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Air

Economic Impact Analysis for the Proposed Miscellaneous Cellulose Manufacturing Industry NESHAP

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EXECUTIVE SUMMARY

This report analyzes the economic impacts of a proposed air pollution regulation to reduce emissions of several hazardous air pollutants (HAPs) generated in the manufacturing of miscellaneous cellulose products. There are two major categories of cellulose products: the viscose category and the ether category. The viscose category is composed of cellulose food casings, cellophane, rayon, and cellulosic sponges. The various types of ethers are grouped together under the ether heading. The HAPs emitted differ between the two categories. Carbon disulfide (CS_2) is the primary HAP emitted during the production of viscose products, but hydrogen sulfide is generated as well. For the ethers, the main pollutants emitted during production are methanol, methyl chloride, ethylene oxide, and propylene oxide.

How do emissions of HAPs occur in the production of miscellaneous cellulose products?

Emissions of HAPs from the production of miscellaneous cellulose products originate from the transfer and storage of CS_2; equipment leaks from piping and tanks; process vents (e.g., xanthation, regeneration/washing, acid/salt recovery, and solvent coating operations); and wastewater.

Which markets are affected by the regulation?

The major affected markets are those for food casings; fibers; sponges; flexible packaging materials; and binders, viscosifiers, and thickeners. Although the proposed regulation affects only the cellulose products in these markets, its impact is expected to be felt in the broader markets in which these products compete. The amount cellulose producers are willing to sell is expected to decrease after the regulation; as a result, the prices of both the cellulose product and its substitutes should increase.

Which producers will be affected?

The directly affected producers are the 14 miscellaneous cellulose manufacturing facilities that are currently (using a 1998 baseline) classified as major sources of HAPs. Both new and existing facilities will be affected. A total of 11 companies are identified as owners of the 14 existing facilities.

How many small businesses will be affected?

Based on Small Business Administration (SBA) definitions, there is one small company in this industry that owns and operates a single facility.

What are the compliance costs associated with the regulation?

The costs that each facility will incur include capital costs; operating and maintenance costs; monitoring, recordkeeping, and reporting costs; and lost production costs (operating costs and lost profits while process changes are implemented). These costs are partially offset for the viscose category by the savings due to increased recapture of CS_2 under the regulation. On an annualized basis, the net compliance costs for viscose plants operating in 1998 were estimated at $7.7 million for regulatory alternative (RA) I and $14.3 million under the more stringent RA II. For cellulose ether plants operating in 1998, the compliance costs were estimated at $289,000 under RA I and $402,000 under RA II.

How large are the compliance costs relative to sales for the entire industry?

Cost-to-sales ratios (CSRs) were calculated by dividing the regulatory compliance costs by facility revenue. For RA I, 8 of the 14 facilities have CSRs below 1 percent, 4 have CSRs between 1 and 3 percent, and 2 facilities have CSRs above 3 percent. For RA II, 7 facilities have CSRs below 1 percent, 3 have CSRs between 1 and 3 percent, and 4 have CSRs of greater than 3 percent. Table ES-1 presents summary statistics for these ratios.

Table ES-1. Full-Cost Absorption: Facility-Level Annualized Compliance Cost-to-Sales Ratios

	Variable Compliance Cost-to-Sales Ratio		Total Compliance Cost-to-Sales Ratio	
	Minimum	Maximum	Minimum	Maximum
Regulatory Alternative 1	0.01%	1.52%	0.02%	4.52%
Regulatory Alternative 2	–0.05%	1.19%	0.04%	6.60%

What are the overall expected effects on prices, output, and profits?

Market models including effects on prices and output were estimated for three markets that include cellulose products: fiber (i.e., rayon, cotton, polyester), food casings, and cellulosic sponges. Compliance costs in the other two cellulose product markets (cellophane and cellulose ethers) were judged to be too small to justify modeling their marketwide impacts. RA I is expected to increase prices by less than 0.2 percent in each of the three modeled markets, leading to a decrease in output of less than 0.2 percent and a decrease in operating profits of 2.1 percent for food casings, 17.5 percent for sponges, and 23.7 percent for fiber (see Table ES-2). Under RA II, prices are expected to increase by less than 0.2 percent for all three markets; output is expected to decrease by less than 0.2 percent; and operating profits are expected to decrease by 3.9 percent for food casings, 17.5 percent for sponges, and 56.0 percent for fiber.

Table ES-2. Market-Level Impacts

	Regulatory Alternative I	Regulatory Alternative II
Fiber (rayon, cotton, polyester)		
Market price ($/lb)	<0.01%	0.01%
Market quantity (10^6 lbs/yr)	<0.01%	–0.01%
Domestic	<0.01%	–0.01%
Directly affected	–0.19%	–0.79%
Indirectly affected	<0.01%	0.01%
Foreign	<0.01%	0.01%
Food Casings		
Market price ($/lb)	0.19%	0.14%
Market quantity (10^6 lbs/yr)	–0.19%	–0.14%
Domestic	–0.28%	–0.21%
Directly affected	–0.55%	–0.42%
Indirectly affected	0.19%	0.14%
Foreign	0.19%	0.14%
Cellulosic Sponges		
Market price ($/unit)	0.14%	0.14%
Market quantity (10^6 units/yr)	–0.14%	–0.14%
Domestic	–0.14%	–0.14%
Directly affected	–0.20%	–0.20%
Indirectly affected	0.14%	0.14%
Foreign	NA	NA

NA = Not available

What are the predicted effects of the regulation on employment in the industry?

Employment is expected to decrease by seven individuals under RA I and by 12 individuals under RA II.

Are any facilities predicted to close under the regulation?

With respect to the modeled baseline conditions, no product-line or facility closures are predicted because of either RA I or II. However, if rayon producers continue to face the declining market trends of recent years, closures in this category may occur (even without the proposed regulation).

What are the total social costs of this regulation?

The total social costs of this regulation are estimated to be $8.0 million for RA I and $14.7 million for RA II. For RA I, a breakdown of the social costs for the three products used in the market model (fiber, food casings, sponges) reveals a consumer surplus loss of $1.2 million, while these directly affected producers suffer a $7.1 million producer surplus loss, indirectly affected domestic producers gain $0.4 million in producer surplus, and foreign producers gain $0.2 million (see Table ES-3). There is also a producer surplus loss of $0.3 million to the directly affected cellophane and ether producers. For RA II, the consumer surplus loss of the regulation was estimated to be $1.4 million, while directly affected producers face a $13.9 million loss in producer surplus, indirectly affected domestic producers are expected to gain $0.8 million in producer surplus, and foreign producers are expected to gain $0.2 million. There is also a producer surplus loss of $0.4 million for cellophane and cellulose ether producers.

Table ES-3. Distribution of Social Costs

	Regulatory Alternative I		Regulatory Alternative II	
Consumer Surplus Loss/Gain	**–$1.2**		**–$1.4**	
Producer Surplus Loss/Gain	**–$6.8**		**–$13.3**	
Directly affected[a]		–$7.4		–$14.3
Indirectly affected		$0.6		$1.0
Social Costs of Regulation	**–$8.0**		**–$14.7**	

[a] Includes producer surplus loss for ether and cellophane producers where the change in producer surplus = engineering cost estimate.

SECTION 1

INTRODUCTION

Miscellaneous cellulose products include goods such as sponges, rayon, ethers, cellophane, and food casings that are used directly by consumers and indirectly in the manufacture of a variety of other products. These goods are produced by a heterogeneous group of facilities that share cellulose as their primary input. Although the products of the miscellaneous cellulose manufacturing industry are valued by their users, their production results in the release of hazardous air pollutants (HAPs) into the environment. Under Section 112 of the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) is required by November 15, 2000, to promulgate national emission standards for hazardous air pollutants (NESHAP) for the source category that manufactures miscellaneous cellulose products. To inform this rulemaking, EPA's Innovative Strategies and Economics Group (ISEG) has developed an economic impact analysis (EIA) to estimate the potential social costs of the regulation. This report presents the results of this analysis in which a market model was used to analyze the impacts of the air pollution rule on society.

1.1 Agency Requirements for an EIA

Congress and the Executive Office have imposed statutory and administrative requirements for conducting economic analyses to accompany regulatory actions. Section 317 of the CAA specifically requires estimation of the cost and economic impacts for specific regulations and standards proposed under the authority of the Act. In addition, Executive Order (EO) 12866 requires a more comprehensive analysis of benefits and costs for proposed *significant* regulatory actions.[1] Other statutory and administrative requirements include examination of the composition and distribution of benefits and costs. For example, the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement and Fairness Act of 1996 (SBREFA), requires EPA to consider the economic impacts of regulatory actions on small entities. The Agency's *Economic Analysis Resource*

[1] Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is required only when the regulatory action has an annual effect on the economy of $100 million or more.

Document provides detailed instructions and expectations for economic analyses that support rulemaking (EPA, 1999). These requirements are fulfilled by examining the effect of the regulatory alternatives on the following:

- miscellaneous cellulose manufacturing facility-level impacts,
- miscellaneous cellulose manufacturing company-level impacts,
- miscellaneous cellulose manufacturing product market-level impacts, and
- societal-level impacts.

1.2 Scope and Purpose

This report evaluates the economic impacts of pollution control requirements in the production of miscellaneous cellulose products. These control requirements are designed to reduce releases of HAPs into the atmosphere. Emissions of HAPs from this source category originate from the transfer and storage of carbon disulfide (CS_2) and equipment leaks from piping and tanks; process vents (e.g., xanthation, regeneration/washing, acid/salt recovery, and solvent coating operations); and wastewater (Schmidtke and Holloway, 1999).

The proposed NESHAP will apply to all existing and new major sources that manufacture miscellaneous cellulose products. A major source is defined as a stationary source or group of stationary sources located within a contiguous area and under common control that emits, or has the potential to emit, 10 tons or more of any one HAP or 25 tons or more of any combination of HAPs. EPA has identified 17 facilities manufacturing miscellaneous cellulose products and has determined that 14 of them are major sources of HAPs.

To reduce emissions of HAPs, the Agency establishes maximum achievable control technology (MACT) standards. The term "MACT floor" refers to the minimum control technology on which MACT standards can be based. For existing major sources, the MACT floor is the average emissions limitation achieved by the best performing 12 percent of sources (if there are 30 or more sources in the category or subcategory). If there are fewer than 30 sources in a category, the Clean Air Act states that emission standards for existing sources must be determined based on the average emissions limitation of the best performing five existing sources. In this particular case, there are categories with fewer than five sources, so the Agency based the MACT on the emissions limitation of the best performing source or sources rather than using the average across the sources. This was done because otherwise there is the possibility of averaging a well-controlled source with a couple of uncontrolled sources and having a low average emissions limitation. The MACT can be more stringent than the floor, considering costs and health and environmental impacts. The estimated costs for individual plants to comply with the MACT are inputs into the EIA presented in this report.

This report analyzes the economic effects of the MACT standard on existing sources. Although the MACT standard is the same for both new and existing sources, the economic impact on new sources is expected to be minimal. Given the current poor financial health of the industry, it is unlikely that there would be entry, whether or not the regulation goes into effect. Even if entry does occur, newly installed equipment is expected to be in compliance with the MACT standard already, so no add-on control equipment will be necessary. Therefore, this report does not explicitly discuss the impact of the proposed regulation on new sources. However, equipment that meets the standards is presumably more expensive and will discourage entry because it will be more costly to enter this industry, making potential entrants more likely to undertake alternative opportunities for investment.

1.3 Organization of this Report

The remainder of this report is divided into four sections that support and detail the methodology and the results of the EIA of the miscellaneous cellulose manufacturing NESHAP summarized above:

- Section 2 presents a summary profile of the affected industry by characterizing the production processes, the users and consumers, and the organization of the industry. Data are presented on market volumes and prices, manufacturing plants, and the companies that own and operate these plants.
- Section 3 summarizes the regulatory control options and associated costs of compliance. This section is based on EPA's engineering analysis conducted in support of the proposed NESHAP.
- Section 4 describes the methodology for assessing the economic impacts of the proposed NESHAP and the results of the analysis, which include market, industry, and social cost impacts. It reports the impacts on facilities, markets, and society.
- Section 5 details the assumptions used in this analysis.

In addition to these sections, Appendix A describes the model used to predict the economic impacts of the NESHAP and discusses how welfare effects were calculated.

SECTION 2

INDUSTRY PROFILE

Cellulose is a natural polymer found in plant cell walls. The cellulose extracted from trees or other plants provides the basic raw material for all of the commercial products produced by the miscellaneous cellulose manufacturing industry. The miscellaneous cellulose manufacturing industry can be divided into two major categories: the viscose category and the cellulose ether category. Both of these categories use some type of cellulose as the primary raw material, normally either wood pulp or cotton linters, but their production processes differ. Although production of viscose products is not identical for all of the viscose outputs, the processes are very similar.

Few firms are involved in the production of these miscellaneous cellulose products. Only 17 miscellaneous cellulose manufacturing facilities are operated in the United States. The final products of these facilities compete in markets with products made from alternative materials, especially plastics. Cellulose products have generally been declining in market share over time as newer noncellulose products have been introduced.

Fourteen of the 17 facilities in the United States are considered major sources of HAPs. The primary pollutant associated with this industry is CS_2, which is used in the viscose production process and may be emitted at several steps during production. Another pollutant generated during the viscose production process is hydrogen sulfide (H_2S). The HAP emitted during the manufacture of cellulose ethers depends primarily on the type of cellulose ether being manufactured. Methanol, methyl chloride, ethylene oxide, and propylene oxide are the primary HAPs released by the cellulose ether manufacturing facilities in the United States.

This industry profile considers five outputs of miscellaneous cellulose manufacturing. The viscose category features four types of products—cellulose food casings, rayon, cellophane, and cellulosic sponges—and cellulose ethers are considered a single category. Brief descriptions of each of these categories are provided below.

- Cellulose food casings: Cellulose food casings were developed in 1925 as a substitute for natural casings and are used in manufacturing meat products such as sausages, hot dogs, salamis, bologna, and other processed meats. The meat is stuffed into a casing that holds the shape of the product during processing. Casings are commonly removed from the meat products prior to retail sale.

- Rayon: Rayon was the first man-made fiber and serves in a wide variety of uses. It is used in apparel, household goods, and various nonwoven fabrics. Textile fabrics may be woven of rayon alone or rayon in combination with other yarns. Nonwoven rayon products include feminine hygiene products, baby wipes, computer disk liners, and surgical swabs.

- Cellophane: Cellophane is a thin, transparent material used in food packaging (especially for candy, cheese, and baked goods); adhesive tapes; and membranes for industrial uses such as batteries.

- Cellulosic sponges: This type of artificial sponge was introduced in 1931 as an alternative to natural sponges. Cellulosic sponges are used for cleaning purposes.

- Cellulose ethers: Various cellulose ethers are produced, including methyl cellulose (MC), carboxymethyl cellulose (CMC), hydroxyethyl cellulose (HEC), hydroxypropyl cellulose (HPC), and hydroxypropyl methyl cellulose (HPMC). These cellulose derivatives are used mainly as thickeners, viscosifiers, and binders in the food, pharmaceutical, paper, cosmetic, adhesive, detergent, and textile industries.

The affected products are classified in the following Standard Industrial Classification (SIC) codes:

- SIC 2823, Cellulosic Manmade Fibers;

- SIC 2869, Industrial Organic Chemicals—Not Elsewhere Classified; and

- SIC 3089, Plastics Products, Not Elsewhere Classified.

Under the North American Industry Classification System (NAICS), the codes for miscellaneous cellulose manufacturing are the following:

- NAICS 32511, Petrochemical Manufacturing;

- NAICS 325199, All Other Basic Organic Chemical Manufacturing;

- NAICS 3252, Resin, Synthetic Rubber, and Artificial and Synthetic Fibers;

- NAICS 326121, Unsupported Plastics Profile Product Manufacturing; and
- NAICS 326199, All Other Plastics Product Manufacturing.

In the remainder of this section, we provide a summary profile of the miscellaneous cellulose industry in the United States as background information for understanding the technical and economic aspects of the industry. Section 2.1 provides an overview of the production processes for the various products of this industry. Section 2.2 discusses the demand side of the markets for these cellulose products. Section 2.3 summarizes the organization of the U.S. miscellaneous cellulose manufacturing industry, including a description of U.S. manufacturing plants and the companies that own them. Finally, Section 2.4 provides market data on U.S. production, consumption, foreign trade, and prices.

2.1 Production Overview

This section provides an overview of the various processes for manufacturing miscellaneous cellulose products.[1] Both the viscose and cellulose ether categories use some type of cellulose as the raw material and begin the production of cellulose products by reacting the cellulose with a sodium hydroxide (NaOH) solution and shredding the cellulose pulp (not necessarily in that order) to produce alkali cellulose. The NaOH breaks the cellulose pulp into shorter lengths by adding a sodium ion to the cellulose chain. This step lowers the viscosity of the generated product (e.g., viscose solution for the viscose category) and creates a site to add constituent groups (e.g., methyl, ethyl, or propyl groups for the cellulose ether category). After this common initial step, the viscose and cellulose ether categories diverge in their production methods. Therefore, process descriptions for the viscose and cellulose ether categories are provided separately below. No major by-products or co-products are associated with the miscellaneous cellulose manufacturing process.

2.1.1 Viscose Category Production Process

The manufacturing processes for the different products in the viscose category are very similar. They all essentially include the same raw materials and process steps. The main difference is simply the shape through which the viscose is extruded at the end of the process. The raw materials used in all of the different viscose manufacturing processes include cellulose, NaOH, CS_2, and sulfuric acid (H_2SO_4). The steps in the process are

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[1] The majority of the information on production processes was drawn from Schmidtke and Holloway (1999).

- production and aging of alkali cellulose,
- reaction with CS_2 to produce sodium cellulose xanthate,
- production and aging of viscose solution,
- extrusion/regeneration and washing to produce the viscose product, and
- acid or salt recovery.

Figure 2-1 illustrates a generic process flow diagram for the viscose category.

The alkali cellulose is aged to decrease the degree of polymerization of the cellulose. The amount of time for the aging step is based on the desired cellulose chain length. The aged alkali cellulose is then reacted with CS_2 to form sodium cellulose xanthate. Following completion of the reaction, most of the viscose category facilities apply vacuum to the reactor and/or purge the reactor with air or nitrogen (N_2) to remove unreacted CS_2. The CS_2 levels are the most concentrated at the beginning of the reactor evacuation and fall as evacuation continues. The reactor area of the facility is well ventilated at most of the viscose category facilities, helping to reduce operator exposure to CS_2.

Following the reactor, the sodium cellulose xanthate is dissolved in a caustic solution to form a viscous material referred to by the industry as “viscose.” The viscose solution is aged or “ripened” and then filtered to remove unreacted alkali cellulose. At most of the viscose category facilities, the viscose is also deaerated to remove entrapped air and filtered to remove any undissolved solids. The exception is sponge manufacturing facilities, which do not include these steps. The viscose is then extruded or formed into various shapes or products; the product forming may occur in an acid bath or by electrifying, depending on the type of viscose manufacturing process. At the majority of the viscose manufacturing facilities, the cellulose precipitates out of a H_2SO_4 solution, and the sodium atom on the cellulose polymer reacts with the H_2SO_4 to generate Na_2SO_4 (i.e., the sodium cellulose xanthate decomposes back to cellulose and CS_2). H_2S is also generated in the extrusion/regeneration steps and emitted. The acid bath for the extrusion/regeneration step becomes diluted from the water in the viscose solution, and a portion of the acid bath solution is treated in the acid recovery area and returned to the acid bath. In sponge plants, glauber salts are added to the viscose prior to generation of the product and are recovered and reused as part of the production process. The formed cellulose product is then washed, dried, finished, and packaged.

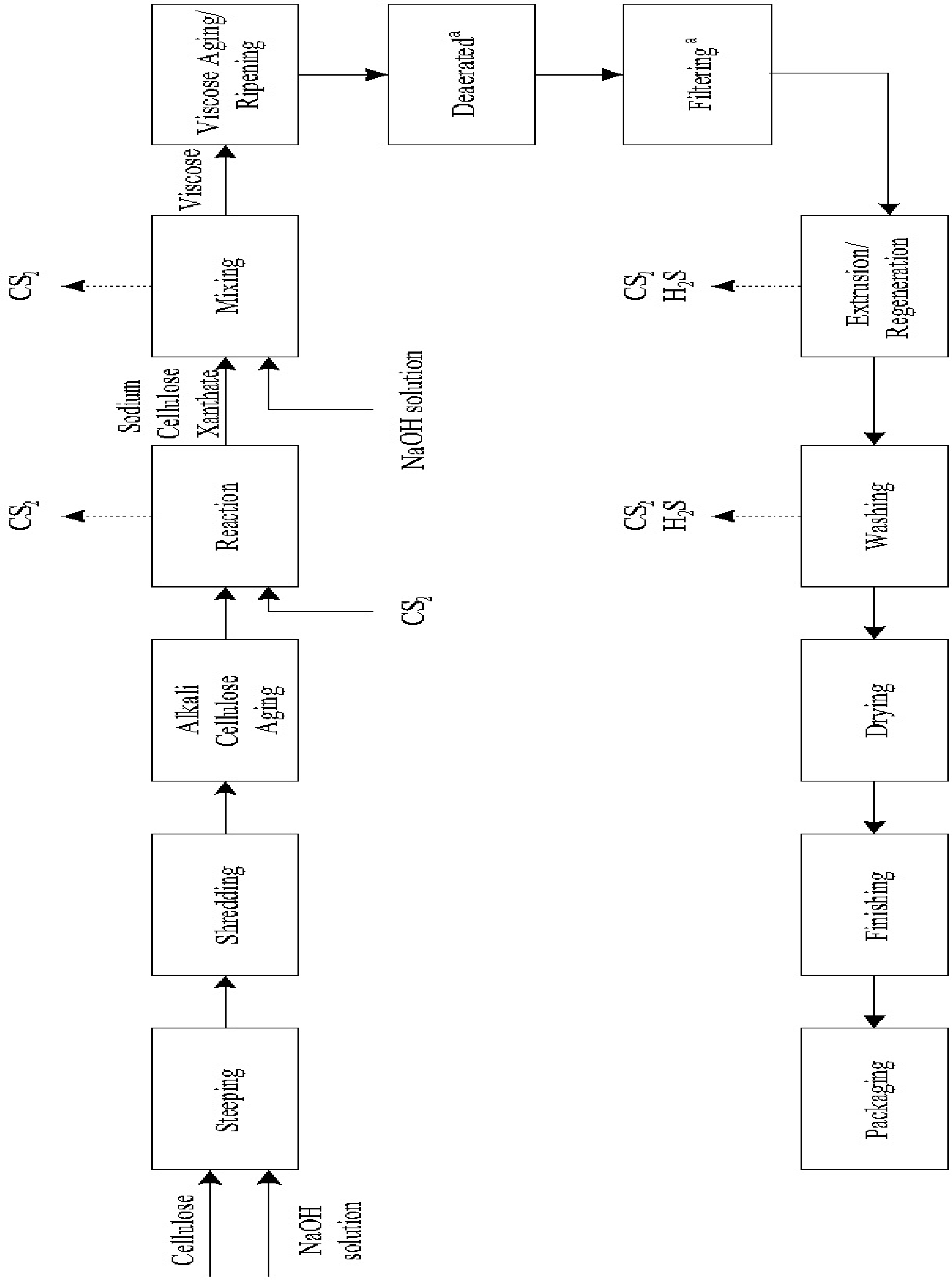

Figure 2-1. Generic Process Diagram for the Viscose Category

[a] Sponge manufacturers do not include the deaeration and filtering steps.

Pollutants can be emitted into the atmosphere from several sources during viscose processing. The primary HAP emitted from the manufacturing process is CS_2. CS_2 is emitted from the reactors and can be emitted from the slurry tanks used to generate the viscose solution. Both CS_2 and H_2S are emitted from the regeneration baths and the wash steps.

2.1.2 Cellulose Ether Category Production Process

All cellulose ether processes include the following steps:

- production of alkali cellulose from cellulose and NaOH,
- reaction of the alkali cellulose with chemical compound(s) to produce a cellulose ether product,
- washing and purification of the cellulose ether product, and
- drying of the cellulose ether product. Cellulose ether products may also be ground to uniform size and coated or blended.

Figure 2-2 displays a simplified flow diagram of the processes used to produce cellulose ethers.

Following the production of alkali cellulose, the raw materials used in the cellulose ether process vary according to the particular ether being produced. To produce MC, CMC, HEC, and HPC, alkali cellulose is reacted with methyl chloride, chloroacetic acid, ethylene oxide, and propylene oxide, respectively. HPMC is produced by reacting alkali cellulose with both methyl chloride and propylene oxide. All of these raw materials (methyl chloride, chloroacetic acid, ethylene oxide, and propylene oxide) added to the alkali cellulose to form the various ether products are considered HAPs.

As shown in Figure 2-2, pollutants can be emitted at various points in the manufacturing process. The primary HAP(s) emitted from the manufacturing of cellulose ethers depends on the type of ether product being produced, as mentioned above.

2.1.3 Costs of Production

This section contains CAA confidential business information, and is therefore not included.

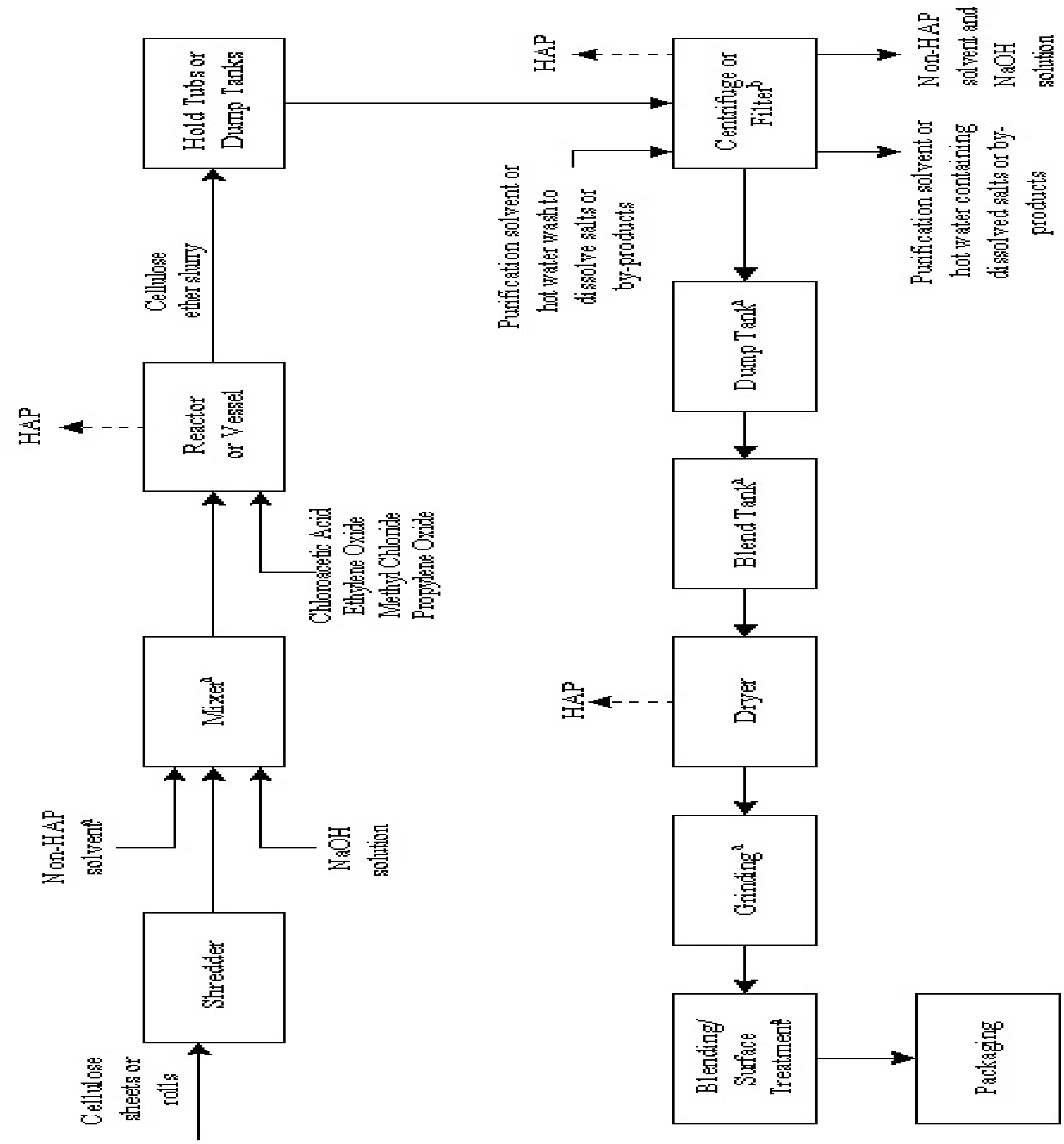

Figure 2-2. Cellulose Ether Manufacturing Process

[a] Not all cellulose ether processes use this material or equipment.

[b] Some cellulose ether processes have multiple centrifuge/filter and wash steps; the solvent is reused and flows countercurrent to the cellulose ether product.

2.2 The Demand Side

This section describes the demand side of the market, including product characteristics, the uses of the final products, the consumers of these products, and the available substitution possibilities.

2.2.1 Characteristics of Miscellaneous Cellulose Products

Cellulose products have many advantageous physical attributes that led to their introduction into various markets. Some of the useful characteristics of cellulosics include a unique combination of toughness and transparency at relatively low cost, an almost unlimited color range, good grease resistance, little effect on mechanical properties due to moisture, and suitability of some grades for use with food products. One of the chief disadvantages is that using a natural polymer base causes greater variation in properties than a truly synthetic polymer ("Cellulose," 2000). Since the introduction of these cellulose products, advances in plastics technology have allowed products made from synthetic polymers to enter many of the markets in which the products comprising the miscellaneous cellulose category compete.

2.2.2 Consumption and Uses of Miscellaneous Cellulose Products

The main uses of these products vary depending on which of the outputs is being considered. In general, the miscellaneous cellulose products under consideration are intermediate goods serving as inputs into other production processes.

Cellulose food casings are purchased primarily by meat packers as an input in the production of processed meat products and are used to encase hot dogs, sausages, deli meats, and whole hams. The casing may either be left on the final product or removed following production.

Rayon can be purchased as a continuous filament yarn or as cut (staple) fiber. Rayon is used as an input in the production of a variety of products, but it is typically used for producing two main categories of products: textiles and nonwoven materials. The buyers of textile fibers produce yarn from the fiber, often as a blend with other fiber materials, and weave the yarns into fabrics used to produce apparel and upholstery, among other things. Nonwoven fibers are used by a variety of producers to make wipes, computer diskette liners, and feminine hygiene products.

Cellophane normally serves as an intermediate good as well and is purchased primarily for packaging items such as food and confectionary products (especially candy, cheese, and baked goods) and batteries; it is also used in adhesive tape.

Cellulosic sponges is the one category under consideration here that is not typically an input into the production of another good, although manufacturers of sponges may sell their output to other firms in large blocks and these firms may then cut, package, and sell the sponges. The main use for these sponges is cleaning various surfaces, and they can be purchased by households or businesses for this purpose.

Cellulose ethers are used as an input into a variety of goods. They are chiefly used as thickeners, viscosifiers, and binders and are used in producing paints, personal care products, inks, pharmaceuticals, and industrial coatings.

2.2.3 Substitution Possibilities in Consumption

The markets in which the miscellaneous cellulose outputs compete generally consist of the cellulose product in addition to several viable alternatives. With advances in the production of plastics, plastic alternatives to cellulose products have become increasingly competitive over time. In many cases, the manufacturers of miscellaneous cellulose goods in the United States have seen their market shares shrinking recently under pressure from substitute products and foreign producers of cellulose goods.

In the food casing market, the major alternatives to cellulose are collagen and plastic. Another category in the industry, known as fibrous, actually contains regenerated cellulose and is considered under cellulose casings. Natural (intestine) casings are also used by some producers, especially in making sausage. Buyers of casings make their choice as to which type of casing will be purchased based on the type of meat product being produced, desired shelf life, desirability of edible casings, smoke permeability, and appearance.

Many fibers, such as cotton, wool, and polyester, among others, can be used in textiles instead of rayon. The textile mills choose which fibers to use for a particular application based on characteristics like comfort, warmth, ease of washing and drying, and resistance to unwanted creasing and wrinkling. As textile production has moved outside of the United States, sales of rayon fibers for use in textiles have declined rapidly. Sales of rayon fibers for use in nonwoven applications have shown much more strength in recent years than sales of textile fibers (Acordis, 1998).

Very strong substitutes exist for cellophane as well. Cellophane has been facing increasing competition in recent years from plastics such as polypropylene and polyethylene. Cellophane twist wrap (used for wrapping single-piece candy) fell from a position of about 85 percent of the U.S. market in 1992 to 35 percent by early 1997 (Duschene, 1997). According to *Plastics World* (1995), polypropylene "has all but replaced cellophane in many packaging applications, such as for snack food and tobacco...."

Cellulosic sponges seems to be the category where there is the least competition from alternative products, because natural sponges are far more expensive and have a relatively small market share. Several retailers were contacted and these retailers sold cellulose sponges exclusively. However, substitute products for cleaning such as paper towels and dishtowels are available.

The cellulose ethers are used in many different end uses and have numerous substitutes, depending on the particular application for which they are being used. Some of the possible substitutes include natural gums, starches, proteins, synthetic polymers, and inorganic clays (Majewicz and Podlas, 1993).

2.3 Industry Organization

This section discusses the products and producers that constitute the market. The affected facilities and parent companies are identified, and their sales and employment distribution are summarized.

2.3.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. If an industry is perfectly competitive, then individual producers are not able to influence the price of the output they sell or the inputs they purchase. This condition is most likely to hold if the industry has a large number of firms, the products sold and the inputs purchased are homogeneous, and entry and exit of firms are unrestricted. Entry and exit of firms are unrestricted for most industries except, for example, in cases where government regulates who is able to produce, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market.

Very few firms are involved in manufacturing each of the cellulose products under examination, implying imperfectly competitive markets. However, there is vigorous competition from foreign sources in this industry. In addition, many viable substitutes for these products exist. Therefore, despite the small number of domestic producers, the miscellaneous cellulose manufacturing facilities are likely to behave fairly competitively.

2.3.2 Manufacturing Plants

Based on facility responses to the Section 114 letters, the Agency identified 17 plants in the United States currently manufacturing miscellaneous cellulose products. These facilities are identified in Table 2-3. Figure 2-3 shows the geographic distribution of U.S. miscellaneous cellulose manufacturing plants by final product. As shown, many of these plants are concentrated in the north-central region of the United States. Since only 14 of the 17 facilities are major sources subject to the MACT standard, subsequent discussion focuses on this subset of the miscellaneous cellulose manufacturing facilities affected by the proposed regulation.

Table 2-3. Miscellaneous Cellulose Manufacturing Facilities

Facility	Facility Location	Major Product(s)
Devro-Teepak, Inc.	Danville, IL	Cellulose food casings
Viskase Corp.	Loudon, TN	Cellulose food casings
Viskase Corp.	Osceola, AR	Cellulose food casings
Acordis Cellulosic Fibers, Inc.	Axis, AL	Rayon
Lenzing Fibers Corp.	Lowland, TN	Rayon
UCB Films, Inc.	Tecumseh, KS	Cellophane
Nylonge Corp.	Elyria, OH	Cellulosic sponges
Spontex, Inc.	Columbia, TN	Cellulosic sponges
3M Corp.	Prairie du Chien, WI	Cellulosic sponges
3M Corp.	Tonawanda, NY	Cellulosic sponges
Dow Chemical Co.	Midland, MI	Cellulose ethers (MC, HPMC)
Dow Chemical Co.	Plaquemine, LA	Cellulose ethers (MC)
Hercules Inc., Aqualon Co.	Hopewell, VA	Cellulose ethers (CMC, HEC, HPC)
Hercules Inc., Aqualon Co.[a]	Parlin, NJ	Cellulose ethers (HEC)
MAK Chemical Corp.[a]	Muncie, IN	Cellulose ethers (crude CMC)
Penn Carbose, Inc.[a]	Somerset, PA	Cellulose ethers (crude CMC)
Union Carbide Corp.	Institute, WV	Cellulose ethers (HEC)

[a] Hercules-Parlin, MAK, and Penn Carbose are area sources not subject to the MACT standard.

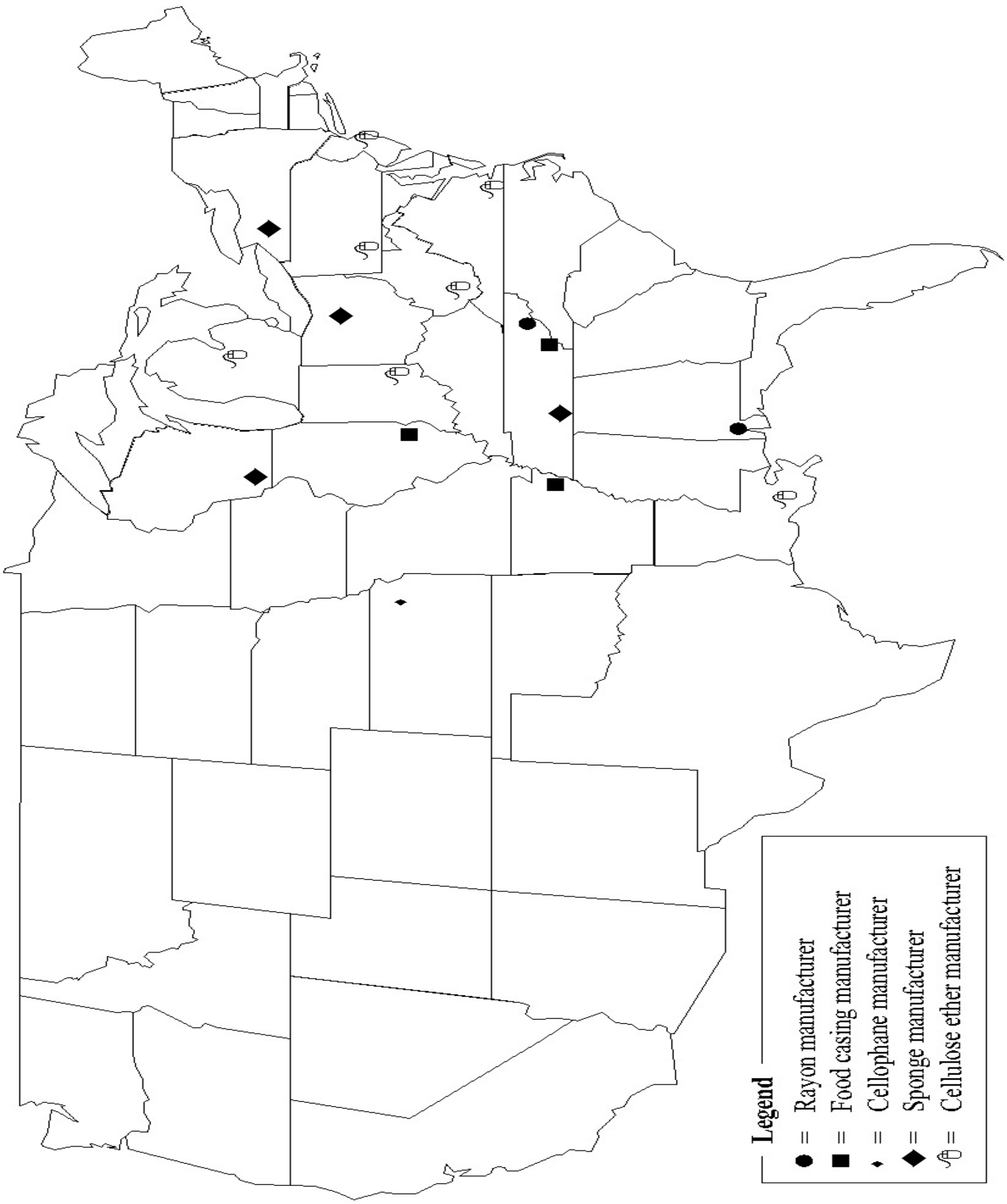

Figure 2-3. Geographic Distribution of Miscellaneous Cellulose Manufacturing Plants in the United States

This section contains CAA confidential business information, and is therefore not included..

2.3.3 Companies

Companies that are directly affected by the regulation include entities that own miscellaneous cellulose manufacturing plants. As shown in Figure 2-4, the chain of ownership may be as simple as one plant owned by one company or as complex as multiple plants owned by subsidiary companies. Based on survey and publicly available source data, the Agency identified 11 ultimate parent companies that own and operate the 14 directly affected facilities. For the economic analysis, EPA obtained sales and employment data from one of the following secondary data sources:

- Hoover's Company Profiles (Hoover's, 2000),
- Business and Company ProFile (Information Access Corporation, 2000),
- *Ward's Business Directory* (Gale Research, 1998), and
- Wrights Research Service (Winthrop Corporation, 2000).

2.3.3.1 Employment and Sales Distribution

This section contains CAA confidential business information, and is therefore not included.

2.3.3.2 Identifying Small Businesses

The RFA of 1980, as amended by SBREFA of 1996, requires that the Agency give special consideration to small entities affected by federal regulation. Companies operating miscellaneous cellulose manufacturing plants can be grouped into small and large categories using Small Business Administration (SBA) general size standard definitions. The SBA defines a small business in terms of the sales or employment of the owning entity, and these thresholds vary by industry classification (SIC code) of the affected company. For this analysis, the Agency identified three primary SIC codes with small business definition ranges as follows:

- 2823 and 2869—1,000 or fewer employees and
- 3089—500 or fewer employees.

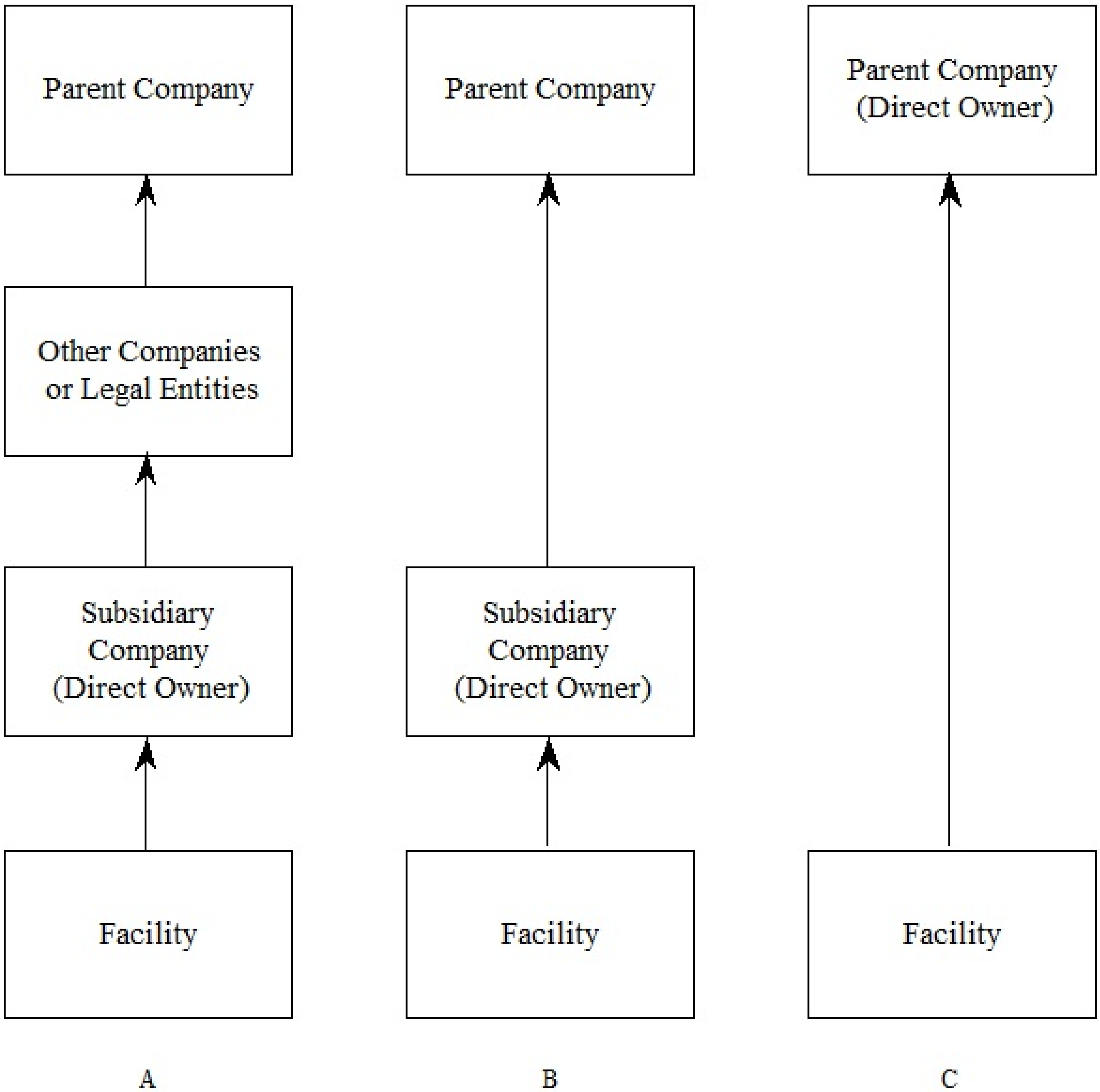

Figure 2-4. Chain of Ownership

Based on the reported company employment and SIC size standard, one company can be classified as small, or 9.1 percent of the total (see Figure 2-5).

2.3.3.3 Issue of Vertical and Horizontal Integration

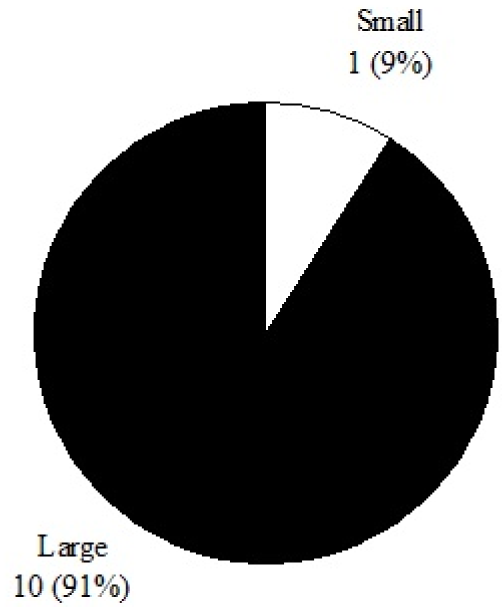

Figure 2-5. Distribution of Miscellaneous Cellulose Companies by Size

Vertical integration is a potentially important dimension in analyzing firm-level impacts because the regulation could affect a vertically integrated firm on more than one level. The regulation may affect companies for whom cellulose manufacturing is only one of several processes in which the firm is involved. For example, a company may produce cellulose products as part of a vertical operation that manufactures and assembles the final commodity. Increased production costs of cellulose manufacturing will affect the cost of the final products that use these as intermediate inputs.

Horizontal integration is also an important dimension in firm-level impact analysis because diversified firms may own facilities in unaffected industries. This may give them resources to spend on complying with this regulation—if they so choose. Several of the larger firms are involved in several different industries other than cellulose manufacturing. For example, Total Fina S.A.'s other operations include petroleum, natural gas, and tires, while 3M provides pharmaceutical, automotive, and dental productions (Hoover's, 2000; Information Access Corporation, 2000).

2.3.3.4 Trends

This section contains CAA confidential business information, and is therefore not included.

2.4 Market Data

This section contains CAA confidential business information, and is therefore not included.

SECTION 3

ENGINEERING COST ANALYSIS

The Agency identified 17 producers of miscellaneous cellulose products in the United States and estimated the costs of complying with the proposed NESHAP for the production of miscellaneous cellulose products. Fourteen of these producers are considered major sources and will therefore be affected by the MACT standards. For each process category, this EIA discusses two regulatory options: Regulatory Alternative (RA) I consists of the MACT floor control options and RA II consists of a combination of MACT floor options as well as options achieving greater emissions reduction. All alternatives are combinations of HAP control techniques.

Five possible HAP emission control techniques are available for viscose and cellulose ether processes:

- carbon adsorbers,
- scrubbers,
- nitrogen unloading systems,
- thermal oxidizers, and
- leak detection and repair (LDAR) programs.

Carbon adsorbers and scrubbers act to filter HAPs from an airflow directed through the unit. Nitrogen unloading systems react nitrogen with CS_2 in the exhaust to remove the CS_2 from the air flow. Another viable emissions control device is a thermal oxidizer. Thermal oxidizers preheat air containing solvents and then pass the air into a combustion chamber. The combustion products are carbon dioxide and water. A flow of natural gas is necessary to maintain combustion. Thermal oxidizers can be either recuperative, in which a heat exchanger is used to preheat the air, or they can be regenerative, in which ceramics are used to improve the heat-sustaining efficiency. The final option is LDAR programs, which reduce emissions from existing systems by sealing all leaks in the airflow channel.

Costs associated with controlling emissions at miscellaneous cellulose manufacturing facilities are reported in five categories. Total capital investment is the total cost of capital equipment for emissions control. The capital costs account for life of the capital equipment, and they are annualized and reported as capital recovery, the annual capital expense. Other fixed costs are included under general annual costs, which include overhead, administrative charges, insurance, and property taxes. Variable annual costs include labor, materials, utilities, replacement parts, and watewater treatment disposal. Recovery credits for carbon adsorbers also affect the variable cost of emissions control. All annual costs are summed for total annual costs.

The total annualized control costs for major sources under the viscose process category are \$7.7 million under RA I, and \$14.3 million under RA II, as shown in Table 3-1. Under both alternatives, Lenzing has the highest variable and annualized capital costs. The other rayon manufacturer, Acordis, experiences the greatest increase in variable and annual capital costs in the move from RA I to RA II. The sponge and cellophane manufacturing facilities experience no increase in costs moving from RA I to RA II.

The total annualized control costs for major sources under the ether process category are \$0.3 million for RA I and \$0.4 million under RA II (see Table 3-2). Union Carbide has the highest total annual costs under both alternatives for this subset of major sources. Hercules has the largest increase in costs moving from RA I to II.

Table 3-1. Control Costs for Viscose Process Facilities ($)

Facility Name	Facility Location	Total Capital Investment	Annual Variable Cost	Recovery Credits Total	Annualized Capital Costs	Annual General Cost	Annual Total Cost
Regulatory Alternative I							
Devro-Teepak, Inc.	Danville, IL	1,423,503	39,180	—	207,418	73,690	320,288
Viskase Corp.	Loudon, TN	2,677,569	702,017	–14,692	305,282	193,782	1,186,390
Viskase Corp.	Osceola, AR	2,160,399	368,324	–6,643	246,302	154,000	761,982
Acordis Cellulosic Fibers Inc.	Axis, AL	2,559,069	91,553	—	366,077	138,513	596,142
Lenzing Fibers Corp.	Lowland, TN	16,643,012	1,313,797	–1,103,760	2,216,898	820,321	3,247,256
UCB Films, Inc.	Tecumseh, KS	11,570	7,181	—	2,822	8,562	18,565
Nylonge Corp.	Elyria, NY	1,568,050	47,487	—	225,696	83,033	356,216
Spontex, Inc.	Columbia, TN	3,066,983	304,200	–131,238	399,882	191,344	764,188
3M Corp.	Prairie du Chien, WI	845,867	58,119	–39,844	116,083	53,751	188,108
3M Corp.	Tonawanda, NY	1,191,367	28,611	—	170,640	59,585	258,835
Total		32,147,390	2,960,469	–1,296,177	4,257,099	1,776,581	7,697,973
Regulatory Alternative II							
Devro-Teepak, Inc.	Danville, IL	5,352,224	335,084	–407,021	729,636	289,115	946,814
Viskase Corp.	Loudon, TN	5,858,159	895,643	–367,441	737,850	357,196	1,623,248
Viskase Corp.	Osceola, AR	4,114,865	468,228	–166,131	519,345	261,703	1,083,145
Acordis Cellulosic Fibers Inc.	Axis, AL	17,873,129	1,714,865	–631,596	2,393,792	884,619	4,361,680
Lenzing Fibers Corp.	Lowland, TN	24,648,462	2,197,512	–1,907,052	3,236,752	1,212,063	4,739,275
UCB Films, Inc.	Tecumseh, KS	11,570	7,181	—	2,822	8,562	18,565
Nylonge Corp.	Elyria, NY	1,568,050	47,487	—	225,696	83,033	356,216
Spontex, Inc.	Columbia, TN	3,066,983	304,200	–131,238	399,882	191,344	764,188
3M Corp.	Prairie du Chien, WI	845,867	58,119	–39,844	116,083	53,751	188,108
3M Corp.	Tonawanda, NY	1,191,367	28,611	—	170,640	59,585	258,835
Total		64,530,675	6,056,931	–3,650,322	8,532,496	3,400,970	14,340,074

Table 3-2. Control Costs for Cellulose Ether Facilities ($)

Facility Name	Facility Location	Total Capital Investment	Annual Variable Cost	Annualized Capital Costs	Annual General Cost	Annual Total Cost
Regulatory Alternative I						
Dow Chemical Co.	Midland, MI	13,622	10,364	3,322	6,763	20,449
Dow Chemical Co.	Plaquemine, LA	13,730	13,641	3,349	8,734	25,723
Hercules Inc.	Hopewell, VA	13,028	13,208	3,178	8,446	24,831
Union Carbide Corp.	Institute, WV	1,053,841	16,420	151,037	50,588	218,045
Total		1,094,221	53,632	160,886	74,530	289,048
Regulatory Alternative II						
Dow Chemical Co.	Midland, MI	24,434	23,435	6,865	7,204	37,505
Dow Chemical Co.	Plaquemine, LA	13,730	13,641	3,349	8,734	25,723
Hercules Inc.	Hopewell, VA	34,652	93,815	17,087	9,345	120,247
Union Carbide Corp.	Institute, WV	1,053,841	16,420	151,037	50,588	218,045
Total		1,126,657	147,312	178,337	75,871	401,520

SECTION 4

ECONOMIC IMPACT ANALYSIS: METHODS AND RESULTS

The proposed NESHAP requires producers of miscellaneous cellulose products (i.e., rayon, food casings, cellulosic sponges, cellophane, and cellulose ethers) to meet emission standards for the release of HAPs into the environment. To meet these standards, firms will have to install equipment to capture pollutants or change to less pollution-intensive methods. These changes result in higher costs of production for the affected producers and may induce some owners to change their current operating rates. Owners may even choose to close down their operations if the costs are large enough. The regulation has broader societal implications because these effects are transmitted through market relationships to indirectly affected producers and consumers of these products and other related products.

EPA evaluated the economic impacts of the rule using two different assumptions regarding behavioral responses to the regulation. Under the first assumption, producers "fully absorb" the compliance costs, and their production choice is limited to compliance at the current operating rates or closure. Unlike a market model approach, there are no market feedback effects (i.e., change in market prices) under this full-cost absorption model. This approach assumes that all factors of production are fixed, leaving the directly affected entity with no means to respond to changes in its costs. The second approach involves developing a market model that analyzes the production (consumption) choices of producers (consumers) in response to changes in costs and market prices associated with the regulation. The Agency determined that a market approach was appropriate for three miscellaneous cellulose products—rayon, food casings, and cellulosic sponges. Given limited market data, small market shares for the affected facilities,[1] and small facility control costs, the Agency used the less complex full-absorption model for the remaining two affected products—cellophane and cellulose ethers. The following sections discuss these approaches in more detail and describe

[1] The market shares are small compared to the broader markets in which the goods compete, although these facilities may produce large shares of the cellulose products. For example, there is only one cellophane plant in the U.S., but cellophane has only a small share of the market for flexible packaging in which it competes.

methods for developing quantitative estimates of the economic impacts resulting from the NESHAP.

4.1 Full-Cost Absorption

This section contains CAA confidential business information, and is therefore not included.

4.2 Market Analysis

As noted in Section 2, Information Collection Request (ICR) survey responses and publicly available sources provided the market-level data necessary to develop a market analysis for three cellulose products. The main elements of the analysis are identified below:

- identification of baseline conditions in the miscellaneous cellulose commodity markets,
- characterization of the regulated facilities and baseline supply,
- determination of baseline demand,
- development of a model that evaluates the behavioral responses of these economic agents to the regulation, and
- presentation and interpretation of economic impact estimates projected by the model.

4.2.1 Fiber, Food Casing, and Cellulosic Sponge Markets

This section contains CAA confidential business information, and is therefore not included.

4.2.2 Market Supply

EPA developed unit cost curves for each miscellaneous cellulose product given estimates of baseline outputs and market prices (see Appendix A for the operational model details). Given the capital in place, each facility was characterized by an upward-sloping supply function, as shown in Figure 4-1. In this case, the supply function is that portion of the marginal cost curve bounded by zero and the production line's technical capacity. The facility owners select their commodity output according to this schedule as long as the market price is sufficiently high to cover average variable costs (i.e., greater than C_0 in Figure 4-1). If the market price falls below average variable costs, then the firm's best response is to cease

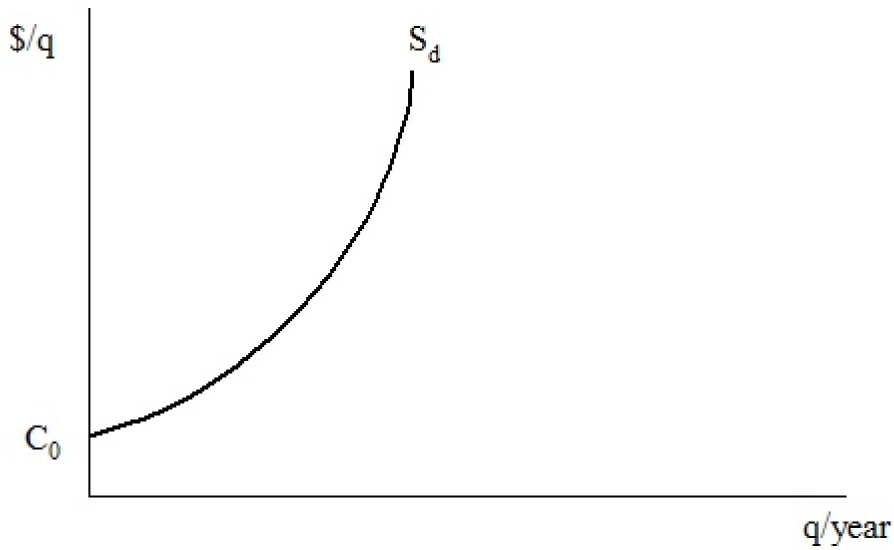

Figure 4-1. Supply Curves for Miscellaneous Cellulose Manufacturing Facilities

production because total revenue does not cover total variable costs of production. In this scenario, producers experience losses on operations as well as capital. By shutting down, the firm avoids additional operating losses. The individual supply decisions of all the firms in the industry are then aggregated (i.e., horizontally summed) to develop the market supply curve.

4.2.3 Market Demand

For the economic analysis, EPA modeled each commodity market as having a single aggregate consumer with a downward-sloping demand curve that is consistent with the theory of demand (see Figure 4-2). This simply indicates that consumption of cellulose products is high at low prices and low at high prices, reflecting the opportunity costs of purchasing miscellaneous cellulose products. The Agency constructed this curve for each product using baseline quantity, price data, and assumptions about the responsiveness to changes in price (demand elasticity). For this analysis, EPA assumed a demand elasticity of -1.0 (i.e., a 1 percent change in the price of miscellaneous cellulose commodities would result in a 1 percent change in quantity demanded).

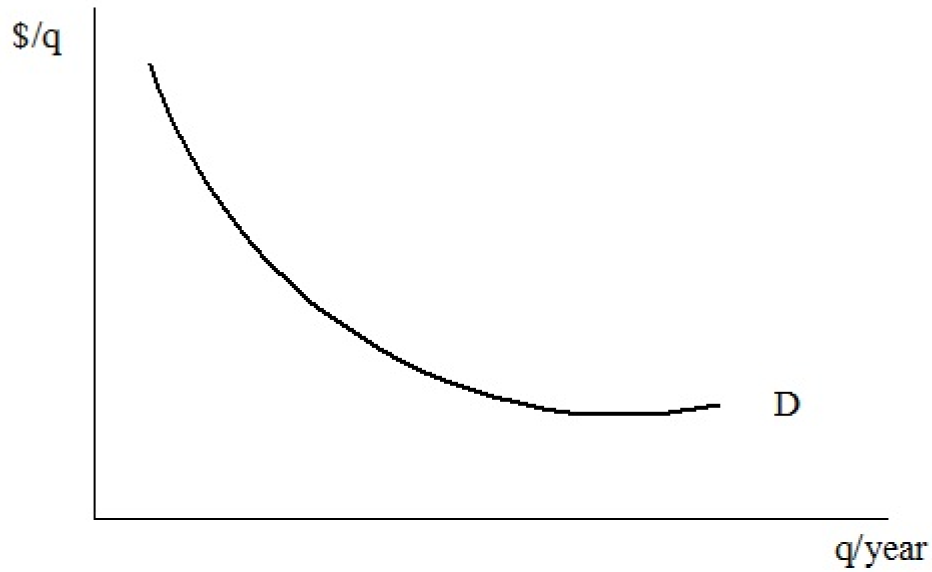

Figure 4-2. Demand Curve for Miscellaneous Cellulose Products

4.2.4 Baseline and With-Regulation Equilibrium

The Agency modeled a competitive market for each of these three miscellaneous cellulose products such that buyers and sellers exert no individual influence on market prices. Price is set by the collective actions of buyers and sellers of miscellaneous cellulose products, who take the market price as a given in making their production and consumption choices.

Under this assumption, prices and quantities of miscellaneous cellulose products are determined by the intersection of market supply and demand curves (see Figure 4-3[a]). The baseline consists of a market price and quantity (P, Q) that is determined by the downward-sloping market demand curve (D^M) and the upward-sloping market supply curve (S^M) that reflects the sum of the individual supply curves of miscellaneous cellulose facilities. Any individual supplier would produce amount q (at price p), and the miscellaneous cellulose facilities would collectively produce amount Q, which equals market demand.

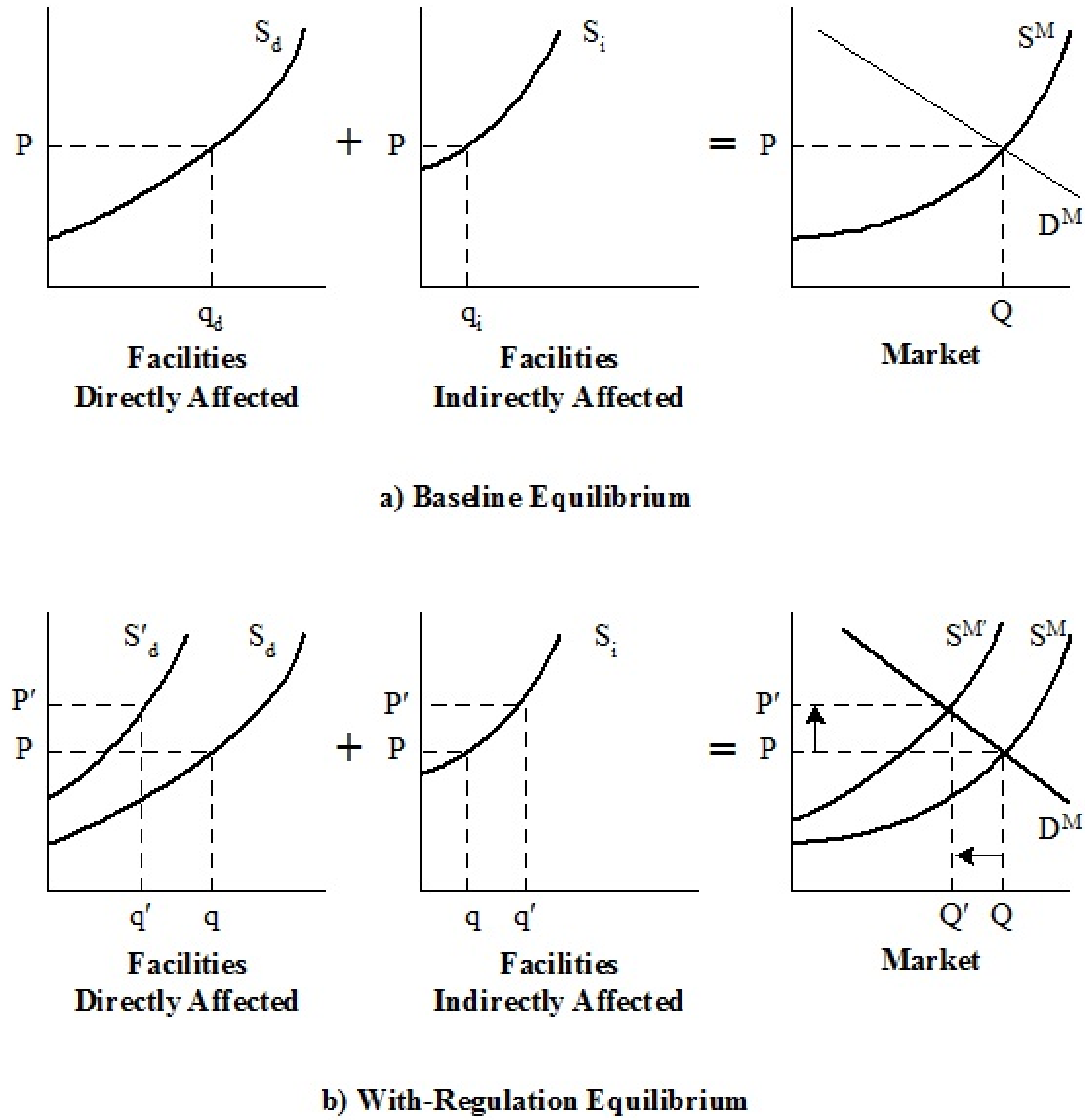

Figure 4-3. Market Equilibrium Without and With Regulation

With the regulation, the costs of production increase for suppliers using the miscellaneous cellulose production process. These additional costs include a variable component consisting of the operating and maintenance costs and the fixed component that does not vary with output (i.e., control devices such as a thermal oxidizer). Incorporating these regulatory control costs is represented by an upward shift (from S to S′) in the individual supply curves by the per-unit variable compliance cost, causing the market supply curve to shift upward to S^M.

At the new equilibrium with the regulation, the market price increases from P to P′ and market output (as determined from the market demand curve, D^M) declines from Q to Q′ (see Figure 4-3[b]). This reduction in market output is the net result of output reductions at directly affected miscellaneous cellulose facilities and output increases at facilities that do not face control costs.

4.2.5 Market Analysis Results

This section contains CAA confidential business information, and is therefore not included.

4.3 Social Costs Estimates

This section contains CAA confidential business information, and is therefore not included.

SECTION 5

ASSUMPTIONS AND LIMITATIONS OF THE ECONOMIC MODEL

In developing the economic model of the cellulose manufacturing industry, several assumptions were necessary to make the model operational. In this section, each operational assumption is listed and explained. Possible impacts and limitations of the model resulting from each assumption are then described.

Assumption: The domestic markets for all of the cellulose products are perfectly competitive.

Explanation: Assuming that the markets for these products are perfectly competitive implies that individual producers are not capable of unilaterally affecting the prices they receive for their products. Under perfect competition, firms that raise their price above the competitive price are unable to sell at that higher price because they are a small share of the market and consumers can easily buy from one of a multitude of other firms that are selling at the competitive price level. Individual firms could sell at a price lower than the competitive price, but since they are already selling all of their output at the competitive price, they would just be selling the same quantity at a lower price. This would lower their profits and therefore would not be chosen as a strategy by rational firm managers. There are very few firms involved in miscellaneous cellulose manufacturing in the United States, which suggests imperfect competition. However, because of the large number of substitute products available and the presence of strong foreign competition, the assumption of perfect competition is appropriate.

Possible Impact: If the markets for miscellaneous cellulose products were in fact imperfectly competitive, implying that individual producers can affect the prices they receive for their products, the economic model would understate possible price increases due to the regulation and the social costs of the regulation. Because producers would be able to pass along more of the costs to consumers under imperfect competition, consumer surplus losses would be higher and producer surplus losses would be smaller than under perfect competition.

Assumption: The United States is not a price-taker on the world market for cellulose products; that is, the United States may influence the price of these products on the world market.

Explanation: Assuming that the United States is not a price-taker on the world market for these products implies that the United States is "large" relative to the rest of the world. That is, the United States produces a sufficient quantity of these products so that changes in the volume of products imported or exported may affect prices in the world market. Thus, producers in the United States have the ability to pass along some portion of the costs of the regulation to consumers of miscellaneous cellulose products.

Possible Impact: If the United States were a price-taker on the world market, then producers would not be able to pass along any of the costs of the regulation to consumers of these products. If U.S. companies that export these products attempted to raise prices as a result of the regulation, importers of U.S. cellulose products would start purchasing from countries other than the United States. Similarly, U.S. companies would be unable to raise the price of their cellulose products domestically because consumers would start buying imports at the lower world price instead. Thus, U.S. consumers would bear none of the costs of the regulation under this scenario.

Assumption: The baseline year of the analysis, 1998, is representative of a typical year for the industry.

Explanation: The engineering costs of the regulation are estimated for all facilities that produced miscellaneous cellulose products in 1998. In order for the economic model to be consistent, all costs, prices, and quantities must be denominated in the same year.

Possible Impact: If 1998 were a good year for the miscellaneous cellulose manufacturing industry relative to typical conditions (i.e., with high output prices and low input prices), then the impacts of the regulation would appear to be smaller (in percentage terms) than they would be for a typical year. Likewise, if 1998 were a relatively poor year for the industry, the impacts of the regulation would appear greater than for a typical year.

Assumption: Rayon, cotton, and polyester are sufficiently similar that they can be considered perfect substitutes for the markets in which they compete.

Explanation: It is assumed that in the markets where rayon is present, cotton and polyester are perfect substitutes for rayon. This assumption limits the ability of rayon producers to pass along the costs of regulation to rayon consumers because rayon consumers will switch to cotton or polyester if rayon's price increases.

Possible Impact: If cotton and polyester are not perfect substitutes for rayon, then rayon producers will have more ability to pass cost increases on to consumers in the form of higher rayon prices. In this case, consumer surplus losses would be higher and producer surplus losses lower than we have estimated.

Assumption: The compliance costs placed on cellophane manufacturing and cellulose ether manufacturing are small enough to have a negligible impact on their respective market prices and quantities.

Explanation: This assumption implies that these firms will not take actions that have any appreciable impact on market prices or quantities as a result of the regulation. In this case, the compliance costs are generally so small compared with firm sales that even if they did adjust output, the adjustment would be so small that no change in price would be observed.

Possible Impact: If these firms make significant changes to their output levels as a result of the regulation, then there may be some noticeable market impact on prices and quantities. These firms hold very small shares of their respective markets (flexible packaging and thickeners, viscosifiers, and binders, respectively), however, so even if they decreased output considerably, the selling price may not change much.

Appendix A

Economic Model of the Miscellaneous Cellulose Industry

The proposed NESHAP will increase the costs of production for existing miscellaneous cellulose manufacturing plants. Facility-level responses to these additional costs will collectively determine the market impacts of the regulation. Specifically, the cost of the regulation may induce some facilities to alter their current level of production, or even to close down. These choices affect, and are affected by, the market price for each product. To model these adjustments, EPA

- characterized production of miscellaneous cellulose products at the individual facility and market levels,
- characterized demand for each product,
- developed the solution algorithm to determine the new with-regulation equilibrium, and
- computed values for all the impacted variables.

A.1 Supply of Miscellaneous Cellulose Products

Market supply of miscellaneous cellulose products (Q^s) can be expressed as the sum of domestic and foreign supply (or imports), that is,

$$Q^s = q^s + q^I \tag{A.1}$$

where q^s is the domestic supply of a particular miscellaneous cellulose product type (which is the sum of production from all domestic sources) and q^I is the foreign supply (or imports). Each of these supply components is described below.

A.1.1 Miscellaneous Cellulose Facilities (Directly Affected)

Producers of miscellaneous cellulose products have some ability to vary output in the face of production cost changes. Production cost curves, coupled with market price, can be used to determine the facility's optimal production rate, including zero (shutdown). For this analysis, the generalized Leontief profit function was used to derive the supply curve for miscellaneous cellulose products at each facility (see Chambers, 1988, p. 172, for a description of the generalized Leontief). This functional form is appropriate given the fixed-proportion material input (cellulose) and (coating and substrate) and the variable-proportion inputs of labor, electricity, and energy. By applying Hotelling's lemma to the generalized Leontief profit function, the following general form of the supply functions for each miscellaneous cellulose product is obtained:

$$q_j = \gamma_j + \frac{\beta}{2}\left[\frac{1}{p}\right]^{\frac{1}{2}} \qquad \text{(A.2)}$$

where p is the market price for each product, γ_j and β are model parameters, and j indexes producers (i.e., individual miscellaneous cellulose facilities). The theoretical restrictions on the model parameters that ensure upward-sloping supply curves are $\gamma_j > 0$ and $\beta < 0$.

Figure A-1 illustrates the theoretical supply function of Eq. (A.2). As shown, the upward-sloping supply curve is specified over a productive range with a lower bound of zero that corresponds with a shutdown price, p_m, equal to $\frac{\beta^2}{4\gamma_j^2}$ and an upper bound given by the productive capacity of qM_j that is approximated by the supply parameter γ_j. The curvature of the supply function is determined by the β parameter.

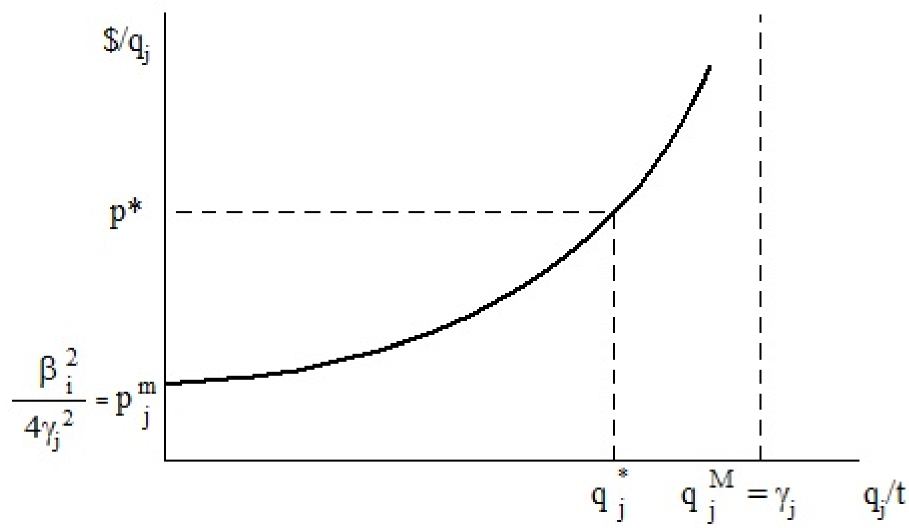

Figure A-1. Theoretical Supply Function for Miscellaneous cellulose Facilities

To specify the supply function of Eq. (A.2) for each facility for this analysis, the β parameter was computed by substituting an assumed market supply elasticity for each miscellaneous cellulose products (ξ), the average annual product line production level of the directly affected miscellaneous cellulose facilities (q), and market price of the product (p) into the following equation:

$$\beta = -\xi 4 q \left[\frac{1}{p}\right]^{-\frac{1}{2}} . \qquad \text{(A.3)}$$

Absent econometric or literature estimates, the market-level supply elasticities were assumed to be 1, reflecting a unitary elasticity (i.e., a 1 percent change in price leads to a 1 percent change in output).

Once the β parameter has been estimated, the remaining unknown parameter (γ_j) can be computed for each facility using Eq. (A.2). This parameter approximates the productive capacity for each miscellaneous cellulose product facility. Unlike the β parameter, this parameter does not influence the facility's production responsiveness to price changes. It is used to calibrate the model so that each miscellaneous cellulose facility's supply equation returns the estimated baseline[1] value (q^{DA}) given the estimated market price (p).

Adjustment of Product-Specific Minimum Prices and Quantities at Facility. The area under the product supply curve at the facility represents the facility's total variable costs of producing that product. This area can be expressed where VC_j is the total variable cost of production at facility i, q_j^* is the level of production at the facility, $f_j(q_i)$ is the inverse supply function, and q_j^m is the minimum

$$VC_j = f_j(q_j^m)\, q_j^m + \int_{q_j^m}^{q_j^*} f_j(q_j)\, dq_j \qquad \text{(A.4)}$$

economically feasible production level at the facility, which corresponds to the price p_i^m.

[1]Given limited data on facility level baseline production values, in some cases the Agency used reported shipment values to approximate production.

q_i^m is unobserved but may be chosen to calibrate the shutdown points for those facilities with reported production cost data.[2] By integrating under the generalized Leontief supply function,[3] given the above relationships, we can express a facility's total variable costs of production as a function of q_i^* and q_i^m:

$$VC_j = \frac{\beta^2}{4}\left[\frac{q_j^m}{(q_j^m - \gamma_j)^2} + \frac{1}{(q_j^m - \gamma_j)} - \frac{1}{(q_j^* - \gamma_j)}\right] \quad \text{(A.5)}$$

where q_i^* is known, while q_i^m is unknown.

The problem can be reduced further if we assume that q_i^m is proportional to base year output, q_i^*, by a factor k, so that

$$q_i^m = k\, q_j^* \quad \text{(A.6)}$$

Thus, the facility's total variable costs can be expressed as

$$VC_j = \frac{\beta^2}{4}\left[\frac{kq_j^*}{(kq_j^* - \gamma_j)^2} + \frac{1}{(kq_j^* - \gamma_j)} - \frac{1}{(q_j^* - \gamma_j)}\right] \quad \text{(A.7)}$$

Facility-specific q_j^m and p_j^m may be derived by solving Eq. (A.5) for the unknown variable k and then backsolving through Eq. (A.4) to solve for q_j^m and using that result with the inverse supply function to solve for p_j^m.

Applying this technique to the questionnaire data for each facility resulted in the outcome summarized in Figure A-2. First, as shown in Figure A-2, the value for k is determined to be greater than zero and less than on (i.e., $0 < k < 1$). Thus, the total variable costs as measured by the area under the facility's product supply function matches the value reported in the Section 114 responses for that facility.

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[2] Cost data were available for rayon and sponge facilities based on Section 114 responses. For regulated food casing facilities, $q_i^m = 0$ (by assumption), with a shutdown price $p_j^m = \frac{\beta_i^2}{4\gamma_j^2}$.

[3] See Eq. (A.2).

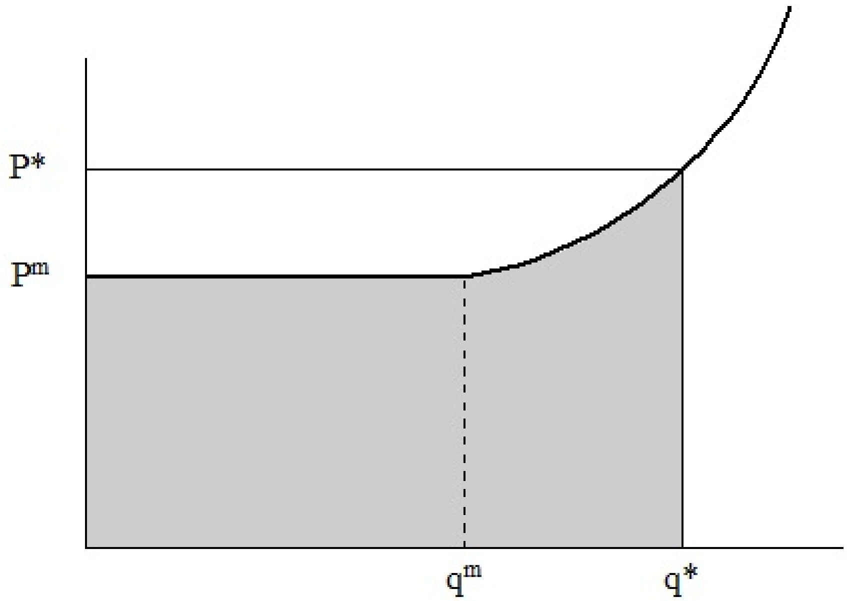

Figure A-2. Model TVC Equal to Reported Value

Regulation-Induced Shift in Supply Functions. The production decisions at these facilities are affected by the total annual variable compliance costs as provided by EPA's engineering analysis. Using baseline facility output rates, EPA estimated annual variable compliance costs per miscellaneous cellulose product unit of production for each facility (c_j).

These costs enter each existing facility's supply equation as a net price change (i.e., the net price is now $p - c_j$). Thus, the supply function from Eq. (A.2) becomes

$$q_j^s = \gamma_j + \frac{\beta}{2}\left[\frac{1}{p-c_j}\right]^{\frac{1}{2}} \quad \text{for } (p - c_j) > p_j^m \tag{A.8}$$

Facility Closure Decision. A facility may shut down its miscellaneous cellulose product manufacturing operation because it is no longer profitable. The sufficient condition for production at each facility in the short run is nonnegative operating profits (π), that is,

$$\pi = TR - TPC \geq 0 \tag{A.9}$$

where total revenue (TR) is the revenue from miscellaneous cellulose product sales and total production cost (TPC) is the sum of total variable production costs (production and compliance) and total avoidable fixed costs (annualized expenditure for compliance capital).

A.1.2 Miscellaneous Cellulose Facilities (Indirectly Affected)

The indirectly affected facilities do not face additional costs of production with the regulation. However, their output decisions are affected by price changes expected to result from the regulation. Individual facility data are not available for these facilities. Therefore, they were modeled as a single representative supplier. Supply from these facilities (q^{IA}) can be expressed by the following general formula:

$$q^{IA} = A^{IA} [p]^{\xi} \qquad \text{(A.10)}$$

where p is the market price for the product, ξ is the domestic supply elasticity (assumed value), and A^{IA} is a multiplicative supply parameter that calibrates the supply equation for this product given data on price and the supply elasticity to replicate the estimated 1998 level of production from these facilities. Since all domestic rayon producers are directly affected by the rule, the only indirectly affected producers are the cotton and polyester producers in competing markets. For these producers, EPA obtained end use data and calculated estimates for cotton and polyester production. For the casings and sponges markets, the Agency obtained estimates of indirectly affected production from Section 114 letters and/or census data.

A.1.3 Foreign Supply (Imports)

Similar to indirectly affected domestic facilities, foreign producers are not directly affected by the regulation but were included in the model as a single representative supplier that responds to changes in the market price. Supply from foreign producers (q^I) can be expressed by the following general formula:

$$q^{I} = A^{I} [p]^{\xi I} \qquad \text{(A.11)}$$

where p is the market price for the product, ξ^I is the import supply elasticity (assumed value of 1), and A^I is a multiplicative supply parameter that calibrates the supply equation for each product, given data on price and the foreign supply elasticity to replicate the estimated level of imports in the baseline year.

A.2 Demand for Miscellaneous Cellulose Products

Market demand for miscellaneous cellulose products (Q^d) can be expressed as the sum of domestic and foreign demand, that is,

$$Q^d = q^d + q^x \tag{A.12}$$

where q^d is the domestic demand and q^x is the foreign demand (or exports), as described below.

A.2.1 Domestic Demand

Domestic demand for miscellaneous cellulose products can be expressed by the following general formula:

$$q^d = B^d [p]^{\eta^d} \tag{A.13}$$

where p is the market price, η^d is the domestic demand elasticity (assumed value of –1), and B^d is a multiplicative demand parameter that calibrates the demand equation for miscellaneous cellulose products, given data on price and the domestic demand elasticity to replicate the estimated baseline year level of domestic consumption. This quantity is estimated as follows:

$$q^d = Q^s - q^x \tag{A.14}$$

A.2.2 Foreign Demand (Exports)

Foreign demand, or exports, for miscellaneous cellulose products can be expressed by the following general formula:

$$q^x = B^x [p]^{\eta^x} \tag{A.15}$$

where p is the market price, η^x is the assumed export demand elasticity (assumed value of –1), and B^x is a multiplicative demand parameter that calibrates the foreign demand equation, given data on price and the foreign demand elasticity to replicate the estimated baseline year level of exports.

A.3 With-Regulation Market Equilibrium

Facility responses and market adjustments can be conceptualized as an interactive feedback process. Facilities face increased production costs due to compliance, which causes facility-specific production responses (i.e., output reduction). The cumulative effect of these responses leads to an increase in the market price that all producers (directly affected and indirectly affected) and consumers face. This increase leads to further responses by all producers and consumers and, thus, new market prices. The new with-regulation equilibrium is the result of a series of these iterations between producer and consumer responses and market adjustments until a stable market price equilibrium in which total market supply equals total market demand (i.e., $Q^s = Q^d$).

This process for determining equilibrium price (and output) with the increased production cost is modeled as a Walrasian auctioneer. The auctioneer calls out a market price for each product and evaluates the reactions by all participants (producers and consumers), comparing total quantities supplied and demanded to determine the next price that will guide the market closer to equilibrium (i.e., where market supply equals market demand). Decision rules are established to ensure that the process will converge to an equilibrium, in addition to specifying the conditions for equilibrium. The result of this approach is prices with the proposed regulation that equilibrate supply and demand for each product.

The algorithm for deriving the post-compliance equilibria in all markets can be generalized to five recursive steps:

1. Impose the control costs on each directly affected facility, thereby affecting their supply decisions.

2. Recalculate the market supply of miscellaneous cellulose products.

3. Determine the new prices via the price revision rule for all product markets.

4. Recalculate the supply functions of all suppliers with the new prices, resulting in a new market supply of miscellaneous cellulose products. Evaluate market demand at the new prices.

5. Return to Step #3, resulting in new prices for miscellaneous cellulose products. Repeat until equilibrium conditions are satisfied (i.e., the difference between supply and demand is arbitrarily small for miscellaneous cellulose products).

A.4 Economic Welfare Impacts

The economic welfare implications of the market price and output changes with the regulation can be examined using two different strategies, each giving a somewhat different insight but the same implications: changes in the net benefits of consumers and producers based on the price changes and changes in the total benefits and costs of these products based on the quantity changes. This analysis focuses on the first measure—the changes in the net benefits of consumers and producers. Figure A-3 depicts the change in economic welfare by first measuring the change in consumer surplus and then the change in producer surplus. In essence, the demand and supply curves previously used as predictive devices are now being used as a valuation tool.

This method of estimating the change in economic welfare with the regulation divides society into consumers and producers. In a market environment, consumers and producers of the good or service derive welfare from a market transaction. The difference between the maximum price consumers are willing to pay for a good and the price they actually pay is referred to as "consumer surplus." Consumer surplus is measured as the area under the demand curve and above the price of the product. Similarly, the difference between the minimum price producers are willing to accept for a good and the price they actually receive is referred to as "producer surplus." Producer surplus is measured as the area above the supply curve and below the price of the product. These areas can be thought of as consumers' net benefits of consumption and producers' net benefits of production, respectively.

In Figure A-3, baseline equilibrium occurs at the intersection of the demand curve, D, and supply curve, S. Price is P_1 with quantity Q_1. The increased cost of production with the regulation will cause the market supply curve to shift upward to S'. The new equilibrium price of the product is P_2. With a higher price for the product, there is less consumer welfare, all else being unchanged as real incomes are reduced. In Figure A-3(a), area A represents the dollar value of the annual net loss in consumers' benefits with the increased price. The rectangular portion represents the loss in consumer surplus on the quantity still consumed, Q_2, while the triangular area represents the foregone surplus resulting from the reduced quantity consumed, Q_1–Q_2.

In addition to the changes in consumer welfare, producer welfare also changes with the regulation. With the increase in market price, producers receive higher revenues on the quantity still purchased, Q_2. In Figure A-3(b), area B represents the increase in revenues due to this increase in price. The difference in the area under the supply curve up to the original market price, area C, measures the loss in producer surplus, which includes the loss associated with the quantity no longer produced. The net change in producer welfare is represented by area B–C.

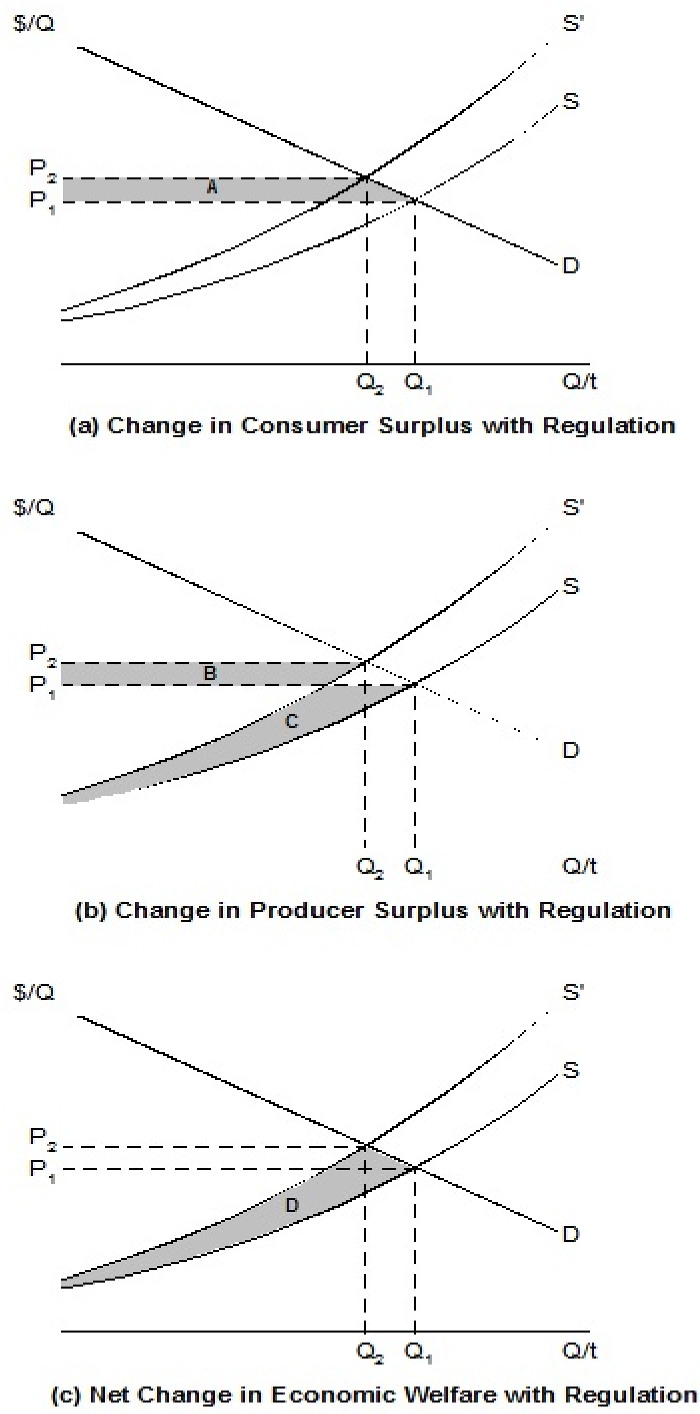

Figure A-3. Economic Welfare Changes with Regulation: Consumer and Producer Surplus

The change in economic welfare attributable to the compliance costs of the regulation is the sum of consumer and producer surplus changes, that is, – (A) + (B–C). Figure A-3(c) shows the net (negative) change in economic welfare associated with the regulation as area D. However, this analysis does not include the benefits that occur outside the market (i.e., the value of the reduced levels of air pollution with the regulation). Including this benefit may reduce the net cost of the regulation or even make it positive.

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16. ABSTRACT

EPA is proposing a national emission standard for hazardous air pollutants (NESHAP) for facilities that manufacture cellulose products. As a result of this NESHAP, facilities in the cellulose industry may incur emission control costs. This report provides an analysis of the economic impact this NESHAP will have on the industry.

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