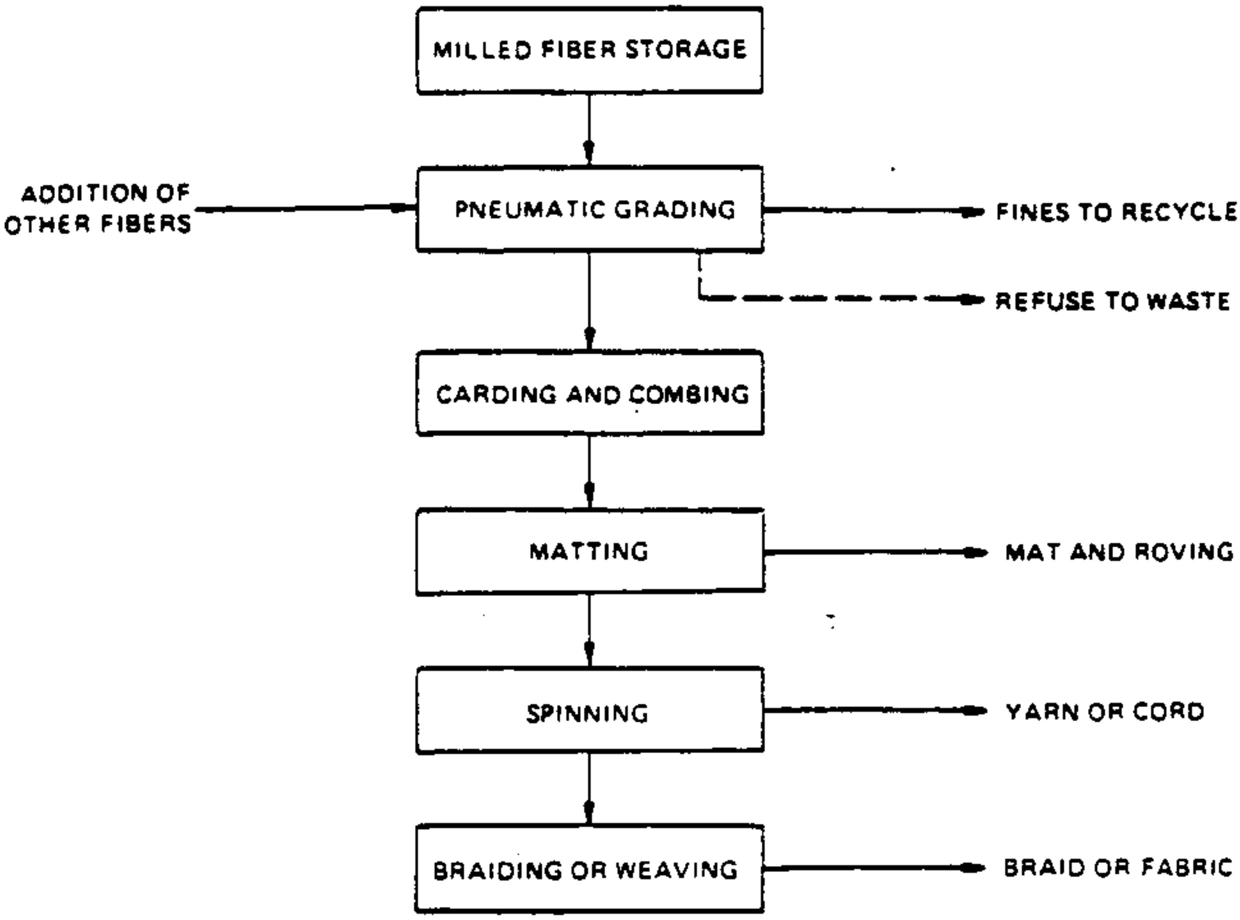

Figure 1. Manufacturing steps for asbestos textiles.

Source: NTIS 1975.

fabric, tubing (sleeving), or tape, as seen in Figure 2. Alternately, plied yarns may be twisted to form wicking and twisted rope, or braided to form braided rope or sleeving.

The conventional process of asbestos yarn manufacture can either be a dry or a damp method. These two methods are identical except that during the damp method the yarn is moistened either by contact with water on a roller or by a mist spray. This moistening of the yarns reduces the amount of fiber that becomes airborne and also aids the processing of fibers into yarn.

2. Wet Processing of Asbestos Fibers to Form Textile Products

The wet process is based on forming single filament fibers by extrusion. The process consists of making a gelatinous mixture of fine asbestos fibers in water with a volatile dispersant. The mass is then extruded through small dies to form asbestos thread. The extruded thread is spun to form yarn which is fabricated into various plied yarn products as in the conventional process.

The textile products formed using this wet technique tend to hold asbestos fibers better than those produced by the conventional processes, thus reducing workplace fiber levels, but the yarn formed has the disadvantage of poor absorption and impregnation characteristics.

3. Asbestos Textile Subcategories

There are eight main subcategories of asbestos textiles that are used in the various applications covered within this section. Each textile subcategory can be grouped into one of the two main categories, asbestos yarn or cloth, as follows:

- asbestos yarn;
  - yarn;
  - thread;
  - wick;
  - cord;
  - braided and twisted rope; and
  - braided tubing (sleeving).

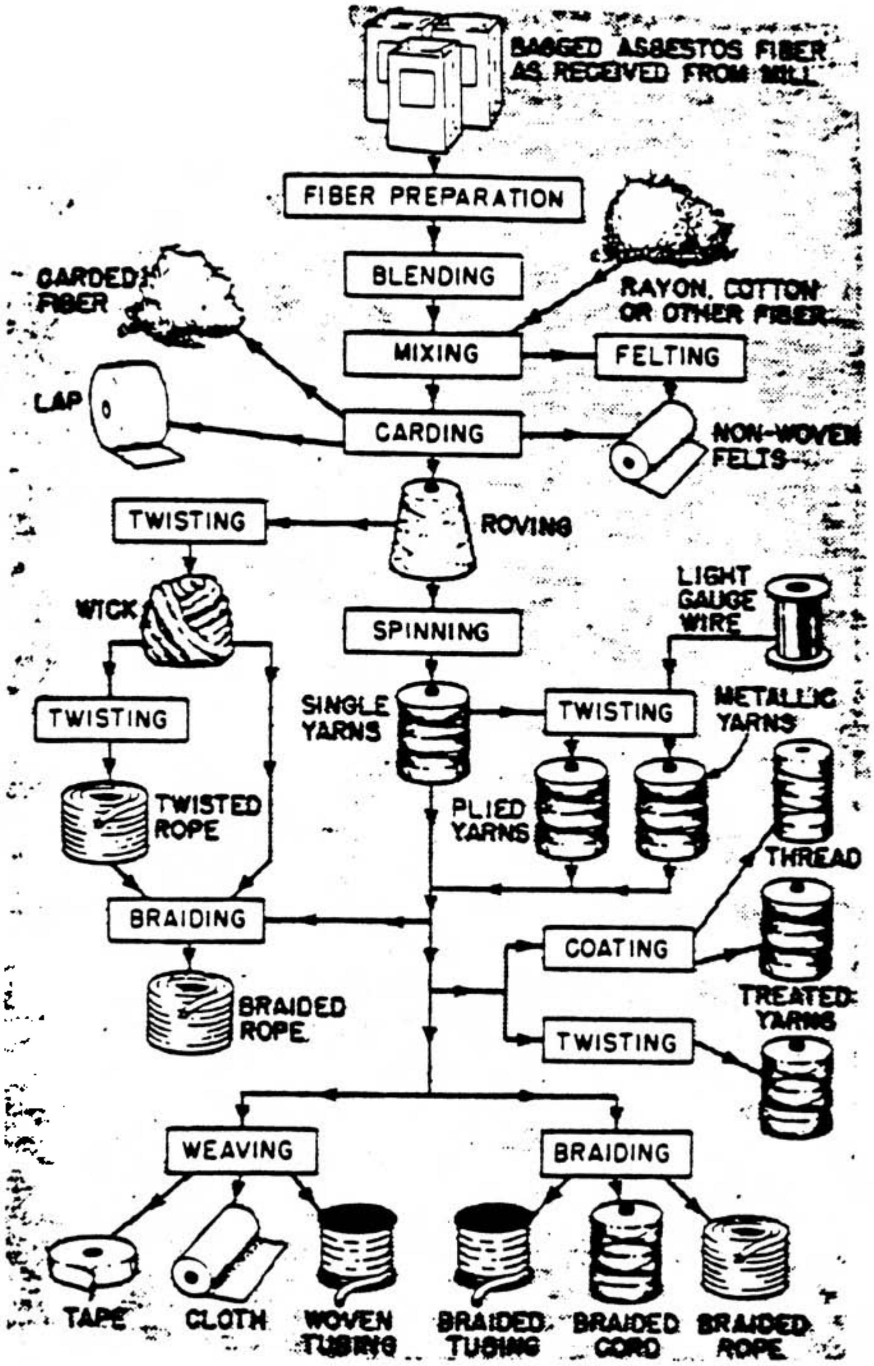

Figure 2. Manufacturing operations for asbestos textiles.

Source: Handbook of Asbestos Textiles. American Textile Institute. 1967.

- asbestos cloth

    -- cloth;
    -- slit and woven tape; and
    -- woven asbestos tubing (sleeving).

The manufacturing process for each of these textile subcategories is briefly described, and some of the typical dimensions of the products are included. In addition, some of the typical fillers, carrier yarns, and inserts that are used in conjunction with asbestos containing materials are described (American Textile Institute 1967).

- Asbestos yarns are commonly reinforced with nylon, cotton, polyester, or wire. The asbestos yarns produced are made in various sizes and plies and serve as the basic components in the fabrication of many other asbestos textiles: twisted, woven, and braided. The amount of asbestos contained in asbestos yarns is the basis for designating asbestos textile grades as listed in Table 1. The American Society for Testing of Materials (ASTM) has designated various grades for asbestos textiles that differ slightly with each textile form.

- Asbestos threads are produced in both metallic (wire-inserted) and plain (non-metallic) classes. Depending on the tensile strength and thermal stability requirements, asbestos thread is furnished in different grades, although most of it is underwriters' grade (80-85 percent asbestos). Asbestos thread is often coated with an acrylic or wax coating to increase its strength and to facilitate the sewing of asbestos fabrics.

- Asbestos wick consists of several strands of asbestos yarn twisted together to form a general utility product with varied industrial applications (e.g., packing, or upon further processing the making of rope and braid).

- Asbestos cord is usually twisted asbestos yarn (a predetermined number of strands) that forms a cord of desired diameter and tensile strength. The yarns used may be sized or unsized, plain or wire-inserted, single or plied, depending on the end use of the product. Asbestos cord is manufactured in all standard ASTM grades and ranges in diameter from 0.06 inches to 0.38 inches.

- Asbestos rope is available in two styles: twisted and braided. Twisted asbestos rope is made by twisting two or more strands of asbestos wick tightly together. Heavier ropes contain a binder to hold the twist. Braided asbestos rope can be manufactured by three different processes: (1) by braiding one or more jackets of asbestos yarn over a

Table 1. Asbestos Textile Grades

Grades[a]	Asbestos Content by Weight
Commercial	75% up to but not including 80%
Underwriters'	80% up to but not including 85%
Grade A	85% up to but not including 90%
Grade AA	90% up to but not including 95%
Grade AAA	95% up to but not including 99%
Grade AAAA	99% up to and including 100%

[a]Asbestos textile grades differ with each asbestos textile form.

Source: Handbook of Asbestos Textiles. American Textile Institute. 1967.

core of asbestos rope or wick; (2) by braiding asbestos yarn braid over asbestos braid; and (3) by plaiting asbestos yarn into a square cross section (square braid). Asbestos rope is available in all ASTM grades and varies in diameter from 0.25 to 2.0 inches.

- Asbestos tubing (sleeving) can be made from asbestos yarns by braiding. Braided tubings are manufactured in all of the ASTM grades and range from 0.02 inches to several inches inner diameter (i.d.). The wall thickness varies from 0.03 inches to approximately 0.13 inches.

- Asbestos cloth is woven from various plied, twisted, and metallic yarns. There are five classes of asbestos yarns that can be used to produce asbestos cloth. The different classes of asbestos cloth are:

  -- Class A -- Cloth constructed of asbestos yarns containing no reinforcing strands.

  -- Class B -- Cloth constructed of asbestos yarns containing wire reinforcing strands.

  -- Class C -- Cloth constructed of asbestos yarns containing organic reinforcing strands.

  -- Class D -- Cloth constructed of asbestos yarns containing non-metallic inorganic reinforcing strands.

  -- Class E -- Cloth constructed of two or more of the yarns used in cloth classes A through D.

  The most widely used asbestos fabrics are woven from Class A (non-metallic) and Class B (wire-inserted) yarns.

- Asbestos tape is manufactured mostly as plain or non-metallic tape in all of the standard ASTM grades. It is a narrow woven fabric manufactured from plied yarn containing selvage edges (finished to prevent raveling). Additionally, tape may be slit from cloth (slit tape). Depending upon the application, the type of tape and the associated manufacturing process varies. For tapes requiring heat reflectivity, aluminum layers may be sprayed on or bonded to the cloth by a thermosetting resin. The thicknesses of plain tape range from 0.01 inches to 0.03 inches. Metallic tapes can be 0.06 inches and thicker. Standard widths of asbestos tape range from 0.5 inches to 6.0 inches.

- Asbestos tubing (sleeving) can also be made in a woven form. Asbestos yarns can be woven to form a tubing that has a significantly greater inner diameter than the braided tubings. Woven tubings are manufactured in all of the ASTM grades in diameters of less than one inch up to 24 inches.

Two additional asbestos textile subcategories are non-woven products that have been used for electrical insulation purposes, but do not fall into the two designated textile categories. Although these products were not produced by any companies identified during the analysis, brief descriptions are included:

- Asbestos roving is simply non-twisted strands of asbestos fibers that have been carded. Roving can be twisted to form wick or spun to form yarn. Asbestos roving is blended with cotton or other organic fibers to meet specific end-user requirements. It is supplied in the five standard ASTM grades. Asbestos roving has been used as electrical insulation, but no current applications could be found.

- Asbestos lap consists of parallel arrangements of asbestos fibers that have been combed and blended with organic fibers. Asbestos lap is a non-woven fabric and has been used in electrical insulation. No current uses of asbestos lap have been identified.

4. Current Application Areas for Asbestos Textiles

Historically, asbestos textiles have been used in a wide range of products, but many of the traditional products are no longer in production. Substitute fibers have taken up the bulk of the market for electrical and thermal insulation, fire resistant materials, and protective clothing.

The products that continue to be made in significant quantities using asbestos textiles are:[1]

- Woven friction materials;
- Packings and gaskets; and
- Specialty products.

Woven friction materials account for the majority of the asbestos textile products made from asbestos yarn and include woven brake blocks and clutch

[1] It should be noted that products made from asbestos textiles are different than similar products made from non-woven asbestos fibers. Woven friction materials and packings/gaskets made from asbestos textiles are not included in the non-woven asbestos product categories, but rather are included in the asbestos textiles category. A careful review of the processors data has been performed in order to ensure that no duplication of information has occurred.

facings. Typically, these woven products have better performance characteristics than molded products and are used in large industrial equipment such as oil well drilling rigs and cranes.

The two largest processors of asbestos textile materials are Standco Industries and Raymark Corporation. These companies are producers of woven friction materials and account for almost 90 percent of the asbestos textile market, although the trend in woven friction materials is away from asbestos containing materials in original equipment markets (OEM). In 1985, 50 percent of all OEM vehicular friction materials were expected to be asbestos free (Scott 1984).

Packings and gaskets made from asbestos textiles[2] include both yarn and cloth products. Asbestos yarn products, braid and rope, are used extensively in pump and valve packings and as seals for oven doors, boilers, and furnaces. Asbestos cloth is used to manufacture manhole and flange gaskets as well as seals in incinerator (hot-air) piping, nuclear power plant cooling water towers, and distillation columns.

Although some gasket and packing products continue to be made from asbestos textile materials, the general trend is to move away from asbestos containing products (Garlock 1986, Darco Southern 1986). Most gasket and packing manufacturers have stated that they will be completely out of the asbestos market by 1990 because of the availability of good substitutes.

Finally, specialty products continue to be made from asbestos textile materials, both asbestos cloth and asbestos yarn. It is often difficult to find substitute materials for these specialized applications, but products of this type are usually produced in relatively small volumes (less than 5,000

[2] The majority of companies involved in the production of asbestos textiles are gasket and packing manufacturers, although they do not account for a very large proportion of the asbestos textile market (11 percent).

pounds). Some products made from asbestos textiles that fall into this category are:

- Mantles for gas lanterns (yarn);
- Wicks for catalytic heaters (yarn);
- Rotor vanes and impellar blades for pumps and compressors used in air tools (cloth);
- Ring type seals for valve and compressor plates (yarn); and
- Bearings for high temperature applications requiring water lubrication (cloth).

It is more difficult to find substitute materials for some applications of asbestos textiles that may require several of the favorable characteristics that asbestos can impart to textile products. For these types of applications, substitute materials may necessitate the use of a mixture of substitute fibers to impart all of the required characteristics to the substitute material. Companies that produce specialty products from asbestos are actively looking for substitute materials if none exist at present.

B. Producers and Importers of Asbestos Textiles

Asbestos textiles account for less than one percent of the total amount of asbestos fibers consumed for end-use products in the United States. In 1985, domestic consumption of asbestos fiber in the form of asbestos textiles was estimated to be approximately 919 tons (ICF 1986a). The majority of this fiber was Grade 3 chrysotile fiber. This figure is 16 percent of the 5,800 tons of fiber consumed in 1981 (ICF 1984a) in this category.

The quantity of asbestos fiber contained in asbestos textile products varies significantly, but an average figure of between 70 and 80 percent is a reasonable estimate of the asbestos content (Garlock 1986) for most asbestos textiles. The total amount of asbestos-containing textiles targeted for consumption in the U.S. is, therefore, estimated to be 1,690 tons of end-use textile products for 1985 (ICF 1986a).

Asbestos textile products consumed in the United States come from two sources: domestic processing of asbestos fibers into yarn and cloth and imports of yarn and cloth. Table 2 compares the imports of asbestos textiles and the domestic output of asbestos textile products for 1981 and 1985. Consumption and output have decreased by over 70 percent for both textile segments over the time period 1981 to 1985 (ICF 1986a).

The two processors involved in the manufacture of asbestos textiles for woven friction materials have stated that their products contain about 50 percent asbestos by weight. The amount of fiber consumed by these companies is estimated to be less than 800 tons.

As other asbestos yarn products are approximately 70 percent asbestos,[3] the remaining products can be estimated to contain less than 100 tons of asbestos fiber. An estimate of less than 900 tons of asbestos fiber consumed in the production of asbestos yarn products for companies that reported using asbestos in 1985 can therefore be made. Although no data for the asbestos content of specific asbestos cloth products were available, an estimate of 80 percent (Garlock 1986) asbestos content has been used to calculate the asbestos fiber consumption for asbestos cloth textiles. It is estimated that the companies that produced asbestos cloth products in 1985 consumed less than 200 tons of fiber. The total amount of fiber consumed in the production of all asbestos textiles in 1985 is therefore less than 1300 tons for 1985.[4]

The discrepancy between the asbestos fiber consumption estimated in Table 2 and the figure presented by the Bureau of Mines (1,344 tons) (Virta 1986) can partially be explained by incomplete reporting or identification of

[3] The amount of fiber consumed in the production of asbestos textiles other than woven friction materials can only be estimated because the secondary processors were not willing to release or did not know the asbestos concentration figures for their products.

[4] Includes estimated fiber consumption of imported products.

Table 2. Asbestos Fiber Consumption for Textile Products and Output of Textile Products for 1981 and 1985

	Domestic Fiber Consumption[c] (tons)	Total Fiber Consumption[d] (tons)	Domestic Production of Textile Products (tons)	Imports of Textile Products (tons)
Asbestos Yarn				
1981[a]	3,920	5,040	5,600	1,600
1985[b]	558	823	1,125	455
Asbestos Cloth				
1981[a]	440	760	550	400
1985[b]	0	96	0	120
Total				
1981[a]	4,360	5,800	6,150	2,000
1985[b]	558	919	1,125	575

NOTE: The table identifies production only for those companies for which data have been collected during the survey. Some companies, especially those that import small quantities from small countries, may not have been identified.

[a]TSCA 1982.

[b]ICF 1986a.

[c]This calculation is based on confidential business information.

[d]Estimated total fiber consumption figures for 1981 are calculated using average asbestos concentration figures: Asbestos yarn is approximately 70 percent asbestos and asbestos cloth is approximately 80 percent asbestos.

companies processing asbestos textiles. The asbestos textile imports that have been accounted for totalled about 600 tons in 1985. The U.S. Imports for Consumption Schedule FT 246, published by the U.S. Department of Commerce (DOC 1985), however, indicates that approximately 1,100 tons of asbestos yarn, slivers, etc. (TSUSA 518.2100) were imported from 17 countries.[5]

Most of the secondary processors of asbestos yarn and cloth receive their materials from foreign companies and process the imported textile mixtures into end-use products. Several companies, however, receive textile mixtures from domestic sources. At least one company, Amatex Corporation, imports asbestos textile mixtures from plants in Mexico. Amatex does not do any secondary processing of these mixtures, but distributes them to other companies that are secondary processors (Amatex 1986).

There are other companies that have similar import/distribution practices (A.W. Chesterton 1986), and this may help to account for the discrepancy between imports identified in the survey and those reported by the Department of Commerce. Some companies are neither primary nor secondary processors, but rather importers and distributors. Data on these companies were not available for the initial 1982 EPA survey (ICF 1984b).

Some of the companies identified in the survey are involved in the processing of both asbestos cloth and yarn into end-products. In addition, the materials used by these companies are sometimes from several sources. Of the companies that have been identified, five are secondary processors of both

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[5] The TSUSA commodity code for yarn and related materials probably includes some products that are not considered textiles or are already finished products not requiring any processing, but the higher figure tends to indicate that information is missing regarding textile products imported from some countries. None of the companies that were contacted during the course of the survey indicated that any asbestos textiles were imported from any countries other than Canada, Mexico, and South Korea (Aztec 1986). Although these three countries account for the bulk of U.S. asbestos imports, other countries are exporting asbestos textiles to the U.S.

asbestos cloth and asbestos yarn. Tables 3 and 4 present quantities of yarn and cloth consumed and imported in secondary processing.

C. Trends

Thirteen companies involved in the production and distribution of asbestos textiles in 1985 have been identified. These 13 companies can be grouped into four categories based on their particular involvement in the asbestos textile market. The categories and the companies that fall under them are listed in Table 5.

In 1981, there were 21 processors of asbestos textiles (four primary, 17 secondary) as identified in the 1982 TSCA Section 8(a) survey. By 1985 the number of processors had dropped to six (one primary and five secondary). The change in processors identified in the survey is a 75 percent drop for primary processors[6] (from four in 1981 to one in 1985) and a 71 percent drop for secondary processors (from 17 in 1981 to five in 1985) (ICF 1986a, TSCA 1982).

In addition to processors identified in the survey, seven out of 16 companies (a 56 percent drop) identified as importers in 1982 (ICF 1984a) continued to import in 1985 (ICF 1986a).

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[6] The only domestic primary processor of asbestos textiles, Raymark Corporation, produces asbestos yarn from asbestos fiber at its plant in Marshville, North Carolina. Subsequently, the yarn is shipped to other Raymark plants where secondary processing to form woven brake blocks and clutch facings is performed (Raymark 1986). This production sequence is slightly different than that used by most manufacturers of woven friction materials. Most processors of these types of friction materials do primary and secondary processing at the same facility, and output is classified as woven friction materials. Raymark does not follow this pattern (the primary and secondary processing facilities are at different locations), so the output of the Marshville facility is classified as asbestos yarn. The yarn is then shipped to other Raymark facilities for secondary processing where it is fabricated into woven friction materials.

Table 3. Quantity of Asbestos Yarn Consumed by Secondary Processors

	Quantity of Domestic Asbestos Mixture Consumed[a] (short tons)	Quantity of Imported Asbestos Mixture Consumed (short tons)
Total	13.4	431.8

[a]The sources of domestic asbestos yarn are companies that import the mixture, but do not perform secondary processing. Only one company of this type could be identified importing 25 short tons of asbestos yarn for distribution to other companies that subsequently do the secondary processing.

Source: ICF 1986a.

Table 4. Quantity of Asbestos Cloth Consumed by Secondary Processors

	Quantity of Domestic Asbestos Mixture Consumed[a] (short tons)	Quantity of Imported Asbestos Mixture Consumed (short tons)
Total	9.4	94.8

[a]The sources of domestic asbestos cloth are companies that import the mixture, but do not perform secondary processing. Only one company of this type could be identified importing 25 short tons of asbestos cloth for distribution to other companies that subsequently do the secondary processing.

Source: ICF 1986a.

Table 5. Companies Involved in Asbestos Production and Distribution in 1985

Category	Company Name and Address	Asbestos Textile Product/Intended Use
Primary Processor of Asbestos Textiles from Asbestos Fibers	Raymark Corporation Marshville, NC	Asbestos yarn/woven brake blocks and clutch facings
Importer of Asbestos Textiles for Distribution Only	Amatex Corporation Norristown, PA	Asbestos yarn and cloth/ distribution to domestic secondary processors
Secondary Processor of Asbestos Textiles Received Directly from Foreign Sources	A.W. Chesterton Woburn, MA	Asbestos yarn and cloth/ packings and gaskets
	Arcy Manufacturing New York, NY	Asbestos cloth/welding blankets
	Aztec Industries N. Brookfield, MA	Asbestos cloth/gaskets
	The Coleman Company Wichita, KS	Asbestos yarn/mantles for gas lanterns
	Darco Southern Independence, VA	Asbestos cloth/gaskets
	Gatke Corporation Warsaw, IN	Asbestos cloth/high-temperature bearings
	Martin Merkel Houston, TX	Asbestos yarn/packings
	Standco Industries Houston, TX	Asbestos yarn/woven brake blocks and clutch facings
	Utex Industries Weimar, TX	Asbestos yarn/packings

Table 5 (Continued)

Category	Company Name and Address	Asbestos Textile Product/Intended Use
Secondary Processor of of Asbestos Textiles Received from Domestic Distributors	A.W. Chesterton Woburn, MA	Asbestos yarn/packings
	General Gasket Corp. St. Louis, MO	Asbestos yarn and cloth/ gaskets
	Rhopac, Inc. Skokie, IL	Asbestos yarn and cloth/ packings and gaskets
	Standco Industries Houston, TX	Asbestos cloth/gaskets
	Utex Industries, Inc. Weimar, TX	Asbestos cloth/packings

Source: ICF 1986a.

D. Substitutes

Asbestos has been used in textile products because it imparts desirable characteristics to the materials that are made from it. Asbestos based textile products have the following characteristics that make them ideally suited for use in high temperature and corrosive environments:

- Fire/acid resistance;
- Non-flammability;
- Low thermal conductivity; and
- Molten metal resistance.

Asbestos is also easily fabricated and exhibits great tensile strength and abrasion resistance. It is a flexible material in its fabricated form and is used for sealing applications especially when good compressibility and recovery are required.

Due to health concerns regarding asbestos inhalation, there has been a major effort to develop substitute materials that exhibit some of the characteristics of asbestos textiles. The major fibers used in the formulation of substitute textile products are:

- Fiber glass;
- Ceramics;
- Carbon/graphite;
- Aramids; and
- Polybenzimidazole (PBI).

In addition, some other fibers have been used to produce small amounts of textile materials that can be substituted for asbestos in some applications. Cotton and wool blends have been used in textile products as substitutes for asbestos, but in general they are not very resistant to heat. Quartz and other mineral fibers have also been used in small volumes. The five major substitute fibers mentioned above, however, account for the majority of the substitute materials that can replace asbestos.

Substitute textile products have already replaced asbestos to a certain extent and can be expected to replace most of the remaining segments of the market. An approximate breakdown of asbestos substitute markets and the percentage of the asbestos market that each has been able to assimilate is listed in Table 6.

1. Fiberglass Textiles

Fiberglass is used preferentially when looking for substitute products due to its good workability, durability, and cost (50-70 percent less than similar asbestos based textiles) (Darco Southern 1986). Other substitute materials tend to be more expensive than asbestos and typically are not used to the same extent as fiberglass (Utex 1986).

Fiberglass textile products have been widely used as substitutes for asbestos, but they do have several major shortcomings. For replacement products requiring abrasion or flux resistance, fiberglass alone is not an adequate substitute. Manufacturers have dealt with this problem by blending glass with other materials. For example, glass can be blended with aramids to produce textile materials that can withstand fairly high temperatures (500°F) and show good abrasion resistance (Chemical Business 1984).

Fiberglass fibers can be treated by chemical leaching with sulfuric acid to form a continuous-filament, amorphous silica product with the thermal performance of a refractory material. After treatment with acid, the resulting filament is almost pure silica (SiO_2) and can be woven to form textile materials with excellent thermal resistance. The temperature limit for ordinary fiberglass materials is around 1000°F, at which point they lose tensile strength and begin to melt. The amorphous silica products, however, retain their strength and flexibility to temperatures of 1800°F and will continue to provide thermal protection up to 3100°F, although some degree of shrinkage and embrittlement does occur as temperatures approach the upper limit (Armco 1979).

Table 6. Existing Market Shares for Asbestos Substitute Fibers

Substitute Fiber	Percentage of Asbestos Market
Glass	50%
Ceramic .	15%
Aramid	15%
PBI	10%
Carbon	10%

Note: As more substitute products are becoming available, the market share for glass is beginning to dwindle.

Source: Garlock 1986.

Amorphous silica textiles have seen widespread use as thermal and electrical barriers and have replaced asbestos products to a great extent in these applications. The cost of high-temperature refractory silica textiles is not much greater than fiberglass textiles (Armco 1979) and only slightly greater than asbestos textiles used in similar applications. As the performance with regard to temperature limit is better than asbestos for the refractory glass products in nonabrasive applications (Amatex 1986a), substitution has taken place to a large degree.

In high temperature applications where compression and abrasion are likely to be encountered, other materials or blends of glass, silica, and other fibers are used. If only slight abrasion resistance is required, the refractory silicas do quite well. Rope gasketing for partial grooves in oven or furnace doors and sealing elements in all types of manufacturing equipment that handle heat (e.g., ovens, furnaces, boilers) can be made from refractory silicas.

Refractory silica textiles are not ideally suited for applications requiring a great deal of abrasion resistance, but their abrasion resistance capability can be augmented by specially treating the material with a hydrocarbon finish (Armco 1979). In general, however, refractory silica textiles are not used in areas where abrasive conditions would be encountered.

2. Ceramic Fiber Textiles

Ceramic fiber, consisting of high purity alumina and silica in various percentages, can be used to produce ceramic textile products. These ceramic textiles are similar to amorphous and textured silica products in that they exhibit refractory characteristics and can be used in high-temperature applications (up to 2300°F).

Fiberfrax yarn, a representative type of ceramic fiber yarn, contains approximately 20 percent organic fiber and is spun around corrosion resistant alloys of nickel and chromium (temperature limit 2000°F) or 1200°F monofilament glass strands. These inserts provide maximum tensile strength at elevated temperatures (Carborundum 1986).

Although ceramic fiber yarns have a high temperature limit in continuous use, the textiles made from them lose tensile strength after exposure to heat for extended periods of time. The temperature limit of the insert material must be considered in determining whether a ceramic fiber textile product can be used in applications where tensile strength is important.

In the application areas where substitution is incomplete, ceramic fiber textiles are viable substitutes for some applications currently using asbestos: furnace and oven door seals, flange and burner gaskets, and static packings. Ceramic fiber textile products have a higher temperature limit, are more flexible, conform to the shape required, and often have a longer service life than comparable asbestos based products. In general the costs of ceramic fiber products are comparable to asbestos products.

There are some drawbacks associated with the use of ceramic fiber for asbestos replacement cloth and yarn products. The ceramic cloth used in expansion joints, a gasket application, exhibits slightly more permeability at low temperatures and may be slightly more expensive (10-15 percent) in some product application areas (Carborundum 1986).

Ceramic rope products made from yarn are less dense than comparable asbestos products, are not as packable (too resilient), and therefore do not exhibit the required characteristics for some gasket applications. Ceramic fiber rope also exhibits poorer performance in some oven furnace door applications. Due to the low density and lower abrasion resistance of the ceramic products, they do not meet the standards of the traditional asbestos based products (Carborundum 1980).

Finally, static packings made from ceramic rope usually perform very well as asbestos replacement products, but there are not as many forms available, so complete substitution for all asbestos packings is not possible.

3. Aramid Fiber Textiles

Other substitute fibers that can replace asbestos in some textile applications are aramid fibers. By spinning a polymeric solution of aramids, a fiber can be produced that is a good replacement for asbestos. Aramid fiber is stronger on a by-weight basis than asbestos and can be used in pump packings, brake linings, and gaskets (DuPont 1980).

Aramids can also be blended with other fibers to produce asbestos replacement textiles that exhibit the favorable characteristics of each fiber type incorporated into the textile material. Amatex Corporation produces a heat-resistant textile that is made from Nomex and Kevlar fibers mixed with small amounts of polybenzimidazole (PBI) and glass fibers to raise the temperature limit of the material (Amatex 1986). The material, NOR-FAB , shows excellent abrasion- and heat-resisting characteristics, is lightweight, and is not susceptible to most acid and alkali solutions. By blending the aramid fibers with other synthetics and glass fibers, the favorable characteristics of aramids can be incorporated into products with higher temperature limits. In the case of NOR-FAB , excellent protection up to 650°F is possible with intermittent protection at much higher temperatures.

4. Carbon Fiber Textiles

Carbon fibers, another asbestos replacement fiber, are characterized by extremely high strength and high temperature resistance. Carbon fibers are made by controlled carbonization of an already formed fibrous structure based on an appropriate organic polymer. The organic polymers most commonly used in the production of carbon fibers are homopolymers of acrylonitrile and viscose rayon multifilament yarns.

The polyacrylonitrile (PAN) based fibers consist of 92-95 percent carbon (the rest being mostly nitrogen), and the higher strength rayon based fibers can be up to 99 percent carbon (Kirk-Othmer 1977). In general, the carbon fiber yarns and cloths are used in applications requiring strength and light weight (e.g., aerospace and industrial applications). Carbon fiber textiles often include other fibers, such as glass, along with a matrix resin (e.g., polyesters, epoxies, or polyimides).

Although there is some ambiguity regarding the term carbon fiber, it should be noted that this term does not include graphite fibers which are materials exhibiting the three-dimensional characteristic of polycrystalline graphite. Essentially all commercial carbon based textiles are made from carbon fibers (Kirk-Othmer 1977).

Carbon fibers have been used as an asbestos replacement in the production of friction materials. Even though the performance is superior to the asbestos goods that they replace, carbon fiber tends to be very expensive and availability can be a factor. In this and other substitution areas, the tradeoff between additional cost and improved performance must be evaluated. Some applications that require a specific level of performance may, therefore, use a more expensive fiber regardless of expense. In other application areas (e.g., aerospace), the cost of the fiber may be insignificant compared to the cost of the finished product in which the textile material is being used.

5. <u>Polybenzimidazole Fiber Textiles</u>

Polybenzimidazole (PBI) fibers can also be used to form asbestos replacement textiles. Based on the reaction of 3,3'-diaminobenzidine and diphenyl isophthalate, these aromatic polymers are prepared by conventional condensation techniques. The resulting polyimides can be fabricated into heat- and flame-resistant fibers that exhibit a unique property for synthetic polymers. Most synthetic polymers do not reabsorb moisture after being exposed to high temperatures. PBI, however, does regain moisture (up to 13 percent) and is therefore not as subject to degradation in some applications.

PBI fibers can be spun into yarns and then woven to form fabrics that are heat resistant up to 932°F. In addition, fabrics made from PBI fibers show good acid resistance, good cryogenic characteristics, and are readily processed on conventional textile equipment (Kirk-Othmer 1977).

Although PBI fibers exhibit excellent characteristics for very specialized applications (e.g., aerospace and other industries requiring high performance products), they tend to be very expensive. Most industries cannot afford to use PBI containing textiles in their asbestos replacement application areas because of the high cost and must either settle for other available substitute fibers or blend PBI fibers with other fibers to reduce the costs.

6. Asbestos Replacement

Typically, less expensive fibers such as fiberglass or ceramic are used to make up the bulk of any asbestos replacement textile, and the more expensive aramid, carbon, and PBI fibers are added to impart favorable properties on an application-by-application basis. For applications in which readily available substitute fiber textiles are available (i.e., commercially available single fiber products and relatively simple blends), the amount of fiber in the substitute product can be determined. In these application areas, however, substitution is considered to be complete.

The simple textile types (non-blended) are not considered to be replacements for the remaining asbestos textile applications as they do not meet the performance requirements for critical uses. For high performance application areas the amount of each fiber that is used in an asbestos replacement textile is determined by experimental procedure. By varying the concentrations of the available substitute fibers, a substitute textile product can be formulated that exhibits all of the required characteristics for a particular application.

The experimental nature of asbestos replacement procedures makes it difficult to speculate on the exact types of fibers that would be used in any given application area. Substitute products can be found for all asbestos textiles even though the exact nature of substitution is complicated. For example, the amount of fiber of a particular type and the weight of the finished product would be different than for a similar product made with asbestos.[7] In addition, actual formulations are often considered confidential and it is difficult to find data on product make-up.

As the level of detail needed to characterize specific replacement textile products is not readily available, some simplifying assumptions must be made for the asbestos textiles market. These assumptions are:

- All asbestos yarn and cloth products will be grouped into one product area (textiles);
- The blends of fibers in replacement textiles will be assumed to equal the market share for existing, asbestos replacement textiles that are made exclusively with one fiber (see Table 6);
- Service life will be assumed to be equal for all asbestos and replacement textiles (actual service life can vary for specific applications from one to 20 times that of asbestos, depending on the application);[8]

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[7] As opposed to other products that use asbestos as an additive, asbestos textiles are comprised of up to 100 percent asbestos. Thus, formulations made with substitute fibers may vary significantly in weight from asbestos products. The relative density of the fiber compared to asbestos and the relative amount used as compared to asbestos determine the weight of the finished product made with substitute fibers.

[8] The actual service life is very dependent on the environment in which the asbestos-containing product and its substitute product would be contained. Depending on various conditions encountered in a particular use scenario (e.g., abrasiveness, high temperature) the possible substitute products would have greatly varying useful lives. Without performing an involved technical assessment of use conditions it is not possible to accurately predict the differences in the actual service life for the various substitute fiber-containing products relative to their asbestos counterparts.

- Unusual and unrepresentative products (e.g., aerospace replacement products that are 1,000 times as expensive as the asbestos product) will be excluded from the cost analysis.[9]

Attachment A contains a discussion of the calculations used in this analysis. The inputs for the Asbestos Regulatory Model for textile products are also presented.

E. Summary

Asbestos textiles can be grouped into two categories: asbestos cloth and asbestos yarn. A third category, asbestos protective clothing, has been eliminated because no producers could be identified.

Production and imports of these materials dwindled significantly between 1981 and 1985, and substitute products have taken over a large portion of the market. All segments of the asbestos textile industry for 1985 were down 70 percent or more compared to 1981 figures.

Substitution is complete for most product areas, but products are still made from asbestos in the following areas: woven friction materials, packings and gaskets, and specialty products. The major fibers that are used as substitutes are glass, ceramic, aramid, polybenzimidazole, and carbon fibers.

Analysis of the asbestos textile market and identification of substitute materials makes it possible to estimate the cost of substitute materials for remaining asbestos markets. The cost range for substitute products varies significantly depending on the application. Limited information makes it difficult to exactly constrain the costs, but average costs based on cost ranges established during the course of this analysis are presented in Table 7 (see Attachment A).

[9] These products tend to be produced in very small volumes and data are generally not available concerning their cost and performance relative to asbestos products.

ATTACHMENT A

The relevant information used to calculate the costs of substitute textile materials relative to representative asbestos products is contained in this attachment.

As has been mentioned, for the application areas where substitution has taken place, the substitute textiles tend to use relatively simple blends of fibers. The remaining product areas are very diverse and replacement products differ significantly. If, however, essentially pure fiber products were made to replace the remaining asbestos textile markets, their costs would be in the ranges identified in Table 7.

Cost ranges are given because there are application-specific factors determining the actual cost of a substitute fiber textile. As the specifications of a particular application may include requirements regarding the quality as well as the quantity of substitute fiber that is used in the final product, the actual end-product costs will vary from application to application.

The cost of replacement for remaining asbestos products will be assumed to be the same for asbestos yarn and cloth products. An average textile product will, therefore, be the basis for determining the costs of substitution.

The average cost of an asbestos textile mixture that was being produced in 1985 was calculated to be $1.65/lb. (ICF 1986a). The equivalent prices for substitute products are given in Table 8.

Table 7. Costs of Substitute Fiber Textiles

Substitute Fiber	Cost Range of Fiber Relative to Asbestos for All Applications	Normalized[a] Weight of Fiber Used Relative to Asbestos	Cost Range of Finished Product Relative to Asbestos	Average Cost Relative to Asbestos
Glass	1-2	0.7	0.7-1.4	1.05
Ceramic	1-5	0.8	0.8-4.0	2.40
Aramid	6-9	0.8	4.8-7.2	6.00
Carbon	4-12	2.0	8.0-24.0	16.00
PBI	10-30	1.2	12.0-36.0	24.00

[a]Normalized with respect to amount used and weight of finished product.

Sources: Chemical Business 1984, Carborundum 1980, Industrial Minerals 1984, Spaulding 1986, Amatex 1986.

Table 8. Data Inputs for Asbestos Regulatory Cost Model for Textiles

Product	Output (tons)	Product Asbestos Coefficient (tons/ton)[a]	Consumption Production Ratio	Price ($/ton)	Useful Life	Equivalent Price ($/ton)	Market Share	Reference
Asbestos Mixtures	1,125	0.4960	1.511	3,300	1 year	3,300	N/A	ICF 1986a
Glass Fiber Mixtures	N/A	N/A	N/A	3,460	1 year	3,460	50%	Carborundum 1986
Ceramic Fiber Mixtures	N/A	N/A	N/A	7,920	1 year	7,920	15%	Chemical Business 1984
Aramid Fiber Mixtures	N/A	N/A	N/A	19,800	1 year	19,800	15%	Scott 1984
Carbon Fiber Mixtures	N/A	N/A	N/A	52,800	1 year	52,800	10%	Spaulding 1986
PBI Fiber Mixtures	N/A	N/A	N/A	79,200	1 year	79,200	10%	Garlock 1986

[a]Tons of fiber per ton of textile output.

N/A: Not Applicable.

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XXVII. SHEET GASKETS

A. Product Description

Gaskets are materials used to seal one compartment of a device from another in static applications. Asbestos gaskets, used to seal and prevent the leakage of fluids between solid non-moving surfaces, can be classified into two categories: compressed sheet and beater-add. Beater-add gaskets are discussed under the Beater-Add Gaskets category.

Compressed sheet gaskets use longer fibers, are more dense, and have a higher tensile strength than beater-add gaskets. They are manufactured on a special calender, known as a "sheeter", in such a manner that the compound is built up under high load, on one role of the "sheeter" to a specific thickness (Union Carbide 1987). Compressed sheet gaskets are used in heavy duty applications where severe temperatures and pressures are likely to exist. Different grades of asbestos sheet gasketing are available for different temperature use limits, and the proportion of fiber to binder in the gasket varies with the intended temperature use range. Fiber content increases as intended range of temperature use increases (Krusell and Cogley 1982). Sheet gaskets are suitable for use with steam, compressed air and other gases, chemicals, fluids, and organic compounds to temperatures of 950°F and pressure to 1500 psi (A.W. Chesterton 1983).

Wire inserted asbestos sheet is also available for use in pipe flanges that has slightly higher temperature and pressure limits (1000°F and 2000 psi, respectively). General service asbestos sheet is usually recommended for temperatures around 700°F and can be used in superheated or saturated steam service, or with weak acids and alkalies (A.W. Chesterton 1982).

Compressed asbestos gaskets are temperature and pressure dependent. As temperature increases their pressure capability decreases. It is difficult, therefore, to give exact pressure and temperature ranges, but Table 1 illustrates the useful fluid temperature and fluid ranges for compressed asbestos gasketing (Union Carbide 1987).

Asbestos sheet gaskets are used in exhaust systems and turbo chargers, cylinder head and intake manifolds, and high load/high extrusion applications. The most common sheet gaskets are used in engines, gear cases, and pipe flanges.[1]

Asbestos is the primary constituent for making compressed sheet gaskets (varying upwards from 75 percent by weight, depending on the application). Elastomeric binders such as neoprene, silicone based rubber, natural rubber, nitrile rubber, Teflon, or styrene-butadiene are used to ensure that gasketing material remains intact.

B. Producers of Sheet Gasketing

In 1985, five companies produced 2,848,308 square yards of compressed sheet gasketing. These companies consumed 4,041 tons of asbestos fiber (ICF 1986a).

In addition, a sixth company produced an estimated 759,000 square yards of compressed asbestos sheet gasketing from 1400 tons of asbestos fiber.[2] The total estimated consumption for this category is, therefore, estimated to be 3,607,408 square yards of sheet gasketing from 5,441.1 tons of fiber. Table 2 presents the production volume and fiber consumption for gaskets in 1985. Known imports make up a small percentage of the total gaskets consumed in the U.S. There were 506.35 tons of sheet gasketing imported in 1985 (ICF 1986a). The asbestos compressed sheet gasketing market was estimated to be worth

[1] Due to the wide variety of gasketing shapes, sizes, compositions, and sheathing materials available, an all-inclusive list of fabricated products is not available.

[2] Based on the methodology for allocating consumption to survey non-respondents in Appendix A.

Table 1. Fluid and Pressure Ranges for Compressed Asbestos Sheet Gasketing Material

Temperature and Pressure	Product[a]
750-1000°F, Vacuum -- 1500 psi	Premium Compressed Asbestos Sheet
250-750°F, Atmos -- 1500 psi	Service Compressed Asbestos Sheet
-70-250°F, Atmos -- 1500 psi	Economy Compressed Asbestos Sheet

[a]Premium indicates the highest grade of compressed asbestos sheet, usually wire inserted. Service indicates general use compressed asbestos sheet and economy is the lowest grade of asbestos sheet available.

Source: Union Carbide 1987.

Table 2. Production of Asbestos Sheet Gasketing and Asbestos Fiber Consumption

	1985 Fiber Consumption (short tons)	1985 Production (sq. yd.)	References
Total	5,441.1	3,607,408.0	TSCA 1982, ICF 1986a, ICF 1987

$20.5 million in 1985, based on an average price of $5.69 per square yard (ICF 1986a).

C. Trends

Between 1981 and 1985, two manufacturers of compressed asbestos sheet gasketing, Jenkins Brothers (Bridgeport, CT) and Manville Sales Corporation (Manville, NJ and Waukegan, IL) discontinued their operations. During those four years, total production fell 44 percent from 6,472,879 square yards to 3,607,408 square yards (see Table 2). Currently, non-asbestos gaskets hold less than 50 percent of the gasket market, but as concerns about asbestos and its health effects grow, the use of asbestos in compressed sheet gaskets is expected to decline (ICF 1986a).

D. Substitutes

Asbestos has been used in sheet gaskets because it is chemically inert, nearly indestructible and can be processed into fiber. Asbestos fibers partially adsorb the binder with which they are mixed during processing; they then intertwine within it and become the strengthening matrix of the product. Since the product contains as much as 80 percent asbestos fiber, manufacturers are also employing it as a filler. The balance of the product is the binder which holds the asbestos in the matrix (Kirk-Othmer 1981).

A single substitute for asbestos is not available. Manufacturers have, therefore, been forced to replace the asbestos fiber with a combination of substitute materials. The formulations of the substitute products most often include a combination of more than one type of substitute fiber and more than one filler in order to reproduce the properties of asbestos necessary for that application. Formulation of substitute products is done on an application-by-application basis by each manufacturer (ICF 1986a). For the purposes of this analysis, the substitute products will be grouped into six major categories according to the type of non-asbestos substitute used (Table 3 presents properties of the substitute fibers):

- aramid mixtures,
- fibrous glass mixtures,
- graphite mixtures,
- cellulose mixtures, and
- PTFE mixtures (ICF 1986a, Palmetto Packing 1986).

The current market share of the different substitute formulations is estimated to be as indicated in Table 4. Industry experts have indicated that asbestos sheet gaskets account for approximately 50 to 60 percent of the current market. It is evident, however, from the survey that the market share of asbestos free sheet 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 stipulate the use of asbestos gaskets. This includes aerospace and Naval specifications. A 100 percent asbestos-free market is impossible to achieve if military specifications continue to require asbestos products.[3]

1. Aramid Mixtures

Aramid fiber products are produced by numerous companies from DuPont's Kevlar(R) and Nomex(R) fibers. Kevlar(R) and Nomex(R) were introduced in late 1980 to act as reinforcing fibers in asbestos free gaskets and other materials. They are highly heat resistant and strong (ten times stronger than steel, by weight). They are about twenty times more expensive than asbestos, by weight. Because it is less dense and stronger, however, less is needed for reinforcement purposes. At high temperatures (above 800°F), the fiber physically degrades, but it is very strong and can withstand very high pressure up to the temperature limit (A.W. Chesterton 1983).

[3] Department of Defense branches seem willing to follow EPA requirements and recommendations for new equipment, but for existing equipment, revalidation with a new gasketing material would be very costly (DOD 1986).

Table 3. Substitutes for Asbestos Sheet Gasketing

Product	Advantages	Disadvantages	Remarks	References
Aramid	Very strong. Year resistant. High tensile strength.	Hard to cut. Wears out cutting dyes quickly. 800°F temperature limit.		ICF 1986a, ICF 1985, Mach. Des., July 10, 1986
Fibrous Glass	Good tensile properties. Chemical resistant.	More expensive than asbestos.	Often used in the auto industry.	ICF 1986a, ICF 1985, Mach. Des., July 10, 1986
Graphite	Heat resistant to 5000°F. Chemical resistant. Light weight.	Expensive. Brittle. Frays.	Fastest growing substitute in the auto market in high temperature seals.	ICF 1986a, ICF 1985, Mach. Des., July 10, 1986
Cellulose	Inexpensive. Good carrier web.	Not heat resistant. Useful to 350°F. Not chemically resistant.	Useful for low temperature applications only.	ICF 1986a, 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 1986a, Palmetto Packing 1986a
Ceramic	High temperature limit. Flexible.	Incompatible with some binders. No test data.	Secret Filler.	ICF 1986a

Table 4. Estimated Market Shares for Substitute Fibers Replacing Compressed Asbestos Sheet

Substitute Fiber	Estimated Market Share	Reference
Aramid	30	Palmetto Packing 1986
Glass Fiber	25	Palmetto Packing 1986
Graphite	15	Union Carbide 1987
Ceramic	5	ICF 1986a
Cellulose	15	Palmetto Packing 1986
PTFE	10	ICF 1986a

Aramid gaskets are usually composed of 20 percent aramid fiber, by weight, and 60 to 65 percent fibers and fillers such as silica and clay. The remaining 20 to 25 percent is the binder which keeps the fibers in a matrix. Typical applications include off-highway equipment, diesel engines, and compressors. These applications require a very strong gasketing material that will withstand moderate temperatures (A.W. Chesterton 1982).

Aramid gaskets as a substitute for asbestos sheet gaskets are used because of the fiber's strength and high temperature resistance. Formulations also include mineral fillers and elastomeric binders. Aramid product costs 1.7 times as much as the asbestos product for some applications, resulting in gaskets that cost $9.72 per square yard.

Industry officials project 30 percent of the total asbestos market will be captured by this substitute (ICF 1986a, Palmetto Packing 1986).

2. Fibrous Glass Mixtures

Fibrous glass is generally coated with a binder such as neoprene, TFE, or graphite in the manufacturing process to make gaskets. Glass fibers are relatively easy to handle and reduce the costs of product formulation. Fibrous glass gaskets are usually 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 is occasionally manufactured into a gasketing which is used as a jacket around a plastic core of carbon or aramid fibers and other materials (OGJ 1986).

"E" glass gaskets are suitable for general service applications where the operating temperature is below 1000°F. Above this temperature, the gasketing loses 50 percent of its tensile strength. The materials can be used with most fluids except strong acids and alkalies (A.W. Chesterton 1982).

The second type of glass 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. The sheet gasketing is caustic resistant and can be used in applications with operating temperatures that reach 1500°F. (OGJ 1986).

Industry representatives project that glass gaskets will capture 25 percent of the total asbestos sheet gasketing market. They estimate that the glass material will cost twice as much as the asbestos material. Thus, the price will be $11.38 per square yard (Palmetto Packing 1986, ICF 1986a).

3. Graphite Mixtures

Flexible graphite, developed by Union Carbide Corp. is made from natural flake graphite, which is expanded several hundred times into a light, fluffy material by mixing it with nitric or sulfuric acid. It is then calendered into a sheet (without additives or binders) (Chem. Eng. News 1986). In addition, graphite based materials can be formed by removing all of the elements except carbon from polyacrylnitrile polymers or viscose rayon (Kirk-Othmer 1981).

These materials are extremely heat resistant and inherently fire-safe. 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 gasketing has excellent chemical resistance with the exception of strong mineral acids. Graphite packings can be used in most applications up to 1500 psi and unlike asbestos sheet gasketing do not show as great a temperature/pressure dependence[4] (Union Carbide 1987).

Graphite material is often used in oil refinery and oil field applications (e.g., oil-well drilling equipment) because of its high temperature

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[4] Flexible graphite temperature limits are independent of gasket compressive load and therefore fluid pressure, whereas all compressed asbestos gaskets are temperature and pressure dependent.

resistance. A wire insert is often added for increased strength in these 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 (Palmetto Packing 1986). The cost of replacement gaskets made from graphite are approximately two times that of the asbestos gaskets they will replace based on fiber requirements and processing costs (Union Carbide 1987). The price of the substitute material is, therefore, $11.38 per square yard. Industry officials project this substitute's market share to be 15 percent of the total asbestos gasketing market (Palmetto Packing 1986, Union Carbide 1987, ICF 1986a).

4. Cellulose Fiber Mixtures

Cellulose fibers are generally milled from unused or recycled newsprint or vegetable fiber in the presence of additives which ease grinding and prevent fires during processing.

Manufacturers of sheet gaskets that contain cellulose fiber consider their specific formulations proprietary. These producers, however, indicate that these fibers are generally used with a combination of clay and mineral thickeners. The gaskets made from cellulose products have a content of 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 1986a).

Traditionally, cellulose fiber gaskets are only used at low pressure (<250 psi) and methods to reinforce the fibers, however, increase their use limits, resulting in excellent crush resistance, excellent dimensional stability, and good sealability below 350°F. Cellulose gaskets can substitute for asbestos sheet gaskets in low temperature applications such as with oil, gas, organic solvents, fuels, and low pressure steam (Union Carbide 1987).

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. Despite this, manufacturers indicate that the service life of these asbestos free gaskets is the same as for asbestos gaskets (Carborundum 1986).

Cellulose fiber formulations in combination with clay and mineral thickeners are estimated to capture 15 percent of the sheet gasketing market in the event of an asbestos ban. Prices would be expected to rise 20 percent to $6.83 per square yard due to increased material and production costs (ICF 1986a).

5. PTFE

PTFE fibers offer 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). This material 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 (Krusell and Cogley 1982).

PTFE, and PTFE and graphite mixtures can be formulated into gasketing material easily, reducing the price of the gasketing that would otherwise be quite high (PTFE is twenty times as expensive as asbestos). The final product, however, is only 3.5 times as expensive as the asbestos product. PTFE gasketing is, therefore, $19.91 per square yard. Industry officials indicated that PTFE gaskets will capture 10 percent of the total asbestos market in the case of an asbestos ban (Palmetto Packing 1986, ICF 1986a).

6. Ceramic Fiber Mixtures

Ceramic fibers, composed of alumina-silica blends are used in the manufacture of gasketing material to replace compressed asbestos sheet, although their performance has not been outstanding (Union Carbide 1987). These fibers impart high temperature resistance to gaskets made from them, but little information is available on the performance characteristics of these materials. Costs are expected to be the same as for other ceramic based products that can replace asbestos products (two times as expensive), but it is unlikely that ceramic products will occupy more than five percent of the market in the event of an asbestos ban (ICF estimate).

E. Summary

It appears that substitutes for asbestos containing sheet gaskets currently exist. However, these products cost more to produce and may not perform as well. Substitute fiber formulations include aramid, glass, graphite, cellulose, PTFE, and ceramic fibers. The substitute materials are a combination of fibers and fillers designed on an application-by-application basis. The substitute materials are classified by the fiber with the highest content.

The estimation of market shares and prices of the substitute formulations in the event of an asbestos ban and the data inputs for the Asbestos Regulatory Cost Model are presented in Table 5.

Table 5. Data Inputs for Asbestos Regulatory Cost Model
Sheet Gasketing

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price (sq. yd.)	Useful Life	Equivalent Price (sq. yd.)	Market Share	References
Asbestos Gasketing	3,607,408 sq. yds.	0.00151 tons/ton	1.07	$5.69	5 years	$5.69	N/A	ICF 1986a
Aramid	N/A	N/A	N/A	$9.72	5 years	$9.72	30%	ICF 1986a, Palmetto Packing 1986a
Fibrous Glass	N/A	N/A	N/A	$11.38	5 years	$11.38	25%	ICF 1986a, Palmetto Packing 1986a
Graphite	N/A	N/A	N/A	$11.38	5 years	$11.38	15%	ICF 1986a, Palmetto Packing 1986a
Cellulose	N/A	N/A	N/A	$6.83	5 years	$6.83	15%	ICF 1986a, Palmetto Packing 1986a
PTFE	N/A	N/A	N/A	$19.91	5 years	$19.91	10%	ICF 1986a, Palmetto Packing 1986a
Ceramic	N/A	N/A	N/A	$11.38	5 years	$11.38	5%	ICF 1986a, Carborundum 1986

N/A: Not Applicable.

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XXVIII. ASBESTOS PACKINGS

A. Product Description

The term packings is generally assigned to the subset of packings that are designated as dynamic (static packings are gaskets). These dynamic or mechanical packings are used to seal fluids in devices where motion is necessary. Examples where these packings have traditionally been used are in pumps, valves, compressors, mixers, and hydraulic (piston-type) cylinders (Kirk-Othmer 1981). Within the mechanical packing segment there are various types of packings (e.g., compression, automatic, and floating packings), but only compression packings are or have been made using asbestos fibers (FSA 1983).

Asbestos-containing compression packings can be formed into various shapes for different uses as illustrated in Figure 1. The simplest form of compression packings (hence forward packings) is of the loose bulk type. Bulk formulations consist of blends of loose fibers and dry lubricants that are bound with a liquid or wax binder. These simple packings have only limited applications (e.g., packings for injection guns) and are not considered in the remainder of this report. Fiber mixtures are more often extruded with a binder and lubricant and used as a core in packings that have a braided yarn jacket that imparts greater durability to the packing (Kirk-Othmer 1981).

The braided variety of packings are the most prevalent and all of the well-known packing manufacturers produce them by similar methods of construction. Asbestos packings are braided of strong, highest quality pure asbestos yarn. In addition, they may be constructed using an Inconel(R) or other wire insert around a resilient asbestos core impregnated with graphite. They are lubricated throughout and surfaced with anti-frictional dry lubricant graphite (EPRI 1982). The simplest form of braided packing is the square braided variety that utilizes asbestos yarns of the six grades defined

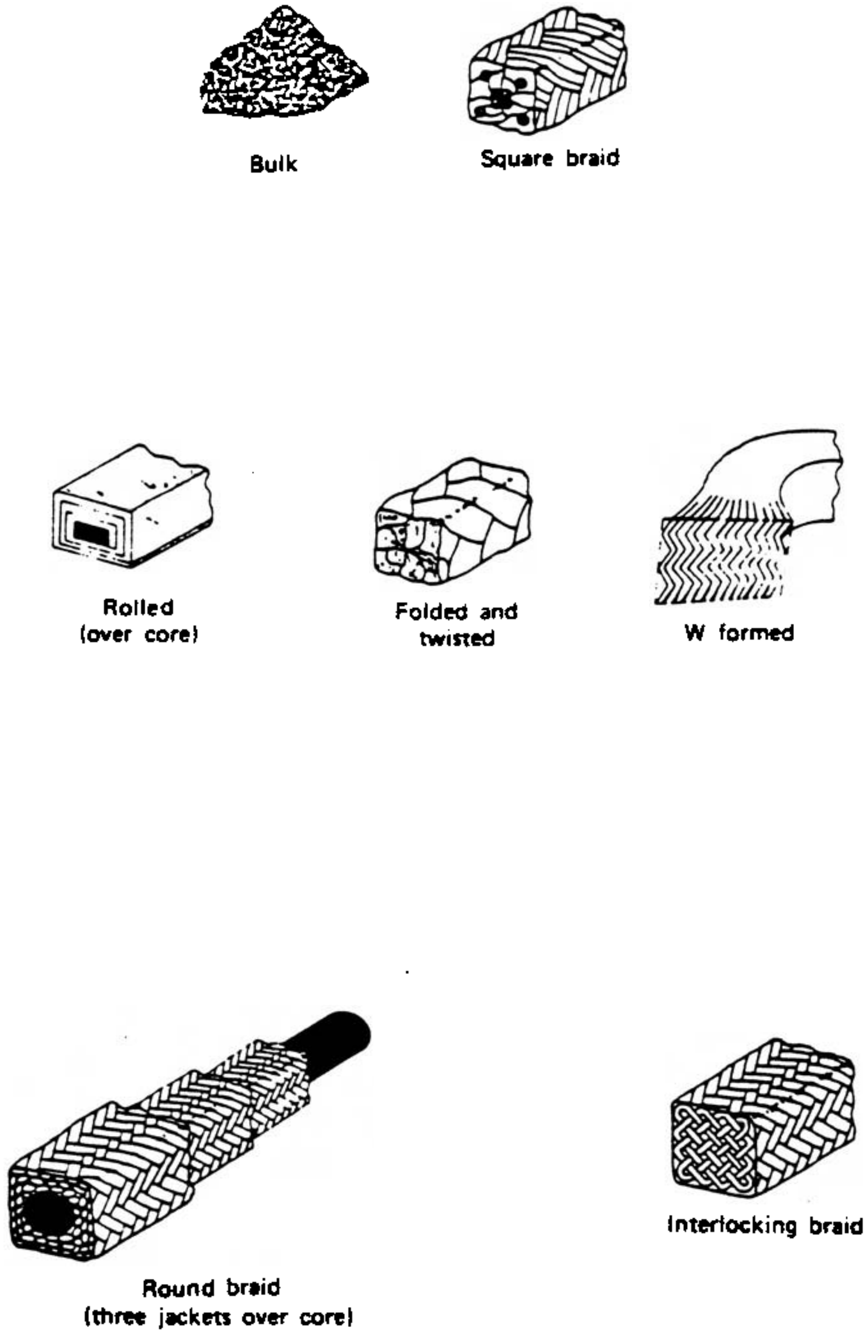

Figure 1. Common Types of Compression Packings. (Source: Kirk-Othmer 1981).

according to ASTM D 299, the standard for such materials. These grades are listed in Table 1 (ASTM 1982). The dimensions of the packing are controlled by the size and number of yarns selected (Kirk-Othmer 1981).

Another type of braided packing, braid-over-braid packing, consists of individually braided jackets layered over a core. These packings use wire-inserted yarns that offer greater strength to the packing material. Rolled compression packings are constructed of woven cloth that is coated with a rubber binder and then cut in strips along the bias to impart maximum cloth stretch during forming. The rubber-saturated strips are wound around a soft rubber core and then formed into the desired final shape. The final cutting, forming, and compression operations for all packing types are usually performed by secondary processors (FSA 1983).[1]

All of the packing formation processes have some characteristics in common. First, impregnation of dry asbestos yarn with a lubricant. After lubricant impregnation, the yarns are braided into a continuous length of packing which in turn is calendered to a specific size and cross-sectional shape. The formed product may then be coated with more lubricant or another material. At this stage packings can be packaged and sold for maintenance operations or they can be further processed by pressing into the required shape (GCA 1980).

Finally, packings can be die-formed directly into solid rings to facilitate handling and installation. The packings that have been formed into a designated shape are referred to as plastic packings (Kirk-Othmer 1981).

The uses and applications of asbestos packings are quite varied, but some of the major areas in which asbestos-containing packing materials have been

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[1] Secondary processing usually occurs at the facility where the gaskets will be used and consists of cutting and compressing the packings as they are needed to replace worn packings already in service in various pumps, valves, etc.

Table 1. Standards of Asbestos Yarns Used in Asbestos Packings

Grade	Asbestos Content (percent)
Commercial	75-80
Underwriters'	80-85
A	85-90
AA	90-95
AAA	95-99
AAAA	99-100

Source: ASTM 1982.

used are valves and pumps employed in the electric power, petroleum refinery, petrochemical, chemical, nuclear power, and pulp and paper industries (Union Carbide 1987). Depending on the scale of these operations, asbestos packings of various shapes and sizes are required. As described earlier, the design of a packing is to control the amount of leakage of fluid at shafts, rods or valve systems and other functional parts or equipment requiring containment of liquids or gases. Packings are used in rotary, centrifugal, and reciprocating pumps, valves, expansion joints, soot blowers, and many other types of mechanical equipment (FSA 1983). Figures 2 and 3 illustrate the design of a typical pump with a packing set and the configuration of a packing, respectively.

Depending on the conditions of use, various types of asbestos packings are used. The temperature and pressure of the system in which the packing is used determine the style of packing that is used and the type of additional constituents incorporated in the packing (e.g., other fibers, binders, fillers). Other factors that affect the composition and configuration of the packing system include: the rotation speed of the valve or pump member, the type of fluid being contained (i.e., caustic, acid, alcohol, petrochemical), and the amount of time between scheduled maintenance operations (FSA 1983).

Table 2 identifies the different packing types traditionally made from asbestos fibers, their service areas, and the conditions under which typical operations are performed.[2]

Asbestos is used in packings because of its unique combination of heat and chemical resistance as well as its low price. The important attributes of asbestos fiber for this application are the following:

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[2] It should be noted that packings can be used in varying applications and are not strictly limited to certain operating conditions. Table 2 gives likely use areas and conditions, but these are not limiting designations.

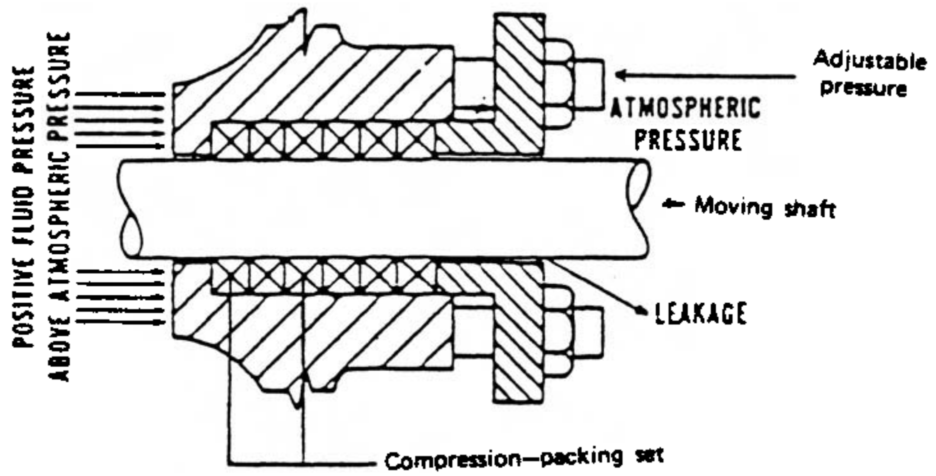

Figure 2. Typical Stuffing Box Construction Utilizing Compression Packings for Effecting a Dynamic Seal. (Source: FSA 1983).

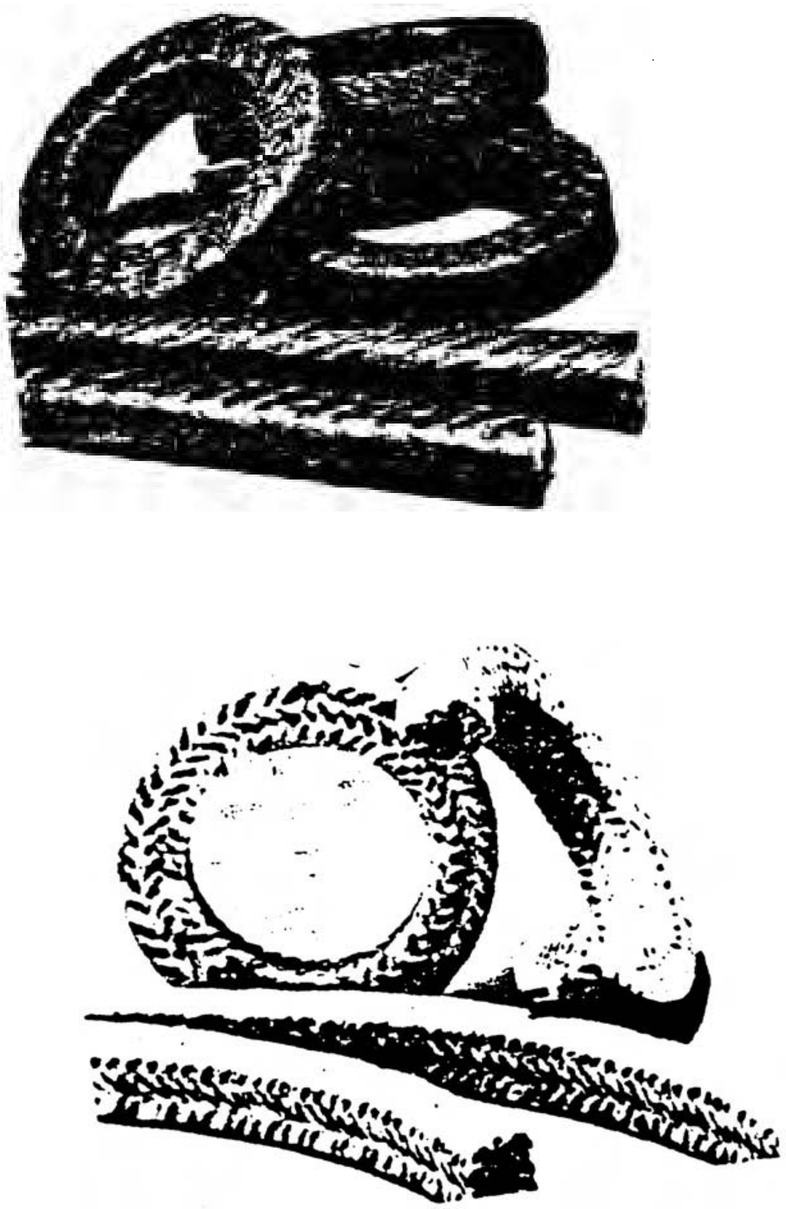

Figure 3. Typical Asbestos-Containing Packing Illustrating the Coil and Pre-Compressed Forms. (Source: A.W. Chesterton 1982).

NOTE: Most packings, although available in pre-compressed ring form, are purchased as a coil and cut and formed on site.

Table 2. Operating Conditions and Use Areas for Various Braided Packing Types

Packing Type	Advantages	Operating Conditions*	Use Area
Square Braid	Wide spectrum sealing ability	High-speed rotation Low pressure <600 psi	Pumps and valves of all types
Braid-Over-Braid	Better sealing than conventional square braid	Slow-speed rotation High pressure >600 psi Hot liquids	Valve stems, expansion joints
Braid-Over-Core	Better shaft sealing More resilient Variations in density	High pressure Steam applications Low-speed rotation	Nuclear powerplants, when congealing or crystalizing liquids are present, turbines and values in powerplants
Interlocking Braid	Denser and more stable	General service High temperature/pressure	Reciprocating and centrifugal pumps, agitators, valves, expansion joints

Source: FSA 1983, A.W. Chesterton 1982, Klein 1987.

NOTE: General service temperature for all types of braided packings are in the range of 500°F although depending on the use conditions, asbestos packings can withstand temperatures between 1200-1500°F.

- heat resistance to prevent thermal decomposition of the packing due to elevated shaft speeds and high temperature fluids;
- chemical resistance to prevent deterioration of the packing due to contact with caustic and potentially explosive fluids;
- durability to provide long lasting control of fluid flow; and,
- low cost (ICF 1986a).

B. Producers and Importers of Asbestos Packing

Table 3 lists the fiber consumption and quantity of packings produced in 1985. (Raymark Corporation refused to provide production and fiber consumption data for 1985, but was a producer in 1981 and so was assumed to have continued production of asbestos packing.) The values for domestic asbestos fiber consumption in the production of asbestos packings and the total amount of asbestos packings produced have been changed to account for the output of Raymark Corporation using the methodology described in Appendix A to this RIA. The adjusted values are 2.1 tons and 3 tons for fiber consumption and packings production, respectively (ICF 1986a).

The secondary processors of asbestos packings in 1983 include: FMC Corporation in Houston, Texas and WKM Division of ACF Industries, Inc. in Missouri City, Texas. While WKM Division imported its asbestos mixture, FMC Corporation used domestic supplies in 1985. These companies received packings and further processed them in order to meet specifications of their customers (ICF 1986a).

C. Trends

Three manufacturers, Johns-Manville Corporation (now Manville Sales Corporation) in Manville, New Jersey, Rockwell International in Pittsburgh, Pennsylvania, and John-Crane Houdaille (now Crane Packing) in Morton Grove, Illinois, ceased production of asbestos packings between 1981 and 1985.

Table 3. Production of Asbestos Packing and Asbestos Fiber Consumption

	1985 Asbestos Fiber Consumption	1985 Production of Asbestos Packings
Total	2.1 tons	3 tons

Values for fiber consumption and packing production for Raymark Corporation have been estimated based on the methodology for non-respondents described in Appendix A to this RIA.

Sources: ICF 1986a.

During this time period, estimated domestic production declined 99.7 percent, from 952.34 to 3 short tons and fiber consumption declined 99.8 percent, from 877.54 to 2.1 short tons (ICF 1986a, ICF 1985, TSCA 1982).

In 1986, Durametallic Corporation, which accounted for two-third of the total output for asbestos packings in 1985, ceased processing because of costly insurance premiums and the possibility of regulatory action (ICF 1986a).

D. Substitutes

Asbestos-containing packings, the large majority of which are based on various compositions and configurations of braided yarn, have dominated the market until very recently. A typical high performance braided asbestos packing includes an alloy wire reinforcement, various lubricants, a zinc powder corrosion inhibitor, and a graphite powder lubricant coating on the yarn itself (Union Carbide 1987). In addition, these packings may contain various binders (e.g., elastomers or resins), fillers (e.g., mica, clay, or asbestos) and dry lubricants (Monsanto 1987).

Asbestos fibers have been used to make the braided jackets for packings because of the favorable qualities that asbestos imparts to products made from it. Asbestos-containing packings are ideally suited for high temperature and pressure, as well as corrosive environments. Braided asbestos packings show good acid/fire resistance, low thermal conductivity, and molten metal resistance. Asbestos also withstands fairly high pressures (up to 4500 psi at room temperature) and exhibits good tensile strength and abrasion resistance (Klein 1987). Another property of asbestos packings that has made them a standard in the packing industry is their good compressibility and recovery (EPRI 1982).

The packing industry has been unable to find a single substitute for asbestos that can reproduce its numerous qualities. Hence, manufacturers have been forced to replace the asbestos fiber with a combination of substitute materials, including cellulose, aramid, PBI, PTFE, glass, and graphite fibers. The formulations of the substitute products most often include a combination of more than one type of substitute fiber and fillers in order to reproduce the properties of asbestos necessary for a particular application.

Formulation of substitute products is done on an application-by-application basis by each manufacturer (ICF 1986a) and for the purposes of this analysis, substitute products will be classified according to the fiber with the largest percentage in content. The substitute products can be grouped into six major categories according to the type of non-asbestos substitute used:[3]

- Aramid fiber mixtures,
- Glass fiber mixtures,
- PBI fiber mixtures,
- PTFE mixtures,
- Graphite mixtures, and
- Other fiber mixtures including cellulose, phosphate, and ceramic (ICF 1986a, Palmetto Packing 1986, Monsanto 1987).

The current market share for the different substitute formulations has been estimated as indicated in Table 4.

1. Aramid Mixture

Aramid fibers act as a reinforcing fiber in asbestos free packings and other materials. They are not as heat resistant as asbestos (500°F), but are quite strong and flexible and can withstand mild acids and alkalies (A.W. Chesterton 1982). Kevlar(R) and Nomex(R) produced by DuPont Corporation are

[3] The grade or the fiber and style of the packing used (e.g., square braid, braid-over-braid) determine the pressure rating for all applications. Any substitute fiber can be formulated into a packing that will meet most pressure requirements, but temperature and chemical limitations may dictate the selection of a particular fiber for a particular application.

about twenty times more expensive than asbestos, by weight, but because they are less dense and stronger, less is needed for reinforcement purposes. At higher temperatures, the fibers physically degrade and thus are not good replacements for asbestos products for high temperature applications.

Aramid packings are usually 20 percent aramid fiber, by weight, and 60 to 65 percent filler, while the remaining 20 to 25 percent is binder to keep the fibers in a matrix. Typical applications for valves and pumps require a very strong packing material that will withstand moderate temperatures and pressures without deteriorating.

Raymark Corporation, in Stratford, CT, was the only asbestos packing manufacturer to cite aramid packings as a substitute for asbestos products. They can be used for general service in most plants (A.W. Chesterton 1983). Aramid-based products are likely to be 1.5 to 3 times as expensive as the asbestos products they replace, therefore aramid packings cost between $45.30 and $90.60 per pound. The price increase is due to production and material cost increases (ICF 1986a).

There are no performance disadvantages due to the dilution of the aramid fiber with mineral fillers and this helps to reduce the price of packings. The service life is estimated to be the same as the life of the asbestos product. Industry estimates indicate that aramid products will capture 20 percent of the total packings market. The average price for an aramid-based packing is estimated to be $67.95 per pound (ICF 1986a, Palmetto Packing 1986).

2. Fibrous Glass Mixtures

Fibrous glass is generally coated with a binder such as neoprene, TFE, or graphite in the manufacturing process to make packings. Glass fibers are relatively easy to process into packing materials and are used extensively in packing materials.

Table 4. Estimated Market Share for Substitute Fibers that can Replace Existing Asbestos Products in Compression Packings

Substitute Fiber	Market Share (percent)	Reference
Glass	30	Palmetto Packing 1986
Graphite	10	Union Carbide 1987
Aramids	30	ICF 1986a
PBI	15	ICF 1986a
PTFE	15	Union Carbide 1987

NOTE: The market shares indicated are estimates based on communications with industry representatives and are likely to change over time. For example, the share of graphite products is likely to increase over the next five years. New products (e.g., phosphate based fibers) are likely to penetrate the market to a certain extent (Monsanto 1987).

Fibrous glass packings are usually divided into two groups, "E" glass packings, and "S" glass packings, depending upon the type of glass fiber used in the formulation. "E" glass is one of the more common glass fibers, and is often manufactured into a packing which is used as a jacket around a plastic core of carbon or aramid fibers, and other materials (OGJ 1986).

"E" glass packings are suitable for applications where the operating temperature is below 1000°F. Above this temperature, the packing loses 50 percent of its tensile strength. Also, 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 generally used as a jacket around a core of graphite and other fibers. The packing is caustic resistant and can be used in applications with operating temperatures of 1500°F (OGJ 1986).

One disadvantage of glass packings is the abrasive nature of the material. In high shaft-speed applications, the abrasiveness of glass wears down the shaft stem requiring frequent replacement of the stem. Glass packings will capture 30 percent of the total asbestos packing market and will cost twice as much as the asbestos material. Thus, the price will be $60.40 per pound (Palmetto Packing, ICF 1986a).

John Crane-Houdaille, previously one of the major producers of asbestos packings, offers an "S"-glass yarn packing replacement that it claims is better than the asbestos packings it replaces. It has a higher temperature limit, good service life in caustics, steam, oil, liquid petroleum, and chemicals, a high pressure limit of 7700 psi and will not score valve stems or other pieces of equipment in which it is used (John-Crane 1987).

3. <u>PBI Mixtures</u>

PBI (polybenzimidazole) is produced by Celanese Engineering. It has a useful temperature limit of approximately 1000°F and has high chemical resistance. It is designed to be used in high temperature, high pressure applications, and it is easy to work with because it can be formed into rings with little difficulty. The non-asbestos packing costs approximately three times as much as the asbestos product, making the cost about $90.60 per pound (ICF 1986a). The service life is the same as the asbestos product.

The non-asbestos product has poorer wettability (is less porous), but this problem can be compensated for in the design of the application. PBI packings will capture 15 percent of the total asbestos packing market with a price of $90.60 per pound (ICF 1986a).

4. PTFE Fibers

Many forms of polytetrafluoroethylene fibers (PTFE) are used as substitutes for asbestos in packings, but the most popular is Dupont's Teflon(R) (Palmetto Packing 1986). PTFE offers 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). This material 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 (Krusell and Cogley 1982) which makes it ideal for use in paper mill applications (A.W. Chesterton 1982).

Palmetto Packing representatives cited PTFE, and PTFE and graphite mixtures as materials they manufacture into packing. PTFE fibers are twenty times as expensive as asbestos, but ease of handling and durability make the product only 3.5 times as expensive as the asbestos product. PTFE packing material, therefore, costs $105.70 per pound (ICF 1986a). Industry officials indicate that PTFE packings will capture 15 percent of the total asbestos market in the case of an asbestos ban (Palmetto Packing 1986, ICF 1986a).

5. Graphite

Flexible graphite was developed by Union Carbide Corp. about twenty years ago. The material is made from natural flake graphite, which is expanded several hundred times into a light, fluffy material by mixing it with nitric or sulfuric acid. It is then calendered into a sheet (without additives or binders) (Chem. Eng. News 1986). It can then be processed into packings by standard techniques. Other forms of graphite are also available (e.g., carbonized viscose rayon and other fibrous graphite materials) that have similar properties. All graphite materials will be grouped together for convenience and because their properties are similar.

Graphite materials are extremely heat resistant and inherently fire-safe (because it does not contain binders). Graphite packings 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 packing has excellent chemical resistance with the exception of strong mineral acids.

Graphite-containing packings are often used in oil refineries and oil fields because of its high temperature resistance. Often, in these high temperature, high pressure applications, a wire insert is added for increased strength (OGJ 1986).

Graphite materials are fairly expensive, but the addition of various fillers helps keep the cost competitive with other substitute materials (Palmetto Packing 1986). Graphite packings cost about two times as much as asbestos packings on a per weight basis and costs are estimated to be $60.40 per pound (Union Carbide 1987). Industry officials project this substitute's market share as 10 percent of the total asbestos packing market (Palmetto Packing 1986, ICF 1986a).

6. Other Substitute Fibers

Other fiber products made from cellulose, phosphate, or ceramic fibers have very small market shares and are not seen as viable replacement for asbestos in general service areas at this time. Ceramic fibers have been used for packing materials, but do not see widespread use due to their abrasive nature and brittleness (Union Carbide 1987). Phosphate fibers may see an increased market share in the future, but currently are only in developmental stages[4] (Monsanto 1987). Cellulose fibers occupy a very limited market share although for applications demanding little in the way of high performance they can be used (ICF 1986a).

E. Summary

It appears that substitutes for asbestos containing packings currently exist. These products, however, cost more to produce and may not perform as well. Since no across the board substitute fiber exists, manufacturers have been forced to replace asbestos with a combination of substitute materials, including graphite, PTFE, glass, aramid, and PBI fibers. The substitute materials are a combination of fibers and fillers designed on an application-by-application basis. The materials are classified by the fiber with the highest content. Table 5 summarizes the characteristics of the asbestos substitutes.

The estimation of market shares, prices of the substitute formulations in the event of an asbestos ban, and data inputs for the Asbestos Regulatory Cost Model are summarized in Table 6.

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[4] Although these fibers seem promising there is little industry data on their performance in field applications.

Table 5. Substitutes for Asbestos Packings

Product	Advantages	Disadvantages	Remarks	References
Aramid	Very strong. Tear resistant. High tensile strength.	Unable to handle strongly acidic or basic fluids. 500°F temperature limit.	Widely known. Used in the paper industry.	ICF 1986a, ICF 1985
Fibrous Glass	Withstands temperature to 1000°F. Good tensile properties.	Abrasive.	Market is growing for glass.	ICF 1986a, OGJ 1986, Chem. Eng. News 1986
Polybenzimidazole (PBI)	Withstands temperature to 1000°F.	Poorer wettability premium premium price.	Used in high temperature, high pressure applications.	ICF 1986a, OGJ 1986
PTFE	Low friction. FDA approved to contact food and medical equipment.	Not as resilient as asbestos. Deforms under heavy loads.	Temperature resistance to 500°F.	ICF 1986a, OGJ 1986, Palmetto Packing 1986
Graphite	Heat resistant up to 5000°F. Chemical resistance.	Brittle. Frays. Premium price.	Usually with a wire insert. Used in high temperature, applications.	Palmetto Packing 1986,

Table 6. Data Inputs for Asbestos Regulatory Cost Model
(028) Packing

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price ($/ton)	Useful Life	Equivalent Price ($/ton)	Market Share	References
Asbestos Packing	3 tons	0.70 tons/ton	1	60,400	1 year	60,400	N/A	ICF 1986a
Aramid	N/A	N/A	N/A	135,900	1 year	135,900	30%	ICF 1986a
Fibrous Glass	N/A	N/A	N/A	120,800	1 year	120,800	30%	ICF 1986a, Palmetto Packing 1986
PTFE	N/A	N/A	N/A	211,400	1 year	211,400	15%	ICF 1986a, Palmetto Packing 1986
Graphite	N/A	N/A	N/A	120,800	1 year	120,800	10%	ICF 1986a, Palmetto Packing 1986
PBI	N/A	N/A	N/A	181,200	1 year	181,200	15%	ICF 1986a

N/A: Not Applicable.

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XXIX. ROOF COATINGS AND CEMENTS

A. Product Description

Roof coatings and roofing cements together accounted for 90 percent of the asbestos containing adhesives, sealants, and coatings produced in the United States in 1985. Other more specialized asbestos containing compounds used by the construction, automobile, and aerospace industries accounted for the remaining 10 percent. They are discussed separately under the Non-Roofing Adhesives, Sealants, and Coatings category.

Roof coatings are cold-applied liquids which may be brushed or sprayed on roofs or foundations to perform a variety of functions such as waterproofing, weather resistance, and surface rejuvenation. Asphalt based, thinned with solvents, and bodied with 5 to 10 percent asbestos fiber, roof coatings are applied to most types of roofs except the typical shingled roof. Commercial and industrial structures such as stores, shopping centers, and office and apartment buildings are common users. Usually black, these coatings may be pigmented with aluminum paste to create a silver coating with high heat reflectance (ICF 1986; Krusell and Cogley 1982).

Roofing cements are more viscous roof coatings. Usually consisting of solvent thinned asphalt and bodied with 15 to 20 percent asbestos, roofing cements are trowel-applied with the consistency of a soft paste. Applied to all types of roofs, they are used to repair and patch roofs, seal around projections such as chimneys and vent pipes, and bond horizontal and vertical surfaces (ICF 1986; Krusell and Cogley 1982).

Asbestos is used in roofing compounds for its unique combination of strength, viscosity control, and price. The important attributes of asbestos fiber for this application are: (ICF 1986, Krusell and Cogley 1982):

- asphalt reinforcement to prevent cracking due to factors such as temperature change;

- viscosity control for waterproofing since asbestos content aids in the application of an even coat without gaps or holes;
- sag resistance to ensure that the compound remains stationary on steep surfaces, and does not melt and run in the event of a fire;
- maintenance of surface protection since asbestos fiber prevents the liquefied asphalt from penetrating the resident surface;
- asphalt affinity to provide uniform asbestos dispersion without bunching or settling of fibers;
- weathering resistance to retard oxidation and deterioration of the asphalt; and,
- low cost.

Companies that manufacture roof coatings also manufacture roofing cements. Production is typically a batch process. Bagged asbestos (usually grade 7 chrysotile) is moved from storage and dumped into a fluffing machine which is used to separate the fibers that may have been compressed together. The fibers are then generally transferred to a batch mixing tank where other ingredients are mixed until the desired consistency is obtained. Finally the mixture is sent for packaging or containerizing, usually into tank trucks and five gallon metal pails with sealed lids. In both products asbestos fibers are thought to be completely encapsulated by other product constituents (ICF 1986; Krusell and Cogley 1982).

B. Producers of Roof Coatings and Cements

In 1985, 31 firms operating 68 plants nationwide produced approximately 76 million gallons[1] of asbestos containing roof coatings and cements. These companies consumed 29.6 thousand tons of fiber accounting for 20.4 percent of

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[1] Four of the 31 companies producing asbestos containing roof coatings and cements in 1985 refused to provide production and fiber consumption data for their 10 plants in operation; their production volume and fiber consumption have been estimated using the method described in Appendix A and are included in the totals presented here.

145.3 thousand tons[2] of total asbestos consumed in 1985 for all product categories. Table 1 lists the total number of plants and the estimated gallons of coatings and cements produced in 1985. There are no importers of these products (ICF 1986).

Asbestos containing roof coating and cement production was estimated to be 76 million gallons. At an average price of $2.49/gallon, this market is estimated to be worth $189.2 million (ICF 1986).

C. Trends

The number of asbestos-based roof coating and cement manufacturers declined steadily from 1981 until 1985. During those four years 13 companies (30 percent), formerly producing asbestos containing roofing compounds, either substituted asbestos with other materials or discontinued their operations. In 1986, 14 of the 31 companies remaining in 1985, accounting for more than 24 percent of 1985 output, ceased processing asbestos because of rising insurance premiums, customer pressure to remove asbestos, and the possibility of regulatory action (ICF 1986).

D. Substitutes

Asbestos is unique among known raw minerals because it is a chemically inert, durable mineral that can be processed into a fiber. By partially adsorbing the asphalt into which it is placed, the fiber becomes an integral component of the mixture without settling or floating. The addition of one pound of asbestos fiber per gallon of thinned asphalt (only 10 percent by weight) imparts a large degree of body and turns the liquid into a soft paste. Industry leaders indicate that they have been unable to find a substitute for asbestos that can simultaneously reproduce the numerous qualities of the

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[2] 145.3 thousand tons of asbestos fiber is the ICF total. The Bureau of Mines (BOM) total is 172 thousand tons. Therefore, asbestos fiber used in roof coatings and cements (accounted for by ICF) will be 17 percent of the BOM total.

Table 1. Production of Asbestos Roof Coatings and Cements

	Number of Plants	Gallons Produced (1985)
TOTAL	68	75,977,365

Source: ICF 1986

mineral. Hence, manufacturers have been forced to replace asbestos with a combination of substitute materials, including cellulose, polyethylene, and ceramic fibers, and clay, talc, wollastonite, calcium carbonate (limestone) and silica gel thickeners (ICF 1986; Krusell and Cogley 1982). The substitute products can be grouped into three major categories according to the type of non-asbestos substitute used:

- cellulose fiber mixtures,
- polyethylene fiber mixtures, and
- other mixtures (ICF 1986).

The current market share of the different substitute formulations is presently unknown and our attempt to project the market shares in the event of an asbestos ban relies more on the informed judgement of industry experts rather than hard numbers. Industry has indicated that asbestos-free roof coatings and cements account for between 20 and 50 percent of the market today. Nevertheless, it is evident from the survey that the market share of asbestos-free roofing products is increasing rapidly as more and more companies replace asbestos. In an effort to gain a portion of the growing non-asbestos market, many manufacturers price their non-asbestos formulations the same as the traditional asbestos-containing products, even though non-asbestos formulations cost from 2 to 37 percent more to produce (ICF 1986).

The description of substitute mixtures is divided into two parts: a description of the fiber replacing asbestos (section a), followed by a description of the roof coatings and cements formulations made using that fiber (section b).

1. Cellulose Fiber Mixtures

a. Cellulose Fibers

Cellulose fibers are generally milled from recycled or unused newsprint in the presence of such additives as kaolin clay, calcium carbonate, or talc. The additives ease grinding, prevent fires during processing, and are normally at least 10 percent by weight of the final product. Fiber lengths vary from 0.02 to 0.5 inch lengths depending on the desired viscosity and ease in dispersion -- the greater the length of fiber, the greater the viscosity, yet the harder the dispersion in asphalt (American Fillers & Abrasives 1986).

Two of the largest producers of cellulose fibers for roof coatings and cements are Custom Fibers International of Los Angeles and American Fillers and Abrasives of Bangor, Michigan. Custom Fibers International produces cellulosic fibers for asbestos replacement in coatings and cements. Their current total capacity for three plants nationwide is approximately 10,000 tons per year (Custom Fibers International 1986). Their product, CF-32500 (R) fiber, is a 75 percent cellulose fiber which has extremely high oil absorbtion capabilities and is used as a substitute fiber in asphalt roof coatings and cements. It is recommended for improving the viscosity, sag resistance, and fiber reinforcement of coating compounds to which it is added (Custom Fibers California 1986). American Fillers & Abrasives of Bangor, Michigan manufactures a range of cellulose fiber products, of which the Kayocel KA690 (R) is a superfine, rapid dispersing fiber containing 90 percent cellulose and 10 percent calcium carbonate. According to the manufacturer, Kaocel fibers can be used to manufacture a stable and uniform roof coating (American Fillers & Abrasives 1986).

b. Cellulose Fibered Roof Coatings and Cements

Manufacturers of cellulose fibered roof coatings and cements consider their specific formulations proprietary. However, producers of cellulose fibers indicate that their fibers are usually used, in combination with clay and mineral thickeners, in concentrations of between 1 and 3 percent for roof coatings, and 3 and 5 percent for roofing cements (American Fillers &

Abrasives 1986; Custom Fibers International 1986). Custom Fibers suggest a starting formulation for an asbestos-free roof coating includes the following:

Asphalt cutback
Surfactant
Attapulgite clay
Talc or calcium carbonate
CF Fibers 32500 (R)

The CF-32500 (R) cellulose fiber, at increased concentration, can also be used for asbestos replacement in an asphalt plastic roof cement in the following formulation: (Custom Fibers California 1986).

Asphalt cutback
Surfactant
Bentonite clay
Talc
CF Fibers 32500

More than 16 companies currently produce cellulose containing roof coatings and cements. Table 2 identifies additional manufacturers of cellulose containing roofing compounds (ICF 1986).

Gardner Asphalt produces asbestos free products that contain a proprietary formulation of cellulose fibers and inorganic thickeners. According to company officials, the formulation costs more to produce and yields an inferior product. However, they do indicate that consumers could switch completely to the substitute formulation if the asbestos product was made unavailable (Gardner Asphalt 1986).

Gibson-Homans Corporation of Twinsburg, Ohio, substituted for asbestos in both their aluminum and standard black roofing products with a mixture of cellulose fibers, kaolin clays, crushed limestone, sodium silicates and water in April, 1986. Initially losing some of their sales due to adhesion,

Table 2. Manufacturers of Cellulose Fibered Roof Coatings and Cements

Manufacturer	Location
American Lubricants Company	Dayton, Ohio
American Tar Company	Seattle, Washington
Asphalt Products Oil Corporation	Long Beach, California
Elixir Industries	Elkhart, Indiana
Gardner Asphalt	Tampa, Florida
The Garland Company	Cleveland, Ohio
Gibson-Homans Corporation	Twinsburg, Ohio
Grundy Industries	Joliet, Illinois
Kool Seal Incorporated	Twinsburg, Ohio
Midwest/Gulf States Incorporated	Chicago, Illinois
National Varnish Company	Detroit, Michigan
Parr Incorporated	Cleveland, Ohio
Russel Standard Corporation	Atlanta, Georgia
Southwestern Petroleum Corporation	Fort Worth, Texas
S.W. Petro-Chem Incorporated	Olathe, Kansas
Tremco Incorporated	Cleveland, Ohio

Source: ICF 1986

reinforcement, and application problems, company officials indicate that reformulations with the same ingredients are expected to retrieve previous customers by early 1987. While production costs have increased due to added material, freight, and maintenance costs, profit margins have been trimmed to retain the same price charged for previously produced mixtures containing asbestos (Gibson-Homans 1986).

Midwest/Gulf States no longer produces asbestos containing products and agrees that consumers could switch to cellulose containing roofing compounds if asbestos was banned. However, prices would probably rise. Currently, cellulose containing roof coatings and cements are priced higher than their previous asbestos containing counterparts (Midwest/Gulf States 1986).

American Tar Company produces both asbestos and cellulose based roof coatings. They indicate that the cellulose containing coating costs more to produce but is currently priced the same as the asbestos based product (American Tar Company 1986).

Although cellulose fiber roof coatings are gaining in popularity, manufacturers of these products have cited some problems with the production and result of these cellulose formulations:

- the cellulose fibers formulations are difficult to mix requiring additional ingredients such as clays and talcs;
- the formulations may sag and run on a steep surfaces;
- the formulations may require additional application time, and;
- the formulations cost between 2 and 37 percent more to produce than asbestos mixtures.

Despite these problems manufacturers of asbestos containing roof coatings and cements recommend cellulose fibered formulations more than any other non-asbestos mixture (ICF 1986a).

Cellulose bodied roof coatings and cements have been in production for only six years. However, both the producers of cellulose fibers and those manufacturers who mix the fibers into roofing compounds indicate that successful formulations have so far lasted six years with no sign of deterioration or sag. Consequently, they claim that cellulose fibered roofing compounds are likely to have the same life as asbestos containing products.

Cellulose fibered formulations in combination with clay and mineral thickeners are estimated to capture 87 percent of the roof coating and cement market as a result of an asbestos ban (see Attachment A). Prices would be expected to rise 18.5 percent (see Attachment B) to $2.95 per gallon due to increased material and production costs (ICF 1986).

2. <u>Polyethylene Fiber Mixtures</u>

a. <u>Polyethylene Fibers</u>

Polyethylene fibers are strong, durable, high surface area, short length fibrils that increase viscosity and improve crack and slump resistance in all types of coatings and cements. Hercules of Wilmington, Delaware and Minifibers of Johnson City, Tennessee are two of the largest producers of raw polyethylene fibers used by manufacturers of non-asbestos roof coatings and cements. Hercules produces Pulpex polyolefin pulps at its Deer Park, Texas plant. The capacity of this single plant is approximately 27,500 tons per year. Pulpex E (R) (Grades D-H) is a dry fluff polyethylene pulp that is an effective replacement for asbestos in roof coatings and cements formulated with thickening clays (Hercules 1983). Minifibers' Short Stuff (R) are high density, highly branched polyethylene fibers. These fibers also increase viscosity and impart significant crack resistance. Minifibers' current output is approximately 4,000 tons per year, although they indicate the potential to quadruple this output within 180 days (Minifibers 1986a).

b. Polyethylene Fibered Roof Coatings and Cements

While roof coatings and cements manufacturers consider their asbestos free formulations proprietary, Hercules and Minifibers, suppliers of these fibers, indicate that polyethylene fibers are used in concentrations of between 1 and 3 percent and in conjunction with clays and other fillers (Minifibers 1986b; Hercules 1983).

According to Hercules, a possible starting formulation for an asbestos-free roof coating includes:

Asphalt cutback (65% solids)
Surfactant
Attapulgite clay
Talc
Pulpex E (R) (D-H)

(Hercules 1983). Minifibers recommends a slightly different formulation for an asbestos-free roof coating containing:

Asphalt cutback (65% solids)
Bentonite clay
Rubber (30 mesh)
Calcium carbonate
Mineral Spirits
Short Stuff (R) Polyethylene

(Minifibers 1986b). Pulpex E (R) (D-H) is recommended at increased levels as a replacement fiber in an asphalt roofing cement formulation containing the following:

Asphalt cutback (65% solids)
Surfactant
Attapulgite clay
Talc
Pulpex E (R) (D-H)

(Hercules 1983).

At least 8 manufacturers of roof coatings and cements have either partially or completely substituted asbestos with polyethylene fibers, in combination with clay and talc fillers, in their roof coatings and cements. While the raw fibers cost 3 or 4 times more than cellulose fibers on an equivalent basis, they are favored by manufacturers of aluminum roof coatings. Unlike cellulose fibers, polyethylene fibers do not contain water which can react with aluminum, forming a dangerous hydrogen gas, eventually resulting in the lids of containers blowing after only six months of storage (Missouri Paint & Varnish 1986). To guarantee a long shelf life many manufacturers of aluminum roof coatings such as Missouri Paint & Varnish and Columbia Paint Corporation use polyethylene fiber formulations (ICF 1986). Table 3 identifies some of the numerous manufacturers of polyethylene fibered roof coatings and cements.

Missouri Paint & Varnish has discontinued asbestos processing completely in 1986 and substituted it with polyethylene fibers in combination with clay and talc fillers. They estimate that aluminum roof coatings with polyethylene fibers cost one-third more to produce than asbestos bearing counterparts (Missouri Paint & Varnish 1986). Columbia Paint Corporation estimates that the prices of the roof coatings and cements have increased over 25 percent as a result of their decision to reformulate their asbestos containing products with polyethylene fibers (Columbia Paint 1986).

Manufacturers of non-asbestos roof coatings and cements whose formulations include polyethylene fibers have indicated some problems producing the formulations.

- The polyethylene fiber formulations are difficult to mix requiring other ingredients such as clay and talc;
- The formulations are not as strong due to the reduced tensile strength of the fibers;
- The formulations cost more to produce; and,
- Their long term performance is still unknown since their life on the market has been relatively short -- 5 yrs.

Many current and former asbestos processors have encountered difficulties in replacing asbestos formulations with polyethylene formulations in some roofing

Table 3. Manufacturers of Polyethylene Fibered Roof Coatings and Cements

Manufacturer	Location
Columbia Paint Corporation	Huntington, West Virginia
Missouri Paint & Varnish Company	St. Louis, Missouri
Parr Incorporated	Cleveland, Ohio
Russel Standard Corporation	Bridgeville, Penn.
Sampson Coatings Incorporated	Richmond, Virginia
S.W. Petro-Chem Incorporated	Olathe, Kansas
Texas Refinery Corporation	Fort Worth, Texas
Tremco Incorporated	Cleveland, Ohio

Source: ICF 1986.

compounds. These formulations have, however, been successful in replacing asbestos in aluminum roof coatings. As more manufacturers of aluminum roof coatings decide to replace asbestos (either due to increased insurance costs or fear of government regulation), the use of polyethylene formulations is expected to increase (ICF 1986).

Polyethylene fibers in combination with clay and mineral thickeners are estimated to account for 15 percent of the roof coatings and cements market as a results of a ban on asbestos (see Attachment A). Manufacturers of aluminum roof coatings are expected to be the largest producers of these formulations. Prices of roof coatings and cements bodied with polyethylene fibers would possibly rise 35 percent (see Attachment B) to $3.36 per gallon reflecting the increased material and production costs (ICF 1986).

3. Other Mixtures

a. Clays, Mineral Fillers, Silica Gels, and Ceramic Fibers

Clays, such as attapulgite, bentonite, and kaolin, are all excellent thixotropes.[3] However, they make poor reinforcers and hence, are usually used in combination with substitutes such as cellulose and polyethylene fibers to produce a desired viscosity in asbestos-free roof coatings and cements. Clay thickeners are used at levels ranging from 2 to 8 percent, by weight, and are almost always used with surfactants[4] (Engelhard, n.d.). Engelhard Corporation of Menlo Park, New Jersey and Floridin Company

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[3] Thixotropy is the property exhibited by certain gels that causes a mixture to liquefy when stirred and reharden when left stationary. The gelling or thixotropic characteristics of these clay additives impart high viscosity at low shear rates which helps in maintaining mix uniformity during processing, packaging, and application; and low viscosity at high shear rates making application easier (Floridin 1986).

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

of Berkeley Springs, West Virginia are the major producers of clay thickeners used by manufacturers of non-asbestos roof coatings and cements.

Engelhard produces Attagel 36 (R), a low cost thixotrope used frequently by manufacturers of non-asbestos roof coatings and cements. Derived from attapulgite clay, the thickener provides thixotropic properties in asphalt coatings and cements superior to asbestos. According to Engelhard, roof coatings and cements exhibit better sag resistance, easier application, and better spraying characteristics than comparable asbestos containing formulations (Engelhard n.d.). Min-U-Gel AR (R), is a similar attapulgite based gelling product manufactured by Floridin Company. Designed for thickening asphalt based coatings and cements, the product delivers superior stability, application, and sag resistance to roofing products than asbestos according to Floridin (Floridin 1986). Southern Clay Products' Claytone 34 (R), and NL Chemicals' Bentone 34 (R), both processed from bentonite clay, are more expensive thixotropes used in asbestos-free roof coatings and cements (ICF 1986).

Mineral fillers such as talc, wollastonite, and limestone are not thixotropes, but act as inexpensive thickeners. They do not have strong reinforcing characteristics and are usually used, at concentrations ranging from 10 to 25 percent, in combination with cellulose and polyethylene fibers to replace asbestos (ICF 1986; American Fillers & Abrasives 1986; Hercules 1983).

Silica gels, such as Cab-o-Sil (R) fumed silica, are good thixotropes, providing the necessary viscosity control in asphalt compounds. However, the gels do not possess the reinforcing capability of either asbestos or substitute fibers (Cabot 1986).

Ceramic fibers are used to increase viscosity and provide asphalt reinforcement.

b. Other Roof Coatings and Cements

Only three companies are currently producing substitute roof coatings and cements that do not contain cellulose or polyethylene fibers. Coopers Creek Chemical Corporation, a small manufacturer of asbestos containing roof coatings in 1985, has completely replaced asbestos with attapulgite clay in 1986. They indicate that the performance of the coating is comparable to the previous asbestos based one, but that the formulation is slightly more expensive to produce (Coopers Creek Chemical 1986). Silica has replaced asbestos in all roof coatings and cements produced by Douglas Chemical of Richmond, Virginia (Douglas Chemical 1986). B.F. Goodrich, Akron, Ohio, indicated that ceramic fibers have been used to formulate an asbestos-free counterpart to their asbestos roof coating. Company officials reported that the mixture costs 5 percent more to produce (B.F. Goodrich 1986). No manufacturers are currently producing roof coatings and cements solely with mineral fillers (ICF 1986).

Formulations not containing either cellulose or polyethylene fibers, but rather clay thickeners, mineral fillers, silica gels, and ceramic fibers are estimated to have only 7 percent of the market resulting from an asbestos ban (see Attachment A). Prices of these compounds could rise perhaps 21.5 percent (see Attachment B) to $3.03 per gallon (ICF 1986).

E. Summary

It appears that substitutes for asbestos containing roof coatings and cements currently exist. However, these products cost more to produce and may not perform as well. Asbestos is unique among known raw minerals because of its combination of strength, viscosity control, and price. Since no across the board substitute fiber exists for the mineral, manufacturers have been forced to replace asbestos with a combination of substitute materials, including cellulose, polyethylene, and ceramic fibers, and clay, talc, wollastonite, calcium carbonate, and silica gel thickeners.

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

If asbestos was made unavailable, perhaps 87 percent (see Attachment A) of the asbestos containing roofing compounds market would be taken by formulations containing cellulose fibers in combination with clay and mineral thickeners. Identified most often by current and former asbestos processors and Gardner Asphalt, a company with a large share of asbestos containing roofing products market, this replacement fiber is cheaper than polyethylene fiber and seems to perform adequately in reinforcement. Prices would be expected to rise 18.5 percent (see Attachment B) to $2.95 per gallon due to increased costs of production (ICF 1986). Formulations containing polyethylene fibers, in conjunction with clay and mineral thickeners, are estimated to account for 8 percent of the asbestos-based roofing compounds (see Attachment A). These fibers costing 3 or 4 times more than cellulose on an equivalent basis tended to be favored by manufacturers of aluminum roof coatings. Prices of formulations bodied with polyethylene fibers would likely rise 35 percent (see Attachment B) to $3.36 per gallon due to increased costs (ICF 1986). The remaining 5 percent would be divided between other formulations containing clays, mineral fillers, silica gels, and ceramic fibers (see Attachment A). Prices of these compounds could be expected to rise 21.5 percent (see Attachment B) to $3.03 per gallon (ICF 1986).

Table 4. Data Inputs for Asbestos Regulatory Cost Model

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price	Useful Life	Equivalent Price	Market Share	Reference
Asbestos Mixture	75,977,365	0.00039 tons/gal	1.0	$2.49/gal	10 years	$2.49/gal	N/A	ICF 1986[a]
Cellulose Fiber Mixture	N/A	N/A	N/A	$2.95/gal	10 years	$2.95/gal	87.42%	ICF 1986[a]
Polyethylene Fiber Mixture	N/A	N/A	N/A	$3.36/gal	10 years	$3.36/gal	7.62%	ICF 1986[a]
Other Mixtures[b]	N/A	N/A	N/A	$3.03/gal	10 years	$3.03/gal	4.95%	ICF 1986[a]

N/A: Not Applicable.

[a]See Appendix A and B.

[b]Includes clay, silica, and ceramic fiber mixtures.

ATTACHMENT A

PROJECTED MARKET SHARES ANALYSIS BASED ON 1985 PRODUCTION OF ASBESTOS ROOF COATINGS AND CEMENTS

Substitute Fiber/Material	Manufacturer(s)	Production Which Would Likely Switch to Substitute	Projected Market Share (subtotal/Grant Total x 100)
Cellulose	American Lubricants		
	American Tar		
	Asphalt Products		
	Elixir (Elkhart, IN)		
	Gardner Asphalt		
	Gibson-Homans		
	Grundy		
	Kool Seal		
	Midwest-Gulf States		
	National Varnish		
	Parr, Inc.[a]		
	Russel[a]		
	Southwestern Petroleum		
	S.W. Petrochemical[b]		
	Tremco[a]		
	Subtotal 1	44,082,488	87.42%
Polyethylene	Columbia Paint		
	Koch Asphalt		
	Missouri Paint and Varnish		
	Parr, Inc.[a]		
	Russel[a]		
	Schaefer Manufacturing		
	S.W. Petrochemical[a]		
	Tremco[a]		
	Subtotal 2	3,844,678	7.62%
Other	B.F. Goodrich		
	Coopers Creek Chemical		
	Elixir (Gardena, CA)		
	Parr, Inc.[a]		
	Russel[a]		
	Tremco[a]		
	Subtotal 3	2,498,318	4.95%
	Grand Total	50,425,484	100.00%

[a]These companies indicated they use all three substitute materials depending upon the product. For the purpose of this analysis, we have divided their production equally between the three substitutes.

[b]This company indicated that it uses cellulose and polyethylene as a substitute material depending upon the product. For the purposes of this analysis, we have divided their production equally between the two substitutes.

ATTACHMENT B

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

Substitute Fiber/Material	Manufacturer(s)	Production (1985)	Current or Probable Price Increase[a] (%)	Average Price Increase[b] (%)
Cellulose	American Lubricants			
	American Tar			
	Asphalt Products			
	Gardner Asphalt			
	Gibson-Homans			
	Grundy			
	Kool Seal			
	Midwest-Gulf States			
	National Varnish		—	
	Subtotal 1	40,732,635		18.5
Polyethylene	Columbia Paint and Oil			
	Missouri Paint and Varnish		—	
	Subtotal 2	256,000		35.0
Other	B.F. Goodrich			
	Coopers Creek Chemical			
	Elixir (Gardena, CA)		—	
	Subtotal 3	373,000		21.5

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

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

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XXX. NON-ROOFING ADHESIVES, SEALANTS, AND COATINGS

A. Product Description

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

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

- Adhesives and cements, generally containing 1 to 5 percent asbestos, manufactured to bond a variety of surfaces such as brick, lumber, mirror, and glass.

- Liquid sealants, containing 1 to 5 percent asbestos, used for waterproofing and sound deadening interior walls.

- Semi-liquid glazing, caulking, and patching compounds, containing 5 to 25 percent asbestos, applied with a caulking gun or putty knife, to seal around glass in windows, joints in metal ducts, and bricks adjacent to other surfaces.

- Asphalt based coatings, containing 5 to 10 percent asbestos, produced to prevent the decay of underground pipes, and corrosion of structural steel in high humidity environments, such as paper mills.

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

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

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

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

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

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

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

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

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

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

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

B. <u>Manufacturers of Non-Roofing Adhesives, Sealants, and Coatings</u>

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

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

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

Table 1. Production of Asbestos Non-Roofing Compounds

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

Source: ICF 1986a.

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

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

C. Trends

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

D. Substitutes

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

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

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

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

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

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

1. Fiber Mixtures

a. Synthetic, Cellulose, and Other Fibers

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

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

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

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

b. Substitute Fibrous Adhesives, Sealants, and Coatings

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

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

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

Table 2. Manufacturers of Substitute Fibered Non-Roofing Compounds

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

Source: ICF 1986a.

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

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

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

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

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

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

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

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

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

2. Clay and Mineral Filler Mixtures

a. Clays, Silica Gels and Other Fillers

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

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

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

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

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

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

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

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

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

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

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

Source: ICF 1986a.

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

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

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

E. Summary

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

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

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

Table 4. Data Inputs for Asbestos Regulatory Cost Model

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

N/A: Not applicable.

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

** See Appendices A and B.

ATTACHMENT A

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

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

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

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

ATTACHMENT B

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

Substitute Material	Manufacturer(s)	Production (1985)	Current or Probable Price Increase[a] (%)	Average Price Increase[b] (%)
Synthetic, Cellulose, and Other Fibers	Cobitco	c		
	Dolphin			
	Gibson-Homans			
	Hercules			
	J.C. Dolph	c		
	Mameco			
	Palmer			
	Sterling-Clarke		—	
	Subtotal 1	1,467,429		8.9%
Clay and Mineral Fillers	American Abrasives			
	Contech			
	Dayton			
	Franklin			
	Futura			
	Republic Powdered Metals	c		
	Widger		—	
	Subtotal 2	930,687		4.1%

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

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

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

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XXXI. ASBESTOS-REINFORCED PLASTICS

A. Product Description

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

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

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

B. Producers and Importers of Asbestos-Reinforced Plastics

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

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[1] See Attachment, Item 1.

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

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

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

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

C. Trends

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

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[2] See Attachment, Item 2.

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

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

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

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

[a]1981 production from ICF 1985.

[b]1985 production from ICF 1986a.

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

D. Substitutes

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

1. Fibrous Glass

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

Table 4. Producers of Substitute Materials

Glass Fibers[a]

Advance Coatings
Armco Steel Corp.
Certainteed Corp, Fiber Glass Reinforcements Division
Compounding Technology Inc.
Durkin Chemicals, Inc.
Fiber Glass Industries, Inc.
Fibre Glass Development
GLS Fiberglass Div., Great Lakes Terminal & Transport
Kristal Kraft, Inc.
LNP Corp.
Manville, Filtration and Minerals Div.
Mead Paper, Specialty Paper Div.
Miles, A.L. Company
Nicofibers, Inc.
Owens-Corning Fiberglas Corp.
PPG Industries, Inc., Fiber Glass Div.
Reichold Chemicals, Inc.
Techni-Glas, Inc.
Trevarno Div., Hexcel Corp.
United Merchants & Mfrs., Inc.
Wilson-Fiberfil International

Carbon Fibers[a]

Avco Specialty
Compounding Technology Inc.
Fibre Glass Development
Great Lakes Carbon Corp.
Hercules, Inc., Aerospace Div.
Hi-Tech Composites, Inc.
Hysol Grafil Co.
LNP Corp.
Mead Paper
Stackpole Corp.
Trevarno Div., Hexcel Corp
Union Carbide Corp.
Wilson-Fiberfil International

Porcelain[b]

Relmech Manufacturing (Canada)

Cab-O-Sil[b]

Cabot Corporation

Teflon Fiber[b]

Celanese Engineering Resins

Product X

Raymark Corporation

[a]From World Plastics Directory 1986.

[b]From ICF 1986a.

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

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

Source: ICF 1986a.

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

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

2. Teflon

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

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[3] See Attachment, Item 4.

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

3. Porcelain

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

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

4. Fumed Silica Powder

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

5. Carbon

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

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

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

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

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

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

E. <u>Summary</u>

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

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

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

N/A: Not Applicable.

[a]See Attachment, Item 1.

[b]See Attachment, Item 8.

[c]See Attachment, Item 5.

[d]See Attachment, Item 6.

[e]See Attachment, Item 10.

[f]See Attachment, Item 7.

[g]See Attachment, Item 9.

ATTACHMENT

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

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

[a]From ICF 1986a.

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

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

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

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

4. Projected Market Share of Fibrous Glass.

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

5. Price of Asbestos-Reinforced Plastic.

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

[a]From ICF 1986a.

6. Price of Glass-Reinforced Plastic.

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

7. Price of Porcelain.

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

8. Consumption/Production Ratio.

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

$$\text{Consumption} = \text{Production} + \text{Imports}$$
$$4{,}962.5 = 4{,}835 + 127.5$$

$$\text{Consumption/Production} = 4{,}962.5/4{,}835 = 1.03$$

9. Useful Life of Products.

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

10. Price of Product X.

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

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XXXII. MISSILE LINER

A. Product Description

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

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

B. Producers and Importers of Missile Liner

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

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

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

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

Table 1. Producers of Asbestos Missile Liner

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

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

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

C. Trends

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

D. Substitutes

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

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

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

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

E. Summary

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

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

Table 2. Data Inputs for Asbestos Regulatory Cost Model

Product	Output	Product Asbestos Coefficient	Consumption Production Ratio	Price[a]	Useful Life	Equivalent Price	Market Share	Reference
Asbestos Liner	4,667 tons	0.15 tons/ton[b]	1.0	$14,000/ton	1 use	$14,000/ton	N/A	ICF 1986
Kevlar(R) Liner	N/A	N/A	N/A	$29,000/ton[b]	1 use	$29,000/ton[b]	80%	ICF 1986
Ceramic Fiber Liner	N/A	N/A	N/A	$140,000/ton	1 use	$140,000/ton	20%	Olin 1986

N/A: Not Applicable.

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

[b]See Attachment for explanations.

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

ATTACHMENT

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

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

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

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

	Ratio	Reference
Average	15%	ICF 1986

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XXXIII. EXTRUDED SEALANT TAPE

A. Product Description

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

B. Producers and Importers of Extruded Sealant Tape

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

C. Trends

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

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[1] See Attachment, Item 1.

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

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

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

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

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

D. Substitutes

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

1. Cellulose Tape

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

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

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

[a]See Attachment, Item 1.

Table 3. Substitutes for Asbestos Sealant Tape

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

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

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

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

2. Structural Urethane

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

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

3. Carbon-based Tape

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

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

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

4. Non-Curing Tape

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

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

E. Summary

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

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

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

N/A: Not Applicable.

[a]See Attachment Item 7.

[b]See Attachment Item 4.

[c]See Attachment Item 3.

[d]See Attachment Item 5.

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

[f]See Attachment Item 6.

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

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

<u>ATTACHMENT</u>

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

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

2. 1981 Fiber Consumption and Sealant Tape Production.

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

From the above 1981 data, two calculations were performed:

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

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

3. Calculation Of Average Price Of Asbestos Sealant Tape.

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

[a]From ICF 1986a.

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

4. Calculation of the Product Asbestos Coefficient.

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

[a]From ICF 1986a.

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

5. Calculation of Price of Cellulose Tape.

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

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

6. Calculation of Equivalent Price of Cellulose Tape.

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

   Let:

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

   In the following present value formula:

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

where

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

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

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XXXIV. ASBESTOS SEPARATORS IN FUEL CELLS AND BATTERIES

A. Product Description

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

B. Producers and Importers of Asbestos Separators

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

C. Trends

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

Table 1. Asbestos Fiber Consumption in Batteries/Fuel Cells

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

D. Substitutes

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

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

E. Summary

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

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XXXV. ASBESTOS ARC CHUTES

A. Product Description

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

B. Producers and Importers of Asbestos Arc Chutes

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

C. Trends

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

D. Substitutes

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

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

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

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

E. Summary

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

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REGULATORY IMPACT ANALYSIS OF CONTROLS ON ASBESTOS AND ASBESTOS PRODUCTS

FINAL REPORT

VOLUME IV
APPENDIX G

Prepared for:
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Office of Toxic Substances
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APPENDIX G -- SENSITIVITY ANALYSES

This appendix presents sensitivity analyses conducted for the Regulatory Impact Analysis. Most of the results reported in the main body of the RIA represent "central" cases in the sense that the assumptions embodied in those results are viewed as most likely and most consistent with Agency policies. The sensitivity results presented here reflect alternative assumptions for the baseline development of asbestos products markets over the future for each of the seven regulatory alternatives considered in detail in this RIA.

In addition to cost/benefit results under alternative assumptions regarding baseline asbestos product trends for the fourteen regulatory alternatives, several illustrative model results are contained in this appendix for (1) a type of regulatory option that is not directly considered in the regulatory alternatives discussed in the RIA -- engineering controls on some markets to reduce exposures, rather than product bans or fiber phase-downs, (2) baseline scenarios in which the costs of asbestos-containing product substitutes decline over time, and (3) additional occupational and nonoccupational exposure assumptions for exposure settings for which quantitative information does not exist. Although the aftermarket exposure controls for brake repair did not appear in the main body of the RIA, results for the latter two classes of sensitivity analyses (declining substitute prices and additional exposure assumptions) were presented in summary tables in Chapter IV of Volume I of this RIA. This appendix presents the detailed cost/benefit results for these model runs underlying those summary results.

The four types of sensitivity analyses are conducted for different reasons. For the alternative baselines for asbestos product market growth or decline, the rationale for the sensitivity analysis is that the central case baseline presented in the main body of this RIA probably overstates the future levels of asbestos product manufacture and use because that baseline assumes no future decline in asbestos product manufacture and use. Recent history suggests, however, that substantial a decline in asbestos use has occurred, and has occurred at a more rapid pace than predicted in previous versions of the RIA. Hence, because the central case for future asbestos product market quantities probably overstates the level of asbestos use, results assuming more rapid declines of asbestos products over time are presented for comparison.

Engineering controls for aftermarket replacement of drum and LMV disc brakes are analyzed to determine the magnitude of the costs associated with such controls. No quantitative information deemed to be reliable concerning the reduction of exposures using these controls, however, was available, so the results for these analyses incorporate only the cost-side impacts of engineering controls on the analysis.

The basis for the possible decline in asbestos substitute prices over time is primarily the empirical observation in the business and economics literature of both economies of scale and experience curves (both of which lead to reduced prices for goods over time).* However, the results presented for this scenario are designed to indicate the sensitivity of the costs of the regulatory alternatives to changing substitute prices over time, hence the 1 percent fall per year in all asbestos substitute prices is an assumption made for illustrative purposes.

Finally, there are a number of product/exposure settings for which no quantitative information on exposures are available but in which exposures are suspected to occur. Omitting these exposures could impart a substantial downward bias to the estimates of benefits of the regulatory alternatives. To examine this possibility, occupational exposures for some settings in which

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* Recent articles concerning pricing, costs, and the experience (or learning) curve include Bass (1980), Lieberman (1984), and Gilman (1982).

quantitative data were not available were estimated based on, among other information, exposures for similar products and exposure settings. Nonoccupational exposures due to product use in some other cases were assumed based on a steady yearly release rate of one percent of the embodied asbestos over the lifetime of each product's use.

A. Sensitivity Analysis for Baseline Product Market Growth Rates

The exhibits which follow contain the cost and benefit results for alternative assumptions regarding the baseline development of asbestos products. A full set of exhibits appears for each of the fourteen regulatory alternatives presented in the main body of the RIA. Exhibit G-1 presents descriptions of the fourteen regulatory alternatives for reference.

The results of this sensitivity analysis are consistent with expectations. The scenarios with greater declines in asbestos-containing product outputs result in lower costs and lower benefits for the various alternatives because baseline exposures are less and the costs of foregoing asbestos use are lower.

B. Sensitivity Analysis for Engineering Controls, Changing Asbestos Substitute Prices, and Additional Exposure Assumptions

This section presents the results of (1) imposing engineering controls on drum brake repair and replacement in the aftermarket (i.e., replacement brakes, not installation of new asbestos drum brakes) and all brakes in the aftermarket (including disc), rather than including these products in a ban or an asbestos fiber phase-down, (2) assuming that all asbestos product substitute prices fall by 1 percent per year throughout the simulation period, and (3) additional occupational and nonoccupational exposure assumptions for exposure settings for which quantitative information does not exist.

The first set of results are based on actual engineering costs associated with a type of exposure-reducing equipment for use during brake repair and replacement (the derivation of these costs appears in Appendix D in Volume II of this RIA). Control equipment required under this scenario is a HEPA vacuum system without enclosure. Establishments already using this system are not required to engage in any additional compliance activities, but those without any control equipment or with equipment of lesser efficiency would be required to upgrade to at least this level of control. In addition, the costs of these controls reflect a requirement that all drum (or all drum and disc) brake repairs and replacements, not just asbestos brakes, use these controls. The rationale for this requirement is that until the brake job is underway, the workers probably would not know which brakes are asbestos and which non-asbestos.

Although the costs estimated for controlling asbestos exposure during repair and replacement are likely to be accurate, the benefits model was not revised for this model run. This is because exposure information required to estimate the benefits of the controls was not available. Hence, neither the benefits nor the cost per cancer case avoided for the markets controlled via engineering measures are appropriate. The engineering controls on brakes scenarios were estimated using Alternatives G, H, and I with controlled brake markets exempted from the all-product bans, using both the 3 percent discount rate for both costs and benefits and the 3 percent discount rate for costs with 0 percent for benefits. Finally, the engineering controls are assumed to be required at the time that the product bans take effect (1987 in G, 1992 in H, and 1997 in I).

As the results in the exhibits indicate, imposing engineering controls on drum brake markets does not affect the costs or benefits in the banned markets. The perhaps surprising result, on the other hand, is that the drum brake markets actually experience gains in welfare as a result of requiring the controls. This comes about because the fall in asbestos prices as a result of the products bans more than offsets the rise in the costs of brake jobs due to the engineering controls requirements. This outcome suggests that as long as the same magnitude of cancer cases will be avoided by the engineering controls, such requirements will have net social benefits if other asbestos markets are banned. This explains why the total social costs of the modeled alternatives with all brakes in the aftermarket exempted and controlled are lower than the total costs of the same situation, but with only drum brakes exempted and controlled. Requiring controls on disc brakes imposes costs, but these are more than outweighed by their exemption from the asbestos product ban as long as the same magnitude of cancer cases are avoided.

The results for the declining asbestos product substitute prices are also presented for Scenarios G, H, I, and J (in which diaphragms and missile liner are exempt from the product bans) under both the 3 percent cost and benefit discounting assumption and the 10 percent for costs and 0 percent for benefits assumption. The exhibits corresponding to these scenarios indicate that, as expected, the social costs of the complete ban fall as asbestos product substitute prices decline, dropping by between 20 and 30 percent for the scenarios in which all products are banned at the same time (G, H, and I), and by about 30 percent for Alternative J. The fall in costs for this scenario is larger than in the all-products-banned simultaneously alternatives because in scenario J, some products are banned later than others. During the time in which some products are banned and others are not, the non-banned products experience additional welfare gains through reductions in asbestos fiber prices which feed back into the asbestos product markets. Because the model restricts the prices of asbestos substitutes to be no less than the prices of the asbestos-containing products, substitute prices in this scenario fall further than in the other scenarios.

Finally, the detailed cost/benefit tables for Alternative J using the additional exposure assumptions for both occupational and nonoccupational exposure settings in which quantitative information did not exist are presented. These are the detailed cost/benefit tables corresponding to the summary information for these model runs that appear at the end of Chapter IV of Volume I of this RIA.

Exhibit G-1. Regulatory Alternatives Descriptions

Alternative B:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 25 (protective clothing and construction products, except for A/C sheet and shingle) in 1987

Alternative BX:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 25 (protective clothing and construction products, except for A/C sheet and shingle) in 1987
- Products 13 and 32 (diaphragms and missile liner) exempt from regulation

Alternative D:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987

Alternative DX:

- Fiber Phase-Down from 1987 to 1997
- Bans on Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987
- Products 13 and 32 (diaphragms and missile liner) exempt from regulation

Alternative E:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987
- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992

Exhibit G-1. Regulatory Alternatives Descriptions (continued)

Alternative F:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987
- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992
- Bans of all Remaining Products in 1997.

Alternative FX:

- Bans of Products 7, 9, 12, 14, 15, 16, 17, 25 (protective clothing and construction products) in 1987
- Bans of Products 18, 19, 20, 21, 22, 23, 24, 36, 37 (friction products) in 1992
- Bans of all Remaining Products in 1997 except Products 13 and 32 (diaphragms and missile liner).

Alternative G:

- Bans of all Products in 1987

Alternative GX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1987

Alternative H:

- Bans of all Products in 1992

Alternative HX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1992

Alternative I:

- Bans of all Products in 1997

Alternative IX:

- Bans of all Products except Products 13 and 32 (diaphragms and missile liner) in 1997

Exhibit G-1. Regulatory Alternatives Descriptions
(continued)

Alternative J:

- Bans of Products 1, 2, 4, 7, 9, 10, 12, 15, 16, 17, and 25 in 1987

- Bans of Products 5, 18, 19, 20, 21, 22, 23, 24, and 27 in 1991

- Bans of Products 14, 36, and 37 in 1994.

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Sensitivity Analysis Exhibits for Alternative Baselines

ALTERNATIVE B -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		10.55	.00	10.55
Foreign Miners & Millers		115.05	.00	115.05
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2107.87	.00	2107.87
Foreign Primary Processors		10.94	.00	10.94
Domestic Product Purchasers	1717.60	.00	.00	1717.60
Foreign Product Purchasers	.00	.00	.00	.00
Government			-276.51	-276.51

NET WELFARE LOSSES

U. S. Welfare: 3559.51

World Welfare: 3685.50

Note: Negative entries are welfare gains.

ALTERNATIVE B -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.6577	8.09
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	157.20	.06	157.25	4.8639	32.33
6	High Grade Electrical Paper	34.62	.00	34.62	.2270	152.55
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	2005.16	2005.23	.0951	21084.15
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	.82	1.55	2.37	.7829	3.02
16	A/C Sheet, Corrugated	.40	.00	.40	.1016	3.92
17	A/C Shingles	30.67	9.34	40.02	.4348	92.03
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	8.3564	2.30
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.9063	4.39
20	Disc Brake Pads HV	.02	.39	.41	.2165	1.88
21	Brake Blocks	17.11	2.92	20.03	12.9784	1.54
22	Clutch Facings	17.42	1.22	18.63	.3025	61.61
23	Automatic Trans. Components	.06	.11	.17	.0002	927.26
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.96	.00	78.96	.4839	163.15
27	Sheet Gaskets	98.40	10.44	108.84	1.2871	84.56
28	Asbestos Packing	.25	.00	.25	.0051	48.93
29	Roof Coatings	206.79	.73	207.52	1.5686	132.29
30	Non-Roofing Coatings	40.15	1.46	41.61	.1966	211.59
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.9557	21.13
32	Missile Liner	486.28	.24	486.51	.1405	3463.27
33	Sealant Tape	20.78	.10	20.88	.1647	126.74
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.08	175.5588	.25
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	43.7111	.19
38	Mining and Milling	.00	10.55	10.55	1.7398	6.06
	Total			3559.51 *	265.9958	13.38

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE B -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.4872	10.92
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	157.20	.06	157.25	3.5130	44.76
6	High Grade Electrical Paper	34.62	.00	34.62	.1569	220.61
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	2005.16	2005.23	.0658	30491.89
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	.82	1.55	2.37	.5988	3.95
16	A/C Sheet, Corrugated	.40	.00	.40	.0769	5.18
17	A/C Shingles	30.67	9.34	40.02	.3345	119.65
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	6.3090	3.05
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.6751	5.90
20	Disc Brake Pads HV	.02	.39	.41	.1641	2.49
21	Brake Blocks	17.11	2.92	20.03	9.6853	2.07
22	Clutch Facings	17.42	1.22	18.63	.2123	87.77
23	Automatic Trans. Components	.06	.11	.17	.0001	1341.00
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.96	.00	78.96	.3576	220.80
27	Sheet Gaskets	98.40	10.44	108.84	.9144	119.03
28	Asbestos Packing	.25	.00	.25	.0035	70.76
29	Roof Coatings	206.79	.73	207.52	1.1433	181.50
30	Non-Roofing Coatings	40.15	1.46	41.61	.1377	302.28
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.7680	26.29
32	Missile Liner	486.28	.24	486.51	.0971	5008.58
33	Sealant Tape	20.78	.10	20.88	.1325	157.55
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.08	136.4880	.32
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	36.3111	.23
38	Mining and Milling	.00	10.55	10.55	1.3520	7.80
	Total			3559.51 *	208.2629	17.09

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE B -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.75	.00	.75	.0641	11.73
4	Pipeline Wrap	.80	.00	.80	.3471	2.32
5	Beater-Add Gaskets	75.14	.04	75.17	2.0867	36.02
6	High Grade Electrical Paper	31.93	.00	31.94	.2224	143.58
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	2.15	.00	2.15	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0119	1.85
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.34	2002.13	2002.46	.0951	21055.08
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.08	.29	.37	.0294	12.52
16	A/C Sheet, Corrugated	.49	.00	.49	.0811	6.07
17	A/C Shingles	15.99	6.71	22.70	.2256	100.59
18	Drum Brake Linings (OEM)	2.65	4.66	7.31	.2757	26.53
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.36	.37	.0091	40.30
21	Brake Blocks	2.39	2.70	5.09	1.3267	3.84
22	Clutch Facings	14.56	1.20	15.77	.2335	67.52
23	Automatic Trans. Components	.06	.11	.17	.0002	923.69
24	Friction Materials	.67	1.98	2.66	.2931	9.07
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.99	.00	6.99	.0484	144.41
27	Sheet Gaskets	19.99	3.51	23.50	.2342	100.33
28	Asbestos Packing	.03	.00	.03	.0007	49.19
29	Roof Coatings	174.30	.75	175.05	1.1837	147.89
30	Non-Roofing Coatings	7.00	1.47	8.46	.0284	298.10
31	Asbestos-Reinforced Plastics	5.29	.24	5.53	.3907	14.15
32	Missile Liner	484.29	.24	484.53	.1405	3449.17
33	Sealant Tape	32.85	.10	32.95	.2069	159.23
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	31.84	10.82	42.65	98.0085	.44
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	33.2487	.30
38	Mining and Milling	.00	4.26	4.26	.9438	4.51
	Total			3122.48 *	145.0432	21.53

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE B -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		4.26	.00	4.26
Foreign Miners & Millers		46.42	.00	46.42
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2083.43	.00	2083.43
Foreign Primary Processors		8.34	.00	8.34
Domestic Product Purchasers	1211.61	.00	.00	1211.61
Foreign Product Purchasers	.00	.00	.00	.00
Government			-176.82	-176.82

NET WELFARE LOSSES

U. S. Welfare: 3122.48

World Welfare: 3177.25

Note: Negative entries are welfare gains.

ALTERNATIVE B -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.75	.00	.75	.0471	15.96
4	Pipeline Wrap	.80	.00	.80	.3019	2.66
5	Beater-Add Gaskets	75.14	.04	75.17	1.4933	50.34
6	High Grade Electrical Paper	31.93	.00	31.94	.1538	207.64
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	2.15	.00	2.15	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0101	2.18
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.34	2002.13	2002.46	.0658	30449.84
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.08	.29	.37	.0227	16.21
16	A/C Sheet, Corrugated	.49	.00	.49	.0595	8.27
17	A/C Shingles	15.99	6.71	22.70	.1732	131.07
18	Drum Brake Linings (OEM)	2.65	4.66	7.31	.2221	32.93
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.36	.37	.0065	56.73
21	Brake Blocks	2.39	2.70	5.09	.9802	5.19
22	Clutch Facings	14.56	1.20	15.77	.1615	97.64
23	Automatic Trans. Components	.06	.11	.17	.0001	1335.84
24	Friction Materials	.67	1.98	2.66	.2359	11.26
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.99	.00	6.99	.0359	194.46
27	Sheet Gaskets	19.99	3.51	23.50	.1665	141.14
28	Asbestos Packing	.03	.00	.03	.0005	70.55
29	Roof Coatings	174.30	.75	175.05	.8469	206.70
30	Non-Roofing Coatings	7.00	1.47	8.46	.0199	426.13
31	Asbestos-Reinforced Plastics	5.29	.24	5.53	.3232	17.11
32	Missile Liner	484.29	.24	484.53	.0971	4988.19
33	Sealant Tape	32.85	.10	32.95	.1617	203.78
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	31.84	10.82	42.65	75.6533	.56
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	27.7744	.35
38	Mining and Milling	.00	4.26	4.26	.7420	5.74
	Total			3122.48 *	114.1260	27.36

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE B -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.44	.00	2.44
Foreign Miners & Millers		26.66	.00	26.66
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2068.38	.00	2068.38
Foreign Primary Processors		6.68	.00	6.68
Domestic Product Purchasers	1024.52	.00	.00	1024.52
Foreign Product Purchasers	.00	.00	.00	.00
Government			-141.67	-141.67

NET WELFARE LOSSES

U. S. Welfare:	2953.68
World Welfare:	2987.02

Note: Negative entries are welfare gains.

ALTERNATIVE B -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0058	21.66
4	Pipeline Wrap	.26	.00	.26	.1020	2.58
5	Beater-Add Gaskets	38.43	.02	38.46	.9076	42.37
6	High Grade Electrical Paper	30.87	.00	30.87	.2185	141.32
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0045	2.08
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.42	2001.38	2001.80	.0951	21048.12
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.01	.06	.06	.0000	***
16	A/C Sheet, Corrugated	.53	.00	.53	.0718	7.32
17	A/C Shingles	8.48	4.70	13.18	.1201	109.69
18	Drum Brake Linings (OEM)	.67	1.10	1.77	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1277.14
21	Brake Blocks	.04	2.28	2.33	.0288	80.68
22	Clutch Facings	13.36	1.20	14.56	.2250	64.72
23	Automatic Trans. Components	.06	.11	.17	.0002	922.84
24	Friction Materials	.25	1.99	2.24	.0461	48.51
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0021	234.14
27	Sheet Gaskets	3.99	1.35	5.34	.0345	154.59
28	Asbestos Packing	.00	.00	.00	.0000	90.51
29	Roof Coatings	155.29	.75	156.04	.9940	156.97
30	Non-Roofing Coatings	1.00	1.47	2.47	.0032	784.28
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1875	8.13
32	Missile Liner	483.82	.24	484.06	.1405	3445.79
33	Sealant Tape	50.32	.10	50.42	.2809	179.52
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.05	10.03	40.08	63.4359	.63
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	28.2421	.37
38	Mining and Milling	.00	2.44	2.44	.6501	3.76
	Total			2953.68 *	99.7125	29.62

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE B -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0043	28.72
4	Pipeline Wrap	.26	.00	.26	.0944	2.79
5	Beater-Add Gaskets	38.43	.02	38.46	.6467	59.46
6	High Grade Electrical Paper	30.87	.00	30.87	.1511	204.35
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0041	2.29
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.42	2001.38	2001.80	.0658	30439.78
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.01	.06	.06	.0000	***
16	A/C Sheet, Corrugated	.53	.00	.53	.0519	10.12
17	A/C Shingles	8.48	4.70	13.18	.0924	142.68
18	Drum Brake Linings (OEM)	.67	1.10	1.77	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1767.86
21	Brake Blocks	.04	2.28	2.33	.0205	113.34
22	Clutch Facings	13.36	1.20	14.56	.1556	93.58
23	Automatic Trans. Components	.06	.11	.17	.0001	1334.61
24	Friction Materials	.25	1.99	2.24	.0341	65.68
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0016	308.31
27	Sheet Gaskets	3.99	1.35	5.34	.0246	216.91
28	Asbestos Packing	.00	.00	.00	.0000	125.28
29	Roof Coatings	155.29	.75	156.04	.7070	220.69
30	Non-Roofing Coatings	1.00	1.47	2.47	.0022	1123.17
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1616	9.43
32	Missile Liner	483.82	.24	484.06	.0971	4983.30
33	Sealant Tape	50.32	.10	50.42	.2167	232.72
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.05	10.03	40.08	48.4434	.83
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	23.2781	.45
38	Mining and Milling	.00	2.44	2.44	.5125	4.77
	Total			2953.68 *	78.0390	37.85

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE BX -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		10.55	.00	10.55
Foreign Miners & Millers		115.04	.00	115.04
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		102.48	.00	102.48
Foreign Primary Processors		10.94	.00	10.94
Domestic Product Purchasers	1228.62	.00	.00	1228.62
Foreign Product Purchasers	.00	.00	.00	.00
Government			-262.69	-262.69

NET WELFARE LOSSES

U. S. Welfare: 1078.96

World Welfare: 1204.94

Note: Negative entries are welfare gains.

ALTERNATIVE BX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.4872	10.92
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	157.20	.06	157.25	3.5130	44.76
6	High Grade Electrical Paper	34.62	.00	34.62	.1569	220.61
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.54	.00	-1.54	.0658	-23.36
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	.82	1.55	2.37	.5988	3.95
16	A/C Sheet, Corrugated	.40	.00	.40	.0769	5.18
17	A/C Shingles	30.67	9.34	40.02	.3345	119.65
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	6.3090	3.05
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.6751	5.90
20	Disc Brake Pads HV	.02	.39	.41	.1641	2.49
21	Brake Blocks	17.11	2.92	20.03	9.6853	2.07
22	Clutch Facings	17.42	1.22	18.63	.2123	87.77
23	Automatic Trans. Components	.06	.11	.17	.0001	1341.00
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.96	.00	78.96	.3576	220.80
27	Sheet Gaskets	98.40	10.44	108.84	.9144	119.03
28	Asbestos Packing	.25	.00	.25	.0035	70.76
29	Roof Coatings	206.79	.73	207.52	1.1433	181.50
30	Non-Roofing Coatings	40.15	1.46	41.61	.1377	302.28
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.7680	26.29
32	Missile Liner	-1.10	.00	-1.10	.0971	-11.33
33	Sealant Tape	20.78	.10	20.88	.1325	157.55
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.08	136.4880	.32
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	36.3111	.23
38	Mining and Milling	.00	10.55	10.55	1.3468	7.83
	Total			1078.96 *	208.2577	5.18

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE BX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.6577	8.09
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	157.20	.06	157.25	4.8639	32.33
6	High Grade Electrical Paper	34.62	.00	34.62	.2270	152.55
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.54	.00	-1.54	.0951	-16.15
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	.82	1.55	2.37	.7829	3.02
16	A/C Sheet, Corrugated	.40	.00	.40	.1016	3.92
17	A/C Shingles	30.67	9.34	40.02	.4348	92.03
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	8.3564	2.30
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.9063	4.39
20	Disc Brake Pads HV	.02	.39	.41	.2165	1.88
21	Brake Blocks	17.11	2.92	20.03	12.9784	1.54
22	Clutch Facings	17.42	1.22	18.63	.3025	61.61
23	Automatic Trans. Components	.06	.11	.17	.0002	927.26
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.96	.00	78.96	.4839	163.15
27	Sheet Gaskets	98.40	10.44	108.84	1.2871	84.56
28	Asbestos Packing	.25	.00	.25	.0051	48.93
29	Roof Coatings	206.79	.73	207.52	1.5686	132.29
30	Non-Roofing Coatings	40.15	1.46	41.61	.1966	211.59
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.9557	21.13
32	Missile Liner	-1.10	.00	-1.10	.1405	-7.84
33	Sealant Tape	20.78	.10	20.88	.1647	126.74
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.08	175.5588	.25
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	43.7111	.19
38	Mining and Milling	.00	10.55	10.55	1.7322	6.09
	Total			1078.96 *	265.9882	4.06

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE BX -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		4.26	.00	4.26
Foreign Miners & Millers		46.42	.00	46.42
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		81.07	.00	81.07
Foreign Primary Processors		8.34	.00	8.34
Domestic Product Purchasers	725.53	.00	.00	725.53
Foreign Product Purchasers	.00	.00	.00	.00
Government			-167.74	-167.74

NET WELFARE LOSSES

U. S. Welfare: 643.11

World Welfare: 697.88

Note: Negative entries are welfare gains.

ALTERNATIVE BX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.75	.00	.75	.0641	11.73
4	Pipeline Wrap	.80	.00	.80	.3471	2.32
5	Beater-Add Gaskets	75.14	.04	75.17	2.0867	36.02
6	High Grade Electrical Paper	31.93	.00	31.94	.2224	143.58
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	2.15	.00	2.15	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0119	1.85
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.84	.00	-.84	.0951	-8.86
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.08	.29	.37	.0294	12.52
16	A/C Sheet, Corrugated	.49	.00	.49	.0811	6.07
17	A/C Shingles	15.99	6.71	22.70	.2256	100.59
18	Drum Brake Linings (OEM)	2.65	4.66	7.31	.2757	26.53
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.36	.37	.0091	40.30
21	Brake Blocks	2.39	2.70	5.09	1.3267	3.84
22	Clutch Facings	14.56	1.20	15.77	.2335	67.52
23	Automatic Trans. Components	.06	.11	.17	.0002	923.69
24	Friction Materials	.67	1.98	2.66	.2931	9.07
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.99	.00	6.99	.0484	144.41
27	Sheet Gaskets	19.99	3.51	23.50	.2342	100.33
28	Asbestos Packing	.03	.00	.03	.0007	49.19
29	Roof Coatings	174.30	.75	175.05	1.1837	147.89
30	Non-Roofing Coatings	7.00	1.47	8.46	.0284	298.10
31	Asbestos-Reinforced Plastics	5.29	.24	5.53	.3907	14.15
32	Missile Liner	-.60	.00	-.60	.1405	-4.30
33	Sealant Tape	32.85	.10	32.95	.2069	159.23
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	31.84	10.82	42.65	98.0085	.44
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	33.2487	.30
38	Mining and Milling	.00	4.26	4.26	.9362	4.55
	Total			643.11 *	145.0356	4.43

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE BX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.75	.00	.75	.0471	15.96
4	Pipeline Wrap	.80	.00	.80	.3019	2.66
5	Beater-Add Gaskets	75.14	.04	75.17	1.4933	50.34
6	High Grade Electrical Paper	31.93	.00	31.94	.1538	207.64
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	2.15	.00	2.15	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0101	2.18
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.84	.00	-.84	.0658	-12.81
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.08	.29	.37	.0227	16.21
16	A/C Sheet, Corrugated	.49	.00	.49	.0595	8.27
17	A/C Shingles	15.99	6.71	22.70	.1732	131.07
18	Drum Brake Linings (OEM)	2.65	4.66	7.31	.2221	32.93
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.36	.37	.0065	56.73
21	Brake Blocks	2.39	2.70	5.09	.9802	5.19
22	Clutch Facings	14.56	1.20	15.77	.1615	97.64
23	Automatic Trans. Components	.06	.11	.17	.0001	1335.84
24	Friction Materials	.67	1.98	2.66	.2359	11.26
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.99	.00	6.99	.0359	194.46
27	Sheet Gaskets	19.99	3.51	23.50	.1665	141.14
28	Asbestos Packing	.03	.00	.03	.0005	70.55
29	Roof Coatings	174.30	.75	175.05	.8469	206.70
30	Non-Roofing Coatings	7.00	1.47	8.46	.0199	426.13
31	Asbestos-Reinforced Plastics	5.29	.24	5.53	.3232	17.11
32	Missile Liner	-.60	.00	-.60	.0971	-6.21
33	Sealant Tape	32.85	.10	32.95	.1617	203.78
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	31.84	10.82	42.65	75.6533	.56
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	27.7744	.35
38	Mining and Milling	.00	4.26	4.26	.7367	5.78
	Total			643.11 *	114.1208	5.64

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE BX -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.44	.00	2.44
Foreign Miners & Millers		26.66	.00	26.66
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		66.76	.00	66.76
Foreign Primary Processors		6.68	.00	6.68
Domestic Product Purchasers	539.29	.00	.00	539.29
Foreign Product Purchasers	.00	.00	.00	.00
Government			-133.73	-133.73

NET WELFARE LOSSES

U. S. Welfare:	474.77
World Welfare:	508.10

Note: Negative entries are welfare gains.

ALTERNATIVE BX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0058	21.66
4	Pipeline Wrap	.26	.00	.26	.1020	2.58
5	Beater-Add Gaskets	38.43	.02	38.46	.9076	42.37
6	High Grade Electrical Paper	30.87	.00	30.87	.2185	141.32
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0045	2.08
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.58	.00	-.58	.0951	-6.10
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.01	.06	.06	.0000	***
16	A/C Sheet, Corrugated	.53	.00	.53	.0718	7.32
17	A/C Shingles	8.48	4.70	13.18	.1201	109.69
18	Drum Brake Linings (OEM)	.67	1.10	1.77	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1277.14
21	Brake Blocks	.04	2.28	2.33	.0288	80.68
22	Clutch Facings	13.36	1.20	14.56	.2250	64.72
23	Automatic Trans. Components	.06	.11	.17	.0002	922.84
24	Friction Materials	.25	1.99	2.24	.0461	48.51
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0021	234.14
27	Sheet Gaskets	3.99	1.35	5.34	.0345	154.59
28	Asbestos Packing	.00	.00	.00	.0000	90.51
29	Roof Coatings	155.29	.75	156.04	.9940	156.97
30	Non-Roofing Coatings	1.00	1.47	2.47	.0032	784.28
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1875	8.13
32	Missile Liner	-.42	.00	-.42	.1405	-2.96
33	Sealant Tape	50.32	.10	50.42	.2809	179.52
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.05	10.03	40.08	63.4359	.63
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	28.2421	.37
38	Mining and Milling	.00	2.44	2.44	.6425	3.80
	Total			474.77 *	99.7049	4.76

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE BX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #.	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0043	28.72
4	Pipeline Wrap	.26	.00	.26	.0944	2.79
5	Beater-Add Gaskets	38.43	.02	38.46	.6467	59.46
6	High Grade Electrical Paper	30.87	.00	30.87	.1511	204.35
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0041	2.29
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.58	.00	-.58	.0658	-8.82
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.01	.06	.06	.0000	***
16	A/C Sheet, Corrugated	.53	.00	.53	.0519	10.12
17	A/C Shingles	8.48	4.70	13.18	.0924	142.68
18	Drum Brake Linings (OEM)	.67	1.10	1.77	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1767.86
21	Brake Blocks	.04	2.28	2.33	.0205	113.34
22	Clutch Facings	13.36	1.20	14.56	.1556	93.58
23	Automatic Trans. Components	.06	.11	.17	.0001	1334.61
24	Friction Materials	.25	1.99	2.24	.0341	65.68
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0016	308.31
27	Sheet Gaskets	3.99	1.35	5.34	.0246	216.91
28	Asbestos Packing	.00	.00	.00	.0000	125.28
29	Roof Coatings	155.29	.75	156.04	.7070	220.69
30	Non-Roofing Coatings	1.00	1.47	2.47	.0022	1123.17
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1616	9.43
32	Missile Liner	-.42	.00	-.42	.0971	-4.28
33	Sealant Tape	50.32	.10	50.42	.2167	232.72
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.05	10.03	40.08	48.4434	.83
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	23.2781	.45
38	Mining and Milling	.00	2.44	2.44	.5073	4.82
	Total			474.77 *	78.0338	6.08

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE D -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		10.77	.00	10.77
Foreign Miners & Millers		117.46	.00	117.46
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2106.44	.00	2106.44
Foreign Primary Processors		10.36	.00	10.36
Domestic Product Purchasers	1750.39	.00	.00	1750.39
Foreign Product Purchasers	.00	.00	.00	.00
Government			-260.49	-260.49

NET WELFARE LOSSES

U. S. Welfare: 3607.11

World Welfare: 3734.93

Note: Negative entries are welfare gains.

ALTERNATIVE D -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.6577	8.08
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	156.98	.06	157.04	4.8483	32.39
6	High Grade Electrical Paper	34.59	.00	34.60	.2270	152.42
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	2005.12	2005.19	.0951	21083.76
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	8.4194	2.29
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.9063	4.39
20	Disc Brake Pads HV	.02	.39	.41	.2165	1.88
21	Brake Blocks	17.11	2.92	20.03	12.9784	1.54
22	Clutch Facings	17.37	1.22	18.59	.3025	61.47
23	Automatic Trans. Components	.06	.11	.17	.0002	927.21
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.94	.00	78.94	.4839	163.12
27	Sheet Gaskets	98.21	10.44	108.65	1.3118	82.82
28	Asbestos Packing	.25	.00	.25	.0051	48.92
29	Roof Coatings	206.79	.73	207.52	1.5773	131.57
30	Non-Roofing Coatings	40.09	1.46	41.55	.1966	211.27
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.9557	21.13
32	Missile Liner	486.25	.24	486.49	.1405	3463.08
33	Sealant Tape	20.77	.10	20.87	.1647	126.71
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.09	177.3033	.24
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	43.1976	.19
38	Mining and Milling	.00	10.77	10.77	1.7796	6.05
	Total			3607.11 *	267.8614	13.47

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE D -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.4872	10.91
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	156.98	.06	157.04	3.5033	44.82
6	High Grade Electrical Paper	34.59	.00	34.60	.1569	220.43
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	2005.12	2005.19	.0658	30491.32
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	6.3659	3.02
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.6751	5.90
20	Disc Brake Pads HV	.02	.39	.41	.1641	2.49
21	Brake Blocks	17.11	2.92	20.03	9.6853	2.07
22	Clutch Facings	17.37	1.22	18.59	.2123	87.56
23	Automatic Trans. Components	.06	.11	.17	.0001	1340.93
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.94	.00	78.94	.3576	220.75
27	Sheet Gaskets	98.21	10.44	108.65	.9327	116.49
28	Asbestos Packing	.25	.00	.25	.0035	70.75
29	Roof Coatings	206.79	.73	207.52	1.1506	180.35
30	Non-Roofing Coatings	40.09	1.46	41.55	.1377	301.81
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.7680	26.29
32	Missile Liner	486.25	.24	486.49	.0971	5008.31
33	Sealant Tape	20.77	.10	20.87	.1325	157.52
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.09	138.1149	.31
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	35.8125	.24
38	Mining and Milling	.00	10.77	10.77	1.3878	7.76
	Total			3607.11 *	209.9691	17.18

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE D -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		4.46	.00	4.46
Foreign Miners & Millers		48.65	.00	48.65
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2084.98	.00	2084.98
Foreign Primary Processors		8.54	.00	8.54
Domestic Product Purchasers	1251.05	.00	.00	1251.05
Foreign Product Purchasers	.00	.00	.00	.00
Government			-178.08	-178.08

NET WELFARE LOSSES

U. S. Welfare: 3162.42

World Welfare: 3219.62

Note: Negative entries are welfare gains.

ALTERNATIVE D -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.77	.00	.77	.0797	9.70
4	Pipeline Wrap	.80	.00	.80	.3346	2.40
5	Beater-Add Gaskets	76.83	.04	76.86	2.0557	37.39
6	High Grade Electrical Paper	32.13	.00	32.14	.2224	144.47
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	2.22	.00	2.22	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0119	1.85
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.34	2002.39	2002.73	.0951	21057.87
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	2.70	4.66	7.36	.2757	26.69
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.33	.34	.0203	16.72
21	Brake Blocks	2.51	2.64	5.15	1.6872	3.05
22	Clutch Facings	14.86	1.20	16.06	.2335	68.79
23	Automatic Trans. Components	.06	.11	.17	.0002	924.03
24	Friction Materials	.67	1.98	2.66	.2931	9.07
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	7.02	.00	7.02	.0484	144.99
27	Sheet Gaskets	20.51	3.54	24.04	.2342	102.64
28	Asbestos Packing	.03	.00	.03	.0007	49.28
29	Roof Coatings	179.91	.75	180.66	1.1865	152.26
30	Non-Roofing Coatings	7.23	1.47	8.70	.0284	306.24
31	Asbestos-Reinforced Plastics	5.30	.24	5.54	.3907	14.18
32	Missile Liner	484.48	.24	484.72	.1405	3450.52
33	Sealant Tape	32.89	.10	32.99	.2069	159.42
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.03	10.82	42.85	99.7529	.43
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	32.7994	.30
38	Mining and Milling	.00	4.46	4.46	.9817	4.54
	Total			3162.42 *	147.1626	21.49

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE D -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.77	.00	.77	.0598	12.93
4	Pipeline Wrap	.80	.00	.80	.2898	2.77
5	Beater-Add Gaskets	76.83	.04	76.86	1.4702	52.28
6	High Grade Electrical Paper	32.13	.00	32.14	.1538	208.94
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	2.22	.00	2.22	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0101	2.18
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.34	2002.39	2002.73	.0658	30453.87
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	2.70	4.66	7.36	.2221	33.13
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.33	.34	.0154	22.12
21	Brake Blocks	2.51	2.64	5.15	1.2733	4.04
22	Clutch Facings	14.86	1.20	16.06	.1615	99.47
23	Automatic Trans. Components	.06	.11	.17	.0001	1336.33
24	Friction Materials	.67	1.98	2.66	.2359	11.26
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	7.02	.00	7.02	.0359	195.25
27	Sheet Gaskets	20.51	3.54	24.04	.1665	144.39
28	Asbestos Packing	.03	.00	.03	.0005	70.68
29	Roof Coatings	179.91	.75	180.66	.8491	212.76
30	Non-Roofing Coatings	7.23	1.47	8.70	.0199	437.76
31	Asbestos-Reinforced Plastics	5.30	.24	5.54	.3232	17.14
32	Missile Liner	484.48	.24	484.72	.0971	4990.14
33	Sealant Tape	32.89	.10	32.99	.1617	204.02
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.03	10.82	42.85	77.1913	.56
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	27.3509	.36
38	Mining and Milling	.00	4.46	4.46	.7759	5.75
	Total			3162.42 *	115.9547	27.27

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE D -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.62	.00	2.62
Foreign Miners & Millers		28.56	.00	28.56
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2070.87	.00	2070.87
Foreign Primary Processors		7.29	.00	7.29
Domestic Product Purchasers	1049.31	.00	.00	1049.31
Foreign Product Purchasers	.00	.00	.00	.00
Government			-135.75	-135.75

NET WELFARE LOSSES

U. S. Welfare: 2987.05

World Welfare: 3022.89

Note: Negative entries are welfare gains.

ALTERNATIVE D -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0058	21.72
4	Pipeline Wrap	.26	.00	.26	.0983	2.67
5	Beater-Add Gaskets	38.48	.02	38.50	.8999	42.79
6	High Grade Electrical Paper	30.88	.00	30.88	.2185	141.34
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0034	2.75
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.42	2001.39	2001.81	.0951	21048.19
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	.68	1.10	1.78	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1277.47
21	Brake Blocks	.04	2.28	2.33	.0288	80.76
22	Clutch Facings	13.37	1.20	14.57	.2250	64.75
23	Automatic Trans. Components	.06	.11	.17	.0002	922.85
24	Friction Materials	.25	1.99	2.24	.0461	48.60
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0021	234.42
27	Sheet Gaskets	4.00	1.34	5.35	.0345	154.88
28	Asbestos Packing	.00	.00	.00	.0000	90.53
29	Roof Coatings	155.43	.75	156.18	1.0027	155.77
30	Non-Roofing Coatings	1.01	1.47	2.48	.0032	785.51
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1875	8.13
32	Missile Liner	483.82	.24	484.06	.1405	3445.83
33	Sealant Tape	50.32	.10	50.42	.2809	179.52
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.19	10.03	40.22	65.8147	.61
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	28.1138	.37
38	Mining and Milling	.00	2.62	2.62	.6842	3.83
	Total			2987.05 *	102.3000	29.20

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE D -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0058	21.72
4	Pipeline Wrap	.26	.00	.26	.0983	2.67
5	Beater-Add Gaskets	38.48	.02	38.50	.8999	42.79
6	High Grade Electrical Paper	30.88	.00	30.88	.2185	141.34
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0034	2.75
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.42	2001.39	2001.81	.0951	21048.19
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	.68	1.10	1.78	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1277.47
21	Brake Blocks	.04	2.28	2.33	.0288	80.76
22	Clutch Facings	13.37	1.20	14.57	.2250	64.75
23	Automatic Trans. Components	.06	.11	.17	.0002	922.85
24	Friction Materials	.25	1.99	2.24	.0461	48.60
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0021	234.42
27	Sheet Gaskets	4.00	1.34	5.35	.0345	154.88
28	Asbestos Packing	.00	.00	.00	.0000	90.53
29	Roof Coatings	155.43	.75	156.18	1.0027	155.77
30	Non-Roofing Coatings	1.01	1.47	2.48	.0032	785.51
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1875	8.13
32	Missile Liner	483.82	.24	484.06	.1405	3445.83
33	Sealant Tape	50.32	.10	50.42	.2809	179.52
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.19	10.03	40.22	65.8147	.61
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	28.1138	.37
38	Mining and Milling	.00	2.62	2.62	.6842	3.83
	Total			2987.05 *	102.3000	29.20

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE D -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0043	28.80
4	Pipeline Wrap	.26	.00	.26	.0908	2.89
5	Beater-Add Gaskets	38.48	.02	38.50	.6409	60.08
6	High Grade Electrical Paper	30.88	.00	30.88	.1511	204.39
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0030	3.08
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.42	2001.39	2001.81	.0658	30439.88
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	.68	1.10	1.78	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1768.32
21	Brake Blocks	.04	2.28	2.33	.0205	113.44
22	Clutch Facings	13.37	1.20	14.57	.1556	93.63
23	Automatic Trans. Components	.06	.11	.17	.0001	1334.62
24	Friction Materials	.25	1.99	2.24	.0341	65.81
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0016	308.69
27	Sheet Gaskets	4.00	1.34	5.35	.0246	217.31
28	Asbestos Packing	.00	.00	.00	.0000	125.32
29	Roof Coatings	155.43	.75	156.18	.7138	218.81
30	Non-Roofing Coatings	1.01	1.47	2.48	.0022	1124.93
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1616	9.43
32	Missile Liner	483.82	.24	484.06	.0971	4983.35
33	Sealant Tape	50.32	.10	50.42	.2167	232.72
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.19	10.03	40.22	50.4883	.80
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	23.1588	.45
38	Mining and Milling	.00	2.62	2.62	.5428	4.83
	Total			2987.05 *	80.2698	37.21

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE DX -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		10.77	.00	10.77
Foreign Miners & Millers		117.45	.00	117.45
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		101.08	.00	101.08
Foreign Primary Processors		10.36	.00	10.36
Domestic Product Purchasers	1261.36	.00	.00	1261.36
Foreign Product Purchasers	.00	.00	.00	.00
Government			-246.73	-246.73

NET WELFARE LOSSES

U. S. Welfare: 1126.48

World Welfare: 1254.30

Note: Negative entries are welfare gains.

ALTERNATIVE DX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.6577	8.08
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	156.98	.06	157.04	4.8483	32.39
6	High Grade Electrical Paper	34.59	.00	34.60	.2270	152.42
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.58	.00	-1.58	.0951	-16.59
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	8.4194	2.29
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.9063	4.39
20	Disc Brake Pads HV	.02	.39	.41	.2165	1.88
21	Brake Blocks	17.11	2.92	20.03	12.9784	1.54
22	Clutch Facings	17.37	1.22	18.59	.3025	61.47
23	Automatic Trans. Components	.06	.11	.17	.0002	927.21
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.94	.00	78.94	.4839	163.12
27	Sheet Gaskets	98.21	10.44	108.65	1.3118	82.82
28	Asbestos Packing	.25	.00	.25	.0051	48.92
29	Roof Coatings	206.79	.73	207.52	1.5773	131.57
30	Non-Roofing Coatings	40.09	1.46	41.55	.1966	211.27
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.9557	21.13
32	Missile Liner	-1.13	.00	-1.13	.1405	-8.05
33	Sealant Tape	20.77	.10	20.87	.1647	126.71
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.09	177.3033	.24
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	43.1976	.19
38	Mining and Milling	.00	10.77	10.77	1.7720	6.08
	Total			1126.48 *	267.8538	4.21

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE DX -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		4.46	.00	4.46
Foreign Miners & Millers		48.65	.00	48.65
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		82.35	.00	82.35
Foreign Primary Processors		8.54	.00	8.54
Domestic Product Purchasers	764.72	.00	.00	764.72
Foreign Product Purchasers	.00	.00	.00	.00
Government			-168.55	-168.55

NET WELFARE LOSSES

U. S. Welfare: 682.99

World Welfare: 740.18

Note: Negative entries are welfare gains.

ALTERNATIVE DX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.32	.00	5.32	.4872	10.91
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	156.98	.06	157.04	3.5033	44.82
6	High Grade Electrical Paper	34.59	.00	34.60	.1569	220.43
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	5.81	.00	5.81	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.58	.00	-1.58	.0658	-24.00
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	12.99	6.25	19.24	6.3659	3.02
19	Disc Brake Pads LMV (OEM)	.10	3.88	3.98	.6751	5.90
20	Disc Brake Pads HV	.02	.39	.41	.1641	2.49
21	Brake Blocks	17.11	2.92	20.03	9.6853	2.07
22	Clutch Facings	17.37	1.22	18.59	.2123	87.56
23	Automatic Trans. Components	.06	.11	.17	.0001	1340.93
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	78.94	.00	78.94	.3576	220.75
27	Sheet Gaskets	98.21	10.44	108.65	.9327	116.49
28	Asbestos Packing	.25	.00	.25	.0035	70.75
29	Roof Coatings	206.79	.73	207.52	1.1506	180.35
30	Non-Roofing Coatings	40.09	1.46	41.55	.1377	301.81
31	Asbestos-Reinforced Plastics	19.96	.23	20.19	.7680	26.29
32	Missile Liner	-1.13	.00	-1.13	.0971	-11.64
33	Sealant Tape	20.77	.10	20.87	.1325	157.52
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.62	10.46	43.09	138.1149	.31
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.37	8.42	35.8125	.24
38	Mining and Milling	.00	10.77	10.77	1.3825	7.79
	Total			1126.48 *	209.9639	5.37

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE DX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.77	.00	.77	.0797	9.70
4	Pipeline Wrap	.80	.00	.80	.3346	2.40
5	Beater-Add Gaskets	76.83	.04	76.86	2.0557	37.39
6	High Grade Electrical Paper	32.13	.00	32.14	.2224	144.47
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	2.22	.00	2.22	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0119	1.85
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.88	.00	-.88	.0951	-9.26
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	2.70	4.66	7.36	.2757	26.69
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.33	.34	.0203	16.72
21	Brake Blocks	2.51	2.64	5.15	1.6872	3.05
22	Clutch Facings	14.86	1.20	16.06	.2335	68.79
23	Automatic Trans. Components	.06	.11	.17	.0002	924.03
24	Friction Materials	.67	1.98	2.66	.2931	9.07
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	7.02	.00	7.02	.0484	144.99
27	Sheet Gaskets	20.51	3.54	24.04	.2342	102.64
28	Asbestos Packing	.03	.00	.03	.0007	49.28
29	Roof Coatings	179.91	.75	180.66	1.1865	152.26
30	Non-Roofing Coatings	7.23	1.47	8.70	.0284	306.24
31	Asbestos-Reinforced Plastics	5.30	.24	5.54	.3907	14.18
32	Missile Liner	-.63	.00	-.63	.1405	-4.49
33	Sealant Tape	32.89	.10	32.99	.2069	159.42
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.03	10.82	42.85	99.7529	.43
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	32.7994	.30
38	Mining and Milling	.00	4.46	4.46	.9741	4.58
	Total			682.99 *	147.1551	4.64

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE DX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.77	.00	.77	.0598	12.93
4	Pipeline Wrap	.80	.00	.80	.2898	2.77
5	Beater-Add Gaskets	76.83	.04	76.86	1.4702	52.28
6	High Grade Electrical Paper	32.13	.00	32.14	.1538	208.94
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	2.22	.00	2.22	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0101	2.18
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.88	.00	-.88	.0658	-13.39
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	2.70	4.66	7.36	.2221	33.13
19	Disc Brake Pads LMV (OEM)	.00	.12	.12	.0000	***
20	Disc Brake Pads HV	.01	.33	.34	.0154	22.12
21	Brake Blocks	2.51	2.64	5.15	1.2733	4.04
22	Clutch Facings	14.86	1.20	16.06	.1615	99.47
23	Automatic Trans. Components	.06	.11	.17	.0001	1336.33
24	Friction Materials	.67	1.98	2.66	.2359	11.26
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	7.02	.00	7.02	.0359	195.25
27	Sheet Gaskets	20.51	3.54	24.04	.1665	144.39
28	Asbestos Packing	.03	.00	.03	.0005	70.68
29	Roof Coatings	179.91	.75	180.66	.8491	212.76
30	Non-Roofing Coatings	7.23	1.47	8.70	.0199	437.76
31	Asbestos-Reinforced Plastics	5.30	.24	5.54	.3232	17.14
32	Missile Liner	-.63	.00	-.63	.0971	-6.50
33	Sealant Tape	32.89	.10	32.99	.1617	204.02
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	32.03	10.82	42.85	77.1913	.56
37	Disc Brake Pads LMV (Aftermarket)	2.60	7.22	9.83	27.3509	.36
38	Mining and Milling	.00	4.46	4.46	.7707	5.79
	Total			682.99 *	115.9495	5.89

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE DX -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.62	.00	2.62
Foreign Miners & Millers		28.55	.00	28.55
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		69.24	.00	69.24
Foreign Primary Processors		7.29	.00	7.29
Domestic Product Purchasers	564.01	.00	.00	564.01
Foreign Product Purchasers	.00	.00	.00	.00
Government			-127.80	-127.80

NET WELFARE LOSSES

U. S. Welfare: 508.07

World Welfare: 543.91

Note: Negative entries are welfare gains.

ALTERNATIVE DX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0058	21.72
4	Pipeline Wrap	.26	.00	.26	.0983	2.67
5	Beater-Add Gaskets	38.48	.02	38.50	.8999	42.79
6	High Grade Electrical Paper	30.88	.00	30.88	.2185	141.34
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0034	2.75
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.62	.00	-.62	.0951	-6.47
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	.68	1.10	1.78	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1277.47
21	Brake Blocks	.04	2.28	2.33	.0288	80.76
22	Clutch Facings	13.37	1.20	14.57	.2250	64.75
23	Automatic Trans. Components	.06	.11	.17	.0002	922.85
24	Friction Materials	.25	1.99	2.24	.0461	48.60
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0021	234.42
27	Sheet Gaskets	4.00	1.34	5.35	.0345	154.88
28	Asbestos Packing	.00	.00	.00	.0000	90.53
29	Roof Coatings	155.43	.75	156.18	1.0027	155.77
30	Non-Roofing Coatings	1.01	1.47	2.48	.0032	785.51
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1875	8.13
32	Missile Liner	-.44	.00	-.44	.1405	-3.14
33	Sealant Tape	50.32	.10	50.42	.2809	179.52
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.19	10.03	40.22	65.8147	.61
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	28.1138	.37
38	Mining and Milling	.00	2.62	2.62	.6766	3.87
	Total			508.07 *	102.2924	4.97

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE E -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		8.72	.00	8.72
Foreign Miners & Millers		95.12	.00	95.12
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		80.14	.00	80.14
Foreign Primary Processors		8.50	.00	8.50
Domestic Product Purchasers	514.72	.00	.00	514.72
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	603.57
World Welfare:	707.20

Note: Negative entries are welfare gains.

ALTERNATIVE E -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.47	.00	-.47	.0000	n/a
4	Pipeline Wrap	-3.58	.00	-3.58	.0000	n/a
5	Beater-Add Gaskets	-13.61	.00	-13.61	.0000	n/a
6	High Grade Electrical Paper	-.80	.00	-.80	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	-.49	.00	-.49	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.10	.00	-.10	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.05	.00	-1.05	.0000	n/a
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	6.99	4.83	11.82	5.6962	2.08
19	Disc Brake Pads LMV (OEM)	-.06	3.39	3.33	.6751	4.93
20	Disc Brake Pads HV	-.01	.30	.29	.1454	1.99
21	Brake Blocks	14.54	2.11	16.65	9.6853	1.72
22	Clutch Facings	21.60	.79	22.39	.4063	55.12
23	Automatic Trans. Components	.15	.13	.28	.0003	877.15
24	Friction Materials	-.19	1.80	1.61	.3522	4.58
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.90	.00	-.90	.0000	n/a
27	Sheet Gaskets	-6.25	.00	-6.25	.0000	n/a
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-23.36	.00	-23.36	.0000	n/a
30	Non-Roofing Coatings	-2.55	.00	-2.55	.0000	n/a
31	Asbestos-Reinforced Plastics	-.79	.00	-.79	.0000	n/a
32	Missile Liner	-.75	.00	-.75	.0000	n/a
33	Sealant Tape	-1.77	.00	-1.77	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	16.65	8.21	24.85	101.6571	.24
37	Disc Brake Pads LMV (Aftermarket)	-1.09	5.21	4.12	17.6734	.23
38	Mining and Milling	.00	8.72	8.72	.9179	9.50
	Total			603.57 *	144.9284	4.16

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE E -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.47	.00	-.47	.0000	n/a
4	Pipeline Wrap	-3.58	.00	-3.58	.0000	n/a
5	Beater-Add Gaskets	-13.61	.00	-13.61	.0000	n/a
6	High Grade Electrical Paper	-.80	.00	-.80	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	-.49	.00	-.49	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.10	.00	-.10	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.05	.00	-1.05	.0000	n/a
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	6.99	4.83	11.82	7.6476	1.55
19	Disc Brake Pads LMV (OEM)	-.06	3.39	3.33	.9063	3.67
20	Disc Brake Pads HV	-.01	.30	.29	.1948	1.48
21	Brake Blocks	14.54	2.11	16.65	12.9784	1.28
22	Clutch Facings	21.60	.79	22.39	.5444	41.13
23	Automatic Trans. Components	.15	.13	.28	.0004	654.58
24	Friction Materials	-.19	1.80	1.61	.4719	3.42
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.90	.00	-.90	.0000	n/a
27	Sheet Gaskets	-6.25	.00	-6.25	.0000	n/a
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-23.36	.00	-23.36	.0000	n/a
30	Non-Roofing Coatings	-2.55	.00	-2.55	.0000	n/a
31	Asbestos-Reinforced Plastics	-.79	.00	-.79	.0000	n/a
32	Missile Liner	-.75	.00	-.75	.0000	n/a
33	Sealant Tape	-1.77	.00	-1.77	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	16.65	8.21	24.85	136.3872	.18
37	Disc Brake Pads LMV (Aftermarket)	-1.09	5.21	4.12	23.2356	.18
38	Mining and Milling	.00	8.72	8.72	1.1694	7.46
	Total			603.57 *	193.1030	3.13

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE DX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.12	.00	.12	.0043	28.80
4	Pipeline Wrap	.26	.00	.26	.0908	2.89
5	Beater-Add Gaskets	38.48	.02	38.50	.6409	60.08
6	High Grade Electrical Paper	30.88	.00	30.88	.1511	204.39
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	.86	.00	.86	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0030	3.08
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.62	.00	-.62	.0658	-9.36
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	.68	1.10	1.78	.0000	***
19	Disc Brake Pads LMV (OEM)	.00	.05	.05	.0000	***
20	Disc Brake Pads HV	.00	.28	.28	.0002	1768.32
21	Brake Blocks	.04	2.28	2.33	.0205	113.44
22	Clutch Facings	13.37	1.20	14.57	.1556	93.63
23	Automatic Trans. Components	.06	.11	.17	.0001	1334.62
24	Friction Materials	.25	1.99	2.24	.0341	65.81
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.49	.00	.49	.0016	308.69
27	Sheet Gaskets	4.00	1.34	5.35	.0246	217.31
28	Asbestos Packing	.00	.00	.00	.0000	125.32
29	Roof Coatings	155.43	.75	156.18	.7138	218.81
30	Non-Roofing Coatings	1.01	1.47	2.48	.0022	1124.93
31	Asbestos-Reinforced Plastics	1.28	.24	1.52	.1616	9.43
32	Missile Liner	-.44	.00	-.44	.0971	-4.54
33	Sealant Tape	50.32	.10	50.42	.2167	232.72
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	30.19	10.03	40.22	50.4883	.80
37	Disc Brake Pads LMV (Aftermarket)	3.44	7.01	10.45	23.1588	.45
38	Mining and Milling	.00	2.62	2.62	.5375	4.87
	Total			508.07 *	80.2646	6.33

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE E -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.08	.00	-.08	.0000	n/a
4	Pipeline Wrap	-.51	.00	-.51	.0000	n/a
5	Beater-Add Gaskets	-5.29	.00	-5.29	.0000	n/a
6	High Grade Electrical Paper	-.47	.00	-.47	.0000	n/a
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	-.17	.00	-.17	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.02	.00	-.02	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.62	.00	-.62	.0000	n/a
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	-.20	3.34	3.13	.4463	7.02
19	Disc Brake Pads LMV (OEM)	-.06	.00	-.06	.0000	n/a
20	Disc Brake Pads HV	-.00	.30	.29	.0201	14.60
21	Brake Blocks	2.49	1.91	4.40	1.6356	2.69
22	Clutch Facings	21.64	.78	22.42	.3948	56.80
23	Automatic Trans. Components	.15	.13	.28	.0003	877.61
24	Friction Materials	.20	1.56	1.75	.1444	12.15
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.15	.00	-.15	.0000	n/a
27	Sheet Gaskets	-1.53	.00	-1.53	.0000	n/a
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-13.10	.00	-13.10	.0000	n/a
30	Non-Roofing Coatings	-.62	.00	-.62	.0000	n/a
31	Asbestos-Reinforced Plastics	-.23	.00	-.23	.0000	n/a
32	Missile Liner	-.44	.00	-.44	.0000	n/a
33	Sealant Tape	-1.36	.00	-1.36	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	17.53	7.71	25.24	67.9765	.37
37	Disc Brake Pads LMV (Aftermarket)	.22	5.09	5.31	13.2788	.40
38	Mining and Milling	.00	3.74	3.74	.5410	6.91
	Total			434.17 *	89.4626	4.85

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE E -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.08	.00	-.08	.0000	n/a
4	Pipeline Wrap	-.51	.00	-.51	.0000	n/a
5	Beater-Add Gaskets	-5.29	.00	-5.29	.0000	n/a
6	High Grade Electrical Paper	-.47	.00	-.47	.0000	n/a
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	-.17	.00	-.17	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.02	.00	-.02	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.62	.00	-.62	.0000	n/a
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	-.20	3.34	3.13	.5434	5.76
19	Disc Brake Pads LMV (OEM)	-.06	.00	-.06	.0000	n/a
20	Disc Brake Pads HV	-.00	.30	.29	.0260	11.30
21	Brake Blocks	2.49	1.91	4.40	2.1198	2.07
22	Clutch Facings	21.64	.78	22.42	.5287	42.41
23	Automatic Trans. Components	.15	.13	.28	.0004	654.93
24	Friction Materials	.20	1.56	1.75	.1903	9.22
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.15	.00	-.15	.0000	n/a
27	Sheet Gaskets	-1.53	.00	-1.53	.0000	n/a
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-13.10	.00	-13.10	.0000	n/a
30	Non-Roofing Coatings	-.62	.00	-.62	.0000	n/a
31	Asbestos-Reinforced Plastics	-.23	.00	-.23	.0000	n/a
32	Missile Liner	-.44	.00	-.44	.0000	n/a
33	Sealant Tape	-1.36	.00	-1.36	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	17.53	7.71	25.24	89.2860	.28
37	Disc Brake Pads LMV (Aftermarket)	.22	5.09	5.31	17.1378	.31
38	Mining and Milling	.00	3.74	3.74	.6690	5.59
	Total			434.17 *	116.5842	3.72

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE E -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.23	.00	2.23
Foreign Miners & Millers		24.27	.00	24.27
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		58.04	.00	58.04
Foreign Primary Processors		6.16	.00	6.16
Domestic Product Purchasers	256.77	.00	.00	256.77
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	317.03
World Welfare:	347.47

Note: Negative entries are welfare gains.

ALTERNATIVE E -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.02	.00	-.02	.0000	n/a
4	Pipeline Wrap	-.13	.00	-.13	.0000	n/a
5	Beater-Add Gaskets	-2.62	.00	-2.62	.0000	n/a
6	High Grade Electrical Paper	-.32	.00	-.32	.0000	n/a
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	-.08	.00	-.08	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.43	.00	-.43	.0000	n/a
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	-.65	.00	-.65	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.03	.00	-.03	.0000	n/a
20	Disc Brake Pads HV	-.00	.29	.29	.0028	103.11
21	Brake Blocks	.29	1.84	2.13	.2884	7.38
22	Clutch Facings	21.28	.77	22.05	.5130	42.99
23	Automatic Trans. Components	.15	.13	.28	.0004	655.07
24	Friction Materials	.08	1.41	1.49	.0739	20.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.04	.00	-.04	.0000	n/a
27	Sheet Gaskets	-.55	.00	-.55	.0000	n/a
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-8.75	.00	-8.75	.0000	n/a
30	Non-Roofing Coatings	-.24	.00	-.24	.0000	n/a
31	Asbestos-Reinforced Plastics	-.10	.00	-.10	.0000	n/a
32	Missile Liner	-.31	.00	-.31	.0000	n/a
33	Sealant Tape	-1.21	.D0	-1.21	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	15.77	7.31	23.08	69.4623	.33
37	Disc Brake Pads LMV (Aftermarket)	.82	5.01	5.83	16.2392	.36
38	Mining and Milling	.00	2.23	2.23	.4624	4.81
	Total			317.03 *	91.4573	3.47

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE E -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.02	.00	-.02	.0000	n/a
4	Pipeline Wrap	-.13	.00	-.13	.0000	n/a
5	Beater-Add Gaskets	-2.62	.00	-2.62	.0000	n/a
6	High Grade Electrical Paper	-.32	.00	-.32	.0000	n/a
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	-.08	.00	-.08	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.43	.00	-.43	.0000	n/a
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	-.65	.00	-.65	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.03	.00	-.03	.0000	n/a
20	Disc Brake Pads HV	-.00	.29	.29	.0023	128.42
21	Brake Blocks	.29	1.84	2.13	.2307	9.23
22	Clutch Facings	21.28	.77	22.05	.3832	57.55
23	Automatic Trans. Components	.15	.13	.28	.0003	877.80
24	Friction Materials	.08	1.41	1.49	.0570	26.16
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.04	.00	-.04	.0000	n/a
27	Sheet Gaskets	-.55	.00	-.55	.0000	n/a
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-8.75	.00	-8.75	.0000	n/a
30	Non-Roofing Coatings	-.24	.00	-.24	.0000	n/a
31	Asbestos-Reinforced Plastics	-.10	.00	-.10	.0000	n/a
32	Missile Liner	-.31	.00	-.31	.0000	n/a
33	Sealant Tape	-1.21	.00	-1.21	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	15.77	7.31	23.08	53.3928	.43
37	Disc Brake Pads LMV (Aftermarket)	.82	5.01	5.83	12.5913	.46
38	Mining and Milling	.00	2.23	2.23	.3795	5.87
	Total			317.03 *	70.7329	4.48

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE F -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		9.21	.00	9.21
Foreign Miners & Millers		100.43	.00	100.43
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2084.22	.00	2084.22
Foreign Primary Processors		8.93	.00	8.93
Domestic Product Purchasers	1392.75	.00	.00	1392.75
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 3486.18

World Welfare: 3595.53

Note: Negative entries are welfare gains.

ALTERNATIVE F -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.36	.00	2.36	.3288	7.19
4	Pipeline Wrap	-2.00	.00	-2.00	.4976	-4.02
5	Beater-Add Gaskets	66.48	.03	66.51	3.1029	21.44
6	High Grade Electrical Paper	27.53	.00	27.54	.2270	121.32
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	2.24	.00	2.24	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.06	.00	-.06	.0146	-4.22
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.66	1996.58	1995.92	.0951	20986.28
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	6.99	4.83	11.82	7.6476	1.55
19	Disc Brake Pads LMV (OEM)	-.06	3.39	3.33	.9063	3.67
20	Disc Brake Pads HV	-.01	.30	.29	.1948	1.48
21	Brake Blocks	14.54	2.11	16.65	12.9784	1.28
22	Clutch Facings	21.60	.79	22.39	.5444	41.13
23	Automatic Trans. Components	.15	.13	.28	.0004	654.58
24	Friction Materials	-.19	1.80	1.61	.4719	3.42
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	73.66	.00	73.66	.2765	266.35
27	Sheet Gaskets	53.29	5.86	59.16	.9863	59.98
28	Asbestos Packing	.24	.00	.24	.0051	47.61
29	Roof Coatings	62.11	.42	62.53	.8504	73.53
30	Non-Roofing Coatings	19.72	.81	20.53	.1704	120.53
31	Asbestos-Reinforced Plastics	18.67	.17	18.84	.2920	64.51
32	Missile Liner	479.71	.13	479.84	.1405	3415.80
33	Sealant Tape	18.25	.07	18.33	.0495	369.97
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	16.65	8.21	24.85	136.3872	.18
37	Disc Brake Pads LMV (Aftermarket)	-1.09	5.21	4.12	23.2356	.18
38	Mining and Milling	.00	9.21	9.21	1.4423	6.39
	Total			3486.18 *	200.4127	17.39

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE F -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.36	.00	2.36	.2274	10.40
4	Pipeline Wrap	-2.00	.00	-2.00	.3441	-5.81
5	Beater-Add Gaskets	66.48	.03	66.51	2.1456	31.00
6	High Grade Electrical Paper	27.53	.00	27.54	.1569	175.45
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	2.24	.00	2.24	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.06	.00	-.06	.0101	-6.10
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.66	1996.58	1995.92	.0658	30350.34
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	6.99	4.83	11.82	5.6962	2.08
19	Disc Brake Pads LMV (OEM)	-.06	3.39	3.33	.6751	4.93
20	Disc Brake Pads HV	-.01	.30	.29	.1454	1.99
21	Brake Blocks	14.54	2.11	16.65	9.6853	1.72
22	Clutch Facings	21.60	.79	22.39	.4063	55.12
23	Automatic Trans. Components	.15	.13	.28	.0003	877.15
24	Friction Materials	-.19	1.80	1.61	.3522	4.58
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	73.66	.00	73.66	.1912	385.19
27	Sheet Gaskets	53.29	5.86	59.16	.6820	86.74
28	Asbestos Packing	.24	.00	.24	.0035	68.86
29	Roof Coatings	62.11	.42	62.53	.5880	106.34
30	Non-Roofing Coatings	19.72	.81	20.53	.1178	174.31
31	Asbestos-Reinforced Plastics	18.67	.17	18.84	.2019	93.30
32	Missile Liner	479.71	.13	479.84	.0971	4939.92
33	Sealant Tape	18.25	.07	18.33	.0343	535.05
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	16.65	8.21	24.85	101.6571	.24
37	Disc Brake Pads LMV (Aftermarket)	-1.09	5.21	4.12	17.6734	.23
38	Mining and Milling	.00	9.21	9.21	1.1066	8.32
	Total			3486.18 *	149.9828	23.24

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE F -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.93	.00	3.93
Foreign Miners & Millers		42.84	.00	42.84
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2067.47	.00	2067.47
Foreign Primary Processors		7.23	.00	7.23
Domestic Product Purchasers	1047.95	.00	.00	1047.95
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 3119.36

World Welfare: 3169.43

Note: Negative entries are welfare gains.

ALTERNATIVE E -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.74	.00	3.74
Foreign Miners & Millers		40.76	.00	40.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		67.94	.00	67.94
Foreign Primary Processors		7.13	.00	7.13
Domestic Product Purchasers	362.49	.00	.00	362.49
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 434.17

World Welfare: 482.06

Note: Negative entries are welfare gains.

ALTERNATIVE F -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.19	.00	.19	.0304	6.22
4	Pipeline Wrap	-.41	.00	-.41	.0274	-14.91
5	Beater-Add Gaskets	33.27	.02	33.29	1.4739	22.59
6	High Grade Electrical Paper	27.40	.00	27.40	.2224	123.17
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	.77	.00	.77	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0014	-9.85
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.15	1996.58	1996.43	.0951	20991.63
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	-.20	3.34	3.13	.5434	5.76
19	Disc Brake Pads LMV (OEM)	-.06	.00	-.06	.0000	n/a
20	Disc Brake Pads HV	-.00	.30	.29	.0260	11.30
21	Brake Blocks	2.49	1.91	4.40	2.1198	2.07
22	Clutch Facings	21.64	.78	22.42	.5287	42.41
23	Automatic Trans. Components	.15	.13	.28	.0004	654.93
24	Friction Materials	.20	1.56	1.75	.1903	9.22
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.09	.00	6.09	.0228	267.04
27	Sheet Gaskets	10.00	1.34	11.34	.1899	59.73
28	Asbestos Packing	.03	.00	.03	.0007	47.28
29	Roof Coatings	66.26	.42	66.68	.7700	86.60
30	Non-Roofing Coatings	2.89	.81	3.70	.0258	143.63
31	Asbestos-Reinforced Plastics	4.71	.17	4.88	.0738	66.14
32	Missile Liner	480.08	.13	480.21	.1405	3418.40
33	Sealant Tape	29.75	.07	29.82	.0765	389.67
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	17.53	7.71	25.24	89.2860	.28
37	Disc Brake Pads LMV (Aftermarket)	.22	5.09	5.31	17.1378	.31
38	Mining and Milling	.00	3.93	3.93	.8396	4.68
	Total			3119.36 *	119.9053	26.02

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE F -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.01	.00	-.01	.0012	-6.80
4	Pipeline Wrap	-.13	.00	-.13	.0000	n/a
5	Beater-Add Gaskets	15.08	.01	15.09	.4632	32.58
6	High Grade Electrical Paper	27.04	.00	27.04	.1511	178.96
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	.21	.00	.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.0001	-92.71
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.05	1996.58	1996.64	.0658	30361.27
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	-.65	.00	-.65	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.03	.00	-.03	.0000	n/a
20	Disc Brake Pads HV	-.00	.29	.29	.0023	128.42
21	Brake Blocks	.29	1.84	2.13	.2307	9.23
22	Clutch Facings	21.28	.77	22.05	.3832	57.55
23	Automatic Trans. Components	.15	.13	.28	.0003	877.80
24	Friction Materials	.08	1.41	1.49	.0570	26.16
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.27	.00	.27	.0005	540.76
27	Sheet Gaskets	1.26	.25	1.50	.0189	79.45
28	Asbestos Packing	.00	.00	.00	.0000	111.47
29	Roof Coatings	63.69	.42	64.11	.4810	133.27
30	Non-Roofing Coatings	.17	.81	.98	.0022	445.36
31	Asbestos-Reinforced Plastics	.98	.17	1.15	.0110	104.08
32	Missile Liner	480.23	.13	480.36	.0971	4945.22
33	Sealant Tape	46.31	.07	46.38	.0806	575.13
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	15.77	7.31	23.08	53.3928	.43
37	Disc Brake Pads LMV (Aftermarket)	.82	5.01	5.83	12.5913	.46
38	Mining and Milling	.00	2.36	2.36	.4765	4.95
	Total			2965.56 *	72.2027	41.07

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE FX -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		9.21	.00	9.21
Foreign Miners & Millers		100.42	.00	100.42
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		87.51	.00	87.51
Foreign Primary Processors		8.93	.00	8.93
Domestic Product Purchasers	911.54	.00	.00	911.54
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	1008.26
World Welfare:	1117.61

Note: Negative entries are welfare gains.

ALTERNATIVE F -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.01	.00	-.01	.0016	-4.84
4	Pipeline Wrap	-.13	.00	-.13	.0000	n/a
5	Beater-Add Gaskets	15.08	.01	15.09	.6671	22.62
6	High Grade Electrical Paper	27.04	.00	27.04	.2185	123.76
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	.21	.00	.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.0001	-66.00
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.05	1996.58	1996.64	.0951	20993.84
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	-.65	.00	-.65	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.03	.00	-.03	.0000	n/a
20	Disc Brake Pads HV	-.00	.29	.29	.0028	103.11
21	Brake Blocks	.29	1.84	2.13	.2884	7.38
22	Clutch Facings	21.28	.77	22.05	.5130	42.99
23	Automatic Trans. Components	.15	.13	.28	.0004	655.07
24	Friction Materials	.08	1.41	1.49	.0739	20.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.27	.00	.27	.0007	390.65
27	Sheet Gaskets	1.26	.25	1.50	.0271	55.46
28	Asbestos Packing	.00	.00	.00	.0000	80.53
29	Roof Coatings	63.69	.42	64.11	.6953	92.21
30	Non-Roofing Coatings	.17	.81	.98	.0032	310.99
31	Asbestos-Reinforced Plastics	.98	.17	1.15	.0158	72.70
32	Missile Liner	480.23	.13	480.36	.1405	3419.46
33	Sealant Tape	46.31	.07	46.38	.1169	396.75
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	15.77	7.31	23.08	69.4623	.33
37	Disc Brake Pads LMV (Aftermarket)	.82	5.01	5.83	16.2392	.36
38	Mining and Milling	.00	2.36	2.36	.6027	3.91
	Total			2965.56 *	93.5793	31.69

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE F -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.36	.00	2.36
Foreign Miners & Millers		25.71	.00	25.71
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2056.48	.00	2056.48
Foreign Primary Processors		6.19	.00	6.19
Domestic Product Purchasers	906.73	.00	.00	906.73
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 2965.56

World Welfare: 2997.45

Note: Negative entries are welfare gains.

ALTERNATIVE F -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.19	.00	.19	.0212	8.94
4	Pipeline Wrap	-.41	.00	-.41	.0191	-21.42
5	Beater-Add Gaskets	33.27	.02	33.29	1.0211	32.60
6	High Grade Electrical Paper	27.40	.00	27.40	.1538	178.13
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	.77	.00	.77	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0009	-14.15
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.15	1996.58	1996.43	.0658	30358.09
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	-.20	3.34	3.13	.4463	7.02
19	Disc Brake Pads LMV (OEM)	-.06	.00	-.06	.0000	n/a
20	Disc Brake Pads HV	-.00	.30	.29	.0201	14.60
21	Brake Blocks	2.49	1.91	4.40	1.6356	2.69
22	Clutch Facings	21.64	.78	22.42	.3948	56.80
23	Automatic Trans. Components	.15	.13	.28	.0003	877.61
24	Friction Materials	.20	1.56	1.75	.1444	12.15
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.09	.00	6.09	.0159	383.27
27	Sheet Gaskets	10.00	1.34	11.34	.1319	86.00
28	Asbestos Packing	.03	.00	.03	.0005	67.82
29	Roof Coatings	66.26	.42	66.68	.5326	125.20
30	Non-Roofing Coatings	2.89	.81	3.70	.0179	206.65
31	Asbestos-Reinforced Plastics	4.71	.17	4.88	.0512	95.29
32	Missile Liner	480.08	.13	480.21	.0971	4943.68
33	Sealant Tape	29.75	.07	29.82	.0529	564.22
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	17.53	7.71	25.24	67.9765	.37
37	Disc Brake Pads LMV (Aftermarket)	.22	5.09	5.31	13.2788	.40
38	Mining and Milling	.00	3.93	3.93	.6590	5.96
	Total			3119.36 *	91.7624	33.99

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE FX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.36	.00	2.36	.2274	10.40
4	Pipeline Wrap	-2.00	.00	-2.00	.3441	-5.81
5	Beater-Add Gaskets	66.48	.03	66.51	2.1456	31.00
6	High Grade Electrical Paper	27.53	.00	27.54	.1569	175.45
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	2.24	.00	2.24	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.06	.00	-.06	.0101	-6.10
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.26	.00	-1.26	.0000	n/a
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	6.99	4.83	11.82	5.6962	2.08
19	Disc Brake Pads LMV (OEM)	-.06	3.39	3.33	.6751	4.93
20	Disc Brake Pads HV	-.01	.30	.29	.1454	1.99
21	Brake Blocks	14.54	2.11	16.65	9.6853	1.72
22	Clutch Facings	21.60	.79	22.39	.4063	55.12
23	Automatic Trans. Components	.15	.13	.28	.0003	877.15
24	Friction Materials	-.19	1.80	1.61	.3522	4.58
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	73.66	.00	73.66	.1912	385.19
27	Sheet Gaskets	53.29	5.86	59.16	.6820	86.74
28	Asbestos Packing	.24	.00	.24	.0035	68.86
29	Roof Coatings	62.11	.42	62.53	.5880	106.34
30	Non-Roofing Coatings	19.72	.81	20.53	.1178	174.31
31	Asbestos-Reinforced Plastics	18.67	.17	18.84	.2019	93.30
32	Missile Liner	-.90	.00	-.90	.0000	n/a
33	Sealant Tape	18.25	.07	18.33	.0343	535.05
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	16.65	8.21	24.85	101.6571	.24
37	Disc Brake Pads LMV (Aftermarket)	-1.09	5.21	4.12	17.6734	.23
38	Mining and Milling	.00	9.21	9.21	1.1014	8.36
	Total			1008.26 *	149.8147	6.73

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE FX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.36	.00	2.36	.3288	7.19
4	Pipeline Wrap	-2.00	.00	-2.00	.4976	-4.02
5	Beater-Add Gaskets	66.48	.03	66.51	3.1029	21.44
6	High Grade Electrical Paper	27.53	.00	27.54	.2270	121.32
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	2.24	.00	2.24	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.06	.00	-.06	.0146	-4.22
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.26	.00	-1.26	.0000	n/a
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	6.99	4.83	11.82	7.6476	1.55
19	Disc Brake Pads LMV (OEM)	-.06	3.39	3.33	.9063	3.67
20	Disc Brake Pads HV	-.01	.30	.29	.1948	1.48
21	Brake Blocks	14.54	2.11	16.65	12.9784	1.28
22	Clutch Facings	21.60	.79	22.39	.5444	41.13
23	Automatic Trans. Components	.15	.13	.28	.0004	654.58
24	Friction Materials	-.19	1.80	1.61	.4719	3.42
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	73.66	.00	73.66	.2765	266.35
27	Sheet Gaskets	53.29	5.86	59.16	.9863	59.98
28	Asbestos Packing	.24	.00	.24	.0051	47.61
29	Roof Coatings	62.11	.42	62.53	.8504	73.53
30	Non-Roofing Coatings	19.72	.81	20.53	.1704	120.53
31	Asbestos-Reinforced Plastics	18.67	.17	18.84	.2920	64.51
32	Missile Liner	-.90	.00	-.90	.0000	n/a
33	Sealant Tape	18.25	.07	18.33	.0495	369.97
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	16.65	8.21	24.85	136.3872	.18
37	Disc Brake Pads LMV (Aftermarket)	-1.09	5.21	4.12	23.2356	.18
38	Mining and Milling	.00	9.21	9.21	1.4347	6.42
	Total			1008.26 *	200.1695	5.04

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE FX -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.93	.00	3.93
Foreign Miners & Millers		42.84	.00	42.84
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		70.76	.00	70.76
Foreign Primary Processors		7.23	.00	7.23
Domestic Product Purchasers	566.75	.00	.00	566.75
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 641.44

World Welfare: 691.50

Note: Negative entries are welfare gains.

ALTERNATIVE FX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.19	.00	.19	.0304	6.22
4	Pipeline Wrap	-.41	.00	-.41	.0274	-14.91
5	Beater-Add Gaskets	33.27	.02	33.29	1.4739	22.59
6	High Grade Electrical Paper	27.40	.00	27.40	.2224	123.17
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	.77	.00	.77	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0014	-9.85
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.75	.00	-.75	.0000	n/a
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	-.20	3.34	3.13	.5434	5.76
19	Disc Brake Pads LMV (OEM)	-.06	.00	-.06	.0000	n/a
20	Disc Brake Pads HV	-.00	.30	.29	.0260	11.30
21	Brake Blocks	2.49	1.91	4.40	2.1198	2.07
22	Clutch Facings	21.64	.78	22.42	.5287	42.41
23	Automatic Trans. Components	.15	.13	.28	.0004	654.93
24	Friction Materials	.20	1.56	1.75	.1903	9.22
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.09	.00	6.09	.0228	267.04
27	Sheet Gaskets	10.00	1.34	11.34	.1899	59.73
28	Asbestos Packing	.03	.00	.03	.0007	47.28
29	Roof Coatings	66.26	.42	66.68	.7700	86.60
30	Non-Roofing Coatings	2.89	.81	3.70	.0258	143.63
31	Asbestos-Reinforced Plastics	4.71	.17	4.88	.0738	66.14
32	Missile Liner	-.54	.00	-.54	.0000	n/a
33	Sealant Tape	29.75	.07	29.82	.0765	389.67
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	17.53	7.71	25.24	89.2860	.28
37	Disc Brake Pads LMV (Aftermarket)	.22	5.09	5.31	17.1378	.31
38	Mining and Milling	.00	3.93	3.93	.8320	4.72
	Total			641.44 *	119.6621	5.36

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE FX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.19	.00	.19	.0212	8.94
4	Pipeline Wrap	-.41	.00	-.41	.0191	-21.42
5	Beater-Add Gaskets	33.27	.02	33.29	1.0211	32.60
6	High Grade Electrical Paper	27.40	.00	27.40	.1538	178.13
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	.77	.00	.77	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0009	-14.15
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.75	.00	-.75	.0000	n/a
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	-.20	3.34	3.13	.4463	7.02
19	Disc Brake Pads LMV (OEM)	-.06	.00	-.06	.0000	n/a
20	Disc Brake Pads HV	-.00	.30	.29	.0201	14.60
21	Brake Blocks	2.49	1.91	4.40	1.6356	2.69
22	Clutch Facings	21.64	.78	22.42	.3948	56.80
23	Automatic Trans. Components	.15	.13	.28	.0003	877.61
24	Friction Materials	.20	1.56	1.75	.1444	12.15
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.09	.00	6.09	.0159	383.27
27	Sheet Gaskets	10.00	1.34	11.34	.1319	86.00
28	Asbestos Packing	.03	.00	.03	.0005	67.82
29	Roof Coatings	66.26	.42	66.68	.5326	125.20
30	Non-Roofing Coatings	2.89	.81	3.70	.0179	206.65
31	Asbestos-Reinforced Plastics	4.71	.17	4.88	.0512	95.29
32	Missile Liner	-.54	.00	-.54	.0000	n/a
33	Sealant Tape	29.75	.07	29.82	.0529	564.22
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	17.53	7.71	25.24	67.9765	.37
37	Disc Brake Pads LMV (Aftermarket)	.22	5.09	5.31	13.2788	.40
38	Mining and Milling	.00	3.93	3.93	.6538	6.01
	Total			641.44 *	91.5942	7.00

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE FX -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.36	.00	2.36
Foreign Miners & Millers		25.70	.00	25.70
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		59.76	.00	59.76
Foreign Primary Processors		6.19	.00	6.19
Domestic Product Purchasers	425.52	.00	.00	425.52
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 487.64

World Welfare: 519.53

Note: Negative entries are welfare gains.

ALTERNATIVE FX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.01	.00	-.01	.0016	-4.84
4	Pipeline Wrap	-.13	.00	-.13	.0000	n/a
5	Beater-Add Gaskets	15.08	.01	15.09	.6671	22.62
6	High Grade Electrical Paper	27.04	.00	27.04	.2185	123.76
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	.21	.00	.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.0001	-66.00
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.54	.00	-.54	.0000	n/a
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	-.65	.00	-.65	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.03	.00	-.03	.0000	n/a
20	Disc Brake Pads HV	-.00	.29	.29	.0028	103.11
21	Brake Blocks	.29	1.84	2.13	.2884	7.38
22	Clutch Facings	21.28	.77	22.05	.5130	42.99
23	Automatic Trans. Components	.15	.13	.28	.0004	655.07
24	Friction Materials	.08	1.41	1.49	.0739	20.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.27	.00	.27	.0007	390.65
27	Sheet Gaskets	1.26	.25	1.50	.0271	55.46
28	Asbestos Packing	.00	.00	.00	.0000	80.53
29	Roof Coatings	63.69	.42	64.11	.6953	92.21
30	Non-Roofing Coatings	.17	.81	.98	.0032	310.99
31	Asbestos-Reinforced Plastics	.98	.17	1.15	.0158	72.70
32	Missile Liner	-.39	.00	-.39	.0000	n/a
33	Sealant Tape	46.31	.07	46.38	.1169	396.75
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	15.77	7.31	23.08	69.4623	.33
37	Disc Brake Pads LMV (Aftermarket)	.82	5.01	5.83	16.2392	.36
38	Mining and Milling	.00	2.36	2.36	.5951	3.96
	Total			487.64 *	93.3362	5.22

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE FX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.01	.00	-.01	.0012	-6.80
4	Pipeline Wrap	-.13	.00	-.13	.0000	n/a
5	Beater-Add Gaskets	15.08	.01	15.09	.4632	32.58
6	High Grade Electrical Paper	27.04	.00	27.04	.1511	178.96
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	.21	.00	.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.0001	-92.71
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.54	.00	-.54	.0000	n/a
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	-.65	.00	-.65	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.03	.00	-.03	.0000	n/a
20	Disc Brake Pads HV	-.00	.29	.29	.0023	128.42
21	Brake Blocks	.29	1.84	2.13	.2307	9.23
22	Clutch Facings	21.28	.77	22.05	.3832	57.55
23	Automatic Trans. Components	.15	.13	.28	.0003	877.80
24	Friction Materials	.08	1.41	1.49	.0570	26.16
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.27	.00	.27	.0005	540.76
27	Sheet Gaskets	1.26	.25	1.50	.0189	79.45
28	Asbestos Packing	.00	.00	.00	.0000	111.47
29	Roof Coatings	63.69	.42	64.11	.4810	133.27
30	Non-Roofing Coatings	.17	.81	.98	.0022	445.36
31	Asbestos-Reinforced Plastics	.98	.17	1.15	.0110	104.08
32	Missile Liner	-.39	.00	-.39	.0000	n/a
33	Sealant Tape	46.31	.07	46.38	.0806	575.13
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	15.77	7.31	23.08	53.3928	.43
37	Disc Brake Pads LMV (Aftermarket)	.82	5.01	5.83	12.5913	.46
38	Mining and Milling	.00	2.36	2.36	.4713	5.00
	Total			487.64 *	72.0346	6.77

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		12.32	.00	12.32
Foreign Miners & Millers		134.29	.00	134.29
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2778.41	.00	2778.41
Foreign Primary Processors		9.81	.00	9.81
Domestic Product Purchasers	4143.77	.00	.00	4143.77
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 6934.49

World Welfare: 7078.59

Note: Negative entries are welfare gains.

ALTERNATIVE G -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	1.1509	9.55
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	310.13	.04	310.17	10.8603	28.56
6	High Grade Electrical Paper	114.72	.00	114.72	.7944	144.41
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.3329	8061.70
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	11.6170	1.77
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.3749	2.98
20	Disc Brake Pads HV	.03	.35	.38	.3031	1.26
21	Brake Blocks	25.70	2.45	28.15	20.1886	1.39
22	Clutch Facings	36.85	.92	37.77	.8469	44.59
23	Automatic Trans. Components	.25	.15	.40	.0007	602.38
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.9679	313.45
27	Sheet Gaskets	235.37	7.88	243.25	3.4521	70.46
28	Asbestos Packing	.99	.00	.99	.0178	55.68
29	Roof Coatings	319.92	.56	320.48	2.9764	107.67
30	Non-Roofing Coatings	87.79	1.09	88.88	.5963	149.07
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	1.0220	77.02
32	Missile Liner	1961.33	.17	1961.50	.4917	3989.45
33	Sealant Tape	79.58	.10	79.67	.1734	459.54
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	36.26	9.05	45.31	209.0213	.22
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	47.9474	.17
38	Mining and Milling	.00	12.32	12.32	2.3709	5.19
	Total			6934.49 *	328.6007	21.10

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	.9286	11.83
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	310.13	.04	310.17	8.7628	35.40
6	High Grade Electrical Paper	114.72	.00	114.72	.6410	178.97
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.2686	9991.41
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	9.3392	2.20
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.1052	3.71
20	Disc Brake Pads HV	.03	.35	.38	.2445	1.56
21	Brake Blocks	25.70	2.45	28.15	16.2894	1.73
22	Clutch Facings	36.85	.92	37.77	.6833	55.27
23	Automatic Trans. Components	.25	.15	.40	.0005	745.38
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.7810	388.48
27	Sheet Gaskets	235.37	7.88	243.25	2.7854	87.33
28	Asbestos Packing	.99	.00	.99	.0143	69.00
29	Roof Coatings	319.92	.56	320.48	2.4015	133.45
30	Non-Roofing Coatings	87.79	1.09	88.88	.4811	184.75
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	.8246	95.45
32	Missile Liner	1961.33	.17	1961.50	.3967	4944.40
33	Sealant Tape	79.58	.10	79.67	.1399	569.53
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	36.26	9.05	45.31	168.1760	.27
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	40.4240	.20
38	Mining and Milling	.00	12.32	12.32	1.9145	6.43
	Total			6934.49 *	266.3603	26.03

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		6.04	.00	6.04
Foreign Miners & Millers		65.81	.00	65.81
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2769.88	.00	2769.88
Foreign Primary Processors		9.22	.00	9.22
Domestic Product Purchasers	3423.43	.00	.00	3423.43
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	6199.35
World Welfare:	6274.38

Note: Negative entries are welfare gains.

ALTERNATIVE G -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.44	.00	3.44	.3247	10.59
4	Pipeline Wrap	.86	.00	.86	.3931	2.20
5	Beater-Add Gaskets	209.04	.04	209.08	6.9583	30.05
6	High Grade Electrical Paper	113.95	.00	113.96	.7848	145.21
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	6.21	.00	6.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0145	1.53
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.95	2683.24	2684.19	.3329	8063.77
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	5.63	5.36	10.99	3.2055	3.43
19	Disc Brake Pads LMV (OEM)	.05	3.87	3.92	.1952	20.09
20	Disc Brake Pads HV	.02	.35	.37	.0777	4.79
21	Brake Blocks	8.40	2.35	10.75	5.8259	1.84
22	Clutch Facings	36.83	.91	37.74	.8275	45.61
23	Automatic Trans. Components	.25	.15	.40	.0007	602.63
24	Friction Materials	.74	1.99	2.73	.3781	7.23
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	88.36	.00	88.36	.2606	339.00
27	Sheet Gaskets	99.82	6.16	105.98	1.3660	77.58
28	Asbestos Packing	.39	.00	.39	.0066	58.89
29	Roof Coatings	317.78	.56	318.34	2.7983	113.76
30	Non-Roofing Coatings	36.81	1.09	37.89	.2287	165.68
31	Asbestos-Reinforced Plastics	39.88	.23	40.11	.4894	81.94
32	Missile Liner	1961.82	.17	1962.00	.4917	3990.46
33	Sealant Tape	105.49	.10	105.59	.2297	459.63
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	38.72	9.05	47.76	161.2858	.30
37	Disc Brake Pads LMV (Aftermarket)	2.84	7.13	9.97	41.7213	.24
38	Mining and Milling	.00	6.04	6.04	1.5787	3.82
	Total			6199.35 *	235.8584	26.28

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.44	.00	3.44	.2827	12.16
4	Pipeline Wrap	.86	.00	.86	.3466	2.49
5	Beater-Add Gaskets	209.04	.04	209.08	5.7635	36.28
6	High Grade Electrical Paper	113.95	.00	113.96	.6337	179.84
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	6.21	.00	6.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0126	1.76
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.95	2683.24	2684.19	.2686	9993.99
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	5.63	5.36	10.99	2.9130	3.77
19	Disc Brake Pads LMV (OEM)	.05	3.87	3.92	.1842	21.30
20	Disc Brake Pads HV	.02	.35	.37	.0680	5.47
21	Brake Blocks	8.40	2.35	10.75	5.0650	2.12
22	Clutch Facings	36.83	.91	37.74	.6685	56.46
23	Automatic Trans. Components	.25	.15	.40	.0005	745.69
24	Friction Materials	.74	1.99	2.73	.3172	8.62
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	88.36	.00	88.36	.2275	388.46
27	Sheet Gaskets	99.82	6.16	105.98	1.1647	90.99
28	Asbestos Packing	.39	.00	.39	.0057	68.09
29	Roof Coatings	317.78	.56	318.34	2.2661	140.48
30	Non-Roofing Coatings	36.81	1.09	37.89	.1972	192.20
31	Asbestos-Reinforced Plastics	39.88	.23	40.11	.4153	96.57
32	Missile Liner	1961.82	.17	1962.00	.3967	4945.65
33	Sealant Tape	105.49	.10	105.59	.1825	578.51
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	38.72	9.05	47.76	133.9481	.36
37	Disc Brake Pads LMV (Aftermarket)	2.84	7.13	9.97	35.9186	.28
38	Mining and Milling	.00	6.04	6.04	1.3078	4.61
	Total			6199.35 *	197.5789	31.38

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.29	.00	1.29	.1159	11.12
4	Pipeline Wrap	.30	.00	.30	.1169	2.54
5	Beater-Add Gaskets	142.29	.04	142.33	4.5691	31.15
6	High Grade Electrical Paper	112.91	.00	112.91	.7757	145.57
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	3.85	.00	3.85	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0051	1.87
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	1.26	2683.24	2684.50	.3329	8064.70
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	3.11	5.12	8.24	1.6303	5.05
19	Disc Brake Pads LMV (OEM)	.03	3.82	3.86	.0986	39.10
20	Disc Brake Pads HV	.01	.34	.35	.0253	13.98
21	Brake Blocks	3.20	2.27	5.47	2.0765	2.63
22	Clutch Facings	36.37	.91	37.29	.8088	46.10
23	Automatic Trans. Components	.25	.15	.40	.0007	602.74
24	Friction Materials	.51	1.90	2.41	.2066	11.68
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	31.75	.00	31.75	.0892	356.03
27	Sheet Gaskets	47.01	4.65	51.66	.6115	84.49
28	Asbestos Packing	.19	.00	.19	.0030	62.92
29	Roof Coatings	307.23	.56	307.80	2.6374	116.71
30	Non-Roofing Coatings	18.33	1.09	19.42	.1083	179.29
31	Asbestos-Reinforced Plastics	22.51	.23	22.74	.2630	86.46
32	Missile Liner	1962.04	.17	1962.22	.4917	3990.91
33	Sealant Tape	139.81	.10	139.90	.3070	455.71
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	37.97	9.05	47.02	140.9863	.33
37	Disc Brake Pads LMV (Aftermarket)	3.77	7.13	10.90	40.7585	.27
38	Mining and Milling	.00	3.98	3.98	1.2395	3.21
	Total			5875.92 *	202.6725	28.99

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.98	.00	3.98
Foreign Miners & Millers		43.35	.00	43.35
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2762.04	.00	2762.04
Foreign Primary Processors		8.68	.00	8.68
Domestic Product Purchasers	3109.90	.00	.00	3109.90
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	5875.92
World Welfare:	5927.95

Note: Negative entries are welfare gains.

ALTERNATIVE G -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.29	.00	1.29	.1063	12.12
4	Pipeline Wrap	.30	.00	.30	.1089	2.73
5	Beater-Add Gaskets	142.29	.04	142.33	3.8823	36.66
6	High Grade Electrical Paper	112.91	.00	112.91	.6267	180.18
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	3.85	.00	3.85	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0047	2.04
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	1.26	2683.24	2684.50	.2686	9995.14
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	3.11	5.12	8.24	1.5385	5.35
19	Disc Brake Pads LMV (OEM)	.03	3.82	3.86	.0948	40.67
20	Disc Brake Pads HV	.01	.34	.35	.0234	15.14
21	Brake Blocks	3.20	2.27	5.47	1.9034	2.87
22	Clutch Facings	36.37	.91	37.29	.6542	56.99
23	Automatic Trans. Components	.25	.15	.40	.0005	745.83
24	Friction Materials	.51	1.90	2.41	.1798	13.42
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	31.75	.00	31.75	.0821	386.77
27	Sheet Gaskets	47.01	4.65	51.66	.5464	94.55
28	Asbestos Packing	.19	.00	.19	.0027	68.93
29	Roof Coatings	307.23	.56	307.80	2.1440	143.56
30	Non-Roofing Coatings	18.33	1.09	19.42	.0981	197.88
31	Asbestos-Reinforced Plastics	22.51	.23	22.74	.2331	97.53
32	Missile Liner	1962.04	.17	1962.22	.3967	4946.20
33	Sealant Tape	139.81	.10	139.90	.2403	582.12
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	37.97	9.05	47.02	118.9540	.40
37	Disc Brake Pads LMV (Aftermarket)	3.77	7.13	10.90	35.1758	.31
38	Mining and Milling	.00	3.98	3.98	1.0374	3.83
	Total			5875.92 *	171.9987	34.16

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE GX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	1.1509	9.55
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	310.13	.04	310.17	10.8603	28.56
6	High Grade Electrical Paper	114.72	.00	114.72	.7944	144.41
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-2.16	.00	-2.16	.0000	n/a
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	11.6170	1.77
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.3749	2.98
20	Disc Brake Pads HV	.03	.35	.38	.3031	1.26
21	Brake Blocks	25.70	2.45	28.15	20.1886	1.39
22	Clutch Facings	36.85	.92	37.77	.8469	44.59
23	Automatic Trans. Components	.25	.15	.40	.0007	602.38
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.9679	313.45
27	Sheet Gaskets	235.37	7.88	243.25	3.4521	70.46
28	Asbestos Packing	.99	.00	.99	.0178	55.68
29	Roof Coatings	319.92	.56	320.48	2.9764	107.67
30	Non-Roofing Coatings	87.79	1.09	88.88	.5963	149.07
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	1.0220	77.02
32	Missile Liner	-1.55	.00	-1.55	.0000	n/a
33	Sealant Tape	79.58	.10	79.67	.1734	459.54
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	36.26	9.05	45.31	209.0213	.22
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	47.9474	.17
38	Mining and Milling	.00	12.31	12.31	2.3444	5.25
	Total			2285.78 *	327.7496	6.97

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE GX -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		12.31	.00	12.31
Foreign Miners & Millers		134.27	.00	134.27
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		94.99	.00	94.99
Foreign Primary Processors		9.81	.00	9.81
Domestic Product Purchasers	2178.48	.00	.00	2178.48
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 2285.78

World Welfare: 2429.86

Note: Negative entries are welfare gains.

ALTERNATIVE GX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	.9286	11.83
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	310.13	.04	310.17	8.7628	35.40
6	High Grade Electrical Paper	114.72	.00	114.72	.6410	178.97
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-2.16	.00	-2.16	.0000	n/a
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	9.3392	2.20
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.1052	3.71
20	Disc Brake Pads HV	.03	.35	.38	.2445	1.56
21	Brake Blocks	25.70	2.45	28.15	16.2894	1.73
22	Clutch Facings	36.85	.92	37.77	.6833	55.27
23	Automatic Trans. Components	.25	.15	.40	.0005	745.38
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.7810	388.48
27	Sheet Gaskets	235.37	7.88	243.25	2.7854	87.33
28	Asbestos Packing	.99	.00	.99	.0143	69.00
29	Roof Coatings	319.92	.56	320.48	2.4015	133.45
30	Non-Roofing Coatings	87.79	1.09	88.88	.4811	184.75
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	.8246	95.45
32	Missile Liner	-1.55	.00	-1.55	.0000	n/a
33	Sealant Tape	79.58	.10	79.67	.1399	569.53
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	36.26	9.05	45.31	168.1760	.27
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	40.4240	.20
38	Mining and Milling	.00	12.31	12.31	1.8931	6.50
	Total			2285.78 *	265.6736	8.60

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE GX -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		6.03	.00	6.03
Foreign Miners & Millers		65.79	.00	65.79
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		86.47	.00	86.47
Foreign Primary Processors		9.22	.00	9.22
Domestic Product Purchasers	1458.14	.00	.00	1458.14
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 1550.64

World Welfare: 1625.65

Note: Negative entries are welfare gains.

ALTERNATIVE GX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.44	.00	3.44	.3247	10.59
4	Pipeline Wrap	.86	.00	.86	.3931	2.20
5	Beater-Add Gaskets	209.04	.04	209.08	6.9583	30.05
6	High Grade Electrical Paper	113.95	.00	113.96	.7848	145.21
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	6.21	.00	6.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0145	1.53
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.47	.00	-1.47	.0000	n/a
14	A/C Pipe	288.58	38.78	327.36	3.7955	86.25
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	5.63	5.36	10.99	3.2055	3.43
19	Disc Brake Pads LMV (OEM)	.05	3.87	3.92	.1952	20.09
20	Disc Brake Pads HV	.02	.35	.37	.0777	4.79
21	Brake Blocks	8.40	2.35	10.75	5.8259	1.84
22	Clutch Facings	36.83	.91	37.74	.8275	45.61
23	Automatic Trans. Components	.25	.15	.40	.0007	602.63
24	Friction Materials	.74	1.99	2.73	.3781	7.23
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	88.36	.00	88.36	.2606	339.00
27	Sheet Gaskets	99.82	6.16	105.98	1.3660	77.58
28	Asbestos Packing	.39	.00	.39	.0066	58.89
29	Roof Coatings	317.78	.56	318.34	2.7983	113.76
30	Non-Roofing Coatings	36.81	1.09	37.89	.2287	165.68
31	Asbestos-Reinforced Plastics	39.88	.23	40.11	.4894	81.94
32	Missile Liner	-1.05	.00	-1.05	.0000	n/a
33	Sealant Tape	105.49	.10	105.59	.2297	459.63
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	38.72	9.05	47.76	161.2858	.30
37	Disc Brake Pads LMV (Aftermarket)	2.84	7.13	9.97	41.7213	.24
38	Mining and Milling	.00	6.03	6.03	1.5522	3.89
	Total			1550.64 *	235.0073	6.60

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE GX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.44	.00	3.44	.2827	12.16
4	Pipeline Wrap	.86	.00	.86	.3466	2.49
5	Beater-Add Gaskets	209.04	.04	209.08	5.7635	36.28
6	High Grade Electrical Paper	113.95	.00	113.96	.6337	179.84
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	6.21	.00	6.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0126	1.76
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.47	.00	-1.47	.0000	n/a
14	A/C Pipe	288.58	38.78	327.36	3.1514	103.88
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	5.63	5.36	10.99	2.9130	3.77
19	Disc Brake Pads LMV (OEM)	.05	3.87	3.92	.1842	21.30
20	Disc Brake Pads HV	.02	.35	.37	.0680	5.47
21	Brake Blocks	8.40	2.35	10.75	5.0650	2.12
22	Clutch Facings	36.83	.91	37.74	.6685	56.46
23	Automatic Trans. Components	.25	.15	.40	.0005	745.69
24	Friction Materials	.74	1.99	2.73	.3172	8.62
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	88.36	.00	88.36	.2275	388.46
27	Sheet Gaskets	99.82	6.16	105.98	1.1647	90.99
28	Asbestos Packing	.39	.00	.39	.0057	68.09
29	Roof Coatings	317.78	.56	318.34	2.2661	140.48
30	Non-Roofing Coatings	36.81	1.09	37.89	.1972	192.20
31	Asbestos-Reinforced Plastics	39.88	.23	40.11	.4153	96.57
32	Missile Liner	-1.05	.00	-1.05	.0000	n/a
33	Sealant Tape	105.49	.10	105.59	.1825	578.51
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	38.72	9.05	47.76	133.9481	.36
37	Disc Brake Pads LMV (Aftermarket)	2.84	7.13	9.97	35.9186	.28
38	Mining and Milling	.00	6.03	6.03	1.2864	4.69
	Total			1550.64 *	196.8922	7.88

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE GX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.29	.00	1.29	.1159	11.12
4	Pipeline Wrap	.30	.00	.30	.1169	2.54
5	Beater-Add Gaskets	142.29	.04	142.33	4.5691	31.15
6	High Grade Electrical Paper	112.91	.00	112.91	.7757	145.57
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	3.85	.00	3.85	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0051	1.87
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.16	.00	-1.16	.0000	n/a
14	A/C Pipe	190.26	34.01	224.27	2.4044	93.28
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	3.11	5.12	8.24	1.6303	5.05
19	Disc Brake Pads LMV (OEM)	.03	3.82	3.86	.0986	39.10
20	Disc Brake Pads HV	.01	.34	.35	.0253	13.98
21	Brake Blocks	3.20	2.27	5.47	2.0765	2.63
22	Clutch Facings	36.37	.91	37.29	.8088	46.10
23	Automatic Trans. Components	.25	.15	.40	.0007	602.74
24	Friction Materials	.51	1.90	2.41	.2066	11.68
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	31.75	.00	31.75	.0892	356.03
27	Sheet Gaskets	47.01	4.65	51.66	.6115	84.49
28	Asbestos Packing	.19	.00	.19	.0030	62.92
29	Roof Coatings	307.23	.56	307.80	2.6374	116.71
30	Non-Roofing Coatings	18.33	1.09	19.42	.1083	179.29
31	Asbestos-Reinforced Plastics	22.51	.23	22.74	.2630	86.46
32	Missile Liner	-.83	.00	-.83	.0000	n/a
33	Sealant Tape	139.81	.10	139.90	.3070	455.71
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	37.97	9.05	47.02	140.9863	.33
37	Disc Brake Pads LMV (Aftermarket)	3.77	7.13	10.90	40.7585	.27
38	Mining and Milling	.00	3.97	3.97	1.2129	3.28
	Total			1227.21 *	201.8214	6.08

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE GX -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.97	.00	3.97
Foreign Miners & Millers		43.33	.00	43.33
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		78.63	.00	78.63
Foreign Primary Processors		8.68	.00	8.68
Domestic Product Purchasers	1144.61	.00	.00	1144.61
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 1227.21

World Welfare: 1279.22

Note: Negative entries are welfare gains.

ALTERNATIVE GX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.29	.00	1.29	.1063	12.12
4	Pipeline Wrap	.30	.00	.30	.1089	2.73
5	Beater-Add Gaskets	142.29	.04	142.33	3.8823	36.66
6	High Grade Electrical Paper	112.91	.00	112.91	.6267	180.18
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	3.85	.00	3.85	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0047	2.04
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.16	.00	-1.16	.0000	n/a
14	A/C Pipe	190.26	34.01	224.27	2.0533	109.22
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	3.11	5.12	8.24	1.5385	5.35
19	Disc Brake Pads LMV (OEM)	.03	3.82	3.86	.0948	40.67
20	Disc Brake Pads HV	.01	.34	.35	.0234	15.14
21	Brake Blocks	3.20	2.27	5.47	1.9034	2.87
22	Clutch Facings	36.37	.91	37.29	.6542	56.99
23	Automatic Trans. Components	.25	.15	.40	.0005	745.83
24	Friction Materials	.51	1.90	2.41	.1798	13.42
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	31.75	.00	31.75	.0821	386.77
27	Sheet Gaskets	47.01	4.65	51.66	.5464	94.55
28	Asbestos Packing	.19	.00	.19	.0027	68.93
29	Roof Coatings	307.23	.56	307.80	2.1440	143.56
30	Non-Roofing Coatings	18.33	1.09	19.42	.0981	197.88
31	Asbestos-Reinforced Plastics	22.51	.23	22.74	.2331	97.53
32	Missile Liner	-.83	.00	-.83	.0000	n/a
33	Sealant Tape	139.81	.10	139.90	.2403	582.12
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	37.97	9.05	47.02	118.9540	.40
37	Disc Brake Pads LMV (Aftermarket)	3.77	7.13	10.90	35.1758	.31
38	Mining and Milling	.00	3.97	3.97	1.0160	3.91
	Total			1227.21 *	171.3120	7.16

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE H -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.27	.00	7.27
Foreign Miners & Millers		79.23	.00	79.23
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2396.09	.00	2396.09
Foreign Primary Processors		8.33	.00	8.33
Domestic Product Purchasers	2464.89	.00	.00	2464.89
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 4868.25

World Welfare: 4955.81

Note: Negative entries are welfare gains.

ALTERNATIVE H -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.5521	11.84
4	Pipeline Wrap	1.18	.00	1.19	.8355	1.42
5	Beater-Add Gaskets	184.46	.04	184.50	5.2101	35.41
6	High Grade Electrical Paper	68.21	.00	68.21	.3811	178.99
7	Roofing Felt	5.30	.00	5.30	.7252	7.31
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0246	.65
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.1597	14495.12
14	A/C Pipe	260.86	37.84	298.71	2.9850	100.07
15	A/C Sheet, Flat	.80	1.19	2.00	.5039	3.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0688	5.36
17	A/C Shingles	37.67	6.99	44.66	.3068	145.59
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	5.6962	2.46
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.6751	5.18
20	Disc Brake Pads HV	.02	.30	.32	.1454	2.22
21	Brake Blocks	15.30	2.11	17.41	9.6853	1.80
22	Clutch Facings	21.92	.79	22.71	.4063	55.89
23	Automatic Trans. Components	.15	.13	.28	.0003	877.36
24	Friction Materials	.26	1.80	2.07	.3522	5.87
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.4643	388.49
27	Sheet Gaskets	139.97	6.80	146.77	1.6561	88.62
28	Asbestos Packing	.59	.00	.59	.0085	69.01
29	Roof Coatings	190.33	.49	190.81	1.4279	133.63
30	Non-Roofing Coatings	52.21	.94	53.15	.2860	185.81
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.4903	95.59
32	Missile Liner	1166.16	.15	1166.31	.2359	4944.61
33	Sealant Tape	47.32	.08	47.41	.0832	569.95
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	22.01	8.21	30.22	101.6571	.30
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	17.6734	.32
38	Mining and Milling	.00	7.27	7.27	1.1331	6.41
	Total			4868.25 *	153.8295	31.65

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE H -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.11	.00	1.11	.1159	9.61
4	Pipeline Wrap	.32	.00	.32	.1194	2.66
5	Beater-Add Gaskets	106.22	.03	106.25	3.8321	27.73
6	High Grade Electrical Paper	67.59	.00	67.60	.5027	134.46
7	Roofing Felt	6.01	.00	6.01	.9717	6.18
8	Acetylene Cylinders	2.83	.00	2.83	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0052	2.01
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.70	2314.59	2315.29	.2140	10819.71
14	A/C Pipe	144.99	24.58	169.56	2.0577	82.40
15	A/C Sheet, Flat	.07	.19	.26	.0424	6.24
16	A/C Sheet, Corrugated	.55	.00	.55	.0923	5.99
17	A/C Shingles	23.80	4.92	28.72	.2393	120.00
18	Drum Brake Linings (OEM)	1.00	3.34	4.33	.5434	7.98
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.01	.30	.31	.0260	11.80
21	Brake Blocks	2.80	1.91	4.71	2.1198	2.22
22	Clutch Facings	21.89	.78	22.67	.5287	42.88
23	Automatic Trans. Components	.15	.13	.28	.0004	655.05
24	Friction Materials	.46	1.56	2.02	.1903	10.59
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	27.12	.00	27.12	.0906	299.45
27	Sheet Gaskets	39.71	2.87	42.58	.6017	70.77
28	Asbestos Packing	.13	.00	.13	.0025	51.75
29	Roof Coatings	187.87	.49	188.35	1.7640	106.78
30	Non-Roofing Coatings	13.19	.94	14.13	.0910	155.35
31	Asbestos-Reinforced Plastics	16.55	.20	16.74	.2248	74.47
32	Missile Liner	1166.55	.15	1166.70	.3161	3691.21
33	Sealant Tape	68.55	.08	68.64	.1593	430.98
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	21.76	7.71	29.47	89.2860	.33
37	Disc Brake Pads LMV (Aftermarket)	1.48	5.09	6.57	17.1378	.38
38	Mining and Milling	.00	2.49	2.49	.8699	2.86
	Total			4295.76 *	122.1451	35.17

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE H -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.49	.00	2.49
Foreign Miners & Millers		27.18	.00	27.18
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2369.84	.00	2369.84
Foreign Primary Processors		6.00	.00	6.00
Domestic Product Purchasers	1923.43	.00	.00	1923.43
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 4295.76

World Welfare: 4328.94

Note: Negative entries are welfare gains.

ALTERNATIVE H -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.11	.00	1.11	.0894	12.45
4	Pipeline Wrap	.32	.00	.32	.0927	3.42
5	Beater-Add Gaskets	106.22	.03	106.25	2.8906	36.76
6	High Grade Electrical Paper	67.59	.00	67.60	.3753	180.11
7	Roofing Felt	6.01	.00	6.01	.7252	8.29
8	Acetylene Cylinders	2.83	.00	2.83	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0040	2.60
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.70	2314.59	2315.29	.1597	14498.53
14	A/C Pipe	144.99	24.58	169.56	1.5540	109.12
15	A/C Sheet, Flat	.07	.19	.26	.0336	7.88
16	A/C Sheet, Corrugated	.55	.00	.55	.0688	8.03
17	A/C Shingles	23.80	4.92	28.72	.1804	159.25
18	Drum Brake Linings (OEM)	1.00	3.34	4.33	.4463	9.71
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.01	.30	.31	.0201	15.25
21	Brake Blocks	2.80	1.91	4.71	1.6356	2.88
22	Clutch Facings	21.89	.78	22.67	.3948	57.43
23	Automatic Trans. Components	.15	.13	.28	.0003	877.78
24	Friction Materials	.46	1.56	2.02	.1444	13.96
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	27.12	.00	27.12	.0700	387.47
27	Sheet Gaskets	39.71	2.87	42.58	.4595	92.66
28	Asbestos Packing	.13	.00	.13	.0020	67.20
29	Roof Coatings	187.87	.49	188.35	1.3183	142.88
30	Non-Roofing Coatings	13.19	.94	14.13	.0699	202.23
31	Asbestos-Reinforced Plastics	16.55	.20	16.74	.1713	97.72
32	Missile Liner	1166.55	.15	1166.70	.2359	4946.26
33	Sealant Tape	68.55	.08	68.64	.1181	581.21
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	21.76	7.71	29.47	67.9765	.43
37	Disc Brake Pads LMV (Aftermarket)	1.48	5.09	6.57	13.2788	.49
38	Mining and Milling	.00	2.49	2.49	.6566	3.80
	Total			4295.76 *	93.1721	46.11

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE H -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		1.35	.00	1.35
Foreign Miners & Millers		14.68	.00	14.68
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2353.25	.00	2353.25
Foreign Primary Processors		4.59	.00	4.59
Domestic Product Purchasers	1733.12	.00	.00	1733.12
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 4087.72

World Welfare: 4106.99

Note: Negative entries are welfare gains.

ALTERNATIVE H -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.16	.00	.16	.0156	10.13
4	Pipeline Wrap	.03	.00	.03	.0087	3.70
5	Beater-Add Gaskets	59.03	.02	59.05	2.0790	28.40
6	High Grade Electrical Paper	66.73	.00	66.73	.4954	134.71
7	Roofing Felt	6.27	.00	6.27	.9717	6.46
8	Acetylene Cylinders	1.21	.00	1.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0007	2.74
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.91	2314.59	2315.49	.2140	10820.66
14	A/C Pipe	75.99	15.53	91.51	1.0444	87.62
15	A/C Sheet, Flat	.00	.01	.02	.0000	***
16	A/C Sheet, Corrugated	.62	.00	.62	.0923	6.73
17	A/C Shingles	14.17	3.40	17.57	.1375	127.79
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.29	.30	.0028	104.87
21	Brake Blocks	.42	1.84	2.26	.2884	7.83
22	Clutch Facings	21.47	.77	22.25	.5130	43.37
23	Automatic Trans. Components	.15	.13	.28	.0004	655.17
24	Friction Materials	.23	1.41	1.64	.0739	22.24
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	3.40	.00	3.40	.0111	307.32
27	Sheet Gaskets	10.37	1.07	11.45	.1504	76.10
28	Asbestos Packing	.03	.00	.03	.0005	57.62
29	Roof Coatings	178.00	.49	178.49	1.6290	109.57
30	Non-Roofing Coatings	3.02	.94	3.96	.0200	198.12
31	Asbestos-Reinforced Plastics	5.60	.20	5.79	.0738	78.47
32	Missile Liner	1166.69	.15	1166.85	.3161	3691.67
33	Sealant Tape	97.67	.08	97.76	.2269	430.88
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	19.11	7.31	26.42	69.4623	.38
37	Disc Brake Pads LMV (Aftermarket)	1.83	5.01	6.84	16.2392	.42
38	Mining and Milling	.00	1.35	1.35	.6330	2.13
	Total			4087.72 *	94.6999	43.16

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE HX -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.26	.00	7.26
Foreign Miners & Millers		79.21	.00	79.21
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		81.35	.00	81.35
Foreign Primary Processors		8.33	.00	8.33
Domestic Product Purchasers	1296.38	.00	.00	1296.38
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 1384.99

World Welfare: 1472.54

Note: Negative entries are welfare gains.

ALTERNATIVE H -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.16	.00	.16	.0125	12.67
4	Pipeline Wrap	.03	.00	.03	.0071	4.55
5	Beater-Add Gaskets	59.03	.02	59.05	1.5859	37.23
6	High Grade Electrical Paper	66.73	.00	66.73	.3699	180.40
7	Roofing Felt	6.27	.00	6.27	.7252	8.65
8	Acetylene Cylinders	1.21	.00	1.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0005	3.44
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.91	2314.59	2315.49	.1597	14499.80
14	A/C Pipe	75.99	15.53	91.51	.7984	114.62
15	A/C Sheet, Flat	.00	.01	.02	.0000	***
16	A/C Sheet, Corrugated	.62	.00	.62	.0688	9.02
17	A/C Shingles	14.17	3.40	17.57	.1047	167.83
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.29	.30	.0023	130.60
21	Brake Blocks	.42	1.84	2.26	.2307	9.79
22	Clutch Facings	21.47	.77	22.25	.3832	58.06
23	Automatic Trans. Components	.15	.13	.28	.0003	877.94
24	Friction Materials	.23	1.41	1.64	.0570	28.83
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	3.40	.00	3.40	.0089	382.49
27	Sheet Gaskets	10.37	1.07	11.45	.1178	97.18
28	Asbestos Packing	.03	.00	.03	.0004	72.02
29	Roof Coatings	178.00	.49	178.49	1.2194	146.37
30	Non-Roofing Coatings	3.02	.94	3.96	.0157	251.44
31	Asbestos-Reinforced Plastics	5.60	.20	5.79	.0575	100.74
32	Missile Liner	1166.69	.15	1166.85	.2359	4946.88
33	Sealant Tape	97.67	.08	97.76	.1672	584.63
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	19.11	7.31	26.42	53.3928	.49
37	Disc Brake Pads LMV (Aftermarket)	1.83	5.01	6.84	12.5913	.54
38	Mining and Milling	.00	1.35	1.35	.4791	2.81
	Total			4087.72 *	72.7922	56.16

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE HX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.7399	8.83
4	Pipeline Wrap	1.18	.00	1.19	1.1196	1.06
5	Beater-Add Gaskets	184.46	.04	184.50	6.9816	26.43
6	High Grade Electrical Paper	68.21	.00	68.21	.5107	133.57
7	Roofing Felt	5.30	.00	5.30	.9717	5.45
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0330	.49
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.28	.00	-1.28	.0000	n/a
14	A/C Pipe	260.86	37.84	298.71	3.9999	74.68
15	A/C Sheet, Flat	.80	1.19	2.00	.6752	2.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0923	4.00
17	A/C Shingles	37.67	6.99	44.66	.4111	108.65
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	7.6476	1.83
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.9063	3.86
20	Disc Brake Pads HV	.02	.30	.32	.1948	1.65
21	Brake Blocks	15.30	2.11	17.41	12.9784	1.34
22	Clutch Facings	21.92	.79	22.71	.5444	41.71
23	Automatic Trans. Components	.15	.13	.28	.0004	654.74
24	Friction Materials	.26	1.80	2.07	.4719	4.38
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.6222	289.91
27	Sheet Gaskets	139.97	6.80	146.77	2.2192	66.14
28	Asbestos Packing	.59	.00	.59	.0114	51.50
29	Roof Coatings	190.33	.49	190.81	1.9134	99.73
30	Non-Roofing Coatings	52.21	.94	53.15	.3833	138.66
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.6570	71.33
32	Missile Liner	-.92	.00	-.92	.0000	n/a
33	Sealant Tape	47.32	.08	47.41	.1115	425.33
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	22.01	8.21	30.22	136.3872	.22
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	23.2356	.24
38	Mining and Milling	.00	7.26	7.26	1.5010	4.84
	Total			1384.99 *	205.3206	6.75

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE HX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.5521	11.84
4	Pipeline Wrap	1.18	.00	1.19	.8355	1.42
5	Beater-Add Gaskets	184.46	.04	184.50	5.2101	35.41
6	High Grade Electrical Paper	68.21	.00	68.21	.3811	178.99
7	Roofing Felt	5.30	.00	5.30	.7252	7.31
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0246	.65
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.28	.00	-1.28	.0000	n/a
14	A/C Pipe	260.86	37.84	298.71	2.9850	100.07
15	A/C Sheet, Flat	.80	1.19	2.00	.5039	3.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0688	5.36
17	A/C Shingles	37.67	6.99	44.66	.3068	145.59
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	5.6962	2.46
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.6751	5.18
20	Disc Brake Pads HV	.02	.30	.32	.1454	2.22
21	Brake Blocks	15.30	2.11	17.41	9.6853	1.80
22	Clutch Facings	21.92	.79	22.71	.4063	55.89
23	Automatic Trans. Components	.15	.13	.28	.0003	877.36
24	Friction Materials	.26	1.80	2.07	.3522	5.87
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.4643	388.49
27	Sheet Gaskets	139.97	6.80	146.77	1.6561	88.62
28	Asbestos Packing	.59	.00	.59	.0085	69.01
29	Roof Coatings	190.33	.49	190.81	1.4279	133.63
30	Non-Roofing Coatings	52.21	.94	53.15	.2860	185.81
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.4903	95.59
32	Missile Liner	-.92	.00	-.92	.0000	n/a
33	Sealant Tape	47.32	.08	47.41	.0832	569.95
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	22.01	8.21	30.22	101.6571	.30
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	17.6734	.32
38	Mining and Milling	.00	7.26	7.26	1.1204	6.48
	Total			1384.99 *	153.4212	9.03

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE HX -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.49	.00	2.49
Foreign Miners & Millers		27.16	.00	27.16
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		55.10	.00	55.10
Foreign Primary Processors		6.00	.00	6.00
Domestic Product Purchasers	754.92	.00	.00	754.92
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	812.51
World Welfare:	845.67

Note: Negative entries are welfare gains.

ALTERNATIVE HX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.11	.00	1.11	.1159	9.61
4	Pipeline Wrap	.32	.00	.32	.1194	2.66
5	Beater-Add Gaskets	106.22	.03	106.25	3.8321	27.73
6	High Grade Electrical Paper	67.59	.00	67.60	.5027	134.46
7	Roofing Felt	6.01	.00	6.01	.9717	6.18
8	Acetylene Cylinders	2.83	.00	2.83	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0052	2.01
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.73	.00	-.73	.0000	n/a
14	A/C Pipe	144.99	24.58	169.56	2.0577	82.40
15	A/C Sheet, Flat	.07	.19	.26	.0424	6.24
16	A/C Sheet, Corrugated	.55	.00	.55	.0923	5.99
17	A/C Shingles	23.80	4.92	28.72	.2393	120.00
18	Drum Brake Linings (OEM)	1.00	3.34	4.33	.5434	7.98
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.01	.30	.31	.0260	11.80
21	Brake Blocks	2.80	1.91	4.71	2.1198	2.22
22	Clutch Facings	21.89	.78	22.67	.5287	42.88
23	Automatic Trans. Components	.15	.13	.28	.0004	655.05
24	Friction Materials	.46	1.56	2.02	.1903	10.59
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	27.12	.00	27.12	.0906	299.45
27	Sheet Gaskets	39.71	2.87	42.58	.6017	70.77
28	Asbestos Packing	.13	.00	.13	.0025	51.75
29	Roof Coatings	187.87	.49	188.35	1.7640	106.78
30	Non-Roofing Coatings	13.19	.94	14.13	.0910	155.35
31	Asbestos-Reinforced Plastics	16.55	.20	16.74	.2248	74.47
32	Missile Liner	-.53	.00	-.53	.0000	n/a
33	Sealant Tape	68.55	.08	68.64	.1593	430.98
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	21.76	7.71	29.47	89.2860	.33
37	Disc Brake Pads LMV (Aftermarket)	1.48	5.09	6.57	17.1378	.38
38	Mining and Milling	.00	2.49	2.49	.8529	2.92
	Total			812.51 *	121.5980	6.68

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE H -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.7399	8.83
4	Pipeline Wrap	1.18	.00	1.19	1.1196	1.06
5	Beater-Add Gaskets	184.46	.04	184.50	6.9816	26.43
6	High Grade Electrical Paper	68.21	.00	68.21	.5107	133.57
7	Roofing Felt	5.30	.00	5.30	.9717	5.45
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0330	.49
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.2140	10817.17
14	A/C Pipe	260.86	37.84	298.71	3.9999	74.68
15	A/C Sheet, Flat	.80	1.19	2.00	.6752	2.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0923	4.00
17	A/C Shingles	37.67	6.99	44.66	.4111	108.65
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	7.6476	1.83
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.9063	3.86
20	Disc Brake Pads HV	.02	.30	.32	.1948	1.65
21	Brake Blocks	15.30	2.11	17.41	12.9784	1.34
22	Clutch Facings	21.92	.79	22.71	.5444	41.71
23	Automatic Trans. Components	.15	.13	.28	.0004	654.74
24	Friction Materials	.26	1.80	2.07	.4719	4.38
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.6222	289.91
27	Sheet Gaskets	139.97	6.80	146.77	2.2192	66.14
28	Asbestos Packing	.59	.00	.59	.0114	51.50
29	Roof Coatings	190.33	.49	190.81	1.9134	99.73
30	Non-Roofing Coatings	52.21	.94	53.15	.3833	138.66
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.6570	71.33
32	Missile Liner	1166.16	.15	1166.31	.3161	3689.98
33	Sealant Tape	47.32	.08	47.41	.1115	425.33
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	22.01	8.21	30.22	136.3872	.22
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	23.2356	.24
38	Mining and Milling	.00	7.27	7.27	1.5181	4.79
	Total			4868.25 *	205.8677	23.65

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE HX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.11	.00	1.11	.0894	12.45
4	Pipeline Wrap	.32	.00	.32	.0927	3.42
5	Beater-Add Gaskets	106.22	.03	106.25	2.8906	36.76
6	High Grade Electrical Paper	67.59	.00	67.60	.3753	180.11
7	Roofing Felt	6.01	.00	6.01	.7252	8.29
8	Acetylene Cylinders	2.83	.00	2.83	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0040	2.60
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.73	.00	-.73	.0000	n/a
14	A/C Pipe	144.99	24.58	169.56	1.5540	109.12
15	A/C Sheet, Flat	.07	.19	.26	.0336	7.88
16	A/C Sheet, Corrugated	.55	.00	.55	.0688	8.03
17	A/C Shingles	23.80	4.92	28.72	.1804	159.25
18	Drum Brake Linings (OEM)	1.00	3.34	4.33	.4463	9.71
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.01	.30	.31	.0201	15.25
21	Brake Blocks	2.80	1.91	4.71	1.6356	2.88
22	Clutch Facings	21.89	.78	22.67	.3948	57.43
23	Automatic Trans. Components	.15	.13	.28	.0003	877.78
24	Friction Materials	.46	1.56	2.02	.1444	13.96
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	27.12	.00	27.12	.0700	387.47
27	Sheet Gaskets	39.71	2.87	42.58	.4595	92.66
28	Asbestos Packing	.13	.00	.13	.0020	67.20
29	Roof Coatings	187.87	.49	188.35	1.3183	142.88
30	Non-Roofing Coatings	13.19	.94	14.13	.0699	202.23
31	Asbestos-Reinforced Plastics	16.55	.20	16.74	.1713	97.72
32	Missile Liner	-.53	.00	-.53	.0000	n/a
33	Sealant Tape	68.55	.08	68.64	.1181	581.21
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	21.76	7.71	29.47	67.9765	.43
37	Disc Brake Pads LMV (Aftermarket)	1.48	5.09	6.57	13.2788	.49
38	Mining and Milling	.00	2.49	2.49	.6439	3.87
	Total			812.51 *	92.7638	8.76

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE HX -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		1.35	.00	1.35
Foreign Miners & Millers		14.67	.00	14.67
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		38.51	.00	38.51
Foreign Primary Processors		4.59	.00	4.59
Domestic Product Purchasers	564.61	.00	.00	564.61
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	604.46
World Welfare:	623.72

Note: Negative entries are welfare gains.

ALTERNATIVE HX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.16	.00	.16	.0156	10.13
4	Pipeline Wrap	.03	.00	.03	.0087	3.70
5	Beater-Add Gaskets	59.03	.02	59.05	2.0790	28.40
6	High Grade Electrical Paper	66.73	.00	66.73	.4954	134.71
7	Roofing Felt	6.27	.00	6.27	.9717	6.46
8	Acetylene Cylinders	1.21	.00	1.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0007	2.74
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.53	.00	-.53	.0000	n/a
14	A/C Pipe	75.99	15.53	91.51	1.0444	87.62
15	A/C Sheet, Flat	.00	.01	.02	.0000	***
16	A/C Sheet, Corrugated	.62	.00	.62	.0923	6.73
17	A/C Shingles	14.17	3.40	17.57	.1375	127.79
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.29	.30	.0028	104.87
21	Brake Blocks	.42	1.84	2.26	.2884	7.83
22	Clutch Facings	21.47	.77	22.25	.5130	43.37
23	Automatic Trans. Components	.15	.13	.28	.0004	655.17
24	Friction Materials	.23	1.41	1.64	.0739	22.24
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	3.40	.00	3.40	.0111	307.32
27	Sheet Gaskets	10.37	1.07	11.45	.1504	76.10
28	Asbestos Packing	.03	.00	.03	.0005	57.62
29	Roof Coatings	178.00	.49	178.49	1.6290	109.57
30	Non-Roofing Coatings	3.02	.94	3.96	.0200	198.12
31	Asbestos-Reinforced Plastics	5.60	.20	5.79	.0738	78.47
32	Missile Liner	-.38	.00	-.38	.0000	n/a
33	Sealant Tape	97.67	.08	97.76	.2269	430.88
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	19.11	7.31	26.42	69.4623	.38
37	Disc Brake Pads LMV (Aftermarket)	1.83	5.01	6.84	16.2392	.42
38	Mining and Milling	.00	1.35	1.35	.6159	2.18
	Total			604.46 *	94.1528	6.42

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE HX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.16	.00	.16	.0125	12.67
4	Pipeline Wrap	.03	.00	.03	.0071	4.55
5	Beater-Add Gaskets	59.03	.02	59.05	1.5859	37.23
6	High Grade Electrical Paper	66.73	.00	66.73	.3699	180.40
7	Roofing Felt	6.27	.00	6.27	.7252	8.65
8	Acetylene Cylinders	1.21	.00	1.21	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0005	3.44
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.53	.00	-.53	.0000	n/a
14	A/C Pipe	75.99	15.53	91.51	.7984	114.62
15	A/C Sheet, Flat	.00	.01	.02	.0000	***
16	A/C Sheet, Corrugated	.62	.00	.62	.0688	9.02
17	A/C Shingles	14.17	3.40	17.57	.1047	167.83
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.29	.30	.0023	130.60
21	Brake Blocks	.42	1.84	2.26	.2307	9.79
22	Clutch Facings	21.47	.77	22.25	.3832	58.06
23	Automatic Trans. Components	.15	.13	.28	.0003	877.94
24	Friction Materials	.23	1.41	1.64	.0570	28.83
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	3.40	.00	3.40	.0089	382.49
27	Sheet Gaskets	10.37	1.07	11.45	.1178	97.18
28	Asbestos Packing	.03	.00	.03	.0004	72.02
29	Roof Coatings	178.00	.49	178.49	1.2194	146.37
30	Non-Roofing Coatings	3.02	.94	3.96	.0157	251.44
31	Asbestos-Reinforced Plastics	5.60	.20	5.79	.0575	100.74
32	Missile Liner	-.38	.00	-.38	.0000	n/a
33	Sealant Tape	97.67	.08	97.76	.1672	584.63
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	19.11	7.31	26.42	53.3928	.49
37	Disc Brake Pads LMV (Aftermarket)	1.83	5.01	6.84	12.5913	.54
38	Mining and Milling	.00	1.35	1.35	.4663	2.88
	Total			604.46 *	72.3839	8.35

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.00	.00	3.00
Foreign Miners & Millers		32.68	.00	32.68
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2066.72	.00	2066.72
Foreign Primary Processors		7.14	.00	7.14
Domestic Product Purchasers	1015.33	.00	.00	1015.33
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 3085.05

World Welfare: 3124.87

Note: Negative entries are welfare gains.

ALTERNATIVE I -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.3288	8.19
4	Pipeline Wrap	.49	.00	.49	.4976	.98
5	Beater-Add Gaskets	75.96	.03	75.99	3.1029	24.49
6	High Grade Electrical Paper	28.09	.00	28.09	.2270	123.76
7	Roofing Felt	2.18	.00	2.18	.4319	5.05
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0146	.48
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0951	20993.95
14	A/C Pipe	107.41	32.64	140.06	1.7777	78.78
15	A/C Sheet, Flat	.33	1.03	1.36	.3001	4.53
16	A/C Sheet, Corrugated	.15	.00	.15	.0410	3.70
17	A/C Shingles	15.51	6.03	21.54	.1827	117.90
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	3.5284	2.36
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.4193	7.16
20	Disc Brake Pads HV	.01	.26	.27	.0866	3.11
21	Brake Blocks	6.30	1.82	8.12	5.7682	1.41
22	Clutch Facings	9.02	.68	9.71	.2420	40.12
23	Automatic Trans. Components	.06	.11	.17	.0002	916.20
24	Friction Materials	.11	1.56	1.66	.2097	7.93
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.2765	268.62
27	Sheet Gaskets	57.64	5.86	63.50	.9863	64.39
28	Asbestos Packing	.24	.00	.24	.0051	47.71
29	Roof Coatings	78.37	.42	78.79	.8504	92.65
30	Non-Roofing Coatings	21.50	.81	22.31	.1704	130.96
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2920	66.39
32	Missile Liner	480.24	.13	480.37	.1405	3419.52
33	Sealant Tape	19.49	.07	19.56	.0495	394.85
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	9.26	7.35	16.61	61.8500	.27
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	7.9591	.49
38	Mining and Milling	.00	3.00	3.00	.6747	4.44
	Total			3085.05 *	90.5084	34.09

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.2274	11.84
4	Pipeline Wrap	.49	.00	.49	.3441	1.42
5	Beater-Add Gaskets	75.96	.03	75.99	2.1456	35.42
6	High Grade Electrical Paper	28.09	.00	28.09	.1569	178.99
7	Roofing Felt	2.18	.00	2.18	.2986	7.30
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0101	.69
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0658	30361.44
14	A/C Pipe	107.41	32.64	140.06	1.2292	113.94
15	A/C Sheet, Flat	.33	1.03	1.36	.2075	6.54
16	A/C Sheet, Corrugated	.15	.00	.15	.0284	5.35
17	A/C Shingles	15.51	6.03	21.54	.1263	170.51
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	2.4413	3.42
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.2901	10.35
20	Disc Brake Pads HV	.01	.26	.27	.0599	4.50
21	Brake Blocks	6.30	1.82	8.12	3.9885	2.04
22	Clutch Facings	9.02	.68	9.71	.1673	58.02
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.01
24	Friction Materials	.11	1.56	1.66	.1450	11.47
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.1912	388.48
27	Sheet Gaskets	57.64	5.86	63.50	.6820	93.11
28	Asbestos Packing	.24	.00	.24	.0035	69.00
29	Roof Coatings	78.37	.42	78.79	.5880	133.99
30	Non-Roofing Coatings	21.50	.81	22.31	.1178	189.39
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2019	96.02
32	Missile Liner	480.24	.13	480.37	.0971	4945.31
33	Sealant Tape	19.49	.07	19.56	.0343	571.03
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	9.26	7.35	16.61	42.7646	.39
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	5.5207	.71
38	Mining and Milling	.00	3.00	3.00	.4666	6.42
	Total			3085.05 *	62.5999	49.28

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		.73	.00	.73
Foreign Miners & Millers		7.97	.00	7.97
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2030.96	.00	2030.96
Foreign Primary Processors		3.82	.00	3.82
Domestic Product Purchasers	760.86	.00	.00	760.86
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 2792.55

World Welfare: 2804.35

Note: Negative entries are welfare gains.

ALTERNATIVE I -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.27	.00	.27	.0304	8.80
4	Pipeline Wrap	.08	.00	.08	.0274	2.84
5	Beater-Add Gaskets	37.76	.02	37.77	1.4739	25.63
6	High Grade Electrical Paper	27.77	.00	27.77	.2224	124.84
7	Roofing Felt	2.53	.00	2.53	.4319	5.87
8	Acetylene Cylinders	.91	.00	.91	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0014	2.25
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.34	1996.58	1996.92	.0951	20996.80
14	A/C Pipe	50.93	15.58	66.51	.7778	85.51
15	A/C Sheet, Flat	.01	.04	.05	.0065	7.28
16	A/C Sheet, Corrugated	.24	.00	.24	.0410	5.93
17	A/C Shingles	8.66	3.30	11.96	.0932	128.41
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.26	.0065	39.52
21	Brake Blocks	.69	1.60	2.29	.5480	4.19
22	Clutch Facings	9.00	.67	9.67	.2335	41.41
23	Automatic Trans. Components	.06	.11	.17	.0002	916.55
24	Friction Materials	.18	1.25	1.43	.0671	21.31
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.24	.00	6.24	.0228	273.33
27	Sheet Gaskets	11.39	1.34	12.73	.1899	67.02
28	Asbestos Packing	.03	.00	.03	.0007	47.51
29	Roof Coatings	76.74	.42	77.16	.7700	100.22
30	Non-Roofing Coatings	3.46	.81	4.27	.0258	165.65
31	Asbestos-Reinforced Plastics	4.92	.17	5.09	.0738	68.98
32	Missile Liner	480.43	.13	480.56	.1405	3420.90
33	Sealant Tape	30.78	.07	30.85	.0765	403.11
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	7.04	5.23	12.27	29.3391	.42
37	Disc Brake Pads LMV (Aftermarket)	.40	3.39	3.78	4.1079	.92
38	Mining and Milling	.00	.73	.73	.3317	2.20
	Total			2792.55 *	39.1348	71.36

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.27	.00	.27	.0212	12.64
4	Pipeline Wrap	.08	.00	.08	.0191	4.07
5	Beater-Add Gaskets	37.76	.02	37.77	1.0211	37.00
6	High Grade Electrical Paper	27.77	.00	27.77	.1538	180.54
7	Roofing Felt	2.53	.00	2.53	.2986	8.49
8	Acetylene Cylinders	.91	.00	.91	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0009	3.23
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.34	1996.58	1996.92	.0658	30365.55
14	A/C Pipe	50.93	15.58	66.51	.5390	123.38
15	A/C Sheet, Flat	.01	.04	.05	.0046	10.23
16	A/C Sheet, Corrugated	.24	.00	.24	.0284	8.58
17	A/C Shingles	8.66	3.30	11.96	.0646	185.36
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.26	.0045	56.71
21	Brake Blocks	.69	1.60	2.29	.3813	6.02
22	Clutch Facings	9.00	.67	9.67	.1615	59.88
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.51
24	Friction Materials	.18	1.25	1.43	.0465	30.73
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.24	.00	6.24	.0159	392.30
27	Sheet Gaskets	11.39	1.34	12.73	.1319	96.50
28	Asbestos Packing	.03	.00	.03	.0005	68.15
29	Roof Coatings	76.74	.42	77.16	.5326	144.89
30	Non-Roofing Coatings	3.46	.81	4.27	.0179	238.35
31	Asbestos-Reinforced Plastics	4.92	.17	5.09	.0512	99.38
32	Missile Liner	480.43	.13	480.56	.0971	4947.30
33	Sealant Tape	30.78	.07	30.85	.0529	583.67
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	7.04	5.23	12.27	20.4089	.60
37	Disc Brake Pads LMV (Aftermarket)	.40	3.39	3.78	2.8682	1.32
38	Mining and Milling	.00	.73	.73	.2299	3.18
	Total			2792.55 *	27.2178	102.60

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		.36	.00	.36
Foreign Miners & Millers		3.90	.00	3.90
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2018.66	.00	2018.66
Foreign Primary Processors		2.90	.00	2.90
Domestic Product Purchasers	691.55	.00	.00	691.55
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 2710.56

World Welfare: 2717.37

Note: Negative entries are welfare gains.

ALTERNATIVE I -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.02	.00	.02	.0016	9.93
4	Pipeline Wrap	.00	.00	.00	.0000	***
5	Beater-Add Gaskets	17.49	.01	17.50	.6671	26.24
6	High Grade Electrical Paper	27.31	.00	27.31	.2185	125.00
7	Roofing Felt	2.64	.00	2.64	.4319	6.11
8	Acetylene Cylinders	.28	.00	.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0001	3.02
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.42	1996.58	1997.00	.0951	20997.63
14	A/C Pipe	21.70	7.09	28.79	.3244	88.75
15	A/C Sheet, Flat	.00	.00	.00	.0000	***
16	A/C Sheet, Corrugated	.27	.00	.27	.0410	6.58
17	A/C Shingles	4.39	1.75	6.14	.0457	134.40
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.25	.0002	1168.94
21	Brake Blocks	.04	1.58	1.62	.0288	56.19
22	Clutch Facings	8.76	.66	9.42	.2250	41.85
23	Automatic Trans. Components	.06	.11	.17	.0002	916.65
24	Friction Materials	.06	1.14	1.20	.0194	62.01
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.31	.00	.31	.0007	452.58
27	Sheet Gaskets	1.79	.25	2.04	.0271	75.23
28	Asbestos Packing	.00	.00	.00	.0000	82.18
29	Roof Coatings	71.11	.42	71.53	.6953	102.88
30	Non-Roofing Coatings	.41	.81	1.21	.0032	384.92
31	Asbestos-Reinforced Plastics	1.07	.17	1.24	.0158	78.86
32	Missile Liner	480.49	.13	480.62	.1405	3421.30
33	Sealant Tape	47.23	.07	47.31	.1169	404.65
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	5.24	4.34	9.58	19.5065	.49
37	Disc Brake Pads LMV (Aftermarket)	.45	3.30	3.75	3.7870	.99
38	Mining and Milling	.00	.36	.36	.2331	1.54
	Total			2710.56 *	26.6252	101.80

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.02	.00	.02	.0012	13.95
4	Pipeline Wrap	.00	.00	.00	.0000	***
5	Beater-Add Gaskets	17.49	.01	17.50	.4632	37.79
6	High Grade Electrical Paper	27.31	.00	27.31	.1511	180.75
7	Roofing Felt	2.64	.00	2.64	.2986	8.83
8	Acetylene Cylinders	.28	.00	.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0001	4.24
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.42	1996.58	1997.00	.0658	30366.76
14	A/C Pipe	21.70	7.09	28.79	.2254	127.75
15	A/C Sheet, Flat	.00	.00	.00	.0000	***
16	A/C Sheet, Corrugated	.27	.00	.27	.0284	9.52
17	A/C Shingles	4.39	1.75	6.14	.0317	193.62
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.25	.0002	1618.09
21	Brake Blocks	.04	1.58	1.62	.0205	78.94
22	Clutch Facings	8.76	.66	9.42	.1556	60.52
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.66
24	Friction Materials	.06	1.14	1.20	.0135	89.08
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.31	.00	.31	.0005	626.48
27	Sheet Gaskets	1.79	.25	2.04	.0189	107.78
28	Asbestos Packing	.00	.00	.00	.0000	113.75
29	Roof Coatings	71.11	.42	71.53	.4810	148.69
30	Non-Roofing Coatings	.41	.81	1.21	.0022	551.24
31	Asbestos-Reinforced Plastics	1.07	.17	1.24	.0110	112.91
32	Missile Liner	480.49	.13	480.62	.0971	4947.89
33	Sealant Tape	47.23	.07	47.31	.0806	586.58
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	5.24	4.34	9.58	13.5968	.70
37	Disc Brake Pads LMV (Aftermarket)	.45	3.30	3.75	2.6416	1.42
38	Mining and Milling	.00	.36	.36	.1616	2.21
	Total			2710.56 *	18.5468	146.15

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE IX -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.00	.00	3.00
Foreign Miners & Millers		32.68	.00	32.68
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		70.01	.00	70.01
Foreign Primary Processors		7.14	.00	7.14
Domestic Product Purchasers	534.12	.00	.00	534.12
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 607.13

World Welfare: 646.94

Note: Negative entries are welfare gains.

ALTERNATIVE IX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.3288	8.19
4	Pipeline Wrap	.49	.00	.49	.4976	.98
5	Beater-Add Gaskets	75.96	.03	75.99	3.1029	24.49
6	High Grade Electrical Paper	28.09	.00	28.09	.2270	123.76
7	Roofing Felt	2.18	.00	2.18	.4319	5.05
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0146	.48
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.53	.00	-.53	.0000	n/a
14	A/C Pipe	107.41	32.64	140.06	1.7777	78.78
15	A/C Sheet, Flat	.33	1.03	1.36	.3001	4.53
16	A/C Sheet, Corrugated	.15	.00	.15	.0410	3.70
17	A/C Shingles	15.51	6.03	21.54	.1827	117.90
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	3.5284	2.36
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.4193	7.16
20	Disc Brake Pads HV	.01	.26	.27	.0866	3.11
21	Brake Blocks	6.30	1.82	8.12	5.7682	1.41
22	Clutch Facings	9.02	.68	9.71	.2420	40.12
23	Automatic Trans. Components	.06	.11	.17	.0002	916.20
24	Friction Materials	.11	1.56	1.66	.2097	7.93
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.2765	268.62
27	Sheet Gaskets	57.64	5.86	63.50	.9863	64.39
28	Asbestos Packing	.24	.00	.24	.0051	47.71
29	Roof Coatings	78.37	.42	78.79	.8504	92.65
30	Non-Roofing Coatings	21.50	.81	22.31	.1704	130.96
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2920	66.39
32	Missile Liner	-.38	.00	-.38	.0000	n/a
33	Sealant Tape	19.49	.07	19.56	.0495	394.85
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	9.26	7.35	16.61	61.8500	.27
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	7.9591	.49
38	Mining and Milling	.00	3.00	3.00	.6671	4.49
	Total			607.13 *	90.2653	6.73

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE IX -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.2274	11.84
4	Pipeline Wrap	.49	.00	.49	.3441	1.42
5	Beater-Add Gaskets	75.96	.03	75.99	2.1456	35.42
6	High Grade Electrical Paper	28.09	.00	28.09	.1569	178.99
7	Roofing Felt	2.18	.00	2.18	.2986	7.30
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0101	.69
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.53	.00	-.53	.0000	n/a
14	A/C Pipe	107.41	32.64	140.06	1.2292	113.94
15	A/C Sheet, Flat	.33	1.03	1.36	.2075	6.54
16	A/C Sheet, Corrugated	.15	.00	.15	.0284	5.35
17	A/C Shingles	15.51	6.03	21.54	.1263	170.51
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	2.4413	3.42
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.2901	10.35
20	Disc Brake Pads HV	.01	.26	.27	.0599	4.50
21	Brake Blocks	6.30	1.82	8.12	3.9885	2.04
22	Clutch Facings	9.02	.68	9.71	.1673	58.02
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.01
24	Friction Materials	.11	1.56	1.66	.1450	11.47
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.1912	388.48
27	Sheet Gaskets	57.64	5.86	63.50	.6820	93.11
28	Asbestos Packing	.24	.00	.24	.0035	69.00
29	Roof Coatings	78.37	.42	78.79	.5880	133.99
30	Non-Roofing Coatings	21.50	.81	22.31	.1178	189.39
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2019	96.02
32	Missile Liner	-.38	.00	-.38	.0000	n/a
33	Sealant Tape	19.49	.07	19.56	.0343	571.03
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	9.26	7.35	16.61	42.7646	.39
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	5.5207	.71
38	Mining and Milling	.00	3.00	3.00	.4614	6.49
	Total			607.13 *	62.4317	9.72

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE IX -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		.73	.00	.73
Foreign Miners & Millers		7.97	.00	7.97
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		34.25	.00	34.25
Foreign Primary Processors		3.82	.00	3.82
Domestic Product Purchasers	279.65	.00	.00	279.65
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	314.64
World Welfare:	326.42

Note: Negative entries are welfare gains.

ALTERNATIVE IX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.27	.00	.27	.0212	12.64
4	Pipeline Wrap	.08	.00	.08	.0191	4.07
5	Beater-Add Gaskets	37.76	.02	37.77	1.0211	37.00
6	High Grade Electrical Paper	27.77	.00	27.77	.1538	180.54
7	Roofing Felt	2.53	.00	2.53	.2986	8.49
8	Acetylene Cylinders	.91	.00	.91	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0009	3.23
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.26	.00	-.26	.0000	n/a
14	A/C Pipe	50.93	15.58	66.51	.5390	123.38
15	A/C Sheet, Flat	.01	.04	.05	.0046	10.23
16	A/C Sheet, Corrugated	.24	.00	.24	.0284	8.58
17	A/C Shingles	8.66	3.30	11.96	.0646	185.36
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.26	.0045	56.71
21	Brake Blocks	.69	1.60	2.29	.3813	6.02
22	Clutch Facings	9.00	.67	9.67	.1615	59.88
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.51
24	Friction Materials	.18	1.25	1.43	.0465	30.73
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.24	.00	6.24	.0159	392.30
27	Sheet Gaskets	11.39	1.34	12.73	.1319	96.50
28	Asbestos Packing	.03	.00	.03	.0005	68.15
29	Roof Coatings	76.74	.42	77.16	.5326	144.89
30	Non-Roofing Coatings	3.46	.81	4.27	.0179	238.35
31	Asbestos-Reinforced Plastics	4.92	.17	5.09	.0512	99.38
32	Missile Liner	-.18	.00	-.18	.0000	n/a
33	Sealant Tape	30.78	.07	30.85	.0529	583.67
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	7.04	5.23	12.27	20.4089	.60
37	Disc Brake Pads LMV (Aftermarket)	.40	3.39	3.78	2.8682	1.32
38	Mining and Milling	.00	.73	.73	.2246	3.25
	Total			314.64 *	27.0497	11.63

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE IX -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.27	.00	.27	.0304	8.80
4	Pipeline Wrap	.08	.00	.08	.0274	2.84
5	Beater-Add Gaskets	37.76	.02	37.77	1.4739	25.63
6	High Grade Electrical Paper	27.77	.00	27.77	.2224	124.84
7	Roofing Felt	2.53	.00	2.53	.4319	5.87
8	Acetylene Cylinders	.91	.00	.91	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0014	2.25
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.26	.00	-.26	.0000	n/a
14	A/C Pipe	50.93	15.58	66.51	.7778	85.51
15	A/C Sheet, Flat	.01	.04	.05	.0065	7.28
16	A/C Sheet, Corrugated	.24	.00	.24	.0410	5.93
17	A/C Shingles	8.66	3.30	11.96	.0932	128.41
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.26	.0065	39.52
21	Brake Blocks	.69	1.60	2.29	.5480	4.19
22	Clutch Facings	9.00	.67	9.67	.2335	41.41
23	Automatic Trans. Components	.06	.11	.17	.0002	916.55
24	Friction Materials	.18	1.25	1.43	.0671	21.31
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	6.24	.00	6.24	.0228	273.33
27	Sheet Gaskets	11.39	1.34	12.73	.1899	67.02
28	Asbestos Packing	.03	.00	.03	.0007	47.51
29	Roof Coatings	76.74	.42	77.16	.7700	100.22
30	Non-Roofing Coatings	3.46	.81	4.27	.0258	165.65
31	Asbestos-Reinforced Plastics	4.92	.17	5.09	.0738	68.98
32	Missile Liner	-.18	.00	-.18	.0000	n/a
33	Sealant Tape	30.78	.07	30.85	.0765	403.11
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	7.04	5.23	12.27	29.3391	.42
37	Disc Brake Pads LMV (Aftermarket)	.40	3.39	3.78	4.1079	.92
38	Mining and Milling	.00	.73	.73	.3241	2.25
	Total			314.64 *	38.8917	8.09

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE IX -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		.36	.00	.36
Foreign Miners & Millers		3.90	.00	3.90
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		21.95	.00	21.95
Foreign Primary Processors		2.90	.00	2.90
Domestic Product Purchasers	210.34	.00	.00	210.34
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	232.64
World Welfare:	239.44

Note: Negative entries are welfare gains.

ALTERNATIVE IX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.02	.00	.02	.0016	9.93
4	Pipeline Wrap	.00	.00	.00	.0000	***
5	Beater-Add Gaskets	17.49	.01	17.50	.6671	26.24
6	High Grade Electrical Paper	27.31	.00	27.31	.2185	125.00
7	Roofing Felt	2.64	.00	2.64	.4319	6.11
8	Acetylene Cylinders	.28	.00	.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0001	3.02
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.18	.00	-.18	.0000	n/a
14	A/C Pipe	21.70	7.09	28.79	.3244	88.75
15	A/C Sheet, Flat	.00	.00	.00	.0000	***
16	A/C Sheet, Corrugated	.27	.00	.27	.0410	6.58
17	A/C Shingles	4.39	1.75	6.14	.0457	134.40
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.25	.0002	1168.94
21	Brake Blocks	.04	1.58	1.62	.0288	56.19
22	Clutch Facings	8.76	.66	9.42	.2250	41.85
23	Automatic Trans. Components	.06	.11	.17	.0002	916.65
24	Friction Materials	.06	1.14	1.20	.0194	62.01
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.31	.00	.31	.0007	452.58
27	Sheet Gaskets	1.79	.25	2.04	.0271	75.23
28	Asbestos Packing	.00	.00	.00	.0000	82.18
29	Roof Coatings	71.11	.42	71.53	.6953	102.88
30	Non-Roofing Coatings	.41	.81	1.21	.0032	384.92
31	Asbestos-Reinforced Plastics	1.07	.17	1.24	.0158	78.86
32	Missile Liner	-.13	.00	-.13	.0000	n/a
33	Sealant Tape	47.23	.07	47.31	.1169	404.65
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	5.24	4.34	9.58	19.5065	.49
37	Disc Brake Pads LMV (Aftermarket)	.45	3.30	3.75	3.7870	.99
38	Mining and Milling	.00	.36	.36	.2255	1.58
	Total			232.64 *	26.3820	8.82

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE IX -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	.02	.00	.02	.0012	13.95
4	Pipeline Wrap	.00	.00	.00	.0000	***
5	Beater-Add Gaskets	17.49	.01	17.50	.4632	37.79
6	High Grade Electrical Paper	27.31	.00	27.31	.1511	180.75
7	Roofing Felt	2.64	.00	2.64	.2986	8.83
8	Acetylene Cylinders	.28	.00	.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.00	.00	.00	.0001	4.24
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.18	.00	-.18	.0000	n/a
14	A/C Pipe	21.70	7.09	28.79	.2254	127.75
15	A/C Sheet, Flat	.00	.00	.00	.0000	***
16	A/C Sheet, Corrugated	.27	.00	.27	.0284	9.52
17	A/C Shingles	4.39	1.75	6.14	.0317	193.62
18	Drum Brake Linings (OEM)	.00	.00	.00	.0000	n/a
19	Disc Brake Pads LMV (OEM)	.00	.00	.00	.0000	n/a
20	Disc Brake Pads HV	.00	.25	.25	.0002	1618.09
21	Brake Blocks	.04	1.58	1.62	.0205	78.94
22	Clutch Facings	8.76	.66	9.42	.1556	60.52
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.66
24	Friction Materials	.06	1.14	1.20	.0135	89.08
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	.31	.00	.31	.0005	626.48
27	Sheet Gaskets	1.79	.25	2.04	.0189	107.78
28	Asbestos Packing	.00	.00	.00	.0000	113.75
29	Roof Coatings	71.11	.42	71.53	.4810	148.69
30	Non-Roofing Coatings	.41	.81	1.21	.0022	551.24
31	Asbestos-Reinforced Plastics	1.07	.17	1.24	.0110	112.91
32	Missile Liner	-.13	.00	-.13	.0000	n/a
33	Sealant Tape	47.23	.07	47.31	.0806	586.58
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	5.24	4.34	9.58	13.5968	.70
37	Disc Brake Pads LMV (Aftermarket)	.45	3.30	3.75	2.6416	1.42
38	Mining and Milling	.00	.36	.36	.1564	2.29
	Total			232.64 *	18.3787	12.66

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.31	.00	7.31
Foreign Miners & Millers		79.76	.00	79.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		77.58	.00	77.58
Foreign Primary Processors		8.64	.00	8.64
Domestic Product Purchasers	663.54	.00	.00	663.54
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 748.43

World Welfare: 836.84

Note: Negative entries are welfare gains.

ALTERNATIVE J -- MODERATE DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.42	.00	2.42
Foreign Miners & Millers		26.36	.00	26.36
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		51.48	.00	51.48
Foreign Primary Processors		6.84	.00	6.84
Domestic Product Purchasers	358.90	.00	.00	358.90
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 412.80

World Welfare: 446.01

Note: Negative entries are welfare gains.

ALTERNATIVE J -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.04	.00	-.04	.0000	n/a
4	Pipeline Wrap	.86	.00	.86	.3931	2.20
5	Beater-Add Gaskets	123.13	.03	123.16	4.3907	28.05
6	High Grade Electrical Paper	-.35	.00	-.35	.0000	n/a
7	Roofing Felt	9.80	.00	9.80	1.5116	6.49
8	Acetylene Cylinders	-.10	.00	-.10	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.46	.00	-.46	.0000	n/a
14	A/C Pipe	99.44	20.48	119.92	1.4977	80.06
15	A/C Sheet, Flat	.36	1.02	1.37	.2055	6.67
16	A/C Sheet, Corrugated	.85	.00	.85	.1435	5.93
17	A/C Shingles	45.54	7.33	52.87	.4266	123.93
18	Drum Brake Linings (OEM)	1.32	3.59	4.90	.8664	5.66
19	Disc Brake Pads LMV (OEM)	-.01	.00	-.01	.0000	n/a
20	Disc Brake Pads HV	.01	.31	.32	.0327	9.65
21	Brake Blocks	3.47	1.98	5.45	2.6245	2.08
22	Clutch Facings	24.65	.81	25.46	.5880	43.30
23	Automatic Trans. Components	.17	.13	.30	.0005	638.19
24	Friction Materials	.46	1.63	2.10	.2218	9.46
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.08	.00	-.08	.0000	n/a
27	Sheet Gaskets	48.24	3.34	51.58	.7200	71.64
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-9.64	.00	-9.64	.0000	n/a
30	Non-Roofing Coatings	-.34	.00	-.34	.0000	n/a
31	Asbestos-Reinforced Plastics	-.14	.00	-.14	.0000	n/a
32	Missile Liner	-.33	.00	-.33	.0000	n/a
33	Sealant Tape	-1.08	.00	-1.08	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.86	6.70	19.56	62.6429	.31
37	Disc Brake Pads LMV (Aftermarket)	.33	4.13	4.46	10.2699	.43
38	Mining and Milling	.00	2.42	2.42	.5288	4.57
	Total			412.80 *	87.0641	4.74

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- MODERATE DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.04	.00	-.04	.0000	n/a
4	Pipeline Wrap	.86	.00	.86	.3466	2.49
5	Beater-Add Gaskets	123.13	.03	123.16	3.3724	36.52
6	High Grade Electrical Paper	-.35	.00	-.35	.0000	n/a
7	Roofing Felt	9.80	.00	9.80	1.2196	8.04
8	Acetylene Cylinders	-.10	.00	-.10	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.01	.00	-.01	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.46	.00	-.46	.0000	n/a
14	A/C Pipe	99.44	20.48	119.92	1.0916	109.85
15	A/C Sheet, Flat	.36	1.02	1.37	.1856	7.39
16	A/C Sheet, Corrugated	.85	.00	.85	.1158	7.35
17	A/C Shingles	45.54	7.33	52.87	.3524	150.04
18	Drum Brake Linings (OEM)	1.32	3.59	4.90	.7249	6.77
19	Disc Brake Pads LMV (OEM)	-.01	.00	-.01	.0000	n/a
20	Disc Brake Pads HV	.01	.31	.32	.0259	12.19
21	Brake Blocks	3.47	1.98	5.45	2.0710	2.63
22	Clutch Facings	24.65	.81	25.46	.4459	57.10
23	Automatic Trans. Components	.17	.13	.30	.0004	842.06
24	Friction Materials	.46	1.63	2.10	.1715	12.23
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.08	.00	-.08	.0000	n/a
27	Sheet Gaskets	48.24	3.34	51.58	.5616	91.84
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-9.64	.00	-9.64	.0000	n/a
30	Non-Roofing Coatings	-.34	.00	-.34	.0000	n/a
31	Asbestos-Reinforced Plastics	-.14	.00	-.14	.0000	n/a
32	Missile Liner	-.33	.00	-.33	.0000	n/a
33	Sealant Tape	-1.08	.00	-1.08	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.86	6.70	19.56	45.9805	.43
37	Disc Brake Pads LMV (Aftermarket)	.33	4.13	4.46	7.6053	.59
38	Mining and Milling	.00	2.42	2.42	.4041	5.98
	Total			412.80 *	64.6751	6.38

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	207.38	.04	207.42	5.8793	35.28
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	2.2514	99.94
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	6.3280	2.28
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.7495	4.72
20	Disc Brake Pads HV	.01	.31	.33	.1641	1.99
21	Brake Blocks	17.10	2.17	19.27	10.9292	1.76
22	Clutch Facings	24.66	.81	25.48	.4585	55.57
23	Automatic Trans. Components	.17	.13	.30	.0004	841.65
24	Friction Materials	.20	1.86	2.06	.3974	5.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	1.8688	88.08
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	76.7895	.26
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	11.5777	.31
38	Mining and Milling	.00	7.31	7.31	.8457	8.65
	Total			748.43 *	122.3435	6.12

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	207.38	.04	207.42	7.7573	26.74
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	3.1110	72.33
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	8.3800	1.72
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.9927	3.57
20	Disc Brake Pads HV	.01	.31	.33	.2165	1.51
21	Brake Blocks	17.10	2.17	19.27	14.4204	1.34
22	Clutch Facings	24.66	.81	25.48	.6049	42.12
23	Automatic Trans. Components	.17	.13	.30	.0005	637.88
24	Friction Materials	.20	1.86	2.06	.5244	3.92
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	2.4658	66.75
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	106.2551	.19
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	15.8541	.23
38	Mining and Milling	.00	7.31	7.31	1.1258	6.50
	Total			748.43 *	166.7950	4.49

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- HIGH DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		1.19	.00	1.19
Foreign Miners & Millers		13.03	.00	13.03
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		34.79	.00	34.79
Foreign Primary Processors		5.61	.00	5.61
Domestic Product Purchasers	206.62	.00	.00	206.62
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 242.61

World Welfare: 261.25

Note: Negative entries are welfare gains.

ALTERNATIVE J -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.01	.00	-.01	.0000	n/a
4	Pipeline Wrap	.30	.00	.30	.1169	2.54
5	Beater-Add Gaskets	71.13	.02	71.15	2.4668	28.84
6	High Grade Electrical Paper	-.20	.00	-.20	.0000	n/a
7	Roofing Felt	10.21	.00	10.21	1.5116	6.75
8	Acetylene Cylinders	-.03	.00	-.03	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.28	.00	-.28	.0000	n/a
14	A/C Pipe	47.86	11.35	59.21	.7022	84.31
15	A/C Sheet, Flat	.13	.65	.78	.0652	11.92
16	A/C Sheet, Corrugated	.96	.00	.96	.1435	6.66
17	A/C Shingles	32.33	6.60	38.93	.2900	134.21
18	Drum Brake Linings (OEM)	-.15	.00	-.15	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.01	.00	-.01	.0000	n/a
20	Disc Brake Pads HV	.00	.30	.30	.0043	70.19
21	Brake Blocks	.60	1.91	2.51	.4326	5.80
22	Clutch Facings	24.24	.80	25.04	.5716	43.79
23	Automatic Trans. Components	.17	.13	.30	.0005	638.32
24	Friction Materials	.25	1.49	1.74	.0918	18.93
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.01	.00	-.01	.0000	n/a
27	Sheet Gaskets	14.06	1.44	15.50	.2022	76.68
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-5.39	.00	-5.39	.0000	n/a
30	Non-Roofing Coatings	-.08	.00	-.08	.0000	n/a
31	Asbestos-Reinforced Plastics	-.04	.00	-.04	.0000	n/a
32	Missile Liner	-.20	.00	-.20	.0000	n/a
33	Sealant Tape	-.87	.00	-.87	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	10.94	6.02	16.96	45.1981	.38
37	Disc Brake Pads LMV (Aftermarket)	.74	4.08	4.82	9.6922	.50
38	Mining and Milling	.00	1.19	1.19	.3089	3.87
	Total			242.61 *	61.7985	3.93

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- HIGH DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.01	.00	-.01	.0000	n/a
4	Pipeline Wrap	.30	.00	.30	.1089	2.73
5	Beater-Add Gaskets	71.13	.02	71.15	1.9205	37.05
6	High Grade Electrical Paper	-.20	.00	-.20	.0000	n/a
7	Roofing Felt	10.21	.00	10.21	1.2196	8.37
8	Acetylene Cylinders	-.03	.00	-.03	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.28	.00	-.28	.0000	n/a
14	A/C Pipe	47.86	11.35	59.21	.5157	114.81
15	A/C Sheet, Flat	.13	.65	.78	.0619	12.56
16	A/C Sheet, Corrugated	.96	.00	.96	.1158	8.25
17	A/C Shingles	32.33	6.60	38.93	.2453	158.72
18	Drum Brake Linings (OEM)	-.15	.00	-.15	.0000	n/a
19	Disc Brake Pads LMV (OEM)	-.01	.00	-.01	.0000	n/a
20	Disc Brake Pads HV	.00	.30	.30	.0036	85.20
21	Brake Blocks	.60	1.91	2.51	.3551	7.07
22	Clutch Facings	24.24	.80	25.04	.4338	57.71
23	Automatic Trans. Components	.17	.13	.30	.0004	842.22
24	Friction Materials	.25	1.49	1.74	.0724	23.98
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.01	.00	-.01	.0000	n/a
27	Sheet Gaskets	14.06	1.44	15.50	.1625	95.44
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-5.39	.00	-5.39	.0000	n/a
30	Non-Roofing Coatings	-.08	.00	-.08	.0000	n/a
31	Asbestos-Reinforced Plastics	-.04	.00	-.04	.0000	n/a
32	Missile Liner	-.20	.00	-.20	.0000	n/a
33	Sealant Tape	-.87	.00	-.87	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	10.94	6.02	16.96	33.3542	.51
37	Disc Brake Pads LMV (Aftermarket)	.74	4.08	4.82	7.1818	.67
38	Mining and Milling	.00	1.19	1.19	.2387	5.01
	Total			242.61 *	45.9901	5.28

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

Sensitivity Analysis Exhibits for Brake Engineering Controls

ALTERNATIVE G -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		12.19	.00	12.19
Foreign Miners & Millers		132.97	.00	132.97
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2769.36	.00	2769.36
Foreign Primary Processors		8.45	.00	8.45
Domestic Product Purchasers	4084.67	.00	.00	4084.67 **
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 6866.22

World Welfare: 7007.64

Note: Negative entries are welfare gains.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

ALTERNATIVE G -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	1.1509	9.55
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	310.13	.04	310.17	10.8603	28.56
6	High Grade Electrical Paper	114.72	.00	114.72	.7944	144.41
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.3329	8061.70
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	11.6170	1.77
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.3749	2.98
20	Disc Brake Pads HV	.03	.35	.38	.3031	1.26
21	Brake Blocks	25.70	2.45	28.15	20.1886	1.39
22	Clutch Facings	36.85	.92	37.77	.8469	44.59
23	Automatic Trans. Components	.25	.15	.40	.0007	602.38
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.9679	313.45
27	Sheet Gaskets	235.37	7.88	243.25	3.4521	70.46
28	Asbestos Packing	.99	.00	.99	.0178	55.68
29	Roof Coatings	319.92	.56	320.48	2.9764	107.67
30	Non-Roofing Coatings	87.79	1.09	88.88	.5963	149.07
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	1.0220	77.02
32	Missile Liner	1961.33	.17	1961.50	.4917	3989.45
33	Sealant Tape	79.58	.10	79.67	.1734	459.54
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-22.84	.00	-22.84 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	47.9474	.17
38	Mining and Milling	.00	12.19	12.19	2.1776	5.60
	Total			6866.22 *	119.3861	57.51

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not

* U.S. net welfare cost

ALTERNATIVE G -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	.9286	11.83
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	310.13	.04	310.17	8.7628	35.40
6	High Grade Electrical Paper	114.72	.00	114.72	.6410	178.97
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.2686	9991.41
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	9.3392	2.20
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.1052	3.71
20	Disc Brake Pads HV	.03	.35	.38	.2445	1.56
21	Brake Blocks	25.70	2.45	28.15	16.2894	1.73
22	Clutch Facings	36.85	.92	37.77	.6833	55.27
23	Automatic Trans. Components	.25	.15	.40	.0005	745.38
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.7810	388.48
27	Sheet Gaskets	235.37	7.88	243.25	2.7854	87.33
28	Asbestos Packing	.99	.00	.99	.0143	69.00
29	Roof Coatings	319.92	.56	320.48	2.4015	133.45
30	Non-Roofing Coatings	87.79	1.09	88.88	.4811	184.75
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	.8246	95.45
32	Missile Liner	1961.33	.17	1961.50	.3967	4944.40
33	Sealant Tape	79.58	.10	79.67	.1399	569.53
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-22.84	.00	-22.84 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	40.4240	.20
38	Mining and Milling	.00	12.19	12.19	1.7490	6.97
	Total			6866.22 *	98.0188	70.05

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not

* U.S. net welfare cost

ALTERNATIVE H -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.10	.00	7.10
Foreign Miners & Millers		77.40	.00	77.40
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2387.88	.00	2387.88
Foreign Primary Processors		7.10	.00	7.10
Domestic Product Purchasers	2420.61	.00	.00	2420.61
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 4815.59

World Welfare: 4900.09

Note: Negative entries are welfare gains.

ALTERNATIVE H -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.7399	8.83
4	Pipeline Wrap	1.18	.00	1.19	1.1196	1.06
5	Beater-Add Gaskets	184.46	.04	184.50	6.9816	26.43
6	High Grade Electrical Paper	68.21	.00	68.21	.5107	133.57
7	Roofing Felt	5.30	.00	5.30	.9717	5.45
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0330	.49
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.2140	10817.17
14	A/C Pipe	260.86	37.84	298.71	3.9999	74.68
15	A/C Sheet, Flat	.80	1.19	2.00	.6752	2.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0923	4.00
17	A/C Shingles	37.67	6.99	44.66	.4111	108.65
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	7.6476	1.83
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.9063	3.86
20	Disc Brake Pads HV	.02	.30	.32	.1948	1.65
21	Brake Blocks	15.30	2.11	17.41	12.9784	1.34
22	Clutch Facings	21.92	.79	22.71	.5444	41.71
23	Automatic Trans. Components	.15	.13	.28	.0004	654.74
24	Friction Materials	.26	1.80	2.07	.4719	4.38
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.6222	289.91
27	Sheet Gaskets	139.97	6.80	146.77	2.2192	66.14
28	Asbestos Packing	.59	.00	.59	.0114	51.50
29	Roof Coatings	190.33	.49	190.81	1.9134	99.73
30	Non-Roofing Coatings	52.21	.94	53.15	.3833	138.66
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.6570	71.33
32	Missile Liner	1166.16	.15	1166.31	.3161	3689.98
33	Sealant Tape	47.32	.08	47.41	.1115	425.33
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-22.27	.00	-22.27	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	23.2356	.24
38	Mining and Milling	.00	7.10	7.10	1.2888	5.51
	Total			4815.59 *	69.2512	69.54

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	207.38	.04	207.42	7.7573	26.74
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	3.1110	72.33
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	8.3800	1.72
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.9927	3.57
20	Disc Brake Pads HV	.01	.31	.33	.2165	1.51
21	Brake Blocks	17.10	2.17	19.27	14.4204	1.34
22	Clutch Facings	24.66	.81	25.48	.6049	42.12
23	Automatic Trans. Components	.17	.13	.30	.0005	637.88
24	Friction Materials	.20	1.86	2.06	.5244	3.92
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	2.4658	66.75
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	106.2551	.19
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	15.8541	.23
38	Mining and Milling	.00	7.31	7.31	1.1258	6.50
	Total			748.43 *	166.7950	4.49

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.31	.00	7.31
Foreign Miners & Millers		79.76	.00	79.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		77.58	.00	77.58
Foreign Primary Processors		8.64	.00	8.64
Domestic Product Purchasers	663.54	.00	.00	663.54
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 748.43

World Welfare: 836.84

Note: Negative entries are welfare gains.

Sensitivity Analysis Exhibits for Additional Exposure Assumptions

ALTERNATIVE J -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.31	.00	7.31
Foreign Miners & Millers		79.76	.00	79.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		77.58	.00	77.58
Foreign Primary Processors		8.64	.00	8.64
Domestic Product Purchasers	425.50	.00	.00	425.50
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare:	510.40
World Welfare:	598.80

Note: Negative entries are welfare gains.

ALTERNATIVE J -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.06	.01	1.07	1.4052	.76
5	Beater-Add Gaskets	168.63	.04	168.67	5.8793	28.69
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.2196	5.99
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	90.04	35.67	125.72	2.2514	55.84
15	A/C Sheet, Flat	.99	1.38	2.37	.8475	2.79
16	A/C Sheet, Corrugated	.29	.00	.29	.1158	2.53
17	A/C Shingles	46.77	8.10	54.87	.5160	106.34
18	Drum Brake Linings (OEM)	2.15	4.74	6.89	6.3280	1.09
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.7495	4.72
20	Disc Brake Pads HV	.01	.31	.33	.1641	1.99
21	Brake Blocks	1.07	2.17	3.24	10.9292	.30
22	Clutch Facings	12.02	.81	12.83	.4585	28.00
23	Automatic Trans. Components	.09	.13	.22	.0004	613.18
24	Friction Materials	.20	1.86	2.06	.3974	5.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	126.05	7.00	133.05	1.8688	71.20
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-.10	7.55	7.45	76.7895	.10
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	11.5777	.31
38	Mining and Milling	.00	7.31	7.31	.8457	8.65
	Total			510.40 *	122.3435	4.17

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.06	.01	1.07	1.7416	.61
5	Beater-Add Gaskets	168.63	.04	168.67	7.7573	21.74
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.5116	4.84
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	90.04	35.67	125.72	3.1110	40.41
15	A/C Sheet, Flat	.99	1.38	2.37	1.0504	2.25
16	A/C Sheet, Corrugated	.29	.00	.29	.1435	2.04
17	A/C Shingles	46.77	8.10	54.87	.6395	85.81
18	Drum Brake Linings (OEM)	2.15	4.74	6.89	8.3800	.82
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.9927	3.57
20	Disc Brake Pads HV	.01	.31	.33	.2165	1.51
21	Brake Blocks	1.07	2.17	3.24	14.4204	.22
22	Clutch Facings	12.02	.81	12.83	.6049	21.22
23	Automatic Trans. Components	.09	.13	.22	.0005	464.73
24	Friction Materials	.20	1.86	2.06	.5244	3.92
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	126.05	7.00	133.05	2.4658	53.96
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-.10	7.55	7.45	106.2551	.07
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	15.8541	.23
38	Mining and Milling	.00	7.31	7.31	1.1258	6.50
	Total			510.40 *	166.7950	3.06

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE H -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.5521	11.84
4	Pipeline Wrap	1.18	.00	1.19	.8355	1.42
5	Beater-Add Gaskets	184.46	.04	184.50	5.2101	35.41
6	High Grade Electrical Paper	68.21	.00	68.21	.3811	178.99
7	Roofing Felt	5.30	.00	5.30	.7252	7.31
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0246	.65
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.1597	14495.12
14	A/C Pipe	260.86	37.84	298.71	2.9850	100.07
15	A/C Sheet, Flat	.80	1.19	2.00	.5039	3.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0688	5.36
17	A/C Shingles	37.67	6.99	44.66	.3068	145.59
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	5.6962	2.46
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.6751	5.18
20	Disc Brake Pads HV	.02	.30	.32	.1454	2.22
21	Brake Blocks	15.30	2.11	17.41	9.6853	1.80
22	Clutch Facings	21.92	.79	22.71	.4063	55.89
23	Automatic Trans. Components	.15	.13	.28	.0003	877.36
24	Friction Materials	.26	1.80	2.07	.3522	5.87
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.4643	388.49
27	Sheet Gaskets	139.97	6.80	146.77	1.6561	88.62
28	Asbestos Packing	.59	.00	.59	.0085	69.01
29	Roof Coatings	190.33	.49	190.81	1.4279	133.63
30	Non-Roofing Coatings	52.21	.94	53.15	.2860	185.81
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.4903	95.59
32	Missile Liner	1166.16	.15	1166.31	.2359	4944.61
33	Sealant Tape	47.32	.08	47.41	.0832	569.95
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-22.27	.00	-22.27	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	17.6734	.32
38	Mining and Milling	.00	7.10	7.10	.9623	7.38
	Total			4815.59 *	52.0015	92.60

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.92	.00	2.92
Foreign Miners & Millers		31.89	.00	31.89
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2059.38	.00	2059.38
Foreign Primary Processors		6.04	.00	6.04
Domestic Product Purchasers	996.72	.00	.00	996.72
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 3059.02

World Welfare: 3096.95

Note: Negative entries are welfare gains.

ALTERNATIVE I -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.3288	8.19
4	Pipeline Wrap	.49	.00	.49	.4976	.98
5	Beater-Add Gaskets	75.96	.03	75.99	3.1029	24.49
6	High Grade Electrical Paper	28.09	.00	28.09	.2270	123.76
7	Roofing Felt	2.18	.00	2.18	.4319	5.05
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0146	.48
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0951	20993.95
14	A/C Pipe	107.41	32.64	140.06	1.7777	78.78
15	A/C Sheet, Flat	.33	1.03	1.36	.3001	4.53
16	A/C Sheet, Corrugated	.15	.00	.15	.0410	3.70
17	A/C Shingles	15.51	6.03	21.54	.1827	117.90
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	3.5284	2.36
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.4193	7.16
20	Disc Brake Pads HV	.01	.26	.27	.0866	3.11
21	Brake Blocks	6.30	1.82	8.12	5.7682	1.41
22	Clutch Facings	9.02	.68	9.71	.2420	40.12
23	Automatic Trans. Components	.06	.11	.17	.0002	916.20
24	Friction Materials	.11	1.56	1.66	.2097	7.93
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.2765	268.62
27	Sheet Gaskets	57.64	5.86	63.50	.9863	64.39
28	Asbestos Packing	.24	.00	.24	.0051	47.71
29	Roof Coatings	78.37	.42	78.79	.8504	92.65
30	Non-Roofing Coatings	21.50	.81	22.31	.1704	130.96
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2920	66.39
32	Missile Liner	480.24	.13	480.37	.1405	3419.52
33	Sealant Tape	19.49	.07	19.56	.0495	394.85
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-9.35	.00	-9.35	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	7.9591	.49
38	Mining and Milling	.00	2.92	2.92	.5705	5.13
	Total			3059.02 *	28.5542	107.13

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET DRUM BRAKES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.2274	11.84
4	Pipeline Wrap	.49	.00	.49	.3441	1.42
5	Beater-Add Gaskets	75.96	.03	75.99	2.1456	35.42
6	High Grade Electrical Paper	28.09	.00	28.09	.1569	178.99
7	Roofing Felt	2.18	.00	2.18	.2986	7.30
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0101	.69
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0658	30361.44
14	A/C Pipe	107.41	32.64	140.06	1.2292	113.94
15	A/C Sheet, Flat	.33	1.03	1.36	.2075	6.54
16	A/C Sheet, Corrugated	.15	.00	.15	.0284	5.35
17	A/C Shingles	15.51	6.03	21.54	.1263	170.51
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	2.4413	3.42
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.2901	10.35
20	Disc Brake Pads HV	.01	.26	.27	.0599	4.50
21	Brake Blocks	6.30	1.82	8.12	3.9885	2.04
22	Clutch Facings	9.02	.68	9.71	.1673	58.02
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.01
24	Friction Materials	.11	1.56	1.66	.1450	11.47
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.1912	388.48
27	Sheet Gaskets	57.64	5.86	63.50	.6820	93.11
28	Asbestos Packing	.24	.00	.24	.0035	69.00
29	Roof Coatings	78.37	.42	78.79	.5880	133.99
30	Non-Roofing Coatings	21.50	.81	22.31	.1178	189.39
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2019	96.02
32	Missile Liner	480.24	.13	480.37	.0971	4945.31
33	Sealant Tape	19.49	.07	19.56	.0343	571.03
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-9.35	.00	-9.35	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	5.5207	.71
38	Mining and Milling	.00	2.92	2.92	.3945	7.41
	Total			3059.02 *	19.7632	154.78

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		12.11	.00	12.11
Foreign Miners & Millers		132.06	.00	132.06
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2762.23	.00	2762.23
Foreign Primary Processors		7.10	.00	7.10
Domestic Product Purchasers	4078.35	.00	.00	4078.35 **
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 6852.69

World Welfare: 6991.85

Note: Negative entries are welfare gains.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

ALTERNATIVE H -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.16	.00	5.16	.5521	9.35
4	Pipeline Wrap	.55	.00	.55	.8355	.66
5	Beater-Add Gaskets	148.35	.04	148.39	5.2101	28.48
6	High Grade Electrical Paper	58.79	.00	58.79	.3811	154.27
7	Roofing Felt	4.04	.00	4.04	.7252	5.58
8	Acetylene Cylinders	.08	.00	.08	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0246	.65
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.1597	14495.12
14	A/C Pipe	140.69	37.84	178.53	2.9850	59.81
15	A/C Sheet, Flat	.53	1.19	1.72	.5039	3.41
16	A/C Sheet, Corrugated	.15	.00	.15	.0688	2.12
17	A/C Shingles	24.67	6.99	31.66	.3068	103.19
18	Drum Brake Linings (OEM)	2.35	4.83	7.19	5.6962	1.26
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.6751	5.18
20	Disc Brake Pads HV	.02	.30	.32	.1454	2.22
21	Brake Blocks	.71	2.11	2.82	9.6853	.29
22	Clutch Facings	10.14	.79	10.93	.4063	26.89
23	Automatic Trans. Components	.07	.13	.20	.0003	637.15
24	Friction Materials	.26	1.80	2.07	.3522	5.87
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	159.15	.00	159.15	.4643	342.73
27	Sheet Gaskets	110.58	6.80	117.38	1.6561	70.88
28	Asbestos Packing	.49	.00	.49	.0085	57.05
29	Roof Coatings	75.14	.49	75.62	1.4279	52.96
30	Non-Roofing Coatings	1.33	.94	2.27	.2860	7.92
31	Asbestos-Reinforced Plastics	40.38	.20	40.57	.4903	82.74
32	Missile Liner	1001.52	.15	1001.67	.2359	4246.61
33	Sealant Tape	41.11	.08	41.19	.0832	495.24
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	5.66	8.21	13.86	101.6571	.14
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	17.6734	.32
38	Mining and Milling	.00	7.27	7.27	1.1331	6.41
	Total			4236.00 *	153.8295	27.54

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		3.00	.00	3.00
Foreign Miners & Millers		32.68	.00	32.68
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2066.72	.00	2066.72
Foreign Primary Processors		7.14	.00	7.14
Domestic Product Purchasers	702.96	.00	.00	702.96
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 2772.68

World Welfare: 2812.50

Note: Negative entries are welfare gains.

ALTERNATIVE I -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.0D	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.99	.00	2.00	.3288	6.07
4	Pipeline Wrap	.22	.00	.23	.4976	.46
5	Beater-Add Gaskets	57.62	.03	57.65	3.1029	18.58
6	High Grade Electrical Paper	23.31	.00	23.31	.2270	102.69
7	Roofing Felt	1.57	.00	1.57	.4319	3.63
8	Acetylene Cylinders	.03	.00	.03	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0146	.48
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0951	20993.95
14	A/C Pipe	46.39	32.64	79.03	1.7777	44.46
15	A/C Sheet, Flat	.19	1.03	1.22	.3001	4.07
16	A/C Sheet, Corrugated	.05	.00	.05	.0410	1.26
17	A/C Shingles	9.16	6.03	15.19	.1827	83.13
18	Drum Brake Linings (OEM)	.97	4.42	5.39	3.5284	1.53
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.4193	7.16
20	Disc Brake Pads HV	.01	.26	.27	.0866	3.11
21	Brake Blocks	.20	1.82	2.02	5.7682	.35
22	Clutch Facings	3.04	.68	3.73	.2420	15.40
23	Automatic Trans. Components	.02	.11	.13	.0002	711.39
24	Friction Materials	.11	1.56	1.66	.2097	7.93
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	63.59	.00	63.59	.2765	229.93
27	Sheet Gaskets	42.71	5.86	48.58	.9863	49.25
28	Asbestos Packing	.19	.00	.19	.0051	37.52
29	Roof Coatings	19.88	.42	20.30	.8504	23.87
30	Non-Roofing Coatings	.16	.81	.97	.1704	5.68
31	Asbestos-Reinforced Plastics	16.02	.17	16.19	.2920	55.45
32	Missile Liner	396.63	.13	396.76	.1405	2824.38
33	Sealant Tape	16.33	.07	16.40	.0495	331.14
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	2.30	7.35	9.64	61.8500	.16
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	7.9591	.49
38	Mining and Milling	.00	3.00	3.00	.6747	4.44
	Total			2772.68 *	90.5084	30.63

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	1.99	.00	2.00	.2274	8.78
4	Pipeline Wrap	.22	.00	.23	.3441	.66
5	Beater-Add Gaskets	57.62	.03	57.65	2.1456	26.87
6	High Grade Electrical Paper	23.31	.00	23.31	.1569	148.51
7	Roofing Felt	1.57	.00	1.57	.2986	5.25
8	Acetylene Cylinders	.03	.00	.03	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0101	.69
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0658	30361.44
14	A/C Pipe	46.39	32.64	79.03	1.2292	64.29
15	A/C Sheet, Flat	.19	1.03	1.22	.2075	5.88
16	A/C Sheet, Corrugated	.05	.00	.05	.0284	1.83
17	A/C Shingles	9.16	6.03	15.19	.1263	120.22
18	Drum Brake Linings (OEM)	.97	4.42	5.39	2.4413	2.21
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.2901	10.35
20	Disc Brake Pads HV	.01	.26	.27	.0599	4.50
21	Brake Blocks	.20	1.82	2.02	3.9885	.51
22	Clutch Facings	3.04	.68	3.73	.1673	22.27
23	Automatic Trans. Components	.02	.11	.13	.0001	1028.81
24	Friction Materials	.11	1.56	1.66	.1450	11.47
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	63.59	.00	63.59	.1912	332.53
27	Sheet Gaskets	42.71	5.86	48.58	.6820	71.23
28	Asbestos Packing	.19	.00	.19	.0035	54.26
29	Roof Coatings	19.88	.42	20.30	.5880	34.52
30	Non-Roofing Coatings	.16	.81	.97	.1178	8.22
31	Asbestos-Reinforced Plastics	16.02	.17	16.19	.2019	80.19
32	Missile Liner	396.63	.13	396.76	.0971	4084.62
33	Sealant Tape	16.33	.07	16.40	.0343	478.90
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	2.30	7.35	9.64	42.7646	.23
37	Disc Brake Pads LMV (Aftermarket)	.15	3.78	3.93	5.5207	.71
38	Mining and Milling	.00	3.00	3.00	.4666	6.42
	Total			2772.68 *	62.5999	44.29

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	1.1509	9.55
4	Pipeline Wrap	1.96	.01	1.97	1.7416	1.13
5	Beater-Add Gaskets	310.13	.04	310.17	10.8603	28.56
6	High Grade Electrical Paper	114.72	.00	114.72	.7944	144.41
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.3329	8061.70
14	A/C Pipe	438.45	43.87	482.32	6.2221	77.52
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	11.6170	1.77
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.3749	2.98
20	Disc Brake Pads HV	.03	.35	.38	.3031	1.26
21	Brake Blocks	25.70	2.45	28.15	20.1886	1.39
22	Clutch Facings	36.85	.92	37.77	.8469	44.59
23	Automatic Trans. Components	.25	.15	.40	.0007	602.38
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.9679	313.45
27	Sheet Gaskets	235.37	7.88	243.25	3.4521	70.46
28	Asbestos Packing	.99	.00	.99	.0178	55.68
29	Roof Coatings	319.92	.56	320.48	2.9764	107.67
30	Non-Roofing Coatings	87.79	1.09	88.88	.5963	149.07
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	1.0220	77.02
32	Missile Liner	1961.33	.17	1961.50	.4917	3989.45
33	Sealant Tape	79.58	.10	79.67	.1734	459.54
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-21.98	.00	-21.98 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	-6.13	.00	-6.13 **	.0000	n/a
38	Mining and Milling	.00	12.11	12.11	2.1208	5.71
	Total			6852.69 *	71.3818	96.00

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

* U.S. net welfare cost

ALTERNATIVE G -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	10.99	.00	10.99	.9286	11.83
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	310.13	.04	310.17	8.7628	35.40
6	High Grade Electrical Paper	114.72	.00	114.72	.6410	178.97
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	10.56	.00	10.56	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.2686	9991.41
14	A/C Pipe	438.45	43.87	482.32	5.0204	96.07
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	14.92	5.65	20.57	9.3392	2.20
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.1052	3.71
20	Disc Brake Pads HV	.03	.35	.38	.2445	1.56
21	Brake Blocks	25.70	2.45	28.15	16.2894	1.73
22	Clutch Facings	36.85	.92	37.77	.6833	55.27
23	Automatic Trans. Components	.25	.15	.40	.0005	745.38
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	303.38	.00	303.38	.7810	388.48
27	Sheet Gaskets	235.37	7.88	243.25	2.7854	87.33
28	Asbestos Packing	.99	.00	.99	.0143	69.00
29	Roof Coatings	319.92	.56	320.48	2.4015	133.45
30	Non-Roofing Coatings	87.79	1.09	88.88	.4811	184.75
31	Asbestos-Reinforced Plastics	78.49	.23	78.72	.8246	95.45
32	Missile Liner	1961.33	.17	1961.50	.3967	4944.40
33	Sealant Tape	79.58	.10	79.67	.1399	569.53
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-21.98	.00	-21.98 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	-6.13	.00	-6.13 **	.0000	n/a
38	Mining and Milling	.00	12.11	12.11	1.6994	7.13
	Total			6852.69 *	57.5452	119.08

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

* U.S. net welfare cost

ALTERNATIVE H -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss	
Domestic Miners & Millers		7.04	.00	7.04	
Foreign Miners & Millers		76.82	.00	76.82	
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00	
Domestic Primary Processors		2382.67	.00	2382.67	
Foreign Primary Processors		6.11	.00	6.11	
Domestic Product Purchasers	2417.81	.00	.00	2417.81	**
Foreign Product Purchasers	.00	.00	.00	.00	
Government			.00	.00	

NET WELFARE LOSSES

U. S. Welfare: 4807.53

World Welfare: 4890.46

Note: Negative entries are welfare gains.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

ALTERNATIVE H -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.7399	8.83
4	Pipeline Wrap	1.18	.00	1.19	1.1196	1.06
5	Beater-Add Gaskets	184.46	.04	184.50	6.9816	26.43
6	High Grade Electrical Paper	68.21	.00	68.21	.5107	133.57
7	Roofing Felt	5.30	.00	5.30	.9717	5.45
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0330	.49
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.2140	10817.17
14	A/C Pipe	260.86	37.84	298.71	3.9999	74.68
15	A/C Sheet, Flat	.80	1.19	2.00	.6752	2.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0923	4.00
17	A/C Shingles	37.67	6.99	44.66	.4111	108.65
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	7.6476	1.83
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.9063	3.86
20	Disc Brake Pads HV	.02	.30	.32	.1948	1.65
21	Brake Blocks	15.30	2.11	17.41	12.9784	1.34
22	Clutch Facings	21.92	.79	22.71	.5444	41.71
23	Automatic Trans. Components	.15	.13	.28	.0004	654.74
24	Friction Materials	.26	1.80	2.07	.4719	4.38
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.6222	289.91
27	Sheet Gaskets	139.97	6.80	146.77	2.2192	66.14
28	Asbestos Packing	.59	.00	.59	.0114	51.50
29	Roof Coatings	190.33	.49	190.81	1.9134	99.73
30	Non-Roofing Coatings	52.21	.94	53.15	.3833	138.66
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.6570	71.33
32	Missile Liner	1166.16	.15	1166.31	.3161	3689.98
33	Sealant Tape	47.32	.08	47.41	.1115	425.33
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-21.66	.00	-21.66 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	-2.93	.00	-2.93 **	.0000	n/a
38	Mining and Milling	.00	7.04	7.04	1.2527	5.62
	Total			4807.53 *	45.9796	104.56

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

* U.S. net welfare cost

ALTERNATIVE H -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	6.53	.00	6.54	.5521	11.84
4	Pipeline Wrap	1.18	.00	1.19	.8355	1.42
5	Beater-Add Gaskets	184.46	.04	184.50	5.2101	35.41
6	High Grade Electrical Paper	68.21	.00	68.21	.3811	178.99
7	Roofing Felt	5.30	.00	5.30	.7252	7.31
8	Acetylene Cylinders	6.28	.00	6.28	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0246	.65
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.1597	14495.12
14	A/C Pipe	260.86	37.84	298.71	2.9850	100.07
15	A/C Sheet, Flat	.80	1.19	2.00	.5039	3.96
16	A/C Sheet, Corrugated	.37	.00	.37	.0688	5.36
17	A/C Shingles	37.67	6.99	44.66	.3068	145.59
18	Drum Brake Linings (OEM)	9.16	4.83	13.99	5.6962	2.46
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.6751	5.18
20	Disc Brake Pads HV	.02	.30	.32	.1454	2.22
21	Brake Blocks	15.30	2.11	17.41	9.6853	1.80
22	Clutch Facings	21.92	.79	22.71	.4063	55.89
23	Automatic Trans. Components	.15	.13	.28	.0003	877.36
24	Friction Materials	.26	1.80	2.07	.3522	5.87
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	180.39	.00	180.39	.4643	388.49
27	Sheet Gaskets	139.97	6.80	146.77	1.6561	88.62
28	Asbestos Packing	.59	.00	.59	.0085	69.01
29	Roof Coatings	190.33	.49	190.81	1.4279	133.63
30	Non-Roofing Coatings	52.21	.94	53.15	.2860	185.81
31	Asbestos-Reinforced Plastics	46.67	.20	46.87	.4903	95.59
32	Missile Liner	1166.16	.15	1166.31	.2359	4944.61
33	Sealant Tape	47.32	.08	47.41	.0832	569.95
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-21.66	.00	-21.66 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	-2.93	.00	-2.93 **	.0000	n/a
38	Mining and Milling	.00	7.04	7.04	.9350	7.53
	Total			4807.53 *	34.3008	140.16

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		2.91	.00	2.91
Foreign Miners & Millers		31.71	.00	31.71
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2055.59	.00	2055.59
Foreign Primary Processors		5.32	.00	5.32
Domestic Product Purchasers	995.90	.00	.00	995.90 **
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 3054.40

World Welfare: 3091.43

Note: Negative entries are welfare gains.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

ALTERNATIVE I -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.3288	8.19
4	Pipeline Wrap	.49	.00	.49	.4976	.98
5	Beater-Add Gaskets	75.96	.03	75.99	3.1029	24.49
6	High Grade Electrical Paper	28.09	.00	28.09	.2270	123.76
7	Roofing Felt	2.18	.00	2.18	.4319	5.05
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0146	.48
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0951	20993.95
14	A/C Pipe	107.41	32.64	140.06	1.7777	78.78
15	A/C Sheet, Flat	.33	1.03	1.36	.3001	4.53
16	A/C Sheet, Corrugated	.15	.00	.15	.0410	3.70
17	A/C Shingles	15.51	6.03	21.54	.1827	117.90
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	3.5284	2.36
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.4193	7.16
20	Disc Brake Pads HV	.01	.26	.27	.0866	3.11
21	Brake Blocks	6.30	1.82	8.12	5.7682	1.41
22	Clutch Facings	9.02	.68	9.71	.2420	40.12
23	Automatic Trans. Components	.06	.11	.17	.0002	916.20
24	Friction Materials	.11	1.56	1.66	.2097	7.93
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.2765	268.62
27	Sheet Gaskets	57.64	5.86	63.50	.9863	64.39
28	Asbestos Packing	.24	.00	.24	.0051	47.71
29	Roof Coatings	78.37	.42	78.79	.8504	92.65
30	Non-Roofing Coatings	21.50	.81	22.31	.1704	130.96
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2920	66.39
32	Missile Liner	480.24	.13	480.37	.1405	3419.52
33	Sealant Tape	19.49	.07	19.56	.0495	394.85
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-9.15	.00	-9.15 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	-0.87	.00	-0.87 **	.0000	n/a
38	Mining and Milling	.00	2.91	2.91	.5572	5.22
	Total			3054.40 *	20.5818	148.40

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

* U.S. net welfare cost

ALTERNATIVE I -- LOW DECLINE BASELINE
ENGINEERING CONTROLS ON AFTERMARKET LMV DRUM AND DISC BRAKES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	2.69	.00	2.69	.2274	11.84
4	Pipeline Wrap	.49	.00	.49	.3441	1.42
5	Beater-Add Gaskets	75.96	.03	75.99	2.1456	35.42
6	High Grade Electrical Paper	28.09	.00	28.09	.1569	178.99
7	Roofing Felt	2.18	.00	2.18	.2986	7.30
8	Acetylene Cylinders	2.59	.00	2.59	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.01	.00	.01	.0101	.69
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.07	1996.58	1996.65	.0658	30361.44
14	A/C Pipe	107.41	32.64	140.06	1.2292	113.94
15	A/C Sheet, Flat	.33	1.03	1.36	.2075	6.54
16	A/C Sheet, Corrugated	.15	.00	.15	.0284	5.35
17	A/C Shingles	15.51	6.03	21.54	.1263	170.51
18	Drum Brake Linings (OEM)	3.93	4.42	8.34	2.4413	3.42
19	Disc Brake Pads LMV (OEM)	.04	2.96	3.00	.2901	10.35
20	Disc Brake Pads HV	.01	.26	.27	.0599	4.50
21	Brake Blocks	6.30	1.82	8.12	3.9885	2.04
22	Clutch Facings	9.02	.68	9.71	.1673	58.02
23	Automatic Trans. Components	.06	.11	.17	.0001	1325.01
24	Friction Materials	.11	1.56	1.66	.1450	11.47
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	74.29	.00	74.29	.1912	388.48
27	Sheet Gaskets	57.64	5.86	63.50	.6820	93.11
28	Asbestos Packing	.24	.00	.24	.0035	69.00
29	Roof Coatings	78.37	.42	78.79	.5880	133.99
30	Non-Roofing Coatings	21.50	.81	22.31	.1178	189.39
31	Asbestos-Reinforced Plastics	19.22	.17	19.39	.2019	96.02
32	Missile Liner	480.24	.13	480.37	.0971	4945.31
33	Sealant Tape	19.49	.07	19.56	.0343	571.03
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-9.15	.00	-9.15 **	.0000	n/a
37	Disc Brake Pads LMV (Aftermarket)	-0.87	.00	-0.87 **	.0000	n/a
38	Mining and Milling	.00	2.91	2.91	.3854	7.55
	Total			3054.40 *	14.2333	214.60

n/a: Not applicable

*** Market is not banned, exempted, or exposure data is not available.

** Includes consumer surplus loss due to engineering controls on non-asbestos brakes. Losses may be overestimated because this analysis assumes that all brake jobs are performed using engineering controls. However, all "do-it-yourself" jobs may not employ these controls.

* U.S. net welfare cost

Sensitivity Analysis Exhibits for Declining Substitute Prices

ALTERNATIVE G -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	9.26	.00	9.26	1.1509	8.05
4	Pipeline Wrap	1.06	.01	1.07	1.7416	.61
5	Beater-Add Gaskets	264.72	.04	264.77	10.8603	24.38
6	High Grade Electrical Paper	102.87	.00	102.87	.7944	129.50
7	Roofing Felt	7.31	.00	7.31	1.5116	4.84
8	Acetylene Cylinders	.54	.00	.54	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0513	.50
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.3329	8061.70
14	A/C Pipe	287.33	43.87	331.20	6.2221	53.23
15	A/C Sheet, Flat	.99	1.38	2.37	1.0504	2.25
16	A/C Sheet, Corrugated	.29	.00	.29	.1435	2.04
17	A/C Shingles	46.77	8.10	54.87	.6395	85.81
18	Drum Brake Linings (OEM)	4.43	5.65	10.08	11.6170	.87
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.3749	2.98
20	Disc Brake Pads HV	.03	.35	.38	.3031	1.26
21	Brake Blocks	6.03	2.45	8.47	20.1886	.42
22	Clutch Facings	22.04	.92	22.95	.8469	27.10
23	Automatic Trans. Components	.15	.15	.30	.0007	458.46
24	Friction Materials	.43	2.09	2.52	.7341	3.43
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	276.42	.00	276.42	.9679	285.59
27	Sheet Gaskets	198.41	7.88	206.29	3.4521	59.76
28	Asbestos Packing	.86	.00	.86	.0178	48.46
29	Roof Coatings	175.07	.56	175.63	2.9764	59.01
30	Non-Roofing Coatings	17.58	1.09	18.66	.5963	31.30
31	Asbestos-Reinforced Plastics	70.57	.23	70.80	1.0220	69.27
32	Missile Liner	1754.29	.17	1754.47	.4917	3568.37
33	Sealant Tape	71.76	.10	71.86	.1734	414.46
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	10.71	9.05	19.76	209.0213	.09
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	47.9474	.17
38	Mining and Milling	.00	12.32	12.32	2.3709	5.19
	Total			6122.14 *	328.6007	18.63

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE G -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		12.32	.00	12.32
Foreign Miners & Millers		134.29	.00	134.29
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2778.41	.00	2778.41
Foreign Primary Processors		9.81	.00	9.81
Domestic Product Purchasers	3331.41	.00	.00	3331.41
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 6122.14

World Welfare: 6266.24

Note: Negative entries are welfare gains.

ALTERNATIVE G -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	9.26	.00	9.26	.9286	9.98
4	Pipeline Wrap	1.06	.01	1.07	1.4052	.76
5	Beater-Add Gaskets	264.72	.04	264.77	8.7628	30.21
6	High Grade Electrical Paper	102.87	.00	102.87	.6410	160.50
7	Roofing Felt	7.31	.00	7.31	1.2196	5.99
8	Acetylene Cylinders	.54	.00	.54	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.03	.0414	.62
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.26	2683.24	2683.50	.2686	9991.41
14	A/C Pipe	287.33	43.87	331.20	5.0204	65.97
15	A/C Sheet, Flat	.99	1.38	2.37	.8475	2.79
16	A/C Sheet, Corrugated	.29	.00	.29	.1158	2.53
17	A/C Shingles	46.77	8.10	54.87	.5160	106.34
18	Drum Brake Linings (OEM)	4.43	5.65	10.08	9.3392	1.08
19	Disc Brake Pads LMV (OEM)	.16	3.94	4.10	1.1052	3.71
20	Disc Brake Pads HV	.03	.35	.38	.2445	1.56
21	Brake Blocks	6.03	2.45	8.47	16.2894	.52
22	Clutch Facings	22.04	.92	22.95	.6833	33.59
23	Automatic Trans. Components	.15	.15	.30	.0005	567.29
24	Friction Materials	.43	2.09	2.52	.5923	4.25
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	276.42	.00	276.42	.7810	353.95
27	Sheet Gaskets	198.41	7.88	206.29	2.7854	74.06
28	Asbestos Packing	.86	.00	.86	.0143	60.06
29	Roof Coatings	175.07	.56	175.63	2.4015	73.13
30	Non-Roofing Coatings	17.58	1.09	18.66	.4811	38.79
31	Asbestos-Reinforced Plastics	70.57	.23	70.80	.8246	85.85
32	Missile Liner	1754.29	.17	1754.47	.3967	4422.53
33	Sealant Tape	71.76	.10	71.86	.1399	513.67
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	10.71	9.05	19.76	168.1760	.12
37	Disc Brake Pads LMV (Aftermarket)	1.05	7.13	8.18	40.4240	.20
38	Mining and Milling	.00	12.32	12.32	1.9145	6.43
	Total			6122.14 *	266.3603	22.98

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE H -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.27	.00	7.27
Foreign Miners & Millers		79.23	.00	79.23
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		2396.09	.00	2396.09
Foreign Primary Processors		8.33	.00	8.33
Domestic Product Purchasers	1832.64	.00	.00	1832.64
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 4236.00

World Welfare: 4323.56

Note: Negative entries are welfare gains.

ALTERNATIVE H -- LOW DECLINE BASELINE
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	5.16	.00	5.16	.7399	6.98
4	Pipeline Wrap	.55	.00	.55	1.1196	.49
5	Beater-Add Gaskets	148.35	.04	148.39	6.9816	21.25
6	High Grade Electrical Paper	58.79	.00	58.79	.5107	115.13
7	Roofing Felt	4.04	.00	4.04	.9717	4.16
8	Acetylene Cylinders	.08	.00	.08	.0000	***
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	.02	.00	.02	.0330	.49
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	.16	2314.59	2314.75	.2140	10817.17
14	A/C Pipe	140.69	37.84	178.53	3.9999	44.63
15	A/C Sheet, Flat	.53	1.19	1.72	.6752	2.55
16	A/C Sheet, Corrugated	.15	.00	.15	.0923	1.58
17	A/C Shingles	24.67	6.99	31.66	.4111	77.01
18	Drum Brake Linings (OEM)	2.35	4.83	7.19	7.6476	.94
19	Disc Brake Pads LMV (OEM)	.10	3.39	3.50	.9063	3.86
20	Disc Brake Pads HV	.02	.30	.32	.1948	1.65
21	Brake Blocks	.71	2.11	2.82	12.9784	.22
22	Clutch Facings	10.14	.79	10.93	.5444	20.07
23	Automatic Trans. Components	.07	.13	.20	.0004	475.48
24	Friction Materials	.26	1.80	2.07	.4719	4.38
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	159.15	.00	159.15	.6222	255.77
27	Sheet Gaskets	110.58	6.80	117.38	2.2192	52.89
28	Asbestos Packing	.49	.00	.49	.0114	42.57
29	Roof Coatings	75.14	.49	75.62	1.9134	39.52
30	Non-Roofing Coatings	1.33	.94	2.27	.3833	5.91
31	Asbestos-Reinforced Plastics	40.38	.20	40.57	.6570	61.75
32	Missile Liner	1001.52	.15	1001.67	.3161	3169.09
33	Sealant Tape	41.11	.08	41.19	.1115	369.58
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	5.66	8.21	13.86	136.3872	.10
37	Disc Brake Pads LMV (Aftermarket)	.48	5.21	5.69	23.2356	.24
38	Mining and Milling	.00	7.27	7.27	1.5181	4.79
	Total			4236.00 *	205.8677	20.58

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	1.4052	1.40
5	Beater-Add Gaskets	207.38	.04	207.42	5.8793	35.28
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	2.2514	99.94
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	6.3280	2.28
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.7495	4.72
20	Disc Brake Pads HV	.01	.31	.33	.1641	1.99
21	Brake Blocks	17.10	2.17	19.27	10.9292	1.76
22	Clutch Facings	24.66	.81	25.48	.4585	55.57
23	Automatic Trans. Components	.17	.13	.30	.0004	841.65
24	Friction Materials	.20	1.86	2.06	.3974	5.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	1.8688	88.08
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	76.7895	.26
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	11.5777	.31
38	Mining and Milling	.00	7.31	7.31	.8457	8.65
	Total			748.43 *	122.3435	6.12

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.31	.00	7.31
Foreign Miners & Millers		79.76	.00	79.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		77.58	.00	77.58
Foreign Primary Processors		8.64	.00	8.64
Domestic Product Purchasers	663.54	.00	.00	663.54
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 748.43

World Welfare: 836.84

Note: Negative entries are welfare gains.

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	2.3105	.85
5	Beater-Add Gaskets	207.38	.04	207.42	25.2685	8.21
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	3.1698	70.99
15	A/C Sheet, Flat	1.35	1.38	2.73	.8475	3.22
16	A/C Sheet, Corrugated	.62	.00	.62	.1158	5.33
17	A/C Shingles	63.31	8.10	71.42	.5160	138.42
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	6.3280	2.28
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.7495	4.72
20	Disc Brake Pads HV	.01	.31	.33	.1641	1.99
21	Brake Blocks	17.10	2.17	19.27	10.9292	1.76
22	Clutch Facings	24.66	.81	25.48	.4585	55.57
23	Automatic Trans. Components	.17	.13	.30	.0004	841.65
24	Friction Materials	.20	1.86	2.06	.3974	5.18
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	11.9583	13.76
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	76.7895	.26
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	11.5777	.31
38	Mining and Milling	.00	7.31	7.31	.8457	8.65
	Total			748.43 *	153.6458	4.87

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	2.8635	.69
5	Beater-Add Gaskets	207.38	.04	207.42	33.3402	6.22
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	4.3801	51.37
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	63.31	8.10	71.42	.6395	111.68
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	8.3800	1.72
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.9927	3.57
20	Disc Brake Pads HV	.01	.31	.33	.2165	1.51
21	Brake Blocks	17.10	2.17	19.27	14.4204	1.34
22	Clutch Facings	24.66	.81	25.48	.6049	42.12
23	Automatic Trans. Components	.17	.13	.30	.0005	637.88
24	Friction Materials	.20	1.86	2.06	.5244	3.92
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	15.7783	10.43
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	106.2551	.19
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	15.8541	.23
38	Mining and Milling	.00	7.31	7.31	1.1258	6.50
	Total			748.43 *	208.0813	3.60

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL NONOCCUPATIONAL EXPOSURE ASSUMPTIONS

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	4.2918	.46
5	Beater-Add Gaskets	207.38	.04	207.42	24.6948	8.40
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	34.2721	6.57
15	A/C Sheet, Flat	1.35	1.38	2.73	2.1813	1.25
16	A/C Sheet, Corrugated	.62	.00	.62	.7727	.80
17	A/C Shingles	63.31	8.10	71.42	8.0623	8.86
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	8.3800	1.72
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.9927	3.57
20	Disc Brake Pads HV	.01	.31	.33	.5368	.61
21	Brake Blocks	17.10	2.17	19.27	14.4204	1.34
22	Clutch Facings	24.66	.81	25.48	1.9553	13.03
23	Automatic Trans. Components	.17	.13	.30	.0005	637.88
24	Friction Materials	.20	1.86	2.06	4.8945	.42
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	9.8746	16.67
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	106.2551	.19
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	15.8541	.23
38	Mining and Milling	.00	7.31	7.31	1.1258	6.50
	Total			748.43 *	240.0764	3.12

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL NONOCCUPATIONAL EXPOSURE ASSUMPTIONS

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.31	.00	7.31
Foreign Miners & Millers		79.76	.00	79.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		77.58	.00	77.58
Foreign Primary Processors		8.64	.00	8.64
Domestic Product Purchasers	663.54	.00	.00	663.54
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 748.43

World Welfare: 836.84

Note: Negative entries are welfare gains.

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL OCCUPATIONAL AND NONOCCUPATIONAL EXPOSURE ASSUMPTIONS
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs discounted at 3% and benefits discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.06	.01	1.07	5.4137	.20
5	Beater-Add Gaskets	168.63	.04	168.67	50.2777	3.35
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.5116	4.84
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	90.04	35.67	125.72	35.5412	3.54
15	A/C Sheet, Flat	.99	1.38	2.37	2.1813	1.09
16	A/C Sheet, Corrugated	.29	.00	.29	.7727	.38
17	A/C Shingles	46.77	8.10	54.87	8.0623	6.81
18	Drum Brake Linings (OEM)	2.15	4.74	6.89	8.3800	.82
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.9927	3.57
20	Disc Brake Pads HV	.01	.31	.33	.5368	.61
21	Brake Blocks	1.07	2.17	3.24	14.4204	.22
22	Clutch Facings	12.02	.81	12.83	1.9553	6.56
23	Automatic Trans. Components	.09	.13	.22	.0005	464.73
24	Friction Materials	.20	1.86	2.06	4.8945	.42
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	126.05	7.00	133.05	23.1871	5.74
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-.10	7.55	7.45	106.2551	.07
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	15.8541	.23
38	Mining and Milling	.00	7.31	7.31	1.1258	6.50
	Total			510.40 *	281.3628	1.81

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL OCCUPATIONAL AND NONOCCUPATIONAL EXPOSURE ASSUMPTIONS
DECLINING SUBSTITUTE PRICES

WELFARE EFFECTS BY PARTY

(Present values, in million dollars, at 3%)

Party	CS Loss	PS Loss	Fiber Value Allocation	Net Loss
Domestic Miners & Millers		7.31	.00	7.31
Foreign Miners & Millers		79.76	.00	79.76
Importers of Bulk Fiber, Mixtures, and Products		.00	.00	.00
Domestic Primary Processors		77.58	.00	77.58
Foreign Primary Processors		8.64	.00	8.64
Domestic Product Purchasers	425.50	.00	.00	425.50
Foreign Product Purchasers	.00	.00	.00	.00
Government			.00	.00

NET WELFARE LOSSES

U. S. Welfare: 510.40

World Welfare: 598.80

Note: Negative entries are welfare gains.

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Table I-3: EPA COST OF NEW CHEMICAL REGULATION PURSUANT TO TSCA SECTION 5

(millions of 1986 dollars)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
PMN Filing Costs[a]	0.00	4.43	8.37	11.39	16.98	14.95	17.71	19.95	20.24	26.73
5(E) SNUR w/o testing[b]	0.00	0.05	0.00	0.04	0.21	0.40	0.71	0.91	0.81	0.47
5(E) SNUR with Ecotox testing[c]	0.00	0.02	0.16	0.07	0.60	0.28	0.25	0.42	0.28	0.50
5(E) SNUR with Health testing[d]	0.00	0.02	0.16	0.07	0.60	0.28	0.25	0.42	0.28	0.50
Total Annual Costs	0.00	4.52	8.68	11.59	18.40	15.90	18.93	21.70	21.60	28.19

Table I-3A: EPA COST OF NEW CHEMICAL REGULATION PURSUANT TO TSCA SECTION 5[e] 1

(millions of 1986 dollars)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
PMN Filing Costs[a]	--	--	--	--	--	--	--	--	--	--	--	--
5(E) SNUR w/o testing[b]	--	--	--	--	--	--	--	--	--	--	--	--
5(E) SNUR with Ecotox testing[c]	--	--	--	--	--	--	--	--	--	--	--	--
5(E) SNUR with Health testing[d]	--	--	--	--	--	--	--	--	--	--	--	--
Total Annual Costs	30.18	32.95	35.72	38.49	41.25	44.02	46.79	49.56	52.33	55.09	57.86	60.63

Footnotes for Tables I-3 and I-3A

a. Reflect annual costs of reviewing pre-manufacturing (PMN) review notices prior to the manufacture, process, or import of new chemicals not on the TSCA Inventory. Estimates were calculated by OTS staff based on an average cost of $11,800 per PMN submission reviewed.

b. Reflect annual costs of imposing Significant New Use Rule (SNUR) requirements that do not require additional testing. Estimates were derived from economic analyses and compiled by OTS staff.

c. Same as b except include requirements for testing of ecological effects.

d. Same as b except include requirements for Ecotox testing.

e. ~~Data~~ Projections for PMNs and SNURs for years 1989 - 2000 were not made & but ~~supplied by OTS staff, and projections~~ were made for the totals of these actions, ~~only and not~~ for each individual category ~~(see footnote f below).~~

~~f. The total annual costs of reviewing all PMNs and SNURs for the years 1989 - 2000 were projected~~ by regressing the total annual costs for these categories over the years 1972 - 1988 against time.

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL NONOCCUPATIONAL EXPOSURE ASSUMPTIONS

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.96	.01	1.97	3.4629	.57
5	Beater-Add Gaskets	207.38	.04	207.42	18.7161	11.08
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.2196	7.30
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	189.34	35.67	225.01	24.8022	9.07
15	A/C Sheet, Flat	1.35	1.38	2.73	1.7600	1.55
16	A/C Sheet, Corrugated	.62	.00	.62	.6235	.99
17	A/C Shingles	63.31	8.10	71.42	6.5052	10.98
18	Drum Brake Linings (OEM)	9.69	4.74	14.43	6.3280	2.28
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.7495	4.72
20	Disc Brake Pads HV	.01	.31	.33	.4069	.80
21	Brake Blocks	17.10	2.17	19.27	10.9292	1.76
22	Clutch Facings	24.66	.81	25.48	1.4819	17.19
23	Automatic Trans. Components	.17	.13	.30	.0004	841.65
24	Friction Materials	.20	1.86	2.06	3.7095	.55
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	157.60	7.00	164.60	7.4839	21.99
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	12.31	7.55	19.87	76.7895	.26
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	11.5777	.31
38	Mining and Milling	.00	7.31	7.31	.8457	8.65
	Total			748.43 *	177.3917	4.22

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

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Table I-2: INDUSTRY COST OF NEW CHEMICAL REGULATION PURSUANT TO TSCA SECTION 5

(millions of 1986 dollars)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
PMN Filing Costs[a]	0.05	1.77	3.33	4.54	6.76	5.95	7.05	7.95	8.06	10.65
5(E) SNUR w/o testing[b]	0.00	0.01	0.00	0.01	0.05	0.10	0.18	0.23	0.20	0.12
5(E) SNUR with Ecotox testing[c]	0.00	0.03	0.07	0.04	0.23	0.12	0.11	0.16	0.11	0.19
5(E) SNUR with Health testing[d]	0.00	0.07	0.12	0.08	0.27	0.15	0.14	0.20	0.15	0.23
Total Annual Costs	0.05	1.87	3.52	4.68	7.32	6.32	7.48	8.54	8.53	11.18

Table I-2A: INDUSTRY COST OF NEW CHEMICAL REGULATION PURSUANT TO TSCA SECTION 5[e] f

(millions of 1986 dollars)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
PMN Filing Costs[a]	--	--	--	--	--	--	--	--	--	--	--	--
5(E) SNUR w/o testing[b]	--	--	--	--	--	--	--	--	--	--	--	--
5(E) SNUR with Ecotox testing[c]	--	--	--	--	--	--	--	--	--	--	--	--
5(E) SNUR with Health testing[d]	--	--	--	--	--	--	--	--	--	--	--	--
Total Annual Costs	11.92	13.01	14.10	15.18	16.27	17.36	18.44	19.53	20.61	21.70	22.79	23.87

Footnotes for Tables D-2 and D-2A

a. Reflect annual costs of filing pre-manufacturing (PMN) review notices prior to the manufacture, process, or import of new chemicals not on the TSCA Inventory. Estimates were calculated by OTS staff based on an average cost of $4,700 per PMNS submission.

b. Reflect annual costs of Significant New Use Rule (SNUR) requirements that do not require additional testing. Estimates were derived from economic analyses and compiled by OTS staff.

c. Same as b except include requirements for testing of ecological effects (Ecotox).

d. Same as b except include requirements for Ecotox testing.

e. ~~Data~~ Projections for PMNs and SNURs for years 1989 - 2000 were not ~~supplied by OTS staff, and projections~~ made but were made for the totals of these actions ~~only and not~~ for each individual category (see footnote f below).

~~f. The total annual costs associated with all PMNs and SNURs for the years 1989 - 2000 were projected~~ by regressing the total annual costs for these categories over the years 1972 - 1988 against time.

ALTERNATIVE J -- LOW DECLINE BASELINE
ADDITIONAL OCCUPATIONAL AND NONOCCUPATIONAL EXPOSURE ASSUMPTIONS
DECLINING SUBSTITUTE PRICES

COST-BENEFIT BY PRODUCT

(Costs and benefits discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	-.43	.00	-.43	.0000	n/a
4	Pipeline Wrap	1.06	.01	1.07	4.3681	.24
5	Beater-Add Gaskets	168.63	.04	168.67	38.1053	4.43
6	High Grade Electrical Paper	-.73	.00	-.73	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.2196	5.99
8	Acetylene Cylinders	-.45	.00	-.45	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.09	.00	-.09	.0000	n/a
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-.97	.00	-.97	.0000	n/a
14	A/C Pipe	90.04	35.67	125.72	25.7206	4.89
15	A/C Sheet, Flat	.99	1.38	2.37	1.7600	1.35
16	A/C Sheet, Corrugated	.29	.00	.29	.6235	.47
17	A/C Shingles	46.77	8.10	54.87	6.5052	8.43
18	Drum Brake Linings (OEM)	2.15	4.74	6.89	6.3280	1.09
19	Disc Brake Pads LMV (OEM)	.08	3.46	3.54	.7495	4.72
20	Disc Brake Pads HV	.01	.31	.33	.4069	.80
21	Brake Blocks	1.07	2.17	3.24	10.9292	.30
22	Clutch Facings	12.02	.81	12.83	1.4819	8.66
23	Automatic Trans. Components	.09	.13	.22	.0004	613.18
24	Friction Materials	.20	1.86	2.06	3.7095	.55
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.83	.00	-.83	.0000	n/a
27	Sheet Gaskets	126.05	7.00	133.05	17.5735	7.57
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	-21.50	.00	-21.50	.0000	n/a
30	Non-Roofing Coatings	-2.35	.00	-2.35	.0000	n/a
31	Asbestos-Reinforced Plastics	-.73	.00	-.73	.0000	n/a
32	Missile Liner	-.69	.00	-.69	.0000	n/a
33	Sealant Tape	-1.63	.00	-1.63	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	-.10	7.55	7.45	76.7895	.10
37	Disc Brake Pads LMV (Aftermarket)	-.74	4.33	3.59	11.5777	.31
38	Mining and Milling	.00	7.31	7.31	.8457	8.65
	Total			510.40 *	208.6940	2.45

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

6000.2/ASB.2 PHASEout

REGULATORY IMPACT ANALYSIS OF CONTROLS ON ASBESTOS AND ASBESTOS PRODUCTS

ADDENDUM

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ASBESTOS RIA ADDENDUM

1. Introduction

This addendum to EPA's Regulatory Impact Analysis of Controls on Asbestos and Asbestos Products (January 19, 1989) presents estimates of the costs and benefits of the Agency's Final Rule concerning controls for asbestos and asbestos products.

The January 19, 1989, Regulatory Impact Analysis (RIA) presents in detail the theoretical approach, data inputs, computer simulation models, and background studies and analyses conducted in the course of developing estimates of the costs and benefits of the Agency's Final Rule. The Regulatory Alternatives examined quantitatively in the January 19, 1989, RIA consist of 14 different control options or combinations of control options ranging from immediate bans of all asbestos products to combinations of phase-downs, product bans, and exemptions of some products. The estimated costs and benefits of those 14 Regulatory Alternatives were provided to EPA decision makers (and to the public) to assist in determining the appropriate characteristics of the Final Rule.

Based on the methods, data inputs, computer simulation models, and background studies presented in the RIA, this Addendum to the RIA presents the costs and benefits of the Agency's Final Rule and the sensitivity of the costs and benefits to alternative assumptions concerning key inputs to the calculations. The Addendum is organized into two sections and two appendices as follows:

- Section 2 describes the Agency's Final Rule and the conditions and assumptions that define the Agency's estimates of the costs and benefits of the regulatory alternative adopted in the Final Rule;

- Section 3 presents the estimated costs and benefits of the Final Rule under several sets of alternative assumptions concerning important inputs to the calculations;
- Appendix I contains the source code for the latest version of the asbestos regulatory cost simulation model (ARCM); and
- Appendix II contains the source code for the latest version of the asbestos benefits simulation model (ABM).

2. The Final Rule and the Main Analysis Assumptions

The Final Rule for controlling asbestos and asbestos products consists of a three (3) stage ban of certain asbestos products. The analysis and results presented in the RIA and in this Addendum are based on the simulation period starting in 1987 because the vintage of the most recent data concerning products and substitutes available to the Agency is 1986. Hence, the dates of the staged bans in this analysis are 1987, 1991, and 1994. In the Final Rule, the staged ban dates are 1990, 1994, and 1997.

Table 1 contains a list of asbestos product categories and associated identification codes. Note that product categories 5 and 27 have been redefined as four distinct product categories (5, 27, 38, and 39) for this analysis. The basis for this division of product categories 5 and 27 is discussed below.

Based on these product definitions and codes, the product categories banned in each stage of the Final Rule are as follows:

Stage	Year	Banned Products' Identification Numbers
I	1987	4, 7, 9, 12, 15, 16, and 25
II	1991	5, 18, 19, 20, 22, 23, 24, and 27
III	1994	1, 2, 3, 10, 11, 14, 17, 21, 29, 30, 36, and 37

TABLE 1. ASBESTOS PRODUCT CATEGORIES AND DESCRIPTIONS

Product #	Product Description
1	Commercial Paper
2	Rollboard
3	Millboard
4	Pipeline Wrap
5	Beater-Add Gaskets
6	High Grade Electrical Paper
7	Roofing Felt
8	Acetylene Cylinders
9	Flooring Felt
10	Corrugated Paper
11	Specialty Paper
12	V/A Floor Tile
13	Asbestos Diaphragms
14	A/C Pipe
15	A/C Sheet, Flat
16	A/C Sheet, Corrugated
17	A/C Shingles
18	Drum Brake Linings (OEM)
19	Disc Brake Pads LMV (OEM)
20	Disc Brake Pads HV
21	Brake Blocks
22	Clutch Facings
23	Automatic Trans. Components
24	Friction Materials
25	Asbestos Protective Clothing
26	Asbestos Thread, Yarn, etc.
27	Sheet Gaskets
28	Asbestos Packing
29	Roof Coatings
30	Non-Roofing Coatings
31	Asbestos-Reinforced Plastics
32	Missile Liner
33	Sealant Tape
34	Battery Separators
35	Arc Chutes
36	Drum Brake Linings (Aftermarket)
37	Disc Brake Pads LMV (Aftermarket)
38	Beater-Add Gaskets/2
39	Sheet Gaskets/PTFE
**	Mining and Milling

All other product categories listed in Table 1 are not subject to the bans under the Final Rule. The Final Rule is thus very similar to the RIA's Alternative "FX" except that the timing of the bans for some product categories is different and some product categories banned under Alternative "FX" are not banned under the Final Rule.

Four of the asbestos product categories in Table 1 are defined somewhat differently from their definitions in the RIA. In particular, products 5 and 38 together form the original product category 5 in the RIA, and products 27 and 39 similarly form the original product 27 in the RIA. These two product categories have been divided in this analysis based on substitution possibilities and exposure considerations into (a) segments that are subject to the bans under the Rule and (b) portions that are not banned under the Rule. The segments that remain under the original product category definitions 5 and 27 are subject to the bans, while the portions now referred to as product categories 38 and 39 are not subject to the bans. Table 2 shows the reorganization of the original product categories 5 and 27 into the new categories 5, 27, 38, and 39 based on the substitutes associated with different segments of the original aggregated markets 5 and 27. The reorganization of these two product categories as shown in Table 2 is guided by the nature of the potential substitutes for each market segment. However, the market segments are composed of various specialty industrial uses of asbestos for which substitution may be difficult at present, very costly, and for which exposures are likely to be low. Hence, the substitutes listed represent these sets of specialty uses which have been exempted from the bans of the Final Rule.

TABLE 2. REORGANIZATION OF BEATER-ADD GASKETS AND SHEET GASKETS MARKETS

New Market	Uses/ Substitutes Included	Market Share of Uses/Substitute Original Market	Market Share of Uses/Substitute New Market
5. Beater-Add Gaskets			
	Cellulose	25%	29.42%
	Aramid	30%	35.29%
	Fibrous Glass	20%	23.53%
	Graphite	10%	11.76%
		-----	---------
		85%	100.00%
38. Beater-Add Gaskets/2			
	PTFE	10%	66.67%
	Ceramic	5%	33.33%
		-----	---------
		15%	100.00%
27. Sheet Gaskets			
	Cellulose	15%	16.67%
	Aramid	30%	33.33%
	Fibrous Glass	25%	27.78%
	Graphite	15%	16.67%
	Ceramic	5%	5.55%
		-----	---------
		90%	100.00%
39. Sheet Gaskets/PTFE			
	PTFE	10%	100.00%

Source: Based on information in Appendix F -- Use and Substitutes Analysis, Volume III, Regulatory Impact Analysis of Controls on Asbestos and Asbestos Products, January 19, 1989.

The RIA presents the theoretical approach, computer simulation procedures, input data, and background studies that underlie the estimates of the costs and benefits of the regulatory alternatives examined in the RIA and of the Final Rule presented in this Addendum. Hence, these will not be reviewed, only referenced, in this Addendum with the exception of the small number of additions and/or revisions of input data and baseline assumptions used in this analysis of the Final Rule that differ from those published in the RIA.

The theoretical approach for estimating the costs and benefits of the Final Rule is that presented in Chapter 2 of the RIA. In addition, the computer simulation models for estimating the costs and benefits of regulatory alternatives for asbestos products are virtually the same as those contained in the RIA.* The most recent computer simulation model codes are contained in appendices to this Addendum.

The input data for estimating the costs and benefits of the Final Rule for asbestos and asbestos products include exposure and dose-response information, product quantity and use data, and product characteristics and substitutes information. In the estimates of the costs and benefits of the Final Rule, virtually all of these input data are as reported in the RIA and its appendices. Hence, only differences between the input information presented in the RIA and its appendices and those that underlie the cost and benefit estimates of the Final Rule presented in this Addendum are reviewed here.

* No changes were made in the approach to estimating costs and benefits of regulation. Some changes in detail were made to the regulatory cost model to simulate variations in the originally proposed regulatory alternatives.

Concerning the basic input data presented in the RIA, a few revisions were made to the product market quantity and/or benefit data for certain markets. The markets and the relevant adjustments are described below:

- Beater-Add Gaskets and Sheet Gaskets: Markets 5 (Beater-Add Gaskets) and 27 (Sheet Gaskets) were each split into two segments based on the nature of uses and substitution possibilities, as discussed above and as shown in Table 2. The non-banned portions of these two markets consist of specialty industrial uses for which substitution is difficult and potentially expensive and for which exposures are likely to be low. These specialty uses are identified by the market shares of several potential substitutes. The quantity in the original Beater-Add Gaskets market is split in the ratio of 85:15 for the new market 5 (Beater-Add Gaskets) and market 38 (Beater-Add Gaskets/2), respectively, based on the market shares of the substitutes which identify specialty industrial uses in the original Beater-Add Gaskets market. Similarly, the quantity in the original Sheet Gaskets market is split in a ratio of 90:10 for the reorganized market 27 (Sheet Gaskets) and market 39 (Sheet Gaskets/PTFE), respectively. The exposure data were also adjusted -- the same ratios were applied to occupational populations exposed and the non-occupational exposure levels (number of fibers breathed per year) to obtain the appropriate exposure figures for the four new markets. Table 3 shows the new quantity and exposure information for these markets.

- Glutch Facings: Occupational exposure estimates for clutch repair were not included in the RIA because no data were available on exposures during clutch repair. Additional information has been obtained, allowing the estimation of the levels of asbestos to which workers are exposed while repairing clutches and the full-time equivalent (FTE) population associated with asbestos clutch repair.* Occupational exposure to asbestos during clutch repair is estimated to be 0.15 fibers/cc and the FTE population is estimated to range from 406 to 543 persons. This translates to 390 million fibers per year [0.15 fibers/cc x 1.3 (breathing rate) x 8 hours/day x 250 days/year] and an FTE population of 475 persons (the average of 406 and 543). The estimates for clutch rebuilding are 73 million fibers per year and an FTE population of 125 persons (shown in Table III-5 of the RIA). Therefore, the exposure inputs for

* ICF Incorporated, 1989, "Exposure and Population Estimates for Clutch Repair." Memorandum to Dr. Kin Wong, EPA from Nora Zirps and Maravene Edelstein, ICF Incorporated, dated February 21, 1989.

TABLE 3. QUANTITY AND EXPOSURE INFORMATION FOR THE REORGANIZED BEATER-ADD GASKETS AND SHEET GASKETS MARKETS[a]

	Original Beater-Add Gaskets Market		Original Sheet Gaskets Market	
	5. Beater-Add Gaskets	38. Beater-Add Gaskets/2	27. Sheet Gaskets	39. Sheet Gaskets/PTFE
Quantity (tons)	14,029.25	2,475.75	3,246,667.2	360,740.8
Occupational Exposure				
Primary Manufacturing				
No. of People	199.75	35.25	150.3	16.7
Million Fibers/Year	110	110	208	208
Secondary Manufacturing				
No. of People	1,101.6	194.4	796.5	88.5
Million Fibers/Year	57	57	276	276
Installation of Products[b]				
No. of People	45,404.45	8,012.55	5,166.9	574.1
Million Fibers/Year	57	57	276	276
Repair & Disposal of Products[b]				
No. of People	45,404.45	8,012.55	5,166.9	574.1
Million Fibers/Year	57	57	276	276
Non-occupational Exposure				
Primary Manufacturing				
No. of People	37,082,888	37,082,888	43,468,616	43,468,616
Million Fibers/Year	0.031705	0.005595	0.00549	0.000561
Use of Products[b]				
No. of People	171,136,373	171,136,373	171,136,373	171,136,373
Million Fibers/Year	0.000317128	0.000055964	0.000146879	0.00001632

[a] Only those exposure settings are shown in this table for which data exists for any of the markets.

[b] Data for this category are estimated based on analogous exposure settings for product categories for which exposure information exists. For details see Appendix A.6 in Volume II of the Regulatory Impact Analysis of Controls on Asbestos and Asbestos Products, January 19, 1989.

clutch facings in the repair and disposal category are an FTE population of 548 persons (475 + 73) and 355 million fibers per year [(475 x 390 + 73 x 125) / (475 + 73)].

In addition to these few revisions of input data and assumptions, EPA has identified a set of conditions and assumptions concerning market demands, exposure to asbestos, and asbestos product substitute costs which, with the other input data contained in the RIA, form the basis for the cost and benefit estimates of the Final Rule presented in this Addendum. The important characteristics of the estimates that are relevant include 1) future growth or decline of demand for each asbestos product, 2) inclusion of occupational exposures to asbestos that are suspected or known, but for which there are no direct quantitative measurements, and 3) the future course of the prices of asbestos and asbestos product substitutes.

EPA has adopted the "Low Decline" baseline set of product growth rates presented in the RIA for this analysis of the Final Rule. These are presented in the RIA in Chapter 3 and in the RIA's Appendix A-1. In general, the "Low Decline" baseline set of assumptions projects no change in the future consumption of asbestos products relative to the present. Because most empirical evidence indicates a fall in asbestos product consumption over time, use of the "Low Decline" baseline tends to overstate the costs of the Final Rule.

EPA has also determined that (1) the exposed populations and fiber concentrations presented in Chapter 3 (subject to the modifications presented above) and (2) the additional occupational exposure information for certain product categories and exposure settings for which no quantitative exposure data were available, as outlined in Chapter 4 of the RIA, are appropriate inputs for this analysis of the Final Rule. Chapter 3 (Tables III-1 through III-5) of the RIA presents estimates of the number of people exposed and their associated annual exposure levels for five exposure settings. These are reproduced here (with the modifications discussed above) in Tables 4 through 8.

Chapter 4 of the RIA (Tables IV-6 through IV-9) and Appendix A-6 of the RIA present additional exposure information for some product categories and exposure settings. In particular, for occupational products and settings for which no quantitative information concerning releases and exposures was available -- occupational exposures in manufacturing, installation, and repair and disposal -- exposures were estimated based on analogous exposures for product categories for which exposure information exists. This procedure for estimating occupational exposures was conducted for one product's manufacturing stage, eight products' repair and disposal stage, and nine products' installation stage. The basic rationale for this procedure is that similar activities involving roughly comparable probable exposure paths and concentrations are likely to result in similar exposures. Tables 9 through 11 tabulate the additional occupational exposure information developed for this analysis for these three different exposure settings (primary manufacturing, installation, and repair and disposal).

The quantitative information on exposures listed in Tables 4 through 8 and the additional occupational exposures listed in Tables 9 through 11 are the exposure estimates used for most of this analysis of the Final Rule. One sensitivity analysis reported in this Addendum, however, also allows for additional information in non-occupational exposure settings for which data did not exist but in which exposures are likely. These additional non-

TABLE 4. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO PRIMARY MANUFACTURING PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

		Occupational		Non-occupational	
		No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1.	Commercial Paper				
2.	Rollboard				
3.	Millboard	12	145	5,747,875	0.0232
4.	Pipeline Wrap	35	134	4,847,937	0.0476
5.	Beater-Add Gaskets	199.75	110	37,082,888	0.031705
6.	High-grade Elect. Paper	27	113	254,772	0.405
7.	Roofing Felt				
8.	Acetylene Cylinders	206			
9.	Flooring Felt				
10.	Corrugated Paper				
11.	Specialty Paper	2	111		
12.	V/A Floor Tile				
13.	Diaphragms	650	87	19,744,593	0.00000185
14.	A/C Pipe	286	270	3,313,602	0.167
15.	A/C Flat Sheet	53	478	21,232,368	0.0218
16.	A/C Corrugated Sheet				
17.	A/C Shingles	11	473	891,143	0.00361
18.	Drum Brake Linings (OEM)	421	385	9,292,154	0.0575
19.	Disc Brake Pads, LMV (OEM)	140	390	3,681,659	0.0214
20.	Disc Brake Pads, HV	15	385	1,704,883	0.000000827
21.	Brake Blocks	283	377	9,785,424	0.00388
22.	Clutch Facings	239	406	8,761,571	0.0027
23.	Auto. Transmiss. Comp.	11	113		
24.	Friction Materials	191	398	12,922,247	0.00234
25.	Protective Clothing				
26.	Thread, yarn etc.	78	457	16,306,866	0.00214
27.	Sheet Gaskets	150.3	208	43,468,616	0.00549
28.	Asbestos Packings	9	198	7,031,484	0.0000534
29.	Roof Coatings	582	273	84,570,429	0.00233
30.	Non-Roofing Coatings	553	220	70,389,388	0.0000394
31.	Asb. Reinforced Plastics	157	164	19,925,386	0.0018
32.	Missile Liners	380	220		
33.	Sealant Tape	134	220		
34.	Battery Separators	207			
35.	Arc Chutes	2			
36.	Drum Brake Linings (A/M)	1,144	385	25,249,953	0.0575
37.	Disc Brake Pads, LMV (A/M)	776	390	20,383,263	0.0214
38.	Beater-Add Gaskets/2	35.25	110	37,082,888	0.005595
39.	Sheet Gaskets/PTFE	16.7	208	43,468,616	0.000561
**	Mining and Milling	155	121	841,214	0.407

TABLE 5. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO SECONDARY MANUFACTURING PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	448	57		
4. Pipeline Wrap				
5. Beater-Add Gaskets	1,101.6	57		
6. High-grade Elect. Paper	30	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	149	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)	731	125		
19. Disc Brake Pads, LMV (OEM)	46	146		
20. Disc Brake Pads, HV				
21. Brake Blocks	19	127		
22. Clutch Facings	48	166		
23. Auto. Transmiss. Comp.				
24. Friction Materials	28	195		
25. Protective Clothing				
26. Thread, yarn etc.	208	408		
27. Sheet Gaskets	896.5	276		
28. Asbestos Packings	25	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics	529	239		
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	1,988	125		
37. Disc Brake Pads, LMV (A/M)	254	146		
38. Beater-Add Gaskets/2	194.4	57		
39. Sheet Gaskets/PTFE	88.5	276		
** Mining and Milling				

TABLE 6. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO INSTALLATION OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-Add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	396	439	171,136,373	0.000018
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	933	296	171,136,373	0.0000264
15. A/C Flat Sheet	49	723	171,136,373	0.00000298
16. A/C Corrugated Sheet	7	723	171,136,373	0.00000043
17. A/C Shingles	323	130	171,136,373	0.00000052
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings			210,250	1.04
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Beater-Add Gaskets/2				
39. Sheet Gaskets/PTFE				
** Mining and Milling				

TABLE 7. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO USE OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-Add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)			60,943,018	0.00058
19. Disc Brake Pads, LMV (OEM)			34,659,752	0.00064
20. Disc Brake Pads, HV				
21. Brake Blocks			226,546,000	0.0061
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)			165,602,982	0.00058
37. Disc Brake Pads, LMV (A/M)			191,886,248	0.00064
38. Beater-Add Gaskets/2				
39. Sheet Gaskets/PTFE				
** Mining and Milling				

TABLE 8. EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO REPAIR/DISPOSAL OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-Add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt	263	296	171,136,373	0.0000067
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet	61	2,080	171,136,373	0.0000173
16. A/C Corrugated Sheet	9	2,080	171,136,373	0.0000025
17. A/C Shingles	225	244	171,136,373	0.0000067
18. Drum Brake Linings (OEM)			49,442,265	0.0123
19. Disc Brake Pads, LMV (OEM)			27,453,272	0.00624
20. Disc Brake Pads, HV	117	390	170,871,494	0.000000587
21. Brake Blocks	3,985	388	170,871,494	0.0000171
22. Clutch Facings	548	355		
23. Auto. Transmiss. Comp.				
24. Friction Materials	43	120		
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	86,398	378	134,351,509	0.0123
37. Disc Brake Pads, LMV (A/M)	32,568	386	151,989,122	0.00624
38. Beater-Add Gaskets/2				
39. Sheet Gaskets/PTFE				
** Mining and Milling				

TABLE 9. ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS FOR PRIMARY MANUFACTURING

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-Add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt				
8. Acetylene Cylinders		200		
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Beater-Add Gaskets/2				
39. Sheet Gaskets/PTFE				
** Mining and Milling				

TABLE 10. ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS FOR INSTALLATION OF PRODUCTS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	20	57		
4. Pipeline Wrap	2,725	52		
5. Beater-Add Gaskets	45,404.45	57		
6. High-grade Elect. Paper	300	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	350	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets	5,166.9	276		
28. Asbestos Packings	2	276		
29. Roof Coatings				
30. Non-Roofing Coatings	1,780	364		
31. Asb. Reinforced Plastics				
32. Missile Liners	260	57		
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Beater-Add Gaskets/2	8,012.55	57		
39. Sheet Gaskets/PTFE	574.1	276		
** Mining and Milling				

TABLE 11. ADDITIONAL OCCUPATIONAL EXPOSURE ASSUMPTIONS FOR REPAIR/DISPOSAL OF PRODUCTS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	20	57		
4. Pipeline Wrap	2,725	18		
5. Beater-Add Gaskets	45,404.45	57		
6. High-grade Elect. Paper	300	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	350	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	1,458	296		
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets	5,166.9	276		
28. Asbestos Packings	2	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Beater-Add Gaskets/2	8,012.55	57		
39. Sheet Gaskets/PTFE	574.1	276		
** Mining and Milling				

occupational exposures were derived by assuming that one-tenth of one percent of the asbestos content of the product is released over the total life of the product. These releases are caused by normal weathering of products or by various activities, such as cutting, sawing, and sanding that occur to the products in the course of their use. Table 12 presents these additional non-occupational exposure assumptions.

The assumptions and numerical calculations used to derive the additional occupational and non-occupational exposures are described in Appendix A-6 of the RIA in greater detail.*

Based on both the original set of occupational and non-occupational exposures and fiber concentrations (Tables 4 through 8 above) in the RIA and the additional exposures for occupational settings (Tables 9 through 11 above) described in the RIA and in this Addendum, Tables 13 through 17 present the combined estimates of exposed populations and asbestos fiber concentrations used in developing the cost and benefit estimates of the Final Rule. Cost and benefit estimates of the Final Rule based on only the original occupational and non-occupational exposures and concentrations (as reported in the RIA and modified for this analysis as outlined above) are presented as a sensitivity analysis in this Addendum as are estimates based on all of the quantitative information and additional exposure information for both occupational and non-occupational settings.

The third major characteristic of the Agency's estimates of the costs and benefits of the Final Rule is the assumption that prices of substitutes

* The RIA appendix describes additional non-occupational exposure assumptions for a one percent release rate. The one-tenth of one percent assumption described here supercedes the RIA's assumption.

TABLE 12. ADDITIONAL NON-OCCUPATIONAL EXPOSURE ASSUMPTIONS FOR USE OF PRODUCTS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard			171,136,373	0.000002615
4. Pipeline Wrap			171,136,373	0.000008025
5. Beater-Add Gaskets			171,136,373	0.000317128
6. High-grade Elect. Paper			171,136,373	0.0000372
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe			171,136,373	0.000098058
15. A/C Flat Sheet			171,136,373	0.000015473
16. A/C Corrugated Sheet			171,136,373	0.00000165
17. A/C Shingles			171,136,373	0.000014599
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV			171,136,373	0.000035285
21. Brake Blocks				
22. Clutch Facings			171,136,373	0.000029745
23. Auto. Transmiss. Comp.				
24. Friction Materials			171,136,373	0.000481319
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets			171,136,373	0.000146879
28. Asbestos Packings			171,136,373	0.00001872
29. Roof Coatings			171,136,373	0.000443328
30. Non-Roofing Coatings			171,136,373	0.000044266
31. Asb. Reinforced Plastics			171,136,373	0.000121815
32. Missile Liners				
33. Sealant Tape			171,136,373	0.000012691
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Beater-Add Gaskets/2			171,136,373	0.000055964
39. Sheet Gaskets/PTFE			171,136,373	0.00001632
** Mining and Milling				

TABLE 13. MAIN ANALYSIS EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO PRIMARY MANUFACTURING PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	12	145	5,747,875	0.0232
4. Pipeline Wrap	35	134	4,847,937	0.0476
5. Beater-Add Gaskets	199.75	110	37,082,888	0.031705
6. High-grade Elect. Paper	27	113	254,772	0.405
7. Roofing Felt				
8. Acetylene Cylinders	206	200		
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	2	111		
12. V/A Floor Tile				
13. Diaphragms	650	87	19,744,593	0.00000185
14. A/C Pipe	286	270	3,313,602	0.167
15. A/C Flat Sheet	53	478	21,232,368	0.0218
16. A/C Corrugated Sheet				
17. A/C Shingles	11	473	891,143	0.00361
18. Drum Brake Linings (OEM)	421	385	9,292,154	0.0575
19. Disc Brake Pads, LMV (OEM)	140	390	3,681,659	0.0214
20. Disc Brake Pads, HV	15	385	1,704,883	0.000000827
21. Brake Blocks	283	377	9,785,424	0.00388
22. Clutch Facings	239	406	8,761,571	0.0027
23. Auto. Transmiss. Comp.	11	113		
24. Friction Materials	191	398	12,922,247	0.00234
25. Protective Clothing				
26. Thread, yarn etc.	78	457	16,306,866	0.00214
27. Sheet Gaskets	150.3	208	43,468,616	0.00549
28. Asbestos Packings	9	198	7,031,484	0.0000534
29. Roof Coatings	582	273	84,570,429	0.00233
30. Non-Roofing Coatings	553	220	70,389,388	0.0000394
31. Asb. Reinforced Plastics	157	164	19,925,386	0.0018
32. Missile Liners	380	220		
33. Sealant Tape	134	220		
34. Battery Separators	207			
35. Arc Chutes	2			
36. Drum Brake Linings (A/M)	1,144	385	25,249,953	0.0575
37. Disc Brake Pads, LMV (A/M)	776	390	20,383,263	0.0214
38. Beater-Add Gaskets/2	35.25	110	37,082,888	0.005595
39. Sheet Gaskets/PTFE	16.7	208	43,468,616	0.000561
** Mining and Milling	155	121	841,214	0.407

TABLE 14. MAIN ANALYSIS EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO SECONDARY MANUFACTURING PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	448	57		
4. Pipeline Wrap				
5. Beater-Add Gaskets	1,101.6	57		
6. High-grade Elect. Paper	30	57		
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	149	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)	731	125		
19. Disc Brake Pads, LMV (OEM)	46	146		
20. Disc Brake Pads, HV				
21. Brake Blocks	19	127		
22. Clutch Facings	48	166		
23. Auto. Transmiss. Comp.				
24. Friction Materials	28	195		
25. Protective Clothing				
26. Thread, yarn etc.	208	408		
27. Sheet Gaskets	896.5	276		
28. Asbestos Packings	25	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics	529	239		
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	1,988	125		
37. Disc Brake Pads, LMV (A/M)	254	146		
38. Beater-Add Gaskets/2	194.4	57		
39. Sheet Gaskets/PTFE	88.5	276		
** Mining and Milling				

TABLE 15. MAIN ANALYSIS EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO INSTALLATION OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	20	57		
4. Pipeline Wrap	2,725	52		
5. Beater-Add Gaskets	45,404.45	57		
6. High-grade Elect. Paper	300	57		
7. Roofing Felt	396	439	171,136,373	0.000018
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	350	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	933	296	171,136,373	0.0000264
15. A/C Flat Sheet	49	723	171,136,373	0.00000298
16. A/C Corrugated Sheet	7	723	171,136,373	0.00000043
17. A/C Shingles	323	130	171,136,373	0.00000052
18. Drum Brake Linings (OEM)				
19. Disc Brake Pads, LMV (OEM)				
20. Disc Brake Pads, HV				
21. Brake Blocks				
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets	5,166.9	276		
28. Asbestos Packings	2	276		
29. Roof Coatings			210,250	1.04
30. Non-Roofing Coatings	1,780	364		
31. Asb. Reinforced Plastics				
32. Missile Liners	260	57		
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)				
37. Disc Brake Pads, LMV (A/M)				
38. Beater-Add Gaskets/2	8,012.55	57		
39. Sheet Gaskets/PTFE	574.1	276		
** Mining and Milling				

TABLE 16. MAIN ANALYSIS EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO USE OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard				
4. Pipeline Wrap				
5. Beater-Add Gaskets				
6. High-grade Elect. Paper				
7. Roofing Felt				
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper				
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe				
15. A/C Flat Sheet				
16. A/C Corrugated Sheet				
17. A/C Shingles				
18. Drum Brake Linings (OEM)			60,943,018	0.00058
19. Disc Brake Pads, LMV (OEM)			34,659,752	0.00064
20. Disc Brake Pads, HV				
21. Brake Blocks			226,546,000	0.0061
22. Clutch Facings				
23. Auto. Transmiss. Comp.				
24. Friction Materials				
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets				
28. Asbestos Packings				
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)			165,602,982	0.00058
37. Disc Brake Pads, LMV (A/M)			191,886,248	0.00064
38. Beater-Add Gaskets/2				
39. Sheet Gaskets/PTFE				
** Mining and Milling				

TABLE 17. MAIN ANALYSIS EXPOSURE LEVELS (IN MILLIONS FIBERS INHALED PER YEAR) AND NUMBER OF PERSONS EXPOSED TO REPAIR/DISPOSAL OF PRODUCTS FOR OCCUPATIONAL AND NON-OCCUPATIONAL SETTINGS

	Occupational		Non-occupational	
	No. of People	Mil. Fib./Yr	No. of People	Mil. Fib./Yr
1. Commercial Paper				
2. Rollboard				
3. Millboard	20	57		
4. Pipeline Wrap	2,725	18		
5. Beater-Add Gaskets	45,404.45	57		
6. High-grade Elect. Paper	300	57		
7. Roofing Felt	263	296	171,136,373	0.0000067
8. Acetylene Cylinders				
9. Flooring Felt				
10. Corrugated Paper				
11. Specialty Paper	350	57		
12. V/A Floor Tile				
13. Diaphragms				
14. A/C Pipe	1,458	296		
15. A/C Flat Sheet	61	2,080	171,136,373	0.0000173
16. A/C Corrugated Sheet	9	2,080	171,136,373	0.0000025
17. A/C Shingles	225	244	171,136,373	0.0000067
18. Drum Brake Linings (OEM)			49,442,265	0.0123
19. Disc Brake Pads, LMV (OEM)			27,453,272	0.00624
20. Disc Brake Pads, HV	117	390	170,871,494	0.000000587
21. Brake Blocks	3,985	388	170,871,494	0.0000171
22. Clutch Facings	548	355		
23. Auto. Transmiss. Comp.				
24. Friction Materials	43	120		
25. Protective Clothing				
26. Thread, yarn etc.				
27. Sheet Gaskets	5,166.9	276		
28. Asbestos Packings	2	276		
29. Roof Coatings				
30. Non-Roofing Coatings				
31. Asb. Reinforced Plastics				
32. Missile Liners				
33. Sealant Tape				
34. Battery Separators				
35. Arc Chutes				
36. Drum Brake Linings (A/M)	86,398	378	134,351,509	0.0123
37. Disc Brake Pads, LMV (A/M)	32,568	386	151,989,122	0.00624
38. Beater-Add Gaskets/2	8,012.55	57		
39. Sheet Gaskets/PTFE	574.1	276		
** Mining and Milling				

for asbestos and asbestos products will decline over time at a rate of one percent per year. Substantial empirical evidence for downward trends in prices due to "experience" exists. The basis for this assumption is the empirical observation in the business and economics literature of both economies of scale and experience curves (both of which lead to reduced costs of and prices for goods over time).* Economies of scale occur when as the volume of production rises, the average cost of production falls. In the case of substitutes for asbestos and asbestos products, many alternatives to asbestos would experience substantial increases in production volume over time under the bans of the Final Rule. Experience in producing goods also tends to reduce costs of production over time through "know-how" and other efficiencies that are discovered only through actually producing a product.

The empirical literature on "experience curves" demonstrates that accumulated production experience can generate reduced costs over time depending on the rate of increase of production volume experience and that these cost reductions are fairly consistent from industry to industry. Thompson (1981)** indicates that in 190 studies, rates of decline of value added with a doubling of production experience varied from 12 percent in automobile production, 15 percent in color television production, to 40 to 50

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* Recent articles concerning pricing, costs, and the experience (or learning) curve include Bass, Frank M., "The Relationship Between Diffusion Rates, Experience Curves, and Demand Elasticities for Consumer Durable Technological Innovations," Journal of Business, Part 2, July 1980; and Lieberman, Marvin B., "The Learning Curve and Pricing in the Chemical Processing Industries," Rand Journal of Economics, Summer 1984.

** Thompson, Donald N., "The Experience Curve Effect on Costs and Prices: Implications for Public Policy", in Regulation of Marketing and the Public Interest: Essays in Honor of Ewald T. Grether, eds., Balderson, F.E., J.M. Carman, and F.M. Nicosia.

percent in semiconductors and integrated circuits. Thus, the one percent decline of prices for substitutes for asbestos is fairly conservative. Although this may overestimate the rate of decline for some products that have been in existence for some time, it may substantially underestimate the rate of decline of prices for other, newer products or products with new applications. A sensitivity analysis based on the assumption of no decline of asbestos product substitute prices is provided in this Addendum.

Another sensitivity analysis uses a methodology different from that of the main analysis to calculate the impact of OSHA's 0.2 f/cc PEL on occupational exposures. The main analysis assumes that exposures that were above the PEL have been lowered to the PEL and that exposures that were below the PEL have not been changed. This approach does not explicitly account for non-compliance with OSHA's standard, but it implicitly accommodates the possibility of non-compliance because the 0.2 f/cc level to which previously high exposures are assumed to be lowered may be seen as an average between work places that have brought exposures below the PEL by some margin and work places that remain above the PEL (and out of compliance). The sensitivity analysis explicitly accounts for non-compliance by assuming that most work places have lowered exposures to the levels that OSHA predicted its analysis for the PEL, but that a few asbestos work places do not comply with the PEL. OSHA assumed that those complying with the PEL will reduce their workplace exposures significantly below the standards to ensure compliance. OSHA's analysis adjusted all exposures in its data base that were at or above 0.2 f/cc to 0.15 f/cc in cases where OSHA assumed that engineering controls were used. In cases where OSHA assumed that respirators were used, OSHA reduced the exposures by a factor equal to the effective protection factor of the respirator. OSHA assumed that exposures below 0.2 f/cc would be reduced by 20 percent due to engineering controls*.

OSHA did not factor non-compliance into its analysis of the costs and benefits of the PEL because with non-compliance both costs and benefits decline in proportion, leaving cost-benefit ratios unchanged. On the other hand, EPA's assessment of the costs and benefits of this rule is affected by non-compliance with the OSHA PEL. Therefore, a non-compliance rate of 2 percent (a relatively low rate compared to non-compliance rates in other Federal health and environmental regulatory settings) is assumed in conjunction with the OSHA fiber level adjustments. The exposure level in non-complying work places is assumed to 1.99 f/cc, the average exposure of work places above the PEL according to OSHA compliance data.** The weighted average of the 1.99 fibers/cc concentration for non-complying firms and the fiber levels that reflect the OSHA methodology for complying firms is then multiplied by the breathing rate, the number of hours per day, and the number of days per year for each product category (as presented in Appendix A.4 of the RIA). Tables 18 through 21 present the million fibers breathed per year for occupation exposure during primary manufacturing, secondary manufacturing, installation, and repair & disposal of products using the original estimates,

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* ICF Incorporated, 1989, "Effect of Applying OSHA's Methodology to EPA's Exposure Data to Estimate Post-0.2 f/cc PEL Exposure Levels." Memorandum to Dr. Kin Wong, EPA from Nora Zirps and Maravene Edelstein, ICF Incorporated, dated January 11, 1989.

** Environmental Protection Agency, 1988, "OSHA Compliance Data for Asbestos." Memorandum to John Rigby, Chemical Control Division, EPA from Kin Wong, Chemical Engineering Branch, Economics & Technology Division, EPA, dated August 1, 1988.

TABLE 18. EXPOSURE LEVELS BASED ON OSHA METHODOLOGY AND NON-COMPLIANCE WITH ASBESTOS PEL DURING PRIMARY MANUFACTURING

		million fibers/year		
	Product Category	Main Analysis	OSHA Estimates	OSHA Estimates with 2% Non-compliance
1.	Commercial Paper			
2.	Rollboard			
3.	Millboard	145	113.03	197.28
4.	Pipeline Wrap	134	104.52	185.63
5.	Beater-Add Gaskets	110	86.99	169.69
6.	High-grade Electrical Paper	113	90.33	172.14
7.	Roofing Felt			
8.	Acetylene Cylinders	200	160.00	239.58
9.	Flooring Felt			
10.	Corrugated Paper			
11.	Specialty Papers	111	90.33	172.14
12.	Vinyl-Asbestos Floor Tile			
13.	Asbestos Diaphragms	87	68.64	158.33
14.	Asbestos-Cement Pipe	270	210.60	309.87
15.	Flat A-C Sheets	478	361.40	457.65
16.	Corrugated A-C Sheets			
17.	A-C Shingles	473	358.80	455.10
18.	Drum Brake Linings (OEM)	385	288.60	386.31
19.	Disc Brake Pads, LMV (OEM)	390	293.80	391.40
20.	Disc Brake Pads (HV)	385	288.60	386.31
21.	Brake Blocks	377	286.00	383.76
22.	Clutch Facings	406	304.20	401.60
23.	Automatic Transmission Components	113	90.33	172.14
24.	Friction Materials	398	293.80	391.40
25.	Asbestos Protective Clothing			
26.	Asbestos Thread, Yarn, etc.	457	346.94	439.35
27.	Sheet Gasketing	208	161.20	261.46
28.	Asbestos Packing	198	153.40	253.81
29.	Roof Coatings and Cements	273	202.80	302.22
30.	Non-Roofing Coatings, etc.	220	164.32	243.82
31.	Asbestos-Reinforced Plastics	164	163.80	264.00
32.	Missile Liner	220	164.32	243.82
33.	Sealant Tape	220	164.32	243.82
34.	Battery Separators			
35.	Arc Chutes			
36.	Drum Brake Linings (A/M)	385	288.60	386.31
37.	Disc Brake Pads, LMV (A/M)	390	293.80	391.40
38.	Beater-Add Gaskets/2	110	86.99	169.69
39.	Sheet Gasketing/PTFE	208	161.20	261.46
**	Mining & Milling	121	135.20	235.98

TABLE 19. EXPOSURE LEVELS BASED ON OSHA METHODOLOGY AND NON-COMPLIANCE WITH ASBESTOS PEL DURING SECONDARY MANUFACTURING

	Product Category	million fibers/year		
		Main Analysis	OSHA Estimates	OSHA Estimates with 2% Non-compliance
1.	Commercial Paper			
2.	Rollboard			
3.	Millboard	57	46.80	149.34
4.	Pipeline Wrap			
5.	Beater-Add Gaskets	57	46.80	149.34
6.	High-grade Electrical Paper	57	46.80	149.34
7.	Roofing Felt			
8.	Acetylene Cylinders			
9.	Flooring Felt			
10.	Corrugated Paper			
11.	Specialty Papers	57	46.80	149.34
12.	Vinyl-Asbestos Floor Tile			
13.	Asbestos Diaphragms			
14.	Asbestos-Cement Pipe			
15.	Flat A-C Sheets			
16.	Corrugated A-C Sheets			
17.	A-C Shingles			
18.	Drum Brake Linings (OEM)	125	96.20	197.76
19.	Disc Brake Pads, LMV (OEM)	146	111.80	213.04
20.	Disc Brake Pads (HV)			
21.	Brake Blocks	127	96.20	197.76
22.	Clutch Facings	166	130.00	230.88
23.	Automatic Transmission Components			
24.	Friction Materials	195	150.80	251.26
25.	Asbestos Protective Clothing			
26.	Asbestos Thread, Yarn, etc.	408	317.20	414.34
27.	Sheet Gasketing	276	213.20	312.42
28.	Asbestos Packing	276	215.80	314.96
29.	Roof Coatings and Cements			
30.	Non-Roofing Coatings, etc.			
31.	Asbestos-Reinforced Plastics	239	182.00	281.84
32.	Missile Liner			
33.	Sealant Tape			
34.	Battery Separators			
35.	Arc Chutes			
36.	Drum Brake Linings (A/M)	125	96.20	197.76
37.	Disc Brake Pads, LMV (A/M)	146	111.80	213.04
38.	Beater-Add Gaskets/2	57	46.80	149.34
39.	Sheet Gasketing/PTFE	276	213.20	312.42
**	Mining & Milling			

TABLE 20. EXPOSURE LEVELS BASED ON OSHA METHODOLOGY AND NON-COMPLIANCE WITH ASBESTOS PEL DURING INSTALLATION OF PRODUCTS

	Product Category	million fibers/year		
		Main Analysis	OSHA Estimates	OSHA Estimates with 2% Non-compliance
1.	Commercial Paper			
2.	Rollboard			
3.	Millboard	57	45.60	148.17
4.	Pipeline Wrap	52	41.60	144.25
5.	Beater-Add Gaskets	57	45.60	148.17
6.	High-grade Electrical Paper	57	45.60	148.17
7.	Roofing Felt	439	44.20	146.80
8.	Acetylene Cylinders			
9.	Flooring Felt			
10.	Corrugated Paper			
11.	Specialty Papers	57	45.60	148.17
12.	Vinyl-Asbestos Floor Tile			
13.	Asbestos Diaphragms			
14.	Asbestos-Cement Pipe	296	296.40	393.95
15.	Flat A-C Sheets	723	811.20	898.46
16.	Corrugated A-C Sheets	723	811.20	898.46
17.	A-C Shingles	130	13.00	116.22
18.	Drum Brake Linings (OEM)			
19.	Disc Brake Pads, LMV (OEM)			
20.	Disc Brake Pads (HV)			
21.	Brake Blocks			
22.	Clutch Facings			
23.	Automatic Transmission Components			
24.	Friction Materials			
25.	Asbestos Protective Clothing			
26.	Asbestos Thread, Yarn, etc.			
27.	Sheet Gasketing	276	220.80	319.86
28.	Asbestos Packing	276	220.80	319.86
29.	Roof Coatings and Cements			
30.	Non-Roofing Coatings, etc.	364	291.20	388.86
31.	Asbestos-Reinforced Plastics			
32.	Missile Liner	57	45.60	148.17
33.	Sealant Tape			
34.	Battery Separators			
35.	Arc Chutes			
36.	Drum Brake Linings (A/M)			
37.	Disc Brake Pads, LMV (A/M)			
38.	Beater-Add Gaskets/2	57	45.60	148.17
39.	Sheet Gasketing/PTFE	276	220.80	319.86
**	Mining & Milling			

TABLE 21. EXPOSURE LEVELS BASED ON OSHA METHODOLOGY AND NON-COMPLIANCE WITH ASBESTOS PEL DURING REPAIR & DISPOSAL OF PRODUCTS

Product Category	Main Analysis (million fibers/year)	OSHA Estimates (million fibers/year)	OSHA Estimates with 2% Non-compliance (million fibers/year)
1. Commercial Paper			
2. Rollboard			
3. Millboard	57	45.60	148.17
4. Pipeline Wrap	18	14.40	117.59
5. Beater-add Gaskets	57	45.60	148.17
6. High-grade Electrical Paper	57	45.60	148.17
7. Roofing Felt	296	28.60	131.51
8. Acetylene Cylinders			
9. Flooring Felt			
10. Corrugated Paper			
11. Specialty Papers	57	45.60	148.17
12. Vinyl-Asbestos Floor Tile			
13. Asbestos Diaphragms			
14. Asbestos-Cement Pipe	296	236.80	335.54
15. Flat A-C Sheets	2,080	5.20	108.58
16. Corrugated A-C Sheets	2,080	5.20	108.58
17. A-C Shingles	244	23.40	126.41
18. Drum Brake Linings (OEM)			
19. Disc Brake Pads, LMV (OEM)			
20. Disc Brake Pads (HV)	390	312.00	409.24
21. Brake Blocks	388	309.40	406.69
22. Clutch Facings	355	283.40	381.21
23. Automatic Transmission Components			
24. Friction Materials	120	93.60	195.21
25. Asbestos Protective Clothing			
26. Asbestos Thread, Yarn, etc.			
27. Asbestos Sheet Gasketing	276	220.80	319.86
28. Asbestos Packing	276	220.80	319.86
29. Roof Coatings and Cements			
30. Non-Roofing Coatings, etc.			
31. Asbestos-Reinforced Plastics			
32. Missile Liner			
33. Sealant Tape			
34. Battery Separators			
35. Arc Chutes			
36. Drum Brake Linings (A/M)	378	301.60	399.05
37. Disc Brake Pads, LMV (A/M)	386	309.40	406.69
38. Beater-Add Gaskets/2	57	45.60	148.17
39. Sheet Gasketing/PTFE	276	220.80	319.86
** Mining & Milling			

the OSHA methodology, and assuming that two percent of all firm's will not comply with the asbestos PEL. The remaining exposure estimates do not change.

Finally, the Agency's assumptions for this analysis of the costs and benefits of the Final Rule also include data concerning the efficiencies of baghouses in collecting asbestos fibers. The baghouse efficiencies underlying the data presented earlier are part of the overall set of baseline assumptions for this analysis. A sensitivity analysis of the results for the Final Rule using an alternative set of baghouse efficiencies used by EPA's Office of Air and Radiation is provided in this Addendum.* These alternative baghouse efficiency estimates are higher than those used in the main analysis and hence, the estimated emissions under these alternative baghouse efficiency assumptions are lower. The Agency's main analysis assumptions and the alternative sensitivity case set of assumptions concerning baghouse efficiencies for different sets of products are presented in Table 22. The exposure estimates for this sensitivity analysis are obtained by multiplying the estimates for ambient fibers breathed per year in the main analysis by the adjustment factors shown in Table 22.**

3. Results and Sensitivity Analyses

The estimated costs and benefits of the Agency's Final Rule under the assumptions outlined above are presented in Tables 23 and 24. Table 23 presents the estimates based on three percent discounting for costs and no discounting for benefits, while Table 24 presents the costs and the benefits

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* EPA, "Asbestos Exposure Assessment", Revised Report, dated March 21, 1988.

** A sample calculation to derive the adjustment factors from the two sets of baghouse efficiencies is shown in Table 22.

TABLE 22. ALTERNATIVE BAGHOUSE EFFICIENCIES AND ADJUSTMENT FACTORS FOR NON-OCCUPATIONAL EXPOSURE DATA

Product Categories	Main Analysis Baghouse Efficiency	Air Office Baghouse Efficiency	Adjustment Factor for Non-occupational Exposure Data
Paper: 3, 4, 6, 7, 10, 11	99.67%	99.988%	12/330[a]
Coatings and Sealants: 29, 30	99.67%	99.987%	13/330
Packings and Gaskets: 5, 27, 28, 38, 39	99.67%	99.988%	12/330
Textiles: 26	99.67%	99.986%	14/330
A/C Pipe: 14	99.95%	99.986%	14/50
A/C Sheet: 15, 16, 17	99.95%	99.988%	12/50
Friction Materials: 18 - 24, 36, 37	99.95%	99.986%	14/50
Plastics: 31	99.95%	99.979%	21/50

[a] The adjustment factor is the relative inefficiency of the baghouses assumed by the Air Office and that assumed for the main analysis. The ambient (non-occupational) exposure data under the main analysis assumptions are multiplied by this factor to effect a reduction in the actual exposure for the sensitivity analysis because the Air Office assumes less inefficient baghouses (that is lesser ambient release of asbestos). The adjustment factor in this case is calculated as:

$$(100 - 99.988) \ / \ (100 - 99.67) = 0.012/0.33 = 12/330$$

TABLE 23. COST BENEFIT BY PRODUCT FOR ALTERNATIVE P - LOW DECLINE BASELINE (1987-2000)

(Main Analysis Assumptions)
(Substitute Prices Declining at 1% Annually)

(Costs Discounted at 3% and Benefits Discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.73	.00	3.73	.5822	6.41
4	Pipeline Wrap	1.06	.01	1.07	2.8635	.37
5	Beater-Add Gaskets	111.17	.03	111.20	28.3392	3.92
6	High Grade Electrical Paper	-.81	.00	-.81	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.5116	4.84
8	Acetylene Cylinders	-.50	.00	-.50	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.1430	-.01
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.06	.00	-1.06	.0000	n/a
14	A/C Pipe	92.36	35.67	128.03	4.3801	29.23
15	A/C Sheet, Flat	.99	1.38	2.37	1.0504	2.25
16	A/C Sheet, Corrugated	.29	.00	.29	.1435	2.04
17	A/C Shingles	16.98	6.59	23.57	.3197	73.71
18	Drum Brake Linings (OEM)	2.39	4.74	7.13	8.3800	.85
19	Disc Brake Pads LMV (OEM)	.10	3.46	3.56	.9927	3.59
20	Disc Brake Pads HV	.02	.31	.33	.2165	1.53
21	Brake Blocks	-.04	1.99	1.95	10.0943	.19
22	Clutch Facings	12.05	.81	12.87	1.3838	9.30
23	Automatic Trans. Components	.09	.13	.22	.0005	464.74
24	Friction Materials	.25	1.86	2.11	.5244	4.01
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.92	.00	-.92	.0000	n/a
27	Sheet Gaskets	90.22	6.30	96.52	14.2005	6.80
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	45.03	.46	45.48	1.4882	30.56
30	Non-Roofing Coatings	-.07	.88	.81	1.8413	.44
31	Asbestos-Reinforced Plastics	-.80	.00	-.80	.0000	n/a
32	Missile Liner	-.76	.00	-.76	.0000	n/a
33	Sealant Tape	-1.80	.00	-1.80	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	1.24	7.55	8.79	106.2551	.08
37	Disc Brake Pads LMV (Aftermarket)	-.39	4.33	3.94	15.8541	.25
38	Beater-Add Gaskets/2	-2.07	.00	-2.07	.0000	n/a
39	Sheet Gaskets/PTFE	-.63	.00	-.63	.0000	n/a
**	Mining and Milling	.00	6.97	6.97	1.2565	5.55
	Total			458.89 *	201.8209	2.27

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

TABLE 24. COST BENEFIT BY PRODUCT FOR ALTERNATIVE P - LOW DECLINE BASELINE (1987-2000)

(Main Analysis Assumptions)
(Substitute Prices Declining at 1% Annually)

(Costs and Benefits Discounted at 3%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.73	.00	3.73	.4213	8.85
4	Pipeline Wrap	1.06	.01	1.07	2.3105	.46
5	Beater-Add Gaskets	111.17	.03	111.20	21.4782	5.18
6	High Grade Electrical Paper	-.81	.00	-.81	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.2196	5.99
8	Acetylene Cylinders	-.50	.00	-.50	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.1035	-.02
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.06	.00	-1.06	.0000	n/a
14	A/C Pipe	92.36	35.67	128.03	3.1698	40.39
15	A/C Sheet, Flat	.99	1.38	2.37	.8475	2.79
16	A/C Sheet, Corrugated	.29	.00	.29	.1158	2.53
17	A/C Shingles	16.98	6.59	23.57	.2314	101.85
18	Drum Brake Linings (OEM)	2.39	4.74	7.13	6.3280	1.13
19	Disc Brake Pads LMV (OEM)	.10	3.46	3.56	.7495	4.75
20	Disc Brake Pads HV	.02	.31	.33	.1641	2.01
21	Brake Blocks	-.04	1.99	1.95	7.3051	.27
22	Clutch Facings	12.05	.81	12.87	1.0488	12.27
23	Automatic Trans. Components	.09	.13	.22	.0004	613.20
24	Friction Materials	.25	1.86	2.11	.3974	5.30
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.92	.00	-.92	.0000	n/a
27	Sheet Gaskets	90.22	6.30	96.52	10.7625	8.97
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	45.03	.46	45.48	1.0770	42.23
30	Non-Roofing Coatings	-.07	.88	.81	1.3325	.61
31	Asbestos-Reinforced Plastics	-.80	.00	-.80	.0000	n/a
32	Missile Liner	-.76	.00	-.76	.0000	n/a
33	Sealant Tape	-1.80	.00	-1.80	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	1.24	7.55	8.79	76.7895	.11
37	Disc Brake Pads LMV (Aftermarket)	-.39	4.33	3.94	11.5777	.34
38	Beater-Add Gaskets/2	-2.07	.00	-2.07	.0000	n/a
39	Sheet Gaskets/PTFE	-.63	.00	-.63	.0000	n/a
**	Mining and Milling	.00	6.97	6.97	.9301	7.49
	Total			458.89 *	148.3600	3.09

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

discounted at three percent (where benefits are discounted from the time of exposure).

For each product category, Tables 23 and 24 list domestic consumer, producer, and total surplus losses (as defined and measured in the RIA*), total cancer cases avoided, and the cost per case avoided (total costs divided by the number of cancer cases avoided). Of course, benefits entries (cancer cases avoided) are positive only for the product categories subject to a ban. Hence, the cost per case avoided entries for the product categories not banned are listed as "n/a".

As the results in Table 23 indicate, banning products causes total discounted consumer and producer surplus losses of about $459 million. The bans avoid an undiscounted total of almost 202 cancer cases. These figures imply that the Final Rule as a whole has a cost-per-cancer-case-avoided of $2.27 million, as shown in Table 23, for the three percent discounting for costs and no discounting for benefits.

The individual product category listings show market-by-market costs and benefits of the Final Rule. Costs are higher for product categories banned earlier and for which substitutes are more expensive, and benefits are higher for product categories banned earlier and which pose greater risks of exposure. The cost-per-cancer-case-avoid entries for each product category (with the exception of the automatic transmission components and A/C shingles categories) range from just over $30 million down to zero and slightly negative costs per cancer case. Negative costs per case are possible if a

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* Domestic consumer and producer surplus losses are those that are borne by U.S. entities. Foreign consumers and producers can also be affected by the U.S. regulations for asbestos, but their gains or losses are not included in these tables (although they are modeled and estimated in the analysis).

product category is banned in the more distant future. During the time the product is not banned but while other products are banned, the cost of asbestos fiber is lower than it otherwise would have been.* Hence, it is possible for the surplus gains for a number of years due to the lower asbestos fiber price to exceed the costs associated with the ban of the product for the remainder of the scenario.

The results in Table 24 are identical to those in Table 23 for costs, but the benefits in this table are discounted at three percent from the time of exposure. As the table indicates, discounting the benefits reduce their present value from almost 202 to just over 148 cancer cases avoided. The reduced estimates of benefits translate into higher (in absolute value) costs-per-cancer-case-avoided for each product category and for the total.

In addition to the main analysis estimates of the costs and the benefits of the Final Rule, several sensitivity analyses of the costs and benefits were conducted. Five sets of sensitivity analyses studied are: (1) assume that prices of substitutes for asbestos products remain constant over time, (2) use only the known quantitative information on exposures reported in Tables 4 through 8, (3) use the main analysis exposure estimates plus the additional non-occupational exposure estimates shown in Table 12, (4) apply the OSHA estimates of exposures and low level non-compliance assumptions to the main analysis assumptions, and (5) assume the alternative set of baghouse efficiencies reported in Table 18.

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* The asbestos supply curve is upward sloping, with an estimated elasticity of 1.46. See Appendix A.2 in Volume II of the Regulatory Impact Analysis of Controls on Asbestos and Asbestos Products, January 19, 1989.

Table 25 reports the costs and benefits of the Final Rule (using three percent discounting for costs and no discounting for benefits) using all of the same data and assumptions underlying the main analysis except that substitute prices are assumed to be constant through the future. Relative to the main analysis results, Table 25 shows that if substitute prices are constant through the future, the costs rise from about \$459 million to about \$806 million; benefits are unaffected by this change of assumptions. This raises the cost-per-cancer-case-avoided from \$2.27 million to \$4 million.

Table 26 shows the costs and benefits (costs discounted at three percent and benefits undiscounted) of the Final Rule using the main analysis assumptions except that only the exposure settings for which quantitative information was available are included (the exposure estimates in Tables 4 through 8 earlier). Relative to the Table 23 benefits, the number of cancer cases in Table 26 is about 38 cases lower (164.04 versus 201.82), and costs are unaffected. Table 27 shows the costs and benefits of the Final Rule using the main analysis exposure information available (in Tables 13 through 17) and the additional non-occupational exposure assumptions reported in Table 12. Relative to the main analysis estimates of benefits, the benefits in Table 27 are about 9 cases higher (210.80 versus 201.82).

Table 28 shows the costs and benefits of the Final Rule using the fiber concentration estimates developed based on the OSHA methodology and assuming that two percent of all firms do not comply with the asbestos PEL, as reported in Tables 18 through 21 above, along with the remaining unaffected information from Tables 13 through 17. Relative to the main analysis estimates of benefits in Table 23, the benefits in Table 28 are about 47 cases higher (248.82 versus 201.82). This indicates that the net effect of using the

TABLE 25. COST BENEFIT BY PRODUCT FOR ALTERNATIVE P - LOW DECLINE BASELINE (1987-2000)

(Main Analysis Assumptions)
(Substitute Prices Constant Over Time)

(Costs Discounted at 3% and Benefits Discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	4.86	.00	4.86	.5822	8.35
4	Pipeline Wrap	1.96	.01	1.97	2.8635	.69
5	Beater-Add Gaskets	140.60	.03	140.63	28.3392	4.96
6	High Grade Electrical Paper	-.81	.00	-.81	.0000	n/a
7	Roofing Felt	8.90	.00	8.90	1.5116	5.89
8	Acetylene Cylinders	-.50	.00	-.50	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.1430	-.01
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.06	.00	-1.06	.0000	n/a
14	A/C Pipe	191.65	35.67	227.33	4.3801	51.90
15	A/C Sheet, Flat	1.35	1.38	2.73	1.0504	2.60
16	A/C Sheet, Corrugated	.62	.00	.62	.1435	4.30
17	A/C Shingles	27.59	6.59	34.18	.3197	106.91
18	Drum Brake Linings (OEM)	9.93	4.74	14.67	8.3800	1.75
19	Disc Brake Pads LMV (OEM)	.10	3.46	3.56	.9927	3.59
20	Disc Brake Pads HV	.02	.31	.33	.2165	1.53
21	Brake Blocks	11.13	1.99	13.12	10.0943	1.30
22	Clutch Facings	24.70	.81	25.51	1.3838	18.44
23	Automatic Trans. Components	.17	.13	.30	.0005	637.90
24	Friction Materials	.25	1.86	2.11	.5244	4.01
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.92	.00	-.92	.0000	n/a
27	Sheet Gaskets	116.08	6.30	122.38	14.2005	8.62
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	140.20	.46	140.66	1.4882	94.52
30	Non-Roofing Coatings	39.01	.88	39.90	1.8413	21.67
31	Asbestos-Reinforced Plastics	-.80	.00	-.80	.0000	n/a
32	Missile Liner	-.76	.00	-.76	.0000	n/a
33	Sealant Tape	-1.80	.00	-1.80	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	13.66	7.55	21.21	106.2551	.20
37	Disc Brake Pads LMV (Aftermarket)	-.39	4.33	3.94	15.8541	.25
38	Beater-Add Gaskets/2	-2.07	.00	-2.07	.0000	n/a
39	Sheet Gaskets/PTFE	-.63	.00	-.63	.0000	n/a
**	Mining and Milling	.00	6.97	6.97	1.2565	5.55
	Total			806.51 *	201.8209	4.00

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

TABLE 26. COST BENEFIT BY PRODUCT FOR ALTERNATIVE P - LOW DECLINE BASELINE (1987-2000)

(Quantitative Estimates of Exposure Only)
(Substitute Prices Declining at 1% Annually)

(Costs Discounted at 3% and Benefits Discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.73	.00	3.73	.5754	6.48
4	Pipeline Wrap	1.06	.01	1.07	1.7416	.61
5	Beater-Add Gaskets	111.17	.03	111.20	6.5937	16.86
6	High Grade Electrical Paper	-.81	.00	-.81	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.5116	4.84
8	Acetylene Cylinders	-.50	.00	-.50	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.0256	-.07
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.06	.00	-1.06	.0000	n/a
14	A/C Pipe	92.36	35.67	128.03	3.1110	41.15
15	A/C Sheet, Flat	.99	1.38	2.37	1.0504	2.25
16	A/C Sheet, Corrugated	.29	.00	.29	.1435	2.04
17	A/C Shingles	16.98	6.59	23.57	.3197	73.71
18	Drum Brake Linings (OEM)	2.39	4.74	7.13	8.3800	.85
19	Disc Brake Pads LMV (OEM)	.10	3.46	3.56	.9927	3.59
20	Disc Brake Pads HV	.02	.31	.33	.2165	1.53
21	Brake Blocks	-.04	1.99	1.95	10.0943	.19
22	Clutch Facings	12.05	.81	12.87	1.3838	9.30
23	Automatic Trans. Components	.09	.13	.22	.0005	464.74
24	Friction Materials	.25	1.86	2.11	.5244	4.01
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.92	.00	-.92	.0000	n/a
27	Sheet Gaskets	90.22	6.30	96.52	2.2192	43.49
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	45.03	.46	45.48	1.4882	30.56
30	Non-Roofing Coatings	-.07	.88	.81	.2981	2.72
31	Asbestos-Reinforced Plastics	-.80	.00	-.80	.0000	n/a
32	Missile Liner	-.76	.00	-.76	.0000	n/a
33	Sealant Tape	-1.80	.00	-1.80	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	1.24	7.55	8.79	106.2551	.08
37	Disc Brake Pads LMV (Aftermarket)	-.39	4.33	3.94	15.8541	.25
38	Beater-Add Gaskets/2	-2.07	.00	-2.07	.0000	n/a
39	Sheet Gaskets/PTFE	-.63	.00	-.63	.0000	n/a
**	Mining and Milling	.00	6.97	6.97	1.2565	5.55
	Total			458.89 *	164.0360	2.80

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

TABLE 27. COST BENEFIT BY PRODUCT FOR ALTERNATIVE P - LOW DECLINE BASELINE (1987-2000)

(Main Analysis Assumptions and Additional Non-Occupational Estimates of Exposure)
(Substitute Prices Declining at 1% Annually)

(Costs Discounted at 3% and Benefits Discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.73	.00	3.73	.6238	5.98
4	Pipeline Wrap	1.06	.01	1.07	3.1187	.34
5	Beater-Add Gaskets	111.17	.03	111.20	29.7789	3.73
6	High Grade Electrical Paper	-.81	.00	-.81	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.5116	4.84
8	Acetylene Cylinders	-.50	.00	-.50	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.1430	-.01
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.06	.00	-1.06	.0000	n/a
14	A/C Pipe	92.36	35.67	128.03	7.4963	17.08
15	A/C Sheet, Flat	.99	1.38	2.37	1.1634	2.04
16	A/C Sheet, Corrugated	.29	.00	.29	.2064	1.42
17	A/C Shingles	16.98	6.59	23.57	.6909	34.11
18	Drum Brake Linings (OEM)	2.39	4.74	7.13	8.3800	.85
19	Disc Brake Pads LMV (OEM)	.10	3.46	3.56	.9927	3.59
20	Disc Brake Pads HV	.02	.31	.33	.2485	1.33
21	Brake Blocks	-.04	1.99	1.95	10.0943	.19
22	Clutch Facings	12.05	.81	12.87	1.5188	8.47
23	Automatic Trans. Components	.09	.13	.22	.0005	464.74
24	Friction Materials	.25	1.86	2.11	.9614	2.19
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.92	.00	-.92	.0000	n/a
27	Sheet Gaskets	90.22	6.30	96.52	14.8673	6.49
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	45.03	.46	45.48	3.5733	12.73
30	Non-Roofing Coatings	-.07	.88	.81	2.0692	.39
31	Asbestos-Reinforced Plastics	-.80	.00	-.80	.0000	n/a
32	Missile Liner	-.76	.00	-.76	.0000	n/a
33	Sealant Tape	-1.80	.00	-1.80	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	1.24	7.55	8.79	106.2551	.08
37	Disc Brake Pads LMV (Aftermarket)	-.39	4.33	3.94	15.8541	.25
38	Beater-Add Gaskets/2	-2.07	.00	-2.07	.0000	n/a
39	Sheet Gaskets/PTFE	-.63	.00	-.63	.0000	n/a
**	Mining and Milling	.00	6.97	6.97	1.2565	5.55
	Total			458.89 *	210.8046	2.18

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

TABLE 28. COST BENEFIT BY PRODUCT FOR ALTERNATIVE P - LOW DECLINE BASELINE (1987-2000)

(Main Analysis Assumptions with OSHA Methodology for Exposure and 2% Non-compliance)
(Substitute Prices Declining at 1% Annually)

(Costs Discounted at 3% and Benefits Discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.73	.00	3.73	.7164	5.21
4	Pipeline Wrap	1.06	.01	1.07	5.9487	.18
5	Beater-Add Gaskets	111.17	.03	111.20	63.5961	1.75
6	High Grade Electrical Paper	-.81	.00	-.81	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	.5767	12.68
8	Acetylene Cylinders	-.50	.00	-.50	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.3715	-.01
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.06	.00	-1.06	.0000	n/a
14	A/C Pipe	92.36	35.67	128.03	4.8518	26.39
15	A/C Sheet, Flat	.99	1.38	2.37	.8980	2.64
16	A/C Sheet, Corrugated	.29	.00	.29	.0465	6.30
17	A/C Shingles	16.98	6.59	23.57	.2283	103.25
18	Drum Brake Linings (OEM)	2.39	4.74	7.13	8.6202	.83
19	Disc Brake Pads LMV (OEM)	.10	3.46	3.56	.9993	3.56
20	Disc Brake Pads HV	.02	.31	.33	.2260	1.46
21	Brake Blocks	-.04	1.99	1.95	10.3201	.19
22	Clutch Facings	12.05	.81	12.87	1.4528	8.86
23	Automatic Trans. Components	.09	.13	.22	.0007	305.08
24	Friction Materials	.25	1.86	2.11	.5393	3.90
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.92	.00	-.92	.0000	n/a
27	Sheet Gaskets	90.22	6.30	96.52	16.2598	5.94
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	45.03	.46	45.48	1.5252	29.82
30	Non-Roofing Coatings	-.07	.88	.81	1.9781	.41
31	Asbestos-Reinforced Plastics	-.80	.00	-.80	.0000	n/a
32	Missile Liner	-.76	.00	-.76	.0000	n/a
33	Sealant Tape	-1.80	.00	-1.80	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	1.24	7.55	8.79	111.7843	.08
37	Disc Brake Pads LMV (Aftermarket)	-.39	4.33	3.94	16.5719	.24
38	Beater-Add Gaskets/2	-2.07	.00	-2.07	.0000	n/a
39	Sheet Gaskets/PTFE	-.63	.00	-.63	.0000	n/a
**	Mining and Milling	.00	6.97	6.97	1.2565	5.55
	Total			458.89 *	248.8178	1.84

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

"lower" OSHA estimates and accounting for non-compliance by a small proportion of firms actually results in higher overall exposure. Empirically, a very low rate of non-compliance with the OSHA PEL more than offsets the reduced exposures based on the OSHA methodology.

Finally, the costs and benefits (costs discounted at three percent and benefits undiscounted) of the Final Rule using the main analysis assumptions and the alternative baghouse efficiencies reported in Table 22 are presented in Table 29. Again, costs are unaffected by this change of assumptions. As the table indicates, the total number of cancer cases falls in this sensitivity analysis relative to the main analysis estimates by about 19 cancer cases (183.19 versus 201.82).

TABLE 29. COST BENEFIT BY PRODUCT FOR ALTERNATIVE P - LOW DECLINE BASELINE (1987-2000)

(Main Analysis Assumptions with Alternative Baghouse Efficiencies)
(Substitute Prices Declining at 1% Annually)

(Costs Discounted at 3% and Benefits Discounted at 0%)

Product TSCA #	Product Description	Domestic Consumer Surplus Loss (10^6 $)	Domestic Producer Surplus Loss (10^6 $)	Gross Domestic Total Loss (10^6 $)	Total Cancer Cases Avoided	Cost per Cancer Case Avoided (10^6 $/case)
1	Commercial Paper	.00	.00	.00	.0000	n/a
2	Rollboard	.00	.00	.00	.0000	n/a
3	Millboard	3.73	.00	3.73	.1049	35.55
4	Pipeline Wrap	1.06	.01	1.07	1.2118	.88
5	Beater-Add Gaskets	111.17	.03	111.20	22.3284	4.98
6	High Grade Electrical Paper	-.81	.00	-.81	.0000	n/a
7	Roofing Felt	7.31	.00	7.31	1.5116	4.84
8	Acetylene Cylinders	-.50	.00	-.50	.0000	n/a
9	Flooring Felt	.00	.00	.00	.0000	n/a
10	Corrugated Paper	.00	.00	.00	.0000	n/a
11	Specialty Paper	-.00	.00	-.00	.1430	-.01
12	V/A Floor Tile	.00	.00	.00	.0000	n/a
13	Asbestos Diaphragms	-1.06	.00	-1.06	.0000	n/a
14	A/C Pipe	92.36	35.67	128.03	2.9004	44.14
15	A/C Sheet, Flat	.99	1.38	2.37	.4494	5.27
16	A/C Sheet, Corrugated	.29	.00	.29	.1435	2.04
17	A/C Shingles	16.98	6.59	23.57	.3106	75.86
18	Drum Brake Linings (OEM)	2.39	4.74	7.13	6.2084	1.15
19	Disc Brake Pads LMV (OEM)	.10	3.46	3.56	.8473	4.20
20	Disc Brake Pads HV	.02	.31	.33	.2165	1.53
21	Brake Blocks	-.04	1.99	1.95	9.9928	.20
22	Clutch Facings	12.05	.81	12.87	1.2934	9.95
23	Automatic Trans. Components	.09	.13	.22	.0005	464.74
24	Friction Materials	.25	1.86	2.11	.4089	5.15
25	Asbestos Protective Clothing	.00	.00	.00	.0000	n/a
26	Asbestos Thread, etc.	-.92	.00	-.92	.0000	n/a
27	Sheet Gaskets	90.22	6.30	96.52	13.0784	7.38
28	Asbestos Packing	.00	.00	.00	.0000	n/a
29	Roof Coatings	45.03	.46	45.48	.9680	46.99
30	Non-Roofing Coatings	-.07	.88	.81	1.8333	.44
31	Asbestos-Reinforced Plastics	-.80	.00	-.80	.0000	n/a
32	Missile Liner	-.76	.00	-.76	.0000	n/a
33	Sealant Tape	-1.80	.00	-1.80	.0000	n/a
34	Battery Separators	.00	.00	.00	.0000	n/a
35	Arc Chutes	.00	.00	.00	.0000	n/a
36	Drum Brake Linings (Aftermarket)	1.24	7.55	8.79	102.5393	.09
37	Disc Brake Pads LMV (Aftermarket)	-.39	4.33	3.94	15.4425	.26
38	Beater-Add Gaskets/2	-2.07	.00	-2.07	.0000	n/a
39	Sheet Gaskets/PTFE	-.63	.00	-.63	.0000	n/a
**	Mining and Milling	.00	6.97	6.97	1.2565	5.55
	Total			458.89 *	183.1895	2.51

n/a: Not applicable
*** Market is not banned, exempted, or exposure data is not available.
* U.S. net welfare cost

APPENDIX I

SOURCE CODE FOR THE ASBESTOS REGULATORY COSTS SIMULATION MODEL (ARCM)

```
c________________________________________________________________________
c
c
c      ASBESTOS REGULATORY COST MODEL (ARCM) : MAIN PROGRAM
c
c      Version 7.1 : May 24, 1989.
c
c      (version for use when aftermarket brakes are not banned within
c       4 years of OEM brakes, declining prices of substitutes are
c       used, or if caps could start later in the simulation period)
c
c      Program written by:
c
c                            Vikram Widge
c                            ICF Incorporated
c                            9300 Lee Highway
c                            Virginia 22031-1207
c
c                            (703) 934-3000
c
c      Accompanying Documentation:
c
c            1. User's Manual
c            2. Technical Support Document
c
c________________________________________________________________________
c
c
$include:'stdsub'
$large
c
c
       program   arcm
c
$include:'stdvar'
$include:'vars.cmn'
c
       integer   onsub(im),bam(36:37)
c
       character istr(6)*55
       real      amq(ny,36:37)
c
       common/amq/amq
c
c________________________________________________________________________
c
c            this section prints the opening statement on the screen
c________________________________________________________________________
c
c
       call vinit
       call crt_cls
       call box (0,3,15,63,vnorm)
       call pcsa (1,17,'EPA/OTS Asbestos Regulatory Cost Model (ARCM)'c,
      -          vbold)
       call pcs  (2,17,'                 Version 7.0'c)
c
       istr(1)='This program models the economic impacts and costs of'c
       istr(2)='asbestos fiber and product regulations.  It permits a'c
       istr(3)='variety of regulatory options to be implemented and'c
       istr(4)='allows flexibility in their implementation.  For'c
       istr(5)='assistance in using this model please refer to the'c
       istr(6)='accompanying user''s manual and related documentation.'c
c
       do 1 i=1,6
        call pcs (i+7,13,istr(i))
 1     continue
c
       call pcs (20,20,'Please respond to queries as indicated.'c)
       call pcs (24,25,'Press any key to continue'c)
       call setcur (vy,vx)
       ipse=key_getc()
c
       call eeop (5,0)
       call pcs (9,20,'Refer any specific questions regarding'c)
       call pcs (10,20,'operation of this program to:'c)
       call pcs (12,30,'Vikram Widge'c)
       call pcs (13,30,'ICF Incorporated'c)
       call pcs (14,30,'9300 Lee Highway'c)
       call pcs (15,30,'Virginia 22031-1207'c)
```

```
      call pcs (17,30,'(703) 934-3000'c)
c
      call pcs (24,25,'Press any key to continue'c)
      call setcur (vy,vx)
      ipse=key_getc()
c
      call eeop (5,0)
      call pcsa (12,25,' Initializing... 'c,vrev)
      call setcur (vy,vx-1)
c
      call sinit
      call asbin
c
c
      bam(36) = 0
      bam(37) = 0
c
      do 10 n = 1, byrs
        ix = byear(n) - baseyr + 1
        do 101 nn = 36, 37
          if ((isban(ix,nn) .eq. 1) .and. (.not. exmpt(nn))) then
            if (bam(nn) .eq. 0) bam(nn) = ix
          endif
101     continue
10    continue
c
      if (cstyr .ge. max0(bam(36),bam(37))) then
        iacap = 1
      else
        iacap = 0
      endif
c
      if ((option .ne. 1) .and. (iacap .eq. 0)) then
        write (*,'(//)')
        write (*,*) 'this version is for declining substitute prices'
        write (*,*) 'and currently does not support non-ban options'
        write (*,*) 'when aftermarket brakes have not been banned'
        write (*,*)
        write (*,*) 'aftermarket bans --  ', bam(36), bam(37)
        write (*,*) 'cap start year   --  ', cstyr
        write (*,*)
        stop
      endif
c
      do 1492 i=1,np
       if ((cprat(i) .lt. 1) .and. (cprat(i) .ne. -1.)) then
        write (*,*) 'this version is for declining substitute prices'
        write (*,*) 'and currently does not support exports'
        stop
      endif
c
      onsub(i)=nsub(i)
c
1492  continue
c
c______________________________________________________________________
c
c  this section transforms data from year of data (ibyd) to specified
c  baseyear, and calculates quasi-rent perpetuities by including the
c  reformulation cost perpetuities.
c______________________________________________________________________
c
c
      do 310 i=1,np
        impinf(i)=.false.
c
        if (cprat(i) .eq. -1) then
          cprat(i)=1
          impinf(i)=.true.
        endif
c
        if (cprat(i) .gt. 1) epq(1,i)=epq(1,i)*cprat(i)
c
        bbpq(i)=epq(1,i)
c
        fqe(1)=fqe(1)+epq(1,i)*awt(i)
c
        idif=baseyr-ibyd
        do 357 ij=1,idif
          if (ij .lt. 15) then
```

```
            ig=ij
          else
            ig=15
          endif
          epq(1,i)=epq(1,i)*(1+grthrt(i,ig))
 357    continue
c
        bepq(1,i)=epq(1,i)
c
 310  continue
c
c
c
      slope=fpe(1)/(selast*fqe(1))
      rint=fpe(1)-slope*fqe(1)
      if (selast .eq. 1) rint=0
c
      bbfq=fqe(1)
      fqe(1)=0
c
      yr=1
c
      do 4638 i=1,np
        fqe(1)=fqe(1)+epq(1,i)*awt(i)
 4638 continue
c
      afpe=fpe(1)
      fpe(1)=rint+slope*fqe(1)
      if (baseyr .eq. ibyd) fpe(1) = afpe
      if (fpe(1) .gt. afpe) go to 44444
c
      do 468 i=1,np
        aepp(i)=epp(1,i)
        epp(1,i)=(fpe(1)-afpe)*awt(i)+epp(1,i)
        bepp(1,i)=epp(1,i)
c
        if (rcost(i) .gt. 0) then
          qrarea(i)=ccost(i)*epq(1,i)+rcost(i)
          avc(i)=epp(1,i)-(qrarea(i)/epq(1,i))
        elseif (ccost(i) .gt. 0) then
          avc(i)=epp(1,i)-ccost(i)
        else
          go to 468
        endif
c
        swqr(i)=1
c
 468  continue
c
      bfpe(1)=fpe(1)
      bfqe(1)=fqe(1)
c
c
      call adjust
c
      yr=2
c
c_______________________________________________________________________
c
c          this section modifies the product demand curves annually.
c_______________________________________________________________________
c
c
 1111 do 300 i=1,np
c
        do 3001 j=1,onsub(i)
            a=(1+fdiscrt)**ns(i,j)
            b=(1+fdiscrt)**na(i)
c
            if (ns(i,j) .ne. na(i))
     -        aps(yr,i,j)=aps(yr,i,j)*(a/b)*(b-1)/(a-1)
c
            if (aps(yr,i,j) .lt. aepp(i)) then
              aps(yr,i,j)=aepp(i)
            endif
c
 3001   continue
c
        if (onsub(i) .eq. 1) then
          ps(yr,i,1)=aps(yr,i,1)
```

```
              ms(i,1)=ams(i,1)
            else
              insub=0
              do 201 j=1,onsub(i)
                do 2011 k=1,insub
                  if (aps(yr,i,j) .eq. ps(yr,i,k)) then
                    ms(i,k)=ms(i,k)+ams(i,j)
                    go to 201
                  endif
 2011           continue
c
                insub=insub+1
                ps(yr,i,insub)=aps(yr,i,j)
                ms(i,insub)=ams(i,j)
 201          continue
c
              nsub(i)=insub
c
              do 4631 j=1,nsub(i)-1
                do 46311 k=j+1,nsub(i)
c
                    if (ps(yr,i,j) .eq. ps(yr,i,k)) then
                      call eeop (5,0)
                      call setcur (12,0)
                      write (*,*) '     PRICES OF SUBSTITUTES STILL EQUAL'
                      write (*,*) '     YEAR:',baseyr+yr-1,'  MARKET:',idp(i)
                      write (*,*) '     SUBSTITUTES:',j,k
                      write (*,*) '     PRICES:',ps(yr,i,j),ps(yr,i,k)
                      call setcur (22,0)
                      stop
                    endif
c
                    if (ps(yr,i,j) .gt. ps(yr,i,k)) go to 46311
                    ptemp=ps(yr,i,j)
                    emtemp=ms(i,j)
                    ps(yr,i,j)=ps(yr,i,k)
                    ms(i,j)=ms(i,k)
                    ps(yr,i,k)=ptemp
                    ms(i,k)=emtemp
c
 46311            continue
 4631           continue
            endif
c
 462        count=0
            do 4621 j=1,nsub(i)
              count=count+ms(i,j)
              lnsub(i,j)=.false.
              if (swqr(i) .eq. 1) lnsub(i,j)=.true.
 4621       continue
c
            if ((count .lt. 0.999999) .or. (count .gt. 1.000001)) then
              call eeop (5,0)
              call setcur (12,0)
              write (*,'(5x,2a,i2,a,f14.7,a,i4)') 'MARKET SHARE(S) OF ',
     -        'SUBSTITUTES IN MARKET ',idp(i),' ADD TO ',count, ' IN YEAR ',
     -        yr+baseyr-1
              call setcur (22,0)
              stop
            endif
c
 300      continue
c
c
          if (option .eq. 3) then
            optn(yr) = 3
          elseif (cstyr .eq . 0) then
            optn(yr) = 1
          elseif (yr .ge. cstyr-baseyr+1) then
            optn(yr) = 2
          else
            optn(yr) = 1
          endif
c
          option = optn(yr)
c
          qcap(yr)=qcapm(yr)
c
          do 400 i=1,np
c
```

```
            cur_bseq=epq(1,i)
            do 4002 ig=baseyr-ibyd+1,yr
c
              if (ig .gt. 15) then
                igj=15
              else
                igj=ig
              endif
c
              cur_bseq=cur_bseq*(1+grthrt(i,igj))
 4002       continue
c
            do 4001 j=1,nsub(i)
              qs(yr,i,j)=cur_bseq*ms(i,j)
              if (j .eq. 1) then
                qs1(yr,i,j)=qs(yr,i,j)
              else
                qs1(yr,i,j)=qs1(yr,i,j-1)+qs(yr,i,j)
              endif
 4001       continue
c
            rq=qs1(yr,i,nsub(i))
            if (rq .eq. 0.) swqr(i)=0
c
            if (swqr(i) .eq. 1) then
              qrarea(i)=ccost(i)*rq+rcost(i)
            endif
c
c           **** engineering control cost calculation ****
c
            if (rq .ne. 0) ecost(i)=(fecost(i)+vecost(i)*rq)/rq
c
            if ((option .eq. 2) .and. exmpt(idp(i))) then
              if (qcap(yr) .eq. 0) then
                qcapm(yr)=qcapm(yr)+(awt(i)*qs1(yr,i,nsub(i)))
              else
               qcap(yr)=qcap(yr)-(awt(i)*qs1(yr,i,nsub(i)))
c
               if (qcap(yr) .lt. 0) then
                 call eeop (5,0)
                 call setcur (12,0)
                 write (*,'(10x,a,i4//)') 'MODIFIED FIBER CAP < 0 IN '//
     -                                     'YEAR ',baseyr+yr-1
                 write (*,'(2(10x,a,f13.7/))') 'INPUT CAP    = ',qcapm(yr),
     -                                         'MODIFIED CAP = ',qcap(yr)
                 write (*,'(/10x,a,i2)') 'ERROR AT EXEMPTED PRODUCT #',
     -                                  idp(i)
                 call setcur (22,0)
                 stop
               endif
c
              endif
            endif
  400     continue
c
          call iddc (0)
          call tddc (0)
          call eqpq
          if (afpe .ge. fpe(yr)) go to 2222
c
44444     iyr=yr+baseyr-1
          call eeop (5,0)
          call setcur (12,0)
          write (*,'(15x,a//)') 'BASELINE FIBER PRICE > '//
     -                          'DATA YEAR FIBER PRICE'
          write (*,'(10x,a,i4,a,f14.7/)') 'Baseline fiber price for ',
     -                                    iyr,' = ',fpe(yr)
          write (*,'(10x,a,i4,a,f14.7)') 'Data year (',ibyd,
     -                                  ') fiber price  = ',afpe
          call setcur (22,0)
          stop
c
c
 2222     bfpe(yr)=fpe(yr)
          bfqe(yr)=fqe(yr)
          do 210 i=1,np
            bepp(yr,i)=epp(yr,i)
            bepq(yr,i)=epq(yr,i)
c
c setting price of exports equal to baseline price.
```

```fortran
c
        if (cprat(i) .lt. 1) then
          ps(yr,i,nsub(i))=bepp(yr,i)
        endif
c
210   continue
c
c  adjustment of fiber demand curve to reflect export
c  markets' last step adjustment.
c
      if ((enf .or. lbf) .and.
     -    (((option .eq. 1) .and.(ibchk .gt. yr)) .or.
     -    ((option .eq. 2) .and. (ibchk .gt. yr) .and.
     -     (qcap(yr) .gt. 0)) .or.
     -    ((option .eq. 3) .and. (qcap(yr) .gt. 0)))) then
        call enlbl
        call iddc (1)
      endif
c
c ***** SUPERIMPOSING AFTERMARKET ADJUSTMENTS *****
c
      do 4926 i=1,np
        if ((idp(i) .eq. 36) .or. (idp(i) .eq. 37)) then
          do 49261 j=1,nsub(i)
            qs(yr,i,j)=amq(yr,idp(i))*ms(i,j)
c
            if (j .eq. 1) then
              qs1(yr,i,j)=qs(yr,i,j)
            else
              qs1(yr,i,j)=qs1(yr,i,j-1)+qs(yr,i,j)
            endif
c
49261     continue
        endif
4926  continue
c
      call iddc (0)
c
c ************************************************
c
      call tddc (1)
      if (option .eq. 3) go to 2339
      call bancsqr
      call eqpq
c
      if (option .eq. 1) then
        if (fpe(yr) .eq. 0) fpe(yr)=rint
        call aronban
        go to 8888
      endif
c
2339  capr=.false.
      call fpc1234
      call fppfpq
      if (exf) call exempt
c
8888  yr=yr+1
      if (.not.(yr .gt. ie)) go to 1111
c
      call benout
      call asbout
      call pcsa (15,38,' completed 'c,vrev)
c
      if (fname(3) .ne. 'lpt1') then
       call pcsa (18,15,'TO PRINT OUTPUT FILE '//
     -            fname(3)(1:lench(fname(3)))//' ENTER'c,vbold)
       call pcsa (19,15,'''PF_ARCM '//fname(3)(1:lench(fname(3)))//
     -            ''' AT THE DOS PROMPT.'c,vbold)
      endif
      call setcur (22,0)
c
      stop
      end
```

```
c_______________________________________________________________________
c
c
c     ARCM : AFTERMAKET ADJUSTMENT DUE TO OEM BAN
c            (used only with arcm_amd.for)
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_______________________________________________________________________
c
c
c_______________________________________________________________________
c
c   Adjustment of Aftermarket due to OEM ban and calculation of OEM losses
c_______________________________________________________________________
c
      subroutine adjust
c
$include:'vars.cmn'
c
      real      amq(ny,36:37),oemq(ny,18:19),amadj(ny,36:37)
      integer   oem(18:19)
c
      common/amq/amq
      common/amadj/amadj
c
c
c ***** regular baseline development for OEM and A/M *****

      do 10 i=1,np
c
        if ((idp(i) .eq. 18) .or. (idp(i) .eq. 19)) then
          oemq(1,idp(i))=bepq(1,i)
          do 20 iy=2,endyr-baseyr+1
            igj=baseyr-ibyd+iy-1
            if (igj .gt. 15) igj=15
            oemq(iy,idp(i))=oemq(iy-1,idp(i))*(1+grthrt(i,igj))
 20       continue
        endif
c
        if ((idp(i) .eq. 36) .or. (idp(i) .eq. 37)) then
          amq(1,idp(i))=bepq(1,i)
          do 30 iy=2,endyr-baseyr+1
            igj=baseyr-ibyd+iy-1
            if (igj .gt. 15) igj=15
            amq(iy,idp(i))=amq(iy-1,idp(i))*(1+grthrt(i,igj))
 30       continue
        endif
c
 10   continue
c
c ***** baseline adjustment for A/M due to OEM bans *****
c
      oem(18)=0
      oem(19)=0
c
      do 40 i=1,np
        do 60 iy=2,endyr-baseyr+1
c
          if ((idp(i) .eq. 18) .or. (idp(i) .eq. 19)) then
            if ((swban(iy,i) .eq. 1) .and. (oem(idp(i)) .eq. 0))
     -        oem(idp(i))=iy
c
            amadj(iy,idp(i)+18)=0
c
            if (oem(idp(i)) .eq. 0) go to 40
c
            if (iy .ge. oem(idp(i))+4) then
              atemp=0
              if ((isban(iy,idp(i)+18) .eq. 1) .and.
     -            (.not. exmpt(idp(i)+18))) go to 40
c
              do 50 k=1,iy-oem(idp(i))
                if (k .eq. 4) then
                  atemp=oemq(iy-4,idp(i))*0.977
```

```
                elseif (k .eq. 8) then
                  atemp=atemp+oemq(iy-8,idp(i))*0.839
                elseif (k .eq. 12) then
                  atemp=atemp+oemq(iy-12,idp(i))*0.451
                endif
50            continue
c
              amq(iy,idp(i)+18)=amq(iy,idp(i)+18)-atemp
              amadj(iy,idp(i)+18)=atemp
c
              if (amq(iy,idp(i)+18) .le. 0) then
                call pcs (15,10,'aftermarket qty. < or = 0'c)
                call setcur (17,10)
                write (*,51) 'year',iy+baseyr-1,'mkt.',idp(i)+18,
     -                       'a/m qty.',amq(iy,idp(i)+18)
51              format (t11,a,2x,i4,3x,a,2x,i2,3x,a,2x,f10.1)
                call setcur (20,0)
                stop
              endif
            endif
          endif
60      continue
40    continue
c
      return
      end
```

```
c
c
c
c      ARCM : CALCULATION OF AREAS UNDER BANS ONLY
c             (version of aronban.for used with arcm_amd.for)
c
c      Version 7.1 : May 24, 1989.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c
c
c
$large
c
c
c
c                     This subroutine calculates the CS gains
c                     and PS losses when only bans take place.
c
c
c
      subroutine aronban
c
$include:'vars.cmn'
c
      real      amadj(ny,36:37)
      common/amadj/amadj
c
      pedif=bfpe(yr)-fpe(yr)
      area2(yr)=pedif*fqe(yr)
      area4(yr)=0.5*pedif*(bfqe(yr)-fqe(yr))
      do 230 i=1,np
        if (swban(yr,i) .eq. 1) go to 230
        area5(yr,i)=(epp(yr,i)-bepp(yr,i))*epq(yr,i)
c
        if ((idp(i) .eq. 36) .or. (idp(i) .eq. 37)) then
          atemp=0
          do 10 j=1,nsub(i)
            atemp=atemp+amadj(yr,idp(i))*ms(i,j)*(ps(yr,i,j)-bepp(yr,i))
10        continue

c ***** area5 is a gain here and so is a negative entity *****
          area5(yr,i)=area5(yr,i)+atemp
        endif
c
230   continue
      return
      end
```

```
c_____________________________________________________________________
c
c
c     ARCM : CALCULATION OF AREAS 5, 6, 7 AND 8
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_____________________________________________________________________
c
c
$large
c
c_____________________________________________________________________
c
c                This subroutine calculates AREAs 5, 6, 7, and 8.
c_____________________________________________________________________
c
c
      subroutine area5678 (i)
c
$include:'vars.cmn'
c
c
      area5(yr,i)=(fpp(yr,i)-bepp(yr,i))*fpq(yr,i)
      if ((fpp(yr,i) .gt. bepp(yr,i)) .or. (fpq(yr,i) .eq. 0)) then
        call sarea6 (i)
      endif
      if (swqr(i) .ne. 1) return
c
      if (fppflag(i) .eq. 1) then
        dif=tfpp(i)-avc(i)
      else
        dif=bepp(yr,i)-avc(i)
      endif
c
      if ((qcap(yr) .eq. 0) .or. (fpq(yr,i) .eq. 0)) then
        area7(yr,i)=0
        do 90 j=1,nsub(i)
          if (.not.(lnsub(i,j))) go to 90
          area8(yr,i)=area8(yr,i)+dif*qs(yr,i,j)
          area8p(yr,i)=area8p(yr,i)+dif*qs(yr,i,j)*(1/fdiscrt-1)
          lnsub(i,j)=.false.
90      continue
        swqr(i)=0
        return
      endif
c
      do 100 j=1,nsub(i)
        if (.not.(lnsub(i,j))) return
        if (fps(i,j) .gt. pf(yr)) then
          area7(yr,i)=area7(yr,i)+dif*qs(yr,i,j)
          go to 100
        elseif (fps(i,j) .eq. pf(yr)) then
          if (j .eq. 1) then
            area7(yr,i)=dif*fpq(yr,i)
          else
            area7(yr,i)=area7(yr,i)+dif*(fpq(yr,i)-qs1(yr,i,j-1))
          endif
          area8(yr,i)=area8(yr,i)+dif*(qs1(yr,i,j)-fpq(yr,i))
        elseif (fps(i,j) .lt. pf(yr)) then
          area8(yr,i)=area8(yr,i)+dif*qs(yr,i,j)
          area8p(yr,i)=area8p(yr,i)+dif*qs(yr,i,j)*(1/fdiscrt-1)
          lnsub(i,j)=.false.
          if (j .eq. 1) swqr(i)=0
        endif
100   continue
c
      return
      end
```

```
c___________________________________________________________________________
c
c
c     ARCM : USER AND DATA INPUT
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c___________________________________________________________________________
c
c
$include:'stdsub'
$large
c
c___________________________________________________________________________
c
c               This subroutine accepts data from user interactively
c               and reads data from input files.
c___________________________________________________________________________
c
c
c
      subroutine asbin
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      real      taps(25,im,ks),sub_dec(ks)
c
      integer   pid(10),beyr
c
      character res,dstr1*65,dstr2*52,dstr4*40,cstr2*60,
     -          cstr3*60,fstr1*60,fstr2*53,dstr5*40,dstr9*65,
     -          dstr7*65,dstr8*54,dstr0*65,fstr3*60,nyc*4,nzc*4,
     -          fstr4*53,prm1*60,prm2*65,cqc*10
c
      logical   ccap
c
c___________________________________________________________________________
c
c                this section obtains the inputs from the operator.
c___________________________________________________________________________
c
c
      call eeop (5,0)
      call pcs (7,10,'Three regulatory scenarios are supported '//
     -               'by this program'c)
      call pcs (10,25,'1. BAN OF PRODUCTS ONLY'c)
      call pcs (12,25,'2. BAN OF PRODUCTS AND AN 'c)
      call pcs (13,25,'     ANNUAL FIBER CAP'c)
      call pcs (15,25,'3. ANNUAL FIBER CAP ONLY'c)
 5550 call pcs (19,22,'Enter # of option desired MM'c)
      option=ichk (1,3)
      if (option .eq. -9999) go to 5550
      if (option .eq. 1) cstyr=0
c
      call eeop (5,0)
      call pcsa (8,28,' SIMULATION PERIOD 'c,vrev)
 5551 call pcs (12,20,'Please enter BASE year MM'c)
      baseyr=ichk (-999,-999)
      if (baseyr .eq. -9999) go to 5551

 5552 call pcs (14,20,'Please enter END year  MM'c)
      endyr=ichk (baseyr+1,-999)
      if (endyr .eq. -9999) go to 5552
      call eeop (22,0)
c
c     if (endyr .le. baseyr) then
c       call pcsa (22,15,' END YEAR SHOULD BE GREATER THAN BASE YEAR 'c,
c    -               vrev)
c       go to 5551
c     endif
c
      ie=endyr-baseyr+1
      if ((endyr-baseyr) .gt. ny-1) then
```

```
          write (nyc,'(i2)') ny
          call pcsa (22,15,' THIS PROGRAM SUPPORTS A SPAN OF '//nyc(1:2)//
     -                  ' YEARS 'c,vrev)
          go to 5551
        endif
c
        ccap=.false.
        fname(1)='caperm.dat'
c
4780    if ((option .eq. 1) .or. (option .eq. 2)) then
          call eeop (5,0)
          call pcsa (8,28,' PRODUCT BAN SCHEDULE 'c,vrev)
c
          do 4692 iyy=1,ny
            do 46921 ixy=1,ip
              isban(iyy,ixy)=0
46921       continue
4692      continue
c
47801     call pcs (12,5,'Enter the number of years in '//
     -                   'which bans will take place MM'c)
          call yr_chk (byrs,0,22)
          call eeop (9,0)
c
          do 22 n=1,byrs
            write (nyc,'(i2)') n
            call pcs (12,15,'Enter ban year #'//nyc(1:2)//' MM'c)
            call yr_chk (byear(n),1,22)
22        continue
c
          ibchk=99
          call eeop (9,0)
          do 33 n=1,byrs
            beyr=byear(n)-baseyr+1
            call nprd_chk (iban,22,'b',byear(n))
c
            if (iban .eq. 99) then
              ibchk=beyr
              byrs=n
c
              do 957 lm=1,ip
                do 9571 ll=beyr,ie
                  isban(ll,lm)=1
9571            continue
957           continue
c
              go to 4922
            endif
c
            call eeop (9,0)
            do 44 nn=1,iban
              call tsca (nn,nban,'b',12)
c
              do 55 ll=beyr,ie
                isban(ll,nban)=1
55            continue
44          continue
33        continue
        endif
c
4922    if (option .eq. 1) go to 9966
c
        call eeop (5,0)
        call pcsa (8,28,' FIBER CAP SCHEDULE 'c,vrev)
4923    call pcs (11,5,'Please enter fiber end amount (tons) MM'c)
        endamt=rchk (0d0,-999d0)
        if (endamt .eq. -9999.) go to 4923
c
415     call pcs (13,5,'What year will phase down start?     MM'c)
        call yr_chk (cstyr,1,14)
c
        call pcs (15,5,'What year will phase down terminate? MM'c)
        call yr_chk (cendyr,2,16)
c
        iss = cstyr  - baseyr + 1
        ise = cendyr - baseyr + 1
c
        if (ccap) go to 4777
c
416     ierr1=0
```

```
      open (1,iostat=ierr1,file=fname(1),status='old')
      if (ierr1 .le. 0) go to 418
      call file_chk (0,1)
      call pcs (17,5,'Please enter name of file containing '//
     -                'annual fiber caps and permit value'c)
      call pcs (18,5,'allocation tonnage.  '//
     -                '(Include path if necessary) MM'c)
      call cchk (fname(1))
      call eeop (22,0)
      go to 416
c
418   read (1,*) (qcapm(i), i = iss, ise - 1)
      do 66 n = ise, ie
        qcapm(n) = endamt
66    continue
c
4792  if (option .ne. 2) go to 4583
c
      do 4582 i = iss, ie
        if (qcapm(i) .ne. 0) go to 4582
        icby = i + baseyr - 1
        do 45821 n = 1, byrs
          if (icby .gt. byear(n)) go to 45821
          call eeop (5,0)
          call pcsa (8,3,' YOU HAVE SPECIFIED PRODUCT BANS FOR '//
     -                'YEAR(S) AFTER FIBER CAP GOES TO ZERO 'c,vrev)
          write (nyc,'(i4)') icby
          call pcs (10,10,'Fiber cap goes to zero in '//nyc//' 'c)
          call pcs (12,10,'One or more products have been banned '//
     -                   'in the following years:'c)
          call setcur (14,0)
          write (*,'(t15,4(5(i4,3x)/))') (byear(j),j=1,byrs)
          call pcsa (20,8,' YOU WILL BE PROMPTED FOR BAN AND '//
     -                   'FIBER CAP SCHEDULES AGAIN 'c,vrev)
          close (1)
          call pcs (24,25,'Press any key to continue'c)
          call setcur (vy,vx)
          ipse = key_getc()
          go to 4780
45821   continue
4582  continue
c
4583  cstr2='____________________________________________________________'c
      cstr3='        Year                  Fiber Cap Amount (tons)'c
      call eeop (5,0)
      call pcsa (5,28,' FIBER CAP SCHEDULE 'c,vrev)
      call pcs (6,13,cstr2)
      call pcs (8,13,cstr3)
      call pcs (9,13,cstr2)
      call setcur (11,0)
c
      if (cendyr .eq. endyr) then
        ix = ie
      else
        ix = cendyr - baseyr
      endif
c
      jj = 10
c
      write (nyc,'(i4)') baseyr + i - 1
      write (cqc,'(a10)') '   No Cap '
c
      if (baseyr + i - 1 .eq. cstyr - 1) then
        call pcs (11,22,nyc//' 'c)
        call pcs (11,vx+18,cqc//' 'c)
        jj = 11
      else
        call pcs (11,22,nyc//'-'c)
        write (nyc,'(i4)') cstyr-1
        call pcs (11,vx,nyc//' 'c)
        call pcs (11,vx+13,cqc//' 'c)
        jj = 11
      endif
c
      do 836 i = iss, ix
        j = jj + 1 + i - iss
c
        if (i .gt. 9 + iss) then
          call more
          j = 20
```

```fortran
          endif
c
          write (nyc,'(i4)') baseyr + i - 1
          call pcs (j,22,nyc//' 'c)
          write (cqc,'(f10.2)') qcapm(i)
          call pcs (j,vx+18,cqc//' 'c)
  836   continue
c
        if (cendyr .ne. endyr) then
          j = vy + 1
c
          if (i .gt. jj + iss) then
            call more
            j = 20
          endif

          write (nyc,'(i4)') cendyr
          call pcs (j,22,nyc//'-'c)
          write (nyc,'(i4)') endyr
          call pcs (j,vx,nyc//' 'c)
          write (cqc,'(f10.2)') endamt
          call pcs (j,vx+13,cqc//' 'c)
        endif
c
        if (ix .gt. 9) ix = 10
        call pcs (ix + 11, 13, cstr2)
        call pcs (ix + 13, 10, 'Do you want to change the annual '//
     -                        'fiber caps? (Y/N) MM'c)
        call ynchk (*4775,*7778)
c
 4775   ccap = .true.
        go to 4922
c
 4777   do 7777 kk = cstyr, cendyr - 1
          write (nyc,'(i4)') kk
 4778     call pcs (16,5,'Please enter fiber cap amount for year '//
     -                  nyc//' MM'c)
          ll = kk - baseyr + 1
          qcapm(ll) = rchk (0d0,-999d0)
          if (qcapm(ll) .eq. -9999.) go to 4778
 7777   continue
c
        do 77771 kk = cendyr, endyr
          ll = kk - baseyr + 1
          qcapm(ll) = endamt
77771   continue
        go to 4792
c
 7778   prm1='___________________________________________________________'c
        prm2='                   Party                               Tonnage'c
        rewind 1
        read (1,*)
        read (1,*) (paloc(i),i=1,9)
c
 9879   call eeop (4,0)
        call pcsa (4,28,' PERMIT ALLOCATION 'c,vrev)
        call pcs (5,10,prm1)
        call pcs (7,10,prm2)
        call pcs (8,10,prm1)
c
        do 6890 i=1,9
          j=i+9
          write (nyc,'(i2)') i
          call pcs (j,13,nyc(1:2)//'. '//perm(i)//' 'c)
          write (cqc,'(f10.2)') paloc(i)
          call pcs (j,vx+6,cqc//' 'c)
 6890   continue
c
        write (nyc,'(i2)') i
        call pcs (vy+2,13,nyc(1:2)//'. '//perm(i)//' 'c)
        call pcs (vy,vx+13,'ALL'c)
        call pcs (21,10,prm1)
c
        call pcs (23,10,'Do you want to change any of these '//
     -                  'allocations (Y/N) MM'c)
        call ynchk (*9876,*9877)
c
 9876   call eeop (23,0)
        call pcs (23,10,'Enter ID # of party with new allocation '//
     -                 '(0 to end)  MM'c)
```

```
        i=ichk (0,9)
c
        if (i .eq. -9999) call pty_chk (0,*9876)
        if (i .eq. 0) go to 9877
c
98761 call pcs (23,10,'Enter new allocation for '//
     -     perm(i)(1:lench(perm(i)))//' MM'c)
        paloc(i)=rchk (0d0,-999d0)
        if (paloc(i) .eq. -9999.) go to 98761

        write (nyc,'(i2)') i
        call pcs (i+9,13,nyc(1:2)//'. '//perm(i)//' 'c)
        write (cqc,'(f10.2)') paloc(i)
        call pcs (vy,vx+6,cqc//' 'c)
        go to 9876
c
9877    call eeop (23,0)
2469    call pcs (23,10,'Enter # of parties to whom permits are to '//
     -                   'be allocated MM'c)
        ires=ichk (1,9)
        call eeop (24,0)
c
        if (ires .eq. -9999) call pty_chk (1,*2469)
c
        call eeop (23,0)
        do 9965 i=1,10
          pflag(i)=0
9965    continue
c
        do 99651 ii=1,ires
          write (nyc,'(i1)') ii
2472      call pcs (23,10,'Please enter ID of party #'//nyc(1:1)//' MM'c)
          pid(ii)=ichk (1,10)
          call eeop (24,0)
c
          if (pid(ii) .eq. -9999) call pty_chk (0,*2472)
          if ((pid(ii) .eq. 10) .and. (ires .ne. 1))
     -       call pty_chk (2,*2469)
c
          pflag(pid(ii))=1
99651 continue
c
9966    if ((option .eq. 1) .and. (iban .lt. ip)) go to 8693
c
        exf=.false.
        call eeop (4,0)
        call pcsa (8,28,' PRODUCT EXEMPTIONS 'c,vrev)
        call pcs (12,5,'Do any products get exempted from '//
     -                  'regulation? (Y/N) MM'c)
        call ynchk (*8692,*8693)
c
8692    exf=.true.
        call pcs (14,5,'Please enter the number of products '//
     -                  'to be exempted MM'c)
        ixmpt=ichk (0,ip)
        call eeop (16,0)
c
        if (ixmpt .eq. ip) then
          call pcsa (18,20,'     YOU HAVE EXEMPTED ALL PRODUCTS 'c,vrev)
          call pcsa (19,20,' IS THERE ANY POINT IN CARRYING ON ?!! 'c,
     -                     vbold)
          call setcur (23,0)
          stop
        endif
c
        if ((ixmpt .lt. 1) .or. (ixmpt .gt. (ip-1))) then
          write (nyc,'(i2)') ip
          call pcsa (22,10,' NUMBER OF PRODUCTS SHOULD BE GREATER '//
     -                     'THAN 1 OR LESS THAN '//nyc(1:2)//' 'c,vrev)
          go to 8692
        endif
c
        do 86921 nn=1,ixmpt
          write (nyc,'(i2)') nn
          call tsca (nn,ires,'x',16)
          exmpt(ires)=.true.
86921 continue
c
8693    if ((option .eq. 1) .and. (iban .eq. ip)) go to 8695
c
```

```
      enf=.false.
      lbf=.false.
c
      call eeop (4,0)
      call pcsa (8,28,' ENGINEERING CONTROLS 'c,vrev)
      call pcs (12,5,'Do any products have engineering controls '//
     -              'put on them? (Y/N) MM'c)
      call ynchk (*8682,*8684)
c
8682  do 5692 iyy=1,ny
        do 56921 ixy=1,ip
          enctl(iyy,ixy)=.false.
56921   continue
5692  continue
c
      enf=.true.
c
      call pcs (14,5,'Enter the number of years in which '//
     -  'engineering'c)
      call pcs (15,5,'controls will be put on products MM'c)
      call yr_chk (ienyrs,0,16)
      call eeop (9,0)
c
      do 522 n=1,ienyrs
        write (nyc,'(i2)') n
        call pcs (12,15,'Enter CONTROL year #'//nyc(1:2)//' MM'c)
        call eeop (14,0)
        call yr_chk (enyr(n),1,14)
522   continue
c
      ienchk=99
      call eeop (9,0)
      do 533 n=1,ienyrs
        ienyr=enyr(n)-baseyr+1
        call nprd_chk (ien,14,'e',enyr(n))
c
        if (ien .eq. 99) then
            ienchk=ienyr
            ienyrs=n
c
          do 5957 lm=1,ip
            do 59571 ll=ienyr,ie
              enctl(ll,lm)=.true.
59571       continue
5957      continue
c
          go to 8684
        endif
c
        call eeop (9,0)
        do 544 nn=1,ien
          call tsca (nn,nen,'e',12)
          do 555 ll=ienyr,ie
            enctl(ll,nen)=.true.
555       continue
544     continue
533   continue
c
c
8684  call eeop (4,0)
      call pcsa (8,28,' PRODUCT LABELING 'c,vrev)
      call pcs (12,5,'Do any products have labels '//
     -              'put on them? (Y/N) MM'c)
      call ynchk (*8688,*8695)
c
8688  do 6692 iyy=1,ny
        do 66921 ixy=1,ip
          label(iyy,ixy)=.false.
66921   continue
6692  continue
c
      lbf=.true.
c
      call pcs (14,5,'Enter the number of years in which'//
     -        ' labeling'c)
      call pcs (15,5,'requirements will be introduced MM'c)
      call yr_chk (ilyrs,0,16)
      call eeop (9,0)
c
      do 622 n=1,ilyrs
```

```
     -       'used'c
      dstr4='   1. Percentage of foreign fiber supply'c
      dstr5='   2. Elasticity of fiber supply'c
      dstr9='YOU HAVE ENTERED AN UNACCEPTABLE PERCENTAGE'c
c
      fsup=91.60
      selast=1.46
c
 8629 call eeop (4,0)
      call pcsa (8,30,' MISCELLANEOUS 'c,vrev)
c
      call eeop (9,0)
      call pcs (10,8,dstr7)
      call pcs (12,8,dstr0)
      call pcs (13,8,dstr7)
86291 call pcs (15,8,dstr4)
      write (cqc,'(f6.2)') fsup
      call pcs (15,vx+9,cqc(1:6)//'%'c)
      call pcs (16,8,dstr5)
      write (cqc,'(f6.2)') selast
      call pcs (16,vx+17,cqc(1:6)//' 'c)
      call pcs (17,8,dstr7)
      call eeop (18,0)
      call pcs(19,8,'Do you want to change any of the above (Y/N) MM'c)
      call ynchk (*8622,*8627)
c
 8622 call pcs (21,8,'Please enter ID of item to be changed MM'c)
      ires=ichk (1,2)
      call eeop (22,0)
c
      if (ires .eq. -9999) then
        call pcsa (24,15,' YOU HAVE ENTERED AN UNACCEPTABLE OPTION 'c,
     -             vrev)
        go to 8622
      endif
c
      go to (8624,8625) ires
c
 8627 fsup=fsup/100.
      go to 7783
c
 8624 call eeop (19,0)
      dstr1='Please enter the new percentage of foreign supply in'c
      dstr2='decimal equivalent, i.e., enter 80% as 0.8 or .8 MM'c
      call pcs (19,8,dstr1)
86241 call pcs (20,8,dstr2)
      fsup=rchk (0d0,1d0)
      call eeop (21,0)
c
      if (fsup .eq. -9999.) then
        call pcsa (24,17,dstr9,vrev)
        go to 86241
      endif
c
      fsup=fsup*100.
      go to 86291
c
 8625 call eeop (19,0)
86251 call pcs (19,8,'Please enter the new elasticity of '//
     -             'supply MM'c)
      selast=rchk (-999d0,-999d0)
      call eeop (20,0)
      if (selast .eq. -9999.) go to 8625
c
      if (selast .lt. 1) then
        call pcsa (24,15,' AN ELASTICITY OF LESS THAN '//
     -             'ONE IS UNACCEPTABLE 'c,vrev)
        go to 86251
      endif
c
      go to 86291
c
 7783 dsup=1-fsup
c
      call eeop (9,0)
      call pcs (12,5,'Which baseline quantity decline scenario '//
     -             'would you like to use:'c)
 7784 call pcs (14,5,'LOW, MODERATE, or HIGH.  Enter L/M/H MM'c)
      call cchk (res)
      call eeop (15,0)
```

```
c
      if ((res .eq. 'L') .or. (res .eq. 'l')) then
        ibgr=1
      elseif ((res .eq. 'M') .or. (res .eq. 'm')) then
        ibgr=2
      elseif ((res .eq. 'H') .or. (res .eq. 'h')) then
        ibgr=3
      else
        go to 7784
      endif
c
      fstr1='Please enter name of data file containing asbestos'c
      fstr2='product market data. (Include path if necessary)  MM'c
      fstr3='Please enter name of data file containing substitute'c
      fstr4='product data. (Include path if necessary)          MM'c
c
      call eeop (4,0)
      call pcsa (8,28,' INPUT FILES 'c,vrev)
 6661 call pcs (12,5,fstr1)
      call pcs (13,5,fstr2)
      call cchk (fname(2))
      call eeop (14,0)
c
      ierr2=0
      open (2,iostat=ierr2,file=fname(2),status='old')
      if (ierr2 .le. 0) go to 6662
      call file_chk (0,2)
      go to 6661
c

 6662 call pcs (15,5,fstr3)
      call pcs (16,5,fstr4)
      call cchk (fname(4))
      call eeop (17,0)
c
      ierr4=0
      open (4,iostat=ierr4,file=fname(4),status='old')
      if (ierr4 .le. 0) go to 6664
      call file_chk (0,4)
      go to 6662
c
 6664 call eeop (4,0)
      call pcsa (8,28,' OUTPUT OPTIONS 'c,vrev)
c
      if (option .eq. 1) then
        cresf=0
        go to 7799
      endif
c
      call pcs (12,5,'Would you like a printout of the '//
     -              'consistency check (Y/N) MM'c)
      call ynchk (*7781,*7782)
c
 7781 cresf=1
      go to 7799
c
 7782 cresf=0
c
 7799 call pcs (14,5,'Would you like a detailed printout (Y/N) MM'c)
      call ynchk (*7791,*7792)
c
 7791   dprf=1
        go to 6660
c
 7792   dprf=0
c
 6660 call pcs (16,5,'Would you like the simulation output'c)
      call pcs (17,5,'to be routed to the printer or disk?'c)
 1924 call pcs (19,5,'Please enter P or D                  MM'c)
      call cchk (res)
c
      if ((res .eq. 'P') .or. (res .eq. 'p')) then
        fname(3)='lpt1'
        go to 1929
      elseif ((res .eq. 'D') .or. (res .eq. 'd')) then
        go to 1926
      else
        go to 1924
      endif
c
```

```
 1926  call eeop (9,0)
 1927  call pcs (12,5,'Please enter name of file where simulation '//
      -              'output'c)
       call pcs (13,5,'should be stored. (Include path if '//
      -              'necessary) MM'c)
       call cchk (fname(3))
       call eeop (14,0)
 c
       ierr3=0
       open (3,file=fname(3),iostat=ierr3,status='new')
       if (ierr3 .le. 0) go to 1929
       call file_chk (1,3)
       call ynchk (*1929,*1927)
 c
 1929  call eeop (9,0)
 2927  call pcs (12,5,'Please enter name of file where BASELINE '//
      -              'indices'c)
       call pcs (13,5,'should be stored. (Include path if '//
      -              'necessary,) MM'c)
       call cchk (fname(8))
       call eeop (14,0)
 c
       ierr8=0
       open (8,file=fname(8),iostat=ierr8,status='new')
       if (ierr8 .le. 0) go to 2929
       call file_chk (1,8)
       call ynchk (*2929,*2927)
 c
 2929  call eeop (9,0)
 3927  call pcs (12,5,'Please enter name of file where ALTERNATIVE '//
      -              'indices'c)
       call pcs (13,5,'should be stored. (Include path if '//
      -              'necessary,) MM'c)
       call cchk (fname(9))
       call eeop (14,0)
 c
       ierr9=0
       open (9,file=fname(9),iostat=ierr9,status='new')
       if (ierr9 .le. 0) go to 3929
       call file_chk (1,9)
       call ynchk (*3929,*3927)
 c
 3929  call eeop (9,0)
 4927  call pcs (12,5,'Please enter name of file where cost-benefit '//
      -              'TABLES'''c)
       call pcs (13,5,'DATA should be stored. (Include path if '//
      -              'necessary,) MM'c)
       call cchk (fname(6))
       call eeop (14,0)
 c
       ierr6=0
       open(6,file=fname(6),iostat=ierr6,status='new',form='unformatted')
       if (ierr6 .le. 0) go to 4929
       call file_chk (1,6)
       call ynchk (*4929,*4927)
 c
 4929  call eeop (4,0)
       call pcsa (12,25,' Processing... 'c,vrev)
       call setcur (vy,vx-1)
 c
 c____________________________________________________________________________
 c
 c                    this section reads the input data files
 c____________________________________________________________________________
 c
 c
       read (2,*) fpe(1),fdiscrt,ibyd
 c
       i=1
 2125  read (2,'(i2,2x,a24)',end=2130) idp(i),desc(i)
       read (2,*) idp(i),awt(i),ccost(i),rcost(i),epp(1,i),epq(1,i),
      -           na(i),cprat(i),fecost(i),vecost(i),lcost(i)
 c
       ccost(i)=(ccost(i)/0.04)*fdiscrt
       rcost(i)=(rcost(i)/0.04)*fdiscrt
 c
       if (ibgr .eq. 1) then
         read (2,*) idp(i),(grthrt(i,k),k=1,15)
         read (2,*)
         read (2,*)
```

```
      elseif (ibgr .eq. 2) then
        read (2,*)
        read (2,*) idp(i),(grthrt(i,k),k=1,15)
        read (2,*)
      else
        read (2,*)
        read (2,*)
        read (2,*) idp(i),(grthrt(i,k),k=1,15)
      endif
c
      read (4,*) idp(i),nsub(i),(taps(1,i,j),ns(i,j),
     -                           ams(i,j),j=1,nsub(i))
      read (4,*) idp(i),(sub_dec(j),j=1,nsub(i))
c
      if (multsub) then
        do 2124 j=1,nsub(i)
          aps(1,i,j)=taps(1,i,j)*(1+sub_dec(j))**(baseyr-ibyd)
          do 21241 iy=2,ie
            aps(iy,i,j)=aps(iy-1,i,j)*(1+sub_dec(j))
21241     continue
2124    continue
      else
        do 2123 j=1,nsub(i)
          do 21231 iy=1,ie
            aps(iy,i,j)=taps(1,i,j)
21231     continue
2123    continue
      endif
c
      do 2126 ik=1,ny
        if ((isban(ik,idp(i)) .eq. 1) .and. (.not. exmpt(idp(i))))
     -    swban(ik,i)=1
2126  continue
      i=i+1
      go to 2125
c
2130  np=i-1
c
      close (1)
      close (2)
      close (4)
c
      return
      end
```

```
c
c
c
c     ARCM : OUTPUT SUBROUTINE
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c
c
c
$include:'stdsub'
$large
c
c
c
c              This subroutine writes the output to a file or printer
c
c
c
      subroutine asbout
c
$include:'stdvar'
$include:'vars.cmn'
c
      real          psl(10),csl(10),alt(ny),a3t(ny),v(10),r(10)
c
      character     opt*40,bopt*16,bans2*100,bans1*125,temp*4,
     -              temp1*125,temp2*100
c
      character*80 bstr1,bstr2,pstr1,fstr1,cs1,cs2,cs3,p0,p1,p2
c
c
      if (option .eq. 1) then
        opt='Product ban only'
      elseif (option .eq. 2) then
        opt='Product ban and annual fiber caps'
      else
        opt='Annual fiber caps only'
      endif
c
      if (ibgr .eq. 1) then
        bopt='Low Decline'
      elseif (ibgr .eq. 2) then
        bopt='Moderate decline'
      else
        bopt='High Decline'
      endif
c
      if (fname(3) .eq. 'lpt1') then
        pgbrk='1'
      else
        pgbrk=' '
      endif
c
c
c
c
c                    this section divides all areas by 1,000
c
c
c
      do 8893 yr = 1, ie
        alt(yr) = 0.
        a3t(yr) = 0.
        do 88931 j = 1, np
          area5(yr,j)  = area5(yr,j)  / 1000.
          area6(yr,j)  = area6(yr,j)  / 1000.
          area7(yr,j)  = area7(yr,j)  / 1000.
          area8(yr,j)  = area8(yr,j)  / 1000.
          area8p(yr,j) = area8p(yr,j) / 1000.
c
          if (option .eq. 1) go to 88931
          if ((swban(yr,j) .eq. 1) .or. exmpt(idp(j))) go to 88931
c
          alt(yr) = alt(yr) + area5(yr,j) + area7(yr,j)
          a3t(yr) = a3t(yr) + area6(yr,j) + area8(yr,j)
```

```
c
88931   continue
           area1(yr) = area1(yr) / 1000.
           area2(yr) = area2(yr) / 1000.
           area3(yr) = area3(yr) / 1000.
           area4(yr) = area4(yr) / 1000.
           areap(yr) = areap(yr) / 1000.
8893  continue
c
c
c________________________________________________________________________
c
c                      this section writes the summary output
c________________________________________________________________________
c
      fmt(1)='(12x,i2,2x,f16.2,1x,f14.2,21x,a)'
      fmt(2)='(/12x,a5,1x,f14.2,1x,f14.2,2x,f16.2)'
      fmt(3)='(2x,a25,1x,f13.2,1x,f12.2,1x,f12.2,1x,f12.2)'
      fmt(4)='(8x,i4,2x,f12.3,5x,f12.3,4x,f12.3,4x,f12.3)'
      fmt(5)='(15x,i2,a2,a30,f12.2)'
      fmt(12)='(/12x,a5,1x,f14.2,1x,f14.2)'
      fmt(14)='(2x,a25,15x,f12.2,1x,f12.2,1x,f12.2)'
      fmt(15)='(/2x,a25,28x,f12.2,1x,f12.2)'
c
      us1='____________________________________________________________
     -__________
c
      call getdat (iyr,imon,iday)
      call gettim (ihr,imin,isec,i100th)
      if (iday .ge. 10) then
        write (dstr,'(2(i2,1h/),i4)') imon,iday,iyr
      else
        write (dstr,'(i2,2h/0,i1,1h/,i4)') imon,iday,iyr
      endif
      if (imin .ge. 10) then
        write (tstr,'(i2,1h:,i2)') ihr,imin
      else
        write (tstr,'(i2,2h:0,i1)') ihr,imin
      endif
c
      call pcsa (12,36,' completed 'c,vrev)
      call pcsa (15,23,' Writing output... 'c,vrev)
      call setcur (vy,vx-1)
c
      open (3,file=fname(3))
      open (6,file=fname(6),form='unformatted')
      if (fname(3) .eq. 'lpt1') write (3,'(a)') pgbrk
      ipage=0
      call header (0)
      write (3,'(//7x,a19,1x,a/)') 'Regulation Option :',opt
      write (3,'(7x,a19,1x,i4/)') 'Beginning Year    :',baseyr
      write (3,'(7x,a19,1x,i4/)') 'Ending Year       :',endyr
      write (3,'(7x,a19,1x,a/)') 'Baseline Growth   :',bopt
      write (3,'(7x,a19,1x,10(f4.1,a,2x)//)') 'Discount Rate(s)  :',
     -(discrt(i)*100.,'%',i=1,nodrt)
      fsup=fsup*100.
      dsup=dsup*100.
      write (3,'(/7x,a,f7.2/)')  'Elasticity of fiber supply :',selast
      write (3,'(7x,a,f6.1,a/)') 'Foreign fiber supply       :',fsup,'%'
      write (3,'(7x,a,f6.1,a/)') 'Domestic fiber supply      :',dsup,'%'
      iline=19
      bstr1='______________________________________________'
      if (option .eq. 3) go to 200
      write (3,'(//7x,a/)') 'PRODUCT BAN SCHEDULE'
      bstr2='    Year of Ban          TSCA Product Nos.'
      write (3,'(15x,a//,15x,a/,15x,a/)') bstr1,bstr2,bstr1
      iline=iline+7
c
      do 10 n=1,byrs
        if (ibchk .eq. 99) go to 103
        if (ibchk .eq. byear(1)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a\)') byear(n),'All Products '
          go to 105
        elseif (ibchk .eq. byear(n)-baseyr+1) then
          write (bans1,'(22x,i4,13x,a)') byear(n),
     -                                   'All Remaining Products '
          go to 105
        endif
c
103   write (bans1,'(22x,i4)') byear(n)
```

```
          ix=byear(n)-baseyr+1
          ic=0
          flag1=0
c
          do 101 nn=1,ip
            if ((isban(ix,nn) .eq. 1) .and. (.not. exmpt(nn))) then
              temp1=bans1
              if (flag1 .eq. 0) then
                write (temp,'(i2)') nn
                bans1=temp1(1:39)//temp
                flag1=1
              else
                write (temp,'(a,i2\)') ',',nn
                bans1=temp1(1:41+ic*3)//temp
                ic=ic+1
              endif

              do 1011 m=ix,ie
                isban(m,nn)=0
 1011         continue

            endif
  101     continue

          write (3,'(a)') bans1
          iline=iline+1
   10   continue
c
        go to 102
c
  105   write (3,'(a)') bans1
        iline=iline+1
        write (bans2,'(40x,a)') 'except'
        ic=0
        do 1051 i=1,ip
          temp2=bans2
          if (exmpt(i)) then
            if (ic .eq. 0) then
              write (temp,'(a,i2)') ' ',i
            else
              write (temp,'(a,i2)') ',',i
            endif
             bans2=temp2(1:46+ic*3)//temp
             ic=ic+1
          endif
 1051   continue
        if (ic .gt. 0) write (3,'(a)') bans2
        iline=iline+1
c
  102   write (3,'(15x,a//)') bstr1
        iline=iline+3
c
c
  200   if (.not.(enf)) go to 703
        if (iline .gt. 50) call header (0)
        write (3,'(//7x,a/)') 'ENGINEERING CONTROLS SCHEDULE'
        bstr2='     Year of Control      TSCA Product Nos.'
        write (3,'(15x,a//,15x,a/,15x,a/)') bstr1,bstr2,bstr1
        iline=iline+7
c
        do 70 n=1,ienyrs
          if (ienchk .eq. 99) go to 203
          if (ienchk .eq. enyr(1)-baseyr+1) then
            write (bans1,'(22x,i4,13x,a\)') enyr(n),'All Products '
            go to 702
          elseif (ienchk .eq. enyr(n)-baseyr+1) then
            write (bans1,'(22x,i4,13x,a)') enyr(n),
     -                                     'All Remaining Products '
            go to 702
          endif
c
  203     write (bans1,'(22x,i4)') enyr(n)
          ix=enyr(n)-baseyr+1
          ic=0
          flag1=0
c
          do 701 nn=1,ip
            if (enctl(ix,nn)) then
              temp1=bans1
              if (flag1 .eq. 0) then
```

```
                write (temp,'(i2)') nn
                bansl=templ(1:39)//temp
                flagl=1
              else
                write (temp,'(a,i2\)') ',',nn
                bansl=templ(1:41+ic*3)//temp
                ic=ic+1
              endif
c
              enctl(0,nn)=.true.
              do 7011 m=ix,ie
                enctl(m,nn)=.false.
7011          continue
c
            endif
701       continue
c
          write (3,'(a)') bansl
          iline=iline+1
70      continue
c
        go to 7021
c
702     write (3,'(a)') bansl
        iline=iline+1
7021    write (3,'(15x,a//)') bstrl
        iline=iline+3
c
703     if (.not.(lbf)) go to 903
        if ((option .ne. 3) .and. enf) call header (0)
        if (iline .gt. 50) call header (0)
        write (3,'(//7x,a/)') 'PRODUCT LABELING SCHEDULE'
        bstr2='  Year of Labeling       TSCA Product Nos.'
        write (3,'(15x,a//,15x,a/,15x,a/)') bstrl,bstr2,bstrl
        iline=iline+7
c
        do 90 n=1,ilyrs
          if (ilchk .eq. 99) go to 503
          if (ilchk .eq. lyr(l)-baseyr+1) then
            write (bansl,'(22x,i4,13x,a\)') lyr(n),'All Products '
            go to 902
          elseif (ilchk .eq. lyr(n)-baseyr+1) then
            write (bansl,'(22x,i4,13x,a)') lyr(n),
     -                                 'All Remaining Products '
            go to 902
          endif
c
503       write (bansl,'(22x,i4)') lyr(n)
          ix=lyr(n)-baseyr+1
          ic=0
          flagl=0
c
          do 901 nn=1,ip
            if (label(ix,nn)) then
              templ=bansl
              if (flagl .eq. 0) then
                write (temp,'(i2)') nn
                bansl=templ(1:39)//temp
                flagl=1
              else
                write (temp,'(a,i2\)') ',',nn
                bansl=templ(1:41+ic*3)//temp
                ic=ic+1
              endif
c
              label(0,nn)=.true.
              do 9011 m=ix,ie
                label(m,nn)=.false.
9011          continue

            endif
901       continue

          write (3,'(a)') bansl
          iline=iline+1
90      continue
c
        go to 9021
c
902     write (3,'(a)') bansl
```

```
           iline=iline+1
     9021  write (3,'(15x,a//)') bstrl
           iline=iline+3
     c
     903   write (3,'(5(/),7x,a)') 'PRODUCT EXEMPTIONS'
           ic=0
           do 21 i=1,ip
             templ=bansl
             if (exmpt(i)) then
               if (ic .eq. 0) then
                 write (temp,'(i2)') i
                 bansl='  '//temp(1:2)
               else
                 write (temp,'(a,i2)') ', ',i
                 bansl=templ(1:ic*4)//temp(1:4)
               endif
               ic=ic+1
             endif
     21    continue
           if (ic .gt. 0) then
             write (3,'(/10x,a/)') 'The following products have been '//
          -                        'exempted from regulation:'
             write (3,'(15x,a)') bansl
           else
             write (3,'(/10x,a/)') 'No products have been exempted '//
          -                        'from regulation'
           endif
     c
     c
           if (option .eq. 1) go to 300
           if (iline .gt. 42) call header (0)
           pstrl='          Party                         Tonnage'
           write (3,'(//7x,a/)') 'FIBER PERMIT ALLOCATION (by tonnage)'
           write (3,'(15x,a//,15x,a/,15x,a/)') bstrl,pstrl,bstrl
           iline=iline+7
           aloc=0
           ipid=0
           if (pflag(10) .eq. 1) then
             write (3,'(15x,2a,7x,a)') '1. ',perm(10),'ALL'
             go to 47
           endif
           do 45 i=1,9
             if (pflag(i) .eq. 0) then
               paloc(i)=0
               go to 45
             endif
             ipid=ipid+1
             write (3,fmt(5)) ipid,'. ', perm(i),paloc(i)
             aloc=aloc+paloc(i)
             iline=iline+1
     45    continue
           write (3,'(/19x,a29,1x,f12.2)') perm(11),aloc
     47    write (3,'(15x,a//)') bstrl
           iline=iline+4
           if (iline .gt. 25) call header (0)
     c
           write (3,'(//7x,a/)') 'FIBER CAP SCHEDULE'
           fstrl='      Year                 Fiber Cap (tons)'
           write (3,'(/10x,a/10x,a/10x,a//)') 'The fiber cap schedule '//
          -      'shown below is the effective cap ','schedule, i.e., '//
          -      'it does not include fiber demanded by','exempted markets.'
           write (3,'(15x,a//,15x,a/,15x,a/)') bstrl,fstrl,bstrl
           if (cendyr .eq. endyr) then
             ix=endyr
           else
             ix=cendyr-1
           endif
           do 20 i=baseyr+1,ix
             if (i .lt. cstyr) then
               write (3,'(20x,i4,19x,a10)') i,'  No Cap  '
             else
               write (3,'(20x,i4,19x,f10.2)') i,qcap(i-baseyr+1)
             endif
     20    continue
     c
           if (cendyr .ne. endyr) then
             write (3,'(20x,i4,a,i4,14x,f10.2)') cendyr,'-',endyr,endamt
           endif
           write (3,'(15x,a)') bstrl
           if (.not.(capr)) go to 300
```

```
      write (3,'(5(/),5x,2a/,5x,2a))') 'Note: Fiber cap schedule ',
     -'revised during model run to','      ensure that cap is ',
     -'binding in all years.'
c
 300  call header (1)
      write (3,'(t20,a)') 'DESCRIPTION OF PRODUCT CATEGORIES'
      if (pgbrk .eq. '1') write (3,'(a,t20,a)') '+',
     -                   '__________________________________'
      write (3,'(/5x,a//13x,a,25x,a/5x,a/)') usl,'TSCA #',
     -        'PRODUCT DESCRIPTION',usl
      do 3001 i=1,np
        write (3,'(15x,i2,27x,a)') idp(i),desc(i)
 3001 continue
      write (3,'(5x,a/)') usl
c
      do 310 j=1,np
        banm(j)='  '
        if (exmpt(idp(j))) banm(j)='X'
        if (swban(ie,j) .eq. 1) banm(j)='B'
c
        if (enctl(0,idp(j))) then
          if (banm(j)(1:1) .eq. ' ') then
            temp1=' E'
          else
            temp1=',E'
          endif
        endif
c
        if (label(0,idp(j))) then
          if (banm(j)(1:1) .eq. ' ') then
            temp2=' L'
          else
            temp2=',L'
          endif
        endif
c
        temp=banm(j)
        banm(j)=' '//temp(1:1)//temp1(1:2)//temp2(1:2)
c
 310  continue
c
c
      write (6) nodrt
      do 346 i=1,nodrt
        dcsl=0
        dpsl=0
        fcsl=0
        fpsl=0
        do 30 j=1,np
          dcons(j)=0
          dpros(j)=0
          fcons(j)=0
          fpros(j)=0
c
          do 301 yr=2,ie
            area5d = area5(yr,j)  / (1 + discrt(i)) ** (yr - 1)
            area6d = area6(yr,j)  / (1 + discrt(i)) ** (yr - 1)
            area7d = area7(yr,j)  / (1 + discrt(i)) ** (yr - 1)
            area8d = area8(yr,j)  / (1 + discrt(i)) ** (yr - 1)
            ar8pd  = area8p(yr,j) / (1 + discrt(i)) ** (yr - 1)
c
            cons = area5d + area6d
c
            if ((optn(yr) .eq. 1) .and. (cprat(j) .lt. 1) .and.
     -          (area5d .lt. 0)) then
              dcons(j) = dcons(j) + cons *      cprat(j)
              fcons(j) = fcons(j) + cons * (1 - cprat(j))
            else
              dcons(j) = dcons(j) + cons
            endif
c
            pros = area7d + area8d + ar8pd
c
            if ((cprat(j) .eq. 1) .and. impinf(j)) then
              fpros(j) = fpros(j) + pros
            elseif (cprat(j) .gt. 1) then
              dpros(j) = dpros(j) + pros / cprat(j)
              fpros(j) = fpros(j) + pros * (1 - 1 / cprat(j))
            else
              dpros(j) = dpros(j) + pros
```

```
            endif
c
301       continue
c
          dcsl =dcsl + dcons(j)
          dpsl =dpsl + dpros(j)
          fcsl =fcsl + fcons(j)
          fpsl =fpsl + fpros(j)
30      continue
c
        fmcs  = dcsl + fcsl + dpsl + fpsl
        fmdcs = dcsl + dpsl
        fmps  = 0.
        fmdps = 0.
        pval  = 0.
        do 40 yr = 2, ie
c
          area1d = area1(yr) / (1 + discrt(i)) ** (yr - 1)
          area3d = area3(yr) / (1 + discrt(i)) ** (yr - 1)
c
          area2d = area2(yr) / (1 + discrt(i)) ** (yr - 1)
          area4d = area4(yr) / (1 + discrt(i)) ** (yr - 1)
c
          areapd = areap(yr) / (1 + discrt(i)) ** (yr - 1)
c
          fmps = fmps + area2d + area4d
c
          if (optn(yr) .eq. 1) go to 40
c
          pval = pval + areapd
40      continue
c
        fmdps = fmps * dsup / 100.
c
        discrt(i) = discrt(i) * 100.
        call tabagg (1,discrt(i),fmcs,fmps,pval)
        call tabagg (2,discrt(i),fmdcs,fmdps,pval)
c
        write (3,'(a)') pgbrk
        ipage=ipage+1
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
        write (3,'(t26,a)') '                TABLE 2'
        if (pgbrk .eq. '1') write (3,'(a,t26,11x,a)') '+','_______'
        write (3,'(//t30,a)') 'WELFARE EFFECTS BY PARTY'
        if (pgbrk .eq. '1') write (3,'(a,t30,a)') '+',
     -                      '________________________'
        write (3,'(/t15,2a,f4.1,a//)') '(Present Values, in thousand ',
     -                           'dollars, at ',discrt(i),' Percent)'
        p0='_______________________________________________________________'//
     -  '_____________________________'
        p1='            Party                CS Loss      PS Loss      '//
     -     'Allocation    Net Loss'
        p2='                                                          of '//
     -     'Permits'
        psl(1)=fmps*dsup/100.
        psl(2)=fmps*fsup/100.
        psl(4)=dpsl
        psl(5)=fpsl
        csl(8)=dcsl
        csl(9)=fcsl
        zero=0.
        ww=0
        usw=0
        write (3,'(//2x,a//,2(4x,a/),2x,a/)') p0,p1,p2,p0
        do 575 j=1,9
          if (pflag(10) .eq. 1) then
            aloc=1
            paloc(j)=0
          endif
          peral=0
          if (option .ne. 1) then
            peral=pval*paloc(j)/aloc
          endif
          rnl=csl(j)+psl(j)+peral
          ww=ww+rnl
          if ((j .eq. 2) .or. (j .eq. 5) .or. (j .eq. 9)) go to 555
          usw=usw+rnl
c
```

```
555        if (j .le. 7) then
             write (3,fmt(14)) perm(j),psl(j),peral,rnl
           else
             write (3,fmt(3)) perm(j),csl(j),psl(j),peral,rnl
           endif
c
           v(j)=peral
           r(j)=rnl
c
575      continue
         if (pflag(10) .eq. 1) then
           write (3,fmt(15)) perm(10),pval,pval
           v(10)=pval
           r(10)=pval
           usw=usw+pval
           ww=ww+pval
         else
           write (3,fmt(15)) perm(10),zero,zero
           v(10)=0
           r(10)=0
         endif
         write (3,'(2x,a/)') p0
         write (3,'(4(/),t30,a)') 'NET WELFARE LOSSES'
         if (pgbrk .eq. '1') write (3,'(a,t30,a)')'+',
     -
         write (3,'(//20x,a,f16.2/)') 'U. S. Welfare: ',usw
         write (3,'(20x,a,f16.2//)') 'World Welfare: ',ww
         write (3,'(///10x,a)') 'Note: Negative entries are welfare '//
     -                          'gains.'
c
         write (6) discrt(i),(csl(j),psl(j),v(j),r(j),j=1,10),usw,ww
c
346   continue
      if (cresf .eq. 0) go to 600
c
c_____________________________________________________________________
c
c                   this section writes the consistency check
c_____________________________________________________________________
c
c
      write (3,'(a)') pgbrk
      ipage=ipage+1
      write (3,'(t64,2a)') 'Date: ',dstr
      write (3,'(t64,2a)') 'Time: ',tstr
      write (3,'(t64,a,i2/)') 'Page: ',ipage
      write (3,'(t26,a)') '    MODEL CONSISTENCY CHECK'
      if (pgbrk .eq. '1') write (3,'(a,t26,a)') '+',
     -
      write (3,*)
      csl='                               Sum of                       '//
     -    '  Sum of'
      cs2='Year       AREA 1     =    AREAs 5 & 7        AREA 3     =    '//
     -    'AREAs 6 & 8'
      cs3='         (Fiber Mkt.)   over output mkts.   (Fiber Mkt.) '//
     -    'over output mkts.'
      write (3,'(//7x,a//,3(8x,a/),7x,a//)') usl,csl,cs2,cs3,usl
c
      do 59 yr=2,ie
        iyr=yr+baseyr-1
        if (optn(yr) .eq. 1) then
          write (3,'(8x,i4,2x,a)') iyr,'*****  PHASEDOWN SCHEDULE '//
     -                                 'NOT IN EFFECT  *****'
        else
          write (3,fmt(4)) iyr,areal(yr),alt(yr),area3(yr),a3t(yr)
        endif
59    continue
      write (3,'(7x,a//)') usl
c
      y(9)='Note: 1. Banned and exempted markets are not included in '//
     -     'Areas 6'
      y(12)='           (output) or Areas 3 (fiber) as of the year of '//
     -     'ban for'
      y(13)='           purposes of the model''s consistency check.'
      y(10)='       2. Differences in decimal places are due to '//
     -      'machine rounding.'
      y(14)='       2. Difference in the consistency check is due to '//
     -      'engineering'
      y(15)='           controls and/or labeling requirements.'
c
```

```
          write (3,'(/3(10x,a/))') y(9),y(12),y(13)
c
          if (enf .or. lbf) then
            write (3,'(2(10x,a/))') y(14),y(15)
          else
            write (3,'(10x,a)') y(10)
          endif
c
  600     if (dprf .eq. 1) call detout (ie)
c
          if (fname(3) .eq. 'lpt1') write (3,'(a)') pgbrk
          endfile 3
          close (3)
c
          return
          end
```

```
c________________________________________________________________________
c
c
c     ARCM : CALCULATION OF CS AND QR LOSSES FOR BANNED PRODUCTS
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c________________________________________________________________________
c
c
$large
c
c________________________________________________________________________
c
c      This subroutine calculates the CS and QR losses in banned markets.
c________________________________________________________________________
c
c
      subroutine bancsqr
c
$include:'vars.cmn'
c
c
      do 80 i=1,np
        if (swban(yr,i) .eq. 0) go to 80
        do 801 j=1,nsub(i)
          area6(yr,i)=area6(yr,i)+(ps(yr,i,j)-epp(yr,i))*qs(yr,i,j)
          if (swqr(i) .ne. 1) go to 801
          if (lnsub(i,j)) then
            area8p(yr,i)=area8p(yr,i)+(epp(yr,i)-avc(i))*qs(yr,i,j)/
     -                 fdiscrt
            lnsub(i,j)=.false.
          endif
801     continue
        swqr(i)=0
80    continue
      return
      end
```

```
c_____________________________________________________________________________
c
c
c     ARCM : BENEFIT MODEL INTERFACE ROUTINE
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_____________________________________________________________________________
c
c
$large
c
c_____________________________________________________________________________
c
c     This subroutine writes the index files for use in the Benefits Model
c_____________________________________________________________________________
c
c
      subroutine benout
c
c     ibp = maximum number of products for benefits routine
      parameter (ibp=37)
c
$include:'vars.cmn'
c
c
      real         bi(2:ny,ibp+1),ai(2:ny,ibp+1)
c
      integer      ina(ibp)
c
c
****  if (idp(np) .ne. ibp) return
c
      open (8,file=fname(8))
      open (9,file=fname(9))
c
      write (8,'(i2,2(5x,i4))') ie-1,baseyr,endyr
      write (9,'(i2,2(5x,i4))') ie-1,baseyr,endyr
c
      do 10 ib=1,ibp
        ina(ib)=0
        do 101 ia=2,ny
          bi(ia,ib)=0.
          ai(ia,ib)=0.
101     continue
10    continue
c
      do 5 i=1,np
        if (na(i) .lt. 1.) then
          ina(idp(i))=1
        else
          ina(idp(i))=na(i)+0.5
        endif
5     continue
      write (8,'(37i3,a3)') ina,'  1'
c
      do 20 ia=2,ie
        do 201 ib=1,np
c
          bi(ia,idp(ib))=bepq(ia,ib)/bbpq(ib)
c
          if (swban(ia,ib) .eq. 1) go to 201
          if (optn(ia) .eq. 1) then
            ai(ia,idp(ib))=bi(ia,idp(ib))
          else
            if ((qcap(ia) .eq. 0) .and. (.not. exmpt(idp(i))))
     -       go to 201
            ai(ia,idp(ib))=fpq(ia,ib)/bbpq(ib)
          endif
c
201     continue
c
        bi(ia,ibp+1)=bfqe(ia)/bbfq
c
        if (optn(ia) .eq. 1) then
```

```
          ai(ia,ibp+1)=fqe(ia)/bbfq
        else
          ai(ia,ibp+1)=qcapm(ia)/bbfq
        endif
c
        write (8,'(38(f4.2,1x))') (bi(ia,ib),ib=1,ibp+1)
        write (9,'(38(f4.2,1x))') (ai(ia,ib),ib=1,ibp+1)
c
 20   continue
c
      endfile 8
      endfile 9
c
      close (8)
      close (9)
c
      return
      end
```

```
c_____________________________________________________________________________
c
c
c     ARCM : DETAILED OUTPUT SUBROUTINE
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_____________________________________________________________________________
c
c
$large
c
c_____________________________________________________________________________
c
c           This subroutine writes the detailed output if requested
c_____________________________________________________________________________
c
c
      subroutine detout
c
$include:'vars.cmn'
c
c
      character    bann*6, begn(2)*11, nf*20
      character*80 ffmt(4)
      logical      stars, pluss
c
      y(1)='                 Baseline      Baseline       Scenario        '//
     -     'Scenario'
      y(2)='  Year            Price        Quantity        Price          '//
     -     'Quantity'
c
      fmt(6)='(12x,i4,1x,f13.2,1x,f13.2,a12,10x,a6)'
      fmt(7)='(12x,i4,1x,f13.2,1x,f13.2,1x,f13.2,1x,f15.2)'
      fmt(10)='(12x,i4,1x,f13.2,1x,f13.2,10x,a3,2x,f15.2)'
      fmt(11)='(12x,i4,1x,f13.2,1x,f13.2,8x,a6,10x,a6)'
      fmt(12)='(12x,i4,10x,a3,2x,f13.2,10x,a3,2x,f15.2)'
      fmt(13)='(12x,i4,1x,f13.2,1x,f13.2,10x,a3,1x,f16.2)'
      ffmt(1)='(9x,i4,1x,f10.2,1x,f12.2,6x,a3,9x,a3,14x,a3)'
      ffmt(2)='(9x,i4,1x,f10.2,1x,f12.2,1x,f10.2,8x,a3,4x,f14.2)'
      ffmt(3)='(9x,i4,1x,f10.2,1x,f12.2,1x,f10.2,2x,f10.2,3x,f14.2)'
      ffmt(4)='(9x,i4,1x,f10.2,1x,f12.2,7x,a3,9x,a3,4x,f14.2)'
c
      do 70 i=1,np+1
        write (3,'(a)') pgbrk
        ipage=ipage+1
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
        write (3,'(//t28,a)') 'PRICES AND QUANTITIES BY MARKET'
        if (pgbrk .eq. '1') write (3,'(a,t28,a)') '+',
     -  '_______________________________'
        write (3,'(/t28,a//)') '      (Undiscounted values)'
        if (i .eq. np+1) then
          y(1)='                                      Scenario    Scenario'
          y(2)='            Baseline     Baseline      Supply      '//
     -         ' Demand          Scenario'
          y(3)=' Year     Price         Quantity       Price        '//
     -         'Price        Quantity'
c
          write (3,'(t33,2a)') 'Market: ','Asbestos Fiber'
          write (3,'(/7x,a//,3(8x,a/),7x,a/)') us1,(y(k),k=1,3),us1
        else
          write (3,'(t28,a,i2,2a)') 'Market: ',idp(i),'. ',desc(i)
          if (exmpt(idp(i))) write (3,'(/t23,a)')
     -                          'This market is EXEMPTED from regulation'
          write (3,'(/7x,a//,2(8x,a/),7x,a/)') us1,y(1),y(2),us1
        endif
c
        if (i .eq. np+1) then
          write (3,ffmt(1)) baseyr,fpe(1),fqe(1),' -',' -',' -'
        else
          write (3,fmt(6)) baseyr,epp(1,i),epq(1,i),'-','   -'
        endif
c
```

```
      pluss = .false.
      do 701 yr=2,ie
        iyr=baseyr+yr-1
        if (i .eq. (np+1)) then
          if (fqe(yr) .eq. 0) then
            pluss = .true.
            if ((optn(yr) .eq. 1) .or. (qcapm(yr) .eq. 0)) then
              write (3,ffmt(4)) iyr,bfpe(yr),bfqe(yr),'+++','+++',
     -                          fqe(yr)
            else
              write (3,ffmt(2)) iyr,bfpe(yr),bfqe(yr),pf1(yr),'+++',
     -                          qcapm(yr)
            endif
          elseif (optn(yr) .eq. 1) then
            write (3,ffmt(2)) iyr,bfpe(yr),bfqe(yr),fpe(yr),' - ',
     -                        fqe(yr)
          elseif (qcap(yr) .eq. 0) then
            pluss = .true.
            if (qcapm(yr) .eq. 0) then
              write (3,ffmt(4)) iyr,bfpe(yr),bfqe(yr),'+++','+++',
     -                          qcap(yr)
            else
              write (3,ffmt(2)) iyr,bfpe(yr),bfqe(yr),pf1(yr),'+++',
     -                          qcapm(yr)
            endif
          else
            write (3,ffmt(3)) iyr,bfpe(yr),bfqe(yr),pf1(yr),pf(yr),
     -                        qcapm(yr)
          endif
        endif
c
        if (i .le. np) then
          stars = .false.
          if (bepq(yr,i) .eq. 0.) then
            write (3,fmt(12)) iyr,'n/a',bepq(yr,i),'n/a',bepq(yr,i)
          elseif (swban(yr,i) .eq. 1) then
            bann='Banned'
            write (3,fmt(11)) iyr,bepp(yr,i),bepq(yr,i),bann,bann
          elseif (optn(yr) .ne. 1) then
            if ((fpq(yr,i) .eq. 0) .or. ((qcap(yr) .eq. 0) .and.
     -          (.not. exmpt(idp(i))))) then
              write (3,fmt(10)) iyr,bepp(yr,i),bepq(yr,i),'***',
     -                          fpq(yr,i)
              stars = .true.
            else
              write (3,fmt(7)) iyr,bepp(yr,i),bepq(yr,i),fpp(yr,i),
     -                         fpq(yr,i)
            endif
          else
            write (3,fmt(7)) iyr,bepp(yr,i),bepq(yr,i),epp(yr,i),
     -                       epq(yr,i)
          endif
        endif
 701  continue
c
      write (3,'(7x,a,4(/))') usl
      if (option .eq. 1) go to 69
c
      if ( i .eq. (np+1)) then
        write (3,'(/7x,2a)') 'Note : 1. Scenario price is the fiber',
     -                       ' price plus the value of a permit.'
        write (3,'(/7x,a/19x,a/)') '       2. Scenario Quantity '//
     -     'includes fiber demanded by','exempted markets, if any.'
      elseif (stars) then
        write (3,'(///7x,2a)') 'Note : ''***'' indicates either ',
     -                         'scenario price is greater than'
        write (3,'(7x,2a)') '    maximum substitute price or ',
     -                      'fiber cap is zero.'
      endif
c
 69   if ((i .eq. (np+1)) .and. pluss) then
        if (option .eq. 1) then
          begn(1)='Note : '
          begn(2)='       '
          nf='(7x,a7,a)'
          go to 691
        elseif (endamt .eq. 0) then
          begn(1)='       3. '
          begn(2)='          '
          nf='(7x,a10,a)'
```

```
            go to 691
          endif
          go to 70
c
691       write (3,nf) begn(1), '''+++'' indicates either '//
     -                  'all markets have been banned or'
c
          write (3,nf) begn(2),'  fiber cap is zero and '//
     -                  'price is no longer meaningful.'
        endif
c
70    continue
      y(3)=' Market       Area 5        Area 6         Area 7        '//
     -    '  Area 8'
      y(4)='(TSCA #)'
      y(5)='Note: 1. Areas 1-4 in the fiber market are listed under '//
     -    'Areas 5-8.'
      y(6)='      2. Areas 6 & 8 include consumer and producer '//
     -    'surplus losses for'
      y(7)='         all banned, exempted, and non-banned markets. '//
     -    'Hence, this is a'
      y(8)='         complete accounting of all welfare effects.'//
     -    '  The model'
      y(11)='         consistency check, however, is defined in terms'//
     -    ' of non-banned'
      y(15)='         and non-exempted product markets and the fiber '//
     -    'market.  There-'
      y(16)='         fore, to perform this check using the '//
     -    'figures in this table,'
      y(17)='         the welfare effects in the banned and '//
     -    'exempted markets should'
      y(18)='         be excluded.  Refer to user''s guide for '//
     -    'further explanation.'
c
      fmt(8)='(13x,i2,1x,f15.3,1x,f14.3,1x,f14.3,1x,f14.3)'
      fmt(9)='(/13x,a5,1x,f12.3,1x,f14.3,1x,f14.3,1x,f14.3)'
c
      do 80  yr=2,ie
        iyr=baseyr+yr-1
        write (3,'(a)') pgbrk
        ipage=ipage+1
        write (3,'(t64,2a)') 'Date: ',dstr
        write (3,'(t64,2a)') 'Time: ',tstr
        write (3,'(t64,a,i2/)') 'Page: ',ipage
        write (3,'(t30,a,i4)') 'AREAS 1-8 FOR ',iyr
        if (pgbrk .eq. '1')write(3,'(a,t30,a)') '+','________________'
        write (3,'(/t29,a/)') '(Undiscounted Values)'
        write (3,'(7x,a//,2(10x,a/),7x,a/)') us1,y(3),y(4),us1
        do 801 i=1,np+1
          if (i .eq. (np+1)) then
            write (3,fmt(9)) 'Fiber',area1(yr),area2(yr),area3(yr),
     -                        area4(yr)
          endif
          if (i .le. np) then
              pros=area8(yr,i)+area8p(yr,i)
              write (3,fmt(8)) idp(i),area5(yr,i),area6(yr,i),
     -                          area7(yr,i),pros
          endif
801     continue
c
        write (3,'(7x,a/)') us1
        write (3,'(7x,a//,8(7x,a/))') (y(k),k=5,8),y(11),(y(k),k=15,18)
80    continue
c
      return
      end
```

```
c
c
c
c      ARCM : ENGINEERING CONTROL AND LABELING COSTS CHECK
c
c      Version 7.1 : May 24, 1989.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c
c
c
$include:'stdsub'
$large
c
c
c
c       This subroutine checks to see if the costs of engg. control and/or
c       labeling added to the baseline price exceed the 1st step of the
c       product's demand function.
c
c
c
      subroutine enlbl
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      character   nyc*4
c
c
      istop=0
      n=0
c
      do 10 i=1,np
        temp=0
        if (enctl(yr,idp(i))) temp=temp+ecost(i)
        if (label(yr,idp(i))) temp=temp+lcost(i)
        if (swqr(i) .eq. 1) then
          temp=temp+avc(i)
        else
          temp=temp+bepp(yr,i)
        endif
c
        if (temp .gt. ps(yr,i,nsub(i))) then
          n=n+1
c
          if (istop .eq. 0) then
            call eeop (4,0)
            write (nyc,'(i4)') baseyr+yr-1
            call pcsa (8,12,' BASELINE PRICE/AVC + ENGINEERING '//
     -        'CONTROL COSTS AND/OR 'c,vrev)
            call pcsa (9,12,' LABELING COSTS EXCEED FIRST STEP IN '//
     -        'YEAR '//nyc//' FOR:    'c,vrev)
            call setcur (12,0)
          endif
c
          if (swqr(i) .eq. 1) then
            temp=avc(i)
          else
            temp=bepp(yr,i)
          endif
c
          if (n .gt. 10) then
            call pcsa (22,12,' More to come... ',vrev)
            call pcsa (23,12,' Press any key to continue',vbold)
            ipse=key_getc()
            call eeop (10,0)
            call setcur (12,0)
          endif
c
          write (*,30) 'Product ',idp(i),swqr(i),temp,ecost(i),lcost(i),
     -                 ps(yr,i,nsub(i))
 30       format (t12,a,i2,t25,i2,5x,4f10.2)
          istop=1
        endif
```

```
c
10    continue
c
      if (istop .eq. 1) then
        call setcur (20,0)
        stop
      endif
c
      return
      end
```

```
c___________________________________________________________________________
c
c
c     ARCM : EQUILIBRIUM PRODUCT PRICES AND QUANTITIES
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c___________________________________________________________________________
c
c
$large
c
c___________________________________________________________________________
c
c                 this subroutine calculates the equilibrium price
c                     & quantity in the asbestos fiber market.
c___________________________________________________________________________
c
c
      subroutine eqpq
c
$include:'vars.cmn'
c
      integer swpe
c
c
      swpe=0
      qerat=1.0
      do 90 i=1,nstd
        fpe(yr)=slope*tfqs(i)+rint
        if ((fpe(yr) .eq. tfps(i)) .or.
     -       (fpe(yr) .ge. tfps(i+1))) then
          fqe(yr)=tfqs(i)
          go to 91
        elseif ((fpe(yr) .lt. tfps(i+1)) .and.
     -            (fpe(yr) .gt. tfps (i+2))) then
          swpe=1
          go to 90
        endif
 91     if ((fpe(yr) .gt. tfps(i)) .and.
     -      (swpe .eq. 1)) then
          fpe(yr)=tfps(i)
          fqe(yr)=(fpe(yr)-rint)/slope
          if (i .eq. 1) then
            qerat=fqe(yr)/tfqs(1)
          else
           qerat=(fqe(yr)-tfqs(i-1))/(tfqs(i)-tfqs(i-1))
          endif
        endif
 90   continue
      if (nstd .eq. 0) then
        fpe(yr)=0
        fqe(yr)=0
      endif
c
c___________________________________________________________________________
c
c          This section translates fiber equilibrium price (fpe) to
c          product market equilibrium price (epp) and quantity (epq).
c___________________________________________________________________________
c
c
      do 150 i=1,np
        if (fps(i,1) .lt. fpe(yr)) then
          qfe(yr,i)=0
          go to 151
        else
          do 1501 j=1,nsub(i)
            if (fps(i,j) .gt. fpe(yr)) then
              if (j .eq. nsub(i)) then
                qfe(yr,i)=fqs(yr,i,j)
                go to 151
              else
                go to 1501
              endif
```

```
            elseif (fps(i,j) .lt. fpe(yr)) then
              qfe(yr,i)=fqs(yr,i,j-1)
            else
              if (j .eq. 1) then
                qfe(yr,i)=fqs(yr,i,1)*qerat
              else
                qfe(yr,i)=(fqs(yr,i,j)-fqs(yr,i,j-1))*qerat+
     -                      fqs(yr,i,j-1)
              endif
              go to 151
            endif
 1501     continue
        endif
 151    epq(yr,i)=qfe(yr,i)/awt(i)
        epdif=fpe(yr)-afpe
        epp(yr,i)=epdif*awt(i)+aepp(i)
        if ((swqr(i) .eq. 1) .and. (epq(yr,i) .ne. 0)) then
          avc(i)=epp(yr,i)-qrarea(i)/epq(yr,i)
        endif
 150  continue
      return
      end
```

```
c
c------------------------------------------------------------------------
c
c      ARCM : CALCULATION OF SCENARIO PRICES AND CS GAINS IN EXEMPTED MARKETS
c
c      Version 7.1 : May 24, 1989.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c------------------------------------------------------------------------
c
$large
c
c------------------------------------------------------------------------
c
c                       This subroutine calculates the price and
c                       consumer surplus gains in exempted markets.
c------------------------------------------------------------------------
c
      subroutine exempt
c
$include:'vars.cmn'
c
c
      do 10 i=1,np
        if (.not. exmpt(idp(i))) go to 10
        tfpp(i)=0
        fppflag(i)=0
c
        fpq(yr,i)=bepq(yr,i)
        pr_drop=-1.*(pfl(yr)-bfpe(yr))*awt(i)
c
        temp=0
        if (enctl(yr,idp(i))) temp=temp+ecost(i)
        if (label(yr,idp(i))) temp=temp+lcost(i)
c
        if (swqr(i) .ne. 1) go to 20
        if (pr_drop .ge. temp) go to 20
c
        pr_inc=temp-pr_drop
        tfpp(i)=pr_inc+avc(i)
c
        if (tfpp(i) .gt. bepp(yr,i)) then
          fpp(yr,i)=tfpp(i)
          area5(yr,i)=(fpp(yr,i)-bepp(yr,i))*fpq(yr,i)
          area7(yr,i)=(bepp(yr,i)-avc(i))*fpq(yr,i)
        else
          fpp(yr,i)=bepp(yr,i)
          area5(yr,i)=0
          area7(yr,i)=(tfpp(i)-avc(i))*fpq(yr,i)
        endif
        go to 10
c
 20     pr_drop=-1.*(pr_drop-temp)
        fpp(yr,i)=pr_drop+bepp(yr,i)
        area5(yr,i)=(fpp(yr,i)-bepp(yr,i))*fpq(yr,i)
        area7(yr,i)=0
c
 10   continue
      return
      end
```

```fortran
c_______________________________________________________________________
c
c
c      ARCM : CALCULATION OF FINAL SCENARIO FIBER PRICE AND AREAS 1, 2, 3, AND 4
c
c      Version 7.1 : May 24, 1989.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c_______________________________________________________________________
c
c
$include:'stdsub'
$large
c
c_______________________________________________________________________
c
c                  this subroutine calculates fiber price after a
c                  usage cap and then calculates areas 1, 2, 3, and 4.
c_______________________________________________________________________
c
c
      subroutine fpc1234
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      integer   st3,end3,flag3
c
      character res,nyc*4,nzc*15
c
c
      iy=yr+baseyr-1
      write (nyc,'(i4)') iy
*40    if (qcap(yr) .ge. fqe(yr)) then
 40   if (qcap(yr) .gt. fqe(yr)) then
        capr=.true.
        call eeop (4,0)
        call pcsa (9,12,' THE FIBER CAP QUANTITY SPECIFIED FOR '//nyc//
     -                 ' IS NOT BINDING 'c,vrev)
        call pcs (12,15,'  The relevant variable values are:'c)
        call pcs (13,15,'                                   YEAR = '//
     -                 nyc//' 'c)
        write (nzc,'(f10.2)') qcap(yr)
        call pcs (14,15,'                  FIBER CAP QUANTITY = '//
     -                 nzc(1:10)//' 'c)
        write (nzc,'(f15.7)') fqe(yr)
        call pcs (15,15,'                EQUILIBRIUM QUANTITY ='//
     -                 nzc//' 'c)
        call pcs (16,15,'(after bans & exemptions, if any)'c)
        write (nzc,'(f15.7)') bfqe(yr)
        call pcs (18,15,'      BASELINE EQUILIBRIUM QUANTITY = '//
     -                 nzc//' 'c)
        call pcs (20,15,'  Do you want to continue? (Y/N) MM'c)
        call ynchk (*45,*44)
c
 44     call setcur (22,0)
        stop
c
 45     call pcs (20,15,'Please enter new fiber cap quantity for '//
     -                 nyc//' MM'c)
        qcap(yr)=rchk (0d0,1d6)
c
        if (qcap(yr) .eq. -9999.) go to 45
        go to 40
c
        call eeop (4,0)
        call pcsa (12,25,' Processing... 'c,vrev)
        call setcur (vy,vx-1)
      endif
c
      qcrat=1.0
      if (qcap(yr) .eq. 0) then
        pf(yr)=tfps(1)
        st3=1
        qcrat=0
```

```
          go to 251
        endif
c
        do 250 i=1,nstd
          if (tfqs(i) .eq. qcap(yr)) then
            pf(yr)=tfps(i)
            st3=i+1
            go to 251
          elseif (tfqs(i) .gt. qcap(yr)) then
            pf(yr)=tfps(i)
            st3=i
            if (i .eq. 1) then
              qcrat=qcap(yr)/tfqs(1)
            else
              qcrat=(qcap(yr)-tfqs(i-1))/(tfqs(i)-tfqs(i-1))
            endif
            go to 251
          endif
          if (bfpe(yr) .ge. tfps(i)) then
            end3=i-1
            go to 252
          endif
  250   continue
  251   end3=nstd
c
  252   pf1(yr)=slope*qcapm(yr)+rint
c
        if (pf(yr) .lt. bfpe(yr)) go to 300
c
        fpdif=pf(yr)-bfpe(yr)
c
        area1(yr) = fpdif                  * qcap(yr)
        area2(yr) = (bfpe(yr) - pf1(yr)) * qcapm(yr)
c
        areap(yr) = (pf(yr) - pf1(yr))   * qcap(yr) * (-1.)
c
        flag3=0
        do 255 j=st3,end3
          if (flag3 .eq. 0) then
            area3(yr)=(tfqs(st3)-qcap(yr))*(tfps(st3)-bfpe(yr))
            flag3=1
          else
            area3(yr)=area3(yr)+(tfqs(j)-tfqs(j-1))*(tfps(j)-bfpe(yr))
          endif
  255   continue
        area4(yr)=0.5*(bfpe(yr)-pf1(yr))*(bfqe(yr)-qcapm(yr))
        return
c
  300   call eeop (4,0)
        call pcsa (15,25,' PF('//nyc//') < BFPE('//nyc//') 'c,vrev)
        call setcur (22,0)
        stop
        end
```

```
c______________________________________________________________________
c
c
c     ARCM : CALCULATION OF SCENARIO PRODUCT PRICES AND QUANTITIES
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c______________________________________________________________________
c
c
$large
c
c______________________________________________________________________
c
c               this subroutine calculates the final price and
c               quantities for all the product markets, using the
c               final price and cap quantity in the fiber market.
c______________________________________________________________________
c
c
      subroutine fppfpq
c
$include:'vars.cmn'
c
c
      do 140 i=1,np
        if (exmpt(idp(i)) .or. (swban(yr,i) .eq. 1)) go to 140
        if (fps(i,1) .lt. pf(yr)) then
          qf(yr,i)=0
          go to 141
        else
          do 1401 j=1,nsub(i)
            if (fps(i,j) .lt. pf(yr)) then
              qf(yr,i)=fqs(yr,i,j-1)
              go to 141
            elseif (fps(i,j) .eq. pf(yr)) then
              if (j .eq. 1) then
                qf(yr,i)=fqs(yr,i,1)*qcrat
              else
                qf(yr,i)=(fqs(yr,i,j)-fqs(yr,i,j-1))*qcrat+
     -                    fqs(yr,i,j-1)
              endif
              go to 141
            endif
1401      continue
        endif
        qf(yr,i)=qfe(yr,i)
141     fpq(yr,i)=qf(yr,i)/awt(i)
c
        if (enctl(yr,idp(i))) fpp(yr,i)=ecost(i)
        if (label(yr,idp(i))) fpp(yr,i)=fpp(yr,i)+lcost(i)
c
        if (swqr(i) .eq. 1) then
          avc(i)=bepp(yr,i)-qrarea(i)/bepq(yr,i)
          fpp(yr,i)=fpp(yr,i)+fpdif*awt(i)+avc(i)
          fppflag(i)=0
c
          if (fpp(yr,i) .lt. bepp(yr,i)) then
            fppflag(i)=1
            tfpp(i)=fpp(yr,i)
            fpp(yr,i)=bepp(yr,i)
          endif
c
        else
          fppflag(i)=0
          fpp(yr,i)=fpp(yr,i)+fpdif*awt(i)+bepp(yr,i)
        endif
        call area5678 (i)
140   continue
      return
      end
```

```
c_______________________________________________________________________________
c
c
c       ARCM : OUTPUT HEADER SUBROUTINE
c
c       Version 7.1 : May 24, 1989.
c
c       Program written by:
c
c          Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c          (703) 934-3000
c
c_______________________________________________________________________________
c
c
$large
c
c_______________________________________________________________________________
c
c       This subroutine writes the header for the output to a file or printer
c_______________________________________________________________________________
c
c
        subroutine header (idt)
c
$include:'vars.cmn'
c
c
          if (ipage .ne. 0) write (3,'(a)') pgbrk
          ipage=ipage+1
c
          write (3,'(t64,2a)') 'Date: ',dstr
          write (3,'(t64,2a)') 'Time: ',tstr
          write (3,'(t64,a,i2/)') 'Page: ',ipage
c
          if (idt .eq. 1) return
c
          if (ipage .eq. 1) then
            write (3,'(t28,a)') 'REGULATION SCENARIO'
            if (pgbrk .eq. '1') write (3,'(a,t28,a)') '+',
     -      '___________________'
          else
            write (3,'(t24,a)') 'REGULATION SCENARIO (contd.)'
            if (pgbrk .eq. '1') write (3,'(a,t24,a)') '+',
     -      '____________________________'
          endif
c
          iline=5
c
          return
          end
```

```fortran
c______________________________________________________________________
c
c
c     ARCM : INDIVIDUAL PROOUCT STEP-DEMAND FUNCTIONS
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c______________________________________________________________________
c
c
$large
c
c______________________________________________________________________
c
c                    This Subroutine calculates the Individual
c                      product market Derived Demand Curves.
c______________________________________________________________________
c
c
      subroutine iddc (elc_fl)
c
$include:'vars.cmn'
c
      integer elc_fl
c
c
      do 30 i=1,np
        temp=0
        if (enctl(yr,idp(i))) temp=temp+ecost(i)
        if (label(yr,idp(i))) temp=temp+lcost(i)
        temp=temp*elc_fl
c
        do 301 j=1,nsub(i)
          fps(i,j)=afpe+(ps(yr,i,j)-aepp(i)-temp)/awt(i)
          fqs(yr,i,j)=qs(yr,i,j)*awt(i)
c
          if (j .gt. 1) then
            fqs(yr,i,j)=fqs(yr,i,j)+fqs(yr,i,j-1)
          endif
c
301     continue
c
        if (swqr(i) .ne. 1) go to 30
        do 302 k=1,nsub(i)
          if (lnsub(i,k))
     -      fps(i,k)=fps(i,k)+qrarea(i)/fqs(yr,i,nsub(i))
302     continue
30    continue
c
      return
      end
```

```
c_______________________________________________________________________
c
c
c      ARCM : USER RESPONSE CHECK SUBROUTINES
c
c      Version 7.1 : May 24, 1989.
c
c      Program written by:
c
c         Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c         (703) 934-3000
c
c_______________________________________________________________________
c
c
$include:'stdsub'
$large
c
c_______________________________________________________________________
c
c               This subroutine scrolls the fiber cap screen one line
c               at a time to display the complete schedule.
c_______________________________________________________________________
c
c
      subroutine more
c
$include:'stdvar'
c
c
      call pcsa (22,28,' More to come... 'c,vrev)
      kk=vx-1
      call pcs (24,25,'Press any key to continue'c)
      call setcur (22,kk)
      ipse=key_getc()
      call eeop (22,0)
      call upscroll (1,11,20,0,79,vnorm)
c
      return
      end
c
c
c_______________________________________________________________________
c
c               This subroutine checks to see if output file exists
c               and informs user appropriately.
c_______________________________________________________________________
c
c
      subroutine file_chk (i,j)
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      if (i .eq. 1) go to 10
c
      call pcsa (22,10,' FILE '//fname(j)(1:lench(fname(j)))//
     -                 ' NOT FOUND ON DEFAULT PATH 'c,vrev)
      return
c
10    call pcsa (15,15,' FILE '//fname(j)(1:lench(fname(j)))//
     -                 ' ALREADY EXISTS! 'c,vrev)
      call pcs (17,5,'Should file be overwritten (Y/N) MM'c)
c
      return
      end
c
c
c_______________________________________________________________________
c
c               This subroutine checks to see if the product # is specified
c               in the valid range and returns the valid product id.
c_______________________________________________________________________
c
c
      subroutine tsca (i,j,a,iy)
c
$include:'stdvar'
$include:'vars.cmn'
```

```
c
c
      character   nyc*2,a
c
c
10    write (nyc,'(i2)') i
      call pcs (iy,5,'Enter the TSCA 8(a) product number of 'c)
c
      if (a .eq. 'b') call pcs (vy,vx,'BANNED'c)
      if (a .eq. 'x') call pcs (vy,vx,'EXEMPTED'c)
      if (a .eq. 'e') call pcs (vy,vx,'CONTROLLED'c)
      if (a .eq. 'l') call pcs (vy,vx,'LABELED'c)
c
      call pcs (vy,vx,' product #'//nyc//' MM'c)
      j=ichk (1,ip)
      call eeop (22,0)
c
      if (j .eq. -9999) then
        write (nyc,'(i2)') ip
        call pcsa (22,10,' THE TSCA # OF THE PRODUCT SHOULD '//
     -        'BE BETWEEN 1 AND '//nyc//' 'c,vrev)
        go to 10
      endif
c
      return
      end
c
c
c____________________________________________________________________
c
c             This subroutine requests a year and checks to see if year is
c             specified correctly within the scenario.
c____________________________________________________________________
c
c
      subroutine yr_chk (ir,ifl,iye)
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      character   nyc*4,nzc*4
c
c
      iy=vy
      ix=vx
c
10    vy=iy
      vx=ix
c
      if (ifl .eq. 0) then
        ir=ichk (1,endyr-baseyr)
      elseif (ifl .eq. 1) then
        ir=ichk (baseyr+1,endyr)
      else
        ir=ichk (cstyr,endyr)
      endif
c
      call eeop (iye,0)
c
      if (ir .eq. -9999) then
        if (ifl .eq. 0) then
          write (nyc,'(i2)') endyr-baseyr
          call pcsa (22,10,' NUMBER OF YEARS SHOULD BE LESS '//
     -                  'THAN OR EQUAL TO '//nyc(1:2)//' 'c,vrev)
        elseif (ifl .eq. 1) then
          write (nyc,'(i4)') baseyr
          write (nzc,'(i4)') endyr
          call pcsa (22,25,' YEAR NOT IN SPECIFIED RANGE 'c,vrev)
          call pcsa (23,20,'SHOULD BE SPECIFIED BETWEEN '//nyc//
     -                  ' AND '//nzc//' 'c,vbold)
        else
          write (nyc,'(i4)') cstyr
          write (nzc,'(i4)') endyr
          call pcsa (22,25,' YEAR NOT IN SPECIFIED RANGE 'c,vrev)
          call pcsa (23,20,'SHOULD BE SPECIFIED BETWEEN '//nyc//
     -                  ' AND '//nzc//' 'c,vbold)
        endif
        go to 10
      endif
```

```
c
      return
      end
c
c
c_______________________________________________________________________
c
c               This subroutine checks to see if the number of products
c               specified are in the acceptable range.
c_______________________________________________________________________
c
c
      subroutine nprd_chk (ir,iye,a,iy4)
c
$include:'stdvar'
$include:'vars.cmn'
c
c
      character   nyc*4,a
c
c

10    write (nyc,'(i4)') iy4
      call pcs (12,5,'Enter # of products to be 'c)
c
      if (a .eq. 'b') call pcs (vy,vx,'BANNED'c)
      if (a .eq. 'e') call pcs (vy,vx,'CONTROLLED'c)
      if (a .eq. 'l') call pcs (vy,vx,'LABELED'c)
c
      call pcs (vy,vx,' in '//nyc//' (99 for all products) MM'c)
      ir=ichk (1,99)
      call eeop (iye,0)
c
      if (ir .eq. -9999) go to 10
      if ((ir .gt. ip) .and. (ir .ne. 99)) then
        write (nyc,'(i2)') ip
        call pcsa (22,20,' A MAXIMUM OF '//nyc(1:2)//
     -                   ' PRODUCTS MAY BE SPECIFIED 'c,vrev)
        go to 10
      endif
c
      return
      end
c
c
c_______________________________________________________________________
c
c               This subroutine displays the appropriate error message
c               regarding party id during the permit allocation process.
c_______________________________________________________________________
c
c
      subroutine pty_chk (i,*)
c
$include:'stdvar'
c
c
      if (i .eq. 0) then
        call pcsa (24,20,' THE PARTY ID ENTERED IS NOT VALID 'c,vrev)
      elseif (i .eq. 1) then
        call pcsa (24,10,' THE NUMBER OF PARTIES SHOULD BE '//
     -                   'SPECIFIED BETWEEN 1 AND 9 'c,vrev)
      elseif (i .eq. 2) then
        call pcsa (24,15,' GOVERNMENT CAN BE THE ONLY '//
     -                   'PARTY WHEN SPECIFIED 'c,vrev)
      endif
c
      return 1
      end
```

```
c_______________________________________________________________________
c
c
c     ARCM : CALCULATION OF AREA 6
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_______________________________________________________________________
c
c
$large
c
c_______________________________________________________________________
c
c                         This Subroutine calculates AREA 6.
c_______________________________________________________________________
c
c
      subroutine sarea6 (i)
c
$include:'vars.cmn'
c
c
      integer st6,end6,flag6
c
c
      area6(yr,i)=0
      if (fpq(yr,i) .eq. bepq(yr,i)) return
c
      do 190 j=1,nsub(i)
        if ((qcap(yr) .eq. 0) .or. (fpq(yr,i) .eq. 0)) then
          st6=1
          fpq(yr,i)=0
          go to 193
        endif
        if (qsl(yr,i,j) .lt. fpq(yr,i)) go to 190
        if (qsl(yr,i,j) .eq. fpq(yr,i)) st6=j+1
        if (qsl(yr,i,j) .gt. fpq(yr,i)) st6=j
        go to 193
190   continue
193   flag6=0
      do 195 l=st6,nsub(i)
        if (flag6 .eq. 0) then
         area6(yr,i)=(qsl(yr,i,st6)-fpq(yr,i))*(ps(yr,i,st6)-bepp(yr,i))
          flag6=1
        else
          area6(yr,i)=area6(yr,i)+(qsl(yr,i,l)-qsl(yr,i,l-1))*
     -                            (ps(yr,i,l)-bepp(yr,i))
        endif
195   continue
      return
      end
```

```
c_______________________________________________________________________
c
c
c       ARCM : INITIALIZATION OF ALL ARRAYS
c
c       Version 7.1 : May 24, 1989.
c
c       Program written by:
c
c          Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c          (703) 934-3000
c
c_______________________________________________________________________
c
c
$large
c
c_______________________________________________________________________
c
c                     This Subroutine INITializes all arrays.
c_______________________________________________________________________
c
c
      subroutine sinit
c
$include:'vars.cmn'
c
c
      do 2727 l=1,ny
        fpe(l)=0
        fqe(l)=0
        bfpe(l)=0
        bfqe(l)=0
        area1(l)=0
        area2(l)=0
        area3(l)=0
        area4(l)=0
        pf(l)=0
        pf1(l)=0
        qcap(l)=0
        qcapm(l)=0
        byear(l)=0
c
        do 3737 i=1,im
          epp(l,i)=0
          epq(l,i)=0
          bepp(l,i)=0
          bepq(l,i)=0
          area5(l,i)=0
          area6(l,i)=0
          area7(l,i)=0
          area8(l,i)=0
          area8p(l,i)=0
          qfe(l,i)=0
          qf(l,i)=0
          fpq(l,i)=0
          fpp(l,i)=0
          swban(l,i)=0
c
          do 4747 j=1,ks
            ps(l,i,j)=0
            qs(l,i,j)=0
            qs1(l,i,j)=0
            fqs(l,i,j)=0
4747      continue
3737    continue
c
        do 3738 i=1,ip
          isban(l,i)=0
3738    continue
2727  continue
c
      do 5757 i=1,im
        avc(i)=0
        swqr(i)=0
        nsub(i)=0
        fppflag(i)=0
        tfpp(i)=0
        qrarea(i)=0
c
```

```
          do 6767 j=1,ks
            fps(i,j)=0
 6767     continue
 5757   continue
c
        do 1234 i=1,10
          discrt(i)=0
 1234   continue
C
          perm(1)='Dom. Miners & Millers'
          perm(2)='Foreign Miners & Millers'
          perm(3)='Importers Of Bulk Fiber'
          perm(4)='Dom. Primary Processors'
          perm(5)='Foreign Primary Processors'
          perm(6)='Importers Of Mixtures'
          perm(7)='Importers Of Products'
          perm(8)='Dom. Product Purchasers'
          perm(9)='For. Product Purchasers'
          perm(10)='Government'
          perm(11)='Total'
C
        return
        end
```

```
c_____________________________________________________________________
c
c
c     ARCM : AGGREGATE TABLES OUTPUT SUBROUTINE
c
c     Version 7.1 : May 24, 1989.
c
c     Program written by:
c
c        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c        (703) 934-3000
c
c_____________________________________________________________________
c
c
$large
c
c_____________________________________________________________________
c
c        This subroutine writes the 'welfare effects by market' tables
c_____________________________________________________________________
c
c
      subroutine tabagg (itab,drt,fibcs,fibps,pval)
c
$include:'vars.cmn'
c
c
      real         c(ip),p(ip)
c
      character    ctab*2
c
      character*80 us2,us3
c
c
      write (3,'(a)') pgbrk
      ipage=ipage+1
c
      if (itab .eq. 1) ctab='1A'
      if (itab .eq. 2) ctab='1B'
c
      write (3,'(t64,2a)') 'Date: ',dstr
      write (3,'(t64,2a)') 'Time: ',tstr
      write (3,'(t64,a,i2/)') 'Page: ',ipage
      write (3,'(t26,2a)') '              TABLE ',ctab
      if (pgbrk .eq. '1') write (3,'(a,t26,a)') '+','        ________'
      write (3,'(//t26,a)') 'WELFARE EFFECTS BY PRODUCT MARKET'
      if (pgbrk .eq. '1') write (3,'(a,t26,a)') '+',
     -'_________________________________'
      if (itab .eq. 2) write (3,'(/t31,a)') '(Domestic Effects only)'
      write (3,'(/t15,2a,f4.1,a//)') '(Present Values, in thousand ',
     -                  'dollars, at ',drt,' percent)'
      us2=' Market          CS Loss        PS Loss          Permit'
      us3='(TSCA #)                                         Value         Sta
     -tus'
      write (3,'(7x,a//2(10x,a/),7x,a/)') us1,us2,us3,us1
c
      do 30 j=1,np
        if (itab .eq. 1) then
          cons=dcons(j)+fcons(j)
          pros=dpros(j)+fpros(j)
        else
          cons=dcons(j)
          pros=dpros(j)
        endif
c
        if (itab .eq. 2) then
          c(idp(j))=cons
          p(idp(j))=pros
        endif
c
        write (3,fmt(1)) idp(j),cons,pros,banm(j)
30    continue
c
      if (itab .eq. 2) write (6) drt,(c(i),p(i),i=1,ip),fibcs,fibps
c
      if (option .eq. 1) then
        write (3,fmt(12)) 'Fiber',fibcs,fibps
      else
        write (3,fmt(2)) 'Fiber',fibcs,fibps,pval
```

```
      endif
c
      write (3,'(7x,a/)') usl
c
      write (3,'(/10x,a/)') 'LEGEND FOR PRODUCT STATUS:'
      write (3,'(10x,a)')   '        B   Banned'
      write (3,'(10x,a)')   '        X   eXempted from regulation'
      write (3,'(10x,a)')   '        E   Engineering controls active'
      write (3,'(10x,a//)') '        L   Labeling requirements'
c
      write (3,'(/10x,a)') 'Note: 1. Negative entries are welfare'//
     -                     ' gains.'
      write (3,'(/10x,a)') '      2. CS Loss in the Fiber market is'//
     -                     ' the sum of all downstream'
      write(3,'(10x,a)')'        producer and consumer welfare losses.'
      write (3,'(/10X,A)') '      3. Consumer and producer surplus '//
     -                     'losses reported above are'
c
      if (itab .eq. 1) then
        write(3,'(10x,a)') '         for foreign and domestic '//
     -                     'consumers and producers.'
      else
        write(3,'(10x,a)') '         for domestic consumers and '//
     -                     'producers only.'
      endif
c
      return
      end
```

```
C__________________________________________________________________________
C
C
C     ARCM : TOTAL DERIVED STEP-DEMAND FUNCTIONS
C
C     Version 7.1 : May 24, 1989.
C
C     Program written by:
C
C        Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
C        (703) 934-3000
C
C__________________________________________________________________________
C
C
$large
C
C__________________________________________________________________________
C
C       This subroutine calculates Total Derived Demand Curve for fiber.
C__________________________________________________________________________
C
c
      subroutine tddc (bflag)
c
$include:'vars.cmn'
c
c
      real    tfhq(250),tfvq(250)
c
      integer bflag
c
c
      do 5757 m=1,250
        tfps(m)=0
        tfqs(m)=0
        tfhq(m)=0
        tfvq(m)=0
 5757 continue
c
      nstd=0
      do 20 i=1,np
        if ((option .eq. 1) .and. (bflag .eq. 1) .and.
     -      (swban(yr,i) .eq. 1)) go to 20
        if ((option .ne.1) .and. (bflag .eq. 1) .and.
     -      ((swban(yr,i) .eq. 1) .or. exmpt(idp(i)))) go to 20
        do 201 j=1,nsub(i)
          if (fqs(yr,i,j) .lt. 0.0001) go to 201
          do 2011 k=1,nstd
            if (fps(i,j) .eq. tfps(k)) go to 201
 2011     continue
          nstd=nstd+1
          tfps(nstd)=fps(i,j)
 201    continue
 20   continue
c
      do 210 i=1,nstd-1
        do 2101 j=i+1,nstd
          if (tfps(i) .gt. tfps(j)) go to 2101
          ttemp=tfps(i)
          tfps(i)=tfps(j)
          tfps(j)=ttemp
 2101   continue
 210  continue
c
      do 10 k=1,nstd
        do 101 i=1,np
          if ((option .eq. 1) .and. (bflag .eq. 1) .and.
     -        (swban(yr,i) .eq. 1)) go to 101
          if ((option .ne.1) .and. (bflag .eq. 1) .and.
     -        ((swban(yr,i) .eq. 1) .or. exmpt(idp(i)))) go to 101
          do 1011 j=1,nsub(i)
            if (tfps(k) .le. fps(i,j)) then
              if (j .eq. 1) then
                tfqs(k)=tfqs(k)+fqs(yr,i,1)
              else
                tfqs(k)=tfqs(k)+fqs(yr,i,j)-fqs(yr,i,j-1)
              endif
            endif
 1011     continue
```

```
101     continue
10    continue
c
      return
      end
```

```
c____________________________________________________________________________
c
c
c    ARCM : PARAMETER DEFINITION & COMMON VARIABLE LIST
c
c    Version 7.1 : May 24, 1989.
c
c    Program written by:
c
c       Vikram Widge, ICF Incorporated, 9300 Lee Hwy., VA 22031-1207
c       (703) 934-3000
c
c____________________________________________________________________________
c
c
c____________________________________________________________________________
c
c                Definition of parameters for the variables
c____________________________________________________________________________
c
c
c    ip = maximum number of products
c    im = maximum number of tangible products
c    ny = maximum number of years in any regulatory scenario
c    ks = maximum number of substitutes for any given product
c
      parameter (ip=44,im=34,ny=15,ks=6)
c
c____________________________________________________________________________
c
c               All variable TYPEs and DIMENSIONs are defined below
c____________________________________________________________________________
c
      real      fpe(ny),fqe(ny),bfpe(ny),bfqe(ny),epp(ny,im),aepp(im),
     -          tfps(250),tfqs(250),area1(ny),area3(ny),qfe(ny,im),
     -          area2(ny),area4(ny),area5(ny,im),area6(ny,im),rcost(im),
     -          area7(ny,im),area8(ny,im),qs1(ny,im,ks),tfpp(im),
     -          ps(ny,im,ks),qs(ny,im,ks),fps(im,ks),fqs(ny,im,ks),
     -          awt(im),qrarea(im),pf1(ny),bepp(ny,im),qcapm(ny),
     -          fpp(ny,im),avc(im),na(im),ns(im,ks),discrt(10),
     -          ms(im,ks),grthrt(im,15),paloc(9),aps(ny,im,ks),
     -          ams(im,ks),qf(ny,im),epq(ny,im),fpq(ny,im),bepq(ny,im),
     -          ccost(im),area8p(ny,im),pf(ny),qcap(ny),bbpq(im),
     -          cprat(im),dcons(im),dpros(im),fcons(im),fpros(im),
     -          fecost(im),vecost(im),ecost(im),lcost(im),areap(ny)
c
      integer   yr,swqr(im),byr,cendyr,nsub(im),dprf,idp(im),ipage,
     -          swban(ny,im),fppflag(im),baseyr,endyr,byrs,byear(ny),
     -          pflag(10),cresf,option,isban(ny,ip),iline,ie,nstd,
     -          enyr(ny),lyr(ny),ienyrs,ilyrs,cstyr,optn(ny)
c
      character perm(12)*30,fname(9)*20,banm(im)*8,dstr*10,y(18)*80,
     -          tstr*5,usl*80,fmt(15)*45,pgbrk,desc(im)*24
c
      logical   impinf(im),lnsub(im,ks),exmpt(ip),enf,lbf,exf,multsub,
     -          enctl(0:ny,ip),label(0:ny,ip),capr
c
c
c____________________________________________________________________________
c
c                    Common blocks are defined below
c____________________________________________________________________________
c
c
      common/afep/afpe,aepp
      common/ar1234/area1,area2,area3,area4,areap
      common/ar5678/area5,area6,area7,area8,area8p
      common/awt/awt
      common/banm/banm
      common/basic/yr,np,fdiscrt,ie
      common/bbq/bbpq,bbfq
      common/bpqe/bfpe,bfqe
      common/bpqp/bepp,bepq
      common/byr/baseyr,endyr,cendyr,cstyr
      common/cap/qcap,qcapm
      common/capr/capr
      common/cdiscrt/discrt,nodrt
      common/cout/option,endamt,selast,fsup,dsup,ibgr,cresf,dprf,
     -            ibchk,ixmpt,ienchk,ilchk,optn
```

```
common/cprat/cprat
common/desc/desc
common/dif/epdif,fpdif,pedif
common/dout/fmt,pgbrk,dstr,tstr,usl,y
common/elcost/fecost,vecost,ecost,lcost
common/elflag/enctl,label
common/elxf/enf,lbf,exf
common/elyr/enyr,lyr,ienyrs,ilyrs
common/epqp/epp,epq
common/exmpt/exmpt
common/fname/fname
common/fpqp/fpp,fpq
common/fpqs/fps,fqs
common/ibyd/ibyd
common/idp/idp
common/impinf/impinf
common/lnsub/lnsub
common/multsub/multsub
common/na/na
common/nstd/nstd
common/nsub/nsub
common/paloc/paloc
common/perm/perm
common/pflag/pflag
common/pqe/fpe,fqe
common/pqf/pf,pfl,qf
common/pqs/ps,qs,qsl
common/qfe/qfe
common/qrat/qerat,qcrat
common/qrent/qrarea,avc
common/readin/aps,ams,rcost,ccost,ns,grthrt
common/sban/byear,byrs,isban
common/slint/slope,rint
common/swban/swban
common/swqr/swqr
common/tffpp/fppflag,tfpp
common/tout/dcons,dpros,fcons,fpros,ipage,iline
common/tpqs/tfps,tfqs
```

APPENDIX II

SOURCE CODE FOR THE ASBESTOS BENEFITS SIMULATION MODEL (ABM)

```
C     INTERACTIVE BENEFITS MODEL FOR ASBESTOS RIA
C     WRITTEN BY JO MAUSKOPF - RESEARCH TRIANGLE INSTITUTE, NORTH
C     CAROLINA
C
C     TEL. (919) 541-6468
C
C     5/16/88
C
C
$LARGE
$NOFLOATCALLS
C
C
C
C
      COMMON/T/MANOP,MANOS,INSO,USEO,DISO,MANAP,MANAS,INSA,USEA,
     *DISA,PMANOP,PMANOS,PINSO,PUSEO,PDISO,PMANAP,PMANAS,PINSA,
     *PUSEA,PDISA
      REAL MANOP(38),MANOS(38),INSO(38),USEO(38),DISO(38),
     *MANAP(38),MANAS(38),INSA(38),USEA(38),DISA(38),PMANOP(38),
     *PMANOS(38),PINSO(38),PUSEO(38),PDISO(38),PMANAP(38),
     *PMANAS(38),PINSA(38),PUSEA(38),PDISA(38)
      DIMENSION POP(38,10),P(5,5),V(5),TOT1(2,28,4),
     *RMAX(38,10),RLEV(38,10), TA(18,4),PPP(2,38),
     * DISC(10),TT1(2,4),BPROJ(38,20),PROJ(38,20),RRR1(38,8,11),
     * R(28,4),RR(28,4),RRR2(38,8,11),TEM1(38,8,11),TEM2(38,8,11)
      REAL FKL(38),FKM(38),OWT(9,3),OSRWT(4,3)
      REAL AGE,DT,TT
      INTEGER LIFE(38),AGEST,AGEINT,NPN(38),A(38),B(10)
      INTEGER AGEMID,YEAR,IYRS
      REAL*8 PP,P,T,R,WT,V,TOT1,TT1,FDTM,FDTL,DISC,RR,
     *EXP1,EX1,E1,TA,RRR1,RRR2,PPP,TEM1,TEM2
      CHARACTER RES,PGBRK
      CHARACTER*25 FILE,FILE2,FILE3,FILE4,FILE7
      COMMON /A1/T(28,4)
      COMMON /01/ F,MAXDT,PP
       DATA FKL/.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,
     * .01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,
     *  .01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01,.01/
      DATA FKM/.00000001,.00000001,.00000001,.00000001,
     * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
     * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
     * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
     * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001,
     * .00000001,.00000001,.00000001,.00000001,
     * .00000001,.00000001,.00000001,.00000001,.00000001,.00000001/
      DATA AGEST/5/
      DATA AGEINT/10/
       DATA OWT/.0,.1,.205,.210,.193,.175,.117,.0,.0,
     * .146,.174,.176,.139,.108,.099,.083,.055,.020,
     * .06,.36,.17,.13,.11,.10,.07,.0,.0/
       DATA OSRWT/.695,.095,.185,.025,.431,.059,.449,.061,
     *  .431,.059,.449,.061/
C
      WRITE (*,'(24(/))')
      WRITE (*,*) 'THIS PROGRAM MODELS THE BENEFITS OF ASBESTOS'
      WRITE (*,*) 'PRODUCT REGULATIONS.'
      WRITE (*,*)
      WRITE (*,*) 'TO RUN THIS PROGRAM, FOLLOW THE USER FRIENDLY'
      WRITE (*,*) 'INSTRUCTIONS!'
      WRITE (*,'(8(/))')
      PAUSE 'Press the <RETURN> or the <ENTER> key to continue'
C
      WRITE (*,'(24(/))')
      WRITE (*,*) 'Please enter name of data file containing BASELINE'
      WRITE (*,*) 'indices.  (Include path if necessary,)'
      READ (*,'(A)') FILE3
      WRITE (*,'(///)')
      WRITE (*,*)'Please enter name of data file containing ALTERNATIVE'
      WRITE (*,*)'indices.  (Include path if necessary,)'
      READ (*,'(A)') FILE4
      WRITE (*,'(///)')
C
 6661 IERR3=0
      OPEN(1,IOSTAT=IERR3,FILE=FILE3,STATUS='OLD')
      IF (IERR3 .LE. 0) GO TO 6662
      WRITE (*,'(//)')
      WRITE (*,*) 'FILE ',FILE3,' NOT FOUND ON SPECIFIED PATH'
      WRITE (*,'(//)')
      WRITE (*,*) 'Please enter name of data file containing BASELINE'
```

```
      WRITE (*,*) 'indices.  (Include path if necessary,)'
      READ (*,'(A)') FILE3
      WRITE (*,'(///)')
      GO TO 6661
 6662 IERR4=0
      OPEN (2,IOSTAT=IERR4,FILE=FILE4,STATUS='OLD')
      IF (IERR4 .LE. 0) GO TO 146
      WRITE (*,'(//)')
      WRITE (*,*) 'FILE ',FILE4,' NOT FOUND ON SPECIFIED PATH'
      WRITE (*,'(//)')
      WRITE (*,*)'Please enter name of data file containing ALTERNATIVE'
      WRITE (*,*) 'indices.  (Include path if necessary,)'
      READ (*,'(A)') FILE4
      WRITE (*,'(///)')
C
  146 WRITE (*,*) 'Would you like the output to be routed to the'
      WRITE (*,*) 'printer or to a file on disk ?  Enter P or D'
      READ (*,'(A)') RES
      WRITE (*,*)
      IF ((RES .EQ. 'P') .OR. (RES .EQ. 'p')) THEN
        FILE2='LPT1'
        PGBRK='1'
        OPEN (3,FILE=FILE2)
      ELSEIF ((RES .EQ. 'D') .OR. (RES .EQ. 'd')) THEN
        PGBRK=' '
        WRITE (*,*) 'Please enter desired name of OUTPUT file.'
        WRITE (*,*) '(Include path if necessary.)'
        READ (*,'(A)') FILE2
 1927   IERR2=0
        OPEN (3,FILE=FILE2,IOSTAT=IERR2,STATUS='NEW')
        IF (IERR2 .LE. 0) GO TO 2929
        WRITE (*,*)
        WRITE (*,*) 'FILE ',FILE2,' ALREADY EXISTS!'
        WRITE (*,*)
 1928   WRITE (*,*) 'Should file be overwritten (Y/N)?'
        READ (*,'(A)') RES
        IF ((RES .EQ. 'Y') .OR. (RES .EQ. 'y')) THEN
          OPEN (3,FILE=FILE2,STATUS='OLD')
          GO TO 2929
        ELSEIF ((RES .EQ. 'N') .OR. (RES .EQ. 'n')) THEN
          WRITE (*,*)
          WRITE (*,*) 'Enter new name of output file    --->'
          READ (*,'(A)') FILE2
          WRITE (*,*)
          GO TO 1927
        ELSE
          GO TO 1928
        ENDIF
      ELSE
        WRITE (*,*)
        WRITE (*,*) 'INVALID OPTION - PLEASE CHOOSE AGAIN'
        WRITE (*,*)
        GO TO 146
      ENDIF
C
 2929   PRINT *
        WRITE (*,*) 'Please enter desired name of '//
     -              'cost-benefit TABLES'' DATA file.'
        WRITE (*,*) '(Include path if necessary.)'
        READ (*,'(A)') FILE7
 2927   IERR7=0
        OPEN (7,FILE=FILE7,IOSTAT=IERR7,STATUS='NEW',FORM='UNFORMATTED')
        IF (IERR7 .LE. 0) GO TO 1929
        WRITE (*,*)
        WRITE (*,*) 'FILE ',FILE7,' ALREADY EXISTS!'
        WRITE (*,*)
 2928   WRITE (*,*) 'Should file be overwritten (Y/N)?'
        READ (*,'(A)') RES
        IF ((RES .EQ. 'Y') .OR. (RES .EQ. 'y')) THEN
          OPEN (7,FILE=FILE7,STATUS='OLD',FORM='UNFORMATTED')
          GO TO 1929
        ELSEIF ((RES .EQ. 'N') .OR. (RES .EQ. 'n')) THEN
          WRITE (*,*)
          WRITE (*,*) 'Enter new name of output file    --->'
          READ (*,'(A)') FILE7
          WRITE (*,*)
          GO TO 2927
        ELSE
          GO TO 2928
        ENDIF
```

```
C
1929  READ(1,743) IYRS,ISY,IEY
      READ(1,744) (LIFE(I),I=1,38)
      READ(2,743) IYY,ISS,IEE
 743  FORMAT(I2,2(5X,I4))
 744  FORMAT(38I3)
      WRITE (*,'(6(/))')
      WRITE (*,*) 'YOU WILL NOW SELECT THE POPULATION TO BE ANALYZED'
      WRITE (*,*) 'FOR THE PROJECTED HEALTH BENEFITS OF THE REGULATION.'
      WRITE (*,*) 'THE POPULATION CAN BE COMPOSED OF THE FOLLOWING'
      WRITE (*,*) 'TEN CATEGORIES:'
      WRITE (*,*)
      WRITE (*,*) '             0 - PRIMARY MANUFACTURING OCCUPATIONAL'
      WRITE (*,*) '             1 - SECONDARY MANUFACTURING OCCUPATIONAL'
      WRITE (*,*) '             2 - INSTALLATION OCCUPATIONAL'
      WRITE (*,*) '             3 - USE OCCUPATIONAL'
      WRITE (*,*) '             4 - REPAIR/DISPOSAL OCCUPATIONAL'
      WRITE (*,*) '             5 - PRIMARY MANUF. AMBIENT NON-OCCUP.'
      WRITE (*,*) '             6 - SECONDARY MANUF. AMBIENT NON-OCCUP.'
      WRITE (*,*) '             7 - INSTALLATION NON-OCCUPATIONAL '
      WRITE (*,*) '             8 - USE NON-OCCUPATIONAL '
      WRITE (*,*) '             9 - REPAIR/DISPOSAL NON-OCCUPATIONAL '
      WRITE (*,'(6(/))')
      PAUSE 'Press the <RETURN> or the <ENTER> key to continue'
      WRITE (*,'(10(/))')
      WRITE (*,*) 'YOU HAVE FOUR OPTIONS FOR CHOOSING THE POPULATION'
      WRITE (*,*) 'TO BE ANALYZED.  THESE OPTIONS AND THEIR CORRESPOND-'
      WRITE (*,*) 'ING REFERENCE NUMBERS ARE THE FOLLOWING;'
      WRITE (*,*)
      WRITE (*,*) '          1 - ALL CATEGORIES'
      WRITE (*,*) '          2 - ALL OCCUPATIONAL CATAGORIES'
      WRITE (*,*) '          3 - ALL NON-OCCUPATIONAL CATAGORIES'
      WRITE (*,*) '          4 - USER SELECTED GROUPS'
      WRITE (*,*)
      WRITE (*,*)
      WRITE (*,*) 'ENTER THE REFERENCE NUMBER OF YOUR CHOICE.'
      READ (*,*) IGROUP
      WRITE (*,'(24(/))')
      IF (IGROUP .EQ. 1) THEN
        NEG=10
        DO 123 I=1,NEG
          B(I)=I
 123    CONTINUE
      ENDIF
      IF (IGROUP .EQ. 2) THEN
      NEG=5
        DO 124 I=1,NEG
          B(I)=I
 124    CONTINUE
      ENDIF
      IF (IGROUP .EQ. 3) THEN
      NEG=5
        DO 125 I=6,10
          B(I-5)=I
 125    CONTINUE
      ENDIF
      IF (IGROUP .EQ. 4) THEN
      WRITE (*,*) 'HOW MANY CATEGORIES ARE YOU INTERESTED IN?'
      READ (*,*) NEG
       WRITE (*,*)
       WRITE (*,*)
      DO 126 I=1,NEG
        WRITE (*,*) 'ENTER CATEGORY ', I
        READ (*,*) B(I)
        b(i)=b(i)+1
 126  CONTINUE
      ENDIF
      WRITE (*,'(20(/))')
      WRITE (*,*) 'THIS PROGRAM GIVES YOU THE OPTION OF RUNNING THE'
      WRITE (*,*) 'MODEL FOR ALL PRODUCTS, SPECIFIC GROUPS OF PRODUCTS,'
      WRITE (*,*) 'OR ANY INDIVIDUAL PRODUCT.  IF YOU WOULD LIKE TO SEE'
      WRITE (*,*) 'A LIST OF ALL THE PRODUCTS AND THEIR REFERENCE'
      WRITE (*,*) 'NUMBERS ENTER 1, IF NOT ENTER 0.'
      READ (*,*) I
      WRITE (*,'(6(/))')
      IF (I .EQ. 1) CALL LIST
      WRITE (*,'(24(/))')
      WRITE (*,*) 'IF YOU WISH TO RUN THE MODEL FOR ALL THE PRODUCTS,'
      WRITE (*,*) 'ENTER 1, IF ONLY FOR A SUBSET OF ALL THE PRODUCTS'
      WRITE (*,*) 'ENTER 0.'
```

```
      READ (*,*) I
      WRITE (*,'(12(/))')
       IF (I .EQ. 1) THEN
        NP=38
        DO 127 N=1,NP
          A(N)=N
127     CONTINUE
       ELSE
        WRITE (*,*)'HOW MANY PRODUCT CATAGORIES ARE YOU INTERESTED IN?'
        READ (*,*) NP
        WRITE (*,'(24(/))')
        DO 128 N=1,NP
          WRITE (*,*) 'ENTER THE PRODUCT REFERENCE # FOR PROOUCT ',N
          READ (*,*) A(N)
      WRITE (*,'(35(/))')
128     CONTINUE
        ENDIF
      WRITE (*,'(27(/))')
        WRITE (*,*) 'THE DEFAULT DOSE RESPONSE CONSTANTS ARE:'
        WRITE (*,*)
        WRITE (*,*) '        LUNG CANCER   = 0.01'
        WRITE (*,*) '        MESOTHELIOMA = 0.00000001'
        WRITE (*,*)
        WRITE (*,*)
        WRITE (*,*)
        WRITE (*,*) 'OO YOU WISH TO CHANGE THESE CONSTANTS FOR ANY'
        WRITE (*,*) 'PRODUCT CATEGORIES?'
        WRITE (*,*)
        WRITE (*,*) 'ENTER 1 IF YOU WANT TO MAKE CHANGES, AND ENTER'
        WRITE (*,*) '0 IF YOU OON"T.'
        READ (*,*) I
        WRITE (*,'(20(/))')
        IF (I .EQ. 1 ) THEN
        WRITE (*,*) 'IN HOW MANY PRODUCT CATEGORIES ARE YOU INTERESTED'
        WRITE (*,*) 'IN CHANGING AT LEAST ONE OF THE DOSE RESPONSE'
        WRITE (*,*) 'CONSTANTS? '
        READ (*,*) I
        WRITE (*,'(21(/))')
        WRITE (*,*) 'RESPOND TO THE PROMPTS TO ENTER THE REFERENCE'
        WRITE (*,*) 'NUMBERS OF THOSE PRODUCTS HAVING DOSE RESPONSE'
        WRITE (*,*) 'CONSTANTS THAT YOU WISH TO MOOIFY.'
        WRITE (*,'(12(/))')
        DO 2112 N=1,I
          WRITE (*,*) 'ENTER PRODUCT NUMBER ',N, '  THAT HAS A DOSE'
          WRITE (*,*) 'RESPONSE CONSTANT TO BE CHANGED.'
          READ (*,*) NPN(N)
        WRITE (*,*)
        WRITE (*,*)
2112    CONTINUE
        WRITE (*,'(24(/))')
        DO 2113 N=1,I
         WRITE (*,*) 'THE LUNG CANCER DOSE RESPONSE CONSTANT FOR '
         WRITE (*,*) 'PRODUCT ',NPN(N),' = ',FKL(NPN(N))
         WRITE (*,*)
          WRITE (*,*) 'ENTER 1 IF YOU WISH TO CHANGE THIS, ENTER 0'
          WRITE (*,*) 'IF YOU DON"T.'
         READ (*,*) II
         WRITE (*,*)
         WRITE (*,*)
         IF (II .EQ. 1) THEN
          WRITE (*,*) 'ENTER THE NEW LUNG CANCER DOSE RESPONSE CONSTANT'
          WRITE (*,*) 'FOR PRODUCT ',NPN(N),' .'
          READ (*,*) FKL(NPN(N))
          ENDIF
         WRITE (*,'(4(/))')
          WRITE (*,*) 'THE MESOTHELIOMA DOSE RESPONSE CONSTANT FOR'
         WRITE (*,*) 'PRODUCT ',NPN(N),' = ',FKM(NPN(N))
          WRITE (*,*)
          WRITE (*,*) 'ENTER 1 IF YOU WISH TO CHANGE THIS, ENTER 0'
          WRITE (*,*) 'IF YOU DON"T.'
          READ (*,*) II
          WRITE (*,*)
          WRITE (*,*)
          IF (II .EQ. 1) THEN
          WRITE (*,*) 'ENTER THE NEW MESOTHELIOMA DOSE RESPONSE '
          WRITE (*,*) 'CONSTANT FOR PRODUCT ',NPN(N)
          READ (*,*) FKM(NPN(N))
          ENDIF
         WRITE (*,'(8(/))')
2113    CONTINUE
```

```
      WRITE (*,'(3(/))')
      ENDIF
      WRITE(*,'(13(/))')
      WRITE(*,*) 'THIS PROGRAM GIVES YOU THE OPTION OF USING THE'
      WRITE(*,*) '1977 OR 1990 BASELINE LUNG CANCER DEATH RATES.'
      WRITE(*,*) 'IF YOU WANT TO USE 1977 RATES ENTER 1977 BELOW'
      WRITE(*,*) 'IF YOU WANT TO USE 1990 RATES ENTER 1990 BELOW.'
      READ(*,*)  IY
      WRITE(*,'(12(/))')
      WRITE(*,*) 'THIS PROGRAM ALLOWS YOU TO CHOOSE THE RATIO OF'
      WRITE(*,*) 'EXCESS GASTROINTESTINAL CANCER DEATHS TO LUNG'
      WRITE(*,*) 'CANCER DEATHS - COMMONLY ASSUMED VALUES ARE '
      WRITE(*,*) ' 0 OR 0.1. YOU MAY ENTER ANY VALUE BELOW '
      READ(*,*) GI
      WRITE (*,'(11(/))')
      WRITE(*,*)        'NOW CHOOSE THE NUMBER OF DISCOUNT RATES'
      READ(*,*) NN
      WRITE(*,*)
      WRITE (*,*) 'NOW SELECT THE',NN,' DISCOUNT RATES.  ENTER THESE'
      WRITE (*,*) 'RATES AS THEIR DECIMAL EQUIVALENTS.  AS AN '
      WRITE (*,*) 'EXAMPLE, A DISCOUNT RATE OF 10% WOULD BE ENTERED'
      WRITE (*,*) 'AS .1'
      WRITE (*,'(4(/))')
      DO 130 N=1,NN
       WRITE (*,'(A,I2)') ' ENTER DISCOUNT RATE # ',N
       READ (*,*) DISC(N)
  130 CONTINUE
      WRITE (*,'(22(/))')
      WRITE (*,*) 'WHAT EXPOSED POPULATION CHARACTERIZATION FILE'
      WRITE (*,*) 'DO YOU WANT TO USE?  REMEMBER TO INCLUDE THE'
      WRITE (*,*) 'DRIVE SPECIFIER!'
      READ (*,'(A)') FILE
      OPEN(UNIT=4,FILE=FILE,FORM='FORMATTED',STATUS='OLD')
      WRITE(*,'(24(/))')
      WRITE (*,*) 'THE OUTPUT OF THIS RUN IS STORED IN THE FILE'//
     -               ' NAMED ',FILE2
      WRITE(*,*)
      WRITE(*,*)
      WRITE(*,*) 'WAIT FOR THE PROGRAM TERMINATED'//
     -               ' MESSAGE BEFORE YOU PROCEED.'
      WRITE (*,'(13(/))')
      CALL INTAB(FILE3,FILE4,FILE2,FILE,IYRS,ISY,IEY,NEG,B,NP,
     * A,FKL,FKM,IY,GI,NN,DISC,PGBRK)
  101 FORMAT (1X)
  202 FORMAT (10(4f20.8/))
      READ (4,101)
      READ (4,202) MANOP
      READ (4,101)
      READ (4,202) MANOS
      READ (4,101)
      READ (4,202) INSO
      READ (4,101)
      READ (4,202) USEO
      READ (4,101)
      READ (4,202) DISO
      READ (4,101)
      READ (4,202) MANAP
      READ (4,101)
      READ (4,202) MANAS
      READ (4,101)
      READ (4,202) INSA
      READ (4,101)
      READ (4,202) USEA
      READ (4,101)
      READ (4,202) DISA
      READ (4,101)
      READ (4,202) PMANOP
      READ (4,101)
      READ (4,202) PMANOS
      READ (4,101)
      READ (4,202) PINSO
      READ (4,101)
      READ (4,202) PUSEO
      READ (4,101)
      READ (4,202) PDISO
      READ (4,101)
      READ (4,202) PMANAP
      READ (4,101)
      READ (4,202) PMANAS
      READ (4,101)
```

```
            READ (4,202) PINSA
            READ (4,101)
            READ (4,202) PUSEA
            READ (4,101)
            READ (4,202) PDISA
           DO 444 K=1,38
           DO 445 I=1,8
           DO 446 J=1,11
            RRR1(K,I,J)=0.0
            RRR2(K,I,J)=0.0
            TEM1(K,I,J)=0.0
            TEM2(K,I,J)=0.0
  446      CONTINUE
  445      CONTINUE
  444      CONTINUE
           DO 447 K=1,2
           DO 448 I=1,38
           PPP(K,I)=0.0
  448      CONTINUE
  447      CONTINUE
            DO 34 K=1,2
           DO 36 I=1,28
           DO 37 J=1,4
           TOT1(K,I,J)=0.0
  37       CONTINUE
  36       CONTINUE
  34        CONTINUE
            DO 3341 I=1,38
            DO 3342 J=1,20
            8PROJ(I,J)=0.0
            PROJ(I,J)=0.0
  3342      CONTINUE
  3341      CONTINUE
C
C          IB=BASELINE/ALTERNATIVE INDEX
C
            DO 98 IB=1,2
            DO 27 K=1,5
            DO 28 KK=1,5
            P(K,KK)=0.0
  28        CONTINUE
  27        CONTINUE
           EXP1=0.0
            CALL OAREAD(POP,RMAX,RLEV,IB,BPROJ,PROJ,IYRS,PGBRK)
C
C         IP=PRODUCT INDEX  NP=NO. OF PRODUCTS(38)
C
          DO 1 IIP=1,NP
           IP=A(IIP)
           DO 46 I=1,28
           DO 47 J=1,4
           RR(I,J)=0.0
  47       R(I,J)=0.0
  46       CONTINUE
           DO 695 I=1,18
           DO 696 J=1,4
           TA(I,J)=0.0
  696      CONTINUE
  695      CONTINUE
          EX1=0.0
          SS1=0.D
C
C         IG=EXPOSURE GROUP INDEX NG=NUMBER OF EXPOSURE GROUPS(10)
C
          DO 11 IIG=1,NEG
           DO 77 I=1,28
           DO 78 J=1,4
           T(I,J)=0.0
  78       CONTINUE
  77       CONTINUE
           IG=B(IIG)
           E1=0.0
           ISH=0
           IF (IG.EQ.5.OR.IG.EQ.10) ISH=LIFE(IP)
          IF (POP(IP,IG).EQ.0.) GOTO 11
          CALL INIT(RLEV,RMAX,IP,IG,NO,POP,SS1)
          AGEMIO=AGEST
C         J=AGE GROUP INDEX   NA=NO. OF AGE GROUPS(9)
          DO 5 J=1,9
          WT=OWT(J,NO)
```

```
      IF (WT.EQ.0.) GOTO 5
C
        DO 2 I=1,5
 2      V(I)=0.
        V(1)=1.
C
      N=(90-AGEMID)/5
C     IA=5 YEAR INDEX   NT=MAX NUMBER OF TIME PERIODS IN A LIFE(18)

      DO 8 IA=1,N
       AGE=(IA-1)*5+AGEMID+2.5
       IPER=IA+(AGEMID/5)
       CALL INC(OSRWT,FDIE,NO,AGE,IPER,IY)
C
C
C      LUNG CANCER
C
C
      DT=IA*5-12.5
      IF(DT .GT .MAXDT) DT=MAXDT
      IF(DT .LT. 0.) DT=0.
      FDTL=FDIE*FKL(IP)*F*DT/1.E5
C
C
C       MESOTHELIOMIA
C
      TT=(IA-1)*5+2.5
      FDTM=0.0
      IF(TT.LE.10) GOTO 10
      FDTM=FKM(IP)*F*(TT-10)**3
      IF(TT.LE.10+MAXDT) GOTO 10
      FDTM=FDTM-FKM(IP)*F*(TT-10-MAXDT)**3
        FDTM=5.*FDTM
10    YEAR=(IA*5)+1984
C
C
C
      CALL TRANSI(FDTL,FDTM,P,V,AGE,IPER,PP,WT,OSRWT,NO,
     * ISH,IP,IG,IB,IA,GI,E1,AGEMID,TA)
8     CONTINUE

5     AGEMID=AGEMID+AGEINT
        CALL AG(T,R,IG,LIFE,IP,E1,EX1)
 11   CONTINUE
       CALL AGG(R,TOT1,IG,IP,IB,BPROJ,PROJ,RR,
     * EXP1,EX1,IYRS,TEM1,TEM2,DISC,NN)
        CALL PRNT(R,RR,28,4,2,IP,TA,SS1,IYRS,IB,PPP,DISC,NN,
     *  RRR1,RRR2)
1     CONTINUE
       CALL TOTAL(TOT1,IB,TT1,EXP1,PGBRK)
 98     CONTINUE
        CALL BANEFF(DISC,TOT1,TT1,IB,NN,RRR1,RRR2,PPP,NP,A,
     *  PGBRK,TEM1,TEM2)
      STOP
      END
```

```
      SUBROUTINE TRANSI(FDTL,FDTM,P,V,AGE,IPER,PP,WT,OSRWT,NO,
     * ISH,IP,IG,IB,IA,GI,E1,AGEMID,TA)
c
      DIMENSION P(5,5),V(5),VV(5),OSRWT(4,3),TA(18,4)
       INTEGER AGEMID
      REAL*8 S,S1,PP,P,T,FMR,AFMR,BFMR,WT,V,VV,S2,S3,
     * FDTL,FDTM,E1,TA
      COMMON /A1/T(28,4)
      CALL LIFE(IPER,FMR,OSRWT,NO)
        IF (AGE.GT.85) GOTO 39
       P(1,2)=FDTL
       P(1,3)=GI*FDTL
       P(1,4)=FDTM
       P(1,5)=FMR
       P(1,1)=1.0-(P(1,2)+P(1,3)+P(1,4)+P(1,5))
       IF(P(1,1).LE.0.0D0) P(1,1)=0.0D0
       P(2,2)=1.0
       P(3,3)=1.0
       P(4,4)=1.0
       P(5,5)=1.0
       GOTO 421
  39    P(1,1)=0.000
       P(1,2)=FDTL
       P(1,3)=GI*FDTL
       P(1,4)=FDTM
       P(1,5)=1.0-(P(1,2)+P(1,3)+P(1,4))
 421  DO 1 I=1,5
      S=0.
      S1=0.
      DO 2 J=1,5
      S1=S1+P(I,J)
 2    S=S+P(J,I)*V(J)
      IF(DABS(S1-1.0D0).GT..00D0001D0) GOTO 99
 1    VV(I)=S
      CALL ACCUM(T,TA,V,VV,28,4,2,IPER,FDTL,FDTM,PP,WT,AGE,
     * ISH,IP,IG,IB,IA,E1,AGEMID)
      DO 3 I=1,5
 3    V(I)=VV(I)
      RETURN
 99   WRITE(3,98) I,(P(I,J),J=1,5)
 98   FORMAT(I4,5F11.8)
      STOP
      END

      SUBROUTINE ACCUM(T,TA,V,VV,N1,N2,N3,IPER,FDTL,FDTM,PP,WT,
     * AGE,ISH,IP,IG,IB,IA,E1,AGEMID)
C    THIS SUBROUTINE ACCUMULATES DATA.  ALL GROUPS ARE ADDED TOGETHER.
c
      REAL*8 PP,S1,T,WT,V,VV,FDTL,FDTM,E1,TA
      DIMENSION T(N1,N2),V(5),VV(5),TA(18,4)
      INTEGER IK(4),AGEMID
      DATA IK/2,3,4,5/
       RIA=(IA-1)*5.+2.5
       RISH=ISH
       IFT=(RISH/5.+.5)
       MIPER=IA+IFT
       SAGE=AGEMID
       IAGE=(AGE+2.5)/5.
      DO 1 K=1,4
      S1=(VV(IK(K))-V(IK(K)))*PP*WT
       T(MIPER,K)=T(MIPER,K)+S1
       TA(IAGE,K)=TA(IAGE,K)+S1
       E1=E1+S1*(AGE-SAGE)
  1    CONTINUE
      RETURN
      END
c
c
       SUBROUTINE AG(T,R,IG,LIFE,IP,E1,EX1)
c
         DIMENSION T(28,4),R(28,4),
     *   LIFE(38)
       REAL*8 A3,A2,R1,R2,R,T,E1,EX1
         IF(IG.NE.4.AND.IG.NE.9) GOTO 10
         N=LIFE(IP)
       RN=N
         DO 20 M=1,4
         DO 30 I=1,28
         DO 40 J=1,N
         K=(J-1)/5+1
```

```
        IF (J.LE.5)              RJ=J
        IF (J.GT.5.AND.J.LE.10)  RJ=J-5
        IF (J.GT.10.AND.J.LE.15) RJ=J-10
        IF (J.GT.15.AND.J.LE.20) RJ=J-15
        IF (J.GT.20.AND.J.LE.25) RJ=J-20
        IF (J.GT.25.AND.J.LE.30) RJ=J-25
        IF (J.GT.30.AND.J.LE.35) RJ=J-30
        IF (J.GT.35.AND.J.LE.40) RJ=J-35
        IF (J.GT.40.AND.J.LE.45) RJ=J-40
        IF (J.GT.45.AND.J.LE.50) RJ=J-45
       A3=1.-(2.*(RJ-1.)/10.)
        A2=1.-A3
        IF((I-(K-1)).LE.0) R1=0.0
        IF((I-(K-1)).GT.0) R1=T((I-(K-1)),M)
        IF((I-K).LE.0) R2=0.0
        IF((I-K).GT.0) R2=T((I-K),M)
       R(I,M)=R(I,M)+((A3*R1)+(A2*R2))
 40    CONTINUE
 30    CONTINUE
 20    CONTINUE
        EX1=EX1+RN*E1
       GOTO 60
 10    CONTINUE
       DO 70 M=1,4
       DO 80 I=1,28
       R(I,M)=R(I,M)+T(I,M)
 80    CONTINUE
 70    CONTINUE
        EX1=EX1+E1
 60    CONTINUE
       RETURN
       END
c
c
      SUBROUTINE AGG(R,TOT1,IG,IP,I8,BPROJ,PROJ,RR,
     * EXP1,EX1,IYRS,TEM1,TEM2,DISC,NN)
c
      DIMENSION R(28,4),TOT1(2,28,4),TEM1(38,8,11),TEM2(38,8,11),
     * BPROJ(38,20),PROJ(38,20),RR(28,4),DISC(10),S(4),CR(4)
      REAL*8 A3,A2,R1,R2,R,TOT1,RR,EXP1,EX1,TEM1,TEM2,DISC,S,CR
      DATA CR/1.09,1.56,1.02,1.0/
      N=IYRS
       DO 64 I=1,4
       S(I)=0.000
 64    CONTINUE
       DO 76 I=1,28
       DO 77 J=1,3
       S(J)=S(J)+R(I,J)
 77    CONTINUE
 76    CONTINUE
       DO 78 I=1,3
       S(4)=S(4)+S(I)
 78    CONTINUE
       IF(BPROJ(IP,1).EQ.0.0) GOTO 999
        NNN=NN+1
       IF(I8.EQ.2) GOTO 99
       DO 37 J=1,NNN
       DO 36 I=1,4
       DO 38 K=1,IYRS
       IF(J.LT.NNN)
     * TEM1(IP,I,J)=TEM1(IP,I,J)+((BPROJ(IP,K)/BPROJ(IP,1))
     * *S(I)*(1.0D0/(1.0D0+DISC(J))**K))
       IF(J.EQ.NNN) TEM1(IP,I,J)=TEM1(IP,I,J)+
     * ((BPROJ(IP,K)/BPROJ(IP,1))*S(I))
 38    CONTINUE
 36    CONTINUE
      DO 22 I=5,7
      II=I-4
      TEM1(IP,I,J)=TEM1(IP,II,J)*CR(II)
 22   CONTINUE
      TEM1(IP,8,J)=TEM1(IP,1,J)*CR(1)+TEM1(IP,2,J)*CR(2)
     * +TEM1(IP,3,J)*CR(3)
 37   CONTINUE
      GOTO 95
 99    CONTINUE
       DO 57 J=1,NNN
       DO 56 I=1,4
       DO 58 K=1,IYRS
       IF(J.LT.NNN) TEM2(IP,I,J)=
     * TEM2(IP,I,J)+((BPROJ(IP,K)/BPROJ(IP,1))
```

```
     *  *S(I)*(1.0D0/(1.0D0+DISC(J))**K))
        IF(J.EQ.NNN) TEM2(IP,I,J)=TEM2(IP,I,J)+
     *  ((BPROJ(IP,K)/BPROJ(IP,1))*S(I))
 58     CONTINUE
 56     CONTINUE
        DO 52 I=5,7
        II=I-4
        TEM2(IP,I,J)=TEM2(IP,II,J)*CR(II)
 52     CONTINUE
        TEM2(IP,8,J)=TEM2(IP,1,J)*CR(1)+TEM2(IP,2,J)*CR(2)
     *  +TEM2(IP,3,J)*CR(3)
 57     CONTINUE
 95     CONTINUE
 999    CONTINUE
       DO 10 M=1,4
       DO 20 I=1,28
       DO 30 J=1,N
       K=(J-1)/5+1
       IF(J.LE.5) RJ=J
       IF(J.GT.5.AND.J.LE.10) RJ=J-5
       IF(J.GT.10.AND.J.LE.15) RJ=J-10
       IF(J.GT.15.AND.J.LE.20) RJ=J-15
       A3=1.-(2.*(RJ-1.)/10.)
       A2=1.-A3
       IF((I-(K-1)).LE.0.0) R1=0.0
       IF((I-(K-1)).GT.0.0) R1=R((I-(K-1)),M)
       IF((I-K).LE.0.0) R2=0.0
       IF((I-K).GT.0.0) R2=R((I-K),M)
       IF(BPROJ(IP,1).GT.0.0) R1=BPROJ(IP,J)/BPROJ(IP,1)*R1
       IF(BPROJ(IP,1).GT.0.0) R2=BPROJ(IP,J)/BPROJ(IP,1)*R2
       IF(BPROJ(IP,1).EQ.0.0) R1=0.0
       IF(BPROJ(IP,1).EQ.0.0) R2=0.0
        TOT1(I8,I,M)=TOT1(I8,I,M)+((A3*R1)+(A2*R2))
       RR(I,M)=RR(I,M)+((A3*R1)+(A2*R2))
 30    CONTINUE
 20    CONTINUE
 10    CONTINUE
        DO 50 J=1,N
        IF(BPROJ(IP,1).GT.0.0) EXP1=
     *  EXP1+(BPROJ(IP,J)/BPROJ(IP,1)*EX1)
 50    CONTINUE
       RETURN
       END
```

```
      SUBROUTINE FILE(IB,BPROJ,PROJ,IYRS,PGBRK)
c
      DIMENSION BPROJ(38,20),S(2,38,20),PROJ(38,20)
       CHARACTER PGBRK
       IF(IB.EQ.2) GOTO 200
       WRITE (3,*)
       WRITE (3,*)
       WRITE(3,396) PGBRK
 396   FORMAT(A,32X,'INPUT DATA 5',//)
       WRITE(3,397)
 397   FORMAT(10X,'Baseline Indexes for the 38 Products over 20 ',
     * 'Years')
       WRITE(3,797)
 797   FORMAT(1X,'__________________________________________',
     * '__________________________________________',//)
      DO 30 K=1,IYRS
      READ(1,40) (S(1,J,K),J=1,38)
 40   FORMAT (38(F4.2,1X))
       WRITE (3,434) (S(1,J,K),J=1,38)
434    FORMAT(30(F4.2,1X),/,8(F4.2,1X))
 30   CONTINUE
        WRITE(3,797)
        WRITE(3,398) PGBRK
 398    FORMAT(A,32X,'INPUT DATA 6',//)
        WRITE(3,399)
 399    FORMAT(10X,'Regulatory Alternative Indexes for 38 ',
     * 'Products over 20 Years')
       WRITE (3,797)
       DO 50 K=1,IYRS
       READ(2,60) (S(2,J,K),J=1,38)
 60    FORMAT (38(F4.2,1X))
       WRITE (3,434) (S(2,J,K),J=1,38)
 50    CONTINUE
       WRITE (3,797)
       DO 70 I=1,38
       DO 80 J=1,IYRS
       BPROJ(I,J)=S(2,I,J)
 80    CONTINUE
 70    CONTINUE
       DO 90 I=1,38
       DO 100 J=1,IYRS
       PROJ(I,J)=S(1,I,J)
 100   CONTINUE
  90   CONTINUE
        GOTO 210
 200   DO 220 K=1,38
       DO 230 L=1,IYRS
 230   BPROJ(K,L)=PROJ(K,L)
 220   CONTINUE
 210   CONTINUE
       RETURN
       END
```

```
      SUBROUTINE DAREAD(POP,RMAX,RLEV,IB,BPROJ,PROJ,IYRS,PGBRK)
c
     COMMON/T/MANOP,MANOS,INSO,USEO,DISO,MANAP,MANAS,INSA,USEA,
    *DISA,PMANOP,PMANOS,PINSO,PUSEO,PDISO,PMANAP,PMANAS,PINSA,
    *PUSEA,PDISA
      CHARACTER PGBRK
      DIMENSION RPOP(38,10),BPROJ(38,20),REXP(38,10)
      DIMENSION RMAX(38,10),POP(38,10),RLEV(38,10),PROJ(38,20),
    *MANOP(38),MANOS(38),INSO(38),USEO(38),DISO(38),MANAP(38),
    * MANAS(38),INSA(38),USEA(38),DISA(38),PMANOP(38),PMANOS(38),
    * PINSO(38),PUSEO(38),PDISO(38),PMANAP(38),PMANAS(38),
    * PINSA(38),PUSEA(38),PDISA(38)
      EQUIVALENCE(REXP(1,1),MANOP(1))
      EQUIVALENCE(RPOP(1,1),PMANOP(1))
      CALL FILE(IB,BPROJ,PROJ,IYRS,PGBRK)
      S1=0.0
     DO 66 I=1,38
      DO 67 J=1,10
      IF(RPOP(I,J).EQ.0.)GOTO 69
      POP(I,J)=RPOP(I,J)*BPROJ(I,1)
      IF(POP(I,J).EQ.0.) GOTO 69
      S1=S1+POP(I,J)
      RMAX(I,J)=1.0
      RLEV(I,J)=REXP(I,J)
      GOTO 67
 69   CONTINUE
      POP(I,J)=0.0
      RLEV(I,J)=0.0
      RMAX(I,J)=0.0
      GOTO 67
 67   CONTINUE
 66   CONTINUE
      RETURN
      END
c
c
     SUBROUTINE INIT(RLEV,RMAX,IP,IG,NO,POP,SS1)
C  THIS SUBROUTINE DEFINES THE PRODUCT-GROUP SPECIFIC PARAMETERS
C       USED IN THE SIMULATION.
C  F=INTENSITY OF EXPOSURE,   GB=EXPOSURE AS OF 1985,
C  MAXDT=MAX DOSE ASSUMED,   V= INITIAL STATE VECTOR.
c
     DIMENSION RLEV(38,10),POP(38,10),RMAX(38,10)
     REAL*8 PP
     INTEGER IOCC(10)
     COMMON /O1/ F,MAXDT,PP
     DATA IOCC/1,1,1,1,1,2,2,2,2,2/
      F=RLEV(IP,IG)/2600.
     MAXDT=RMAX(IP,IG)
     PP=POP(IP,IG)
     SS1=SS1+PP
     NO=IOCC(IG)
       IF(IP.EQ.12.AND.IG.EQ.9) NO=3
     RETURN
     END
c
c
      SUBROUTINE INC(OSRWT,FDIE,NO,AGE,IPER,IY)
      DIMENSION OSRWT(4,3),FEG(18,4)
      REAL FDEG(18,4),FNEG(18,4)
      DATA FDEG/
    * 0.,0.,0.,.5,1.0,3.0,9.0,33.5,93.0,247.5,489.5,802.0,
    * 1330.5,1797.5,2283.0,2632.5,2300.5,1700.5,
    * 0.5,0.5,0.5,0.5,3.5,3.0,19.5,54.5,198.0,453.0,872.0,
    * 1328.5,1775.5,1857.5,2358.0,2351.0,1618.5,1264.D,
    * 0.,0.,0.,0.5,0.5,1.5,5.0,18.0,54.5,114.0,191.5,277.0,
    * 383.5,400.0,410.5,429.5,402.5,394.0,
    * 0.,0.,0.,1.0,0.5,3.0,6.5,26.0,82.0,131.0,236.5,290.0,
    * 348.0,321.5,402.0,404.5,228.5,254.0/
      DATA FNEG/
    * 0.,0.,0.,.5,1.,3.,9.,33.5,93.,247.5,518.9,850.1,
    * 1712.4,2313.4,2938.2,3388.,2960.8,2188.6,
    * .5,.5,.5,.5,3.5,3.,19.5,54.5,198.,453.,924.3,
    * 1408.2,2285.,2390.6,3034.8,3025.8,2083.,1626.8,
    * 0.,0.,0.,.5,.5,1.5,5.,18.,91.1,190.6,320.1,463.,
    * 641.,668.6,686.1,717.8,672.7,658.5,
    * 0.,0.,0.,1.,.5,3.,6.5,26.,137.,219.,395.3,484.7,
    * 581.7,537.4,671.9,676.1,381.9,424.6/
       FDIE =0.0
       DO 190 I=1,4
```

```
      IF(IY.EQ.1977) FEG(IPER,I)=FDEG(IPER,I)
      IF(IY.EQ.1990) FEG(IPER,I)=FNEG(IPER,I)
        FDIE=FDIE+FEG(IPER,I)*OSRWT(I,NO)
  190   CONTINUE
        RETURN
        END
C
C
      SUBROUTINE LIFE(IPER,FMR,OSRWT,NO)
      REAL*8 FMR
      DIMENSION OSRWT(4,3)
      REAL GMR(18,4)
      DATA GMR/
     * 1708.5,192.0,212.5,729.0,950.0,836.5,821.0,1096.5,1698.5,2825.5,
     * 4627.0,7200.0,11690.0,17182.0,26169.5,40523.0,57987.5,90208.5,
     *3212.8,258.,269.5,725.,1383.,1910.,2075.5,2804.,3965.,5504.,
     *8121.,11554.,16800.5,18976.,30980.5,43252.,44930.,56430.5,
     *1314.8,128.,125.,276.,296.5,307.,391.5,578.,958.5,1548.5,2400.5,
     *3631.,5720.,8163.5,13173.,23016.5,37474.5,70198.5,
     *2652.9,171.5,140.,314.,495.5,658.5,828.,1280.5,2020.5,2998.5,
     *4572.5,6537.5,9475.,10880.5,21493.,32254.,31325.,43367.5/
      IF(IPER.GT.18) IPER=18
      FMR=0.
      DO 1 K=1,4
    1 FMR=FMR+GMR(IPER,K)*OSRWT(K,NO)/1.0E5
C    MAKE CERTAIN FMR NON ZERO
      FMR=DMAX1(FMR,0.0D0)
      RETURN
      END
```

```
      SUBROUTINE INTAB(FILE3,FILE4,FILE2,FILE,IYRS,ISY,IEY,NEG,B,
     * NP,A,FKL,FKM,IY,GI,NN,DISC,PGBRK)
c
      REAL FKL(38),FKM(38),GI
      REAL*8 DISC(10)
      INTEGER IYRS,ISY,IEY,IGROUP,B(10),NP,A(38),IY,NN
      CHARACTER PGBRK
      CHARACTER*25 FILE,FILE2,FILE3,FILE4,PROD(38)
      CHARACTER*45 GROUP(10)
      WRITE(3,10) PGBRK
 10   FORMAT(A,32X,'INPUT DATA 1',//)
      WRITE(3,20)
 20   FORMAT(30X,'Scenario Modelled')
      WRITE(3,30)
 30   FORMAT(1X,'________________________________________________',
     * '_________________________________________________',//)
      WRITE(3,40)
 40   FORMAT(6X,'DATA FILES',//)
      WRITE(3,50) FILE,FILE3,FILE4,FILE2
 50   FORMAT(9X,'Exposure Data',25X,A25,/,9X,
     * 'Baseline Product Indexes',14X,A25,/,9X,
     * 'Product Indexes with Regulation',7X,A25,/,9X,
     * 'Output File',27X,A25,///)
      WRITE(3,60)
 60   FORMAT(6X,'TIME PERIOD FOR ANALYSIS',//)
      WRITE(3,70) IYRS,ISY,IEY
 70   FORMAT(9X,'Number of Years',25X,I4,/,9X,
     * 'Start Year',28X,I4,/,9X,'End Year',30X,I4,//)
      WRITE(3,30)
      WRITE(3,80) PGBRK
 80   FORMAT(A,32X,'INPUT DATA 2',//)
      WRITE(3,90)
 90   FORMAT(25X,'Exposure Groups Analyzed')
      WRITE(3,30)
      CALL GR(GROUP)
      DO 100 I=1,NEG
      WRITE(3,110) GROUP(B(I))
 110  FORMAT(15X,A45,/)
 100  CONTINUE
      WRITE(3,30)
      WRITE(3,120) PGBRK
 120  FORMAT(A,32X,'INPUT DATA 3',//)
      WRITE(3,130)
 130  FORMAT(12X,'Products Analyzed and their Dose-Response',
     * ' Parameters')
      WRITE(3,30)
      WRITE(3,140)
 140  FORMAT(1X,'PRODUCT',20X,'LUNG CANCER',4X,'MESOTHELIOMA',
     * 3X,'YEAR FOR',3X,'RATIO OF')
      WRITE(3,15)
 15   FORMAT(27X,'DOSE-RESPONSE',2X,'DOSE-RESPONSE',2X,'BASELINE',
     * 3X,'GI CANCER')
      WRITE(3,160)
 160  FORMAT(27X,' CONSTANT ',5X,' CONSTANT ',5X,' LUNG',6X,
     * 'TO LUNG')
      WRITE(3,170)
 170  FORMAT(57X,'CANCER',5X,'CANCER')
      WRITE(3,175)
 175  FORMAT(68X,'RATIO')
      WRITE(3,30)
      CALL PR(PROD)
      DO 180 I=1,NP
      WRITE(3,190) PROD(A(I)),FKL(A(I)),FKM(A(I)),IY,GI
 190  FORMAT(1X,A25,3X,F10.3,5X,F10.9,5X,I4,7X,F6.4)
 180  CONTINUE
      WRITE(3,30)
      WRITE(3,200) PGBRK
 200  FORMAT(A,32X,'INPUT DATA 4',//)
      WRITE(3,210)
 210  FORMAT(28X,'Discount Rates Used')
      WRITE(3,30)
      DO 220 I=1,NN
      RR=DISC(I)*100.
      WRITE(3,230) I,RR
 230  FORMAT(6X,I2,'.',3X,F5.2,' PERCENT',/)
 220  CONTINUE
      WRITE(3,30)
      RETURN
      END
c
```

```
c
      SUBROUTINE GR(GROUP)
      CHARACTER*45 GROUP(10)
      GROUP(1)='PRIMARY MANUFACTURING-OCCUPATIONAL'
      GROUP(2)='SECONDARY MANUFACTURING-OCCUPATIONAL'
      GROUP(3)='INSTALLATION-OCCUPATIONAL'
      GROUP(4)='USE-OCCUPATIONAL'
      GROUP(5)='REPAIR/DISPOSAL-OCCUPATIONAL'
      GROUP(6)='PRIMARY MANUFACTURING-NON-OCCUPATIONAL'
      GROUP(7)='SECONDARY MANUFACTURING-NON-OCCUPATIONAL'
      GROUP(8)='INSTALLATION-NON-OCCUPATIONAL'
      GROUP(9)='USE-NON-OCCUPATIONAL'
      GROUP(10)='REPAIR/DISPOSAL-NON-OCCUPATIONAL'
      RETURN
      END
c
c
       SUBROUTINE PR(PROD)
c
       CHARACTER*25 PROD(38)
       PROD(1)='COMMERCIAL PAPER'
       PROD(2)='ROLLBOARD'
       PROD(3)='MILLBOARD'
       PROD(4)='PIPELINE WRAP'
       PROD(5)='BEATER-ADD GASKETS'
       PROD(6)='HGH-GRD ELECTRICAL PAPER'
       PROD(7)='ROOFING FELT'
       PROD(8)='ACETYLENE CYLINDERS'
       PROD(9)='FLOORING FELT'
       PROD(10)='CORRUGATED PAPER'
       PROD(11)='SPECIALTY PAPER'
       PROD(12)='V/A FLOOR TILE'
       PROD(13)='DIAPHRAGMS'
       PROD(14)='A/C PIPE'
       PROD(15)='A/C FLAT SHEET'
       PROD(16)='A/C CORRUGATED SHEET'
       PROD(17)='A/C SHINGLES'
       PROD(18)='DRUM BRAKE LIN. NEW'
       PROD(19)='DISC BRK PADS,LV,NEW'
       PROD(20)='DISC BRK PADS,HV'
       PROD(21)='BRAKE BLOCKS'
       PROD(22)='CLUTCH FACINGS'
       PROD(23)='AUTO. TRANS. COMP.'
       PROD(24)='FRICTION MATERIALS'
       PROD(25)='ASB PROTECT. CLOTH'
       PROD(26)='ASB THRD, YARN ETC'
       PROD(27)='SHEET GASKETS'
       PROD(28)='ASBESTOS PACKINGS'
       PROD(29)='ROOF COATINGS ETC'
       PROD(30)='OTHER COAT. & SEAL.'
       PROD(31)='ASB REINF. PLAST.'
       PROD(32)='MISSILE LINERS'
       PROD(33)='SEALANT TAPE'
       PROD(34)='BATTERY SEPARATORS'
       PROD(35)='ARC CHUTES'
       PROD(36)='DRM BRK LIN.,OLD'
       PROD(37)='DISC BRK PADS,LV,OLD'
       PROD(38)='MINING/MILLING'
       RETURN
       END
c
c
     SUBROUTINE PRNT(R,RR,N1,N2,N3,IP,TA,SS1,IYRS,IB,PPP,DISC,
    * NN,RRR1,RRR2)
C    THIS SUBROUTINE AGGREGATES AND PRINTS THE DATA ASSEMBLED
C      IN THE ACCUM SUBROUTINE
c
     REAL*8 S1,S2,RT,R,RR,RRT,TA,TTA,AVA,CR,CRRT,CRT,TRT,TRRT
      REAL*8 CTRT,CTRRT,PPP,RRR1,RRR2,DISC,SST,SS
      DIMENSION CR(4),CRRT(4),CRT(4),PPP(2,38)
      DIMENSION RRR1(38,8,11),RRR2(38,8,11),DISC(10),SST(11)
      DIMENSION SS(4,11)
     DIMENSION R(28,4),RT(4),RR(28,4),RRT(4),TA(18,4),TTA(4),AVA(4)
      DATA CR/1.09,1.56,1.02,1.0/
       TRT=0.
       TRRT=0.
       CTRT=0.
       CTRRT=0.
       DO 57 I=1,11
       SST(I)=0.000
```

```
 57      CONTINUE
         DO 59 I=1,4
         DO 61 J=1,11
         SS(I,J)=0.0D0
 61      CONTINUE
 59      CONTINUE
       DO 3 K=1,N2
       S2=0.
       S3=0.
       DO 4 I=1,28
        N=I+NN
        DO 27 KK=1,N
        IF(KK.EQ.N) SS(K,KK)=SS(K,KK)+RR(I,K)
        IF(KK.LT.N) SS(K,KK)=SS(K,KK)+(RR(I,K)*(1.0D0/(1.0D0+
     *  DISC(KK))**(I*5-3)))
 27     CONTINUE
4      S2=S2+R(I,K)
       RT(K)=S2
         CRT(K)=RT(K)*CR(K)
 3       CONTINUE
         DO 88 K=1,3
         TRT=TRT+RT(K)
         CTRT=CTRT+CRT(K)
         DO 89 KK=1,N
         SST(KK)=SST(KK)+SS(K,KK)
 89      CONTINUE
 88      CONTINUE
        DO 6 K=1,4
        S4=0.
        DO 7 I=1,18
 7      S4=S4+TA(I,K)
 6      TTA(K)=S4
        DO 8 K=1,4
        S5=0.
         IF(TTA(K).LE.0.0001) GOTO 8
        DO 14 I=1,18
 14     S5=S5+TA(I,K)/TTA(K)*(I*5-2.5)
 8      AVA(K)=S5
         PPP(IB,IP)=SS1
         IF(IB.EQ.2) GOTO 95
         DO 47 J=1,N
         DO 49 I=1,3
         RRR1(IP,I,J)=SS(I,J)
 49      CONTINUE
         RRR1(IP,4,J)=SST(J)
         DO 51 I=5,7
         II=I-4
         RRR1(IP,I,J)=SS(II,J)*CR(II)
 51      CONTINUE
         RRR1(IP,8,J)=SS(1,J)*CR(1)+SS(2,J)*CR(2)+SS(3,J)*CR(3)
 47      CONTINUE
         GOTO 99
 95      CONTINUE
         DO 67 J=1,N
         DO 69 I=1,3
         RRR2(IP,I,J)=SS(I,J)
 69      CONTINUE
         RRR2(IP,4,J)=SST(J)
         DO 71 I=5,7
         II=I-4
         RRR2(IP,I,J)=SS(II,J)*CR(II)
 71      CONTINUE
         RRR2(IP,8,J)=SS(1,J)*CR(1)+SS(2,J)*CR(2)+SS(3,J)*CR(3)
 67      CONTINUE
 99      CONTINUE
       RETURN
       END
c
c
       SUBROUTINE TOTAL(TOT1,IB,TT1,EXP1,PGBRK)
C
C       THIS SUBROUTINE PRINTS TOTALS FOR ALL PRODUCTS
c
        REAL*8 TOT1,TT1,EXP1,TD,TC,CR,TTD,TTC,TNP
        CHARACTER PGBRK
        DIMENSION TOT1(2,28,4),TD(28),TC(28),CR(4),
     *  TT1(2,4)
         DATA CR/1.09,1.56,1.02,1.00/
         TTD=0.
         TTC=0.
```

```
          TNP=0.
          DO 7 I=1,28
          TD(I)=0.
          TC(I)=0.
  7       CONTINUE
         DO 1 I=1,4
         TT1(IB,I)=0.0
  1      CONTINUE
         DO 10 K=1,4
         DO 20 J=1,28
         TT1(IB,K)=TT1(IB,K)+TOT1(IB,J,K)
 20      CONTINUE
 10      CONTINUE
         DO 42 J=1,28
         DO 43 K=1,3
         TD(J)=TD(J)+TOT1(IB,J,K)
         TC(J)=TC(J)+(TOT1(IB,J,K)*CR(K))
 43      CONTINUE
 42      CONTINUE
         DO 44 K=1,3
         TTD=TTD+TT1(IB,K)
         TTC=TTC+(TT1(IB,K)*CR(K))
 44      CONTINUE
         DO 48 K=1,4
         TNP=TNP+TT1(IB,K)
 48      CONTINUE
         IF(IB.EQ.1) GOTO 46
         WRITE(3,95) PGBRK
 95      FORMAT(A,32X,'OUTPUT DATA 2',//)
         WRITE(3,62)
 62      FORMAT(25X,'       Totals for All Products-Baseline    ',///)
         GOTO 47
 46       WRITE(3,96) PGBRK
 96       FORMAT(A,32X,'OUTPUT DATA 1 ',//)
         WRITE(3,63)
 63      FORMAT(25X,' Totals for All Products - Alternative',///)
 47      CONTINUE
          WRITE(3,30)
 30       FORMAT(1X,'________________________________________',
        * '________________________________________',//)
         WRITE(3,64)
 64      FORMAT(1X,'TIME SINCE',3X,'LUNG CANCER',5X,'G.I.CANCER',5X,
        * 'MESOTHELIOMA',3X,'ALL EXCESS',5X,'ALL EXCESS')
         WRITE(3,65)
 65      FORMAT(1X,'EXP. ONSET',51X,'CANCER DEATHS',2X,'CANCER CASES')
         DO 50 I=1,28
         I1=(I-1)*5
         I2=I1+5
 50      WRITE(3,60) I1,I2,(TOT1(IB,I,J),J=1,3),TD(I),TC(I)
 60      FORMAT(I4,'-',I3,3F16.5,2f15.5)
          WRITE(3,76)
 76       FORMAT(1X,/)
         WRITE(3,70) (TT1(IB,J),J=1,3),TTD,TTC
 70      FORMAT(' TOTALS ',3F16.5,2f15.5,///)
          WRITE(3,30)
           RETURN
           END
c
c
              SUBROUTINE BANEFF(DISC,TOT1,TT1,IB,NN,RRR1,RRR2,PPP,NP,
        *  A,PGBRK,TEM1,TEM2)
c
          DIMENSION TOT1(2,28,4),DISC(10),
        * TT1(2,4),DIF1(28,4),DD(28),DC(28),CR(4),TEM1(38,8,11),
        * DT1(4),PPP(2,38),DIFP(38,8),TRRR(8),TEM2(38,8,11),
        * DIS(10,5),RRR1(38,8,11),RRR2(38,8,11),DIFT(38,8),TRRM(8)
          REAL*8 TOT1,TT1,DIF1,DD,DC,TDD,TDC,CR,DIFT,TRRM,
        * DIS,DISC,EXP1,RRR1,RRR2,PPP,DIFP,TRRR,TEM1,TEM2
          INTEGER A(38),NP
          CHARACTER PGBRK
          CHARACTER*25 PROD(38)
          DATA CR/1.09,1.56,1.02,1.00/
           N=1+NN
            DO 197 K=1,N
          DO 444 I=1,8
          TRRR(I)=0.0
          TRRM(I)=0.0
 444      CONTINUE
          DO 200 I=1,38
          DO 210 J=1,8
```

```
            DIFP(I,J)=0.000
            DIFT(I,J)=0.000
            DIFT(I,J)=TEM2(I,J,K)-TEM1(I,J,K)
            DIFP(I,J)=RRR2(I,J,K)-RRR1(I,J,K)
  210       CONTINUE
  200       CONTINUE
            DO 445 I=1,8
            DO 446 J=1,38
            TRRR(I)=TRRR(I)+DIFP(J,I)
            TRRM(I)=TRRM(I)+DIFT(J,I)
  446       CONTINUE
  445       CONTINUE
            CALL PR(PROD)
            IF(K.EQ.N) RR=0.
            IF(K.LT.N) RR=DISC(K)*100.
            DO 320 JJ=1,4
            IF (JJ.EQ.2) GO TO 330
            IF(JJ.EQ.3) GOTO 830
            IF(JJ.EQ.4) GOTO 840
            WRITE(3,230) PGBRK
  230       FORMAT(A,32X,'OUTPUT DATA 3',//)
            WRITE(3,240) RR
  240       FORMAT(4X,'Cancer Deaths Avoided by Product',
     *      ' Discounted from Time of Effect at ',F5.1,'%')
            GOTO 340
  330       WRITE(3,350) PGBRK
  350       FORMAT(A,32X,'OUTPUT DATA 4',//)
            WRITE(3,360) RR
  360       FORMAT(4X,'Cancer Cases Avoided by Product',
     *      ' Discounted from Time of Effect at ',F5.1,'%')
            GOTO 340
  830       WRITE(3,47) PGBRK
  47        FORMAT(A,32X,'OUTPUT DATA 3A',//)
            WRITE(3,471) RR
  471       FORMAT(3X,'Cancer Deaths Avoided by Product',
     *      ' Discounted from Time of Exposure at ',F5.1,'%')
            GOTO 340
  840       WRITE(3,48) PGBRK
  48        FORMAT(A,32X,'OUTPUT DATA 4A',//)
            WRITE(3,472) RR
  472       FORMAT(3X,'Cancer Cases Avoided by Product',
     *      ' Discounted from Time of Exposure at ',F5.1,'%')
  340       WRITE(3,250)
  250       FORMAT(1X,'______________________________________________',
     *      '____________________________________________',//)
            WRITE(3,260)
  260       FORMAT(8X,'PRODUCT NAME',8X,'LUNG CANCER',2X,'GI CANCER',
     *      2X,'MESOTHELIOMA',2X,'TOTAL CANCER',//)
            IF(JJ.EQ.1.OR.JJ.EQ.3) ILOW=1
            IF(JJ.EQ.1.OR.JJ.EQ.3) IHIGH=4
            IF(JJ.EQ.2.OR.JJ.EQ.4) ILOW=5
            IF(JJ.EQ.2.OR.JJ.EQ.4) IHIGH=8
            IF(JJ.EQ.1) WRITE (7) (DIFP(I,IHIGH),I=1,38),TRRR(IHIGH)
            IF(JJ.EQ.2) WRITE (7) (DIFP(I,IHIGH),I=1,38),TRRR(IHIGH)
            IF(JJ.EQ.3) WRITE (7) (DIFT(I,IHIGH),I=1,38),TRRM(IHIGH)
            IF(JJ.EQ.4) WRITE (7) (DIFT(I,IHIGH),I=1,38),TRRM(IHIGH)
            DO 290 I=1,NP
            IP=A(I)
            IF(JJ.EQ.1.OR.JJ.EQ.2)
     *      WRITE(3,280) PROD(IP),(DIFP(IP,J),J=ILOW,IHIGH)
            IF(JJ.EQ.3.OR.JJ.EQ.4)
     *      WRITE(3,280) PROD(IP),(DIFT(IP,J),J=ILOW,IHIGH)
  280       FORMAT(3X,A25,F10.5,3X,F10.5,1X,F10.5,4X,F10.5)
  290       CONTINUE
            WRITE(3,300)
  300       FORMAT(3X,//)
            IF(JJ.EQ.1.OR.JJ.EQ.2)
     *      WRITE(3,310) (TRRR(I),I=ILOW,IHIGH)
            IF(JJ.EQ.3.OR.JJ.EQ.4)
     *      WRITE(3,310) (TRRM(I),I=ILOW,IHIGH)
  310       FORMAT(12X,'TOTAL',11X,F10.5,3X,F10.5,1X,F10.5,4X,F10.5)
            WRITE(3,250)
  320       CONTINUE
  197        CONTINUE
            WRITE(3,385) PGBRK
  385       FORMAT(A,32X,'OUTPUT DATA 5',//)
            WRITE(3,395)
  395       FORMAT(24X,'Number of People Exposed in Base Year')
            WRITE(3,250)
            WRITE(3,405)
```

```
 405    FORMAT(12X,'PRODUCT',12X,'NUMBER OF PEOPLE',//)
        DO 415 I=1,NP
        IP=A(I)
        WRITE(3,425) PROD(IP),PPP(2,IP)
 425    FORMAT(3X,A25,3X,F10.0)
 415     CONTINUE
        WRITE(3,250)
        TDD=0.
        TDC=0.
        DO 24 I=1,28
        DD(I)=0.
        DC(I)=0.
 24     CONTINUE
        DO 6 I=1,NN
        DO 5 J=1,5
        DIS(I,J)=0.D0
 5      CONTINUE
 6      CONTINUE
        DO 10 I=1,28
        DO 20 J=1,4
        DIF1(I,J)=(TOT1(2,I,J)-TOT1(1,I,J))
 20     CONTINUE
 10     CONTINUE
        DO 50 J=1,4
        DT1(J)=(TT1(2,J)-TT1(1,J))
 50     CONTINUE
        DO 76 I=1,28
        DO 77 K=1,3
        DD(I)=DD(I)+DIF1(I,K)
        DC(I)=DC(I)+(DIF1(I,K)*CR(K))
 77     CONTINUE
 76     CONTINUE
        DO 79 K=1,3
        TDD=TDD+DT1(K)
        TDC=TDC+(DT1(K)*CR(K))
 79     CONTINUE
        DO 55 K=1,NN
        DO 70 J=1,3
        DO 80 I=1,28
         DIS(K,J)=DIS(K,J)+DIF1(I,J)*(1.D0/(1.D0+DISC(K))**(I*5-3))
 80     CONTINUE
 70     CONTINUE
 55     CONTINUE
        DO 56 K=1,NN
        DO 83 I=1,28
         DIS(K,4)=DIS(K,4)+DD(I)*(1.0D0/(1.D0+DISC(K))**(I*5-3))
         DIS(K,5)=DIS(K,5)+DC(I)*(1.0D0/(1.D0+DISC(K))**(I*5-3))
 83     CONTINUE
 56     CONTINUE
        WRITE(3,437) PGBRK
 437    FORMAT(A,32X,'OUTPUT DATA 6',//)
        WRITE(3,120)
 120    FORMAT(15X,'Cancers Avoided for All Products by Time Period')
        WRITE(3,250)
         WRITE(3,87)
 87      FORMAT(1X,'TIME SINCE',3X,'LUNG CANCER',3X,'GI CANCER',
     *  3X,'MESOTHELIOMA',3X,'ALL EXCESS',3X,'ALL EXCESS')
         WRITE(3,88)
 88      FORMAT(1X,'START OF',46X,'DEATHS',7X,'CASES')
         WRITE(3,489)
 489    FORMAT(1X,'ANALYSIS',//)
        DO 130 I=1,28
        I1=(I-1)*5
        I2=I1+5
 130     WRITE(3,140) I1,I2,(DIF1(I,J),J=1,3),DD(I),DC(I)
 140     FORMAT(3X,I4,'-',I3,3X,F10.4,4X,F10.4,2X,F10.4,5X,F10.2,
     *  3X,F10.2)
         WRITE(3,796)
 796     FORMAT(1X,/)
       WRITE(3,78) (DT1(J),J=1,3),TDD,TDC
 78      FORMAT(4X,'TOTAL',5X,F10.4,4X,F10.4,2X,F10.4,5X,F10.2,
     *  3X,F10.2,/)
         WRITE(3,478)
 478     FORMAT(1X,'DISCOUNTED TOTALS',/)
         DO 27 K=1,NN
         RR=DISC(K)*100.
         WRITE(3,81) RR,(DIS(K,J),J=1,5)
 81      FORMAT(1X,F5.2,' PERCENT'3X,F10.4,4X,F10.4,2X,F10.4,5X,
     *  F10.2,3X,F10.2)
 27      CONTINUE
```

```
      WRITE(3,250)
      RETURN
      END
c
c
      SUBROUTINE LIST
C
C     THIS SUBROUTINE LISTS TO THE SCREEN THE PRODUCT NUMBERS AND THEIR
C     ASSOCIATED REFERENCE NUMBERS.
C
C
      WRITE(*,*) ' List of Products and Their Reference Numbers: '
      WRITE(*,*)
      WRITE(*,*) ' 1-COMMERCIAL PAPER        19-DISC BRK PADS,LV,NEW'
      WRITE(*,*) ' 2-ROLLBOARD               20-DISC BRK PADS,HV'
      WRITE(*,*) ' 3-MILLBOARD               21-BRAKE BLOCKS'
      WRITE(*,*) ' 4-PIPELINE WRAP           22-CLUTCH FACINGS'
      WRITE(*,*) ' 5-BEATER-ADD GASKETS      23-AUTO.TRANS.COMP '
      WRITE(*,*) ' 6-HGH-GRD ELECTRICAL PAPER 24-FRICTION MATERIALS'
      WRITE(*,*) ' 7-ROOFING FELT            25-ASB PROTECT. CLOTH'
      WRITE(*,*) ' 8-ACETYLENE CYLINDERS     26-ASB THRD,YARN,ETC'
      WRITE(*,*) ' 9-FLOORING FELT           27-SHEET GASKETS '
      WRITE(*,*) '10-CORRUGATED PAPER        28-ASBESTOS PACKINGS '
      WRITE(*,*) '11-SPECIALTY PAPER         29-ROOF COATINGS ETC'
      WRITE(*,*) '12-V/A FLOOR TILE          30-OTHER COAT. & SEAL.'
      WRITE(*,*) '13-DIAPHRAGMS              31-ASB.-REINF. PLAS'
      WRITE(*,*) '14-A/C PIPE                32-MISSILE LINERS'
      WRITE(*,*) '15-A/C FLAT SHEET          33-SEALANT TAPE'
      WRITE(*,*) '16-A/C CORRUGATED SHEET    34-BATTERY SEPARATORS'
      WRITE(*,*) '17-A/C SHINGLES            35-ARC CHUTES'
      WRITE(*,*) '18-DRUM BRAKE LININGS,NEW  36-DRM BRK LIN,OLD'
      WRITE(*,*) '                           37-DISC BRK PADS,LV,OLD'
      WRITE(*,*) '                           38-MINING/MILLING'
      PAUSE 'Press the <RETURN> or the <ENTER> key to continue'
      RETURN
      END
```