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Air

ECONOMIC IMPACT ANALYSIS OF THE PROPOSED NESHAP FOR FLEXIBLE POLYURETHANE FOAM

Final Report

Economic Impact Analysis
of the Proposed NESHAP for
Flexible Polyurethane Foam

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) is developing National Emission Standards for Hazardous Air Pollutants (NESHAP) for new and existing producers of flexible polyurethane foam. The flexible polyurethane foam industry includes producers of flexible slabstock foam and flexible molded foam. Both slabstock and molded foam are used as intermediate products in a number of industries. The primary uses of flexible slabstock foam are in the furniture, automobile, carpet and bedding industries. Among the industries which use flexible molded foam are automobile, furniture, packaging, and textiles and fiber manufacturing. Both slabstock and molded foam producers emit hazardous air pollutants (HAPs)[1] identified by the Clean Air Act Amendments of 1990.

Accordingly, this Economic Impact Analysis (EIA) has been conducted to satisfy the requirements of the Clean Air Act (Section 317), and the Regulatory Flexibility Act.

ANALYSIS OBJECTIVES

The primary objective of this analysis is to describe the magnitude and distribution of adverse impacts associated with alternative NESHAPs among various members of society. This study estimates the costs to society and describes the adverse impacts associated with the alternative NESHAPs. Those members of society who could potentially suffer adverse impacts include:

- Producers whose facilities require emission controls.
- Buyers of goods produced by industries requiring controls.
- Employees at plants requiring controls.

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[1] These HAPs are methylene chloride ($MeCl_2$) and toluene diisocyanate (TDI).

- Individuals who could be affected indirectly such as residents of communities proximate to controlled facilities, and producers and employees in industries that sell inputs to or purchase inputs from directly affected firms.

BACKGROUND

Affected Markets

EPA expects the alternative NESHAPs to affect two sectors of the foam production industry included in Standard Industrial Classification (SIC) 3086. These are:

- Producers of flexible polyurethane slabstock foam.
- Producers of flexible polyurethane molded foam.

Foam Chemistry and Production

Polyurethane foams are made by adding water to a polyol/diisocyanate reaction mixture. During the reaction, CO_2 is formed and acts as a “blowing agent” by creating bubbles that expand and create a network of cells separated by thin membranes. The formation of the cells I n the foam determine the foam’s properties, such as softness and durability. Because certain foam properties are limited when using CO_2 as the sole blowing agent, auxiliary blowing agents (ABAs) are often used. The ABAs vaporize due to the heat generated during the reaction and help the carbon dioxide expand the foam, and also reduces the heat formation from the isocyanate reaction (thus preventing scorching of the foam). Previously, the principal ABA used was chlorofluorocarbon 11 (CFC-11). However, since this compound has been shown to deplete the earth's ozone layer, U.S. producers have almost completely phased out its use. Methylene chloride ($MeCl_2$), a listed HAP, has replaced CFC-11 as the principal ABA. Since the role of the methylene chloride is simply to volatize and expand the foam, it does not directly participate in the polyurethane reaction. Therefore, all $MeCl_2$ used in the reaction is eventually emitted.

As mentioned previously, there are two types of foam production processes: slabstock and molded. While the chemistry and final products of slabstock and molded foam production are similar, the production processes, emission sources, and control techniques are very different. While molded foam is manufactured in a batch-type process, slabstock is produced using a continuous method. The major emission source for slabstock foam is from the use of ABAs, but there is no analogous emission point for molded foam production. The only significant HAP emission point that the two segments share is equipment cleaning. Generally, the reasons for emissions and available control technologies are quite different for the two industry segments.

Regulatory Alternatives

The Clean Air Act Amendments of 1990 stipulate that HAP emission standards for existing sources must at least match the percent reduction of HAPs achieved by either (a) the best 12 percent of existing sources, or (b) the best five sources in a category or subcategory consisting of fewer than 30 sources. This minimum standard is called a MACT Floor.

Because of the technical differences in the flexible polyurethane foam production industry noted above, EPA has separated the industry into several subcategories. This analysis evaluates the molded foam production and slabstock foam production subcategories. For each of these subcategories, three regulatory alternatives have been analyzed. The first represents the maximum achievable control technology (MACT) "floor" level of control. This level of control is the minimum stringency for a NESHAP developed in accordance with section 112(d) of the Clean Air Act Amendments. Existing source regulatory alternatives that achieve greater emission reductions than the floor level were also developed for each of these subcategories (Regulatory Alternative 1 and Regulatory Alternative 2).

There are currently seventy-eight (78) facilities producing flexible slabstock foam and approximately two-hundred-thirty-four (234) facilities producing molded foam. For both sectors, the MACT Floor for existing sources was constructed by averaging the emissions levels of the best 12 percent of existing sources. A source type is a piece of equipment or component of production which produces HAPs. The MACT Floor requires controls on HAP emissions from the following slabstock foam source types:

- Production processes.
- Storage/unloading processes.
- Equipment cleaning.
- Equipment leaks.

Molded foam source types controlled by the MACT Floor are:

- Mixhead cleaning, or "flushing."
- Mold release agent usage.
- The use of HAP-based adhesives to repair damaged foam.

Table ES-1 shows the three existing source regulatory alternatives for slabstock foam. Regulatory Alternative 1 increases the stringency of the requirements for equipment leak and ABA usage emissions in that it requires a combination of equipment modifications and the execution of a leak detection and repair (LDAR) program to reduce equipment leak emissions. Alternative 1 also includes a lower allowable HAP ABA emission level. Regulatory Alternative 2 prohibits HAP ABA emissions. This would, in effect, prohibit the usage of any $MeCl_2$ as an ABA. Since no HAP ABA would be allowed, there is no need for HAP ABA storage or equipment leak requirements.

Table ES-2 shows the three existing source regulatory alternatives for molded foam production by source and type of control. Since the MACT Floor prohibits the use of HAP-based mold release agents and adhesives, the only emission source with the potential for more stringent requirements is mixhead flushing. Regulatory Alternative 1 requires work practices to reduce mixhead flushing emissions and Regulatory Alternative 2 prohibits the use of HAP-based mixhead flushes.

Table ES-1

REGULATORY ALTERNATIVES FOR SLABSTOCK FOAM EXISTING SOURCES

Reg. Alt.	Storage/ Unloading	Components in HAP Service	Equipment Cleaning	HAP ABA Emissions
MACT Floor	HAP ABA & TDI- vapor balance/carbon	Leakless TDI pumps	HAP prohibition	Existing HAP ABA emission limit
1	HAP ABA & TDI- vapor balance/carbon	Leakless TDI pumps Unique LDAR	HAP prohibition	Intermediate HAP ABA emission limit
2	TDI- vapor balance/carbon	Leakless TDI pumps	HAP prohibition	HAP prohibition

Source: EC/R Incorporated (1996a).

Table ES-2

REGULATORY ALTERNATIVES FOR MOLDED FOAM EXISTING SOURCES

Regulatory Alternative	Mixhead Flush	Mold Release Agents	Repair Adhesive
MACT Floor	No control	HAP prohibition	HAP prohibition
1	Work practice	HAP prohibition	HAP prohibition
2	HAP prohibition	HAP prohibition	HAP prohibition

Source: EC/R Incorporated (1996a).

SUMMARY OF ESTIMATED IMPACTS

Primary and Secondary Impacts

Table ES-3 summarizes the estimates of the primary and secondary economic impacts associated with the MACT Floor and the two additional regulatory alternatives. Primary impacts include price increases, reductions in market output levels, changes in the value of shipments by domestic producers, and plant closures. Note that for the slabstock sector, we report a range of plant closures based on a sensitivity analysis of emission control technologies (found in Appendix D). Secondary impacts include employment losses, reduced energy use, changes in net exports, and potential regional impacts.

Table ES-3

SUMMARY OF ESTIMATED ECONOMIC IMPACTS

Analysis	Estimated Impacts
Primary Impacts	
Price Increases	Estimated price increases range from 2.20 to 3.82 percent for the slabstock segment and from 0.07 to 1.14 percent for the molded foam segment of the industry under the three regulatory alternatives.
Market Output	Estimated reductions in market output range from 1.08 to 1.86 percent for slabstock foam and from 0.04 to 0.56 percent for molded foam.
Value of Domestic Shipments	Increases in the value of domestic shipments range from 1.10 to 1.89 percent for slabstock foam and from 0.04 to 0.57 percent for molded foam.

Plant Closures	For the slabstock foam market segment, predicted closures range from one to two under the MACT Floor, one to three under Regulatory Alternative 1, and one to four under Regulatory Alternative 2. Predicted molded foam plant closures are zero under the MACT Floor, three under Regulatory Alternative 1, and zero under Regulatory Alternative 2. These predicted closures are due in part to worst-case assumptions adopted in the analyses.
Secondary Impacts	
Employment	Under the three regulatory scenarios, employment losses are estimated to range from 1.08 to 1.86 percent (95 to 164 jobs) in the slabstock segment and 0.04 to 0.56 percent (2 to 31 jobs) in the molded segment.
Energy Use	Estimated industry-wide energy use to decline by 1.08 to 1.86 percent ($409.6 to $703.0 thousand) in the slabstock industry and by 0.04 to 0.56 percent ($8.9 to $133.5 thousand) in the molded industry.
Net Exports	No significant trade impacts are expected.
Regional Impacts	No significant regional impacts are expected.

The market price for slabstock foam is estimated to increase by 2.28 percent ($0.03/lb) under the MACT Floor, 2.20 percent ($0.03/lb) under Regulatory Alternative 1, and 3.82 percent ($0.05/lb) under Regulatory Alternative 2. Corresponding decreases in market output are estimated as: 1.12 percent under the MACT Floor, 1.08 percent under Regulatory Alternative 1, and 1.86 percent under Regulatory Alternative 2.

The estimated impacts of the MACT Floor on price and output in the molded foam sector are smaller than those predicted for the slabstock market. For the molded foam industry, we estimate an increase in price of only 0.07 percent ($0.0017/lb) under the MACT Floor, 0.84 percent ($0.02/lb) under Regulatory Alternative 1, and 1.14 percent ($0.03/lb) under Regulatory Alternative 2. Corresponding decreases in market output are estimated as: 0.04 percent under the MACT Floor, 0.42 percent under Regulatory Alternative 1, and 0.56 percent under Regulatory Alternative 2.

Note, however, that we expect *increases* in the value of shipments by both domestic slab-stock and molded foam producers under all regulatory alternatives. This occurs because estimated price increases more than offset the lower production volumes. The value of shipments of slabstock foam are estimated to increase by 1.14 percent ($19.53 million) under the MACT Floor, 1.10 percent ($18.82 million) under Regulatory Alternative 1, and 1.89 percent ($32.56 million) under Regulatory Alternative 2. The value of shipments of molded foam is estimated to increase by 0.04 percent ($0.391 million) under the MACT Floor, 0.42 percent ($4.50 million) under Alternative 1, and 0.57 percent ($6.10 million) under Alternative 2.

For the slabstock foam industry, the analysis predicts one to two plant closures under the MACT Floor, one to three plant closures under Regulatory Alternative 1 and one to four plant closures under Regulatory Alternative 2. These predicted closures, however, are due in part to some of the "worst-case" assumptions adopted in the analysis.[2]

For the molded foam industry, the analysis predicts no plant closures under the MACT Floor, three plant closures under Regulatory Alternative 1, and no plant closures under Regulatory Alternative 2. Again, these predicted closures are due in part to the worst-case assumptions adopted in the analysis.

The estimates of slabstock sector secondary impacts reported in Table ES-3 are consistent with the primary impacts estimates described above. We estimate reductions in employment and energy use of 1.12 percent under the MACT Floor, 1.08 percent under Regulatory Alternative 1,

[2] For example, we assume that plants with the highest emission control costs are the least efficient producers in the market. Also, our analysis does not consider that some plants are protected by regional trade barriers. Actual plant closures will be fewer than predicted closures if plants with high emission control costs are not the least efficient producers or if these plants are protected by regional trade barriers. We also note that predicted plant closures are sensitive to assignments of emission control technologies (see Appendix D).

and 1.86 percent under Regulatory Alternative 2.[3] Since no significant export or import markets for slabstock foam exist, no significant trade impacts are expected.

The secondary impacts on the molded foam industry are less than those for the slabstock segment. Reductions in employment and energy use are estimated to be only 0.04 percent under the MACT Floor, 0.42 percent under Regulatory Alternative 1, and 0.56 percent under Regulatory Alternative 2. As with slabstock foam, no significant export or import markets for molded foam exist; accordingly, no significant trade impacts are expected.

Financial Analysis

The analysis of financial data for a sample of firms indicates that capital and annual emission control costs are small relative to the financial resources of the firms producing flexible polyurethane slabstock and molded foam. As a result, we do not find evidence that it will be difficult for these firms to raise the capital required to purchase and install emission controls. We note, however, that data in not available for most privately owned companies. The producers for which financial data are available tend to be larger publicly held companies. As a result, these firms might not be representative of all producers in the industry.

Sensitivity Analyses

Appendix C examines the sensitivity of the estimated primary impacts to alternative assumptions about market demand and supply elasticities. The results reported in Appendix C indicate that the primary impacts summarized in Table ES-3 are relatively insensitive to reasonable ranges of elasticities.

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[3] As was the case for predicted plant closures, our estimates of employment and energy impacts are due in part to the worst-case assumptions adopted in our analysis.

Appendix D examines the sensitivity of the counts of predicted plant closures to the assignment of compliance technologies for the slabstock industry segment. Given that there exist multiple technologies (of different costs) which will bring a source type into compliance with a regulatory scenario, altering the assignment of compliance technologies to model plants affects the estimated impacts of the regulatory scenario. Impacts can be reduced by assuming that more plants will opt for lower-cost emission control technologies.

Potential Small Business Impacts

The Regulatory Flexibility Act (RFA) requires an analysis of potential impacts on small entities, which are defined by the employment or sales level of the parent company that owns a facility. Due to insufficient data on the ownership of numerous plants in the flexible polyurethane foam industry, an analysis of each parent company in the industry is not feasible. Alternatively, data collected in the section 114 survey is used to evaluate the impact on small flexible foam businesses based on model facilities. The Initial Regulatory Flexibility Analysis (IRFA) indicates that there are a total of 71 small businesses (18 slabstock, 53 molded) that are affected by the regulatory alternatives.

For the molded foam sector, the IRFA indicates that the smallest model plant does not incur any compliance costs, and the average change in operating costs as a percentage of revenues for all other model plant sizes is less than one percent. This impact is not considered to be significant to affected small businesses. In addition, the economic analysis does not indicate any closures of molded foam facilities as a result of the MACT floor and Regulatory Alternative 2, however, Regulatory Alternative 1 indicates 3 closures of the mid-sized model plant (LP2).

For the slabstock sector, the average change in operating costs as a percent of revenues at the smallest model plant is 1.59 percent for the MACT floor, 1.84 percent for Regulatory Alternative 1, and 2.29 for Regulatory Alternative 2. For all other model plant sizes, this value is equal to or less than one percent. The economic analysis estimates a range of closures for each slabstock model plant size. The smallest model plant is estimated to have between 0 and 2 closures for the MACT floor, and between 0 and 3 closures for Regulatory Alternatives 1 and 2. The next largest model plant is estimated to have between 0 and 1 closure for all regulatory alternatives. Because there is insufficient data to determine the exact ownership of the plants that may close, the analysis cannot determine if these impacts will occur at small businesses. Given that any estimate of closures is based upon worst-case assumptions, it is likely that these impacts are overestimated and the affect on small businesses will be minimal.

Social Costs and Economic Efficiency

Table ES-4 reports estimates of the social (economic) costs associated with the alternative NESHAPs for the slabstock and molded foam segments of the industry. We measure social costs as changes in economic surplus resulting from compliance costs.[4] The total estimated annualized social costs for the slabstock and molded subcategories combined range from $7.24 million (Regulatory Alternative 1) to $12.05 million (MACT Floor). The estimates of emission reductions reported in Table ES-4 include lower emission reductions due to controls as well as adjustments for predicted plant closures. Specifically, we assume that emissions fall to zero at plants predicted to close. Because the proposed options choose Regulatory Alternative 1 for the slabstock subcategory and Regulatory Alternative 2 for the molded subcategory, this equates to a total social cost of the proposed rule to be $7.89 million.

Table ES-4

SOCIAL COSTS AND ECONOMIC EFFICIENCY OF
REGULATORY ALTERNATIVES

Regulatory Alternative	Annual Social Costs ($1994MM)			Annual Emission Reduction (tons)		
	Slabstock	Molded	Total	Slabstock	Molded	Total

[4] See Section 7 for a discussion of changes in economic surplus as a measure of social costs.

MACT Floor	11.86	0.19	12.05	9,774	331	10,105
Regulatory Alternative 1	7.18	0.06	7.24	11,796	1,846	13,642
Regulatory Alternative 2	10.92	0.71	11.63	16,958	2,331	19,289

A regulatory alternative is economically efficient if it generates larger net benefits (benefits minus costs) than other alternatives. A dominant alternative generates the same or larger total emission reductions at a lower cost than any other alternative. Since we presume that larger emission reductions yield higher benefits, a dominant alternative is economically efficient relative to all other alternatives (since it produces the same or larger benefits at a lower cost).

An inferior alternative, on the other hand, generates the same or smaller emission reductions at a higher cost than at least one other alternative. An inferior alternative is economically inefficient because at least one other alternative generates higher net benefits.

As the results in Table ES-4 indicate, none of the three regulatory alternatives is clearly dominant. However, the MACT Floor is inferior to both Alternative 1 and Alternative 2. The MACT Floor generates lower annual emission reductions at higher annual costs than either Alternative 1 or Alternative 2. Therefore, we conclude that the MACT Floor is economically inefficient relative to these two regulatory alternatives.

Note that Alternative 2 generates larger emission reductions than Alternative 1, but at higher costs. As a result, the information provided in Table ES-4 is not sufficient to evaluate the economic efficiency of Alternative 2 relative to Alternative 1. Alternative 2 would be efficient relative to Alternative 1 if the additional benefits associated with higher emission reductions (5,647 tons annually) exceed its incremental costs ($4.39 million annually).

One final comment on why this analysis is worthwhile. Some of the estimated economic impacts associated with Alternatives 1 and 2 are more adverse than for the MACT Floor (e.g., more closures) even though the MACT Floor gives rise to higher social costs. This occurs because, compared with the MACT Floor, Alternatives 1 and 2 impose higher compliance costs on marginal (higher cost) plants, but more than offsetting lower costs on non-marginal plants. Thus, while the MACT Floor is inferior, some of its economic impacts are less severe than those for Alternatives 1 and 2. In other words, some of the distributional impacts of the MACT floor are less severe than those of the other regulatory alternatives.

LIMITATIONS

Several limitations of the analyses used to estimate the impacts of the alternative NESHAPs are described throughout this report. All of these limitations should be considered in interpreting the estimated impacts summarized above. In particular, many of the assumptions adopted in the analyses tend to cause the estimated adverse impacts associated with the alternative NESHAPs to be overstated.

ORGANIZATION OF REPORT

Section 1 of this report is an industry profile of the flexible polyurethane foam industry. In Section 2, we describe the model plants and report the estimated compliance costs used in the analyses. We describe the analytical methods employed to estimate the economic impacts associated with the alternative NESHAPs in Section 3. In Section 4, we report estimates of primary economic impacts, including those on market prices, market output levels, value of shipments by domestic producers, and plant closures. Section 5 presents estimates of secondary impacts, including the effects on employment, foreign trade, energy use and regional economies. We describe potential adverse impacts of small businesses in Section 6. In Section 7, we report estimates of the social costs and assess the economic efficiency of the alternative NESHAPs.

There are four appendices to this report. We describe the model plants used in the analyses and report estimates of emission control costs and other baseline data in Appendix A. Appendix B provides a detailed technical description of the analytical methods employed to estimate economic impacts and costs. We report in Appendix C the results of sensitivity analyses in which we consider ranges of demand and supply elasticities. In Appendix D, we report the results of sensitivity analyses for the slabstock sector in which assumptions regarding the assignment of compliance technologies to model plants are modified.

REFERENCE

EC/R Incorporated (1996a). Technical memorandum from Phil Norwood and Amanda Williams to David Svendsgaard (EPA/OAQPS), January 26.

SECTION 1

INDUSTRY PROFILE

INTRODUCTION

The following is a profile of the industry segments affected by the Maximum Achievable Control Technology (MACT) standards for producers of flexible polyurethane foam. These are producers of flexible slabstock and flexible molded polyurethane foam. Both slabstock and molded foam producers emit hazardous air pollutants (HAPs) identified by the Clean Air Act Amendments of 1990. Information in this section is used to conduct analyses that are required by Section 317 of the Clean Air Act, which requires EPA to evaluate regulatory alternatives through an Economic Impact Analysis (EIA), and the Regulatory Flexibility Act, which requires an evaluation of the impacts on small entities.

The objective of this section is to describe the markets for flexible polyurethane foams. Specifically, we:

- Describe flexible polyurethane foam products and their uses,
- Present data on foam prices and production levels,
- Describe the market outlook for flexible polyurethane foam,
- Characterize the industry's market structure,
- Provide a brief description of the limited foreign trade in flexible polyurethane foam,
- Present financial data for foam producers, and
- Present data on industry employment and energy use.

PRODUCT DESCRIPTIONS

Polyurethanes are made by reacting a polyol with a diisocyanate. The polyol is typically a polyester or a polyether with two or more -CH_2OH functional groups. The diisocyanate is usually a mixture of a 2, 4- and 2, 6- isomers of toluene diisocyanate (TDI). Polyurethane foams are made by adding water to the reaction mixture. Surfactants and catalysts are also added to the mixture. The surfactants aid in mixing incompatible components of the reaction mixture, and also help control the size of the foam cells by stabilizing the forming gas bubbles. Catalysts balance the isocyanate/water and isocyanate/polyol reactions, and assist in driving the polymerization reaction to completion.

The CO_2 formed in this reaction acts as the "blowing agent" creating bubbles that expand. The bubbles eventually come into close contact, forming a network of cells separated by thin membranes. At full foam rise, the cell membranes are stretched to their limits and rupture, releasing the blowing agent and leaving open cells supported by polymer "struts." The more water added, and CO_2 formed, the more expanded the polymer network, and the lower the resultant foam density. However, the reaction of isocyanate with water is extremely exothermic. The addition of too much water can cause the foam to scorch or auto-ignite.

Because certain foam properties are limited when using CO_2 as the sole blowing agent, auxiliary blowing agents (ABA's) are often used. The ABA's vaporize due to the heat generated during the reaction and help the carbon dioxide expand the foam. The ABA also reduces the heat formation from the isocyanate reaction. Previously, the principal ABA used was chlorofluorocarbon 11 (CFC-11). However, since this compound has been shown to deplete the earth's ozone layer, U.S. producers have almost completely phased out its use. Methylene chloride ($MeCl_2$), a listed HAP, has replaced CFC-11 as the principal ABA. Since the role of the methylene chloride is simply to volatilize and expand the foam, it does not directly participate in the polyurethane reaction. Therefore, all methylene chloride used in the reaction is eventually emitted.

Polyurethane products can be classified into two major categories: foams and non-foams. Non-foam polyurethanes are coatings, adhesives, sealants, and elastomers. Polyurethane foams are produced in rigid and flexible forms. The industry producing flexible polyurethane foams is separated into two distinct segments, flexible slabstock foam and flexible molded foam. Although the foam chemistry in these sectors of the industry is analogous, the equipment, emission sources, and control technologies are different. Molded foam is produced by pouring, or "shooting" the foam reaction mixture into a mold of the desired shape and size. Slabstock foam is produced as large "buns" on semi-continuous moving conveyors. These buns are then cut, glued, or otherwise fabricated into the desired sizes and shapes.[5]

Flexible Slabstock Foam

Toluene diisocyanate (TDI) and polyether polyol are the predominant raw materials used to produce flexible slabstock foam. Catalysts, surfactants, blowing agents and other additives comprise the balance of materials used in the production process. The raw ingredients are pumped to a mixing head and discharged through the nozzle onto the front of a conveyor belt (called the foam line) at a rate of between 400 and 1,000 pounds per minute. The conveyor first passes through an enclosed, ventilated tunnel, where the ingredients react quickly to form the foam bun. From the point of its maximum expansion, the foam begins to release blowing agents and unreacted chemicals. These chemicals are exhausted from the enclosed section. As the bun leaves the conveyor, it is sawed into sections and transported to a curing area, where the foam reaction continues to completion and the remainder of the blowing agents leave the bun.

There are no standard dimensions for a slabstock bun. A typical bun can be 4 feet tall, 8 feet wide, and 50 to 100 feet long. However, buns can range from a width of 3 to 9 feet and may be up to hundreds of feet in length. Slabstock foam is produced on a need basis, generally to fill

[5] For a further discussion of the technical processes involved in the manufacture of flexible polyurethane foam, see Schultz (1989) and EC/R Incorporated (1995).

existing orders. The size of the facility, more than the speed of the foam line, acts as a constraint on how much foam can be produced. The foam line production process generally takes between 2 and 4 hours before the bun is ready for transport to the curing area. After the foam bun is transported to the curing area, it must sit untouched for between 24 and 48 hours before any fabrication, shipping, or movement to storage can occur. Foam production in smaller facilities is thus limited by the amount of space available for foam curing and in some cases storage (Peters, 1995).

Figure 3-1 illustrates the most popular machinery used in the production of flexible polyurethane slabstock buns, the Maxfoam process. As the figure indicates, the mixing head is fixed and the liquid coming from the head is fed into the bottom of a trough where it begins to react. The reacting mass then flows over the forward edge of the trough and onto the bottom paper, which is sliding on an inclined fall-plate. The fall-plate is made up of five sections hinged together at pivot points. The angle of each fall-plate section can be changed by raising or lowering the height of the pivot points. By changing the configuration of the fall-plate sections, the rise of the foam can be controlled. The foam, which expands downward, reaches the horizontal conveyor as a fully expanded slab. When the fall-plate sections are properly adjusted, the reacting foaming mass flowing out of the trough will be evenly distributed between the sidewalls. The surface of the slab will follow the side paper on a horizontal line at the same level as the top of the foam expanding from the trough, thus producing a flat-topped block (Harrington and Hack, 1991).

Prior to being delivered to the end-user, the large buns are fabricated according to their end-use. The simplest method of fabrication is to cut the foam into the desired shape and size. However, many customers require the gluing of foam-to-foam or foam to some other non-foam product.

Figure 1-1. Maxfoam Process

By altering the relative quantities of water, TDI, polyol, and auxiliary blowing agent used in the reaction, slabstock properties can be changed significantly. Foam properties and characteristics can be further altered by the addition of colorants, combustion modifiers, and fillers.

The most important foam properties are density and Indentation Force Deflection (IFD). Foam is graded, or categorized, with two numbers, representing these properties. The first, density, is measured in lb/ft^3 and is used to categorize slabstock into three general groupings as follows:

- Foam with density less than 1.2 lbs/ft^3.

- Foam with density between 1.2 lbs/ft^3 and 1.8 lbs/ft^3.
- Foam with density greater than 1.8 lbs/ft^3 (Hull and Co., 1992).

The second grading measure, the IFD, is a measure of foam stiffness (or softness). IFD is the amount of force (lbs) it takes to push a 50 square inch disk down 25 percent of the total thickness of the foam. Density and IFD, although both measuring physical foam characteristics, are independent of one another. For example, a 1.0/30 foam is typically used in sofa arms and quilting. A 1.8/30 foam is considered quality sofa seat foam. These pieces differ in their density to correspond with their intended end use but are of the same softness. A foam with a given density can have any IFD value, just as foam with any IFD may be of any density. Desired density and IFD values are determined by the foam's application in the end-use market.

As previously stated, IFD is a direct indicator of foam stiffness. However, density does not provide a direct measure of foam quality or durability. Generally, the higher the foam density, the higher the quality, but this is not always the case. Quality is often subjective to the end-use of the foam. Other foam properties and characteristics may provide a relative measure of "quality" unrelated to density.

Some slabstock facilities also have rebond operations on-site. Rebond is the process by which scrap foam is ground up, placed in large molds and adhered together using an isocyanate (methylene chloride) and heat. This causes the small pieces to adhere and form a solid cylinder of foam. The cylinder is then peeled into sheets, which is primarily used as carpet underlay (carpet padding). Bonded carpet underlay is the major use for flexible polyurethane foam scrap. Because polyurethane foam producers are generally not in the business of producing scrap, the amount of material poured intentionally for bonded carpet underlay is limited by the amount of available storage space as much as it is by economic considerations. Intentional scrap is often made by using off-spec materials that would not be acceptable for use in cushions or bedding material. Intentional scrap does not hold together well and is used as an extender. Therefore, generally no more than 50 percent of the material used in a batch of rebond carpet underlay can be intentionally poured scrap.

Flexible Molded Foam

Although the basic polyurethane foam reaction is the same, molded foam production uses somewhat different chemical formulations from those used in slabstock production. These foams have higher densities than flexible slabstock foams, and therefore, seldom use an auxiliary blowing agent. In contrast to the slabstock process, the molding method is an intermittent batch process where the raw ingredients are shot into a mold and allowed to react. Unlike slabstock foam, where cutting and fabrication is necessary for the creation of the final foam product, the result of the molded foam production process is the final or intermediate product. Flexible molded foams are categorized into three classes in accordance with variance in their properties:

- High resiliency (HR)
- Semi-flexible
- Hot molded.

A typical foam molding line will consist of many functional parts. The majority of floor space will be taken up by conveying systems for the molds, ovens and related finished-foam handling systems. Conveyors for moving the foam molds from station to station can be of any number of layouts. Long racetrack-style designs are still as common as the newer, smaller, and more specialized carousel lines similar to that shown in Figure 3-2. In most cases, the mold moves under the mixing head where it received a charge of foam. It is

Figure 1-2: Carousel Molding Line

common to find the mixing head mounted on a robot or other computerized pour bridge for purposes of optimizing pour pattern for each individual mold cavity. After receiving the correct dose of foam, the mold is moved to a curing/storage area where the reaction continues to completion and the product is ready for delivery (Harrington and Hack, 1991).

END-USE MARKETS

Flexible slabstock and molded foams have a myriad of uses in six primary markets. These markets, which are described below, are:

- Furniture
- Transportation
- Carpet
- Bedding
- Packaging
- Textiles and Fibers.

Table 1-1 shows the 1991 distribution of slabstock foam to end-use markets. As this table indicates, the major uses of slabstock foam include the manufacture of furniture, vehicles, carpeting, and bedding. Table 1-2 shows the major uses of molded flexible polyurethane foam. About 86 percent of molded foam is used in the manufacture of vehicles.

Table 1-1

END-USE MARKET CONSUMPTION OF FLEXIBLE SLABSTOCK FOAM (1991)

INDUSTRY SEGMENT	CONSUMPTION (million lbs.)	% TOTAL
Furniture	560	44
Transportation	117	9
Carpet*	340	27
Bedding	161	13
Packaging	36	3
Textiles and Fibers	22	2
Other	29	2
Total	1,265	100

* Carpet includes poured scrap and binder adhesives

Source: Hull & Co., End-Use Market Survey on the Polyurethane Industry in the U.S. and Canada, 1992.

Table 1-2

END-USE MARKET CONSUMPTION OF FLEXIBLE MOLDED FOAM (1991)

INDUSTRY SEGMENT	CONSUMPTION (million lbs.)	% TOTAL
Transportation		
Auto	213	63
Non-auto	76	23
Furniture	24	7
Packaging	12	4
Textiles & Fibers	5	1
Bedding	4	1
Other	5	1
Total	339	100

Source: Hull & Co., End-Use Market Survey on the Polyurethane Industry in the U.S. and Canada, 1992.

Transportation

Uses in transportation include automobiles and light trucks, recreational vehicles, trucks, trailers, and railroad and aerospace applications. Cushions, shock-absorbent pads, and seating surfaces account for approximately 30 percent of total flexible foam production, and represent 80 percent of the flexible foam used in automotive applications. Typical automotive uses for flexible polyurethane foam are for such items as seat cushions, seat backs, headrests, arm rests, headliners, and under carpet sound insulation. Most of the parts are produced by molding rather than fabricating pieces cut from slabstock.

In 1991, total production of flexible polyurethane molded foam products for the U.S. transportation industry was reported at 289 million pounds. Table 1-3 shows molded foam usage in a typical automobile.

Table 1-3

MOLDED FOAM CONSUMPTION PER AUTOMOBILE

APPLICATION	CONSUMPTION PER VEHICLE (pounds)
Seating	25.5
Instrument Panels	3.2
Head Rests	0.8
Arm Rests	1.2
Consoles	0.3
Carpets (molded)	0.5
Other	0.5
Total	32.0

Source: Hull & Co., End-Use Market Survey on the Polyurethane Industry in the U.S. and Canada, 1992.

Furniture

Furniture is the largest end use of flexible polyurethane foam. In 1991, 584 million pounds, or 36 percent of total flexible foam produced, was used in the furniture industry, mainly for cushions, pillows, and padding. Table 1-7 describes the distribution of slabstock foam densities used in the furniture industry. The density and IFD chosen will vary with the desired properties of the furniture. Fabrication processes used in the manufacture of furniture generates a considerable amount of scrap during the conversion of slabstock to finished products. This scrap goes through "rebond" treatment and is used in the production of other flexible foam products, especially carpet underlay. The furniture market is primarily served by six large companies.[6]

Carpet Underlay

In 1991, the U.S. market for carpet underlay used an estimated 570 million pounds of flexible polyurethane foam. Of this total, 119 million pounds represent virgin carpet underlay while 451 million pounds is bonded carpet underlay (rebond). Carpet underlay is produced by flexible slab foam producers and by stand-alone carpet underlay producers. Approximately 52 plants, located in 26 states, manufacture bonded carpet underlay in the U.S. (Hull & Co., 1992). In 1991, a total of 139 million pounds of virgin flexible slab foam was produced for carpet underlay applications. Of this quantity, 119 million pounds were used as produced and the remaining 20 million pounds were sent as scrap to bonded carpet underlay manufacturers. Table 1-4 shows the foam components and quantities of each used in the 1991 production of bonded carpet underlay.

Table 1-4
FOAM COMPONENTS OF BONDED CARPET UNDERLAY

SCRAP SOURCE	MILLIONS OF POUNDS
Flexible Foam Scrap	251
Imported Foreign Scrap	133
Binder Adhesives	40
Molded Foam Scrap	17
Post-Consumer Scrap	10
Total Bonded Carpet Underlay Production	451

[2] This information is provided by Hull & Co. (1992). The six companies were not identified.

Source: Hull & Co., End-Use Market Survey on the Polyurethane Industry in the U.S. and Canada, 1992.

Bedding

The bedding industry is the fourth largest user of flexible polyurethane foam, consuming about 165 million pounds, or 5 percent of the total flexible foam produced. The bedding market consists of toppers and mattresses. Toppers are typically less than 1.5 inches thick and account for about 51 million pounds of foam, or 35 percent of bedding foam usage. Mattresses are 4 to 6 inches thick and use 94 million pounds of foam. Six or seven large companies share most of the market (Hull & Co., 1992).

Packaging

The packaging industry uses a wide range of polyurethane materials. In 1991, this industry used approximately 36 million pounds of flexible slab foam and 12 million pounds of molded foam. Polyurethane for packaging is limited by its higher cost relative to polystyrene. Flexible foams have important applications in packaging high cost speciality items as well as uses in interiors of carts for in-plant transport of speciality items.

Textiles and Fibers

In 1991, the textiles and fibers industry consumed approximately 27 million pounds of flexible foam. Apparel applications use flexible foam, mostly 1-1.5 lb / ft^3 based on polyester polyol, melt-bonded onto fabric. Relatively small quantities of flexible foam are used as laminates to textile materials as backing.

PRICES

As previously discussed, flexible polyurethane slabstock foam is produced in large buns. The buns are sold to fabricators where they are cut and or glued to form foam of the desired shape and size for use in the end-use market. Prices paid by fabricators for slab foam varies with the grade (density) of the foam. They also vary somewhat with the geographic location of the end-use market. For example, foam to be used in California must adhere to stricter fire retardants and chemical use guidelines than the rest of the country (Bush, 1995). The necessary modifications to the production process results in higher production costs, and thus higher costs to the fabricators.

Table 1-5 shows August 1995 median prices paid by fabricators for different grades of bulk slabstock foam. As this table indicates, higher density slabstock foam commands higher prices. Also, median California prices are moderately higher than prices for the rest of the domestic market. Molded foam prices vary depending on the amount of value added to the foam during the molding process. One industry source reports that molded foam prices in the range of $2.25 to $2.45 per pound are typical.[7]

Table 1-5

BULK SLABSTOCK FOAM PRICES

Density (lbs/ft^3)	Price (per board foot)	California Price (per board foot)
1.00	$0.125	$0.135
1.20	$0.145	$0.170
1.45	$0.165	$0.185
1.80	$0.200	$0.225

[7] Jody Bevilaqua, Woodbridge Foam, telecom with Jeffrey Sassin, Mathtech, Inc., 3/15/96.

Source: Bobby Bush Jr., Hickory Springs Manufacturing Company, telecom with Jeffrey Sassin, 8/30/95.

OUTPUT

From the period 1987 through 1994, production of flexible slabstock foam has increased over 35 percent, with annual increases during that span averaging about 4.6 percent (Peters, 1995) Decreases from previous year production levels occurred in 1990, and again in 1991.[8] Since that time, industry production figures have been increasing, with the largest increase occurring from 1993 to 1994 (15.68 percent). In 1992, flexible molded foam production is estimated to have been approximately 339 million pounds, of which 58 percent was used in the automotive manufacturing industry (Hull & Co., 1992). Flexible slabstock production quantities and yearly trends are reported in Table 1-6.

As discussed earlier, slabstock foam is classified into one of three foam grades based upon its lbs/ft^3 density. Table 1-7 shows the distribution of slabstock foam, by foam grade, to end-use market. The data in this table are consistent with our earlier discussion that a variety of foam densities are often included in single end-use products. Because several different grades are produced at a facility throughout the year, it would be difficult to maintain control at specified emission limits for each foam grade. Therefore, the proposed MACT rule allows foam facilities to achieve compliance by averaging emissions across foam grades. Some foam grades require less ABA and therefore can meet emission limitations more easily than others. This raises the issue of whether compliance with the proposed rule will cause relatively larger adverse impacts in specific end-use markets. However, the data in Table 1-7 do not permit a straightforward answer to this question as the major end-use markets use a variety of foam densities.

[8] The recession in 1990-91 caused a drop in production because the end-use markets for foam (i.e., automobiles, home furnishings, etc.) were severely affected by the slowed U.S. economy.

Table 1-6

FLEXIBLE SLABSTOCK FOAM PRODUCTION

YEAR	PRODUCTION (billion lbs)	% CHANGE
1994	1.512	15.68
1993	1.307	5.66
1992	1.237	5.91
1991	1.168	-6.34
1990	1.247	-0.24
1989	1.250	5.31
1988	1.187	6.27
1987	1.117	---

Source: Lou Peters, Polyurethane Foam Association, telecom with Jeffrey Sassin, Mathtech, Inc., 8/8/95.

SUBSTITUTES

There are a limited number of products which serve as substitutes to flexible polyurethane foam. Primary among these are polyester fibers. Other products which may serve as substitutes to flexible foam are springs, rubber, and natural fibers. These products do not have the same properties as foam but in some cases may be applicable to similar uses.

Table 1-7

1991 DISTRIBUTION OF FLEXIBLE SLAB FOAM
TO END-USE MARKET BY FOAM GRADE

Industry Segment	< 1.2 lbs/ft^3	1.2 -1.8 lbs/ft^3	>1.8 lbs/ft^3	Total	% Total
Furniture	168	224	168	560	44
Transportation	17	83	17	117	9
Carpet*	138	127	75	340	27
Bedding	89	18	56	161	13
Packaging	14	20	2	36	3
Textiles and Fibers	16	4	2	22	2
Other	11	11	7	29	2
Total	453	485	328	1,265	100

* Carpet includes poured scrap and binder adhesives

Source: Hull & Co., End-Use Market Survey on the Polyurethane Industry in the U.S. and Canada, 1992.

Since 1990, the use of polyester fiber as a substitute for flexible foams has been increasing. Among the end-use markets which may potentially be impacted by the substitution of polyester fiber for foam are the transportation, furniture, and bedding markets. In the furniture market, which accounts for approximately 44 percent of slabstock and 24 percent of molded foam consumption (see Tables 1-1 and 1-2), sheet and rolled polyester fiber is finding uses in furniture cushions, backs, and arms (McGovern, 1995). In the bedding market, which consumes almost 13 percent of U.S. slabstock production, polyester fiber can be substituted for foam in pillows, stuffing, mattress quilting, and fabric bulking for comforters.

Differences in foam and fiber properties and characteristics influence decisions concerning which material to use. Reasons polyester fiber is chosen over flexible foam include: styling trends, its high filling capacity, surface softness, fabrication ease, and price. However, foam surpasses fiber when considering cushioning, recovery, durability, shape retention, and recyclability traits.

Although trends in the bedding end-use market may be toward some fiber for foam substitution, bedding is the only major comfort application where full foam has yet to achieve its potential as the principal support material (Schultz, 1989). Despite the inherent advantages of the material, notably the availability of high quality grades, durability, comfort, and price, the innerspring industry has pre-empted competition in this multi-billion dollar market. A 1984 survey found that 78.1 percent of Americans still used a traditional innerspring mattress, and only 7.1 percent used foam mattresses. By contrast, nearly 50 percent of the bedding market in Europe is held by foam mattresses (Schultz, 1989).

MARKET OUTLOOK

The data presented earlier show that flexible polyurethane foam is used extensively in the manufacture of durable goods (e.g., vehicles and furniture). Since the demand for these goods tends to be highly cyclical, the derived demand for flexible polyurethane foam also tends to be cyclical, moving with the general economy. Flexible foam was hit hard by the recession of the early 1990's. The furniture and bedding market segments lost ground as consumers delayed making large purchases. However, the market recovered in 1992-1993 and flexible foam has bounced back.

Unlike furniture and bedding, the carpet underlay market experienced stability during the 1991 recession when volume in this segment was down only slightly. This is a strong segment of the flexible foam market and should continue to see significant growth, particularly the rebond carpet underlay segment, which uses scrap generated from the automotive and furniture market

(Friedrich, 1994). Although this application takes market share from prime underlay, it is a useful outlet for scrap and recycled foam.

The growth in the transportation industry's use of flexible foam in 1992 can be expected to continue as long as car sales continue to rise. The 1993 model year was the best for passenger vehicles since 1989, with over 14 million cars, light trucks, and vans sold. More polyurethane is used in the automotive industry than any other plastic, and molded flexible foam seats and seatbacks are the largest application. A trend toward flatter seat cushions to save head space in compact cars should not affect polyurethane volume as cushions must be denser to offer the same comfort. Other uses of flexible polyurethane foam that should see incremental growth in the future include packaging, fabric laminates, weather stripping and household products.

After the healthy growth in the polyurethane market in the mid 1980s, a slowdown in 1989 and a slump in 1990-1991, the future of the industry over the next decade is mixed. With traditional polyurethane foam markets such as furniture and automotive seat cushions at the saturation point, future growth is now more dependent on the economy than it has ever been before. Housing starts, commercial construction, consumer spending, and the domestic automotive industry will all help determine the growth in sales of flexible foams for the remainder of the decade. Nonetheless, some segments of the market are at an earlier point of the growth curve, and stronger gains can be expected in these areas. Here, new applications and systems technologies will continue to generate growth beyond incremental increases in the traditional segments. While the healthy growth of the mid 1980s may not return, modest increases in demand are expected for the remainder of the 1990s (Harrington, 1994).

MARKET STRUCTURE

Flexible foam products are large-volume, commodity products with little proprietary differentiation. Although certain companies have developed their own specialities in which they are pre-eminent (either in product application or geographic area), for the most part polyurethane foam produced by a manufacturer is interchangeable with that produced by any other manufacturer. Within the flexible polyurethane foam industry, vertical integration commonly exists from the raw materials market to foam production. Also, some vertical integration exists from foam production to end-product production.

The flexible foam market in the United States totaled 1,604 million pounds in 1991, or approximately 51 percent of all polyurethanes produced. This total compares with a 1989 total of 1,735 pounds and represents an 8 percent drop in production across those years. Flexible slab foam production was 1,265 million pounds and accounted for 79 percent of this total. Flexible molded foam production was 339 million pounds, 21 percent of the total (Friedrich, 1994).

Immediately below, we present data describing the horizontal structure of the flexible polyurethane industry. Next, we provide a brief qualitative description of the degree of vertical integration in the industry. Finally, we discuss industry demand and supply elasticities.

HORIZONTAL MARKET STRUCTURE

Flexible Slabstock Foam

There are approximately seventy-eight facilities that produce slabstock flexible polyurethane foam in the United States. In 1992, the 10 largest firms accounted for almost 90 percent of industry-wide production of slabstock foam.[9] Table 1-8 shows the 10 largest slabstock producers in the United States, with the number of facilities each own, 1992 production and company market share. The remaining companies individually accounted for only small

[9] Computed from Responses to the Industry Questionnaire 1993, issued under Section 114 of the CAAA.

fractions of industry-wide output in 1992. However, because slabstock is a homogeneous, undifferentiated product, it is unlikely that any single producer commands significant market power. Slabstock is homogeneous in that foam with a given technical specification (e.g., density and IFD) can be viewed as a commodity.

Table 1-8

LARGEST SLABSTOCK FOAM PRODUCERS (1992)

COMPANY RANK	FACILITIES OWNED	Production (1000 lbs)	MARKET SHARE (%)
1	14	265,996	22.1
2	8	216,472	17.99
3	9	132,586	11.02
4	3	107,150	8.9
5	7	102,256	8.5
6	9	95,706	7.95
7	4	44,716	3.75
8	4	44,178	3.67
9	2	33,648	2.8
10	2	33,000	2.74
Total	62	1,075,708	89.38

Source: Responses to the Industry Questionnaire 1993, issued under Section 114 of the CAAA.

Due to the cost of shipping foam relative to its size and weight (typical slabstock foam weighs one to two lbs/ft^3), shipping cost considerations and end-use market location are important determinants in the location of foam production facilities. Production facilities are usually found within close proximity to their end-use market or fabrication operation. It is economically advantageous for foam producing companies to establish a number of smaller facilities in proximity to end-use markets, rather than establish a single larger plant and incur greater transportation costs (Bush, 1995). Because foam is large and bulky, yet light in weight, shipping costs are high relative to the value of the foam. The economically feasible shipping distance of foam is limited to about 300 miles.[10] Table 1-9 shows the distribution of slabstock facilities by state. While these facilities are geographically dispersed, they tend to be clustered close to end-use markets (e.g., carpeting in California and furniture manufacturing in North Carolina).

[10] EC/R Incorporated (1993).

Table 1-9

DISTRIBUTION OF SLABSTOCK FACILITIES BY STATE

State	Number of Facilities	State	Number of Facilities
Arkansas	3	Michigan	2
California	9	Minnesota	1
Delaware	1	Mississippi	8
Florida	4	New Jersey	2
Georgia	4	New Mexico	1
Illinois	3	North Carolina	7
Indiana	8	Ohio	2
Iowa	1	Oregon	1
Kansas	1	Tennessee	6
Kentucky	1	Pennsylvania	3
Maryland	1	Texas	5
Massachusetts	1	Virginia	1

Source: Responses to Industry Questionnaire 1993, issued under Section 114 of the CAAA.

Flexible Molded Foam

There are approximately 234 facilities in the United States that produce flexible polyurethane molded foam. As of the date of this report, estimates of production for some plants in this industry segment are unavailable. As a result, market shares of the largest producers cannot be computed. However, because of the large number of facilities in the industry and the largely homogeneous nature of the product, it is unlikely that any single molded foam producer enjoys significant market power.

VERTICAL MARKET STRUCTURE

As noted earlier, vertical integration from foam production to fabrication is fairly commonplace in the industry. For example, 57 of the 78 slabstock facilities (about 73 percent) report having fabrication operations at their plants.[11] Also, vertical integration in the molded foam segment exists in that the molding process adds value to the foam.

DEMAND AND SUPPLY ELASTICITIES

Both demand and supply elasticities in markets affected by the alternative MACT standards will determine the ability of affected plants to pass through control costs to buyers. Other things being the same, highly elastic demand will be associated with relatively small post-control price increases and with relatively large reductions in post-control output. On the other hand, elastic supply will be associated with relatively large post-control price increases and relatively large output reductions. Unfortunately, we have not identified any previous studies that provide estimates of demand and supply elasticities. Also, the data required to econometrically derive estimates for this study are unavailable. Below, we provide a qualitative discussion of elasticities for the flexible polyurethane industry.

Demand Elasticity

Three factors are important determinants of the demand elasticities faced by firms operating in affected industries. These three factors are:

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[11] Computed from Responses to the Industry Questionnaire 1993, issued under Section 114 of the CAAA.

- The elasticity of demand for end-use products.
- The fraction of total end-use costs attributable to inputs provided by affected plants.
- The potential for substitutability with other inputs.

In general, the elasticities of demand for end-use and intermediate products are directly related; other things being the same, elastic (inelastic) demand for an end-use product is associated with elastic (inelastic) demand for the primary or intermediate product. The fraction of total end-use costs attributable to an intermediate product, on the other hand, is inversely related to its demand elasticity; for example, an intermediate input which accounts for only a small fraction of the total cost of producing an end-use product will, other things being the same, have relatively inelastic demand, in part because it will have little influence on the price of the end-use product. Finally, the demand for an intermediate product will tend to be relatively elastic if substitute inputs are available.

Earlier, we described the end uses of flexible polyurethane foam. The demand for these end-use products probably ranges from unit elastic (i.e., a demand elasticity of −1.0) to moderately elastic. For example, two major uses of flexible polyurethane foam are the manufacture of automobiles and furniture. Several studies of the automobile market are consistent with a long-run demand elasticity ranging from −1.0 to −1.5.[12] There have been fewer studies of the furniture market, but a recent study by Mathtech (1994) in support of the Wood Furniture MACT, reports an estimated demand elasticity for the household sector of the wood furniture market of −3.36.

Flexible polyurethane foam probably constitutes a small fraction of the total cost of manufacturing most end-use products. This is clearly the case for automobiles and trucks. Based

[12] This range is consistent with early estimates reported by Nerlove (1957) and Suits (1958) and more recent estimates reported by Gallasch (1984).

on the slabstock prices reported earlier, it is also no doubt true that the polyurethane foam content of furniture is a small fraction of total costs in the furniture industry.

Finally, flexible polyurethane foam is superior to its substitutes in a number of respects, including appearance, performance, durability and comfort. While some substitutes exist (e.g., polyester fibers, natural fibers and "springs" in furniture manufacturing), these mostly have inferior attributes relative to foam.

Taken as a whole, the evidence suggests that the demand for flexible polyurethane foam is relatively inelastic. While the demand for some end-use products might be moderately elastic, polyurethane foam constitutes a small fraction of the total cost of producing most end-use products and close substitutes for foam are generally unavailable.

SUPPLY ELASTICITY

The marginal cost of providing additional output in the relevant range of production is the most important factor determining supply elasticity. If the marginal cost of incremental output is relatively constant, then supply will be relatively elastic. However, if marginal costs rise steeply, supply will be relatively inelastic. In the short run, incremental costs will be determined largely by the properties of the production process and the existence of excess capacity in the industry. Long-run incremental costs are determined primarily by the production costs associated with newly constructed facilities, and the opportunity costs associated with investments in existing facilities.

Unfortunately, our ability to characterize supply elasticity in the industry is somewhat limited. We do know that the national market is served by a large number of relatively small plants. This suggests the absence of significant scale economies in production and that supply is relatively elastic, at least in the long run (i.e., output can be added or deleted at about the same costs by constructing additional plants or closing existing plants).[13] We caution, however, that the observed structure of the industry (i.e., a large number of geographically dispersed plants) represents a trade-off between scale economies in production and economizing on transportation costs (i.e., even if production economies exist, they could be outweighed by transportation costs associated with shipping greater distances).

FOREIGN TRADE

Given the nature of the product, foreign trade in flexible polyurethane foam is negligible. It is a large volume product with very little cost (value) per weight. Shipping a cargo of foam is quite similar to shipping ‹air'. High transportation costs relative to foam value makes long distance foam transport uneconomical. However, some international trade in flexible polyurethane foam exists in the form of end-use products (e.g., in automobiles).

Imports

Although there is no import market for flexible slabstock or molded foam, there is a market for imports of flexible foam scrap for use in the rebond process. Foam scrap is primarily imported in the form of slabstock scrap but does include a small amount of molded scrap. In 1991, an estimated 133 million pounds of scrap foam was imported from abroad. Approximately 60 percent of this total was imported by three large brokers. The balance was imported directly by five large bonded carpet underlay manufacturers.[14]

Imported scrap competes with intentionally poured scrap. The quantity of scrap that is imported varies from year to year, depending on relative economics. During the first quarter of

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[13] Ignoring transportation costs, significant scale economies in production would result in a small number of relatively large facilities serving the national market.

[14] This information is provided by Hull & Co. The five companies were not identified.

1991, the price of imported scrap foam ranged from $0.45 to $0.60 per pound. By comparison, "intentional scrap" ranged from $0.58 to $0.70 cents per pound. The estimated volume of scrap imported to the United States in recent years is shown in Table 1-10.

Table 1-10

ESTIMATED U.S. IMPORTS OF FLEXIBLE POLYURETHANE SCRAP

Year	Million Pounds
1991	133
1990	96
1989	134
1988	80
1987	74

Source: Hull & Co., End-Use Market Survey on the Polyurethane Industry in the U.S. and Canada, 1992.

Exports

Due to the nature of the product, there are no exports of domestically produced flexible polyurethane foam to areas outside of the United States. As noted earlier, the typical weight of flexible foam ranges from 1 to 2 lbs/ft^3, and shipping costs are prohibitive. The flexible polyurethane foam industries in other countries produce foam to satisfy domestic demand.

FINANCIAL DATA FOR FLEXIBLE POLYURETHANE FOAM FIRMS

Financial data are needed to analyze the impact of the proposed regulations on firm profitability and to provide insight regarding firms' abilities to raise capital to finance the investment in emission control equipment. Immediately below, we present publicly available financial data for SIC 3086. We caution, however, that SIC 3086 includes other foam producers (e.g., rigid foam) in addition to flexible polyurethane foam. After the industry data are presented, we report available firm-specific financial data. Note that all financial data are reported at the firm level and therefore do not isolate the contribution of foam production to a company's financial status.[15]

SIC 3086 FINANCIAL DATA

Financial data are available from Dun and Bradstreet, Inc. (D&B) and Robert Morris Associates (RMA) for the affected industry, SIC code 3086 — Plastics Foam Products. D&B and RMA present industry sector financial ratios that can be used to characterize the baseline (pre-regulatory) profitability and capital availability of firms in the affected industry. Both D&B and RMA compile profitability ratios for a sample of firms in the industry, and each of these ratios are then independently ranked from "most healthy" to "least healthy." The ratio that falls in the middle of the values represents the median ratio, those that occur mid-way between that median and the least healthy represent the lower quartile ratios, and those that fall mid-way between the median and the most healthy represent the upper quartile. This methodology is expected to adequately approximate the financial values of average firms in three relative states of financial health. This ranking is not available for the capital availability measure — only the average industry long term-debt to long-term debt plus equity ratio is available from both of these sources.

[15] We note that firm-level financial data do not pose an issue for conducting a financial analysis of the impacts of the proposed MACT rule in the EIA. The purpose of this analysis is to assess the ability of affected firms to raise the capital required to finance investments required to achieve compliance with the proposed MACT rule. The financial resources available to the firm (not the foam facility) will determine the ability to raise capital.

RMA also presents financial ratios by company sales and company asset ranges. However, only a portion of the applicable sales/asset ranges that are listed for the affected SIC code are displayed because RMA only presents data for sales/asset ranges with 10 or more financial statements. Table 1-11 presents both the overall financial ratios calculated using all of the financial data, and the ratios for the available individual size ranges. As with the D & B data, lower quartile, median, and upper quartile ratios are presented for profitability. To reduce the effect of business cycles and short-term perturbations, the profitability ratios are averaged over the 1991-1993 period (or 1992-1993 for RMA because data for SIC code 3086 were not available before 1991). Because changes in the long-term debt ratio represent actual structural changes, 1993 data are presented.

The Society of the Plastics Industry, Inc. (SPI) publishes financial data for plastic product firms in different size ranges. However, these ratios are for the overall plastic products industry, and are not specific to the industry subject to the regulation (i.e., ratios are based on data for SIC code 308, and not SIC code 3086). Table 1-12 presents the profitability and capital availability information from the SPI.

FIRM-SPECIFIC DATA

Table 1-13 reports financial data (the ratio of net income to assets, long-term debt to long-term debt plus equity ratios and sales) for 35 firms producing flexible polyurethane foam. We report sales data in Table 1-13 for firms for which data on the financial ratios are unavailable. Comparable firm-specific financial and sales data for other firms in the industry are not publicly available.[16] We caution that the firm-specific data reported in Table 1-13 might not be representative of all firms in the flexible polyurethane foam industry. Specifically, financial data

[16] A total of 57 firms report producing flexible polyurethane foam in Responses to Industry Questionnaire 1993, issued under Section 114 of the CAAA. However, we understand that the survey does not capture all molded foam facilities. Accordingly, the survey count of 57 firms might understate the industry total.

are more likely to be available for publicly-held firms which may have greater financial resources than firms that are not publicly held.

Table 1-11
PROFITABILITY AND CAPITAL AVAILABILITY MEASURES FOR SIC CODE 3086 - PLASTICS FOAM PRODUCTS

FINANCIAL MEASURE	FINANCIAL CONDITION	SALES RANGE (in millions)	Dun & Bradstreet				Robert Morris Associates[1]		
			1991	1992	1993	**'91-'93 Average**	1992	1993	**'92-'93 Average**
Profitability (% Net Income to Assets)[2]	Lower	All	2.9	0.2	1.6	**1.6**	2.4	3.3	**2.9**
		$0-1					n/a	n/a	**n/a**
		$1-3					n/a	-0.3	**-0.3**
		$3-5					n/a	1.8	**1.8**
		$5-10					n/a	2.1	**2.1**
		$10-25					n/a	n/a	**n/a**
		$25+					7.9	6.8	**7.4**
	Upper	All	20.2	23.0	13.6	**18.9**	15.4	16.9	**16.2**
		$0-1					n/a	n/a	**n/a**
		$1-3					n/a	5.2	**5.2**
		$3-5					n/a	6.4	**6.4**
		$5-10					n/a	5.9	**5.9**
		$10-25					n/a	n/a	**n/a**
		$25+					12.3	12.8	**12.6**
	Median/ Average	All	9.0	4.0	7.1	**6.7**	8.7	9.3	**9.0**
		$0-1					n/a	n/a	**n/a**
		$1-3					n/a	10.9	**10.9**
		$3-5					n/a	15.3	**15.3**
		$5-10					n/a	11.2	**11.2**
		$10-25					n/a	n/a	**n/a**
		$25+					18.8	17.1	**18.0**
Capital Availability (% Long-term Debt to Long-term Debt + Equity)	Average	All	NA	NA	19.4	**NA**	NA	16.8	**NA**
		$0-1						n/a	
		$1-3						25.1	
		$3-5						17.1	
		$5-10						14.4	
		$10-25						n/a	
		$25+						15.3	

Notes: [1]Pre-1992 data for SIC code 3086 are not available from this source.
[2]For Robert Morris Associates, profit before taxes to total assets.
n/a - not available.
NA - not applicable.

Sources: Dun and Bradstreet, Inc. *Industry Norms and Key Business Ratios*, 1992, 1993, and 1994; Robert Morris Associates, *Annual Statement Studies*, 1992 and 1993.

Table 1-12

PROFITABILITY AND CAPITAL AVAILABILITY MEASURES FOR PLASTIC PRODUCTS PRODUCERS, 1991

FINANCIAL MEASURE	ALL	BY SALES VOLUME			
		< $5 million	$5-$10 million	$10-25 million	> $25 million
Profitability (% Return on Assets before Taxes)	6.4	5.8	1.4	11.2	4.1
Capital Availability (% Long-term Debt to Long-term Debt + Equity)	8.4	10.1	10.1	5.6	8.7

Sources: The Society of the Plastics Industry, Inc., *Financial and Operating Ratios, Survey No. 30, Plastic Processing Companies*, July 1992.

Table 1-13

FIRM-SPECIFIC FINANCIAL INFORMATION FOR FLEXIBLE POLYURETHANE FOAM INDUSTRY

FIRM	% NET INCOME TO ASSETS (averaged over 1991-1993)	% 1993 LONG-TERM DEBT TO LONG-TERM DEBT + EQUITY	SALES (in $millions)
Company 1	2.57	13.41	
Company 2			257.0
Company 3	−1.37	19.41	
Company 4			400.0
Company 5			27.5
Company 6			23.1
Company 7	2.23	11.21	
Company 8	−0.65	23.56	
Company 9	2.22	21.40	

FIRM	% NET INCOME TO ASSETS (averaged over 1991-1993)	% 1993 LONG-TERM DEBT TO LONG-TERM DEBT + EQUITY	SALES (in $millions)
Company 10	4.02	15.53	
Company 11	6.79	15.17	
Company 12			30.0
Company 13			5.7
Company 14			30.7
Company 15			128.0
Company 16			3.4
Company 17			14.6
Company 18			6.9
Company 19	4.49	26.32	
Company 20	−1.17	11.13	
Company 21			585.0
Company 22			200.0
Company 23			155.0
Company 24	12.93	21.70	
Company 25	7.78	10.59	
Company 26			68.5
Company 27	5.52	31.84	
Company 28			20.0
Company 29			50.0
Company 30	1.43	42.22	
Company 31			22.1
Company 32			32.9
Company 33			40.0
Company 34			108.0
Company 35	−0.87	9.99	

Notes: [a] Net income assets ratio represents 1992-1993 only (1991 data were unavailable).
[b] Net income assets ratio represents 1989-1991 (later data were unavailable).

Sources: *Moody's Industrial Manual, 1994; Moody's OTC Industrial Manual, 1994; Moody's OTC Unlisted Manual, Dun & Bradstreet's Million Dollar Directory, 1994; Herman Miller Annual Reports,* 1989-1991.

EMPLOYMENT

The production of flexible polyurethane foam industry is non-labor intensive. Both large and small facilities need only a small number of specially trained employees to operate the foam production line. Foam production is, for the most part, an automated process requiring only monitoring once the proper mix of chemicals is completed and the production process is underway.[17] Table 1-14 and 1-15 give employment figures for the plastic foam industry (SIC 3086), of which the flexible polyurethane foam industry is a subset. Due to data limitations, figures for the broader plastic foam industry were used as a proxy for the flexible polyurethane foam industry.

Table 1-14
EMPLOYMENT STATISTICS (SIC 3086)

Year	Total Employ-ees (1,000)	Production Workers (1,000)	Hours (millions)	Wages (million $)	Payroll per Employee
1992	66.9	52.3	100.5	1053.9	$23,735
1991	62	47.8	92.1	924.1	$23,090
1990	63.7	49.6	95.6	932.3	$21,911
1989	64.3	48.8	92.4	858.0	$20,347
1988	63.9	50	97.5	854.6	$19,892
1987	61.3	47.7	91.8	782.9	$19,315

[17] While foam production is not labor intensive, foam fabrication is. This is an issue because the proposed MACT rule could indirectly affect fabrication operations through its impacts on foam production.

Source: 1992 Census of Manufactures, U.S. Department of Commerce

Table 1-15

VALUE OF SHIPMENTS AND VALUE-ADDED PER LABOR HOUR (SIC 3086)

Year	Value of Shipments (million $)	Value Added by Manufacture (million $)	Value of Shipments per Production Worker Hour ($)	Value Added per Production Worker Hour ($)
1992	9,488.4	4,335.8	94.41	43.14
1991	8,578.0	3,790.5	93.14	41.16
1990	8,988.2	3,788.3	94.02	39.63
1989	8,108.9	3,271.0	87.76	35.40
1988	7,506.5	3,290.3	76.99	33.75
1987	6,912.8	3,045.6	75.30	33.18

Source: 1992 Census of Manufactures, U.S. Department of Commerce

ENERGY USE

As with employment data, disaggregate fuel and energy use data were not available beyond the four-digit SIC level. Tables 3-16 and 3-17 report 1992 consumption of fuels and electricity for SIC 3086 (Plastic Foams) for the industry and average facility, respectively.

Table 1-16
INDUSTRY ENERGY USE (SIC 3086)

Energy Source	Value (million $)	Quantity (million kWh)
Fuels	61.2	---
Purchased Electricity	146.6	2,475.7

Source: 1992 Census of Manufactures, U.S. Department of Commerce

Table 1-17

AVERAGE FACILITY ENERGY USE (SIC 3086)

Energy Source	Value ($)	Quantity (million kWh)
Fuels	50,288	---
Purchased Electricity	120,460	2.034

Source: 1992 Census of Manufactures, U.S. Department of Commerce

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SECTION 2
MODEL PLANTS AND COMPLIANCE TECHNOLOGIES

Because plants in the flexible polyurethane industry are numerous, the analyses in this EIA rely on model plants. These model plants are characterized by product type (either molded or slabstock foam), production technology and production volume.

MOLDED FOAM

EPA estimates that there are approximately 234 molded foam production facilities in the United States. Each of these facilities is represented as one of four molded foam production model plants. One of these model plants (HP1) represents larger molded foam facilities using high-pressure mixheads, primarily to produce automobile seats. The remaining three model plants (LP1, LP2 and LP3) represent smaller producers that use low-pressure mixheads to produce a variety of foam products. Table 2-1 describes the baseline parameters of the molded foam model plants. For example, model plant HP1 produces up to 15,000 tons of molded foam annually (average annual production volume is 3,331 tons), represents 27 facilities nationwide, and has average annual emissions of 2.09 tons.

Molded Foam: Emission Controls

Only major sources of HAP will be subject to the foam production NESHAP. Since the high-pressure molded foam plants and the smallest low-pressure molded foam plants have emissions below the major source threshold, we assume that the facilities represented by these model plants (HP1 and LP1) will not be affected by the NESHAP. Therefore, the estimated impacts presented in this report for molded foam are based on compliance costs and emission reductions associated with the production facilities represented by model plants LP2 and LP3.

Table 2-1

MOLDED FOAM MODEL PLANT BASELINE PARAMETERS

	HP1	LP1	LP2	LP3
Foam production range (tons/yr)	0-15,000	0-99	100-499	>499
Average foam production (tons/yr)	3,331	26	308	2,718
Number of facilities represented	27	109	54	44
Model plant emissions (tons/yr)	2.09	5.29	19.81	28.66

Source: EC/R Incorporated (1996a).

Model plant compliance costs and emission reductions were estimated for a number of technologies to bring the following molded foam production source types into compliance:

- Mixhead flushing.
- Mold release agents.
- Repair adhesive.

Mixhead flushing emissions require no control under the MACT Floor, while Alternatives 1 and 2 prohibit the use of HAP flushes. Model plant compliance costs were estimated for four compliance technologies for mixhead flushing emissions: work practices for Regulatory Alternative 1; and non-HAP flushes, high pressure mixheads, and self-cleaning mixheads for Regulatory Alternative 2.

All three regulatory alternatives prohibit the use of HAP-based mold release agents, resulting in 100 percent emission reduction for this source type. Model plant compliance costs were estimated for three technologies that can achieve this result: reduced volatile organic compound (VOC) mold release agents, naphtha-based mold release agents, and water-based mold release agents.

All three regulatory alternatives also prohibit the use HAP-based adhesives. Model plant costs were estimated for three technologies that can achieve this result: hot-melt adhesives, water-based adhesives, and hydrofuse adhesives.

Molded Foam: Nationwide Compliance Costs and Emission Reductions

Since different technologies (with different costs) can bring a source type into compliance, nationwide compliance costs depend on the compliance technologies chosen by affected plants. Table 2-2 gives the distribution of technologies assigned to model plants producing molded foam.

Table 2-2
DISTRIBUTION OF COMPLIANCE TECHNOLOGIES
FOR MOLDED FOAM MODEL PLANTS

Emission Source/Technology	Number of Facilities with the Assigned Technology	
	LP2	LP3
Mixhead Flush		
Reg Alt I		
Solvent recovery	54	44
Reg Alt II		
Non-HAP flush	54	35
HP mixheads	0	9
Mold Release Agents		
All Regulatory Alternatives	18	15
Reduced VOC agents	18	14
Naphtha-based agents	18	15
Water-based agents		
Repair Adhesives		
All Regulatory Alternatives	N/A	22
Hot-melt adhesives	N/A	22
Water-based adhesives		

Sources: EC/R Incorporated (1996a and 1996b).

While Table 2-2 shows the assumed distributions of control technologies assigned to model plants for each emission source separately, it does not give the distribution for combinations of control technologies. For example, under Alternative 2, 35 of 44 LP3 type model plants are assumed to adopt non-HAP flush to control mixhead flush and 15 to adopt reduced VOC agents to control mold release agents. However, Table 2-2 does not show how many LP3 plants adopt non-HAP flush *and* reduced VOC agents. For the economic impact analysis, we assume that model plants adopt combinations of control technologies consistent with the proportions shown in Table 2-2. For example, we assume that 34 percent (15 of 44) of the 35 plants using non-HAP flush also use reduced VOC agents. We note, however, that the estimated impacts presented in this report are not sensitive to assumptions about the distribution of combinations of control technologies as long as *some* plants adopt the most costly combinations. The economic impacts are driven by the level of control costs facing the highest cost producers, and not necessarily the number of high cost producers.

We report estimates of the nationwide compliance costs and emission reductions for molded foam plants in Table 2-3.[18] For example, the MACT Floor would require affected molded foam plants to incur total, nationwide capital costs of $149,688, annual costs of $182,090, and would result in reduced HAP emissions of 331 tons annually. Annual costs include annual operating and maintenance (O&M) costs and amortized capital costs.[19] Note that annual costs for the mixhead flush source type are negative under Alternative 1. This compliance technology is expected to result in net cost savings due to the salvaging and reuse of the mixhead flushing agent.

[18] Appendix A provides detailed estimates of compliance costs and emission reductions by individual model plants, source types and control technologies.

[19] Capital costs are amortized at 10 percent, assuming a 10-year equipment life.

In addition to the compliance costs reported in Table 2-3, the estimated economic impacts presented in this report include the effects of monitoring, inspection, recordkeeping and reporting (MIRR) costs at affected plants. Total annual MIRR costs are estimated as 10

Table 2-3

MOLDED FOAM NATIONWIDE COMPLIANCE COSTS

	Impacts by Emission Source			
Regulatory Alternative	Mixhead Flush	Mold Release Agent	Repair Adhesive	Total
MACT Floor				
Capital Investment ($)	0	0	149,688	149,688
Annual Cost ($/yr)	0	143,106	38,984	182,090
Emission Reduction (tons/yr)	0	270	61	331
Regulatory Alternative 1				
Capital Investment ($)	4,630,500	0	149,688	4,780,188
Annual Cost ($/yr)	(115,038)	143,108	38,984	67,052
Emission Reduction (tons/yr)	1,501	270	61	1,832
Regulatory Alternative 2				
Capital Investment ($)	5,923,125	0	149,688	6,072,813
Annual Cost ($/yr)	524,098	143,108	38,984	706,188
Emission Reduction (tons/yr)	2,001	270	61	2,332

Sources: EC/R Incorporated (1996b and 1996c).

percent of nationwide annual emission control costs.[20] Annual MIRR costs per plant are estimated as nationwide MIRR costs for the industry segment divided by the number of affected plants in the industry segment.

[20] EC/R Incorporated (1996e).

SLABSTOCK FOAM

There are 78 slabstock facilities in the United States. Since slabstock foam is produced as large “buns” which must be cut into the desired sizes and shapes, fabrication operations are sometimes co-located with slabstock foam production facilities. As with molded foam, model plants were constructed to characterize the production volumes and production processes of the slabstock facilities.

There are five basic model plants for slabstock foam (MP1, MP2, MP3, MP4 and MP5), each representing a range of production volume. Also, each basic model plant is separated into facilities that use $MeCl_2$ as an equipment cleaner, and those that do not (e.g., MP1a uses $MeCl_2$ as an equipment cleaner and MP1b does not). Table 2-4 describes the baseline parameters of the slabstock foam model plants. For example, model plant MP1 averages 2,000 tons of foam production annually and represents 19 plants nationwide. Model plant MP1a averages 64.19 tons of HAP emissions a year, while MP1b emits 59.19 tons annually.

Table 2-4

SLABSTOCK FOAM MODEL PLANT BASELINE PARAMETERS

	MP1	MP2	MP3	MP4	MP5
Foam production range (tons/yr)	0-3.9	4.0-7.9	8.0-11.9	12.0-15.9	>15.9
Average foam production (tons/yr)	2,000	6,000	10,000	13,750	19,000
Number of facilities represented	19	28	14	11	6
Model plant (a) emissions (tons/yr)	64.19	174.16	339.42	343.93	388.53
Model plant (b) emissions (tons/yr)	59.19	169.16	334.42	338.93	383.53

Source: EC/R Incorporated (1996a).

Slabstock Foam: Emission Controls

Model plant compliance costs and emission reductions were estimated for a number of technologies to bring the following slabstock foam production source types into compliance:

- Storage/unloading.
- Equipment cleaning.
- Equipment leaks.
- HAP auxiliary blowing agent (ABA) emissions.

The MACT Floor level of control for storage and unloading of both TDI and HAP ABA is an equipment standard that requires either a vapor balance system to return the displaced HAP vapors to the tank truck or rail car, or a carbon canister through which emissions must be routed prior to being emitted to the atmosphere. Regulatory Alternatives 1 and 2 do not contain more stringent requirements for storage and unloading. The estimated costs and economic impacts presented in this report are based on the assumption that all affected plants adopt the vapor balance system.

The MACT Floor level of control for equipment cleaning is the complete elimination of HAP emissions. Again, Regulatory Alternatives 1 and 2 do not contain more stringent requirements.

The MACT Floor level of control for equipment leaks requires the use of sealless pumps for TDI transfer pumps. Regulatory Alternative 1 adds a unique LDAR program for HAP ABA components. Since Regulatory Alternative 2 does not allow the emission of any HAP ABA (which, in effect, prohibits the use of $MeCl_2$ or any other HAP as an ABA), this alternative only contains the MACT Floor requirement for TDI pumps.

There are three levels of control for HAP ABA emissions, one for each regulatory alternative. The MACT Floor and Regulatory Alternative 1 have emission limits based on product formulations. Applying the two sets of formulation limitations to the product mix of the model plants results in the emission reductions shown in Table 2-5. Regulatory Alternative 2 requires the complete elimination of HAP ABA emissions.

Table 2-5

SLABSTOCK MODEL PLANT HAP ABA EMISSION REDUCTIONS

Model Plant	Baseline HAP ABA Emissions (tons/yr)	HAP ABA Emission Reduction (tons/yr)		
		MACT Floor	Reg Alt 1	Reg Alt 2
1	55.0	31.3	35.9	55.0
2	165.0	93.8	111.7	165.0
3	330.0	184.0	220.7	330.0
4	335.0	195.9	235.7	335.0
5	380.0	220.4	266.0	380.0

Sources: EC/R Incorporated (1996a and 1996b).

There are several technologies available to reduce HAP ABA emissions to levels required by the regulatory alternatives. Table 2-6 lists these technologies for each regulatory alternative.

Table 2-6
TECHNOLOGIES CAPABLE OF ACHIEVING HAP ABA
REGULATORY ALTERNATIVE EMISSION LEVELS

Regulatory Alternative	Technology
MACT Floor Level	Chemical alternatives Carbon dioxide as an ABA (CarDio) Acetone as an ABA Variable pressure foaming (VPF) Forced cooling
Regulatory Alternative 1	Carbon dioxide as an ABA Acetone as an ABA Variable pressure foaming Forced cooling

Regulatory Alternative 2	Carbon dioxide plus chemical alternatives Acetone as an ABA Variable pressure foaming Forced cooling plus chemical alternatives

Source: EC/R Incorporated (1996a).

As can be seen in Table 2-6, some technologies can be used to meet more than one level of control. In these cases, it was assumed that the technologies would only be used to the degree necessary to meet the level of the regulatory alternative. In other words, although variable pressure foaming can be used to totally eliminate the use of HAP ABA, it was assumed that for the MACT Floor, the allowable amount of $MeCl_2$ would still be used and emitted.

Table 2-7 gives the assumed distribution of HAP ABA emission control for technologies for the slabstock model plants. Since different technologies (with different costs) can bring a source type into compliance, nationwide compliance costs depend on the compliance technologies assigned to the model plants. Appendix D contains a sensitivity analysis of economic impacts when these compliance technology assignments are modified.

Table 2-7

DISTRIBUTION OF HAP EMISSION REDUCTION TECHNOLOGIES

Technology	Number of Facilities Using the Technology				
	MP1	MP2	MP3	MP4	MP5
MACT Floor					
CarDio	4	9	4	4	1
Acetone	1	1	1	1	0
VPF	0	0	0	0	2
Forced Cooling	2	4	3	3	2
Chem Alternatives	12	14	6	3	1

Reg Alt I					
CarDio	13	18	6	5	1
Acetone	3	4	3	2	1
VPF	0	0	0	0	2
Forced Cooling	3	6	5	4	2
Reg Alt II					
CarDio + Chem	10	15	5	3	1
Alternatives	3	3	2	2	1
Acetone	0	1	1	2	2
VPF	6	9	6	4	2
Forced Cooling + Chem					
Alts					

Sources: EC/R Incorporated (1996a and 1996b).

Slabstock Foam: Nationwide Compliance Costs and Emission Reductions

Table 2-8 reports estimates of nationwide compliance costs and emission reductions for the slabstock foam industry segment.[21] For example, the MACT Floor would require affected slabstock foam plants to incur nationwide capital costs of about $47 million and annual costs of about $11 million. Annual costs include O&M costs and amortized capital costs. The MACT Floor would reduce annual HAP emissions at slabstock foam plants by an estimated 9,422 tons annually. Costs are negative for equipment cleaning because this compliance technology is expected to result in net cost savings primarily due to reduced wast disposal costs by switching to non-HAP cleaning material.

In addition to the compliance costs reported in Table 2-8, the estimated economic impacts presented in this report include the effects of monitoring, inspection, recordkeeping and reporting (MIRR) costs at affected slabstock plants. Total annual MIRR costs are

[21] Appendix A provides detailed estimates of compliance costs and emission reductions by individual model plants, source types and control technologies.

estimated as 10 percent of nationwide annual emission control costs. Annual MIRR costs per plant are estimated as nationwide MIRR costs for the industry segment divided by the number of affected plants in the industry segment.

Table 2-8

SLABSTOCK FOAM NATIONWIDE COMPLIANCE COSTS

AND EMISSION REDUCTIONS

Regulatory Alternative	Impacts by Emission Source				
	Storage/ Unloading	Equipment Leaks	Equipment Cleaning	ABA	Total
MACT Floor					
Capital Investment ($)	558,960	95,000	0	46,362,700	47,016,660
Annual Cost ($/yr)	105,119	24,035	(7,150)	10,925,497	11,047,501
Emission Reduction (tons/yr)	15	3	130	9,274	9,422
Regulatory Alternative 1					
Capital Investment ($)	558,960	682,754	0	66,981,900	68,858,534
Annual Cost ($/yr)	105,119	489,455	(7,150)	6,241,347	7,111,821
Emission Reduction (tons/yr)	15	80	130	11,262	11,644
Regulatory Alternative 2					
Capital Investment ($)	308,250	95,000	0	93,665,425	94,068,675
Annual Cost ($/yr)	65,447	24,035	(7,150)	10,346,338	10,428,670
Emission Reduction (tons/yr)	0	3	130	16,250	16,383

Sources: EC/R Incorporated (1996b, 1996c and 1996d).

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EC/R Incorporated (1996a). Technical memorandum from Phil Norwood and Amanda Williams to David Svendsgaard (EPA/OAQPS), January 26.

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EC/R Incorporated (1996c). Technical memorandum from Phil Norwood to David Svendsgaard and Lisa Conner (EPA/OAQPS), March 26.

EC/R Incorporated (1996d). Technical memorandum from Phil Norwood to Jeffrey Sassin (Mathtech), June 6.

EC/R Incorporated (1996e). Technical memorandum from Phil Norwood to Jeffrey Sassin (Mathtech), March 25.

SECTION 3

ECONOMIC IMPACT ANALYSIS METHODOLOGY

We assess the economic impacts associated with the alternative NESHAPs by conducting studies of the affected industry segments. These industry segments are flexible polyurethane slabstock foam and flexible polyurethane molded foam. We describe the analytical methods employed in these studies below.

OVERVIEW OF DISTRIBUTIONAL IMPACTS

As noted earlier in the introduction to this report, several groups might potentially suffer from adverse impacts associated with the alternative NESHAPs. These groups include:

- Foam producers.
- Foam buyers.
- Employees at affected plants.
- Individuals affected indirectly by the NESHAP.

We describe the potential adverse impacts affecting each of these groups below.

Impacts on Producers

As affected producers purchase, install and operate emission control equipment or change production practices to comply with the standard, their costs will increase, reducing the profitability of at least some of the affected plants. However, a portion of the compliance costs can be passed on to consumers through increased product prices. Ultimately, the magnitude of the adverse impacts incurred by affected plants will depend on the extent to which control costs can be passed on to buyers.

Some plants in the affected industry may not suffer adverse impacts as a result of the implementation of an emission control standard. The post-control profitability of an affected plant will improve if post-control price increases more than offset the plant's emission control costs. This could occur if control costs for some plants are substantially higher, per unit of output, than those for other plants in the industry. Also, plants not affected by the standard may enjoy the benefit of higher market prices without incurring the additional operating costs associated with compliance.

An impact on producers that cannot be measured in this analysis is the affect of a potential change in product quality. Industry representatives maintain that the effect of a few of the control technologies on product quality is uncertain. If the use of these technologies causes quality degradation, foam producers might face reduced demand for their output.

Impacts on Consumers or Buyers

Both slabstock and molded foam are purchased primarily by firms which use these products as inputs to produce other goods. These firms and the consumers of the goods which they produce are likely to suffer from two related adverse impacts. First, post- control prices for foam produced at the affected plants are likely to be higher as sellers attempt to pass through some of the costs of emission controls. This will cause profits to be smaller, at least in the short run, for firms which purchase slabstock and molded foam as inputs to other final goods such as automobiles. It will also cause prices of final goods to be higher as firms attempt to pass through some of the increase in production costs. Second, the shift in supply caused by emission control costs is likely to reduce the amount of foam sold in affected markets, as well as the level of output sold in markets which use the foam as an input. These two effects are related in that post-control equilibrium prices and output levels in affected markets will be determined simultaneously. Also, customers of foam producers might suffer adverse impacts if the use of a control technology causes quality degradation.

Indirect or Secondary Impacts

Two countervailing impacts on employees of affected plants are likely to result from the implementation of the alternative NESHAPs. Employment will fall if affected plants either reduce output or close operations altogether. If this occurs, firms that supply inputs to foam producers might also suffer adverse impacts. On the other hand, increases in employment associated with the installation, operation, maintenance and monitoring of emission controls are likely. Also, firms that produce substitutes to foam products could benefit from reduced foam production.

A number of other indirect or secondary adverse impacts may be associated with the implementation of a standard. The indirect impacts we consider in this study include: impacts on regional economies and effects on energy consumption. We also assess potential small business impacts.

ECONOMIC IMPACT STUDIES

The industry segment studies that follow in this report include six major components of analysis. These components or phases of analysis, which are designed to measure and describe economic impacts, are:

- Industry profile.
- Direct impacts (market price and output, domestic production and plant closures).
- Capital availability analysis.
- Evaluation of secondary impacts (employment, foreign trade, energy consumption, and regional and local impacts).

- Analysis of potential small business impacts.

Each of these phases of analysis is described below.

INDUSTRY PROFILE

The industry profile provided in Section 3 describes conditions in affected industry segments that are likely to determine the nature of economic impacts associated with the implementation of the NESHAP. We discuss the following seven topics in the industry profile:

- Product descriptions.
- Prices and output.
- Market outlook.
- Market structure.
- Foreign trade.
- Financial conditions.
- Employment and energy use.

PRIMARY IMPACTS

We employ a partial equilibrium model of the slabstock and molded foam segments to estimate the primary impacts of emission control costs, including market equilibrium prices, market output levels, the value of domestic shipments, and the number of potential plant closures.[22] This analysis is so named because the predicted impacts are driven by estimates of how the affected industries achieve market equilibrium after the regulatory alternatives are implemented.

In a competitive market, equilibrium price and output are determined by the intersection of demand and supply. The supply function is determined by the marginal (avoidable) operating costs of existing plants and potential entrants. A plant will be willing to supply output so long as

[22] The results of the partial equilibrium analyses are also used to estimate employment, energy and foreign trade impacts and the economic costs associated with the regulatory alternatives.

market price exceeds its average (avoidable) operating costs. The installation, operation, maintenance and monitoring of emission controls will result in an increase in operating costs. An associated upward shift in the supply function will occur. The procedures employed in the market analysis are illustrated in Figure 3-1. Constructing the model and predicting impacts requires completing the following four tasks.

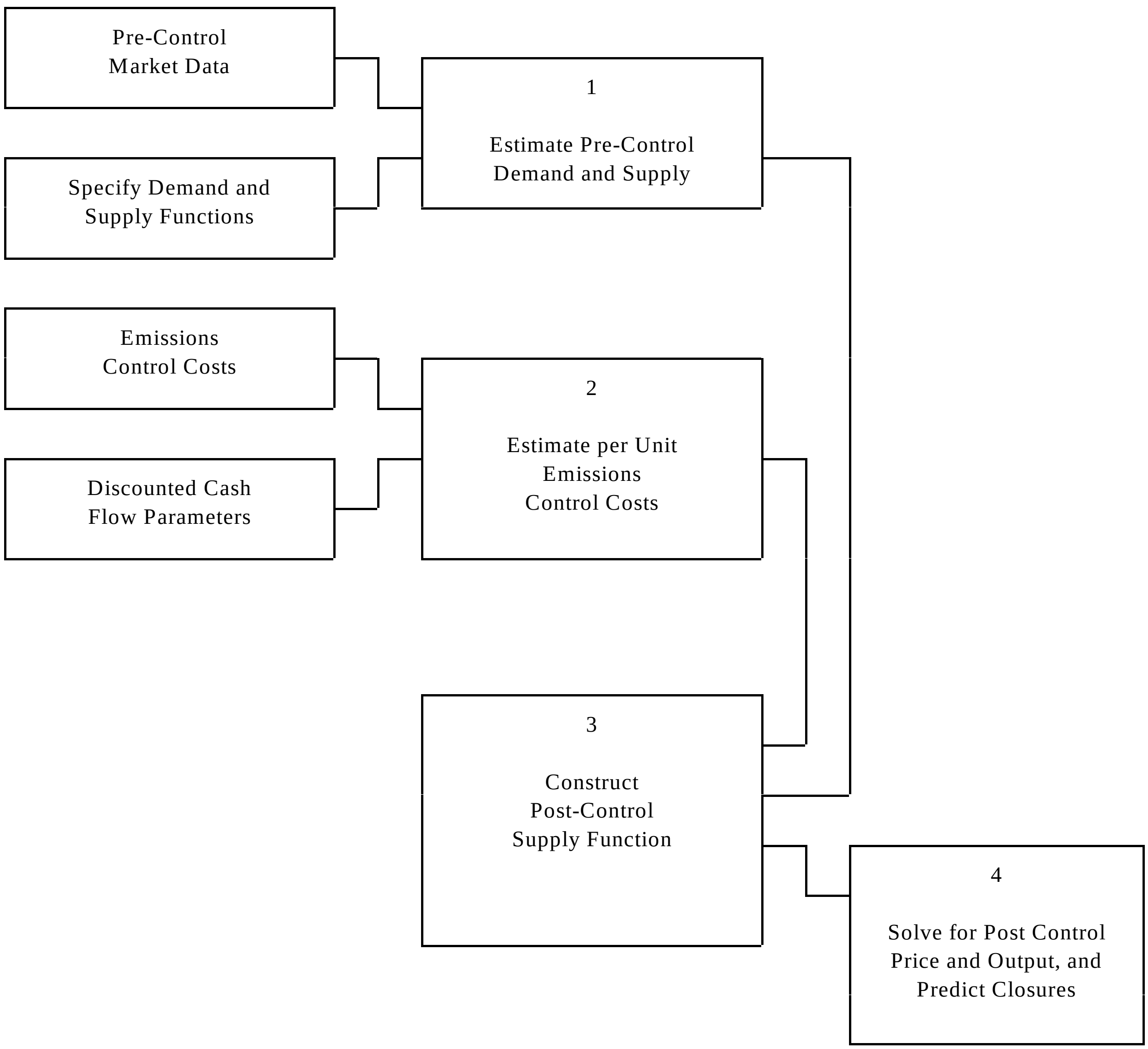

Figure 3-1
Partial Equilibrium Analysis of Slabstock and
Molded Foam Industry Segments

- Estimate pre-control market demand and supply functions.

- Estimate per unit emission control costs.

- Construct the post-control supply function.

- Solve for post-control price, output and employment levels, and predict plant closures.

We briefly describe each of these tasks below.[23]

<u>Pre-Control Market Demand and Supply Functions</u>

Pre-control equilibrium price and output levels in competitive markets are determined by market demand and supply. When the supply curve shifts because of compliance costs, the economic impacts are driven primarily by market demand and supply elasticities. Unfortunately, estimates of demand and supply elasticities for the affected industry segments are not available in the economic literature and the data required to obtain estimates tailored for this study are unavailable.

We expect that the market demand for flexible foam is relatively inelastic (i.e., changes in price will have only a small affect on the level of output), because (1) close substitutes for the product are unavailable, and (2) the foam content of final products generally comprises only a small fraction of total product cost. The base case results reported in the text of this report are based on an assumed demand elasticity of −0.5. In Appendix C, we report the results of sensitivity analyses for which we assume a high demand elasticity of −1.0 and a low demand elasticity of −0.25.

Unfortunately, we have little *a priori* basis for restricting the range for the market supply elasticity. The base case results reported in the text of this report are based on relatively elastic

[23] See Appendices A, and B for more detailed descriptions of the data and methods employed in the partial equilibrium analysis.

supply of 10.0. In Appendix C, we report the results of sensitivity analyses for which we assume a high supply elasticity of 50.0 and a low supply elasticity of 5.0.

Per Unit Emission Control Costs

Emission control costs will cause an upward vertical shift of the supply curves in affected markets. The height of the vertical shift for each affected plant is given by the after-tax cash flow required to offset the per unit increase in production costs resulting from the installation, maintenance, operation and monitoring of emission control equipment.

Estimates of the capital, operating, maintenance and monitoring costs associated with emission controls for affected plants are reported in Appendix A. Per unit, after-tax costs are estimated by dividing after-tax annualized costs by annual output.[24] This cost reflects the offsetting cash flow requirement which, in turn, yields an estimate of the post-control vertical shift in the supply function.

Computing per unit after-tax control costs requires, as inputs, estimates of the following parameters:

- The useful life of emission control equipment.
- The discount rate (marginal cost of capital).
- The marginal corporate income tax rate.

[24] Our use of after-tax costs is consistent with the assumption that firms attempt to maximize after-tax profits. An alternative view is that what matters to the firm are costs net of any adjustments for taxes. Thus, the use of after-tax costs is consistent both with rational behavior by affected firms and our objective of predicting how the market will respond to implementation of the regulatory alternatives.

The expected life of emission control equipment for slabstock and molded foam plants is 10 years. The economic impacts presented in this report are based on a 10 percent real private discount rate[25] and a 25 percent marginal tax rate.

<u>The Post-Control Supply Function</u>

Estimated after-tax per unit control costs are added to pre-control supply prices to determine the post-control supply prices for affected producers. We construct the post-control domestic supply function by sorting affected plants, from highest to lowest, by per unit post-control costs. We assume that plants with the highest per unit emission control costs are marginal (i.e., have the highest cost) in the post-control market. We define the "marginal" plant as the plant with the highest per unit operating costs in the market. As price adjusts to competition among producers, unprofitable producers exit the market until price rests at equilibrium. At equilibrium, the market price must be high enough to cover the per unit avoidable costs of the marginal plant, the highest-cost plant remaining in the market.

<u>Post-Control Prices, Output, and Closures</u>

The baseline, pre-control equilibrium output in an affected market is taken as the level of observed national consumption. We compute post-control equilibrium price and output levels in affected markets by solving for the intersection of the market demand curve and the market post-control, segmented supply curve. The estimated reduction in market output is given by the difference between the observed pre-control output level and the predicted post-control output level. Similarly, the estimated increase in price is taken as the difference between the observed pre-control price and the predicted post-control equilibrium price.

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[25] The discount rate referred to here measures the private marginal cost of capital to affected firms. This rate, which is used to predict the market responses of affected firms to emission control costs, should be distinguished from the social cost of capital. The social cost of capital is used to measure the economic costs of emission controls. See Section 7 for a more detailed discussion of this issue.

Reporting Results of Market Analyses

The results of the partial equilibrium market analyses for each of the affected industries are presented in Section 4 of this report. In particular, estimates of the following are reported:

- Price increase.
- Reduction in market output.
- Annual change in the value of domestic shipments.
- Number of plant closures.

Limitations of the Market Analysis

The partial equilibrium model has a number of limitations. First, a single national market for homogeneous output is assumed in the analysis. However, as explained in Section 2, due to the nature of the product, markets may be regional. Because of transportation costs, foam producers tend to be located proximate to end-use markets. Each regional market will be affected primarily by cost changes of plants in the region, rather than all plants in the national market. Output reductions and price effects will vary across regions depending on locations of affected plants. The assumption of a national market is likely to cause predicted closures to be overstated to the extent that affected firms are protected somewhat by regional trade barriers.

Second, the analysis assumes that plants with the highest per unit compliance costs are marginal post-control. This assumption produces an upward bias in estimated effects on industry output and price changes because the control costs of non-marginal plants will not affect market price. This also results in predicted closures to be overstated. Plants with the highest per unit emission control costs might not be marginal if other plants with lower per unit emission control costs experience higher baseline costs. These other plants would be marginal if higher baseline costs more than offset the lower compliance costs.

Third, the analysis assumes that the implementation of controls does not induce any domestic producers to expand production. An incentive for expansion would exist if some plants have post-control incremental unit costs between the baseline price and the post-control price predicted by the partial equilibrium analysis. Plants unaffected by the standard may indeed face this incentive to expand production. Expansion by domestic producers will result in reduced impacts on industry output and price levels. While plant closures will increase as expanding producers squeeze out plants with higher post-control costs, net closures (closures minus expansions) will be reduced.

Fourth, the effect of using chemical alternatives on product quality is uncertain. If using chemical alternatives as a control strategy causes quality degradation, the estimates of impacts presented in this report could be understated.

Finally, estimates of demand and supply elasticities are unavailable and the base case results presented in the text of this report are based on assumed values to characterize the relative importance of elasticity. In the analyses reported in Appendix C, we assess the sensitivity of the estimated impacts to ranges of assumed values for the elasticities. In addition, it is likely that uncertainty in the estimates of compliance costs exist, causing costs for some plants to be either overstated or understated. The estimated impacts also depend on assumptions about which control strategies plants adopt. We report estimates of impacts based on alternative assumption about control strategy selections in Appendix D.

CAPITAL AVAILABILITY ANALYSIS

We assume in the market analysis that affected firms will be able to raise the capital associated with controlling emissions at a specified marginal cost of capital. The capital availability analysis, on the other hand, examines the variation in firms' ability to raise the capital necessary for the purchase, installation, and testing of emission control equipment.

The capital availability analysis also serves three other purposes. First, it provides information for evaluating the appropriateness of the selected discount rate as a proxy for the marginal cost of capital of the industry; implications for bias in the partial equilibrium analysis follow.

Second, it provides information on potential variation in capital costs across firms. Third, it provides measures of the potential impacts of controls on the profitability of affected firms.

Evaluation of Impacts on Capital Availability

For each model plant[26] included in the capital availability analysis, the impact of the regulatory alternatives on the following two measures is evaluated:

- Net income/assets.
- Long-term debt/long-term debt and equity.

Net income is measured before-tax and is defined to include all operations, continued and discontinued.

The ratio of net income to assets is a measure of return on investment. The implementation of emission controls is likely to reduce this ratio to the extent that net income falls (e.g., because of higher operating costs) and assets increase (because of investments in emission control equipment).

The ratio of long-term debt to long-term debt plus equity is a measure of risk perceived by potential investors. Other things being the same, a firm with a high debt-equity ratio is likely to be perceived as being more risky, and as a result, may encounter difficulty in raising capital. This ratio will increase if affected firms purchase emission control equipment by issuing long-term debt.

Baseline Values for Capital Availability Analysis --

[26] The model plants included in the analysis are described in more detail in Appendix A.

Baseline values for net income and net income/assets are derived by averaging data that are available between 1991 and 1993. Data from several years are employed to reduce distortions caused by year-to-year fluctuations. Since changes in the long-term debt ratio represent actual structural changes, data for the most recent year available are used.

Post-Control Values for Capital Availability Analysis --

Post-control values for the two measures identified above are computed to evaluate the ability of affected firms to raise required capital. The post control values are computed as follows:

- Post-control net income — pre-control before-tax net income plus additional revenues due to higher post-control prices minus the annualized compliance costs.
- Post-control return on assets — post-control net income divided by the sum of pre-control assets plus investments in emission control equipment.
- Post-control long-term debt ratio — the sum of pre-control long-term debt and investments in emission control equipment divided by the sum of pre-control long-term debt, equity, and investments in emission control equipment.

Note that post-control return on assets is adjusted for higher post-control prices predicted in the partial equilibrium analysis. However, we adopt a worst-case assumption for the debt ratio in that we assume that the total investment in emission control equipment is debt-financed rather than paid for out of cash flow.

Limitations of the Capital-Availability Analysis --

The first limitation of the capital availability analysis is that future baseline performance may deviate from past levels. The financial position of a firm during the period 1991-1993 may not be a good approximation of the company's position later during the implementation period, even in the absence of the impacts of emission control costs.

Second, a limited set of measures is used to evaluate the impact of controls. These measures reflect accounting conventions and provide only a rough approximation of the factors that will influence capital availability.

Third, financial data are not available for all firms expected to be affected by the regulatory alternatives. Financial data tend to be available for larger, publicly-held firms. These companies might not be representative of all affected firms.

EVALUATION OF SECONDARY IMPACTS

The secondary impacts that we consider in this study include:

- Employment impacts.
- Energy impacts.
- Foreign trade impacts.
- Regional impacts.

Employment Impacts

As equilibrium output in affected industry segments falls because of control costs, employment in the industry will decrease. On the other hand, operating and maintaining emission control equipment requires additional labor for some control options. Direct net employment impacts are equal to the decrease in employment due to output reductions, less the increase in employment associated with the operation and maintenance of emission control equipment.

The estimates of the employment impacts associated with the alternative NESHAPs are based on employment-output ratios and estimated changes in domestic production. Specifically, we compute changes in employment proportional to estimated changes in domestic production.[27]

[27] See Appendix B for descriptions of the data and methods used to estimate employment impacts.

Estimates of the labor hours required to operate and maintain emission control equipment are unavailable. Accordingly, the employment impacts presented in this report are overstated to the extent that potential employment gains attributable to operating and maintaining control equipment are not considered. Also, we do not include estimates of employment impacts at firms indirectly affected by the regulatory alternatives, such as those at firms selling inputs to the flexible foam industry.

The estimates of direct employment impacts are driven by estimates of output reductions obtained in the market analyses. Biases in these estimates will likely cause the estimates of employment impacts to be biased in the same direction.

Energy Effects

The energy effects associated with the alternative NESHAPs include reduced energy consumption due to reduced output in affected industry segments plus the net change in energy consumption associated with the operation of emission controls.

The method we use to estimate reduced energy consumption due to output reductions is similar to the approach employed for estimating employment impacts.[28] Specifically, we assume that changes in energy use are proportional to estimated changes in domestic production. Estimates of the net change in energy consumption due to operating emission controls are unavailable.[29]

Regional Impacts

[28] See Appendix B for a more detailed description of this procedure.

[29] We view these as short-run estimates of reduced energy consumption. In the long run, resources diverted from the production of flexible foam will likely be directed to producing other goods and services.

Substantial regional or community impacts may occur if a plant that employs a significant percent of the local population or contributes importantly to the local tax base is forced to close or to reduce output because of emission control costs.

Secondary employment impacts may be generated if a substantial number of plants close as a result of emission control costs. Secondary employment impacts include those suffered by employees of firms that provide inputs to the directly affected industry, employees of firms that purchase inputs from directly affected firms for end-use products, and employees of other local businesses.

SECTION 4

PRIMARY ECONOMIC IMPACTS AND CAPITAL AVAILABILITY ANALYSIS

INTRODUCTION

This section presents estimates of the primary economic impacts of the alternative NESHAPs on the slabstock and molded foam segments of the flexible polyurethane foam industry. Primary impacts include changes in market prices and output levels, changes in the value of shipments by domestic producers, and plant closures. For the slabstock industry sector, we report a range of plant closures based on the results of a sensitivity analysis reported in Appendix D. We also present the results of the capital availability analysis for the two industry segments. The capital availability analysis assesses the ability of affected firms to raise capital and assesses the impacts of control costs on plant profitability. We consider the three regulatory alternatives, the MACT floor, Regulatory Alternative 1, and Regulatory Alternative 2 in our analyses.

ESTIMATES OF PRIMARY IMPACTS

As explained earlier in Section 3, we use partial equilibrium models of the affected industry segments to estimate primary impacts. The increase in production costs resulting from the purchase and operation of emission control equipment causes upward, vertical shifts in the industry supply curves. The height of these shifts is determined by the after tax cash flow required to offset the per unit increase in production costs resulting from compliance. Because control costs vary across plants within each industry segment, the post-control supply curves are segmented. We assume a worst case scenario in which plants with the highest control costs (per unit of output) are marginal (highest cost) in the post-control market.

We assume that the alternative NESHAPs will not affect foreign trade in foam products. Given the nature of the product, foreign trade in flexible polyurethane foam is negligible. It is a large volume product with very little cost (value) per unit weight. Shipping a cargo of foam is similar to shipping "air." High transportation costs relative to foam value makes long distance foam transport uneconomical. However, some international trade in flexible polyurethane foam exists in the form of end-use products (e.g., in automobiles).

Table 4-1 presents the primary impacts predicted by the partial equilibrium analysis for the flexible slabstock and flexible molded foam segments. For example, we estimate that the implementation of the MACT floor will result in a $0.03/lb (2.28 percent) increase in the price of slabstock foam and an annual reduction in domestic production of 6.87 thousand tons (1.12 percent of baseline production). Although the industry faces compliance costs resulting from the rule, the analysis shows that the MACT floor will cause the annual value of domestic shipments to increase by $19.53 million (1.14 percent). The value of shipments increases because the price increase more than offsets the reduction in output. We estimate that the MACT Floor will result in one to two slabstock plant closures. The range of estimates of plant closures reflects alternative assumptions about which control strategies slabstock plants adopt.[30]

[30] See Appendix D for a more detailed discussion of this issue.

Table 4-1

ESTIMATED PRIMARY IMPACTS
ON THE FLEXIBLE SLABSTOCK FOAM MARKET

Impact	MACT Floor	Reg. Alt I	Reg. Alt II
Price Change			
$/lb	.03	.03	.05
percent	2.28	2.20	3.82
Annual Change in Domestic Output			
1000 tons/yr	-6.87	-6.62	-11.36
percent	-1.12	-1.08	-1.86
Annual Change in Value of Shipments			
$million[a]	19.53	18.82	32.56
percent	1.14	1.10	1.89
Plant Closures[b]	1 to 2	1 to 3	1 to 4

[a] 1994 dollars.
[b] Ranges of predicted plant closures reflect alternative assumptions about different control technologies adopted by model plants.

Table 4-1 also shows the estimated primary impacts from the implementation of Regulatory Alternatives 1 and 2. Slabstock foam price increases are estimated to be $0.03/lb (2.20 percent) under Regulatory Alternative 1, and $0.05/lb (3.82 percent) under Regulatory Alternative 2. We estimate decreases in annual domestic output of 6.62 thousand tons (1.08 percent) under Alternative 1, and 11.36 thousand tons (1.86 percent) under Alternative 2. Our analysis predicts one to three plant closures for Regulatory Alternative 1 and one to four plant closures under Regulatory Alternative 2. As with the MACT floor, increases in the value of shipments are predicted under both regulatory alternatives. We estimate increases in the value of domestic shipments of $18.82 million (1.10 percent) under Regulatory Alternative 1 and $32.56 million (1.89 percent) under Regulatory Alternative 2.

Table 4-2 displays estimated primary impacts on the molded foam industry. We estimate that the implementation of the MACT floor will result in a $0.0017/lb (0.07 percent) increase in the price of molded foam. The associated reduction in domestic production is estimated to be 0.09 thousand tons (0.04 percent), and no plant closures are predicted. The estimated effect of the MACT floor on the value of domestic shipments is small, about $390 thousand (0.04 percent).

Table 4-2

ESTIMATED PRIMARY IMPACTS
ON THE FLEXIBLE MOLDED FOAM MARKET

Impact	MACT Floor	Reg. Alt 1	Reg. Alt 2
Price Change			
$/lb	0.00	0.02	0.03
percent	0.07	0.84	1.14
Annual Change in Domestic Output			
1000 tons/yr	-0.09	-0.95	-1.29
percent	-0.04	-0.42	-0.56
Annual Change in Value of Shipments			
$Million[a]	0.39	4.50	6.10
percent	0.04	0.42	0.57
Plant Closures	0	3	0

[a] 1994 dollars.

Table 4-2 also displays the estimated primary impacts of Regulatory Alternatives 1 and 2 on the molded foam segment. Foam price increases are estimated to be $0.02/lb (0.84 percent) under Regulatory Alternative 1, and $0.03/lb (1.14 percent) under Regulatory Alternative 2. We estimate decreases in annual domestic output of 0.95 thousand tons (0.42 percent) under Alternative 1, and 1.29 thousand tons (0.56 percent) under Alternative 2. Annual increases in the value of shipments are expected under both regulatory alternatives. We estimate increases in the value of domestic shipments of $4.50 million (0.42 percent) under Regulatory Alternative 1 and $6.10 million (0.57 percent) under Regulatory Alternative 2. Our analysis predicts three plant closures under Regulatory Alternative 1 and no plant closures under Regulatory Alternative 2.

We emphasize that many of the assumptions we adopt in the analysis are likely to cause an overestimate of predicted plant closures. First, we assume that the plant with the highest per unit emission control costs also is the least efficient in that it has the highest baseline per unit production costs. Second, we assume a national market, but regional trade barriers might afford some protection for some plants. The costs of the available technologies for complying with the alternative NESHAPs vary substantially for slabstock plants. Some plants might adopt less costly technologies than those assigned in this analysis, thus reducing compliance costs and plant closures. By altering the assumptions about the technologies some model plants employ to achieve ABA emission reductions, the count of predicted plant closures changes. As Appendix D demonstrates, replacing the Forced Cooling technology with Acetone will reduce predicted slabstock closures from 2 to 1 under the MACT floor, from 3 to 1 under Regulatory Alternative 1, and from 4 to 1 under Regulatory Alternative 2.

The estimated primary impacts reported above depend on a set of parameters used in the partial equilibrium model of the slabstock and molded foam industries. One of the parameters, the elasticity of demand, measures how sensitive buyers are to price changes. A second parameter, the elasticity of supply, measures how sensitive suppliers, or producers, are to price changes. For this analysis, we were not able to find supply or demand elasticity estimates for either industry segment in the literature. Also, we were unable to identify data required to derive our own estimates.

The estimated impacts reported above in Tables 4-1 and 4-2 are based on a demand elasticity of −0.5 and a supply elasticity of 10.0 for both the slabstock and molded foam segments. In Appendix C, we report the results of analyses that show the sensitivity of the estimated impacts to changes in these elasticity estimates. The “low” elasticity case adopts a demand elasticity of −0.25 and a supply elasticity of 5.0 for both markets (slabstock and molded). These results show smaller reductions in market output and generally slightly less adverse impacts on domestic producers than results reported above. The "high" elasticity case reported in Appendix C employs a demand elasticity of −1.0 and a supply elasticity of 50.0 for both markets. In general, this case shows slightly more adverse impacts on domestic producers. However, the sensitivity analyses generally show that the estimated primary impacts are relatively insensitive to reasonable ranges of demand and supply elasticity estimates.

CAPITAL AVAILABILITY ANALYSIS

The capital availability analysis involves examining pre- and post-control values of selected financial ratios. These ratios include net income divided by assets and long term debt divided by the sum of long term debt and equity. In order to reduce the effects of year-to-year fluctuations in net income, a three-year average (1991 through 1993) of net income over assets was used as the baseline. Changes in the long term debt ratio represent structural changes and so are not subject to the same cyclical fluctuations. Long term debt ratios from 1993 were used as the baseline.

As explained in Section 3, these financial statistics lend insight into the ability of affected firms to raise the capital needed to acquire emission controls. They also provide estimates of the changes in profitability which would arise from the implementation of the NESHAP.

To calculate the post-control ratio of net income to assets, additional revenues due to higher post-control prices less annualized control costs were added to pre-control net income, and capital control costs were added to pre-control assets. To calculate the post-control long term debt ratio, capital control costs were added to pre-control long term debt, both in the numerator and denominator of this ratio. Note that we have adjusted the return on assets measure for higher post-control prices. However, the post-control debt ratios reflect a worst-case assumption that affected firms are required to finance emission controls entirely through debt. Second, for this analysis we assume that production facilities will choose the highest cost (capital cost) compliance technology. In reality, some facilities may choose other technologies with lower costs.

As discussed in Section 1, the slabstock and molded foam industries are characterized by individual firms owning multiple production facilities. Financial data are available for only 7 of the 28 firms which produce slabstock. This represents 26 of the 78 production facilities nationwide. Data for the molded sector were only available for 9 firms. These 9 firms operate 17 of the approximately 234 production facilities nationwide.

Tables 4-3 through 4-5 show the results of the capital availability analyses conducted for the three regulatory alternatives. Note that the company number identification corresponds with those found in Table 1-13. In many cases, the regulatory alternatives have a negligible effect on the ratio of net income to assets for affected companies (i.e., the impacts round to zero at two significant digits). The largest declines in this ratio are very small, in the neighborhood of about one-tenth of a percent. Note that the post-control net income to assets ratio increases relative to the baseline for some affected companies. This occurs when additional revenues from higher post-control prices more than offset compliance costs.

Similarly, effects of the regulatory alternatives on the long-term debt ratios appears to be negligible in most cases. Except for Companies 24 and 25, the post-control debt ratios are all within one percent of pre-control levels. Even after controls, Companies 24 and 25 appear to have long-term debt ratios typical of the industry.

All of the companies with available data are large publicly held corporations. As a result, emission controls costs, which are small relative to their overall financial resources, have no significant impacts on the firms' financial ratios. Accordingly, we conclude that the companies which we analyzed will not find it difficult to raise the capital necessary to purchase and install the required emission controls. We note, however, that the firms for which financial data are available might not be representative of other affected firms in the industry.

Table 4-3

CAPITAL AVAILABILITY ANALYSIS
MACT FLOOR

FIRM	PRE-CONTROL		POST-CONTROL	
	NI/A[a] (Percent)	LTD/(LTD+E)[b] (Percent)	NI/A[a] (Percent)	LTD/(LTD+E)[b] (Percent)
Company 1	2.57	13.41	2.57	13.41
Company 3	−1.37	19.41	−1.37	19.41
Company 7	2.23	11.21	2.22	11.21
Company 8	−0.65	23.56	−0.65	23.57
Company 9	2.22	21.40	3.60	22.22
Company 10	4.02	15.53	4.02	15.53
Company 11	6.79	15.17	6.79	15.17
Company 19	4.49	26.32	4.47	26.34
Company 20	−1.17	11.13	−1.17	11.13
Company 24	12.93	21.70	12.95	23.65
Company 25	7.78	10.59	7.80	13.24
Company 27	5.52	31.84	5.46	32.20
Company 30	1.43	42.22	1.45	42.33
Company 35	−0.87	9.99	−0.87	10.16

Notes:
[a] Net income divided by assets (1991-1993 average).
[b] Long-term debt divided by long-term debt plus equity (1993).

Sources: *Moody's Industrial Manual, 1994; Moody's OTC Industrial Manual, 1994' Moody's OTC Unlisted Manual, Dun & Bradstreet's Million Dollar Directory, 1994; Herman Miller Annual Reports, 1989-1991.*

Table 4-4

CAPITAL AVAILABILITY ANALYSIS
REGULATORY ALTERNATIVE 1

FIRM	PRE-CONTROL		POST-CONTROL	
	NI/A[a] (Percent)	LTD/(LTD+E)[b] (Percent)	NI/A[a] (Percent)	LTD/(LTD+E)[b] (Percent)
Company 1	2.57	13.41	2.61	13.42
Company 3	−1.37	19.41	−1.37	19.41
Company 7	2.23	11.21	2.27	11.21
Company 8	−0.65	23.56	−0.65	23.57
Company 9	2.22	21.40	3.86	22.13
Company 10	4.02	15.53	4.04	15.53
Company 11	6.79	15.17	6.79	15.18
Company 19	4.49	26.32	4.47	26.34
Company 20	−1.17	11.13	−1.17	11.13
Company 24	12.93	21.70	12.95	23.65
Company 25	7.78	10.59	7.81	13.24
Company 27	5.52	31.84	5.47	32.20
Company 30	1.43	42.22	1.44	42.33
Company 35	−0.87	9.99	−0.87	10.16

Notes:
[a] Net income divided by assets (1991-1993 average).
[b] Long-term debt divided by long-term debt plus equity (1993).

Sources: *Moody's Industrial Manual, 1994; Moody's OTC Industrial Manual, 1994' Moody's OTC Unlisted Manual, Dun & Bradstreet's Million Dollar Directory, 1994; Herman Miller Annual Reports, 1989-1991.*

Table 4-5

CAPITAL AVAILABILITY ANALYSIS
REGULATORY ALTERNATIVE 2

FIRM	PRE-CONTROL		POST-CONTROL	
	NI/A[a] (Percent)	LTD/(LTD+E)[b] (Percent)	NI/A[a] (Percent)	LTD/(LTD+E)[b] (Percent)
Company 1	2.57	13.41	2.60	13.50
Company 3	−1.37	19.41	−1.37	19.41
Company 7	2.23	11.21	2.10	11.23
Company 8	−0.65	23.56	−0.65	23.59
Company 9	2.22	21.40	4.57	22.52
Company 10	4.02	15.53	3.93	15.63
Company 11	6.79	15.17	6.76	15.28
Company 19	4.49	26.32	4.47	26.34
Company 20	−1.17	11.13	−1.17	11.13
Company 24	12.93	21.70	13.05	24.07
Company 25	7.78	10.59	7.74	16.35
Company 27	5.52	31.84	5.54	32.34
Company 30	1.43	42.22	1.44	42.46
Company 35	−0.87	9.99	−0.87	10.16

Notes:
[a] Net income divided by assets (1991-1993 average).
[b] Long-term debt divided by long-term debt plus equity (1993).

Sources: *Moody's Industrial Manual, 1994; Moody's OTC Industrial Manual, 1994' Moody's OTC Unlisted Manual, Dun & Bradstreet's Million Dollar Directory, 1994; Herman Miller Annual Reports, 1989-1991.*

LIMITATIONS

Several qualifications of the results presented in this section need to be made. A single market for homogeneous output is assumed in the partial equilibrium analysis. However, there may be some regional trade barriers which would protect producers. Furthermore, the analysis assumes that plants with the highest per unit emission control costs are marginal post-control. This assumption will cause the impacts presented above to be overstated since market impacts are determined by the costs of marginal plants. Some plants may find that the price increase resulting from regulations make it profitable to expand production. This would occur if a firm found its post-control incremental unit costs to be smaller than the post-control market prices. Expansion by these firms would result in smaller decreases in output and smaller increases in prices than predicted by our analysis. For instance, plants that emit less than the major source threshold do not have to comply with the standard. They enjoy price increases without incurring of compliance costs.

Furthermore, some plants may choose to alter their production mix of different foam grades, choosing to drop altogether or reduce certain foam grades and increase production of other grades requiring and/or emitting less HAP. Plants unaffected by the standard may increase production to produce those foam grades whose production is reduced or dropped by other producers.

We have also noted that the estimated primary impacts depend on the parameters of the partial equilibrium model. The results of the sensitivity analyses presented in Appendix C, which are based on alternative estimates of demand and supply elasticity, show slightly less adverse impacts on domestic producers in the case of lower elasticities and slightly more adverse impacts in the case of more elastic supply and demand estimates. Also note that in Appendix D, we report the results of a sensitivity analysis which alters assumptions about the assignments of the control technologies for the slabstock industry.

SUMMARY

Under the MACT Floor and Regulatory Alternative 1, we estimate that slabstock foam prices will increase by about 2.2 percent and output is will fall by about 1 percent. However, under both of these alternatives, the value of slabstock shipments will increase by about 1 percent. One to two slabstock plant closures are predicted under the MACT floor and one to three are predicted under Regulatory Alternative 1. We predict more adverse impacts under Regulatory Alternative 2, with slabstock prices increasing by about 3.8 percent and output declining by about 1.86 percent. One to four plant closures are possible. Finally, because emission control costs are very small relative to the financial resources of the affected producers examined, they should not find it difficult to raise the capital necessary to finance the purchase and installation of emission controls.

For the molded foam sector, the estimated economic impacts of the NESHAP are relatively small. Predicted price increases and reductions in domestic output are approximately 1 percent or less under all three regulatory alternatives. The estimated value of shipments for the molded foam segment increases under all three alternatives. No plant closures are expected under the MACT Floor or Alternative 2. However, three closures are predicted under Regulatory Alternative 1.

SECTION 5

SECONDARY ECONOMIC IMPACTS

INTRODUCTION

This section presents estimates of the secondary economic impacts that would result from the implementation of the alternative NESHAPs. Secondary impacts include changes in employment, energy use, foreign trade and regional impacts.

LABOR IMPACTS

The estimated labor impacts associated with the NESHAP are based on the results of the partial equilibrium analyses of the two segments of the flexible polyurethane foam industry. These impacts depend primarily on the estimates of reduction in domestic production reported earlier in Section 4.[31] Note that changes in employment due to the operation and maintenance of control equipment have been omitted from this analysis due to lack of data. Also, the estimated employment impacts reported below do not include potential employment gains in industries which produce substitute commodities that might benefit from reduced flexible slabstock and flexible molded foam production or employment losses in industries supplying inputs to the foam industry. Thus, the changes in employment estimated in this section reflect only the direct employment losses due to reductions in domestic production of flexible slabstock and flexible molded foam.

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[31] More specifically, we estimate employment impacts by assuming that labor use per unit of output will remain constant when the quantity of output changes. Production worker hours per dollar of output was calculated from 1992 Census of Manufactures. See Appendix B for a more detailed discussion.

Table 5-1 presents estimates of employment losses for the two industry sectors. As Table 5-1 indicates, estimated job losses in the slabstock industry segment range from 95 jobs (in Regulatory Alternative 1) to 164 jobs (in Regulatory Alternative 2). As expected, the estimated employment losses in Regulatory Alternative 1 are slightly less than those predicted for the MACT Floor. This less severe labor impact occurs primarily because smaller reductions in output are expected to occur as a result of the implementation of Regulatory Alternative 1 than from the implementation of the MACT Floor. As a result, the associated labor impacts are less.

Table 5-1 also displays labor impacts for the molded foam industry segment. The estimated labor reductions associated with the implementation of the MACT floor are quite small, with only two production job losses expected. We estimate the implementation of Regulatory Alternatives 1 and 2 to result in 23 and 31 job losses, respectively, in the molded foam segment.

Table 5-1

FLEXIBLE POLYURETHANE FOAM INDUSTRY
ESTIMATED EMPLOYMENT REDUCTIONS

Industry Segment	MACT Floor	Regulatory Alternative 1	Regulatory Alternative 2
Slabstock (jobs) (% reduction)	99 1.12	95 1.08	164 1.86
Molded (jobs) (% reduction)	2 0.04	23 0.42	31 0.56

Note: Estimates do not include potential employment gains due to operating and maintaining emission controls.

As noted above, our estimates of employment impacts are driven by the estimates of output reductions and plant closures reported in Section 4. This means that the estimated employment impacts reflect the worst-case assumptions adopted in the analysis for the same reasons provided earlier.

ENERGY USE IMPACTS

The approach we employ to estimate reductions in energy use is similar to the approach employed to estimate labor impacts. Again, these impacts depend primarily on the estimated reductions in domestic output reported earlier in Section 4. Note that the changes reported below do not account for the potential increases in energy use due to operating and maintaining emission control equipment or possible changes in production times for reformulated foam products. This omission is due to lack of data.

Table 5-2 presents changes in the use of energy for the two industry segments. The change in the use of energy by the slabstock foam industry ranges from 1.08 percent (in Regulatory Alternative 1) to 1.86 percent (in Regulatory Alternative 2). Given the magnitude of national production impacts on the molded sector, smaller energy use reductions are expected for the molded foam industry under all three regulatory alternatives. Energy impacts associated with the implementation of the MACT Floor are estimated to be only 0.04 percent. We expect energy impacts under Regulatory Alternatives 1 and 2 to be 0.42 percent and 0.56 percent respectively.

FOREIGN TRADE IMPACTS

Other factors being the same, the implementation of the NESHAP will raise the production costs of domestic foam manufacturers relative to foreign producers. In an industry with no barriers to international trade, this would cause U.S. imports to increase and U.S. exports to decrease. However, as discussed previously, due to the nature of the product, foreign trade in flexible polyurethane foam is negligible. It is a large volume product with very little value per unit volume. High transportation costs relative to foam value makes long distance foam transport financially prohibitive. As such, flexible polyurethane foam industries in other countries produce foam to satisfy their domestic demand. Due to the absence of international trade in flexible polyurethane foam, no significant foreign trade impacts are anticipated.

Table 5-2

ESTIMATED ENERGY USE REDUCTIONS

Industry Segment	MACT Floor	Regulatory Alternative 1	Regulatory Alternative 2
Slabstock (1000$94) (% reduction)	424.73 1.12	409.57 1.08	703.03 1.86
Molded (1000$94) (% reduction)	8.00 0.04	98.00 0.42	134.00 0.56

Note: Estimates do not include potential employment gains due to operating and maintaining emission controls.

REGIONAL IMPACTS

Although it is not possible to identify the specific locations of plants that might close as a result of the alternatives, our analysis of slabstock plant locations revealed that, apart from a few exceptions, foam production facilities tend to be geographically dispersed. As a result, we do not anticipate any significant regional impacts as a result of the implementation of the proposed NESHAP. The flexible polyurethane foam industry is non-labor intensive. Both large and small facilities need only a small number of employees to operate the foam production line. Foam production is, for the most part, an automated process requiring only monitoring once the production process is underway. As such, labor utilization at production plants are small relative to regional labor supplies. Therefore, even in cases where plant closures are predicted, no significant labor or regional impacts are expected because employment impacts are likely to be small relative to total local employment.

LIMITATIONS

The estimates of the secondary impacts associated with the NESHAP are based on changes in market equilibria predicted by the partial equilibrium models of the two affected markets. Accordingly, the caveats discussed earlier in Section 4 for the primary impacts apply as well to the estimates of secondary impacts. Also, we note that the estimates of employment impacts are based on the average value of production per worker hour for SIC 3086. Labor productivity in the slabstock and molded foam segments could differ from the four-digit industry-wide level.

As noted earlier, the estimates of employment impacts do not include potential employment gains due to operating and maintaining emission control equipment or employment gains in the manufacturing of substitute products. Similarly, the estimates we report exclude potential indirect employment losses in industries that supply inputs to the flexible polyurethane foam industries and employment gains in industries producing substitute products. In short, the reported estimates of employment impacts include only direct production job losses in the flexible polyurethane slabstock and molded industries.

SUMMARY

The estimated secondary economic impacts of the alternative NESHAP are generally small for the molded foam segment of the industry because only small reductions in industry output are expected for this sector. Impacts range from 0.04 percent to 0.56 percent under the three regulatory alternatives. There are no expected foreign trade impacts because there is virtually no international trade in flexible polyurethane molded foam. No significant impacts on regional economies are expected.

The estimated secondary economic impacts of the alternative NESHAPs are somewhat larger for the slabstock segment of the industry because larger reductions in domestic production are predicted for this industry segment. Estimated employment and energy impacts range from

1.08 percent to 1.86 percent under the three regulatory alternatives. As with the molded foam sector, there exists virtually no international trade in slabstock foam. As such, no significant trade impacts are expected. Also, no significant regional impacts are expected.

SECTION 6

POTENTIAL SMALL BUSINESS IMPACTS

INTRODUCTION

The Regulatory Flexibility Act (RFA) requires an analysis of the potential effects of proposed regulations on small business entities. Specifically, the RFA requires that a determination be made as to whether the subject regulation will significantly impact a substantial number of small entities.

Firms are classified as small based on company-wide employment rather than plant employment. The Small Business Administration (SBA) classifies firms in the flexible poly-urethane foam industry (SIC 3086) as small if total company-wide employment is less than 500 employees.[32] This definition is consistent with recent guidance from EPA's General Counsel on the interpretation of the Small Business Regulatory Enforcement Fairness Act of 1996.[33]

We describe below the results of two analyses designed to assess the potential impacts of the regulatory alternatives on small businesses. In the first analysis, we estimate the impact that the alternatives will have on the costs of differently sized plants. In the second analysis, we predict, under a worst-case scenario, plant closures by plant size. First, however, we explain how we matched model plants with firms to determine small business status.

MATCHING MODEL PLANTS WITH FIRMS

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[32] See 13 CFR 121.

[33] See EPA (1996).

As noted above, firms are classified as small entities based on company-wide rather than plant-level employment. However, because plants in the flexible polyurethane foam industry are so numerous, the analysis in this report is conducted using model plants rather than actual plants whose identities can be linked to specific firms. Nonetheless, it is possible to draw some conclusion about the small business status of affected facilities by matching model plants to companies responding to the Industry Questionnaire 1993, issued under Section 114 of the CAAA.

The questionnaire reports company-wide employment and plant-level production for each facility included in the survey. By matching annual production levels, it is possible to assign probable model plant types to each facility included in the survey. Because company-wide employment is reported for plants included in the sample, it is possible to estimate the percent of each model plant type that satisfies the small business criteria (i.e., company-wide employment under 500).

Table 6-1 shows the results of the matching exercise. For example, we estimate that ten (50.0 percent) of model plant type MP1 slabstock facilities could be owned by small businesses, based on the 500 employee criterion. Note that we cannot determine the number of HP1 molded foam plants that could be small entities. This model plant type is characterized by production technology (high-pressure mixhead) and not production level. Also, note that some companies may own both slabstock and molded facilities. In these cases, it is likely that the parent company is too large to be considered a small business.

Based on our estimates, 71 possible small businesses could be affected by the NESHAP, 18 slabstock and 53 molded foam producers. Recall that molded foam facilities of the LP1 model plant type will not require controls and are therefore not included in the count of affected small businesses.

We urge caution in interpreting the results reported in Table 6-1. First, we assume that respondents to Industry Questionnaire 1993 interpreted “total employment” as total company-wide employment rather than total plant employment. Fewer plants would satisfy the small business employment criterion if respondents reported plant employment. Second, some of the molded foam plants assigned to LP1, LP2 and LP3 could be HP1 type plants. This issue is significant since the HP1 plants are not expected to incur any costs as a result of the regulatory alternatives. Finally, the results for molded foam plants are based on a sample of plants.[34]

Table 6-1

ESTIMATED SMALL BUSINESS STATUS OF MODEL PLANTS

Model Plant Number	Estimated Small Businesses (Percent)	Estimated Small Businesses (Count)
Slabstock		
MP1	50.0	10
MP2	26.7	7
MP3	6.7	1
MP4	0.0	0
MP5	7.7	0
Molded		
HP1	--[a]	--[a]
LP1	76.9	84
LP2	80.0	43
LP3	22.2	10

Source: Responses to Industry Questionnaire 1993, issued under Section 114 of the CAAA.

Notes: [a] The HP1 model plant is characterized by production technology (high-pressure mixhead) and not production level. As a result, the percent of these plants that could be small businesses cannot be estimated.

[34] The EPA estimates that about 234 plants produce molded foam nationwide, however, the questionnaire includes only 47 plants. Data from the questionnaire were used to determine the percentage of small businesses in each model plant classification. These percentages were then used to extrapolate to the 234 plants to estimate the number (count) of small businesses in each model plant classification.

IMPACTS ON COSTS BY PLANT SIZE

Compliance costs associated with the implementation of the regulatory alternatives will increase the costs of producing flexible polyurethane foam. To place these costs in perspective, we compute annualized compliance costs as a percent of baseline revenues for each model plant.[35] Tables 6-2 and 6-3 show the results of the analysis for the slabstock and molded foam segments, respectively. For example, under the MACT Floor, the smallest slabstock model plant, MP1, is expected to incur average annualized compliance costs of about 1.59 percent of estimated baseline revenues, which is the largest average compliance costs relative to baseline revenues.[36] The relative difference between compliance costs as a percent of revenues for model plant MP1 and the next largest plant, MP2, is larger for Regulatory Alternatives 1 and 2 than for the MACT Floor.

Table 6-2

IMPACT ON COSTS BY PLANT SIZE: SLABSTOCK

Regulatory Alternative	Model Plant Number	Number of Plants	Average Change in Costs (% of Revenues)
MACT Floor	MP1	19	1.59
	MP2	28	0.92
	MP3	14	0.67
	MP4	11	0.46
	MP5	6	0.76
Alternative 1	MP1	19	1.84
	MP2	28	0.65
	MP3	14	0.29
	MP4	11	0.22
	MP5	6	0.57

[35] The capital costs associated with compliance costs are amortized over a 10 year equipment life at a 10 percent real private discount rate.

[36] MP1 produces less than 100 tons of foam product annually. See Appendix A.

Alternative 2	MP1 MP2 MP3 MP4 MP5	19 28 14 11 6	2.29 1.02 0.54 0.54 0.52

Table 6-3

IMPACT ON COSTS BY PLANT SIZE: MOLDED

Regulatory Alternative	Model Plant Number	Number of Plants	Average Change in Costs (% of Revenues)
MACT Floor	HP1	27	0.0000
	LP1	109	0.0000
	LP2	54	0.0088
	LP3	44	0.0328
Alternative 1	HP1	27	0.0000
	LP1	109	0.0000
	LP2	54	0.7983
	LP3	44	−0.0815
Alternative 2	HP1	27	0.0000
	LP1	109	0.0000
	LP2	54	−0.2641
	LP3	44	0.1891

As Table 6-3 indicates, the smallest mold foam model plant, LP1, is not expected to incur any compliance costs as a result of the regulatory alternative. The same is true for model plant HP1, which could be very small or large.[37] The largest molded foam model plant, LP3, is expected to incur the highest compliance costs relative to baseline revenues under the MACT Floor.[38]

Table 6-1 shows that the smallest slabstock model plant, MP1, is more likely to be operated by a small business than the other slabstock model plants. Accordingly, the finding in Table 6-2 that this model plant is also likely to incur the highest relative compliance costs

[37] Recall that MP1 is characterized by production process and not plant size.

[38] Average compliance costs are negative for LP3 under Regulatory Alternative 1 and negative for LP2 under Alternative 2 because of savings associated with control strategies.

suggests potential adverse impacts on small businesses. However, we note that the results reported in Table 6-2 and 6-3 are *average* compliance costs for each model plant. Because of variations in the costs of control technologies, compliance costs vary within model plant categories, even for a given regulatory alternative. Also, affected plants will be able to offset at least some compliance costs by passing price increases to their customers. In fact, the slabstock price increases we predict in Section 4 are sufficient to offset *average* compliance costs, even for the smallest model plants.[39]

PREDICTED PLANT CLOSURES BY PLANT SIZE

Earlier in Section 4, we used our partial equilibrium model to predict plant closures caused by the implementation of the regulatory alternatives. Tables 6-4 and 6-5 report, respectively, predicted plant closures by model plants for the slabstock and molded foam segments. For example, our analysis predicts that 0 to 2 of the 19 model plants MP1 will close

Table 6-4

PREDICTED PLANT CLOSURES: SLABSTOCK

Regulatory Alternative	Model Plant Number	Number of Plants	Predicted Closures
MACT Floor	MP1	19	0 to 2
	MP2	28	0 to 1
	MP3	14	0
	MP4	11	0
	MP5	6	0
Alternative 1	MP1	19	0 to 3
	MP2	28	0 to 1
	MP3	14	0
	MP4	11	0
	MP5	6	0

[39] This does not mean that all plants of a given model plant type will be able to offset all compliance costs through higher prices. Again, compliance costs vary within plant types due to differences in costs of selected control technologies.

Alternative 2	MP1 MP2 MP3 MP4 MP5	19 28 14 11 6	0 to 3 1 0 0 0

Table 6-5

PREDICTED PLANT CLOSURES: MOLDED

Regulatory Alternative	Model Plant Number	Number of Plants	Predicted Closures
MACT Floor	HP1 LP1 LP2 LP2	27 109 54 44	0 0 0 0
Alternative 1	HP1 LP1 LP2 LP3	27 109 54 44	0 0 3 0
Alternative 2	HP1 LP1 LP2 LP3	27 109 54 44	0 0 0 0

and 0 to 1 of the 28 model plants MP2 will close under the MACT Floor[40]. There is insufficient data to determine the exact ownership of the plants that may close. It is estimated

[40] The range is dependent upon the assignment of control technology to the model plants, with the least-cost technology yielding the lower value of the range and the highest-cost technology yielding the upper value of the range.

that half of the MP1 plants, 27 percent of the MP2 plants, and 15 percent of the other slabstock model plants are owned by small businesses. Without facility-specific data, the analysis cannot determine if these impacts will occur at small businesses owning these facilities.

Table 6-5 shows that no plant closures are predicted for molded foam producers under the MACT Floor or Regulatory Alternative 2. Also, no plant closures are predicted for the smallest model plants, LP1, for Regulatory Alternative 1. Recall that these small plants are not expected to incur compliance costs under any of the regulatory alternatives.

The finding that the smallest slabstock plants are most likely to close under the regulatory alternatives provides the potential adverse impacts on small businesses. Given that any estimate of closures is based upon worst-case assumptions[41], it is likely that these impacts are overestimated and the affect on small businesses will be minimal.

REFERENCE

EPA (1996). Memorandum from Jonathan Z. Cannon, EPA General Counsel, to the Administrator, April 2.

[41] See Section 4 for a discussion of these assumptions.

SECTION 7

SOCIAL COSTS AND ECONOMIC EFFICIENCY

Estimates of the social (economic) costs associated with the implementation of the alternative NESHAPs for the flexible polyurethane slabstock and flexible polyurethane molded foam industry segments are presented below in this section of the report. We also present an analysis of the economic efficiency of the regulatory alternatives.

SOCIAL COSTS OF EMISSION CONTROLS: CONCEPTUAL ISSUES

Air quality regulations affect society's economic well-being by causing a reallocation of productive resources within the economy. Specifically, resources are allocated to the production of cleaner air and away from other goods and services that could otherwise be produced. Accordingly, the social, or economic, costs of emission controls can be measured as the value that society places on those goods and services not produced as a result of resources being diverted to the production of improved air quality. According to economic theory, the conceptually correct valuation of these costs requires the identification of society's willingness to be compensated for these foregone consumption opportunities that would otherwise be available.[42,43]

In the discussion that follows, we distinguish between emission control costs and the social or economic costs associated with the regulatory alternatives. The former are measured simply as the annualized capital and annual operating and maintenance costs of controls under the assumption that all affected plants install controls. As noted above, economic costs reflect society's willingness to be compensated for foregone consumption opportunities.

Estimates of emission control costs will correspond to the conceptually correct measure of economic costs only if the following conditions hold:

- Marginal plants affected by an alternative standard must be able to pass forward all emission control costs to buyers through price mark-ups without reducing the quantity of goods and services demanded in the market.
- The prices of emission control resources (e.g., pollution control equipment, alternative materials, and labor) used to estimate costs must correspond to the prices that would prevail if these factors were sold in competitive markets.
- The discount rate employed to compute the present value of future costs must correspond to the appropriate social discount rate.
- Emission controls do not affect the prices of goods imported to the domestic economy.

Market Adjustments

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[42] Willingness to be compensated is the appropriate measure of economic costs, given the convention of measuring benefits as willingness to pay. Under this convention, the potential to compensate those members of society bearing the costs associated with a policy change is compared with the potential willingness of gainers to pay for benefits. See Mishan (1971).

[43] These costs are often referred to as “Social Costs,” as well as economic costs.

A plant is marginal if it is among the least efficient producers in the market and, as a result, the level of its costs determine the post-control equilibrium price. A marginal plant can pass on to buyers the full burden of emission control costs only if demand is perfectly inelastic. Otherwise, consumers will reduce quantity demanded when faced with higher prices. If this occurs, estimated control costs will overstate the economic costs associated with a given air quality standard.

The emission control costs estimates do not reflect any market adjustments that are likely to occur as affected plants and their customers respond to higher post-control production costs. As a result, the estimates of economic costs presented later in this section will differ from the emission control costs to reflect estimates of such market adjustments.

Markets for Emission Control Resources

Other things being the same, estimated emission control costs will overstate the economic costs associated with an alternative air quality standard if the estimates are based on factor prices (e.g., emission control equipment prices and wage rates) which reflect monopoly profits earned in resource markets. Monopoly profits represent a transfer from buyers to sellers in emission control markets, but do not reflect true resource costs. We note that some of the available emission control technologies are patented. To the extent that the patents confer monopoly power, the estimates of compliance costs used in this analysis are higher than they would be if emission controls were sold in competitive markets. If this is the case, the analysis overstates true economic costs.

The Social Discount Rate

The estimates of annualized emission control costs presented earlier in this report were computed by adding the annualized estimates of capital expenditures associated with the purchase and installation of emission control equipment to estimates of annual operating and maintenance costs. Capital expenditures were annualized using a 7 percent discount rate. The private cost of capital is appropriate for estimating how producers adjust supply prices in response to control costs.[44] In order to estimate the economic costs associated with the alternative NESHAPs, an appropriate measure of the social discount rate should be used in the amortization schedule.

There is considerable debate regarding the use of alternative discounting procedures and discount rates to assess the economic benefits and costs associated with public programs.[45] The approach adopted here is a two-stage procedure recommended by Kolb and Scheraga (1990).

First, annualized costs are computed by adding annualized capital expenditures (over the expected life of emission controls) and annual operating costs. Capital expenditures are annualized using a discount rate that reflects a risk-free marginal return on investment.[46] This discount rate, which is referred to below as the social cost of capital, is intended to reflect the opportunity cost of resources displaced by investments in emissions controls. Kolb and Scheraga (1990) recommend a range of 5 to 10 percent for this rate. We adopt a midpoint value of 7.0 percent in this analysis.[47]

Second, the present value of the annualized stream of costs should be computed using a consumption rate of interest which is taken as a proxy for the social rate of time preference. This discount rate, which is referred to below as the social rate of time preference, measures society's willingness to be compensated for postponing current consumption to some future date. Kolb and Scheraga (1990) argue that the consumption rate of interest probably lies between 1 and 5

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[44] In other words, a discount rate reflecting the private cost of capital to affected firms should be used in analyses designed to predict market adjustments associated with emission control costs. The private cost of capital, assumed to be 10 percent in this analysis, is higher than the 7 percent social discount rate because it reflects the greater risk faced by individual producers relative to the risk faced by society at large.

[45] See Lind, et al. (1982) for a more detailed discussion of this debate.

[46] The risk-free rate is appropriate if the NESHAP, as a program, does not add to the variance of the return on society's investment portfolio.

[47] The 7 percent discount rate is also consistent with recent OMB recommendations.

percent. We do not, however, present estimates of the present value of the costs associated with the NESHAP in this report.

The resulting estimates of the present value of the economic costs associated with the alternative NESHAPs can be compared with estimates of the present value of corresponding benefits of the regulatory alternatives. The social rate of time preference should be employed to discount the future stream of estimated benefits.

OTHER COSTS ASSOCIATED WITH NESHAP

It should be recognized that the estimates of costs reported later in this section do not reflect all costs that might be associated with the NESHAP. Examples of these include some administrative, monitoring, and enforcement costs (AME), and transition costs.

AME costs may be borne by directly affected firms and by different government agencies. These latter AME costs, which are likely to be incurred by state agencies and EPA regional offices, for example, are reflected neither in the estimates of emission control costs, nor in the estimates of economic costs. However, our estimates do include administrative and monitoring costs incurred by affected firms.

Transition costs are also likely to be associated with the alternative standards. Analyses described in previous sections of this report, for example, predict that some plants will close because of emission control costs. This will cause some individuals to suffer transition costs associated with temporary unemployment and affected firms to incur shutdown costs. These transition costs are not reflected in the cost estimates reported later in this section.

CHANGES IN ECONOMIC SURPLUS AS A MEASURE OF COSTS

As was noted earlier, the willingness to be compensated for foregone consumption opportunities is taken here as the appropriate measure of the costs associated with the alternative

NESHAPs. In this case, compensating variation is an exact measure of willingness to be compensated. In practice, however, compensating variation is difficult to measure; consequently, the change in economic surplus associated with the air quality standard is used as an approximation to compensating variation.

The degree to which a change in economic surplus coincides with compensating variation as a measure of willingness to be compensated depends on whether the surplus change is measured in an input market or a final goods market. The surplus change is an exact measure of compensating variation when it is measured in an input market, but it is an approximation when measured in a final goods market.[48]

The direction of the bias in the approximation of compensating variation when the surplus change is measured in a final goods market depends on whether affected parties realize a welfare gain or suffer a welfare loss, but in either case, the bias is likely to be small.[49] Affected firms (and their customers) will suffer a welfare loss as the result of the implementation of emission controls. In this case, the change in economic surplus will exceed compensating variation, the exact measure of willingness to be compensated.[50] We note, however, that this study measures surplus changes in input markets.

ESTIMATES OF SOCIAL COSTS

Estimates of the annualized total social costs associated with the NESHAP are reported in Tables 7-1 and 7-2 (for a social cost of capital equal to 7.0 percent). For the slabstock segment, estimates of total annual costs of the NESHAP are $11.86 million under the MACT Floor, $7.18 million under Regulatory Alternative 1, and $10.92 million under Regulatory Alternative 2. For

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[48] See Just, Hueth, and Schmitz (1982) for a more detailed discussion.

[49] See Willig (1974).

[50] See Appendix B for a detailed, technical description of the methods employed to compute changes in economic surplus.

the molded foam industry, estimates of total annual costs are much smaller. They are $190 thousand under the MACT Floor, $60 thousand under Regulatory Alternative 1, and $710 thousand under Regulatory Alternative 2.

We measure economic costs as net losses in economic surplus. Tables 7-1 and 7-2 show how losses in surplus are distributed among consumers, domestic producers and society at large. The latter is referred to as "residual" surplus in the tables.

The loss in consumer surplus includes higher outlays for foam plus a dead weight loss due to foregone consumption. As Tables 7-1 and 7-2 indicate, consumers in each market suffer a loss in surplus. These losses are due mostly to higher expenditures on slabstock and molded foam.

We compute the loss in producer surplus as annualized monitoring and emission control costs incurred by plants remaining in operation plus the dead weight loss in surplus due to reduced output less increased revenue due to higher post-control prices. The estimated losses in producer surplus reported in Tables 7-1 and 7-2 are negative, meaning that producers would realize a net gain in economic surplus. This occurs because higher post-control market prices more than offset emission control costs.

Table 7-1

SLABSTOCK FOAM INDUSTRY
ESTIMATES OF ANNUALIZED ECONOMIC COSTS

Regulatory Alternative	Loss in Consumer Surplus (MM$94)	Loss in Producer Surplus (MM$94)	Loss in Residual Surplus (MM$94)	Loss in Surplus Total (MM$94)
MACT Floor	39.05	−19.03	−8.16	11.86
Regulatory Alt. 1	37.64	−20.83	−9.63	7.18

Regulatory Alternative	Loss in Consumer Surplus (MM$94)	Loss in Producer Surplus (MM$94)	Loss in Residual Surplus (MM$94)	Loss in Surplus Total (MM$94)
Regulatory Alt. 2	65.12	−37.97	-16.24	10.92

Table 7-2

MOLDED FOAM INDUSTRY
ESTIMATES OF ANNUALIZED ECONOMIC COSTS

Regulatory Alternative	Loss in Consumer Surplus (MM$94)	Loss in Producer Surplus (MM$94)	Loss in Residual Surplus (MM$94)	Loss in Total Surplus (MM$94)
MACT Floor	0.81	−0.46	−0.16	0.19
Regulatory Alt. 1	8.99	−6.56	−2.38	0.06
Regulatory Alt. 2	12.21	−8.44	−3.05	0.71

Surplus losses to society at large are computed as “residual” adjustments to account for differences in private and social discount rates and transfer effects of taxes. The estimates of changes in producer surplus reflect a 10 percent real private rate on emission control capital costs. Recall that social costs are discounted at a 7.0 percent real rate.[51]

[51] Since the loss in producer surplus measures the burden of the alternative borne by producers, we calculate it using the private cost of capital.

We note that the distribution of economic costs between consumers and domestic producers depends, in part, on the way we have constructed the post-control supply curve. As explained earlier, we have assumed that plants with the highest emission control costs (per unit of output) are marginal in the post-control market. This assumption is worst case in that it results in large increases in prices (relative to an alternative assumption that plants with high control costs are not marginal), thus shifting the cost burden to consumers and away from plants that continue to operate in the post-control market. Any alternative construction of the post-control supply curve would result in smaller price increases and shift a larger share of economic costs away from consumers to domestic producers. In other words, smaller price increases would reduce the economic rent realized by domestic producers in the post-control market.

Earlier, we explained that economic costs differ from emission control costs. Recall that the latter are computed simply as annualized capital costs plus annual operating and maintenance costs, assuming that all plants install controls. Table 7-3 reports estimates of annualized emission control and monitoring costs. These estimates are higher than the economic costs reported in Tables 7-1 and 7-2. Recall that the estimates of economic costs reflect market adjustments to higher prices, while the estimates of emission control costs do not.

Table 7-3

ESTIMATES OF THE ANNUALIZED EMISSION CONTROL COSTS
(Millions of 1994 dollars)

Regulatory Alternative	Slabstock Foam	Molded Foam
MACT Floor	12.14	0.19
Regulatory Alternative 1	7.53	0.07
Regulatory Alternative 2	11.46	0.73

NOTE: Estimates are computed as annualized capital costs plus annual operating, monitoring and maintenance costs, assuming all plants continue to operate after controls are installed. Capital costs are annualized at a 7 percent discount rate.

ECONOMIC EFFICIENCY

A regulatory alternative is economically efficient if it generates larger net benefits (benefits minus costs) than other alternatives. A dominant alternative generates the same or larger total emission reductions at a lower cost than any other alternative. Since we presume that larger emission reductions yield higher benefits, a dominant alternative is economically efficient relative to all other alternatives (since it produces the same or larger benefits at a lower cost).

An inferior alternative, on the other hand, generates the same or smaller emission reductions at a higher cost than at least one other alternative. An inferior alternative is economically inefficient because at least one other alternative generates higher net benefits.

We use the estimates of economic costs (reported in Tables 7-1 and 7-2) for the efficiency analysis. Also, our estimates of emission reductions include lower emission reductions due to controls as well as adjustments for predicted plant closures. Specifically, we assume that emissions fall to zero at plants predicted to close.

Table 7-4 reports the results of the analysis. None of the three regulatory alternatives is clearly dominant. However, the MACT Floor is inferior to both Alternative 1 and Alternative 2. The MACT Floor generates lower annual emission reductions at a higher annual cost than either Alternative 1 or Alternative 2. Therefore, we conclude that the MACT floor is economically inefficient relative to these two regulatory alternatives.

Note that Alternative 2 generates larger emission reductions than Alternative 1, but at higher costs. As a result, the information provided in Table 7-4 is not sufficient to evaluate the economic efficiency of Alternative 2 relative to Alternative 1. Alternative 2 would be efficient relative to Alternative 1 if the additional benefits associated with higher emission reductions (5,647 tons annually) exceed its incremental costs ($4.39 million annually).

Table 7-4

ECONOMIC EFFICIENCY OF REGULATORY ALTERNATIVES

Regulatory Alternative	Annual Economic Costs ($1994MM)	Annual Emission Reduction (tons)
MACT Floor	12.05	10,105
Regulatory Alternative 1	7.24	13,642
Regulatory Alternative 2	11.63	19,289

NOTE: Estimates include costs and emission reductions for both the slabstock and molded foam industry segments.

One final comment on why this analysis is worthwhile. Some of the estimated economic impacts associated with Alternatives 1 and 2 are more adverse than for the MACT Floor (e.g., more closures) even though the MACT Floor gives rise to higher social costs. This occurs because, compared with the MACT Floor, Alternatives 1 and 2 impose higher compliance costs on marginal (higher cost) plants, but more than offsetting lower costs on non-marginal plants. Thus, while the MACT Floor is inferior, some of its economic impacts are less severe than those for Alternatives 1 and 2. In other words, some of the distributional impacts of the MACT floor are less severe than those of the other regulatory alternatives.

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APPENDIX A

AFFECTED PLANTS AND EMISSION CONTROL COSTS

This appendix describes the model plants and the estimates of emission control and monitoring costs used in this study.

AFFECTED PLANTS

The model plants used in the analyses are characterized by product type (either molded or slabstock foam) and production quantity. Tables A-1 and A-2 describe the model plants used in the molded and slabstock sector analyses.

Table A-1

MOLDED FOAM MODEL PLANT BASELINE PARAMETERS

	HP1	LP1	LP2	LP3
Foam production range (tons/yr)	0-15,000	0-99	100-499	>499
Average foam production (tons/yr)	3,331	26	308	2,718

Number of facilities represented	27	109	54	44
Model plant emissions (tons/yr)	2.09	5.29	19.81	28.66

Source: EC/R Incorporated (1996a).

Table A-2

SLABSTOCK FOAM MODEL PLANT BASELINE PARAMETERS

	MP 1	MP 2	MP 3	MP 4	MP 5
Foam production range (tons/yr)	0-3.9	4.0-7.9	8.0-11.9	12.0-15.9	>15.9
Average foam production (tons/yr)	2,000	6,000	10,000	13,750	19,000
Number of facilities represented	19	28	14	11	6
Model plant (a) emissions (tons/yr)	64.19	174.16	339.42	343.93	388.53
Model plant (b) emissions (tons/yr)	59.19	169.16	334.42	338.93	383.53

Source: EC/R Incorporated (1996a).

MOLDED FOAM

There are four molded foam production model plants. One of these model plants represents larger molded foam facilities using high-pressure mixheads (HP1), primarily to produce automobile seats. The remaining three model plants represent smaller producers that use low-pressure mixheads (LP1, LP2, LP3) to produce a variety of foam products. Model plant impacts and compliance control costs were developed for a number of technologies to bring the following source types into compliance:

- mixhead flushing,
- mold release agents,
- repair adhesive.

Emission Control Costs

Model plant impacts were developed for four technologies to reduce or eliminate mixhead flushing emissions: work practices for Regulatory Alternative 1; and non-HAP flushes, high pressure mixheads, and self-cleaning mixheads for Regulatory Alternative 2. Table A-3 presents a summary of the model plant costs and emission reductions for mixhead flushing compliance.

For all regulatory alternatives, the level of control for mold release agents is the prohibition of the use of HAP-based mold release agents, resulting in a 100 percent emission reduction. Model plant impacts were developed for three technologies that can achieve this level: reduced volatile organic compound (VOC) mold release agents, naphtha-based mold release agents, and water-based mold release agents. A summary of mold release agent model plant impacts is contained in Table A-4.

Table A-3

MOLDED FOAM MODEL PLANT IMPACTS FOR TECHNOLOGIES
TO REDUCE MIXHEAD FLUSHING HAP EMISSIONS

Technology	HP1	LP1	LP2	LP3
Non-HAP Flush				
Capital Investment ($)	0	0	0	0
Annual Cost ($/yr)	0	(920)	(3,823)	(8,065)
Emission Reduction (tons/yr)	0	5.14	19.69	21.31
Cost Effectiveness ($/ton)	0	[a]	[a]	[a]
High-Pressure Mixhead				
Capital Investment ($)	0	658,125	658,125	658,125
Annual Cost ($/yr)	0	163,815	146,107	112,535
Emission Reduction (tons/yr)	0	5.14	19.69	21.31
Cost Effectiveness ($/ton)	0	31,871	7,420	5,281

Self-Cleaning Mixhead				
Capital Investment ($)	0	225,688	225,688	225,688
Annual Cost ($/yr)	0	34,938	17,231	(16,341)
Emission Reduction (tons/yr)	0	5.14	19.69	21.31
Cost Effectiveness ($/ton)	0	6,797	875	[a]
Solvent Recovery System				
Capital Investment ($)	0	47,250	47,250	47,250
Annual Cost ($/yr)	0	23,412	10,131	(15,048)
Emission Reduction (tons/yr)	0	3.86	14.77	15.98
Cost Effectiveness ($/ton)	0	6,073	686	[a]

$ are 1994 dollars.

a Cost effectiveness not calculated because net annualized cost is a negative quantity (cost savings).

Sources: EC/R Incorporated (1996a and 1996b).

For all regulatory alternatives, the level of control for repair adhesives is also the prohibition of the use HAP-based adhesives, resulting in a 100 percent emission reduction. Model plant impacts were developed for three technologies that can achieve this level: hot-melt adhesives, water-based adhesives, and hydrofuse adhesives. Table A-5 provides a summary of repair adhesive model plant impacts.

Table A-4

MOLDED FOAM MODEL PLANT IMPACTS FOR TECHNOLOGIES
TO REDUCE MOLD RELEASE AGENT HAP EMISSIONS

Technology	HP1	LP1	LP2	LP3
Reduced-VOC Agent				
Capital Investment ($)	0	0	0	0
Annual Cost ($/yr)	0	50	39	1,023
Emission Reduction	0	0.15	0.12	6.00
(tons/yr)	0	337	328	171
Cost Effectiveness ($/ton)				
Naphtha-Based Agent				
Capital Investment ($)	0	05	0	0
Annual Cost ($/yr)	0	375	293	7,599
Emission Reduction	0	0.15	0.12	6.00
(tons/yr)	0	2,500	2,439	1,267
Cost Effectiveness ($/ton)				
Water-Based Agent				
Capital Investment ($)	0	0	0	0
Annual Cost ($/yr)	0	48	38	981
Emission Reduction	0	0.15	0.12	6.00
(tons/yr)	0	323	315	163
Cost Effectiveness ($/ton)				

$ are 1994 dollars.

Sources: EC/R Incorporated (1996a and 1996b).

In calculating nationwide regulatory impacts, only major sources of HAP will be subject to the Foam Production NESHAP. Since the high-pressure molded model plant and the smallest low-pressure molded model plant have emissions below the major source thresholds, it was assumed that the facilities represented by these model plants would not be affected by the NESHAP. Therefore, nationwide regulatory alternative impacts are based on the costs and emission reductions associated with the production facilities represented by model plants LP2 and LP3.

Table A-5

MOLDED FOAM MODEL PLANT IMPACTS FOR TECHNOLOGIES TO REDUCE HAP EMISSIONS FROM THE USE OF FOAM ADHESIVES

Technology	HP1	LP1	LP2	LP3
Hot-Melt Adhesive				
Capital Investment ($)	6,804	0	0	6,804
Annual Cost ($/yr)	6,377	0	0	1,869
Emission Reduction (tons/yr)	2.09	0	0	1.35
Cost Effectiveness ($/ton)	3,047	0	0	1,384
Hydrofuse Adhesive				
Capital Investment ($)	5,670	0	0	5,670
Annual Cost ($/yr)	738	0	0	1,001
Emission Reduction (tons/yr)	2.09	0	0	1.35
Cost Effectiveness ($/ton)	353	0	0	5,281
Water-Based Adhesive				
Capital Investment ($)	0	0	0	0
Annual Cost ($/yr)	(854)	0	0	(97)
Emission Reduction (tons/yr)	2.09	0	0	1.35
Cost Effectiveness ($/ton)	[a]	0	0	[a]

$ are 1994 dollars.

a Cost effectiveness not calculated because net annualized cost is a negative quantity (cost savings).

Sources: EC/R Incorporated (1996a and 1996b).

For affected model plants, a compliance technology (corresponding to the above tables) is assigned to each source type. Table A-6 gives the distribution of technologies to model plants and source types used to estimate the molded foam nationwide regulatory alternative costs. Since different technologies (with different costs) can bring a source type into compliance, nationwide impacts are dependent upon the compliance technology chosen by the plant.

Table A-6

DISTRIBUTION OF TECHNOLOGIES USED TO ESTIMATE
THE MOLDED FOAM NATIONWIDE REGULATORY
ALTERNATIVE COSTS BY MODEL PLANT

Emission Source/Technology	Number of Facilities with the Assigned Technology	
	LP2	LP3
Mixhead Flush		
Reg Alt I		
Solvent recovery	54	44
Reg Alt II		
Non-HAP flush	54	35
HP mixheads	0	9
Mold Release Agents		
All Regulatory Alternatives		
Reduced VOC agents	18	15
Naphtha-based agents	18	14
Water-based agents	18	15
Repair Adhesives		
All Regulatory Alternatives		
Hot-melt adhesives	N/A	22
Water-based adhesives	N/A	22

Sources: EC/R Incorporated (1996a and 1996b).

While Table A-6 shows the assumed distributions of control technologies adopted by model plants for each emission source separately, it does not give the distribution for combinations of control technologies. For example, under Alternative 2, 35 of 44 LP3 type model plants are assumed to adopt non-HAP flush to control mixhead flush and 15 to adopt reduced VOC agents to control mold release agents. However, Table A-6 does not show how many LP3 plants adopt non-HAP flush *and* reduced VOC agents. For the economic impact analysis, we assume that model plants adopt combinations of control technologies consistent with the proportions shown in Table A-6. For example, we assume that 34 percent (15 of 44) of the 35 plants using non-HAP flush also use reduced VOC agents. We note, however, that the estimated impacts presented in this report are not sensitive to assumptions about the distribution of combinations of control technologies as long as *some* plants adopt the most costly combinations. The economic impacts are driven by the level of control costs facing the highest cost producers, and not the number of high cost producers.

Table A-7

SLABSTOCK FOAM MODEL PLANT COSTS
FOR STORAGE/UNLOADING

	MP1	MP2	MP3
Regulatory Alternative 1 and			
MACT Floor	8,220	12,330	4,110
Capital Investment ($)	1,673	1,756	438
Annual Cost ($/yr)	0.083	0.247	0.494
Emission Reduction (tons/yr)	20,218	9,700	887
Cost Effectiveness ($/ton)			
Regulatory Alternative 2			
Capital Investment ($)	4,110	8,220	
Annual Cost ($/yr)	873	1,740	N/A
Emission Reduction (tons/yr)	0.000095	0.000475	
Cost Effectiveness ($/ton)	9,186,710	3,673,295	

$ are 1994 dollars.

Sources: EC/R Incorporated (1996a and 1996b).

SLABSTOCK FOAM MODEL PLANTS

There are five basic model plants for slabstock foam, each representing a range of production. Each basic model plant is separated into facilities that use $MeCl_2$ as an equipment cleaner, and facilities that do not (e.g. MP1a uses $MeCl_2$ as an equipment cleaner and MP1b does not). Model plant impacts and compliance control costs were developed for a number of technologies to bring the following source types into compliance:

- storage/unloading,

- equipment cleaning,
- equipment leaks,
- HAP auxiliary blowing agent (ABA) emissions.

The MACT floor level of control for storage and unloading of both TDI and HAP ABA is an equipment standard that requires either a vapor balance system to return the displaced HAP vapors to the tank truck or rail car, or a carbon canister through which emissions must be routed prior to being emitted to the atmosphere. The subsequent regulatory alternatives do not contain more stringent requirements. The model plant impacts are based on the installation of vapor balance. The slabstock foam production model plant costs for storage/unloading emission control are provided in Table A-7. There are no costs for model plants 4 and 5 because all TDI and $MeCl_2$ storage tanks at these model plants are assumed to be controlled at baseline.

The MACT floor level of control for equipment cleaning is the complete elimination of HAP emissions. The subsequent regulatory alternatives do not contain more stringent requirements. Model plant costs were developed for the use of non-HAP equipment cleaners. These costs are shown in Table A-8. The amount of $MeCl_2$ used to clean the equipment is consistent for all model plants. Therefore, the impacts shown in Table A-8 are applicable for all model plants.

The MACT floor level of control for equipment leaks was determined to be sealless pumps for TDI transfer pumps. The first regulatory alternative adds a unique LDAR program for HAP ABA components. Since Regulatory Alternative 2 does not allow the emission of any HAP ABA (which, in effect, prohibits the use of $MeCl_2$ or any other HAP as an ABA), this alternative only contains the MACT floor requirement for TDI pumps. Table A-9 shows model plant MACT floor level impacts. Table A-10 shows model plant Regulatory Alternative 1 impacts.

Table A-8

SLABSTOCK FOAM MODEL PLANT COSTS FOR EQUIPMENT CLEANING

EQUIPMENT CLEANING IMPACTS FOR ALL REGULATORY SCENARIOS FOR ALL MODEL PLANTS	
Capital Cost	$0
Annual Cost	($275)
Emission Reduction	5.0 tons/yr
Cost Effectiveness	N/A

$ are 1994 dollars.
Sources: EC/R Incorporated (1996a and 1996b).

Table A-9

MACT FLOOR SLABSTOCK FOAM MODEL PLANT EQUIPMENT LEAK IMPACTS

Model Plant	Capital Cost ($1994)	Annual Cost ($/yr)	Emission Reduction (ton/yr)	Cost Effectiveness ($/ton)
1	5,000	932	0.33	2,800
2,3,4,5	N.A.	N.A.	N.A.	N.A.

$ are 1994 dollars.
Sources: EC/R Incorporated (1996a and 1996b).

Table A-10

ALTERNATIVE 1 SLABSTOCK FOAM MODEL PLANT EQUIPMENT LEAK IMPACTS

Model Plant	Capital Cost ($1994)	Annual Cost ($/yr)	Emission Reduction (ton/yr)	Cost Effectiveness ($/ton)
1	12,544	7,245	1.2	6,038
2	7,544	5,980	1.0	5,980

3	7,544	5,980	1.0	5,980
4	7,544	5,980	1.0	5,980
5	7,431	5,810	0.8	7,263

Source: EC/R Incorporated (1996c).

There are three levels of control for HAP ABA emissions. The MACT Floor and Regulatory Alternative 1 have emission limits based on formulation limitations. Applying the two sets of formulation limitations to the product mix of the model plants results in the emission reductions shown in Table A-11. The second regulatory alternative requires the complete elimination of HAP ABA emissions.

Table A-11

MODEL PLANT HAP ABA
REGULATORY ALTERNATIVE EMISSION REDUCTIONS

Model Plant	Baseline HAP ABA Emissions (tons/yr)	HAP ABA Emission Reduction (tons/yr)		
		MACT Floor	Reg Alt 1	Reg Alt 2
1	55.0	31.3	35.9	55.0
2	165.0	93.8	111.7	165.0
3	330.0	184.0	220.7	330.0
4	335.0	195.9	235.7	335.0
5	380.0	220.4	266.0	380.0

Sources: EC/R Incorporated (1996a, 1996b, and 1996d).

For each level of control, model plant impacts were developed for several technologies. While there are numerous technologies available to reduce HAP ABA emissions, the effectiveness of individual technologies is widely disputed within the foam industry. Therefore, the engineering contractor made assumptions, based on their knowledge of the industry, regarding the technologies that could be used to meet each of the three HAP ABA levels of control. Table A-12 shows the technologies assumed for each regulatory alternative level.

Table A-12

TECHNOLOGIES CAPABLE OF ACHIEVING HAP ABA REGULATORY ALTERNATIVE LEVELS

Regulatory Alternative	Technology
MACT Floor Level	Chemical alternatives Carbon dioxide as an ABA Acetone as an ABA Variable pressure foaming Forced cooling
Regulatory Alternative 1	Carbon dioxide as an ABA Acetone as an ABA Variable pressure foaming Forced cooling
Regulatory Alternative 2	Carbon dioxide plus chemical alternatives Acetone as an ABA Variable pressure foaming Forced cooling plus chemical alternatives

Source: EC/R Incorporated (1996a).

As can be seen in Table A-12, some technologies can be used to meet more than one level of control. In these cases, it was assumed that the technologies would only be used to the degree necessary to meet the level of the regulatory alternative. In other words, although variable pressure foaming can be used to totally eliminate the use of HAP ABA, it was assumed that at the MACT floor level, the amount of $MeCl_2$ allowed would still be used and emitted. Tables A-13 through A-17 provide model plant costs associated with the compliance technologies found in Table A-12.

Table A-13

SLABSTOCK FOAM MODEL PLANT COSTS FOR CHEMICAL ALTERNATIVES HAP ABA EMISSION REDUCTION

	Model Plant Costs				
	MP1	MP2	MP3	MP4	MP5
MACT Floor					
Capital Investment ($)	31,725	31,725	31,725	31,725	31,725
Annual Cost ($/yr)	54,523	151,713	274,276	335,202	378,997
Emission Reduction (tons/yr)	31.3	93.8	184.0	195.9	220.4
Cost Effectiveness ($/ton)	1,742	1,617	1,491	1,711	1,720

$ are 1994 dollars.
Sources: EC/R Incorporated (1996a and 1996b).

Table A-14

SLABSTOCK FOAM MODEL PLANT COSTS FOR CARDIO HAP ABA EMISSION REDUCTION

	Model Plant Costs				
	MP1	MP2	MP3	MP4	MP5
MACT Floor					
Capital Investment ($)	31,725	31,725	31,725	31,725	31,725
Annual Cost ($/yr)	54,523	151,713	274,276	335,202	378,997
Emission Reduction (tons/yr)	31.3	93.8	184.0	195.9	220.4
Cost Effectiveness ($/ton)	1,742	1,617	1,491	1,711	1,720
Regulatory Alternative 1					
Capital Investment ($)	429,300	429,300	429,300	429,300	429,300
Annual Cost ($/yr)	66,354	23,254	(42,403)	(38,631)	(43,559)
Emission Reduction (tons/yr)	37.9	113.7	222.7	237.7	268.0
Cost Effectiveness ($/ton)	1,751	204	[a]	[a]	[a]
Regulatory Alternative 2 - CarDio plus Chemical Alternatives					
Capital Investment ($)	461,025	461,025	461,025	461,025	461,025
Annual Cost ($/yr)	84,163	27,660	(29,666)	17,561	16,227
Emission Reduction (tons/yr)	55	165	330	335	380
Cost Effectiveness ($/ton)	1,530	168	[a]	52	43

$ are 1994 dollars.
a. Cost effectiveness not calculated because net annualized cost is a negative quantity (cost savings).

Sources: EC/R Incorporated (1996a and 1996b).

Table A-15

SLABSTOCK FOAM MODEL PLANT COSTS FOR
ACETONE ABA EMISSION REDUCTION

	Model Plant Costs				
	MP1	MP2	MP3	MP4	MP5
MACT Floor					
Capital Investment ($)	194,000	31,725	31,725	31,725	31,725
Annual Cost ($/yr)	35,121	151,713	274,276	335,202	378,997
Emission Reduction (tons/yr)	31.3	93.8	184.0	195.9	220.4
Cost Effectiveness ($/ton)	1,122	1,617	1,491	1,711	1,720
Regulatory Alternative 1					
Capital Investment ($)	194,000	429,300	429,300	429,300	429,300
Annual Cost ($/yr)	32,455	23,254	(42,403)	(38,631)	(43,559)
Emission Reduction (tons/yr)	37.9	113.7	222.7	237.7	268.0
Cost Effectiveness ($/ton)	856	204	[a]	[a]	[a]
Regulatory Alternative 2					
Capital Investment ($)	194,000	194,000	194,000	194,000	194,000
Annual Cost ($/yr)	25,306	(22,633)	(99,520)	(101,750)	(121,840)
Emission Reduction (tons/yr)	55	165	330	335	380
Cost Effectiveness ($/ton)	460	[a]	[a]	[a]	[a]

$ are 1994 dollars.
a. Cost effectiveness not calculated because net annualized cost is a negative quantity (cost savings).
Sources: EC/R Incorporated (1996a and 1996b).

Table A-16

SLABSTOCK FOAM MODEL PLANT COSTS FOR
VARIABLE PRESSURE FOAMING HAP ABA EMISSION REDUCTION

	Model Plant Costs				
	MP1	MP2	MP3	MP4	MP5
MACT Floor					
Capital Investment ($)	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000
Annual Cost ($/yr)	774,400	724,400	652,240	642,720	623,120
Emission Reduction (tons/yr)	31.3	93.8	184.0	195.9	220.4
Cost Effectiveness ($/ton)	24,741	7,723	3,545	3,281	2,827
Regulatory Alternative 1					
Capital Investment ($)	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000
Annual Cost ($/yr)	769,120	708,480	621,280	609,280	585,040
Emission Reduction (tons/yr)	37.9	113.7	222.7	237.7	268.0
Cost Effectiveness ($/ton)	20,293	6,231	2,790	2,563	2,183
Regulatory Alternative 2					
Capital Investment ($)	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000
Annual Cost ($/yr)	755,440	667,486	535,531	531,546	495,679
Emission Reduction (tons/yr)	55	165	330	335	380
Cost Effectiveness ($/ton)	13,735	4,047	1,623	1,587	1,305

$ are 1994 dollars.
Sources: EC/R Incorporated (1996a and 1996b).

Table A-17

SLABSTOCK FOAM MODEL PLANT COSTS FOR
FORCED COOLING HAP ABA EMISSION REDUCTION

	Model Plant Costs				
	MP1	MP2	MP3	MP4	MP5
MACT Floor					
Capital Investment ($)	1,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Annual Cost ($/yr)	162,500	305,180	243,300	243,418	237,310
Emission Reduction (tons/yr)	31.3	93.8	184.0	195.9	220.4
Cost Effectiveness ($/ton)	5,192	3,254	1,322	1,243	1,076
Regulatory Alternative 1					
Capital Investment ($)	1,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Annual Cost ($/yr)	157,220	289,260	212,340	209,978	199,230
Emission Reduction (tons/yr)	37.9	113.7	222.7	237.7	268.0
Cost Effectiveness ($/ton)	4,148	2,544	953	883	743
Regulatory Alternative 2 Forced Cooling plus Chemical Alternatives					
Capital Investment ($)	1,031,725	2,031,725	2,031,725	2,031,725	2,031,725
Annual Cost ($/yr)	167,441	308,350	227,636	217,033	207,189
Emission Reduction (tons/yr)	55	165	330	335	380
Cost Effectiveness ($/ton)	3,044	1,869	690	648	545

$ are 1994 dollars.
Sources: EC/R Incorporated (1996a, 1996b and 1996c).

Table A-18 shows the distribution of ABA emission reduction technologies used to estimate slabstock foam nationwide regulatory alternative costs by model plant. Note, Appendix D contains sensitivity analyses of regulatory impacts when technology combination assumptions are modified.

Table A-18

DISTRIBUTION OF ABA EMISSION REDUCTION TECHNOLOGIES USED TO ESTIMATE THE SLABSTOCK FOAM NATIONWIDE REGULATORY ALTERNATIVE COSTS BY MODEL PLANT

Technology	Number of Facilities Using the Technology				
	MP1	MP2	MP3	MP4	MP5
MACT Floor					
CarDio	4	9	4	4	1
Acetone	1	1	1	1	0
VPF	0	0	0	0	2
Forced Cooling	2	4	3	3	2
Chem Alts	12	14	6	3	1
Reg Alt I					
CarDio	13	18	6	5	1
Acetone	3	4	3	2	1
VPF	0	0	0	0	2
Forced Cooling	3	6	5	4	2
Reg Alt II					
CarDio + Chem Alts	10	15	5	3	1
Acetone	3	3	2	2	1
VPF	0	1	1	2	2
Forced Cooling + Chem Alts	6	9	6	4	2

Sources: EC/R Incorporated (1996a and 1996b).

MONITORING COSTS

In addition to the emission control costs described earlier in this appendix the estimated economic impacts presented in this report include the effects of monitoring, inspection, record-keeping and reporting costs (MIRR) at affected plants. Total annual MIRR costs are estimated for each industry segment as 10 percent of nationwide annual emission control costs. Annual

MIRR costs per plant are estimated as nationwide MIRR costs for the industry segment divided by the number of affected plants in the industry segment.[52]

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[52] EC/R Incorporated (1996d).

APPENDIX B

TECHNICAL DESCRIPTION OF ANALYTICAL METHODS

This technical appendix provides detailed descriptions of the analytical methods employed to conduct the following analyses:

- Partial equilibrium analysis (i.e., computing post-control price, output and trade impacts).
- Estimating changes in economic surplus.
- Labor and energy impacts.
- Capital availability.

We also present the baseline values used in the partial equilibrium analysis.

PARTIAL EQUILIBRIUM ANALYSIS

The partial equilibrium analysis requires the completion of four tasks. These tasks are:

- Specify market demand and supply.
- Estimate the post-control shift in market supply.
- Compute the impact on market quantity.
- Compute the impact on market price.
- Predict plant closures.

The following description of the partial equilibrium model is fully general in that it includes a foreign sector. Recall, however, that trade in flexible foam is negligible. Accordingly, we set foreign supply (net imports) at zero for this study.

Market Demand and Supply

Baseline or pre-control equilibrium in a market is given by:

$$Q_d = \alpha P^{\varepsilon} \quad (B.1)$$

$$Q_s^d = \beta P^{\gamma} \quad (B.2)$$

$$Q_s^f = \rho P^{\gamma} \quad (B.3)$$

$$Q_d = Q_s^d + Q_s^f = Q \quad (B.4)$$

where, Q = output;

P = price;

ε = demand elasticity;

γ = supply elasticity;

α, β and ρ are constants;

Subscripts d and s reference demand and supply, respectively; and,

Superscripts d and f reference domestic and foreign supply, respectively.

The constants α, β and ρ are computed such that the baseline equilibrium price is normalized to one. Note that the market specification above assumes that domestic and foreign supply elasticities are the same.

Market Supply Shifts

Supply price for a model plant will increase by an amount just sufficient to equate the net present value of the investment and operation of the control equipment to zero. Specifically,

$$\frac{[(C\cdot Q) - (V+D)](1-t)+D}{S} = k \tag{B.5}$$

where C is the change in the supply price;

Q is output;

V is a measure of annual operating and maintenance control costs.

t is the marginal corporate income tax rate;

S is the capital recovery factor;

D is annual depreciation (we assume straight-line depreciation);

k is the investment cost of emissions controls.

Solving for C yields the following expression:

$$C = \frac{kS-D}{Q(1-t)} + \frac{V+D}{Q} \tag{B.6}$$

Estimates of k and V were obtained from EPA (1991). The variables, D, I, and S are computed as follows:

$$D = k/T \tag{B.7}$$

and

$$S = r(1+r)^T/((1+r)^T-1) \tag{B.8}$$

where r is the discount rate or cost of capital faced by producers;

T is the life of emission control equipment.

Solving for P in Equation (B.2) yields the following expression for the baseline inverse market supply function for domestic producers.

$$P = (Q_s^d/\beta)^{1/\gamma} \tag{B.9}$$

Emission control costs will raise the supply price of the i^{th} model plant by C_i (as computed in Equation (B.6)). The aggregate domestic market supply curve, however, does not identify the supply price for individual plants. Accordingly, we adopt the worst-case assumption that model plants with the highest after-tax per unit control costs are marginal in the post-control market. Specifically, we write the post-control supply function as

$$P = (Q_s^d/\beta)^{1/\gamma} + C(C_i,q_i) \tag{B.10}$$

where q_i is the total output of all model plants of type i.

The function $C(C_i,q_i)$ shifts segments of the pre-control domestic supply curve vertically by C_i. The width or horizontal distance of each segment is q_i. The resulting segmented post-control domestic supply curve is illustrated in Figure B-1 as S_2, compared with pre-control supply S_1.[53]

[53] The supply curves in Figure B-1 are drawn as linear functions for ease of exposition. Because the supply curves are specified as Cobb-Douglas, they are log-linear.

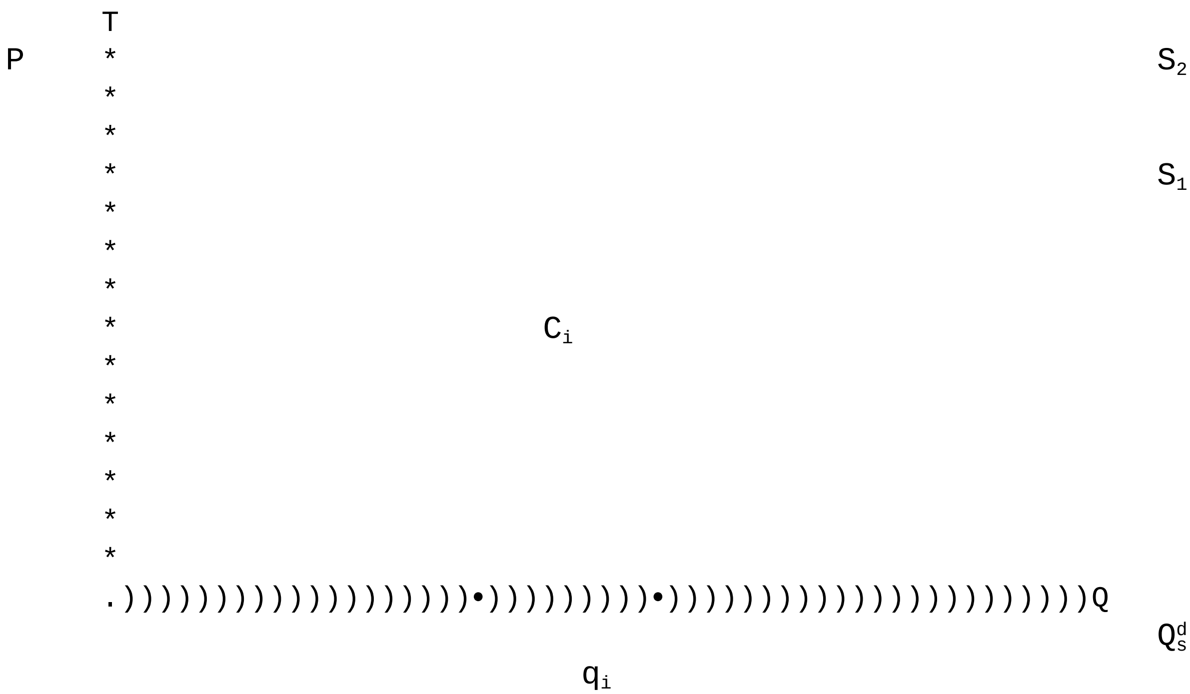

Figure B-1.

Domestic Market Supply Shift Due to Emission Control Costs

<u>Impact on Market Price and Quantity</u>

The impacts of the alternative standards on market output are estimated by solving for post-control market equilibrium and then comparing that output level, Q_2, to the pre-control output level, Q_1. Because post-control domestic supply is segmented, a special iterative algorithm was developed to solve for post-control market equilibrium. The algorithm first searches for the segment in the post-control supply function at which equilibrium occurs and then solves for the post-control market price that clears the market.

Since the market clearing price occurs where demand equals post-control domestic supply plus foreign supply, the algorithm simultaneously solves for the following post-control variables.

- Equilibrium market price.
- Equilibrium market quantity.

We assess the market impacts of control costs by comparing baseline values to post-control values for each of the variables listed above.

We also report the change in the dollar value of shipments by domestic producers. This value, ΔVS, is given by

$$\Delta VS = P_2 \cdot Q_{s_2}^{d} - P_1 Q_{s_1}^{d} \qquad \text{(B.11)}$$

where P_1 and P_2 are, respectively, pre- and post-control market equilibrium prices.

Plant Closures

We predict that any plant will close if its post-control supply price is higher than the post-control equilibrium price. Post-control supply prices are computed by Equation (B.10). We round fractions of plant closures to the nearest integer.

CHANGES IN ECONOMIC SURPLUS

The shift in market equilibrium will have impacts on the economic welfare of three groups:

- Consumers.
- Producers.
- Society at large.

The procedure for estimating the welfare change for each group is presented below. The total change in economic surplus, which is taken as an approximation to economic costs, is computed as the sum of the surplus changes for the three groups.

Change in Consumer Surplus

Consumers will bear a dead weight loss associated with the reduction in output. This loss represents the amount over the pre-control price that consumers would have been willing to pay for the eliminated output. This surplus change is given by:

$$\int_{Q_2}^{Q_1} (Q/\alpha)^{1/\varepsilon}\, dQ - P_1 \cdot (Q_1 - Q_2) \qquad \text{(B.12)}$$

In addition, consumers will have to pay a higher price for post-control output. This surplus change is given by:

$$(P_2 - P_1) \cdot Q_2 \qquad \text{(B.13)}$$

The total impact on consumer surplus, ΔCS, is given by (B.12) plus (B.13). Specifically,

$$\Delta CS = \int_{Q_2}^{Q_1} (Q/\alpha)^{1/\varepsilon}\, dQ - P_1 Q_1 + P_2 Q_2 \qquad \text{(B.14)}$$

This change, ΔCS, includes losses of surplus incurred by foreign consumers. In this report we are only concerned with domestic surplus changes. We have no method for identifying the marginal consumer as foreign or domestic.

To estimate the change in domestic consumer surplus we assume that total consumer surplus is split between foreign and domestic consumers in the same proportion that sales are split between foreign and domestic consumers in the pre-control market. That is, the change in domestic consumer surplus, ΔCS_d, is:

$$\Delta CS_d = \left[1 - \left(\frac{Q_e}{Q^d_{s_1}} + Q^f_{s_1} \right) \right] \Delta CS \qquad \text{(B.15)}$$

While ΔCS is a measure of the consumer surplus change from the perspective of the world economy, ΔCS_d represents the consumer surplus change from the perspective of the domestic economy.

Change in Producer Surplus

To examine the effect on producers, output can be divided into two components:

- Output eliminated as a result of controls.
- Remaining output of controlled plants.

The total change in producer surplus is given by the sum of the two components.

Note that post-tax measures of surplus changes are required to estimate the impacts of controls on producers' welfare. The post-tax surplus change is computed by multiplying the pre-tax surplus change by a factor of (1-t) where t is the marginal tax rate. As a result, every one dollar of post-tax loss in producer surplus will be associated with a complimentary loss of t/(1-t) dollars in tax revenues.

Output eliminated as a result of control costs causes producers to suffer a dead-weight loss in surplus analogous to the dead-weight loss in consumer surplus. The post-tax dead-weight loss is given by:

$$\left[P_1 (Q_{s_1}^d - Q_{s_2}^d) - \int_{Q_{s_2}^d}^{Q_{s_1}^d} (Q/\beta)^{1/\gamma}\, dQ \right] (1-t) \tag{B.16}$$

Plants remaining in operation after controls realize a welfare gain of $P_2 - P_1$ on each unit of output, but incur a per unit welfare loss of C_i. Thus, the post-tax loss in producer surplus for m model plant types remaining in the market is

$$\left[(P_1 - P_2)\, Q_{s_2}^d + \sum_{i=1}^{m} C_i q_i \right] (1-t) \tag{B.17}$$

The total post-tax change in producer surplus, ΔPS, is given by the sum of (B.16) and (B.17). Specifically,

$$\Delta PS = \left[P_1 Q_{s_1}^d - P_2 Q_{s_2}^d - \int_{Q_{s_2}^d}^{Q_{s_1}^d} (Q/\beta)^{1/\gamma}\, dQ + \sum_{i=1}^{m} C_i q_i \right] (1-t) \tag{B.18}$$

Recall that we are interested only in domestic surplus changes. For this reason we do not include the welfare gain experienced by foreign producers due to higher prices. This procedure treats higher prices paid for imports as a dead-weight loss in consumer surplus. Higher prices paid to foreign producers represent a transfer from the perspective of the world economy, but a welfare loss from the perspective of the domestic economy.

Residual Effect on Society

The changes in economic surplus, as measured above, must be adjusted to account for two effects which cannot be attributed specifically to consumers and producers. These two effects are caused by tax impacts and differences between private and social discounts rates.

Two adjustments for tax impacts are required. First, per unit control costs C_i, which are required to predict post-control market equilibrium, reflect after-tax control costs. The true resource costs of emissions controls, however, must be measured on a pre-tax basis. For example, if after-tax control costs exceed pre-tax control costs, C_i overstates the true resource costs of controlling emissions.

A second tax-related adjustment is required because changes in producer surplus have been reduced by a factor of (1-t) to reflect the after-tax welfare impacts of emissions control costs on affected plants. As was noted earlier, a one dollar loss in pre-tax producer surplus imposes an after-tax burden on the affected plant of (1-t) dollars. In turn, a one dollar loss in after-tax producer surplus causes a complimentary loss of t/(1-t) dollars in tax revenues.

A second adjustment is required because of the difference between private and social discount rates. The rate used to shift the supply curve reflects the private discount rate (or the marginal cost of capital to affected firms). This rate must be used to predict the market impacts associated with emission controls. The economic costs of the NESHAP, however, must be computed at a rate reflecting the social cost of capital. This rate is intended to reflect the social opportunity cost of resources displaced by investments in emission controls.[54]

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[54] See Section 7 for a more detailed discussion of this issue.

The adjustment for the two tax effects and the social cost of capital, which we refer to as the residual change in surplus, ΔRS, is given by:

$$\Delta RS = -\sum_{i=1}^{m} (C_i - pc_i) q_i + \Delta PS \cdot [t/(1-t)] \qquad \text{(B.19)}$$

where pc_i = per unit cost of controls for model plant type i, computed as in (B.5) with t=0 and r=social cost of capital.

The first term on the right-hand-side of (B.20) adjusts for the difference between pre- and post-tax differences in emission control costs and for the difference between private and social discount rates. Note that these adjustments are required only on post-control output. The second term on the right-hand-side of (B.19) is the complimentary transfer of the sum of all post-tax producer surplus.

Total Economic Costs

The total economic costs, EC, is given by the sum of changes in consumer and producer surplus plus the change in residual surplus. Specifically,

$$EC = \Delta CS_d + \Delta PS + \Delta RS \qquad \text{(B.20)}$$

LABOR AND ENERGY IMPACTS

Our estimates of the labor and energy impacts associated with the alternative standards are based on input-output ratios and estimated changes in domestic production.

Labor Impacts

Labor impacts, measured as the number of jobs lost due to domestic output reductions, are computed as:

$$\Delta L = \frac{P_1 (Q_{s_1}^{d} - Q_{s_2}^{d}) L_1}{2000} \tag{B.21}$$

where ΔL is the change in employment, L_1 is the production worker hours per dollar of output, and all else is as previously defined. The number 2000 is used to translate production worker hours into jobs (i.e., we assume a 2000 hour work year).

Energy Impacts

We measure the energy impacts associated with the alternative standards as the reduction in expenditures on energy inputs due to output reductions. The method we employ is similar to the procedure described above for computing labor impacts. Specifically,

$$\Delta E = E_1 P_1 \left(Q_{s_1}^{d} - Q_{s_2}^{d} \right) \tag{B.22}$$

where ΔE is the change in expenditures on energy inputs, E_1 is the baseline expenditure on energy input per dollar output and all else is as previously defined.

BASELINE INPUTS

The partial equilibrium model described above requires, as inputs, data on the characteristics of affected plants and baseline values for variables and parameters that characterize each market. The characteristics of affected plants have been described earlier in Appendix A. These include the number of plants by model type and a measure of output for each model plant. Appendix A also reports estimates of capital and annual emission control costs.

Table B-1 reports the baseline values of variables and parameters for each market segment. The baseline prices of slabstock foam are taken from Table 3-5, converted to a weight measure using the average of the densities in the table, and adjusted to 1994 dollars using the GDP implicit deflator. The molded foam price is given at $2.35 per pound in current dollars and adjusted to 1994 dollars using the GDP implicit deflator. Baseline domestic output in each market is computed as the sum of production at all domestic plants (see Appendix A for production rates at slabstock and molded foam plants).

The demand and supply elasticities in Table B-1 are assumed values used in the base case analysis reported in the text of this report. We assess the sensitivity of the estimated impacts to demand elasticity by reporting in Appendix D results based on “low” and “high” estimates.

We use a marginal tax rate of 25 percent to assess the impacts of emission controls. We adopt a 10 percent private discount rate (real marginal cost of capital) and a 7.0 percent social discount rate. The expected life of emission control equipment is 10 years.

Finally, the values for labor hours per unit of output (L_1) and energy use per unit of output (E_1) are computed from the data reported in Tables 3-14, 3-15 and 3-16 and adjusted to 1994 dollars using the GDP implicit deflator. Recall that these data are available at the 4-digit SIC code level. Both slabstock and molded foam products are included in SIC code 3086. For this reason, L_1 and E_1 are the same in both market segments.

CAPITAL AVAILABILITY ANALYSIS

Pre- and post-control values of the following financial measures are compared in the capital availability analyses:

- Net income/assets.

- Long-term debt/long-term debt plus equity.

Pre-Control Financial Measures

Pre-control measures of net income and net income/assets are computed by averaging data for the period 1991 through 1993 where these data are available. The long-term debt ratio is computed from 1993 data, or the most recent year available.

Table B-1

BASELINE INPUTS

Variable/Parameter	MARKET	
	Slabstock	Molded

Price (P_1)[a]	\$2,812	\$4,700
Domestic Output $(Q^d_{s_1})$ [b]	611,250	228,995
Supply Elasticity (ε)	10.0	10.0
Demand Elasticity (γ)	−0.5	−0.5
Tax Rate (t)	0.25	0.25
Private Discount Rate (r)	0.1	0.1
Social Discount Rate	0.07	0.07
Equipment Life (T)[c]	10	10
Labor (L_1)[d]	.01025	.01025
Energy (E_1)[e]	0.022	0.022

Notes:
[a] Dollars (1992) per kilogram (wet weight).
[b] Tons per year.
[c] Years.
[d] Production worker hours per dollar of output.
[e] Energy expenditure per dollar of output.

Then, pre-control values are estimated by:

i) $$n = \sum_{i=1991}^{1993} n_i/4 \quad \text{(B.23)}$$

ii) $$r = \sum_{i=1991}^{1993} (n_i/a_i)/4 \quad \text{(B.24)}$$

iii) $$l = l_{1993}/(l_{1993} + e_{1993}) \quad \text{(B.25)}$$

where n = average net income

n_i = net income in year i

r = average return on assets

a_i = assets in year i

l = long-term debt ratio

l_{1993} = long-term debt in 1993

e_{1993} = equity in 1993

Post-Control Values

To determine the impact of controls, an estimate of the cost of controls is made. In order to get an idea of the steady-state cost, an annualized cost is used. The annualized cost, AC, for a plant is:

$$AC = V + kS \tag{B.26}$$

where the variables are as defined previously.

However, affected firms will realize an increase in revenue, ΔR, because of higher post-control prices. We compute this value as

$$\Delta R = (P_2 - P_1) \cdot q \tag{B.27}$$

where $P_2 - P_1$ is the price change and q is the firm's output.

Annualized costs and capital costs are estimated for each model plant type. For each establishment, post-control measures are given by:

$$pn = \sum_{i=1991}^{1993} \frac{n_i + \Delta R - AC}{4} \tag{B.28}$$

$$pr = \sum_{i=1991}^{1993} \frac{(n_i - \Delta R - AC)/(a_i + k)}{4} \tag{B.29}$$

$$pl = \frac{l_{1993}+k}{l_{1993}+e_{1993}+k} \quad \text{(B.30)}$$

where pn = post-control average net income

AC = annualized cost for the company

pr = post-control return on assets

k = capital cost for the company

pl = post-control long-term debt ratio

APPENDIX C

SENSITIVITY ANALYSES:
DEMAND AND SUPPLY ELASTICITIES

INTRODUCTION

This appendix presents the results of sensitivity analyses that explore the degree to which the results presented earlier in this report are sensitive to estimates of demand and supply elasticities.

SUPPLY AND DEMAND ELASTICITY

The "base case" results presented earlier in this report are based on a demand elasticity of −0.5 and a supply elasticity of 10.0 for both molded and slabstock foam. Below, we report results for "low" and "high" elasticity cases. These alternative cases use the following elasticities values:

- Low demand elasticity: −0.25 for molded and slabstock foam.
- Low supply elasticity: 5.00 for molded and slabstock foam.
- High demand elasticity: −1.00 for molded and slabstock foam.
- High supply elasticity: 50.00 for molded and slabstock foam.

The greater the elasticity of demand and supply (in absolute value), the greater the change in market clearing quantity in response to a given change in price. Therefore, we expect that when we use higher demand and supply elasticities in the partial equilibrium analysis, the reduction in market output will be greater than in the base case. Similarly, when we use lower elasticities, we expect the change in market quantity to be smaller, relative to the base case.

Tables C-1 through C-4 present estimates of the primary economic impacts associated with the alternative forms of the NESHAP for the molded and slabstock industry segments in the case of low and high elasticities. Tables C-1 and C-2 report results based on low elasticities and Tables C-3 and C-4 report results based on high elasticities. Note that these results do not take into consideration the sensitivity analysis conducted in Appendix D for the slabstock segment of the industry. These results assume the distribution of higher-cost control technology.

For the molded foam segment, plant closures and market output impacts are unchanged or less severe under all regulatory alternatives for the low elasticity case. The three predicted closures under Regulatory Alternative I mid-elasticity assumptions are reduced to two closures when a low elasticity is assumed. For the slabstock segment, plant closures and market impacts are also less severe or unchanged under the assumptions of low elasticities. The four predicted closures under Regulatory Alternative 2 mid-elasticity assumptions are reduced to one closure under low elasticity assumptions.

For the molded and slabstock markets, impacts on domestic output, value of domestic shipments, and energy and employment are all more severe under the assumptions of "high" elasticities. Predicted plant closures increase from three under the base case to six for the molded sector under Regulatory Alternative 1. Under the MACT Floor, slabstock closures increase from two under the base case to four under the high elasticity case. Slabstock plant closures under the high elasticity case also increase for Regulatory Alternatives 1 and 2.

Table C-1

SENSITIVITY ANALYSIS: ESTIMATED PRIMARY IMPACTS ON THE SLABSTOCK FOAM MARKET WITH LOW ELASTICITIES

Regulatory Alternative	Price (%)	Market Output (%)	Value of Domestic Shipments (%)	Value of Domestic Shipments ($MM[a])	Plant Closures
MACT Floor	2.66	-0.65	1.99	34.19	2
Alternative 1	3.68	-0.90	2.75	47.23	3
Alternative 2	4.02	-0.98	3.00	51.63	1

[a] 1994$

Note: Results based on demand elasticity of -0.25 and supply elasticity of 5.0 and a distribution of higher-cost control technologies.

Table C-2

SENSITIVITY ANALYSIS: ESTIMATED PRIMARY IMPACTS ON THE MOLDED FOAM MARKET WITH LOW ELASTICITIES

Regulatory Alternative	Price (%)	Market Output (%)	Value of Domestic Shipments (%)	Value of Domestic Shipments ($MM[a])	Plant Closures
MACT Floor	0.07	-0.02	0.06	0.60	0
Alternative 1	0.84	-0.21	0.63	6.75	2
Alternative 2	1.14	-0.28	0.85	9.17	0

[a] 1994$

Note: Results based on demand elasticity of -0.25 and supply elasticity of 5.0.

Table C-3

SENSITIVITY ANALYSIS: ESTIMATED PRIMARY IMPACTS ON THE SLABSTOCK FOAM MARKET WITH HIGH ELASTICITIES

Regulatory Alternative	Price (%)	Market Output (%)	Value of Domestic Shipments (%)	Value of Domestic Shipments ($MM[a])	Plant Closures
MACT Floor	2.35	-2.30	0.00	0.00	4
Alternative 1	2.27	-2.22	0.00	0.00	4
Alternative 2	3.03	-2.94	0.00	0.00	7

[a] 1994$

Note: Results based on demand elasticity of -1.0 and supply elasticity of 50.0 and a distribution of higher-cost control technologies.

Table C-4

SENSITIVITY ANALYSIS: ESTIMATED PRIMARY IMPACTS ON THE MOLDED FOAM MARKET WITH HIGH ELASTICITIES

Regulatory Alternative	Price (%)	Market Output (%)	Value of Domestic Shipments (%)	Value of Domestic Shipments ($MM[a])	Plant Closures
MACT Floor	0.08	-0.08	0.00	0.00	0
Alternative 1	0.86	-0.85	0.00	0.00	6
Alternative 2	1.17	-1.16	0.00	0.00	1

[a] 1994$

Note: Results based on demand elasticity of -1.0 and supply elasticity of 50.0.

APPENDIX D

SENSITIVITY ANALYSIS OF EMISSION CONTROL TECHNOLOGIES

This appendix presents the results of sensitivity analyses that explore the degree to which predicted plant closures in the slabstock sector are sensitive to the assignment of control technologies. As has been previously discussed, there are several different technologies which can satisfy the requirements of the regulatory alternatives. When calculating nationwide regulatory costs, assumptions have been made as to the specific technology, or combination of technologies, that model plants would adopt (and thus the costs that would be incurred). Different assumptions about which control technology combinations plants will adopt affect the costs and impacts of the alternatives.

Predicted closures for the slabstock segment are sensitive to control technology assignments. Tables A-15 and A-17 (see Appendix A), show that Acetone and Forced Cooling provide the same level of emission reductions at very different costs. General economic principle dictates that given the comparable performance of the control technologies, facilities would choose the lowest-cost option. However, because there are facilities in the industry using the higher-cost technology in favor of the lower-cost options, the EPA includes the higher-cost technology in the distribution of technologies to model plants. As Table D-1 indicates, switching compliance technologies chosen by model plants MP2 and MP3 (from forced cooling to acetone) will decrease predicted plant closures from two to one under the MACT Floor, from three to one under Regulatory Alternative 1, and from four to one under Regulatory Alternative 2.

Table D-1

PREDICTED PLANT CLOSURES WITH REASSIGNMENT OF SLABSTOCK ABA EMISSION REDUCTION TECHNOLOGIES

Technology		Number of Facilities Using the Technology (Original)		Number of Facilities Using the Technology (Revised)		Predicted Closures	
		MP1	MP2	MP1	MP2	Original	Revised
MACT Floor						2	1
	Cardio	4	9	4	9		
	Acetone	1	1	3	5		
	VPF	0	0	0	0		
	Forced Cooling	2	4	0	0		
	Chem Alts	12	14	12	14		
Reg Alt I						3	1
	Cardio	13	18	13	18		
	Acetone	3	4	6	10		
	VPF	0	0	0	0		
	Forced Cooling	3	6	0	0		
Reg Alt II						4	1
	Cardio + Chem Alts	10	15	10	15		
	Acetone	3	3	9	3		
	VPF	0	1	0	1		
	Forced Cooling +Chem Alts	6	9	0	9		

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The report evaluates the distribution of economic impacts among various members of society (producers and consumers) from the regulatory alternatives considered for the Flexible Polyurethane Foam NESHAP.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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