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ECONOMIC IMPACT AND REGULATORY FLEXIBILITY ANALYSES OF THE FINAL ARCHITECTURAL COATINGS VOC RULE

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EXECUTIVE SUMMARY

Under Title I of the Clean Air Act of 1990, the U.S. Environmental Protection Agency (EPA) is developing regulations to reduce volatile organic compound (VOC) emissions from various consumer and commercial products. One of the first categories of consumer and commercial products to be regulated is architectural coatings. This report analyzes the costs and economic impacts of the final architectural coatings rule.

The general purpose of the regulation is to reduce the flow of VOCs into the atmosphere from the use and disposal of architectural coating products. These emissions are distinguished from the manufacturing-related emissions that are controlled by other forms of regulation (as are emissions to land and water).

VOC emissions are regulated because of their contribution to the formation of ground-level ozone. Elevated levels of ozone degrade air quality and pose a variety of health risks to exposed populations.

ES.1 COMPLIANCE ACTIONS

The regulation imposes a set of standards for VOC content for individual architectural coating products. Products that exceed the limits imposed by these standards must either be brought into compliance with the limits, have an exceedance fee assessed on the product's VOC content above the limit, or be withdrawn from the market. These actions, however, can be avoided for products subject to the small tonnage exemption.

ES.2 COMPLIANCE COSTS

The number of compliance actions was estimated using survey data on VOC content and sales volumes for almost 5,000 architectural coating products manufactured by 116 companies. The surveyed products constitute about three-quarters of industry output. The survey data were used to estimate the compliance activity for the products and manufacturers not covered in the survey and is thereby the basis for the national estimate of costs.

Initially, the regulatory impacts were viewed in a very restrictive light, assuming that reformulation down to the standards is the only option available to producers. The aggregate costs of this restrictive option were then computed to give a benchmark measure of regulatory costs under a restrictive set of conditions. The costs in Table ES-1 present both the initial one-time expenditure for the reformulations and the costs expressed in annualized terms.

TABLE ES-1. NATIONAL COST FOR ARCHITECTURAL COATINGS PRODUCERS–REFORMULATION-ONLY

Total Initial Expenditure ($1991)	Total Annualized Cost ($1991)
204.0 million	34.2 million

The analysis was expanded by progressively shedding the restrictive assumptions of forced reformulation. First, the exceedance fee option was incorporated, taking into account that producers may choose to pay an exceedance fee rather than reformulate if it is a less costly alternative for them.

Then, the least-cost compliance option (fee or reformulation) was compared with benefit streams (net revenues) to determine if the least-cost option is also profitable. If the value of the benefit stream is less than the cost of compliance, firms are assumed to remove the products from the market as a best-response strategy. Alternative response options reduce the cost of the regulation by approximately 20 percent for the architectural coating producers included in the survey. Cost reductions are likely to be greater for the nonsurvey population and are further reduced when market-level responses are factored in (see below). Most of the cost savings is attributable to adopting the exceedance fee, which is projected to be the compliance option for a number of products that are either very small in volume or have a VOC content relatively close to the limit. Because the fee is generally adopted for relatively small sources of VOC "exceedance," the effect on VOC emissions reductions is projected to be relatively small.

ES.3 MARKET EFFECTS

The compliance actions lead to a reallocation of society's resources toward VOC controls, which imposes opportunity costs directly on the producers and indirectly on other members of society as producers act, markets respond, and prices and output change. The purpose of the architectural coatings market analysis is to characterize the reallocation of resources and quantify them in dollar-denominated terms to assess the distribution of costs and economic impacts of the regulation.

The collective effect of some producers removing unprofitable products and some producers bearing a per-unit fee on output will contract the aggregate supply of architectural coatings and lead to changes in market prices and quantities. The optimal best-response actions and resulting market outcomes will determine how the welfare costs of the policy are distributed across producer groups, consumers, and the government sector.

Several scenarios were modeled for the standards. In general, market model results indicate a very small change in baseline market conditions as a result of the regulation. This derives from the expectation that aggregate costs of the regulation are a small share of aggregate industry costs. However, because there is a high degree of producer heterogeneity within the architectural coatings sector, the costs for some producers may be large. The distribution of impacts across affected parties is presented in Table ES-2.

TABLE ES-2. MARKET IMPACTS SUMMARY

Aggregate Welfare Effects on....	(MM $1991)
Architectural coating producers	-22.0
Architectural coating consumers	-4.3
Government (fee receipts)	+4.0
Net social welfare effect ("social cost")	-22.3

A portion of the cost for architectural coating producers is passed on to consumers in the form of higher prices, which lowers their welfare. An important impact to consider is the effect of the fee payments. While these payments constitute losses for the producers paying the fee (less the amount they are able to pass on to the consumer via higher prices), these fee payments are simply transfer payments to the government and therefore do not constitute a net increase in social costs. In other words, while the fee serves as a private cost for firms that do not reduce VOCs to the statutory limit and a continuing incentive for producers to reduce VOCs to the limit, it does not constitute an allocation of society's resources to a particular use as, in contrast, the allocation of resources for reformulation does.

The net social cost estimate is substantially lower than the annualized cost estimate under the reformulation-only scenario described above. The market analysis demonstrates the potential for substantial cost savings due to adopting the fee alternative and how this cost savings is likely to accrue especially to producers of small volume products. Moreover, this cost savings is not expected to have a significant impact on undercutting aggregate emissions reduction targets.

ES.4 TRAFFIC COATING USER COSTS

The economic analysis up to this point has focused entirely on the primary impacts of the regulation, those borne directly by producers in the architectural coatings industry in the form of higher costs and indirectly by the consumers of architectural products in the form of higher prices. The driving force of those impacts is the requirement that, except for products subject to the tonnage exemption, noncompliant products must either be reformulated to a compliant VOC level, be subject to a fee on the excess VOCs over the allowable level, or be withdrawn from the market. However, this analysis considered a type of *secondary* impact, one that is caused by the costs that users of a newly compliant product must incur to purchase the special equipment necessary to apply the compliant coating. The secondary impact analysis focuses exclusively on users of traffic marking paints, primarily government entities such as state transportation departments, for whom the costs of switching application equipment ("striper" trucks) are thought to be potentially significant.

Traffic coating user costs are summarized in Table ES-3. Costs are estimated as the incremental cost associated with the accelerated replacement of striper trucks and are expressed both in terms of the present value of the one-time acceleration ($53.2 million total) and on an annualized basis ($3.7 million).

TABLE ES-3. NATIONAL INCREMENTAL COST SUMMARY FOR TRAFFIC COATING EQUIPMENT ($1996)

Striper Type	Present Value of Cost	Annualized Cost
Medium (see Table 4-1)	$42,844,912	$2,999,144
Large (see Table 4-2)	$10,393,011	$727,511
Total	$53,237,923	$3,726,655

ES.5 SOCIAL COST-EFFECTIVENESS

The social cost estimates from the market analysis and the estimate of traffic coating user costs can be used to compute measures of the social cost-effectiveness of the regulation. The distinction of "social" cost-effectiveness is made to illuminate the fact that the costs evaluated are the net costs imposed on society (i.e., the net welfare costs estimated in the architectural coatings market plus the resource costs incurred by traffic coating users to switch application equipment).

Cost-effectiveness results are summarized in Table ES-4. Emission reduction effects of the regulation are estimated by taking the national target for VOC emission reductions from

TABLE ES-4. SOCIAL COST-EFFECTIVENESS SUMMARY

Social Cost ($1991)	Estimated Emissions Reduction (Mg)	Social Cost per Mg ($1991)
25.6 million	103,471	247

architectural coatings and modifying that total to account for market responses (fee adoption and changes in output levels).

This estimate allows for an evaluation of cost-effectiveness implications of the fee option. Allowing the fee reduces social costs by about $12 million but foregoes about 1,802 Mg of emissions reduction, about 1.7 percent of the targeted reductions. Dividing the cost savings by foregone reductions approximates the marginal social cost of the foregone reductions. This figure is $6,580/Mg, which is substantially higher than the $247/Mg average social cost-effectiveness measure reported above. This difference indicates that the fee's main effect is to reduce the very most expensive emission reductions without substantially undercutting the achievement of emissions reduction.

For external reporting purposes, the economic impacts are reported in 1996 dollars. Costs are converted from the base year used in the analysis (1991) to 1996 using the Gross Domestic Product (GDP) price deflator. The conversion results are presented in Table ES-5.

TABLE ES-5. CONVERSION OF SUMMARY IMPACTS TO 1996 DOLLARS

Impact Estimate	$1991	$1996
Net social cost	$25.6 million	$29.2 million
Net social cost per Mg of emissions reduction	$247/Mg	$282/Mg

ES.6 SMALL BUSINESS IMPACTS AND REGULATORY FLEXIBILITY ANALYSIS

The potential for significant impacts on small businesses of the regulation arises from two primary sources:

- Products made by small producers, on average, have a higher VOC content than the industry average.
- The costs of reformulating products to comply with the regulation are fixed and thereby impose higher average costs on small volume coatings.

The first problem is related to small producers' tendency to specialize in coatings categories that are naturally higher in VOC content and to their tendency to concentrate in the "high-VOC" end of the distribution of products within a given category. Thus, the potential for disproportionate impacts of VOC reduction regulation on small businesses follows partly from the fact that small businesses contribute a disproportionate amount of the aggregate VOC emissions that are targeted for reduction.

The second problem follows from the nature of reformulation costs. A coating's formula is the product of an intellectual capital investment, much like the development of a drug or a computer software product. The cost of the investment follows directly from the level of effort necessary to revise the formula to meet both the VOC standards imposed by the regulation and performance standards imposed by the marketplace. This level of effort is essentially independent of the quantity of the product that is eventually sold. Therefore, the relative impacts on smaller volume products is, by definition, greater.

The data used in this analysis suggest that these two primary factors are relevant in the case of small architectural coating producers. The average VOC content of the products made by the small business producers in the survey is 75 percent higher than the average VOC content of all products combined (see Table ES-6). A little over half of the difference in the averages is attributed to the specialization of small producers in high-VOC content product categories, with the remainder attributed to the tendency for small businesses to produce higher VOC products within each product group. Moreover, the average product volume of products made by small businesses is less than 20 percent of the average product volume for the entire survey population, implying much larger average reformulation costs (see Table ES-7). Thus, without mitigating factors, the impacts on some small businesses are potentially significant.

TABLE ES-6. BASELINE VOC CONTENT

Size Category[a]	VOC Emissions (Mg)	Sales (kL)	Average VOC Content (g/L)
All products	344,059	1,853,623	186
Small business products	21,431	65,914	325

[a] The survey had 116 respondents and 36 of those identified themselves as having under $10 million in annual sales. Twelve survey respondents did not report company size.

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

At proposal, the Agency included specialized coating categories and limits designed to preserve niche product markets. To evaluate whether further steps were still needed to accommodate niche market coatings, the Agency requested that commenters identify any additional specialty coatings that would not comply with applicable VOC content requirements. The Agency also requested comment on whether to include an "exceedance fee" in the final rule, which would allow companies the option of paying a fee, based on the amount that VOC content limits are exceeded, instead of achieving the limit. In addition, the Agency requested comment on the concept of a low volume cut-off, under which a coating might be exempt from regulation. In the final rule, the Agency has included the exceedance fee compliance option and a provision that enables each manufacturer to claim as exempt a specified amount of VOC per year (known as the tonnage exemption). Also, in response to public comments, the Agency created seven new niche product categories and increased the VOC content limits for four product categories in the final rule. The Agency also added an extended period for compliance after promulgation to allow additional time for reformulations. These provisions are designed to mitigate rule impacts on small businesses' low production volumes and to allow for the preservation of several niche markets. However, based on the limited data available to the Agency, only the mitigating impact of exceedance fees can be quantified.

The analysis shows that, when reformulation is the only option for compliance, the cost/revenue ratio is estimated to be 2.5 percent on average (see Table ES-7). When the alternative compliance options of the exceedance fee or product withdrawal are considered, the ratio decreases to 2.0 percent (see Table ES-8). This ratio would decrease further if the cost effects of the additional niche product categories, use of the tonnage exemption, and reduction in cost to reformulate due to resin supplier assistance could be specifically quantified.

TABLE ES-7. AVERAGE REGULATORY IMPACT BY FIRM SIZE—"REFORMULATION-ONLY" SCENARIO[a]

	Industry Average	Small Firm Average
Revenue[b] ($1991)	38,990,000	4,614,000
Number of products[b]	42.4	27.5
Number of products facing major reformulation[c]	9.9	7.8
Annualized reformulation cost[d] ($1991)	144,272	113,669
Ratio of annualized reformulation cost to revenues (percent)	0.4	2.5

[a] The survey has 116 respondents and 36 of those identified themselves as having under $10 million in annual sales. Twelve survey respondents did not report company size.
[b] Data for revenues and products per firm were based on data reported in Table 6-1. The number of products per firm is based on the total number of products for which quantity data are available.
[c] This number represents two-thirds of the products over the 1998 TOS. Industry experts estimate that approximately two-thirds of the products with VOC contents exceeding the TOS limits face a "major" reformulation.
[d] Annualized cost of reformulation is the number of major reformulations multiplied by the annualized reformulation cost estimate per product of $14,573 ($1991).

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

The Agency prepared analyses to support both the proposed and final rules that are equivalent to those required by the Regulatory Flexibility Act (RFA) as modified by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA). The Agency undertook these analyses because of the large presence of small entities in the architectural coatings industry and because the initial impact analysis indicated that there could be a significant economic impact on a substantial number of small entities if mitigating regulatory options were not adopted for the rule. After evaluating public comment on the proposed mitigating options, EPA made a

TABLE ES-8. AVERAGE REGULATORY IMPACT FOR SMALL COMPANIES—"BEST-RESPONSE" SCENARIO

Compliance Strategy	Percent of All Constrained Survey Products Selecting Option	"Expected" Number of Products Selecting Strategy[a]	Average Compliance Cost per Product ($1991)	Compliance Cost ($1991)
Reformulate	60.5%	4.7	14,573	68,767
Fee	35.5%	2.8	7,197[b]	19,936
Withdrawal	4.0%	0.3	12,705[c]	3,955
Total	100.0%	7.8	11,879	92,658
Average percent of sales				2.0%

[a] Equals average number of constrained products for small companies (7.8) multiplied by percentage of all constrained products in the survey selecting each strategy.
[b] Average fee cost computed by taking the average fee rate ($0.084/L), multiplying by the average size per small company product (65,914 L), and adding the recordkeeping cost per product of $590.
[c] Equals the average value of foregone profits for the 46 surveyed products that select the fee as the best-response strategy.

number of changes to the proposed rule to further mitigate the rule's small business impacts. As a result, the Agency believes that it is highly unlikely that the rule will have a significant economic impact on a substantial number of small entities. However, in light of the Agency's inability to quantify the effect of the mitigating options, the EPA has elected to conduct a regulatory flexibility analysis and to prepare a SBREFA compliance guide to eliminate any potential dispute on whether EPA has fulfilled SBREFA requirements.

ES.7 EPILOGUE

Because regulatory development is an evolving process, the final Table of Standards for VOC content limits differs slightly from the interim Table of Standards used in the analysis reported here. The main difference between the two sets of standards is the addition of seven new categories in the final standards and an increase in the VOC content limits for three categories.

By and large, new categories were added to accommodate specialty products that were previously included in other categories with lower VOC limits. As a result, some products that would be over the limit in the previous category, thereby necessitating a compliance action (reformulate, fee payment, withdrawal), are no longer constrained by the regulation. Therefore, in most cases the addition of the new categories reduces the number of required compliance actions and, as a result, also cuts compliance costs. In addition, raising the VOC limits in the other categories reduces compliance actions and costs as well.

However, one of the new product categories, concrete curing and sealing (CCS) compounds, applies to products that were considered outside of the regulated universe in the economic analysis presented in this report. Therefore, the costs associated with the compliance actions required for those products are not estimated in the analysis. If they were, the cost estimate would be larger.

Data were available to approximate cost effects for only two of the seven new product categories. One of these was the CCS category, which allowed for an estimate of the corresponding increase in costs just described. The other new product category for which data were obtained is zone markings. The original 1991 emissions inventory provided data to analyze the cost reductions due to the increase in content limits for three product categories. Taken together, the available data allowed for quantification of a $580,000 (1991 dollars) net increase in the estimate of annual social costs. However, this increase in cost must be considered against the unquantified decrease in costs from the expected fall in compliance activity in the five other new categories for which data were unavailable. Without additional data, it is difficult to conclude whether the cost reductions from those categories will together outweigh the net cost increases quantified. Given that the social cost effects quantified here are less than 3 percent of the total estimated social costs of the regulation, factors that reduce (or reverse the sign) of these costs lead to the conclusion that the total social cost estimate is not greatly affected by the differences between the interim standards used in the analysis and the final standards issued in the rule.

SECTION 1
INTRODUCTION, REGULATORY BACKGROUND, AND INDUSTRY PROFILE

1.1 INTRODUCTION

Under Title I of the Clean Air Act of 1990, the U.S. Environmental Protection Agency (EPA) is developing regulations to reduce volatile organic compound (VOC) emissions from various consumer and commercial products. One of the first categories of consumer and commercial products to be regulated is architectural coatings.

This report analyzes the economic impacts of the final architectural coating regulation. Section 183(e)(1)(B) of the Clean Air Act Amendments of 1990 defines a consumer or commercial product as

> any substance, product (including paints, consumer and commercial products, and solvents), or article (including any container or packaging) held by any person, the use, consumption, storage, disposal, destruction, or decomposition of which may result in the release of volatile organic compounds.

Thus, the general purpose of the regulation is to reduce the flow of VOCs into the atmosphere from consumption and disposal of products that contain VOCs. Figure 1-1 shows the dissipative emissions and the disposal emissions into the air that are the target of this regulation.[1] These emissions are

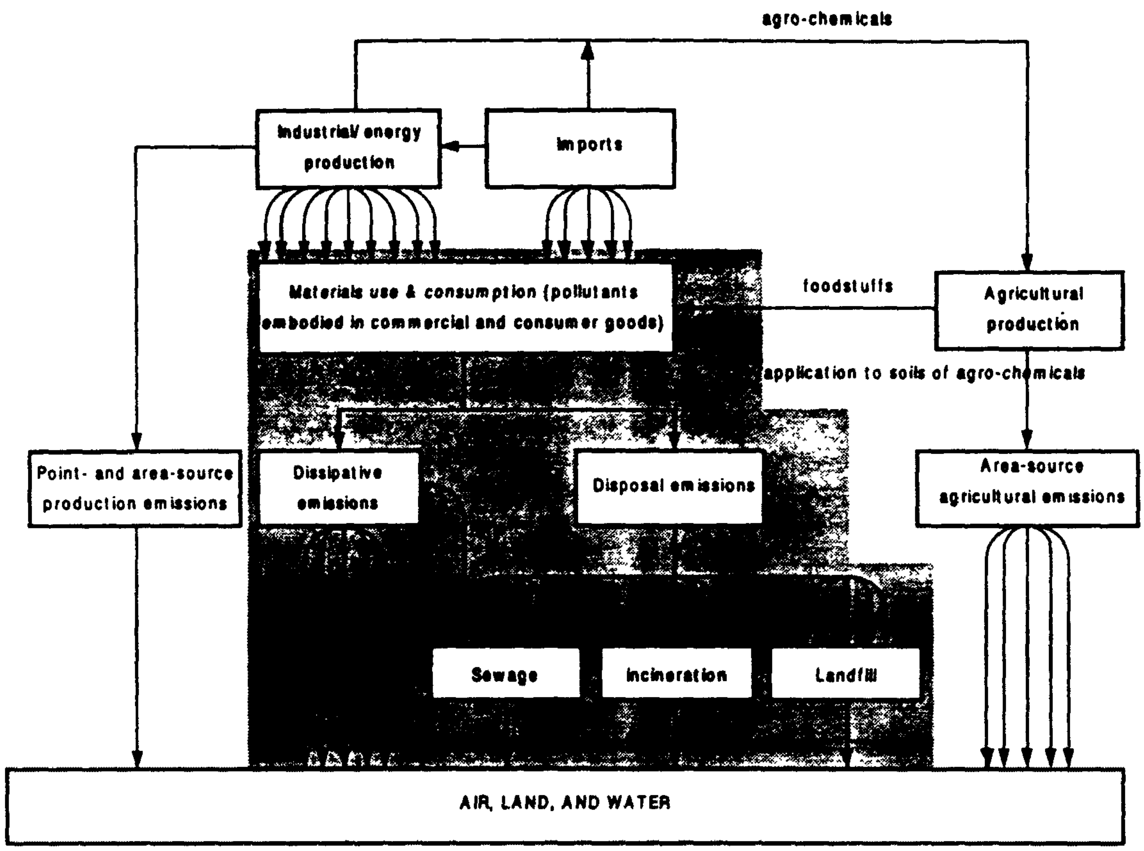

Figure 1-1. Comprehensive classification of emissions from consumer and commercial products.

Source: Adapted from Stigliani, William M. Chemical Emissions from the Processing and Use of Materials: The Need for an Integrated Emissions Accounting System. Ecological Economics 2(4):325-341. 1990. (Figure 2).

distinguished from the manufacturing-related emissions that are controlled by other forms of regulation. The regulatory structure is presented here followed by an overview of the architectural coatings industry.

1.2 REGULATORY BACKGROUND

Section 183(e)(3)(A) directs the EPA to list categories of consumer or commercial products that account for at least

80 percent of VOC emissions on a reactivity-adjusted basis in ozone nonattainment areas. The EPA divided this category list into four groups and established priorities for regulation. Architectural coatings is in the first group of categories to be regulated.

The design of regulatory strategies to reduce VOCs emitted by architectural coatings is shaped in specific ways by the Clean Air Act as amended. Two components of the legislation are of particular importance:

- determining regulated entities and
- establishing best available controls.

Regulations developed under Section 183(e) may be imposed only with respect to "manufacturers, processors, wholesale distributors, or importers of consumer or commercial products for sale or distribution in interstate commerce in the United States" or certain entities that supply such products to the former Sections 183(e)(1)(C) and 183(e)(3)(B). The definition of regulated entities excludes retailers and users.

The regulations affecting architectural coatings will require best available controls. The EPA Administrator, on the basis of "technological and economic feasibility, health, environmental, and energy impacts," will determine the desired degree of emissions reduction that

> is achievable through the application of the most effective equipment, measures, processes, methods, systems or techniques, including chemical reformulation, product or feedstock substitution, repackaging, and directions for use, consumption, storage, or disposal. (Section 183[e][1]).

1.2.1 Regulatory Structure

One hundred sixteen architectural coatings manufacturers responded to a survey conducted by the National Paint and

Coatings Association for products manufactured and their VOC contents.[2] The Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey (the survey) provides VOC content information and 1990 sales quantities by product. Based in part on these data, EPA is promulgating VOC content limit standards, which manufacturers and importers will be required to meet in 1999. Once the regulation becomes law, manufacturers and importers of architectural coatings subject to the regulation must limit the VOC content per liter of coating to the standards specified for each coating product they manufacture. The EPA has included an option of allowing manufacturers and importers to choose to pay an exceedance fee instead of meeting the limit for a particular product category. Another option manufacturers and importers have is to use a tonnage exemption to claim a set amount of product as exempt from VOC limits. The VOC content limits are presented in the Table of Standards (TOS) for 1999 in Section 2 (Table 2-1). The limits specified in this table were used in this economic impact analysis. They cover all the major architectural coatings categories as well as certain special purpose coating products for which a less stringent limit is granted in order for the coating to adequately perform its designed purpose (e.g., high-temperature coatings).

Architectural coatings manufacturers who choose to pay a fee on their products that do not meet the standards will pay the fee on the VOC content of the product that is in excess of the limit.[a] The fee rate is $2,500 (1996 dollars, adjusted to $2,200 in 1991 dollars) per metric ton (Mg) of excess VOCs. Fees will be paid semi-annually and will be placed in a "special fund" specified under Section 183(e). If EPA is able

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[a]Excess VOCs are defined as the maximum VOC content of the coating, as applied, in grams per liter of coating, less water and exempt compounds, minus the applicable VOC standard.

to obtain these funds through a subsequent Congressional appropriation they may be used by the Administrator to support the administration of the regulation or to promote additional VOC emission reductions from architectural coatings through technological development grants, award programs, or other means.

This report includes an overview of the architectural coatings industry, products, and technologies and an analysis of the economic impacts on the affected entities and the industry as a result of the TOS VOC content limits, exceedance fees, and tonnage exemption. An economic model of the architectural coatings industry is developed to obtain estimates of the potential price and quantity changes associated with the regulation. In addition, a Regulatory Flexibility Analysis is conducted, which estimates the impacts of the regulation on small businesses and presents alternatives that may be implemented to mitigate those impacts.

1.3 INDUSTRY PROFILE

This profile of the architectural coatings industry describes commodities and VOC content, demand for architectural coatings, production of architectural coatings, and industry conditions.

1.3.1 Commodities and VOC Content

The "architectural coatings" regulation applies primarily to products that the U.S. Census Bureau also categorizes as architectural coatings, but some products in the Census categories of special purpose coatings and miscellaneous allied paint products are affected as well.[3] Unless otherwise indicated, the term "architectural coatings" is used throughout this report to indicate the entire group of regulated products. Product categories covered under the regulation are listed in Table 1-1.[4] The products are grouped into the three Census categories in which they are found.[b] As indicated, the largest quantity of regulated coatings is included in the architectural coatings category, but some coatings are classified with the special purpose and allied paint products categories, which also include other products not covered by this regulation such as marine paints and putty.

Examples of Census-defined architectural coatings, all of which are represented in Table 1-1, include exterior and interior organic solventborne and waterborne tints, enamels, undercoats, clear finishes, stains, and architectural lacquers. These coatings are used for general purpose on-site application to residential, commercial, institutional, and industrial structures. They are intended for ordinary use and exposure and provide protection and decoration.

Special purpose coatings are similar to architectural coatings in that they can be classified as stock or shelf goods, rather than formulated to customer specifications, as are OEM coatings. The difference is that they are formulated for special applications or environmental conditions such as extreme temperatures, chemicals, fumes, fungi, or corrosive conditions.

VOC content varies substantially between specific types of coating products. Most of this variety is due to the type of solvent used in the coating and the ratio of the solvent to other ingredients in the formulation. Based on the 1990

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[b]See Appendix A for a detailed explanation of products for regulation and their corresponding Census classification.

TABLE 1-1. AVERAGE VOC CONTENT FOR ARCHITECTURAL COATINGS TO BE COVERED BY REGULATION

Product Category	Sales-Weighted Average VOC Content (g/L)	
	Organic Solvent	Waterborne
Architectural coatings		
Exterior flat architectural coatings	336	68
Exterior nonflat architectural coatings	404	76
Interior flat architectural coatings	315	48
Interior nonflat architectural coatings	413	74
Semitransparent stains	527	85
Opaque stains	429	56
Undercoaters	379	41
Primers	374	48
Sealers	607	41
Waterproofing sealers, clear	659	200
Waterproofing sealers, opaque	242	a
Quick dry undercoaters, primers, and sealers	441	31
Bituminous coatings	290	4
High performance architectural coatings	431	113
Roof coatings	269	28
Lacquer	667	300
Varnish	481	143
Special purpose/industrial maintenance Coatings		
Swimming pool coatings	554	a
Dry fog coatings	365	149
Mastic texture coatings	278	107
Metallic pigmented coatings	461	a
Fire retardant coatings	a	23
Antigraffiti	577	131
Concrete curing compounds	717	71
Form release compounds	601	a
Graphic arts coatings	386	42
High-temperature coatings	560	a
Industrial maintenance coatings	392	112
Multicolored coatings	321	a
Pretreatment wash primers	718	a
Sanding sealers	531	192
Shellacs	539	a
Traffic marking paints	398	85
Allied paint products		
Below ground wood preservatives	541	a
Semitransparent wood preservatives	591	67
Clear wood preservatives	493	419
Opaque wood preservatives	446	a

[a] Sales-weighted average VOC content not available.

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for the National Paint and Coatings Association in Cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

survey data collected, the sales-weighted average VOC contents for surveyed coating products are listed in Table 1-1.[c,5]

1.3.2 Demand for Architectural Coatings

1.3.2.1 Conceptual View of Coating Decision. The demand for architectural coatings derives from the demand for the treatment of architectural surfaces. Surface treatment services include not only coating treatment, but also noncoating treatment alternatives such as wallpaper or exterior siding. While the choice among coating alternatives is emphasized below, it is implicitly recognized that the substitution between coating and noncoating surface treatments is possible as well.

The coatings themselves are an input into the production of surface treatment services, the final product of interest. Each surface possesses certain attributes that affect the demand for surface treatment. These include surface material (substrate), age, exposure (e.g., weather, chemicals), and other physical factors that intrinsically affect the relative performance of treatment alternatives.

In an economic decisionmaking context, we think of the owner of the surface as seeking to maximize the utility derived from the services provided by the surface (i.e., shelter, decoration, etc.). Let process i indicate the activity of treating a surface defined by the attributes above. Through this process, labor, capital, and materials are employed to treat the surface. Thus we can characterize

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[c]Sales-weighted average VOC content is

$$\frac{\sum_{i=1}^{n} (\text{VOC Content})_i \cdot (\text{Sales})_i}{\sum_{i-1}^{n} (\text{Sales})_i}$$

where VOC content is equal to the percentage by weight, sales are measured in pounds per year, and n equals the number of product categories.

the production of a unit of surface treatment through process i as follows:

$$Q_i = Q(L,K,X_i)$$

where Q_i is the surface area unit (e.g., 1,000 ft^2) treated using process i and L, K, and X_i are the quantities of labor, capital, and material (e.g., coatings) used to produce Q_i.

For the processes that include coatings application, assume there is a fixed proportions relationship between each input and output, determined by the type of coating being used. For example, process A requires 1 gallon of coating A, 40 hours of labor, and 10 units of capital to cover a unit area of a given surface type. Therefore, for a given set of input prices, there is a (constant) per-unit cost of treatment. Costs of noncoating alternatives can be similarly computed. Considering all n possible treatment alternative for a given surface generates an array of costs $(C_1,C_2,...,C_n)$.

Each owner/consumer places a subjective value on the outcome of each treatment alternative. This value derives from such factors as innate preferences for the visual appeal of treatment alternatives and perceptions of the structural quality and durability. For example, consumer A may prefer the look of glossy solvent-based coatings to flat water-based coatings and/or may perceive other differences in product quality. The consumer explicitly or implicitly monetizes these preferences, and the associated monetary values for each of the n alternatives comprise the array of perceived benefits for $(B_1,B_2,...,B_n)$.

In evaluating the choice among treatment alternatives, the consumer weighs each alternative's monetized benefit, B_i, against the cost of treatment, C_i. The subjective payoff from each alternative can be expressed as

$$\pi_i = B_i - C_i.$$

The consumer maximizes utility with respect to the surface treatment choice by selecting the alternative with the highest payoff. This of course presumes that at least one of the payoffs is not negative. If all potential payoffs are negative, the consumer is better off by choosing no surface treatment at all.

1.3.2.2 Substitution Effects.

The purpose of this discussion is to describe how consumption choices may change in response to any price effects of the regulations. If the regulations induce a change in the price schedule of various architectural coatings, the unit costs of treatment alternatives will be directly affected. Furthermore, the regulations may induce a change in the structural characteristics of the coating that alters the application technology. For example, a different VOC content may change the volume of the coating that must be applied and the amount of labor and capital necessary to achieve the same surface area treatment; consequently, the technological parameters may change with the new VOC requirements. Therefore, treatment costs will be affected jointly by what we call the factor price effect and the technology effect. If, for example, the VOC-content regulations would raise the price of the affected coatings and reduce the technological efficiency of the treatment process (e.g., more coats necessary), then both the factor price effect and technology effect would combine to increase the cost of the affected treatment alternatives, generating a new set of treatment costs $(C_1', \ldots, C_n')$. Alternatively the new formulas could improve technical efficiency, but at a higher cost and the net effect on price would be unknown.

VOC-content regulations may also affect consumer valuation of the treatment alternatives through a change in visual characteristics and altered perceptions of quality or durability. These changes generate a new set of subjective values for the treatment alternatives of $(B_1', \ldots, B_n')$. As a result, evaluating the new arrays of benefits and costs produces a new array of treatment payoffs, $(\Pi_1' \ldots, \Pi_n')$. The consumer can again be expected to select the treatment alternative with the highest payoff. This situation may produce a different optimal selection than the no-regulation case. The consumer may in fact choose a noncoating alternative or no-treatment alternative, where coating treatment would be selected without the regulation.

1.3.2.3 Aggregate Demand.

If all consumers' preferences were identical and all surfaces to be treated possessed the same characteristics, the consumer choice model above would predict only one optimal type of surface treatment throughout the economy. A wide array of treatments and coatings are actually applied, however, indicating a variety of surfaces with different characteristics as well as individual preferences that vary across consumers.

Aggregating over all consumers and all surfaces, we can see how the regulatory changes can induce substitution among treatment alternatives and changes in aggregate demand for the affected coatings. These aggregate changes in demand and the associated effect on consumer welfare are the focus of this study.

1.3.2.4 Coating Users. Users of coatings can be divided into two groups: professionals and nonprofessionals. The nonprofessional is typically a "do-it-yourselfer" who purchases only a small amount of coatings each year. The application of coatings by nonprofessionals is limited primarily to residential architectural coatings. Professional users of coatings may be professional painters or contractor/ builders. These professionals apply coatings to a broad array of surfaces in residential, commercial, institutional, and industrial settings. Table 1-2 shows that in 1991 do-it-yourselfers purchased two-thirds of all residential architectural coatings.[6] It seems reasonable to assume that contractors purchased all of the nonresidential architectural coatings and thus accounted for 60 percent of the use of all architectural coatings.

TABLE 1-2. CONSUMERS OF ARCHITECTURAL COATINGS

	Percentage of Total Gallons in 1991 (%)
Residential	
Do-it-yourselfers	41
Contractors	19
Nonresidential[a]	40
Total	100

[a] Commercial, institutional, light industrial.

Source: National Paint and Coatings Association. U.S. Paint Industry Data Base. Menlo Park, CA, SRI International. 1992.

1.3.3 Production of Architectural Coatings

1.3.3.1 Raw Material Inputs. Coatings comprise four basic types of materials: pigment, resin (binder), solvent, and additives. Pigment is the solid component consisting of uniform particles of a controlled size that are insoluble in the vehicle (the liquid portion of the coating). Pigments are used in coatings to decorate and protect and as fillers.[7] Pigmentation, although it varies depending on desired properties, is similar in both waterborne and solventborne formulations.

Film-forming binders surround and hold together the elements of the coating film and make up the nonvolatile portion of the vehicle. Resins aid in adhesion; determine the cohesiveness of the dried film; affect gloss; and provide resistance to chemicals, water, and acids. Natural and synthetic resins and oils, along with certain additives such as driers and plasticizers, serve as binders in coatings and are one of three types: multiuse resins (acrylics, vinyls, urethanes, polyesters); thermoset resins (alkyds, epoxies); and oils (drying oils, bodied oils).

The vehicles in organic solventborne and waterborne paints differ not only by the type of resin used, but also in the way they form a film and dry (or cure). Alkyd paints are oxidizing film formers in which the drying oils react with the oxygen in the air when the paint dries. The chemical reaction binds the molecules of the vehicle into a hard, dry film. Alkyd coatings continue to oxidize long after they dry and eventually provide a rock hard surface. Latexes consist of tiny, heat-sensitive plastic particles (latex) that are dispersed but not dissolved in water along with the pigment. As the water evaporates, a layer of closely packed plastic particles and pigment is left behind. The softened plastic particles then lose their shape and molecules diffuse and reattach to form a binding film.[8] The chemical characteristics of latex and alkyd paint influence some of their characteristics, such as gloss and resistance to blocking and water. Heat-sensitive plasticizers in latex paint cause the residual tackiness called blocking, which is more of a problem in glossy latex paints where the ratio of resin to pigment is higher. Precise control of particle shape and size in the film former is necessary to increase gloss.

The plastic mesh also breathes better, allowing water and air to pass through it. The oxidizing process of alkyds forms a smooth (thus glossier), watertight skin of hardened resin that provides durability and water resistance.

Petroleum distillates in alkyd paints and water in latex paint function as the carrier, or volatile vehicle, that disperses the pigment and resin and provides the necessary fluidity for applying the coating. Basically there are two types of solvents: water and organic. In alkyd paints organic solvents dissolve the components of the film former, keeping them in solution. In latex paints, water separates and suspends the droplets of film former. Following application, the evaporation rate of the particular solvent controls the rate at which the film forms, leaving the pigment and resin bonded to the surface. Latent solvents, which dissolve the film former when combined with true solvents, and diluents may be added to the true solvent.[9] Diluents can be blended with the dissolved solution to extend the true and latent solvents. Water is the true solvent used in latex paints but may function as a diluent in alkyd formulations. Three types of organic solvents are used in coatings: hydrocarbons (aliphatic, aromatic); oxygenated solvents (alcohols, esters, ketones, glycol ethers); and chlorinated solvents (1,1,1-trichloroethane, methyl chloroform).[10] Architectural solventborne paints are mainly formulated with aliphatic hydrocarbons.

Additives are used in relatively small amounts in both organic solventborne and waterborne formulations to provide additional necessary properties or augment the properties of other inputs. They may be added to the film former, solvent, or pigment. Waterborne paints in particular may use additives such as agents to reduce foaming or bubbling of paint when it is shaken and applied; wetting agents, which can improve pigment dispersion or adhesion; freeze-thaw agents, which reduce the temperature at which the paint will freeze to prevent coagulation; and coalescing agents, which aid the flow of the latex particles to form a more continuous film.[11] VOC contents in latex paints (4 to 10 percent, or 50 to 200 g/L) are due to the additives used.[12] Solvents such as alcohols and ethylene glycols are added as co-solvents to waterborne formulations. They are often necessary to allow the plastic particles to soften and be mobile enough to bind into a continuous film.[13]

The additives used in the largest volume are thickeners, fungicides and preservatives, plasticizers, and defoamers.[14] Figures 1-2 and 1-3 show the principal raw material ingredients discussed above as they are used in organic solventborne and waterborne coating formulations.

1.3.3.2 Formulations. One of the distinguishing characteristics of each coating is the relative amount of the three main material inputs contained in the coating: pigment, binder, and solvent. Different formulations, particularly different ratios of pigmentation in the dried film to total volume of the dried film (pigment-volume concentration), will lead to correspondingly different protective and decorative functions.[15] For example, a coating designed to hide surface irregularities (like a mastic texture coating) has a higher pigment-volume concentration than a gloss varnish whose decorative function is to impart a shiny transparent or semi-transparent coating. Low pigment-volume concentrations have an increased resin content and in general have high durability, gloss, and washability. The ratio of solvent to nonvolatile components ("solids") also characterizes types of

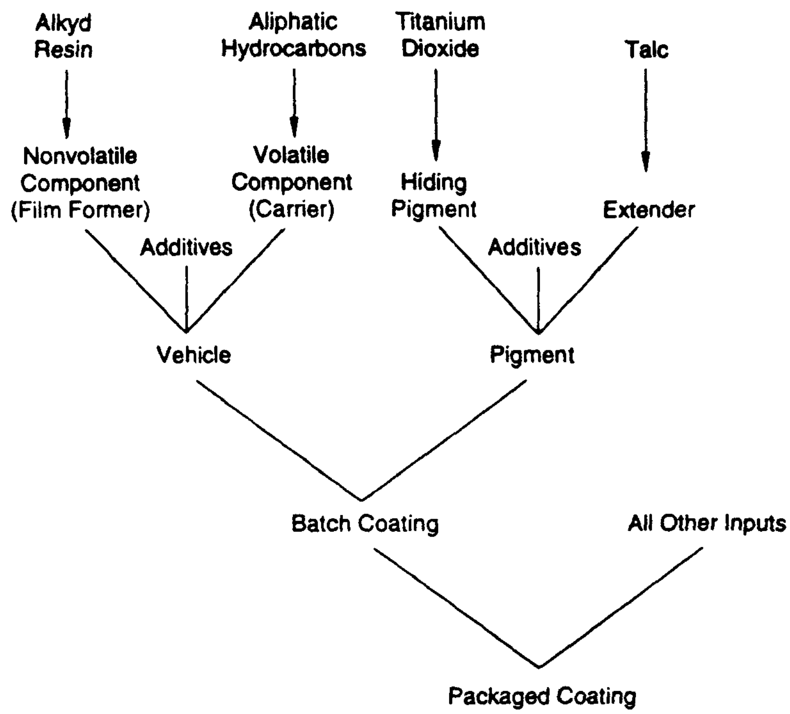

Figure 1-2. Inputs generally used in the manufacture of a solventborne coating.

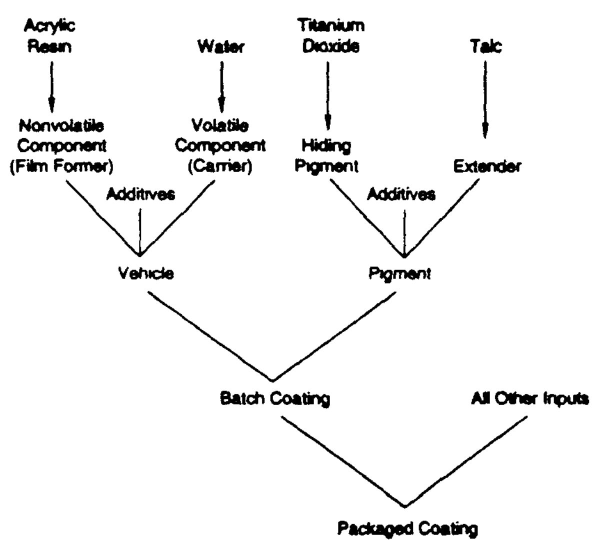

Figure 1-3. Inputs generally used in the manufacture of a waterborne coating.

coatings.[d] Penetrating stains have a low solids-to-solvent ratio, and, when the solvent evaporates, virtually no film is left behind.

Figure 1-4 shows typical formulations and average VOC contents for a few architectural coatings.[16] The coatings in Figure 1-4 with higher solvent content also have higher VOC content. A low solids-to-solvent ratio, as with semi-transparent stain, is associated with high VOC content in coatings with organic solvents because VOCs are contained almost exclusively in the solvent portion of the coating. Two ways to reduce the amount of VOCs released from coatings are to increase the solids-to-solvent ratio and to substitute water for an organic solvent.

1.3.3.3 Manufacturers' Substitution Options and New Technologies. Manufacturers face two substitution possibilities to reduce VOC emissions from coatings. They may reformulate the coating to increase the solids-to-solvent ratio. Alternatively, manufacturers may reformulate the coating so that it contains the same amount of solvent but emits fewer VOCs during application (i.e., substitute water for an organic solvent). Certain coatings such as interior flat wall paint, interior semigloss, and exterior house and trim paint have been formulated using water for several years. Between 1950 and 1980, waterborne coatings replaced approximately 70 percent of solventborne coatings.[17] The performance of latex paints often meets and even exceeds alkyd counterparts; therefore, manufacturers may choose to discontinue organic solventborne paints in these product classes.

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[d]Nonvolatile components are often referred to as the "solids" portion of the coating, which includes pigments, resins, and other additives, although resins are not really solid until the film forms and are considered part of the nonvolatile vehicle, or liquid portion of the formulation.

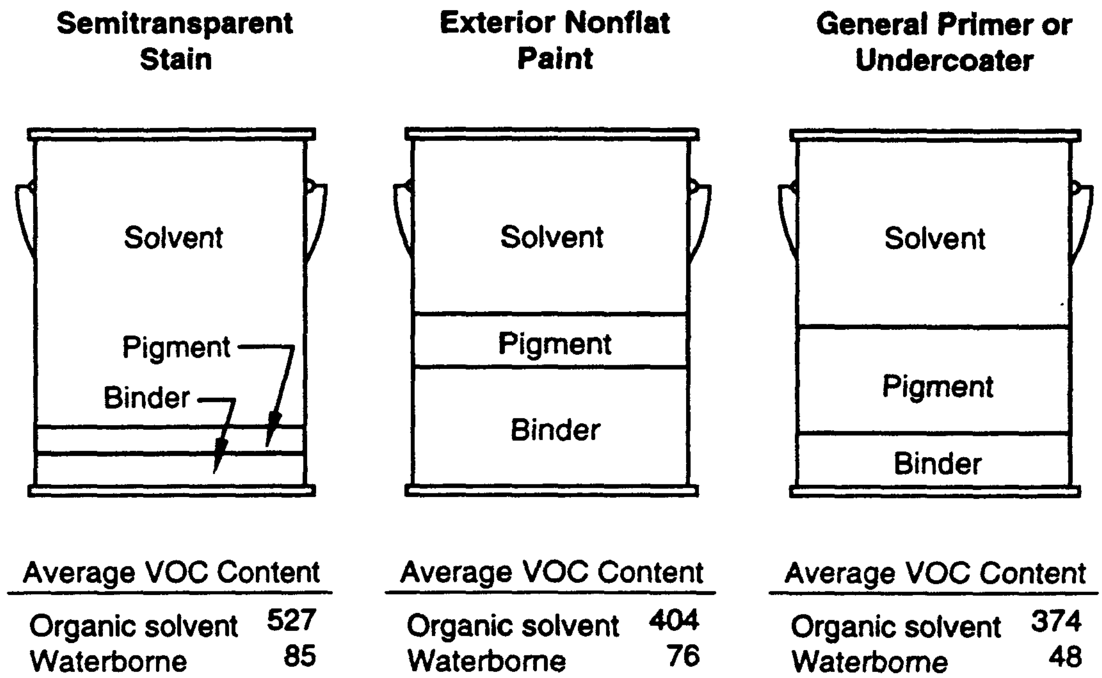

Figure 1-4. Approximate volume relationships of coating ingredients.

Note: VOC content in grams per liter from Table 1-1.

Source: Whittington, Trevellyan V. Paint Fundamentals. In Paint Handbook. Guy E. Weismantel (ed.). New York, McGraw-Hill. Pp. 1-1 to 1-23. 1981. (Adapted from Figure 1.4)

Other products, including stains, clears, high-gloss enamels, outdoor varnishes, and some special purpose coatings, are more difficult to reformulate. According to a 1990 article, clear coatings have two problems associated with them: waterbornes are transparent to UV radiation, whereas organic solventbornes absorb UV rays thus protecting the substrate; and waterborne acrylic polymers are not strong enough.[18] Quality performance in reformulated products is currently possible, but the cost may be very high.[19] As new technologies become more refined, new resin systems, such as alkyd systems once used only in solventbornes, will be used in more coatings, so prices will become more competitive.

High solids content formulation is an alternative technology to waterborne formulations that manufacturers have employed to reduce VOC emissions from coatings. A high solids coating is formulated with a high solids-to-solvent ratio.[e] Since a smaller percentage of solvent is contained in the coating, fewer VOCs are released during application. Table 1-3 shows example reduced solvent contents of three different types of reformulated organic solventborne products.[20]

TABLE 1-3. PERCENTAGE OF SOLVENT IN CONVENTIONAL AND REFORMULATED ORGANIC SOLVENTBORNE COATINGS

Product	Conventional Solvent Content (%)	Reformulated Solvent Content (%)
Interior semigloss	60	47
Clear coatings	55 - 62	35 - 37
Stains	72 - 85	30 - 35

Source: Bakke, Timothy O. Clean Air Paints. Popular Science. 237:85. August 1990.

Disadvantages noted in the past of higher solids organic solventborne paints include increased viscosity, longer drying time, reduced durability, and generally higher prices.[21] Reformulated organic solventbornes may be thicker, which would make them harder to apply and extend drying time, but they may offer greater protection. Durability may be compromised because of the reduced strength of shorter chain alkyd molecules substituted for longer chain molecules to improve flow.[22] Reformulated alkyd products can offer some advantages

[e]Note that the definition of high solids varies by coating type.

however. Durability may be traded for flexibility, which provides increased resistance to cracking and peeling. Presealers may not be necessary for wood substrates because the thicker coatings penetrate more evenly. Reduced VOC emissions, lower odor, and reduced toxicity and flammability are other benefits.

Raw material suppliers are expanding and improving upon existing technologies to meet demand for performance in new waterborne and high solids formulations. Solvents for use in waterborne formulations (i.e., glycol ethers) and high solids (keytones, esters) are replacing many of the hydrocarbon solvents used in solventborne formulations. Resins are being developed with a goal toward improved performance in new low-VOC formulations; similarly additives are being developed to improve flow and leveling characteristics of the new resins. Additional low-VOC technologies are reactive diluent technology, radiation curing technologies, and powder coatings, which currently are mainly used in manufacturing applications.

1.3.4 Industry Conditions

1.3.4.1 Shipments and Manufacturer Specialization. In 1991, the architectural coatings segment of the paint and allied products industry shipped $4,881.9 million in potentially regulated products (Table 1-4).[23,24,25,26,27,28,29,30,31,32] The value of shipments steadily increased by approximately 59 percent between 1981 and 1991, with a slight decrease between 1990 and 1991. The strong construction market throughout the 1980s helped contribute to this growth, but the industry as a whole was generally considered to be maturing in the early 1990s.[33] In 1991, the size of the architectural coatings component relative to the total coatings industry was 37.8 percent. New products are important to the paint and allied products industry, because growth for individual

TABLE 1-4. VALUE SHIPPED OF POTENTIALLY REGULATED PAINT AND ALLIED PRODUCTS: 1981 THROUGH 1991 ($$10^6$)

1987 Product Code	Product Class	Year										
		1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981
28511	Architectural coatings	4,881.9	4,913.6	4,525.3	4,426.8	4,245.4	4,010.0	3,830.8	3,559.3	3,320.8	3,092.2	3,065.6
	Exterior solventborne	856.8	890.3	819.7	817.7	816.9	765.3	757.8	731.0	672.4	621.9	609.6
	Exterior waterborne	1,166.0	1,201.9	1,062.3	1,014.3	952.7	899.8	851.1	875.4	833.8	789.1	719.7
	Interior solventborne	647.2	644.1	655.1	621.4	603.0	553.5	544.7	512.6	490.2	473.1	445.5
	Interior waterborne	2,054.8	2,018.9	1,850.8	1,779.2	1,620.1	1,491.9	1,405.5	1,343.0	1,210.7	1,119.7	1,090.6
28511 93	Architectural lacquers	83.3	85.5	73.5	84.7	81.7	81.2	79.2	64.9	57.6	45.3	37.1
28511 00	Architectural coatings, n.s.k.[a]	73.7	72.9	63.9	109.6	170.9	218.2	192.4	32.9	35.9	42.9	163.2
28513	Special purpose coatings											
28513 0	Industrial new construction and maintenance paints											
	Interior	293.8	265.9	240.0	208.6	179.9	128.7	149.7	126.9	103.5	120.0	88.4
	Exterior	503.2	484.7	497.4	395.2	343.1	321.8	330.2	252.9	191.9	209.7	203.9
28513 11	Traffic marking paints	132.4	138.0	138.0	136.5	104.6	78.5	95.9	N/A	N/A	N/A	N/A

N/A = Not available.
[a] n.s.k. = Not specified by kind.

Sources: U.S. Department of Commerce. Current Industrial Reports: Paints and Allied Products, 1982. Washington, DC, Government Printing Office. 1983
U.S. Department of Commerce. Current Industrial Reports: Paints and Allied Products, 1983. Washington, DC, Government Printing Office. 1984.
U.S. Department of Commerce. Current Industrial Reports: Paints and Allied Products, 1984. Washington, DC, Government Printing Office. 1985.
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U.S. Department of Commerce. Current Industrial Reports: Paints and Allied Products, 1990. Washington, DC, Government Printing Office. 1991.
U.S. Department of Commerce. Current Industrial Reports: Paints and Allied Products, 1991. Washington, DC, Government Printing Office. 1992.

Note: Inflation factors used by the Census to produce estimates for the entire industry for aggregated data were applied to the disaggregated figures here. For architectural coatings: 1987-1991, 1.00; 1982-1986, 1.004; and 1981, 1.04. For special purpose coatings: 1987-1991, 1.06; 1982-1986, 1.00; and 1981, 1.08. The inflation factors for 1981 are based on 1977 Census relationships and for 1982-1986 on 1982 Census relationships.

producers is predicted to come from market share expansion, new product introductions, and improvements in established products.[34]

Sales in the architectural sector generally reflect activity in house redecoration, maintenance and repair, as well as sales of existing homes, new home building, and, to a lesser extent, commercial and industrial construction. Among interior and exterior architectural coatings, the waterborne coatings market dominates the sector and experienced a larger percentage increase in growth than did organic solventborne coatings. Interior waterbornes grew the most, 88.4 percent from 1981 through 1991. In 1991, 76 percent of interior coatings and 57.6 percent of exterior coatings were waterborne. Partly in response to environmental regulations aimed at the reduction of VOC emissions, the industry has shifted from manufacturing conventional organic solventborne paints in favor of paints with high solids-to-solvent ratios and waterborne and solventless paints.[35] However, much of this trend has also been driven by consumer demand.

Although the historical Census data do not identify value of shipments for paint products within the four product classes, other sources indicated that the majority of interior wall and exterior siding paint jobs use waterborne products.[36,37,38] Therefore, the exterior and interior solvent-borne shares probably account for mainly coatings used on exterior and interior trim, floors, decks, and high-gloss enamels.

Industrial new construction and maintenance paints and traffic marking paints are classified by the Census as special purpose coatings, which comprised 22 percent of the total coatings market in 1991. Market shares for industrial maintenance and traffic marking paints within the special purpose segment were 28 percent and 4.6 percent, respectively.

Growth prospects for this segment are expected to be above average, especially for industrial and machinery maintenance coatings.

For all companies classified in the paints and allied products industry in 1987, 98 percent of their value of shipments was generated from the manufacture of paints and allied products (Table 1-5).[f,39] Only 3 percent of the value of paints and allied products shipped were manufactured by companies outside the industry. The top three secondary producers of paint and allied products account for about half the value produced as secondary products in other industries and are shown in Table 1-6: adhesives and sealants, plastics materials and resins, and printing ink.[40] Because coating products often function as sealants, the adhesives and sealants industry is a logical secondary producing industry.

1.3.4.2 Company Size and Industry Structure. Information on industry structure is highly dependent on one's definition of the industry in question. The data used in this discussion apply to the entire Paint and Allied Products Industry (SIC 2851). As indicated above, architectural coatings account for just under 40 percent of industry shipments. Unfortunately, the industry structure data are not available for the architectural coatings component of the industry. Therefore, the information presented here may not always accurately reflect the structure of the architectural coatings sector.

In 1987, the paint and allied products industry comprised 1,121 companies owning a total of 1,428 establishments (Table 1-7).[41,42] Single establishments were held by approximately 77 percent of the companies, and they had an

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[f]Industry statistics, unless otherwise noted, include figures for all segments of the paint and allied products industry, not just those to be regulated.

TABLE 1-5. NUMBER OF COMPANIES, ESTABLISHMENTS, AND PRODUCER SPECIALIZATION—PAINT AND ALLIED PRODUCTS: 1987

		Industry				Product Class Total Made in All Industries ($10[6])
SIC Code	Industry/ Primary Product Class	Number of Companies	Number of Establishments	Primary Product Specialization Ratio (%)[a]	Coverage Ratio (%)[b]	
2851	Paints and allied products	1,123	1,426	98	97	12,078.8
28511	Architectural coatings		282			
28513	Special purpose coatings		131			

[a] Value of primary products for the industry divided by the sum of the value of primary products produced by the industry and the value of secondary products produced by the industry.

[b] Value of primary products for the industry divided by the total value of products for that industry produced in any industry.

Source: U.S. Department of Commerce. 1987 Census of Manufactures, Industry Series: Paint and Allied Products. Washington, DC, Government Printing Office. 1990.

average value added of $1.1 million. The multiestablishment companies had an average value added of $20.4 million and produced almost 85 percent of the total value added for the industry. Also shown in Table 1-7, the 50 largest companies in 1987 produced 66 percent of the total value of shipments for the industry. Data from the Small Business Administration (SBA) indicate that in 1991 there were 1,152 companies and approximately 98 percent of those were classified as small businesses as defined by having fewer than 500 employees.[43] Figure 1-5 displays the location of manufacturing establishments in the paint and allied products industry by state.[44] California has the greatest number, 201, followed by Illinois with 118. Paint manufacturing is fairly well represented in most states east of the Mississippi River.

TABLE 1-6. COMMODITY PRODUCTION IN 1982: PAINT AND ALLIED PRODUCTS

(SIC 2851) Product Examples	Producing Industries	Value[a] ($$10^6$)	Percentage Produced
Interior and exterior paint, lacquers, and varnishes; OEM coatings; industrial new construction and maintenance paints, traffic paints, automotive refinish paints, marine paints, aerosol coatings, paint and varnish removers, thinners, putty and glazing compounds, brush cleaners	Primary	8,243.3	96.5
	All secondary producers	303.2	3.5
	All producers	8,546.5	100.0
	Top three secondary:	142.6	1.7
	Adhesives and sealants	68.8	0.8
	Plastics materials and resins	45.8	0.5
	Printing ink	28.0	0.3
	All other secondary producers	160.6	1.9

[a] Measured at producers' prices.

Source: U.S. Department of Commerce. The 1982 Benchmark Input-Output Accounts of the United States. Washington, DC, Government Printing Office. 1991.

In the 1980s, consolidation was a major trend in the paint and allied products industry. The maturity of the industry and increased technology requirements are factors contributing to the restructuring. A large number of mergers and acquisitions took place in response to pressure from the higher cost of paint ingredients, intense industry competition, compliance with government regulations, and low profit margins.[45] Other companies divested their paint and coating operations to focus on other businesses or as an alternative to making the capital and research and development (R&D) commitments required to remain competitive. The number of coating manufacturers and the number of establishments

TABLE 1-7. LARGE FIRM DOMINANCE AND NUMBERS OF COMPANIES AND ESTABLISHMENTS IN THE PAINT AND ALLIED PRODUCTS INDUSTRY: 1987

					Value of Shipments				
						Percentage Accounted for by [a]			
Industry (SIC 2851)	Number of Companies	Number of Establish-ments	Value Added ($$10^6$)	Average Value Added[b] ($$10^6$)	Total ($$10^6$)	4 Largest Companies	8 Largest Companies	20 Largest Companies	50 Largest Companies
Paint and allied product producers	1,121	1,428	6,220.7	5.5	12,702.4	27	40	53	66
Multiestablishment companies	259	566	5,271.3	20.4	10,651.9				
Single-establishment companies	862	862	949.3	1.1	2,050.5				

[a] Percentages consist of the sum of value of shipments of the four largest companies (or 8, 20, or 50 companies), divided by the total value of shipments of the industry.

[b] The total value added divided by the number of companies.

Sources: U.S. Department of Commerce. Census of Manufactures, Subject Series: Type of Organization. Washington, DC, Government Printing Office, February 1991.

Source for Percentage Accounted for Data: U.S. Department of Commerce. 1987 Census of Manufactures, Concentration Ratios of Manufacturers. Washington, DC, Government Printing Office. 1992.

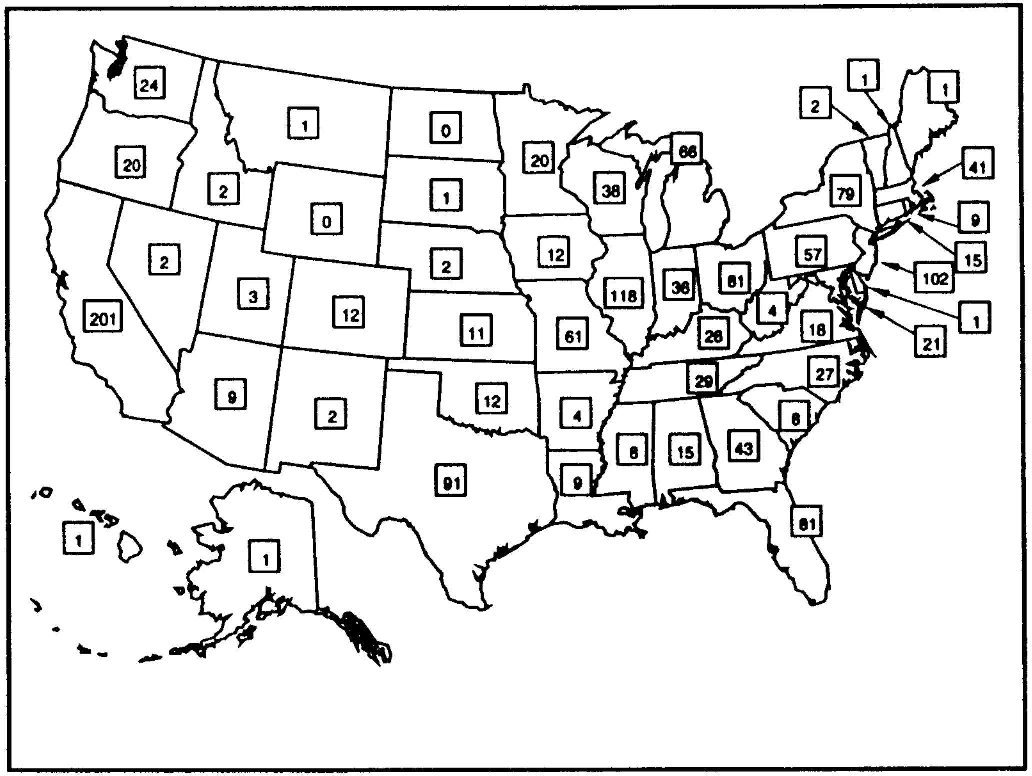

Figure 1-5. Location of manufacturing establishments in the paints and allied products industry in 1987: SIC 2851.

Source: U.S. Department of Commerce. 1987 Economic Censuses. Volume 1, Report Series, Release 1D. Census of Manufactures: Location of Manufacturing Plants. file MC87LMCO. 1991.

operated by these manufacturers has decreased. As indicated in Table 1-8, from 1972 to 1991, the number of companies decreased by 12 percent, and the number of manufacturing establishments decreased by over 20 percent.[46]

TABLE 1-8. NUMBER OF COMPANIES AND ESTABLISHMENTS IN THE COATINGS INDUSTRY, SELECTED YEARS, 1972-1991

Year	Number of Establishments	Number of Companies
1972	1,599	1,317
1977	1,579	1,288
1982	1,441	1,170
1987	1,426	1,123
1991	1,400[a]	1,030[a]
% change 1972-1991	-12.4%	-21.8%

[a] 1991 figures are from Finishers' Management. The U.S. Paint and Coatings Industry. pp. 23-25. April 1991.

Source: U.S. Department of Commerce. 1987 Census of Manufactures, Industry Series: Paints and Allied Products. Washington, DC, Government Printing Office. 1990.

On average, 35 to 40 mergers or acquisitions took place each year in the coatings industry in the late 1980s and early 1990s.[47] A transaction involves the transfer of production capacity from one company to another but does not necessarily indicate the dissolution of the company making the transfer. The selling company could sell only a division or product line and remain in business. Some of the larger acquisitions reported in trade journals, by the press, and in companies' annual reports are listed in Table 1-9.[48]

TABLE 1-9. ACQUISITIONS IN THE COATINGS INDUSTRY: CIRCA 1990

Selling Company	Acquiring Company	Division Sold
DeSoto	Sherwin Williams	Consumer Paint Operation
Whittaker Corp.	Morton International	Specialty Chemicals Operation
Azko Coatings Inc.	Reliance Universal Inc.	Buyout
DeSoto	Valspar	Coil Coatings Operation
Clorox Co.	PPG Industries, Inc.	Olympic and Lucite finishes

Source: Loesel, Andrew. Coatings Industry Faces New Mix. In Chemical Marketing Reporter. 238(18):SR3-SR8. New York, Schnell Publishing Co. 1990.

Most of the larger companies produce architectural, original equipment manufacturer (OEM), and special purpose coatings. Several of the largest coatings producers are chemical corporations; however, paint manufacturing represents only a small part of their overall business.[49] In 1991, merger activity slowed down and left the industry basically divided into two groups: a few, well-financed and highly diversified multinationals and a large number of regional paint companies.[50]

SECTION 2
COSTS OF REGULATION FOR ARCHITECTURAL COATING PRODUCERS

This section estimates the costs to comply with the architectural coatings regulation and examines the economic impacts of these costs as they are distributed across producers and consumers of the regulated products through market processes. The analysis in this section focuses on the (primary) impacts defined within the architectural coatings product markets. An assessment of impacts on users of traffic coatings addresses selected secondary impacts in other sectors of the economy. That analysis is presented in Section 4.

2.1 BACKGROUND

The EPA plans to control VOC emissions from architectural coatings using a combined regulatory approach: (1) product-specific VOC content limits, (2) an option for producers of products that exceed the content limits to pay a fee on the VOC content in excess of the limit, and (3) a phased tonnage exemption that allows each manufacturer the option to claim as exempt a limited number of products that result in a specified amount of emissions annually. Using reformulation cost estimates and an exceedance fee rate, the Agency analyzed the potential impacts of the regulation, first using static analyses of regulatory response options and second using a dynamic market analysis that estimates changes in prices, quantities, and social welfare.

2.2 OVERVIEW OF RESPONSE OPTIONS

The regulation to reduce the VOC content of architectural coatings will affect both production decisions for the suppliers of the coatings (through its impact on costs and revenues) and consumption decisions for the demanders (through its impact on product prices). Before developing a formal economic model to analyze these regulations, the Agency needed to characterize the scope of responses available to producers and consumers.

2.2.1 Supply

The EPA is proposing a set of limits for the VOC content in specific product categories to be met in 1999. Firms that produce products exceeding the VOC limits essentially have three compliance options:

- reformulate the products so that they comply with the standard,
- pay a fee on the excess VOC content over the standard, or
- remove the product from the market.

Each producer also may exempt a small quantity of product from compliance.

This analysis assumes that firms will choose the option that maximizes their net benefits, as measured by the expected (discounted) value of the profits generated under each option. Although decisions in the short-run may differ from decisions made to maximize net benefits in the long run, this analysis primarily considers the long-run decisions and their impact on the architectural coatings markets. Uncertainties pertaining to short-run decisions are discussed in Section 2.7.

The first option for producers to comply with the rule is to reformulate products that exceed the specified VOC content. Product reformulation often involves an investment in research and development (R&D) to develop a compliant product. The extent of the reformulation necessary to bring a product into compliance can vary from product to product. In some cases, compliance can be achieved for a particular product without large R&D investments because the product is similar enough to an existing formula or another product undergoing reformulation. A major reformulation, as is discussed throughout this analysis, typically requires a significant resource and time commitment. The process can take several years and is divided into a number of different stages. Figure 2-1 identifies the basic reformulation stages for a prototype architectural paint (other coatings such as varnishes may have fewer stages).[51] The firm may subsequently need to alter its capital equipment to produce the reformulated product, but these physical capital adjustments are usually small compared to developing the intellectual capital to devise the new formula.

The analysis that follows assumes that manufacturers bear the full cost of each reformulation. Since the VOC content limits in the rule reflect available resin technologies, it is likely that the costs associated with reformulation will at least partially be shared by resin manufacturers/suppliers. In that regard, the direct impacts on manufacturers will be overstated in the analysis. This and other potential upward and downward biases in the cost estimation methodology are addressed later in this section.

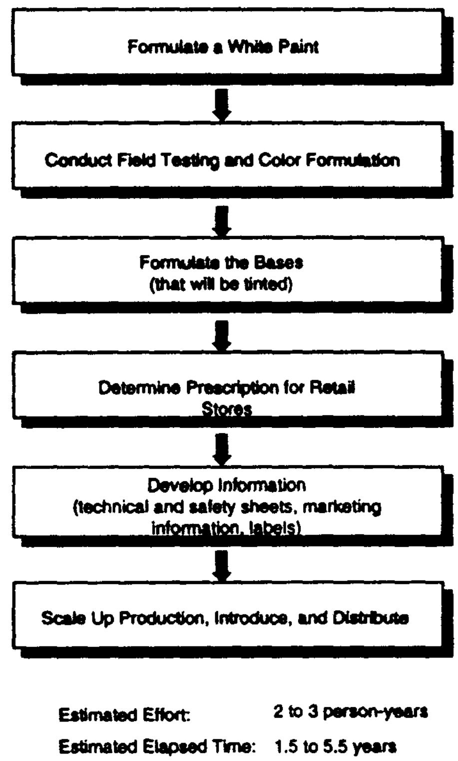

Figure 2-1. Basic stages of architectural coating reformulation (prototype firm and product).

Source: AIM Coatings Regulatory Negotiation Committee meeting. July 28-30, 1993, Washington, DC. Meeting Summary.

2.2.2 Demand

The regulation can be expected to induce changes in the prices of the affected products. Product consumers may alter their selection of coatings based on the relative prices of coating products and on the relative prices of coating versus noncoating alternatives. For example, consumers might opt for a waterborne coating rather than its solventborne alternative if the regulation-induced change in prices increases the relative price of the solventborne product. Moreover, a potential user of a high-VOC coating product facing reformulation may even opt for a noncoating alternative if the price rises too much.

The reformulated products can also possess different characteristics that affect their demand. For instance, VOC content reduction in a typically high-VOC product may change consumers' perceptions of the product's performance, durability, and ease of application. The lower VOC content may also work as a signaling device for the "green" consumer in pursuit of products deemed more friendly to the environment.[a] These factors collectively affect the benefit consumers derive from using the product and thus their willingness to pay for the reformulated product versus other product alternatives.

2.3 COST ANALYSIS

This section evaluates the costs imposed on manufacturers to reformulate noncompliant products, describes and quantifies the exceedance fee provision, and incorporates the option of withdrawing products from the market into the decision process.

2.3.1 Costs of Reformulation

Of the compliance options referenced above, reformulation of products that have a VOC content exceeding the category limit in the TOS (see Table 2-1) is the most significant both in terms of potential cost and emission reductions. The economic analysis begins by estimating the national cost of the regulation in the absence of other compliance options (fee, withdrawal) and ignoring market responses. This will provide an upper-bound estimate for the true national costs of the regulation. The national estimate will be modified (reduced) as the other compliance options and market behavior are explicitly considered below.

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[a]Some manufacturers currently produce zero-VOC-content coatings that are marketed as "clean air" coatings.

TABLE 2-1. TABLE OF STANDARDS[a]

Architectural Coating	VOC Content Limit (g/L)
Antenna coatings	500
Antifouling coatings	450
Antigraffiti coatings	600
Bituminous coatings and mastics	500
Bond breakers	600
Chalkboard resurfacers	450
Concrete curing compounds	350
Concrete protective coatings	400
Dry fog coatings	400
Extreme high-durability coatings	800
Fire-retardant/resistive coatings	
Clear	850
Opaque	450
Flat coatings, N.O.S.	
Exterior	250
Interior	250
Floor coatings	400
Flow coatings	650
Form release compounds	450
Graphic arts coatings (sign paints)	500
Heat reactive coatings	420
High-temperature coatings	650
Impacted immersion coatings	780
Industrial maintenance coatings	450
Lacquers (including lacquer sanding sealers)	680
Magnesite cement coatings	600
Mastic texture coatings	300
Metallic pigmented coatings	500
Multicolor coatings	580
Nonferrous ornamental metal lacquers	870

(continued)

TABLE 2-1. TABLE OF STANDARDS[a] (CONTINUED)

Architectural Coating	VOC Content Limit (g/L)
Nonflat coatings, N.O.S.	
Exterior	380
Interior	380
Nuclear power plant coatings	450
Pretreatment wash primers	780
Primers and undercoaters, N.O.S.	350
Quick dry coatings	
Enamels	450
Primers, sealers, and undercoaters	450
Repair and maintenance thermoplastic coatings	650
Roof coatings	250
Rust preventive coatings	400
Sanding sealers	550
Sealers	400
Shellacs	
Clear	650
Opaque	550
Stains	
Opaque	350
Clear and semitransparent	550
Waterborne low solids	120
Swimming pool coatings	600
Thermoplastic rubber coatings and mastics	550
Traffic marking paints	150
Varnishes	450
Waterproofing sealers and treatments	
Clear	600
Opaque	400
Wood preservatives	
Below ground	550
Clear and semitransparent	550
Opaque	350

N.O.S. = Not otherwise specified.

[a] The final Table of Standards included in the regulation differs slightly from this list. See Section 7 for a discussion.

The method for estimating the national costs of the regulation under this scenario is to:

1. Estimate reformulation cost per product
2. Estimate the total number of products nationwide facing reformulation
3. Multiply the cost per product times the number of reformulations

These steps are now presented in sequence.

2.3.1.1 Product-Level Reformulation Cost Estimates. Developing a new formula for an architectural coating involves altering the mix of the four coating components: resins, solvents, pigments, and additives. For solventborne products, a new formula might increase the ratio of solids (resins) to solvents to reduce the solvent's contribution to VOC emissions.

Reformulation is a one-time investment to develop a formula that complies with the VOC requirement. This generally involves applying R&D effort to develop and test the new formula. Various other expenses (e.g., administrative and marketing) are incurred to get the reformulated product to market; however, for the purposes of this report, all relevant costs are collectively referred to as "reformulation" costs.

The level of effort for reformulation varies across products, depending on the product's characteristics and the difference between a product's VOC content and the standard. For the analysis at proposal, EPA used information provided at a regulatory negotiation meeting on July 28, 1993 on the cost of developing a new product formula to meet a standard that was more stringent than that which was proposed.[52] Because other data were not available to gauge the reasonableness of this estimate, the EPA solicited input during the public comment period for this rule to determine the appropriateness of the value used at proposal. Appendix B provides a summary of the information received. These data show that the value used at proposal was considerably above estimates provided by commenters. Thus, the value used for this analysis is revised to reflect both the initial estimate from the regulatory negotiation and the subsequent estimates provided during the public comment period. Not enough information was provided in these comments, however, to estimate separate costs for each specific product category; therefore, the average of the estimates provided is used as the cost of reformulation for all products subject to the regulation. That average cost is $87,000 per product and will be used throughout this analysis to estimate the economic impacts, unless otherwise indicated.[b]

Cost annualization. Several of the comments received during the public comment period indicate a concern that the cost estimate used at proposal was too low. However, the lump-sum cost estimate used at proposal ($250,000) was considerably higher than the estimates provided in the public comments. Therefore, the concern appears to be centered around the annualized cost estimate used at proposal ($17,772 per year). In many cases, commenters appeared to be comparing the annualized cost used in the proposal to their estimate of lump-sum costs to reformulate. The purpose of annualizing costs and the methods for doing so in this analysis are presented below.

Reformulation is a one-time effort to develop a new formula. But the useful life of the formula goes beyond the year in which reformulation occurs. In this regard, it is

[b]Please note that because the base year for all information to develop the regulation (i.e., product inventories, VOC content limits, estimated emission reductions, etc.) is 1991, all costs and economic impacts presented in the analysis are expressed in 1991 dollars unless otherwise indicated. All cost and economic impact measures are transformed to present dollars in Section 7 for external reporting purposes.

much like any other capital investment (in this case, "knowledge" capital), so the cost must be amortized over the useful life of the investment.

The standard formula for annualizing a lump sum investment cost is

$$a = I \cdot [i(1+i)^n / ((1+i)^n - 1)]$$

where a equals the annualized amount, I is the initial lump sum investment cost, i is the interest (discount) rate, and n is the useful life of the investment. As indicated above, the revised value for the lump-sum investment used throughout this analysis is $87,000 per product. The discount rate is 7 percent, which is the rate recommended by the Office of Management and Budget (OMB) for cost-benefit analysis of federal regulations.[53] Determining the number of years to use in the annualization formula, n, requires considering the "useful life" of the knowledge developed in reformulation. More specifically, how long do the benefits of the current investment accrue? Reformulation allows the firm to continue to sell the current product (at a lower VOC content), rather than remove the product from the market. Therefore, the time stream of the benefits to the firm is at least as long as the reformulated product will remain on the market (i.e., the product life). This is a complicated issue. A particular version (formula) of a product may remain on the market for many years, then be reformulated to add different product attributes and kept in the market as a new and improved version of the old product. This product reformulation rotation may recur continuously into the future. If so, what is the best way to estimate the useful life of the VOC reduction technology induced by the regulation?

Two assumptions were considered to capture the range of possibilities for the useful life of the reformulation investment.

1. The low-VOC technology developed for the new formula is applicable only to that formula and cannot be transferred to future adjustments of the product.

2. The low-VOC technology developed for the new formula is applicable to that formula and is transferrable to all future versions of the product forever.

Case 1: In the first case, if the reformulated product is expected to remain on the market for a certain number of years (T), then the useful life of the VOC reduction investment is T years and the initial cost should be annualized accordingly (n=T). Moreover, if the current product is simply replaced T years hence by a reformulated version of the product, it is assumed that the VOC reduction technology developed for the current product is nontransferrable to the next product. Thus, an entirely new investment in VOC reduction technology T years in the future (the time of the next reformulation) is assumed necessary. This defines the most pessimistic (i.e., shortest) estimate for the useful life of the current VOC reduction investment. Because shortening the useful life of an investment reduces the amortization period, it also raises the annualized cost of compliance, therefore providing the upper-bound estimate for this analysis.

Estimating the cost under the first assumption requires determining an appropriate product life for a typical architectural product. Attempts to obtain this information from secondary data and industry sources proved unsuccessful since a "typical" product was too difficult to define. A life of T=8 years was assumed to be a reasonable, if conservative, base case estimate of a single product life cycle. Thus a_1 is the annualized reformulation cost per product for case 1 (high estimate), with an $87,000 reformulation investment, a useful life of 8 years, and discounted at 7 percent, which is computed as follows:

$$a_1 = \$87,000\ [0.07(1.07)^8 / ((1.07)^8 - 1)] = \$14,573.$$

Case 2: In the second case, the low-VOC technology developed for the regulation applies to all current and future versions of the reformulated product. In other words, once the VOC technology is developed for the new formula, it does not need to be re-developed in the future, even if the product is modified in the future to add new attributes. As a result, the useful life is the length of time the firm expects to remain in the product market. In the extreme case, the firm has no plans to remove the product from the market and the useful life is essentially infinite. Under this assumption, the cost is amortized in perpetuity to make it comparable with the benefits of the VOC technology. Thus, the cost annualization formula yields a_2, the estimate of reformulation cost per product:

$$a_2 = \$87,000 \bullet 0.07 = \$6,090.$$

Because a firm may not expect to remain in the market forever and/or the current VOC reduction technology may not transfer perfectly to all future versions of the current product, the assumption for case 2 can be viewed as a lower-bound estimate of annualized costs.

However, under an alternative interpretation, the costs may be lower still. Suppose a company, in the absence of the VOC standards, would routinely reformulate its product every few years. Then, the VOC regulation can be viewed not as forcing firms to reformulate the product; rather, it forces them to reformulate their products sooner than they otherwise would. Thus, the one-time cost to the firm is the present value of accelerating the series of costs that would occur (later) without the regulation. This cost will, in general, be less than the lump-sum cost of reformulation referenced above; therefore, the annualized measures would be lower as well. This is demonstrated by numerical example in Appendix C.

To summarize, data from the regulatory negotiation and public comment periods were used to provide EPA's best estimate of the cost of reformulation. The average reformulation cost estimate is $87,000 per product. This is a one-time cost that must be annualized for policy analysis. The annualized cost estimate depends on the assumption about the new formula's useful life. Under a useful life estimate of 8 years, the annualized cost per product is $14,573. As indicated, a number of assumptions can be justified on theoretical and empirical grounds that would reduce this estimate. For example, the useful life of the reformulation investment may well exceed 8 years. Also, reformulations occur as a normal business practice and the cost of reformulation for VOC content may not be entirely incremental. However, the $14,573 estimate is the maintained value throughout the analysis, except where otherwise indicated, thereby providing a conservatively high cost estimate.

<u>South Coast Air Quality Management District (SCAQMD) study</u>. As a point of comparison, estimates of the cost of architectural coatings reformulation are provided in a study conducted for the SCAQMD to address economic impacts of VOC content regulations in California.[54] This study identified costs associated with product reformulation and temporary and permanent product sales losses. Reformulation costs varied

depending on the extent of the reformulation necessary. Most of the small firms surveyed indicated that they did not have full-time R&D employees. Costs for additional research and development due to the regulation ranged from $1,000 to $5,000 annually for firms with few products affected by the California rule and more than $50,000 for firms with many affected products and little or no research staff.

The SCAQMD study also identified other compliance costs not related to R&D. Rough estimates of the cost of equipment adjustments necessary to accommodate reformulation ranged from $5,000 to $35,000 per firm. Costs attributed to temporarily or permanently discontinued products ranged from zero to $3,000 for firms with few affected products to more than $75,000 for firms with many affected products. Per-product estimates were not presented. Employment changes for the surveyed firms in the SCAQMD study were expected to be minimal, affecting only the possible addition of R&D chemists.

Because the timing, number of reformulated products, cost components, and regulatory structure associated with each SCAQMD cost estimate are not apparent from the report, they cannot be combined with the estimates presented above in any meaningful fashion to improve the estimate of regulatory costs.

2.3.1.2 National Reformulation Costs. The analysis of national reformulation costs begins with the recognition that the population of regulated products can be broken into two groups: those included in the emissions survey and those omitted from the survey. The methods used to estimate costs for each group are presented in turn.

Survey population. In this section, aggregate reformulation costs are for the products reported in the Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey (the survey).[55] The survey population represents roughly three-fourths of total industry output. The analysis is then extended to the industry level to calculate a national estimate.

To estimate reformulation costs for the entire survey population, the number of architectural products that will need reformulation to comply with the standards is determined. This number depends on the number of architectural products with a VOC content exceeding the standards for the respective product categories.

The survey reports the number of products, sales volume, and average VOC content for specific VOC content ranges (e.g., 0 to 50 g/L, 51 to 100 g/L, 101 to 150 g/L) within specific product groups (e.g., exterior flat waterborne, exterior flat solventborne, interior flat waterborne). Knowing the limits imposed by the TOS, the number, volume, and average VOC content of products over the limit can be derived using the survey data. These data can be used to generate estimates of the expected cost of reformulating products subject to the TOS, as well as the associated reduction in emissions accomplished by the reformulations.

Nonsurvey population. By definition, characterizing the population of nonsurveyed products introduces further uncertainty into the analysis. To estimate the number of nonsurveyed products facing reformulation, one must use product information from the survey population and apply it to the nonsurvey population subject to some assumption about the correspondence between the two populations. The economic analysis presented at proposal performed this task subject to the assumption that the overall survey population was representative of the nonsurvey population. Further scrutiny suggested a more appropriate assumption would be that the nonsurvey population was more accurately represented by the small company component of the survey population. A supplemental analysis in the appendix of the proposal analysis addressed this issue and indicated that national cost of the regulation is higher when the assumption that all nonsurveyed products are produced by small companies is applied. That assumption is maintained and further refined to generate cost estimates for the nonsurvey population in this analysis, as described below.

For each of the 13 defined market segments in the architectural coatings industry, data were available on total market volume (in liters) derived from the Census of Manufactures data for the baseline year (1991) and the total volume of surveyed products for that category. From that data the total volume omitted from the survey (i.e., volume produced by the nonsurvey population) can be computed:

$$\text{Nonsurveyed volume} = \text{Market volume} - \text{Surveyed volume} \quad (2.1)$$

If the average size of nonsurveyed products is known, the number of nonsurveyed products can be estimated as follows:

$$\text{Nonsurveyed products} = \text{Nonsurveyed Volume} / \text{Average volume of an nonsurveyed product} \quad (2.2)$$

If the proportion of nonsurveyed products needing reformulation is known, then the number of nonsurveyed product reformulations can be computed:

$$\text{Nonsurveyed product reformulations} = \text{Nonsurveyed products} \cdot \text{Proportion of nonsurveyed products needing reformulation} \quad (2.3)$$

and the corresponding reformulation costs are then

Cost of nonsurveyed product reformulations =
Nonsurveyed product reformulations •
Reformulation cost per product (2.4)

Because no specific data on nonsurveyed products were available for this analysis, the average product volume needed in Eq. (2.2) and the reformulated product proportions needed in Eq. (2.3) are not known. However, the information from the surveyed products can be used to impute values for the nonsurveyed products. One option is to assume that nonsurveyed products are the same average size and have the same rate of product reformulation as surveyed products. However, as indicated above, the survey population is not necessarily representative of the nonsurvey population, because the former includes mostly large companies and the latter mostly small companies. To more appropriately capture the differences between the nonsurvey population and the survey population, the following assumptions are proposed:

(1) Let the average size of nonsurveyed products in each market segment equal the average size of **small** company products reported for that market segment in the survey data.

(2) Let the nonsurveyed product reformulation rate in each market segment equal the reformulation rate for **small** company products reported for that market segment in the survey data.

The effect of assumption (1) is to increase the number of nonsurveyed products and thereby increase the number of nonsurveyed product reformulations and associated costs, relative to the alternative assumption that nonsurveyed products are produced by both large and small companies. Assumption (2) adjusts the estimates based on market segment-specific reformulation rates, which is greater on average for small companies. The combined effect of these two assumptions is to raise the cost of the regulation relative to the alternative assumption.

National estimate. Typically during the development of an air pollution regulation, an engineering analysis identifies the pollution control equipment required to comply with the rule and estimates the total installed capital cost in a memorandum to the public docket or as a section of the rule's Background Information Document (BID). The economic analysis typically uses this information to amortize costs on an annual basis and perform a market analysis. For the architectural rule, the control cost estimates are highly dependent on decisions made by the regulated producers in a market setting to either reformulate, pay an exceedance fee, or remove the over-limit product from the market. With the market emphasis, all costs were expressed in annual terms in the economic analysis presented at proposal. EPA received public comments suggesting that an estimate of total initial reformulation cost (the analog to total installed capital cost) would also be informative. This cost is computed and presented below, along with the standard annual cost estimates.

The national reformulation costs can then be estimated as follows:

National reformulation cost =
Cost of surveyed product reformulations +
Cost of nonsurveyed product reformulations (2.5)

Table 2-2 presents the results of the analysis for the TOS.[56] The first row of Table 2-2 reports reformulation costs and emissions reduction summed across all surveyed products. A total of 1,730 products from the survey exceed the limits that manufacturers and importers will be subject to, which is 36 percent of the total number of products in the survey

TABLE 2-2. NATIONAL COSTS: REFORMULATION-ONLY SCENARIO

Population	Number of Products Over Limit	Estimated Reformulations[a]	Initial Lump-Sum Cost[b] ($1991)	Annualized Cost of Reformulation ($1991)	
				Low[c]	High[d]
Surveyed products	1,730	1,153	$100,282,029	$7,019,742	$16,797,240
Nonsurveyed products	1,759	1,193	$103,760,202	$7,263,214	$17,379,834
Total	3,519	2,345	$204,042,231	$14,282,956	$34,177,074

Totals subject to rounding error.
NA = not applicable
[a] Based on the assumption that one-third of products over the limit do not need a major reformulation (see text).
[b] Based on an initial investment of $87,000 cost per product.
[c] Based on an annualized value of $6,090 cost per product.
[d] Based on an annualized value of $14,573 cost per product.

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for the National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

(4,846).[c] A presentation to the Regulatory Negotiation Committee indicated that roughly one in three products that exceeds the limits would not need a reformulation, primarily because the product lines are similar to others that will be reformulated. Thus, the costs are assessed for the remaining two-thirds of products over the limit to compute the aggregate cost estimate. After reducing the number of products, the estimated number of reformulations for the survey population is 1,153, yielding a range for an aggregate cost of reformulation of $7.0 to $16.8 million dollars (1991 dollars), depending on which useful life assumption is used to annualize the lump-sum value.

Nationally, about 2,345 products are subject to reformulation. The initial lump-sum cost to reformulate these products (at $87,000 per product) is just over $200 million. Depending on the annualized cost per product estimate used, annualized costs range from about $14 to $34 million per year. Again, these estimates overstate the expected cost of the regulation because they do not account for producers' best response (i.e., their lowest cost option) to the regulation. The next section discusses the part of the analysis that accounts for these actions.

2.3.2 Exceedance Fee Provision

Architectural coatings producers have the alternative of paying a fee per unit of output for products that exceed the limit. The fee will be computed as follows:

$$\text{fee} = (\text{actual VOC content} - \text{VOC limit}) \bullet \text{fee rate}. \quad (2.6)$$

[c]The actual survey total number of products is 4,920. However, throughout Section 2 of this report 4,846 is used as the total number (and the corresponding quantity and emissions) because product-level data were unavailable for 74 products in the survey.

VOC content is measured in grams per liter (less water and exempt compounds), and the fee rate is paid on the grams per liter in excess of the limit. The fee rate is $0.0024 per excess gram per liter with annual adjustments based on the gross domestic product (GDP) price deflator. Total fee payment per product simply equals the per-liter fee times total liters of production.

In this step of the analysis, the premise is that architectural coatings producers will choose the less costly of the reformulation and exceedance fee options as a compliance strategy. The choice is based largely on two product-specific factors: quantity of output produced and the "excess" VOC per unit.

The diagram in Figure 2-2 helps explain the effect that output quantity has on the choice between reformulating the product and paying an exceedance fee. The vertical axis represents the cost per liter of compliance and the horizontal axis measures product volume in liters annually. Since the cost of reformulation is a fixed cost (i.e., it is independent of the level of output), the average reformulation cost per liter of output falls as output levels increase. This situation is represented by the downward-sloping line in Figure 2-2. However, the exceedance fee per unit of output is constant with respect to the output levels. Let F be the exceedance fee per liter of output; the flat line extending from F on the vertical axis indicates that the fee rate is constant. For the purposes of this discussion, we ignore the role of fixed recordkeeping costs under the fee option. These costs are included in the empirical analysis that follows. In Figure 2-2, for all output levels less than Q^T the average cost of reformulation is higher than the per-unit fee, and for all output levels greater than Q^T, the average cost is below

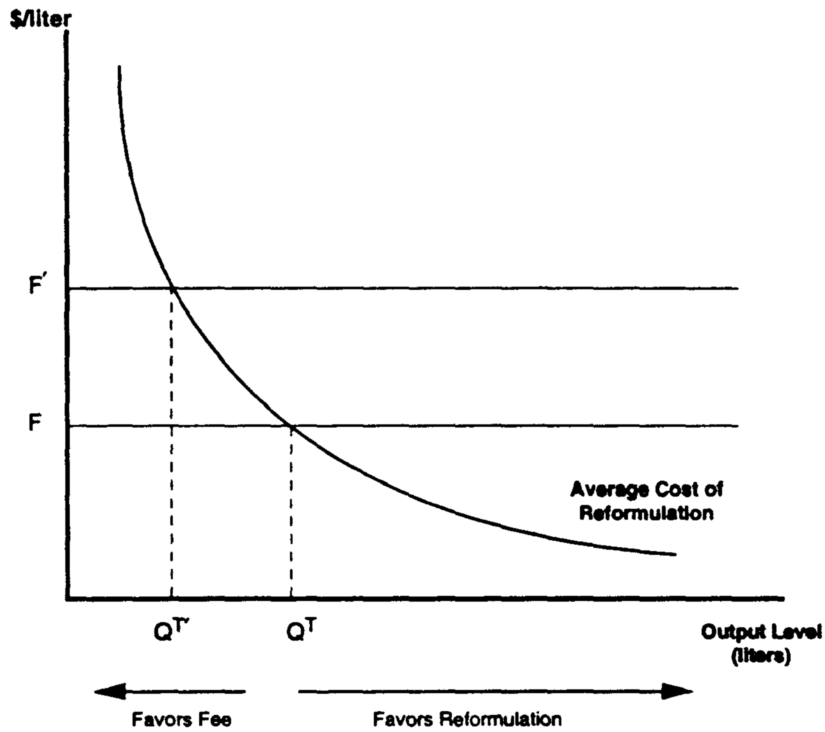

Figure 2-2. Fee versus reformulation.

the fee. This relationship indicates that the fee is the less costly alternative when output is less than Q^T and reformulation is the less costly alternative when output is greater than Q^T. Thus small volume producers are more likely to choose the fee, all else equal. As Figure 2-2 illustrates, the existence of a fee places an upper limit on the per-liter costs of complying with the regulation: $F \cdot Q$.

Figure 2-2 also illustrates the effect of different fee rates on the "threshold point" of quantity, below which the fee is the preferred option. If the fee were F' instead of F, reflecting either a higher assessment rate per Mg of emissions or a higher amount of excess VOC per unit, the threshold point would be lower. Thus, for higher excess VOC categories and for higher fee rates, fewer producers would probably select the fee option, all else equal. Because the fee will be more cost-effective only for lower-volume products and lower excess-VOC categories, allowing the fee option should have a relatively small impact on variation from the aggregate emission reduction targets as long as the fee assessment rate is not set at an extremely low level.

2.3.3 Product Withdrawal

Up to this point, the analysis has focused on firms responding to the regulation by choosing the less costly alternative between reformulation and the fee regulatory response. However, this view of a producer's likely response is incomplete because the cost of the regulatory response must be weighed against the benefits of the action to the firm. Here the analysis equates regulatory compliance with the decision to pay the costs and remain in the market. Thus, the benefits of the compliance action are the net returns (revenues minus variable costs) obtained from continuing to produce the product. The net payoff of compliance for a particular architectural coating exceeding the limit can be expressed as follows:

$$\pi^R = P \bullet q - c(q) - r^*. \tag{2.7}$$

To ease the notational burden, all terms are expressed in their annualized form: P is product price, q is annual output, c(q) is the product cost function (without regulation) with respect to annual output, and r* is the annualized cost of the least-cost option among regulatory responses (i.e., reformulation or fee). In other words, r* gives the cost of the solution to the least-cost decision discussed in the previous section.

The firm is assumed to select an output level (q*) that maximizes profits (π^{R*}). In a competitive market, this is the point at which the marginal cost of production equals the market price. However, the firm will only operate in this market if it can cover its production costs and compliance costs; that is, if the following condition is met:

$$\pi^{R*} (q^{R*} r^*) \geq 0. \qquad (2.8)$$

If the condition in Eq. (2.8) is not met, then the firm's best response is to withdraw the product, produce no output ($q^{R*}=0$), and generate zero profits for the product ($\pi^{R*}=0$). In this regard, product withdrawal would be the firm's least cost option, because the alternative implies they lose money by remaining in the market.

2.3.4 "Best-Response" Analysis

The analysis presented here determines which option (fee, reformulation, or withdrawal) is the best response for specific products within a certain VOC content range from the survey.

For the purpose of this analysis, a product stratum is defined as all products existing in a specific VOC content range for a specific product category. An example of a stratum would be all exterior flat waterborne products in the 101 to 150 g/L VOC content range. For the TOS, all strata in the survey were examined to determine those that exceed limits for their respective product categories. As indicated above, the survey includes data on the number of products, sales volume, and baseline VOC emissions for each stratum. These data were used to compute average sales volume per product for all strata exceeding the TOS limits. These average volume estimates formed the basis for computing exceedance fee costs and product-level profits.

An example of a best response determination is as follows:

(Best-Response Example)

Suppose the average sales volume per product for one stratum is 100,000 L/yr. To determine the exceedance fee for each stratum, the midpoint of the VOC content range was used as an estimate of average VOC for the stratum. This measure was used to compute excess VOC content because it is consistent with the regulatory definition of VOC content (grams per liter less water and exempt compounds) and is available for each stratum.

First the fee rate was adjusted to 1991 dollars by multiplying the fee rate (in 1996 dollars) of 0.0028/g by the ratio 1991/1996 of GDP price deflators. The resulting fee rate is 0.0024/g. Suppose the midpoint of the stratum is 150 g/L above the limit. The associated fee per unit would be 150 • $0.0024 = $0.36/L. The total exceedance fee payment for the product is ($0.36/liter) • 100,000 liters = $36,000 per year. Fixed recordkeeping costs must also be incurred for products subject to the fee. Fee-related recordkeeping costs were estimated to be $590 per product per year.[57] Adding these numbers together, the compliance cost under the fee option is $36,590 per year. This exceeds the annualized cost of reformulation ($14,570 per year). Under these conditions, it is assumed that products in this stratum would reformulate rather than pay the exceedance fee.[d] This decision would be reversed if, for instance, the stratum exceedance were 50 g/L, in which case the fee

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[d]By conducting the fee-versus-reformulation decision at the stratum level, and basing the decision on average cost and fee for each stratum, it is implied that all products within the stratum are identical to the mean values. In reality, there will be some variation around the mean so that some producers may find one alternative less costly while others find the other alternative less costly. This analysis is unable to capture this heterogeneity with the available data, but presumably these effects are smoothed out as the analysis compares means across the hundreds of strata in the survey.

payments would be $12,000, which, adding in the fixed cost of $590, is below the reformulation cost per product.

To simulate the reformulation/fee/withdrawal decision, per-unit profits were estimated to compare with unit costs for each stratum and computed as follows:

$$\pi^u = P \bullet m \tag{2.9}$$

where P is the output price and m is the profit margin. For each product category analyzed, the average market price for the market in which the product category belongs was used (see Table 2-3).[58,59] The model derives the returns-to-fixed-factors (RFF) profit margin as follows:

$$m = 1 - (\text{variable cost/revenues}). \tag{2.10}$$

The ratio of variable cost to revenue can be computed using values provided by the NPCA. The variable cost component in the numerator includes the cost of goods sold plus variable selling and storage costs. These variable costs comprise 81.7 percent of revenues for the mean producer surveyed by NPCA, so the estimate of the RFF profit margin is 0.183.

These average reformulation cost per liter and profit calculations were performed for each stratum above the TOS limits to determine the relative frequency of reformulation/fee/withdrawal selections and their impact on compliance costs. These analyses were performed directly for the survey population, with the results used to impute values for the nonsurvey population. Results are presented for the survey population in Table 2-4.

Under the chosen fee rate of $0.0024 (1991 dollars), the fee is the preferred alternative for 409 (35.5 percent) of the

TABLE 2-3. ARCHITECTURAL COATINGS MARKET SEGMENTS BASELINE DATA FOR 1991

No.	Market Segment[a]	Quantity Produced (kL)[b]	Value ($$10^3$)	Average Price ($/L)
1	Exterior & high performance solventborne coatings	162,937	540,511	3.32
2	Exterior & high performance waterborne coatings	468,345	1,046,383	2.23
3	Interior solventborne coatings	94,935	302,264	3.18
4	Interior waterborne coatings	833,434	1,747,341	2.10
5	Solventborne primers & undercoaters	61,298	171,583	2.80
6	Waterborne primers & undercoaters	75,212	160,960	2.14
7	Solventborne clear coatings, sealers, & stains	134,678	412,743	3.06
8	Waterborne clear coatings & stains	120,738	266,174	2.20
9	Architectural lacquers	40,011	83,320	2.08
10	Wood preservatives[c]	27,449	493,965	1.45
11	Traffic marking paints	91,067	132,358	1.45
12	Special purpose coatings	34,568	141,633	4.10
13	Industrial maintenance coatings	231,261	797,006	3.45
	Totals/averages	2,375,933	6,296,241	2.65

[a] See Appendix A for an explanation of products included in each market segment.

[b] The quantities and values are taken from Census data except the quantity for wood preservatives, which is taken from the survey.

[c] For wood preservatives the quantity is taken from the survey, but the price is taken from the Census data.

Sources: U.S. Department of Commerce. Current Industrial Reports: Paints and Allied Products, 1991. Washington, DC, Government Printing Office. 1992.

Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for the National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

TABLE 2-4. BEST-RESPONSE OPTION ANALYSIS—SURVEY POPULATION: FEE = $2,200/TON ($1991)

	Number[a] of Products Above the Limit	Product Quantity (L)	Reformulation Cost	Fee Payments	Foregone Profits	Total Costs	Cost Savings from Not Reformulating[b]
Reformulation selected	697	239,183,643	$10,160,142	$0	$0	$10,160,142	$0
Fee selected	409	38,235,442	$0	$3,225,366	$0	$3,225,366	$2,738,616
Withdrawal selected	46	772,807	$0	$0	$415,178	$415,178	$255,042
Total	1,153	278,191,893	$10,160,142	$3,225,366	$415,178	$13,800,686	$2,993,658

[a] Total products over-limit times (2/3)

[b] If fee not selected, reformulation costs for the 409 products that selected the fee are $5,963,982. If withdrawal is not selected, reformulation costs for the 46 products that selected withdrawal are $670,220.

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for the National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

1,153 products facing the reformulation versus fee decision.[e] However, these products only account for 38 million liters of output, about 14 percent of the volume subject to the decision, reinforcing the notion that the fee is selected for lower-volume products. The total fee payment for those products is about $3.7 million (average is $0.08/L), but the estimated avoided reformulation cost for the 409 products choosing the fee is over $5.9 million for a net aggregate savings to producers of about $2.7 million. Moreover, because the fee payment is simply a transfer from one sector of society (architectural coatings producers) to another (the government), the social cost savings due to incorporating the fee are the full $5.96 million reformulation cost savings, less any costs of administering the fee.

Table 2-4 indicates that 46 products elect withdrawal as the best response strategy to the regulation, which is less than 0.1 percent of the 4,846 products surveyed. The estimated foregone profits for those products total approximately $415,000, which should be considered a component of "compliance cost" of the regulation. However, this produces a $255,000 savings to society over the reformulation-only option.

All told, allowing for options other than reformulation substantially reduces compliance costs for the survey population. The option to pay the fee or to withdraw reduces the compliance cost estimate by about $3.0 million, or about 18 percent of the costs that would be incurred by the survey population if reformulation were the only compliance option.

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[e]Note that 1,153 products represent two-thirds of the total number exceeding the limits because the other one-third were assumed to reformulate without incurring the "major" reformulation cost.

2.3.5 Tonnage Exemption

All producers will be allowed to exempt the following quantity of VOC emissions from control that is phased in over three years:

Period 1: 23 Mg (25 tons)
Period 2: 18 Mg (20 tons)
Period 3: 9 Mg (10 tons)

Because these represent relatively small volumes, especially after the 3-year phase-in, the tonnage exemption will likely serve in lieu of the exceedance fee for small volume products and thereby reduce fee payments by producers employing the tonnage exemption.

To the extent that the tonnage exemption replaces the fee as a compliance option for some products, the foregone fee payments represent the reduced impact on producers. Consider the post-year 3 case where 9 Mg of VOC emissions are exempted from control. Suppose that 3.6 Mg of these emissions are "exceedance" emissions (i.e., emissions above the amount allowed in the VOC content standards). If a fee were assessed to these emissions, the cost to the firm would be 3.6 • $2,200 = $7,920 ($1991). Therefore, the exemption allows the firm to avoid this impact. Note that while this reduces the private impact on firms subject to the exemption/fee, there is no corresponding effect on the social cost of the regulation as the reduced fee payments are just reduced transfers from one party (producers) to another party (government).

2.4 COST ANALYSIS UNCERTAINTIES

Table 2-5 lists the key assumptions and main areas of uncertainty surrounding the cost estimates. Items of

TABLE 2-5. REFORMULATION COST ANALYSIS UNCERTAINTIES

Assumptions

- Initial reformulation cost is $87,000.
- Useful life of reformulation is (1) 8 years, (2) forever.
- Discount rate is 7 percent.

Potential upward bias factors

- Effects of tonnage exemption not considered.
- Costs assumed constant in the future; but may fall over time as new technology is developed and disseminated.
- Industry trends since 1991 have moved toward lower VOC formulations.
- Costs may be borne partly by material suppliers.
- Regulatory baseline is changing. State regulations have been implemented (e.g., Massachusetts), and some producers have already developed formulations and incurred reformulation costs to comply with new as well as existing regulations. These formulas can be applied to a federal rule at a minimal cost.

Potential downward bias factors

- Costs are confined to the reformulated product itself; users may incur additional costs to adapt application systems.
- Multiple products may be lumped together as one in the survey. Therefore, multiple reformulations may be necessary in some cases where a single reformulation is projected.

Potential factors with unknown directional effects

- Estimate is for a "typical" product; individual products may differ.
- Lower-bound estimate of 8 years for useful life of reformulation is speculative.
- Reformulation may positively or negatively affect variable production costs (e.g., materials).
- Effects on product quality and performance are unknown; anecdotal evidence shows both positive and negative effects depending on the product.
- Costs may rise/fall based on amount of "excess VOC" to reduce.
- The number of reformulations for nonsurveyed products may be mis-estimated due to lack of data.

uncertainties are grouped by the likely direction of bias on the cost estimate: upward, downward, or unknown.

2.4.1 Upward Bias

As indicated in the previous section, one source of upward bias in the cost estimates is that the analysis does not directly account for the effect that the tonnage exemption would have on cost mitigation.

The analysis may overstate reformulation costs incurred by architectural producers by not explicitly accounting for cost-saving technological innovation. Spillover effects from early reformulation efforts could substantially reduce the costs for other formulas. This may be facilitated by the role that material suppliers play in developing formulas, particularly in the case of smaller architectural coatings manufacturers. Economies of scale may occur because material suppliers solve the problem for multiple clients and formulas.

Since this rule was initially proposed, for example, Massachusetts has implemented its own regulation for architectural coatings. In compliance with that regulation, 104 companies have registered compliant architectural coatings with the Massachusetts Department of Environmental Protection.[60] Many of those companies operate on a national scale. Therefore, products those companies make that currently meet the Massachusetts regulation do not need to be further reformulated to comply with the national rule. Those costs are not "backed-out" in this analysis, which imparts an upward bias of unknown magnitude on the costs presented.

2.4.2 Downward Bias

A couple of factors may lead to an understatement of the reformulation costs presented here. First, by focusing on costs to the coatings manufacturer, the current analysis does not account for any fixed costs that coating users may bear as they switch to compliant formulas. Based on public comments, the item of greatest concern in this category is application equipment for traffic marking coatings. These costs are now explicitly addressed in a separate section of this report and included in the final cost-effectiveness analysis below.

The second item that may cause downward bias in the cost estimates relates to the definition of products in the survey data. The analysis treats each survey entry as a separate product and assigns each noncompliant entry a single reformulation. If, instead, survey respondents combined several products requiring several reformulations into one survey entry, total reformulation costs for the survey population would be underestimated. It is impossible to determine whether this is a systematic problem with the survey data and, if so, the extent to which it biases the current estimate.

While the reformulation cost estimate is the main source of uncertainty in the analysis, another item that bears mentioning relates to the selection of nonreformulation response options (fee or withdrawal). The analysis assumes that producers will select the lower-cost option (reformulation or the fee) and exit if the lower-cost option exceeds the value of the profit stream. However, some rigidities (e.g., shortage of scientist hours for new formula development) might make reformulation difficult in the very short run. However, the phased tonnage exemption period mentioned above should provide some relief in overcoming the short-run rigidity particularly for smaller producers.

2.4.3 Unknown Directional Effects

Several items that have unknown directional effects on the cost estimates are listed in Table 2-9. Of particular relevance is the absence of variable production cost effects, notably the difference in material costs. The EPA was unable to obtain verifiable information on material cost effects of reformulation. Anecdotally, it was suggested that solventborne material costs might rise in some situations (e.g., those described in the comment) but might fall in others (e.g., substitution of water carriers for solvent). The net effect across all products is unknown. Without any hard data on the size or direction of material cost effects, the EPA assumed no net material cost effects in the analysis.

The compliance strategy decision is likely to be complicated by issues other than cost that relate to the profitability of reformulation. If a product serves a narrow market niche, reformulation may fundamentally alter the product's attributes and erode the niche position. In such a case, the producer may find that choosing reformulation is not profitable. Although concerns regarding the regulation's constraints on product differentiability are undoubtedly real in some cases, this complexity is not explicitly addressed in the quantitative analysis, primarily because of the difficulty in observing both levels of and changes in product quality.

SECTION 3

ARCHITECTURAL COATINGS MARKET ANALYSIS

In this section, market effects of the regulatory action are analyzed by presenting a model of how the outcome of the reformulate/fee/withdrawal decision collectively affects aggregate supply conditions and market outcomes in the architectural coatings industry. Then, operationalizing the model using baseline market data and regulatory costs is discussed to analyze the social cost effects of these market outcomes in the architectural coatings industry. The section ends with an analysis of employment impacts.

3.1 MARKET EFFECTS OF FIRM RESPONSES TO REGULATION

Firms' decisions to either reformulate or pay the exceedance fee and remain in the market or to do neither and exit the market collectively affect market outcomes (price, quantity, and welfare). The change in market price depends on the aggregate effects of the supply responses of the individual producers. Product exits will shift the aggregate supply function inward, and marginal cost effects, such as the per-unit fee, will shift the function upward. This change can be expected to raise the post-regulatory market price as the new equilibrium is attained. This process is described in more detail in Appendix D.

Appendix D describes the methodology for incorporating the reformulation/fee/withdrawal effects into a linked multiple-market model framework. This appendix also presents the methodology for measuring the social welfare effects (e.g., producer and consumer surplus) of the changes in market equilibrium, which is affected by the regulation.

3.1.1 Model Execution and Results

To estimate the effect of VOC content limits on architectural coatings markets, a baseline characterization of affected markets was constructed, empirically estimated shifts in market supply and demand as a result of the regulations were computed, and the market equilibrium model was applied to the data to generate changes in prices and quantities in each market.

3.1.1.1 Baseline. The coatings categories are grouped into market segments, as defined in Table 2-3. The price and quantity data necessary to analyze market effects are not provided in the survey conducted for this study but are available from the U.S. Census Bureau Current Industrial Reports publications.[61] Because the Census Bureau categorizes architectural coatings products differently than they are classified in the survey for this study, the market segments were constructed so that data can be used from both sources and provide the necessary level of resolution for market analysis. This process resulted in the 13 market segments presented in Table 2-3. Appendix A provides the details of this product/market cross-referencing scheme.

Table 2-3 lists quantities and value of shipments for each market segment. From these data, the average price for each market was imputed. Because the market segment price is an average value, it may obscure heterogeneity of products within each group. Although the model aggregates different products together to construct individual market segments, the objective in aggregating to the market segments in Table 2-3 is to provide a level of resolution that both highlights differences in the end use of the product (e.g., exterior coatings versus interior coatings) and distinguishes between groups that will be affected differently by the VOC content regulation (e.g., solventborne versus waterborne). Eight of the 13 segments consist of four pairs of related product groups; one in each pair represents solventborne products and the other represents waterborne products (e.g., interior coatings). Although the products in each of the paired market segments possess different attributes, they perform similar functions, thereby suggesting a high degree of product substitutability in demand. Demand elasticities were estimated using procedures outlined in Appendix A. Supply elasticities could not be econometrically estimated because of data limitations; therefore, the aggregate supply elasticity for each market segment was assumed to be unitary (1.0).

3.1.1.2 Quantifying Market Shocks. The best-response regulatory strategy for each stratum in the survey exceeding the TOS limits is computed in the previous section. For the market analysis, the least-cost solution obtained previously was compared to an estimate of per-unit profits. If the cost term exceeded the profit term, that stratum was identified as a "withdrawal" stratum. Throughout this section, the market results using upper bound of product reformulation cost ($14,573 per year) are presented unless otherwise indicated. If the profit term exceeded the cost term and the least-cost option was reformulation, the stratum was identified as a "reformulation" stratum. If the profit term exceeded the cost term and the least-cost option was the fee, the stratum was identified as a "fee" stratum. The model computes the total quantity share of the withdrawal strata by summing the total quantity from these strata (Q_s^X) and dividing by the total baseline quantity from all strata for that market segment in the survey (Q_S^T). This share was then multiplied by two-thirds (the previously referenced share of all noncompliant formulas needing reformulation) to compute the market quantity subject to the withdrawal option, which is denoted as the term R^X.[a]

$$R^X = (Q_S^X/Q_S^T) \bullet (2/3). \tag{3.1}$$

Similarly, the model computes the total quantity shares for the reformulation R superscript) and the fee strata (F superscript), respectively:

$$R^R = (Q_S^R/Q_S^T) \bullet (2/3) \tag{3.2}$$

$$R^F = (Q_S^F/Q_S^T) \bullet (2/3). \tag{3.3}$$

Finally, all quantities not allocated to the exit, reformulation, or fee actions can be viewed as the unconstrained share:

$$R^U = 1 - R^X - R^R - R^F. \tag{3.4}$$

To perform the market and welfare effects calculations, the initial baseline market-level values for the exiting, reformulating, fee-paying, and unconstrained sectors are obtained for reasons explained in the methodology description in Appendix D. The model derives baseline quantities by multiplying the quantity shares derived from the survey data by the initial baseline market quantity, Q_0:

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[a]Multiplication by two-thirds incorporates the previously discussed assumption that one-third of all products exceeding the limit can be costlessly reformulated (and thus would not be withdrawn).

$$Q^X = R^X \cdot Q_0 \tag{3.5}$$

$$Q^R = R^R \cdot Q_0 \tag{3.6}$$

$$Q^F = R^F \cdot Q_0 \tag{3.7}$$

$$Q^U = R^U \cdot Q_0. \tag{3.8}$$

To quantify the supply effects of the per-unit fee on the fee-paying sector, as indicated in the equilibrium model discussion in Appendix D, the model computes a value for the unit fee as follows.

$$F = \sum_{i=1}^{N^F} F_i \cdot (Q_{Si}{}^F / Q_S{}^F) \tag{3.9}$$

where F_i is the fee for fee-paying stratum i, $Q_{Si}{}^F$ is stratum i's quantity, and N is the number of fee strata in the market.

Finally, note that the measure of producer surplus losses requires an estimate of marketwide reformulation costs. The model estimates this cost by taking the estimated number of (surveyed and nonsurveyed) products in each market opting to reformulate and multiplying this number by the annualized cost of reformulation.

Changes in Output and Price. Table 3-1 reports the estimated output and price effects of the final regulation. In general, the annual output and price effects are quite small relative to baseline values. Price increases are typically well below 1 percent of baseline price, with the exception of the solventborne primers and undercoaters market segment, where the projected price increase is \$0.012/L (0.4 percent). In fact, to show any price effect, the change in price is displayed to the fourth significant digit. In

TABLE 3-1. REGULATORY EFFECTS ON ARCHITECTURAL COATINGS MARKET OUTPUT AND PRICES

No.	Market Segment	Change in Output Produced (10^3 L)	% Change from Baseline	Change in Price ($1991)	% Change from Baseline	New Quantity (10^3 L)	New Price ($/L)
1	Exterior & high performance—solventborne	-195	-0.12%	$0.0029	0.09%	162,741	$3.32
2	Exterior & high performance—waterborne	69	0.01%	$0.0003	0.02%	468,414	$2.24
3	Interior solventborne	-36	-0.04%	$0.0010	0.03%	94,900	$3.19
4	Interior waterborne	22	0.00%	$0.0001	0.01%	833,456	$2.10
5	Solventborne primers and undercoaters	-349	-0.57%	$0.0120	0.43%	60,950	$2.81
6	Waterborne primers and undercoaters	52	0.07%	$0.0015	0.07%	75,264	$2.14
7	Solventborne clear coating, sealers, stains	-172	-0.13%	$0.0029	0.10%	134,506	$3.07
8	Waterborne clear coatings and stains	19	0.02%	$0.0004	0.02%	120,757	$2.21
9	Architectural lacquers	0	0.00%	$0.0000	0.00%	40,011	$2.08
10	Wood preservatives	-2	-0.01%	$0.0003	0.02%	27,446	$1.45
11	Traffic marking paints	-42	-0.05%	$0.0013	0.09%	91,025	$1.46
12	Special purpose	-15	-0.04%	$0.0035	0.08%	34,554	$4.10
13	Industrial maintenance	-277	-0.12%	$0.0083	0.24%	230,984	$3.46
	Total	-926	-0.04%			2,375,006	

other words, the average market price for nearly all 13 market segments changes by less than 1 cent per unit. Estimated quantity reductions, across all architectural coatings markets are approximately 926,000 L/yr. This figure is less than one-tenth of a percent of the industry baseline quantity.

The results indicate differential impacts across market segments. For example, solventborne primers and Industrial Maintenance show the largest reduction in output. However, four of the waterborne market segments show a net increase in output produced. These projected increases result as consumers substitute away from the solventborne counterparts because of the regulation-induced supply contraction and price increases in those segments. While noteworthy, these increases are quite small in absolute terms.

Total Social Costs. The method for estimating changes in consumer and producer welfare effects is demonstrated in Appendix D. In general, the net welfare effect (social cost) of the regulation equals the sum of consumer surplus, producer surplus, and government surplus measures. Costs are distributed across parties in such a way that reformulating, fee-paying, and exiting producers experience welfare losses by incurring the regulatory costs (or withdrawing products) and consumers bear welfare costs through higher prices. Changes in consumer surplus measure losses to consumers from higher prices and foregone consumption. The total change in producer surplus for each scenario equals the sum of the change in producer surplus for the exiting products, fee-paying products, reformulating products, and unconstrained products. Losses to exiting products reflect the foregone profits the producers would have received had the products stayed in the market. Losses for fee-paying products measure the net effect of fee payments and recordkeeping costs plus the partial offset of these losses by the rise in price caused by the regulation.

In Table 3-2, the producer losses for reformulating producers total -$20.4 million. The model actually projects total reformulation costs of $19.0 million, but $0.8 million of total reformulation costs are recovered from offsetting price gains accruing to the reformulating producers.

Note that the producer surplus effect for unconstrained products is positive, reflecting the fact that producers of these products gain the benefits of the regulation-induced rise in price, without any change in their cost structure caused by the regulation. However, the welfare gains accruing to the unconstrained products are transfers from coating consumers and, as such, should not be viewed as a net welfare gain to society due to the regulation.

The net annual welfare cost estimate is $22.3 million. This is approximately $12 million (41 percent) less than the initial cost estimate for the regulation under the reformulation-only scenario (Table 2-2). Therefore, accounting for economic responses substantially reduces the estimate of regulatory costs. Welfare gains accrue to unconstrained producers through higher prices ($3.2 million) and the recipient of exceedance fee revenues ($4.0 million), identified here as the government sector.[b] However, the government may redistribute these revenues back to any of the parties affected directly by the regulations or back to the citizenry via the Federal Treasury. From society's perspective, the net welfare effects of the current transfer method (architectural producers to the government) or alternative

[b]Note that the difference in losses to fee-paying producers ($4.9 million) and government receipts ($4.7 million) is due to two factors: the payment of fee-related recordkeeping costs (+$0.6 million) and gains from offsetting price increases (-$0.4 million).

TABLE 3-2. ARCHITECTURAL COATINGS MARKET WELFARE EFFECTS

No.	Market Segment	Change in Producer Surplus ($1991): Exiting Products ($$10^3$)	Fee-Paying Products ($$10^3$)	Reformulating Producers[a] ($$10^3$)	Unconstrained (Net) Total PS Sector ($$10^3$)	Total ($$10^3$)	Change in Consumer Surplus ($1991 10^3)	Change in Government Surplus ($1991 10^3)	Net Welfare Effects ($1991 10^3)
1	Exterior & high performance—solventborne	-31.73	-960.37	-1,865.42	252.74	-2,604.79	-463.76	910.87	-2,157.68
2	Exterior & high performance—waterborne	-0.92	-13.60	-276.45	148.42	-142.54	-161.17	1.82	-301.90
3	Interior solventborne	-13.89	-165.22	-6,584.09	48.77	-6,714.43	-93.62	128.44	-6,679.62
4	Interior waterborne	-11.15	-4.35	-64.01	107.77	28.26	-107.81	1.74	-77.81
5	Solventborne primers and undercoaters	-138.79	-923.23	-1,582.38	454.72	-2,189.67	-726.69	913.45	-2,002.91
6	Waterborne primers and undercoaters	0	-6.96	-17.74	116.42	91.72	-116.66	4.51	-20.43
7	Solventborne clear coating, sealers, stains	-79.38	-500.31	-2,142.77	230.17	-2,492.30	-396.04	481.06	-2,407.28
8	Waterborne clear coatings and stains	0	-16.76	0	43.36	26.60	-43.38	1.85	-14.93
9	Architectural lacquers	0	0	-416.23	0	-416.23	0	0	-416.23
10	Wood preservatives	0	-10.67	-288.86	4.28	-295.25	-6.89	9.47	-292.67
11	Traffic marking paints	-33.16	0	-1,475.26	47.91	-1,460.51	-120.82	0	-1,581.33
12	Special purpose	-6.44	-166.63	-159.66	107.94	-224.79	-119.53	140.84	-203.47
13	Industrial maintenance	-268.98	-1,386.52	-5,571.14	1,600.84	-5,625.80	-1,907.30	1,370.29	-6,162.80
	Total	-584.44	-4,154.61	-20,444.01[a]	3,163.33	-22,019.73	-4,263.66	3,964.32	-22,319.06

[a] Actual reformulation cost is $19.0 million, but $0.8 million is recovered by producers through price increases.

distributions (e.g., back to architectural producers) are zero.

As a point of comparison, market results were estimated subject to the lower-bound cost assumption for reformulation ($6,090/product/year). The total welfare cost under that scenario is $13.2 million per year. Because of the low reformulation cost, few products would opt for the fee under that cost scenario.

3.2 ARCHITECTURAL COATINGS INDUSTRY EMPLOYMENT IMPACTS

Regulation-induced reductions in industry output may lead to corresponding reductions in architectural coatings employment. Employment impacts are estimated by multiplying the baseline industry employment level (L_0) by the proportional change in industry output from its baseline level:

$$\Delta L = (\Delta Q/Q_0) \bullet L_0. \qquad (3.10)$$

This assumes a fixed relationship between output and employment, at least for the marginal changes considered here.

Table 3-3 presents the employment impacts results. Total employment for SIC 2581 is 51,100 employees.[62,63] The architectural coatings sector is a subset of SIC 2581, so the architectural coatings employment was computed by taking the ratio of architectural coatings output to SIC 2581 output and multiplying it by SIC 2581 employment. This produced an estimate of approximately 26,100 employed in the architectural coatings sector.

The proportional change in architectural coatings output was computed by taking the ratio of the change in output from the market model (summed across all market segments) over

TABLE 3-3. ESTIMATED EMPLOYMENT EFFECTS

Architectural Coatings		
Output Change (10^3 L)	Share of Baseline Output[a] (%)	Imputed Employment Change (no. of employees)
-926	-0.039%	-10.2

[a] Baseline quantity and employment computations are as follows:

Sector	Output (10^3 gal)	Output (10^3 L)	Industry Employment
SIC 2581	1,229,800	4,654,793	51,100 from Census
Architectural model	627,723	2,375,933	26,083 imputed from output share

Sources: U.S. Department of Commerce. Current Industrial Reports: Paints and Allied Products, 1991. Washington, DC, Government Printing Office. 1992.

U.S. Department of Commerce. 1991 Annual Survey of Manufactures: Statistics for Industry Groups and Industries. Washington, DC, Government Printing Office. 1992.

baseline architectural coatings output. This computation was performed for all four scenarios of the market model.

Given that the output change estimates in the market model are relatively small, it follows that the estimated employment impacts are also small. Under the standard scenario, approximately 10 jobs are lost nationwide, a 0.04 percent reduction.

SECTION 4

TRAFFIC COATING USER COSTS

The economic analysis up to this point has focused entirely on the primary impacts of the regulation, those borne directly by producers in the architectural coatings industry in the form of higher costs and indirectly by the consumers of architectural products in the form of higher prices. The driving force of those impacts is the requirement that noncompliant products must either be reformulated to a compliant VOC level, be subject to a fee on the excess VOCs over the allowable level, or be withdrawn from the market. However, in this section a type of *secondary* impact is considered, one that is caused by the costs that users of a newly compliant product must incur to purchase the special equipment necessary to apply the compliant coating. The analysis focuses exclusively on users of traffic marking paints, primarily consisting of government entities such as state transportation departments, for whom the costs of equipment switching are thought to be potentially significant. While it is possible that other significant secondary impacts exist, the extent and size of those is unknown and therefore not quantified in this report.

One complicating factor in estimating the cost of the regulation for traffic coating users is the fact that equipment replacement is a normal activity that would occur in the absence of the regulation. Therefore, rather than viewing the regulation as creating equipment replacement responsibilities, it is more correct to say that a different (accelerated) time pattern of equipment replacement is required. This section presents the issue analytically and then computes the incremental costs imposed on the population of traffic coating users.

According to the data collected for this study, the service life of traffic marking coating trucks (stripers) is typically 20 years.[64] If the average truck is midway through its replacement cycle, it will be replaced 10 years in the future in the absence of the regulation. However, to apply waterborne coatings that are likely to result from the regulation, users will be required to change the application equipment. The application equipment can be changed by either purchasing new trucks with the proper equipment or retrofitting the current trucks with special equipment to handle the new coatings. The incremental costs of each are discussed in turn below.

4.1 TRUCK REPLACEMENT COST METHOD

In an example of truck replacement, new trucks will be purchased now rather than 10 years in the future, and this acceleration imposes costs on the government entity. To estimate the costs of this replacement acceleration process, the cost of a large replacement truck ($250,000) is used to compute the net present value (NPV) today (at a 7 percent real interest rate) of replacing the truck 10 years in the future:

$$NPV(-10) = \$250,000/1.07^{10} = \$127,087. \qquad (4.1)$$

Instead, the government entity is now required to replace the truck today at a cost of

$$NPV(0) = \$250,000. \quad (4.2)$$

Assuming no salvage value for the current truck, the NPV cost of accelerating the next replacement is then the difference in these values.

$$\text{Initial net effect} = NPV(0) - NPV(-10) = \$122,913. \quad (4.3)$$

Thus, if the regulation just accelerates the next replacement, the one-time cost of that acceleration is approximately $123,000.

However, accelerating the replacement of the current equipment by 10 years also accelerates the next round of equipment replacements (from 30 years hence to 20 years hence) and so on. Thus, the effects reverberate into all future replacement decisions. This point is demonstrated graphically by the alternative time lines of expenditures in Figure 4-1. The regulation effectively moves up the entire replacement schedule by 10 years. The computation must therefore be expanded to measure the present value of the current and all future adjustments. To start, the present value of an initial $250,000 cash expenditure repeated every 20 years thereafter is computed:

$$\begin{aligned} V(0) &= \$250,000 + \$250,000*(1/((1.07)^{20} - 1)) \\ &= \$337,118. \end{aligned} \quad (4.4)$$

Without the regulation, this stream of costs would be deferred 10 years into the future. Evaluating this in present value terms gives

$$V(-10) = V(0)/1.07^{10} = \$171,373. \quad (4.5)$$

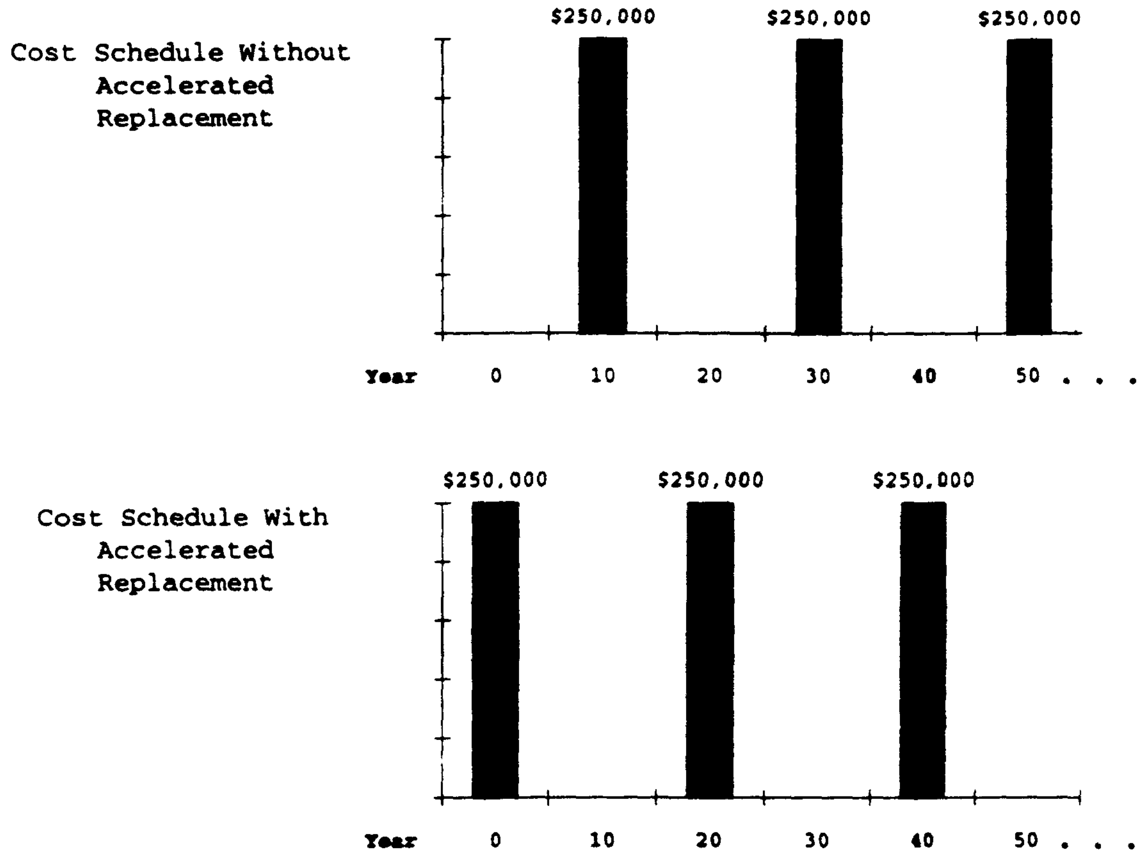

Figure 4-1. Cost schedules with and without accelerated replacement.

Thus, the difference in present value between the two replacement cost streams is the total cost of accelerating this and all future purchases:

$$\text{Total net effect} = V(0) - V(-10) = \$165{,}744. \quad (4.6)$$

This can be viewed as a *one-time cost* of the regulation for the component of a government entity's traffic coating striper fleet that is 10 years old. This explicitly accounts for the present value of the regulation's effect on all future replacement costs.

4.2 EQUIPMENT RETROFIT METHOD

An alternative to early replacement of a traffic coating truck is to retrofit the current truck with equipment that can use the compliant coating. This allows the government entity to continue to use the current truck until the end of its service life, at which time it will be replaced with a new truck that is able to apply compliant coatings. Assuming that the replacement schedule for the truck is unaffected by the retrofit, then none of the costs of accelerated replacement just discussed will apply. This is demonstrated in Figure 4-2. As with the example in Figure 4-1, replacement costs without the regulation would occur 10, 30, 50, etc. years hence. Under the retrofit example, the government entity incurs the retrofit costs now (Year 0) but still maintains the same future replacement cost schedule. Therefore, assuming no salvage value for the retrofit equipment, the one-time cost of the regulation is simply the cost of purchasing the retrofit equipment in Year 0. The present value of all future costs is identical with and without the regulation.

4.3 NATIONAL INCREMENTAL COST CALCULATION

The cost of the regulation for traffic coating users is computed separately for the estimated current fleet of medium stripers (Table 4-1) and large stripers (Table 4-2). Costs are aggregated across both types and summarized in Table 4-3.

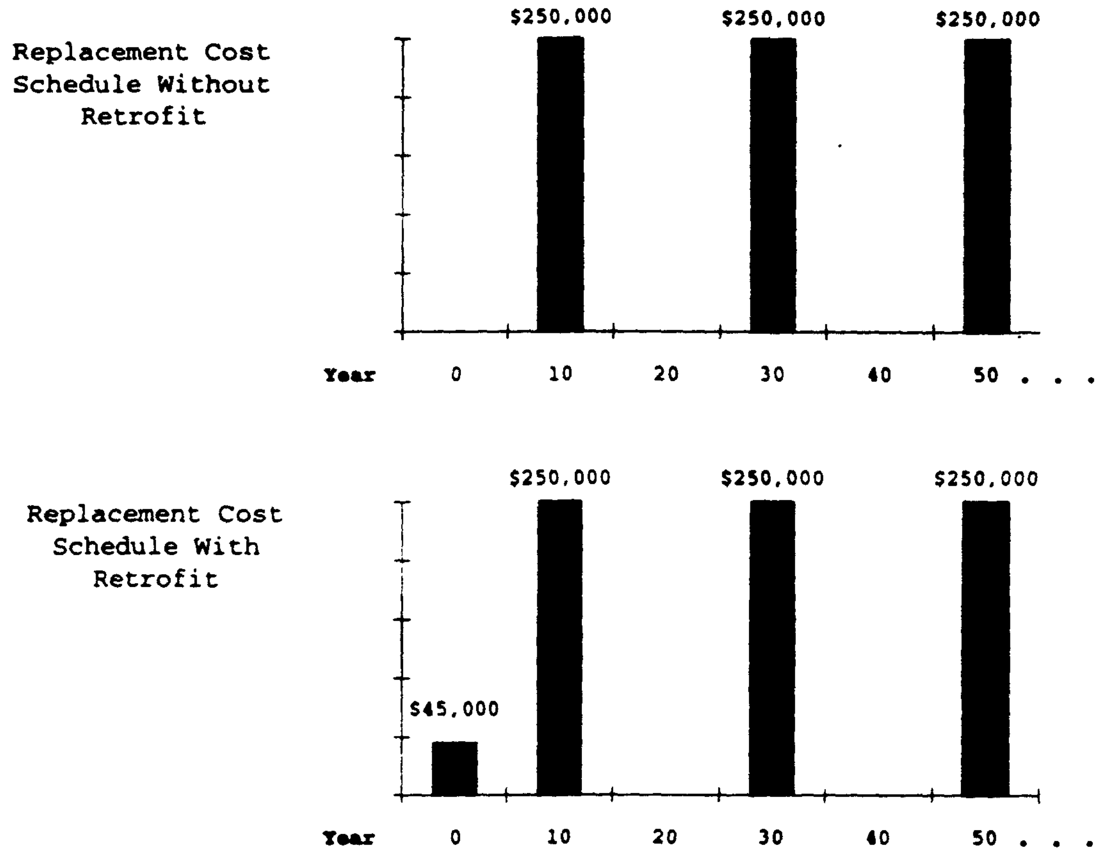

Figure 4-2. Replacement cost schedules with and without equipment retrofit.

Data on the vintage of the national fleets of medium and large stripers are provided in the traffic coating analysis report by ERG.[65] The government entities facing the decision to replace trucks now or to retrofit each vintage striper in the fleet are assumed to select the option that minimizes the present value of costs. When the PV of a new truck vs. retrofit is calculated, it appears that it would cost less for government entities to retrofit medium trucks that are under 15 years old than to purchase new trucks. As a result, all medium stripers currently older than 15 years (i.e., will be replaced within 5 years) are projected to be scrapped (at no

TABLE 4-1. NATIONAL INCREMENTAL COST OF TRAFFIC COATING EQUIPMENT REPLACEMENT AND RETROFITS—MEDIUM STRIPERS ($1996)

Assumptions

Baseline year equipment vintage	1999
Replacement cost	$100,000
T = service life	20
PV of replacement cost every 20 years	$134,847 computed
Retrofit cost	$35,000
Retrofit cutoff age	15
i = discount rate	0.07
Salvage value	0

Replacement scheme

**** This is the present value (PV) (Year 0) of accelerating the replacement schedule.

Age	Scheduled Replace- ment Year	PV Replacement Cost Without Regulation	PV Replacement Cost With Regulation	PV Incremental Cost	Number of Replace- ments	PV Total Replace- ment	Annualized Cost
20	0	134,847	134,847	0	150	0	0
19	1	126,025	134,847	8,822	150	1,323,265	92,629
18	2	117,781	134,847	17,066	150	2,559,962	179,197
17	3	110,075	134,847	24,772	150	3,715,753	260,103
16	4	102,874	134,847	31,973	150	4,795,932	335,715
						12,394,912	867,644

(continued)

TABLE 4-1. NATIONAL INCREMENTAL COST OF TRAFFIC COATING EQUIPMENT REPLACEMENT AND RETROFITS—MEDIUM STRIPERS ($1996) (CONTINUED)

Retrofit scheme

Assume that replacement schedule is unaffected by retrofit. Therefore service life of retrofit is equal to the remaining life of the current equipment.

Retrofit	Scheduled Replacement = Useful Life of Retrofit	PV per Retrofit	Number of Retrofits	PV of Retrofits	Annualized Cost
15	5	35,000	150	5,250,000	367,500
14	6	35,000	90	3,150,000	220,500
13	7	35,000	90	3,150,000	220,500
12	8	35,000	90	3,150,000	220,500
11	9	35,000	90	3,150,000	220,500
10	10	35,000	90	3,150,000	220,500
9	11	35,000	90	3,150,000	220,500
8	12	35,000	90	3,150,000	220,500
7	13	35,000	90	3,150,000	220,500
6	14	35,000	0	0	0
5	15	35,000	0	0	0
4	16	35,000	0	0	0
3	17	35,000	0	0	0
2	18	35,000	0	0	0
1	19	35,000	0	0	0
				30,450,000	2,131,500
			Sum	42,844,912	2,999,144

[a] The PV of the replacement scheme is the PV cost of an accelerated replacement schedule. This is a one-time event; thus, we annualize this value by multiplying it by the discount rate. All service life issues are implicitly captured in the PV calculation.

[b] The PV of each retrofit is $35,000. This is also a one-time cost (i.e., it does not need to be repeated). Therefore, it is also annualized by multiplying by the discount rate.

Note: The replacement of retrofitted vehicles will follow the same schedule as without regulation, so there is no replacement acceleration taking place.

TABLE 4-2. NATIONAL INCREMENTAL COST OF TRAFFIC COATING EQUIPMENT REPLACEMENT AND RETROFITS—LARGE STRIPERS ($1996)

Assumptions

Baseline year equipment vintage	1999
Replacement cost	$250,000
T = service life	20
PV of replacement cost every 20 years	$337,118 computed
Retrofit cost	$45,000
Retrofit cutoff age	17
i = discount rate	0.07
Salvage value	0

Replacement scheme

**** This is the PV (Year 0) of accelerating the replacement schedule.

Age	Scheduled Replace- ment Year	PV Replacement Cost Without Regulation	PV Replacement Cost With Regulation	PV Incremental Cost	Number of Replace- ments	PV Total Replace- ment	Annualized Cost
20	0	337,118	337,118	0	25	0	0
19	1	315,063	337,118	22,054	25	551,361	38,595
18	2	294,452	337,118	42,666	25	1,066,651	74,666
						1,618,011	113,261

(continued)

TABLE 4-2. NATIONAL INCREMENTAL COST OF TRAFFIC COATING EQUIPMENT REPLACEMENT AND RETROFITS–LARGE STRIPERS ($1996) (CONTINUED)

Retrofit scheme

Assume that the replacement schedule is unaffected by retrofit.

Retrofit	Scheduled Replacement = Useful Life of Retrofit	PV per Retrofit	Number of Retrofits	PV of Retrofits	Annualized Cost
17	3	45,000	25	1,125,000	78,750
16	4	45,000	25	1,125,000	78,750
15	5	45,000	25	1,125,000	78,750
14	6	45,000	15	675,000	47,250
13	7	45,000	15	675,000	47,250
12	8	45,000	15	675,000	47,250
11	9	45,000	15	675,000	47,250
10	10	45,000	15	675,000	47,250
9	11	45,000	15	675,000	47,250
8	12	45,000	15	675,000	47,250
7	13	45,000	15	675,000	47,250
6	14	45,000	0	0	0
5	15	45,000	0	0	0
4	16	45,000	0	0	0
3	17	45,000	0	0	0
2	18	45,000	0	0	0
1	19	45,000	0	0	0
				8,775,000	614,250
			Sum	10,393,011	727,511

[a] The PV of the replacement scheme is the PV cost of an accelerated replacement schedule. This is a one-time event; thus, we annualize this value by multiplying it by the discount rate. All service life issues are implicitly captured in the PV calculation.

[b] The PV of each retrofit is $45,000. This is also a one-time cost (i.e., it does not need to be repeated). Therefore, it is also annualized by multiplying by the discount rate.

Note: The replacement of retrofitted vehicles will follow the same schedule as without regulation, so there is no replacement acceleration taking place.

TABLE 4-3. NATIONAL INCREMENTAL COST SUMMARY FOR TRAFFIC COATING EQUIPMENT ($1996)

Striper Type	PV of Cost	Annualized Cost
Medium (see Table 4-1)	$42,844,912	$2,999,144
Large (see Table 4-2)	$10,393,011	$727,511
Total	$53,237,923	$3,726,655

salvage value) and replaced with new trucks, while all medium stripers under 15 years old are projected to retrofit the current vehicles. The corresponding age threshold for this decision is 17 years for large stripers.

Present value costs are computed for each vintage year, dependent on the replacement/retrofit decision, and then are multiplied by the number of stripers of that vintage in the fleet. This calculation is then summed across all vintage years to estimate the present value of national costs. As Table 4-3 indicates, the present value of total national costs is estimated at $53.2 million - $42.8 million for medium stripers and $10.4 million for large stripers.

This present value figure is the one-time cost of the regulation for the government entities faced with equipment replacement. For comparability with the other estimates in this analysis, this figure must be expressed in annualized terms. Because the acceleration (and its costs) are a one-time event not to be repeated in the future, the appropriate form of annualization is to compute the corresponding perpetual annuity value—the amount, if paid out in annual installments into perpetuity, that would have a present value equal to the one-time cost estimate. This number is computed simply by multiplying the one-time cost estimate by the discount rate of 7 percent

Annualized cost = ($53.2 million) • .07 = $3.7 million

This is the conceptually correct figure for the annualized costs incurred by government entities to switch equipment for traffic marking coating application. This annual estimate is used to compute cost-effectiveness measures in the next section.

SECTION 5
SOCIAL COST-EFFECTIVENESS ANALYSIS

The social cost estimates from the market analysis and the estimate of traffic coating user costs can be used to compute measures of the social cost-effectiveness of the regulation. The distinction of "social" cost-effectiveness is made to illuminate the fact that the costs evaluated are the net costs imposed on society, i.e., the net welfare costs estimated in the architectural coatings market plus the resource costs incurred by traffic coating users to switch application equipment.

The measure of social cost-effectiveness is computed as follows:

$$SCE = (|\Delta WF| + TMEC)/|\Delta E|. \qquad (5.1)$$

$|\Delta WF|$ is the absolute value of the aggregate annual net change in welfare (i.e., total social costs), summed across all markets in the market analysis. TMEC is the annualized traffic marking equipment costs, and $|\Delta E|$ is the absolute value of emission reductions. The $|\Delta WF|$ of 20.2 million is produced by the market model. The TMEC value is estimated at $3.7 million in the previous section and is adjusted to $3.3 million (1991 dollars) for comparison with the market results, leading to a total social cost estimate of $23.5 million. For external reporting purposes, all numbers will be converted to 1996 dollars later in this section.

The emissions reduction estimate needs some elaboration. To correspond with the cost estimates, a national estimate of emissions reduction must be used. The baseline estimate of national VOC emissions from regulated architectural coatings products is 509,900 Mg.[a,66] Given the reduction of 20.6 percent in 1998, the aggregate emissions reduction in 1998 is 105,075 Mg, which is ΔE^T. However, the emissions target must be adjusted by two market-related factors: foregone emissions reduction due to selecting the fee option and changes (net reduction) in emissions due to regulation-induced changes in industry output.

The first adjustment, ΔE^{FR}, was computed by taking the total quantity of "exceedance" emissions for products electing the fee option. These targeted emissions reductions will not be accomplished because of the fee option:

$$\Delta E^{FR} = (\Delta E_s^{FR}/\Delta E_s^{T}) \bullet \Delta E^T. \qquad (5.2)$$

The second adjustment was computed by taking the ratio of the change in industry output to baseline industry output and multiplying by baseline industry emissions:

$$\Delta E^Q = (\Delta Q/Q_0) \bullet E_0. \qquad (5.3)$$

ΔQ is the change in industry output, which is the sum of market-level changes, Q_0 is baseline industry output (2.375 billion liters), and E_0 is baseline emissions (509,000 Mg indicated above).

Thus, the net emissions reduction is computed as follows:

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[a]This estimate is based on a national baseline emissions estimate provided by Eastern Research Group of 560,900 tons, which is converted to Mg by multiplying by the ratio of tons/Mg = 0.9072. The result is a national estimate of 509,900 Mg.

$$\Delta E = \Delta E^{T} + \Delta E^{FR} + \Delta E^{Q}. \tag{5.4}$$

Absolute reductions are reported in Table 5-1. The net reduction equals the targeted reduction, less foregone emissions reductions (due to fee), plus emission changes due to changes in industry output via regulation-induced market interactions.

The analysis focuses on computing social cost per Mg of emissions reduction based on the market welfare costs and traffic marking coating user costs estimated in the previous sections. Table 5-1 presents the results. The social cost-effectiveness estimate is $247/Mg.

This estimate allows for an evaluation of cost-effectiveness implications of the fee option. Allowing the fee reduces social costs (compared to the static national reformulation cost estimate of $34 million) by about $12 million but foregoes about 1,802 Mg of emissions reduction, about 1.7 percent of the targeted reductions. Dividing the cost savings by foregone reductions approximates the marginal social cost of the foregone reductions. This figure is $6,580/Mg, which is substantially higher than the $247/Mg average social cost-effectiveness measure reported in Table 5-1. This indicates that the fee's main effect is to reduce the most expensive emission reductions.

An important implication of these estimates is that the fee option, while leading to a substantial reduction in the social costs of the regulation, does not significantly undercut the emissions reduction target. Moreover, by charging the VOC exceedance fee, firms that opt for the fee have a continued incentive to achieve marginal reductions in VOC content.

TABLE 5-1. SOCIAL COST-EFFECTIVENESS ESTIMATES

Social Cost: Architectural Coatings Market ($1991)	Traffic Coating User Costs ($1991)	Total Social Cost ($1991)	National Emissions Reduction[a] (Mg)	Estimated Foregone Emissions Change[b] (Mg)	Estimated Market Output Adjustment[c] (Mg)	Net Emission Reduction[d] (Mg)	Social Cost per Mg ($1991)
22,319,063	3,269,994	25,589,057	105,075	1,802	198	103,471	$247

[a] National estimate of baseline emissions (509,900 Mg) times 0.2061 (estimated proportional emissions reduction in 1998).

[b] National emissions foregone due to adoption of exceedance fee, as estimated in architectural coatings market model.

[c] Baseline emissions times ratio of industry market quantity reduction to baseline industry output.

[d] Net emissions reduction = targeted reduction - foregone reduction + quantity adjustment.

5.1 CONVERSION OF IMPACTS TO CURRENT DOLLARS

As indicated previously, all impacts presented in the analysis are in constant 1991 dollars. Some commenters indicated a preference for values to be expressed in more recent years. Therefore, this section provides a demonstration of how 1991 dollars can be converted into a value closer to the current year. This conversion is performed using the 3GDP price deflator. At the time of this analysis, the most recent year of data was for 1996; thus a conversion is provided for 1996. Given that the GDP index in 1991 is 97.4 and in 1996 the index is 111.0, a conversion factor of 1.1397 can be applied to any value in the report. Table 5-2 demonstrates the conversion to 1996 dollars. The estimated annual net social welfare cost of the regulation of $25.6 million in 1991 dollars converts to $29.2 million in 1996 dollars. Thus, social cost-effectiveness estimate converts from $247 Mg ($1991) to $282 Mg ($1996).

TABLE 5-2. CONVERSION OF SUMMARY IMPACTS TO 1996 DOLLARS

Impact Estimate	$1991	$1996
Net social cost	$25.6 million	$29.2 million
Net social cost per Mg of emissions reduction	$247/Mg	$282/Mg

SECTION 6
SMALL BUSINESS IMPACT ANALYSIS

The Regulatory Flexibility Act (RFA) of 1980 (5 U.S.C. 601, et seq.), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), requires the EPA to give special consideration to the effect of federal regulations on small entities and to consider regulatory options that might mitigate any such impacts. The EPA is required to prepare a regulatory flexibility analysis, including consideration of regulatory options for reducing any significant impact, unless the Agency determines that a rule will not have a significant economic impact on a substantial number of small entities.

The Agency prepared analyses to support both the proposed and final rules to meet the requirements of the RFA as modified by SBREFA. The Agency undertook these analyses because of the large presence of small entities in the architectural coatings industry and because the initial impact analysis indicated that there could be a significant economic impact on a substantial number of small entities if mitigating regulatory options were not adopted for the rule. The analysis supporting the proposed rule was published in the report titled, "Economic Impact and Regulatory Flexibility Analysis of Air Pollution Regulations: Architectural and Industrial Maintenance Coatings" (June 1996). The proposed rule contained a number of provisions to mitigate the rule's impact on small businesses, and the Agency requested comment on additional measures to reduce the impacts.

This section presents the small business impacts and the final regulatory flexibility analysis, including responses to significant issues raised by public comments on proposed compliance options to mitigate the rule's impact on small entities. After evaluating public comment on the proposed mitigating options, EPA made a number of changes to the proposed rule to further mitigate the rule's small business impacts. As a result, the Agency believes that it is highly unlikely that the rule will have a significant economic impact on a substantial number of small entities. However, in light of the Agency's inability to quantify the effect of the mitigating options, the EPA has elected to conduct a regulatory flexibility analysis and to prepare a SBREFA compliance guide to eliminate any potential dispute on whether EPA has fulfilled SBREFA requirements.

6.1 BACKGROUND AND AFFECTED ENTITIES

Small businesses can be defined using the criteria prescribed in the RFA or some other criteria identified by EPA. The SBA's general size standard definitions for Standard Industrial Classification (SIC) codes is one way to define small businesses. These size standards are presented either by number of employees or by annual receipt levels, depending on the SIC code. For SIC 2851, Paint and Allied Products (of which architectural manufacturers represent approximately 40 percent), the SBA defines small business as fewer than 500 employees. The coatings manufacturing industry, however, is not labor-intensive. For example, given the average value of shipments per employee (based on data presented in Sections 1 and 3), a firm with 400 employees might have close to

$100 million in sales (1991 $). Therefore, use of this SBA definition would result in almost all firms in the architectural coatings industry being classified as small, which does not appear appropriate given the sales level of many firms. Alternatively, based on input from the regulatory negotiation process, the EPA has defined small businesses as having less than $10 million in annual architectural coatings sales and less than $50 million in total annual sales of all products. Using this definition, the section assesses the baseline presence of small producers in specific architectural coatings markets. The distribution of small producers by market segment is important because impacts vary substantially by market segment. After the baseline assessment, an analysis is performed to estimate the extent to which specialization in higher VOC products causes small companies to incur disproportionate impacts. This is followed by an estimate of the average impacts of regulatory compliance on small architectural coatings companies, as measured by the ratio of compliance costs to sales. The role of special provisions such as the fee and small tonnage exemption allowance are also examined in terms of their mitigating impacts on small producers.

6.1.1 Potentially Affected Entities

A regulatory action to reduce VOC emissions from architectural coatings products will potentially affect the business entities that produce the products. Firms, or companies, that produce architectural coatings are legal business entities that have the capacity to conduct business transactions and make business decisions. Figure 6-1 shows the chain of ownership may be as simple as one facility owned by one company (firm) or as complex as multiple facilities owned by subsidiary companies.

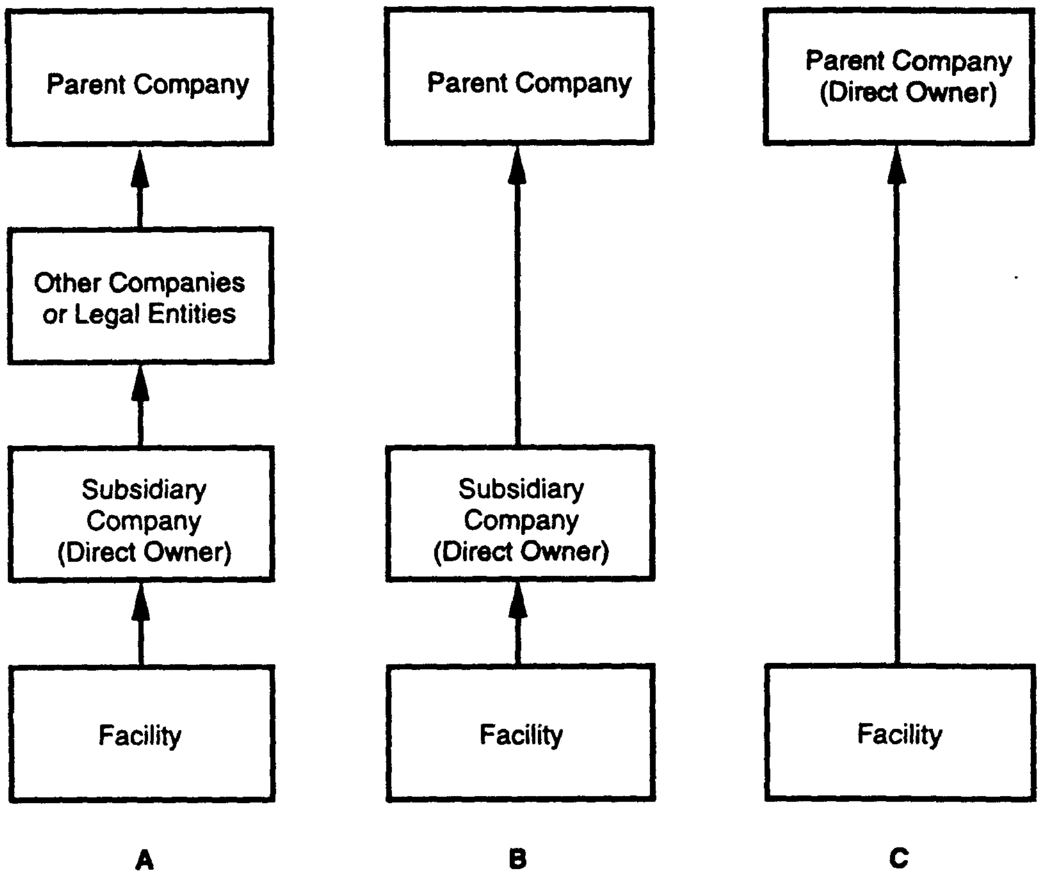

Figure 6-1. Chain of ownership.

Determining the total number of firms that will be affected by the regulation is difficult because most of the available Census data are reported at the four-digit SIC code, and architectural coatings manufacturers, for whom this regulation applies, are a subset of the entire coatings industry represented by SIC 2851. The 1987 Census of Manufactures, Industry Series: Paint and Allied Products identified 530 companies with shipments of $100,000 or more that manufacture architectural and special purpose coatings.[a,67] For the purpose of this analysis, 500 architectural coating manufacturers were assumed to exist. Data from the Architectural and Industrial Surface Coatings VOC Emissions Inventory Survey (the survey) conducted by the National Paint and Coatings Association provided data for 116 firms, 36 of which identified themselves as having under $10 million in annual net sales.[b,68] While small businesses represent about 31 percent of the firms in the survey, a larger share of nonsurveyed firms appear to fall in the small business category.[c]

6.1.2 Regulatory Requirements

As discussed in Section 2, the regulation constrains firms that produce architectural coatings products over the VOC content limits in one of three ways:

- requires they produce products with VOC content under the established set of limits,
- imposes a fee on each unit of product that exceeds the limits established in the regulation, or
- requires they withdraw the product from the market.

Thus, absent the small tonnage exemption, firms with a heavy (baseline) concentration of products above the limit for their respective product categories are more tightly constrained by

[a]These are the two Census categories within SIC 2851 where most of the architectural coatings products are represented, and this figure includes companies that produce architectural products, whether or not it is their primary product.

[b]Twelve survey respondents did not indicate company size.

[c]The 116 survey respondents comprise about one-fifth of the firms making architectural coatings products but account for about three-fourths of industry output. Thus the nonsurveyed firms are relatively numerous but produce relatively little volume.

the regulation than those with a lighter concentration of above-limit products, all else equal.

6.2 ANALYSIS

The quantitative analysis of small business impacts draws from the NPCA survey data for the 36 companies classified as small (less than $10 million in architectural sales and $50 million in total sales). While this is a relatively small sample of all potentially impacted small companies (less than 10 percent), it is assumed that the surveyed small companies are fairly representative of the nonsurveyed small companies. As described below, efforts were made to expand the sample beyond the 36 surveyed small companies, but the inability to estimate firm-specific costs made such an extension problematic. Therefore the results of this analysis should be interpreted with the usual caution surrounding small samples.

6.2.1 Baseline Market Presence of Small Architectural Coatings Producers

Small business presence in specific coatings markets indicates one dimension of how small firms may be affected by the regulation. For certain product markets, small businesses predominate and thus may be disproportionately affected if limits are particularly restrictive on those categories. Table 6-1 lists the coatings product categories provided in the survey.[69] The survey data represent producers that account for approximately three-quarters of the total industry product volume.[d]

Small companies produce more than 20 percent of the products in the survey, but these products account for just 3.6 percent of total coatings volume and 3.7 percent of total

[d]This is based on the ratio of Census product volume (part of the total SIC 2851 volume) to the survey product volume.

TABLE 6-1. SMALL BUSINESS PRESENCE IN THE ARCHITECTURAL COATINGS MARKET[a]: SURVEY POPULATION

		Total Survey Population (116 respondents)[b]				Small Business (36 respondents)					
Market Segment Number	Regulation Category	Sales (10^3 L)	Imputed Revenues[c] (10^3 $1991)	Number of Products	Average Volume per Product (10^3 L)	Sales (10^3 L)	Share of Total Sales Volume (%)	Imputed Revenues (10^3 $1991)	Number of Products	Share of Total Products (%)	Average Volume per Product (10^3 L)
12	Bond breakers	NR	NA	1	NA	NR	100.0	NA	1	100.0	NA
13	Magnesite cement coatings	NR	NA	2	NA	0.0	NA	0	0.0	0.0	0.0
3,4	Flat, interior	440,498	973,502	391	1,126.6	4,214	1.0	9,313	81	20.7	52.0
3,4	Nonflat, interior	316,786	700,097	529	598.8	2,802	0.9	6,192	87	16.4	32.2
1,2	Flat, exterior	188,764	473,799	344	548.7	3,320	1.8	8,334	92	26.7	36.1
1,2	Nonflat, exterior	152,705	383,290	494	309.1	4,765	3.1	11,960	155	31.4	30.7
5,6	Primers	109,850	268,034	634	173.3	2,780	2.5	6,782	137	21.6	20.3
13	Industrial maintenance coatings	92,412	318,820	652	141.7	2,603	2.8	8,980	78	12.0	33.4
1,2	Roof coatings	89,515	224,683	80	1,118.9	19,939	22.3	50,046	20	25.0	996.9
1,2	Bituminous coatings and mastics	79,051	198,418	34	2,325.0	4,450	5.6	11,170	22	64.7	202.3
7,8	Stains, semitransp.	53,057	141,131	205	258.8	602	1.1	1,601	18	8.8	33.4
7,8	Stains, opaque	47,168	125,466	125	377.3	39	0.1	103	11	8.8	3.5
11	Traffic marking paints	46,886	67,985	85	551.6	5,649	12.0	8,192	21	24.7	269.0
7,8	Waterproofing sealers, clear	37,393	99,464	71	526.7	318	0.9	846	14	19.7	22.7
7,8	Varnishes	26,184	69,649	215	121.8	3,177	12.1	8,452	48	22.3	66.2

TABLE 6-1. SMALL BUSINESS PRESENCE IN THE ARCHITECTURAL COATINGS MARKET[a]: SURVEY POPULATION (CONTINUED)

		Total Survey Population (116 respondents)[b]				Small Business (36 respondents)					
Market Segment Number	Regulation Category	Sales (10^3 L)	Imputed Revenues[c] (10^3 $1991)	Number of Products	Average Volume per Product (10^3 L)	Sales (10^3 L)	Share of Total Sales Volume (%)	Imputed Revenues (10^3 $1991)	Number of Products	Share of Total Products (%)	Average volume per Product (10^3 L)
12	Metallic pigmented coatings	22,163	90,868	128	173.1	2,390	10.8	9,798	50	39.1	47.8
1,2	High-performance	19,233	48,274	186	103.4	145	0.8	364	23	12.4	6.3
9	Lacquers	17,351	36,090	65	266.9	4,384	25.3	9,118	13	20.0	337.2
7,8	Sealers	15,375	40,898	100	153.8	350	2.3	932	9	9.0	38.9
10	Clear wood preservatives	15,064	21,843	15	1,004.3	0	0.0	0	0	0.0	0.0
12	Dry fog coatings	14,107	57,837	68	207.4	63	0.4	259	7	10.3	9.0
5,6	Quick dry primers, undercoaters	13,612	33,212	40	340.3	0.0	0.0	0	0.0	0.0	0.0
7,8	Waterproofing sealers, opaque	10,214	27,169	29	352.2	17	0.2	44	2	6.9	8.4
10	Semitransp. wood preservatives	8,902	12,909	32	278.2	0.0	0.0	0.0	0.0	0.0	0.0
5,6	Undercoaters	7,096	17,313	43	165.0	66	0.9	162	7	16.3	9.5
13	Mastic texture coatings	6,443	22,230	42	153.4	2,637	40.9	9,096	10	23.8	263.7
3	Quick dry enamels	6,390	20,321	85	75.2	280	4.4	890	14	16.5	20.0
7	Shellacs, clear & opaque solventborne	3,937	12,047	11	357.9	0.0	0.0	0.0	0.0	0.0	0.0
10	Opaque wood preservatives	2,974	4,312	8	371.7	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 6-1. SMALL BUSINESS PRESENCE IN THE ARCHITECTURAL COATINGS MARKET[a]: SURVEY POPULATION (CONTINUED)

		Total Survey Population (116 respondents)[b]				Small Business (36 respondents)					
Market Segment Number	Regulation Category	Sales (10³ L)	Imputed Revenues[c] (10³ $1991)	Number of Products	Average Volume per Product (10³ L)	Sales (10³ L)	Share of Total sales Volume (%)	Imputed Revenues (10³ $1991)	Number of Products	Share of Total Products (%)	Average Volume per Product (10³ L)
13	Sanding sealers	2,796	9,648	41	68.2	80	2.9	277	8	19.5	10.0
12	Multicolor coatings	1,613	6,614	4	403.3	0	0	0	0	0	0
12	Concrete curing compounds	1,256	5,148	6	209.3	NR	NA	NA	1.0	16.7	NA
12	Form release compounds	1,026	4,206	5	205.2	0	0	0	0	0	0
12	Graphic arts coatings	994	4,075	30	33.1	251.3	25.3	1,030.5	20.0	66.7	12.6
12	Pretreatment wash primers	668	2,739	18	37.1	11.3	1.7	46.2	4.0	22.2	2.8
12	Swimming pool coatings	656	2,689	27	24.3	126.4	19.3	518.1	14.0	51.9	9.0
10	Below ground wood preservatives	507	736	8	63.4	0	0	0	0	0	0
13	High temperature coatings	483	1,665	44	11.0	4.4	0.9	15.1	9.0	20.5	0.5
13	Appurtenances	205	707	7	29.3	200.5	97.9	691.6	5.0	71.4	40.1
12	Antigraffiti coatings	42	172	8	5.3	40.1	95.3	164.2	6.0	75.0	6.7
	Sums/averages	1,853,623[d]	4,528,916	4,920	376.8	65,914	3.6	166,022	992	20.2	66.4

See notes at end of table.

(continued)

TABLE 6-1. SMALL BUSINESS PRESENCE IN THE ARCHITECTURAL COATINGS MARKET[a]: SURVEY POPULATION (CONTINUED)

[a] Small businesses are defined as producing less than $10 million in architectural coatings products or less than $50 million in total sales.

[b] The survey had 116 respondents and 36 of those identified themselves as having under $10 million in annual sales. Twelve survey respondents did not report company size.

[c] Revenues were imputed using average prices taken from Section 2. A weighted average was used when the product category belongs in two market segments.

[d] The actual total volume reported in the survey is 1,853,658,716 L. The difference here, 35,677 L, is attributed to bond breakers and magnesite cement coatings, and waterborne quick dry enamels, which are not reported. The quantity reported here is slightly greater than the total survey quantity used in the market analysis because quantities in the survey that were identified as either "exempt" or "unknown" (with respect to solventborne or waterborne) were not included in the total for the market analysis.

NR = Not reported due to disclosure of individual companies.

NA = Not available.

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

revenue. This is evidence that small businesses tend to produce lower volumes per product. The average price per product in the small business segment is $2.52/L, compared to $2.44/L for the industry. The largest volume category for small producers is roof coatings, at 19.9 million L/yr. Small producers comprise just over 22 percent of the volume in that category. Small businesses produce over 95 percent of the total volume of antigraffiti coatings, but the volume is quite low, with six products totaling about 40,060 L.

Other categories in which small producers comprise more than 20 percent of the market volume are lacquers, mastic texture coatings, graphic arts coatings, bond breakers, and appurtenances. In addition to roof coatings, small producers collectively produce over 4 million L in the following categories: traffic marking paints, exterior nonflats, bituminous coatings, lacquers, and interior flats.

6.2.2 VOC Content of Small Business Products: Technology and Specialization Effects

The extent to which small businesses are affected by the architectural coatings regulation will depend partly on the average VOC content of small business products relative to the industry average. Table 6-2 presents the average baseline VOC content for products manufactured by small businesses as compared with those manufactured by the industry as a whole.[70] Small business products generate approximately 6.2 percent of total VOC emissions in the survey, which is substantially greater than their output share. The average VOC content for small business products, 325 g/L, is almost 75 percent higher than the average VOC content for all surveyed products combined, 186 g/L.

Small business products have a higher VOC content than the industry average for two possible reasons. First, small businesses specialize in products that tend to be higher in

TABLE 6-2. BASELINE VOC CONTENT

Size Category[a]	VOC Emissions (Mg)	Sales (kL)	Average VOC Content (g/L)
All products	344,059	1,853,623	186
Small business products	21,431	65,914	325

[a] The survey had 116 respondents and 36 of those identified themselves as having under $10 million in annual sales. Twelve survey respondents did not report company size.

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

VOCs because of fundamental performance requirements of the products. Second, small businesses tend to produce higher VOC-content products regardless of the product category. The first reason can be called a specialization effect and the second reason a technology effect.

Some further clarification may be in order. Many of the small companies in the architectural coatings industry are regional firms whose product line is tailored to the region in which they operate and may tend to focus on smaller "niche" markets for which larger manufacturers may not choose to devote manufacturing and marketing resources. Thus small businesses may "specialize" in higher VOC coatings within categories. Therefore, what is referred to here as a technology effect (higher VOC within categories in which small and large manufacturers compete) may be caused by specialization strategies. In other words, some technology effect may actually be due to specialization within a category. With that caveat in mind, this report refers to across-category factors as the specialization effect and within-category factors as the technology effect.

Distinguishing between specialization and technology factors underlying small companies' higher VOC content is important in terms of the scope for regulatory flexibility. To the extent that the specialization effect dominates, small business impacts can potentially be addressed by modifying the VOC limits in the high VOC categories where small companies specialize. If the technology effect dominates, there is less scope for modifying category limits to reduce impacts.

The observed difference in average VOC content of small businesses and all products was separated into the specialization and technology effects using a simple procedure. First, a measure of the *projected* average VOC content of small business products was computed. The projected value was based on the distribution of small business products among the different product groups, weighted by the average VOC content of each group. This is a measure of its specialization-based VOC content:

$$V^S = \sum_{i=1}^{N} V_i^I \cdot S_i^B \,. \qquad (6.1)$$

Here, V_i^I is the industry average VOC content for all products in product category i, S_i^B is the share of total small business product quantity attributable to product category i, and N is the total number of product categories.[e] The separation of the average VOC content difference into the two component effects derives from the following equation:

$$(V^B - V^I) = (V^B - V^S) + (V^S - V^I) \qquad (6.2)$$

Difference in Average Content	=	Technology Effect	+	Specialization Effect

[e] s_i^B is not the small business share of total production in category I, but rather the contribution of category I to total small business production.

V^B and V^I are, respectively, the small business and industrywide VOC content averages. The technology effect quantifies the difference between the actual average VOC content for small businesses and the specialization-adjusted average. The specialization effect quantifies the difference between the specialization-adjusted average for small businesses and the overall industry average.

Table 6-3 yields the computation of the V^S measure for the small business products in the survey.[71] The computed V^S value is 261, meaning that one would expect an average VOC content of 261 g/L for the small business sector, based purely on the way their products are distributed among product groups (i.e., their specialization). Placing this value into Eq. (6.2), along with the values for V^B and V^I given above (325 and 186), the breakdown is computed as follows:

$$(V^B - V^I) = (V^B - V^S) + (V^S - V^I)$$

$$(325-186) = (325-261) + (261-186)$$

$$139 = 64 + 75$$

Approximately 54 percent of the 139 g/L difference between the small business sector's VOC content average and the industrywide average can be attributed to greater specialization in high-VOC product categories (specialization effect), and the remaining 46 percent can be attributed to the disproportionate presence of small business products in the high-VOC end of the respective product categories (technology effect).

As indicated above, this finding has implications for the feasibility of designing a TOS to minimize small business impacts. Since small business producers are somewhat concentrated in the higher VOC categories, as indicated by the

TABLE 6-3. SPECIALIZATION-BASED AVERAGE VOC CONTENT: SMALL BUSINESS PRODUCTS[a]

Market Segment Number	Regulation Category	All Products Average VOC (g/L)	Share of Total Small Business Volume	Share-Weighted Content Factor (g/L)
12	Bond breakers	NA	NA	NA
12	Concrete curing compounds	621	NA	NA
1,2	Roof coatings	239	0.3025	72.20
11	Traffic marking paints	369	0.0857	31.66
1,2	Nonflat, exterior	173	0.0723	12.49
1,2	Bituminous coatings and mastics	23	0.0675	1.54
9	Lacquers	657	0.0665	43.72
3,4	Flat, interior	52	0.0639	3.30
1,2	Flat, exterior	79	0.0504	3.99
7,8	Varnishes	474	0.0482	22.84
3,4	Nonflat, interior	134	0.0425	5.71
5,6	Primers	172	0.0422	7.23
13	Mastic texture coatings	146	0.0400	5.85
13	Industrial maintenance coatings	374	0.0395	14.78
12	Metallic pigmented coatings	459	0.0363	16.66
7,8	Stains, semitransparent	475	0.0091	4.34
7,8	Sealers	312	0.0053	1.66
7,8	Waterproofing sealers, clear	632	0.0048	3.05
3	Quick dry enamels	461	0.0042	1.96
12	Graphic arts coatings	366	0.0038	1.40
7	Shellacs, clear & opaque solventborne	539	0.0032	1.72
13	Apurtenances	411	0.0030	1.25
1,2	High performance	335	0.0022	0.74

(continued)

TABLE 6-3. SPECIALIZATION-BASED AVERAGE VOC CONTENT: SMALL BUSINESS PRODUCTS[a] (CONTINUED)

Market Segment Number	Regulation Category	All Products Average VOC (g/L)	Share of Total Small Business Volume	Share-Weighted Content Factor (g/L)
12	Swimming pool coatings	552	0.0019	1.06
13	Sanding sealers	525	0.0012	0.64
5,6	Undercoaters	206	0.0010	0.21
12	Dry fog coatings	300	0.0010	0.29
12	Antigraffiti coatings	397	0.0006	0.24
7,8	Stains, opaque	257	0.0006	0.15
7,8	Waterproofing sealers, opaque	239	0.0003	0.06
12	Pretreatment wash primers	706	0.0002	0.12
13	High-temperature coatings	561	0.0001	0.04
10	Below ground wood preservatives	541	0.0000	0.00
10	Clear wood preservatives	419	0.0000	0.00
10	Opaque wood preservatives	362	0.0000	0.00
10	Semitransparent wood preservatives	548	0.0000	0.00
12	Form release compounds	599	0.0000	0.00
12	Multicolor coatings	321	0.0000	0.00
13	Fire-resistant/ retardant coatings	16	0.0000	0.00
13	Magnesite cement coatings	NA	0.0000	NA
5,6	Quick dry primers, undercoaters	439	0.0000	0.00
	Sums/averages		1.0000	260.87[b]

[a] Small businesses are defined as producing less than $10 million in architectural coatings products or less than $50 million in total sales.
[b] Specialized average VOC content equals the sum of share-weighted content factors.
NA = Not available

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

empirically sizable specialization effect, the regulation can be designed to be somewhat less restrictive in categories with high small business presence. However, the effectiveness of such an approach in mitigating small business impacts will be limited by the fact that small business producers are also concentrated in the high-VOC range of each product category. An additional approach taken by the EPA was to evaluate requests for additional categories to determine if a breakout category for products in the higher-VOC range of a category was needed.

In 1993, the National Paint and Coatings Association (NPCA) analyzed the VOC content limits that were under discussion during the regulatory negotiation and found that the projected emissions reduction from the small business sector would be 19.65 percent of baseline emissions, compared to a projected 25 percent reduction for the industry.[72] This estimate provides some evidence of relief for small business products under the standards under consideration at the time. Moreover, the final regulation is less stringent than the form provided to NPCA in 1993. Unfortunately, data were not available to recompute these estimates based on the *current* content limits to see whether the proportional reduction from the small business sector is still less than the current overall reduction target of 20 percent.

6.2.3 Costs Associated With Regulatory Compliance

As discussed in Section 2, compliance options that can be quantitatively evaluated include product reformulation and the payment of an exceedance fee. The cost of a typical reformulation is estimated at $87,000 per reformulation.[73] This initial cost is converted to an annualized cost of

$14,573.[f] The per-unit fee that producers can use as an alternative compliance mechanism is computed as follows:

$$\text{fee} = (\text{VOC content} - \text{VOC limit}) \bullet \text{rate}. \quad (6.3)$$

VOC content is measured in grams per liter, and the fee rate is paid on the grams per liter in excess of the limit. The fee rate is $2,500 per ton or $0.0028 per excess g/L (in 1996 dollars, $0.0024 when converted to 1991 dollars). Total fee payment per product simply equals the per-liter fee multiplied by total liters of production.

6.2.4 Reformulation Cost Impact Estimates

Given the data from the survey and the VOC content limits set by the standard, the number of products produced by small businesses that exceed the VOC limits were identified. The number of potential reformulations was estimated by applying the content limits to the number of products reported by category and VOC content in the survey to determine the number exceeding the limit for each category. Results are reported in Table 6-4.[74] An estimated 421 small business products in the survey (42 percent) exceed the VOC content limits. This figure is slightly higher than the proportion of all surveyed products that exceed the limit (36 percent). As established in Section 2, approximately one-third of products over the VOC limit can costlessly comply with the regulation because of their similarity to the remaining over-the-limit products that are being reformulated. The remaining over-the-limit products are referred to as "constrained" by the regulation and the sum of the costless compliance products and under-the-limit products as "unconstrained" by the regulation.

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[f]Details of the derivation of these estimates are presented in Section 2 of this report.

TABLE 6-4. SMALL BUSINESS COSTS BY MARKET SEGMENT: REFORMULATION OPTION ONLY[a]

Market Segment Number	Regulation Category	Sales (L)	Average Price[b] ($/L)	Imputed Revenues ($1991)	Number of Products over VOC Limit	Number of Constrained Products[c]	Total Cost of Reformulating Constrained Products[d] ($1991)	Reform Cost per Unit ($/L)	Reformulation Cost/Revenues (%)
12	Bondbreakers	NA	$4.10	NA	0	0	$0	NA	NA
12	Concrete curing compounds	NA	$4.10	NA	0	0	$0	NA	NA
1,2	Roof coatings	19,938,649	$2.51	$50,046,010	13	9	$126,273	$0.01	0.3%
11	Traffic marking paints	5,649,468	$1.45	$8,191,729	14	9	$135,987	$0.02	1.7%
1,2	Nonflat, exterior	4,764,963	$2.51	$11,960,057	70	47	$679,933	$0.14	5.7%
1,2	Bituminous coatings and mastics	4,450,233	$2.51	$11,170,084	1	1	$9,713	$0.00	0.1%
9	Lacquers	4,383,825	$2.08	$9,118,356	5	3	$48,567	$0.01	0.5%
3,4	Flat, interior	4,214,045	$2.21	$9,313,039	13	9	$126,273	$0.03	1.4%
1,2	Flat, exterior	3,320,278	$2.51	$8,333,897	34	23	$330,253	$0.10	4.0%
7,8	Varnishes	3,177,311	$2.66	$8,451,646	33	22	$320,540	$0.10	3.8%
3,4	Nonflat, interior	2,801,665	$2.21	$6,191,679	26	17	$252,547	$0.09	4.1%
5,6	Primers	2,779,526	$2.44	$6,782,044	79	53	$767,353	$0.28	11.3%
13	Mastic texture coatings	2,636,665	$3.45	$9,096,494	1	1	$9,713	$0.00	0.1%
13	Industrial maintenance coatings	2,602,918	$3.45	$8,980,067	33	22	$320,540	$0.12	3.6%
12	Metallic pigmented coatings	2,389,690	$4.10	$9,797,729	19	13	$184,553	$0.08	1.9%
7,8	Stains, semitransparent	601,978	$2.66	$1,601,261	12	8	$116,560	$0.19	7.3%
7,8	Sealers	350,434	$2.66	$932,155	2	1	$19,427	$0.06	2.1%

(continued)

TABLE 6-4. SMALL BUSINESS COSTS BY MARKET SEGMENT: REFORMULATION OPTION ONLY[a] (CONTINUED)

Market Segment Number	Regulation Category	Sales (L)	Average Price[b] ($/L)	Imputed Revenues ($1991)	Number of Products over VOC Limit	Number of Constrained Products[c]	Total Cost of Reformulating Constrained Products[d] ($1991)	Reform Cost per Unit ($/L)	Reformulation Cost/Revenues (%)
7,8	Waterproofing sealers, clear	318,046	$2.66	$846,002	9	6	$87,420	$0.27	**10.3%**
3	Quick dry enamels	279,893	$3.18	$890,060	9	6	$87,420	$0.31	9.8%
12	Graphic arts coatings	251,343	$4.10	$1,030,506	8	5	$77,707	$0.31	7.5%
7	Shellacs, clear & opaque solventborne	210,817	$3.06	$645,100	0	0	$0	$0.00	0.0%
13	Apurtenances	200,473	$3.45	$691,630	5	3	$48,567	$0.24	7.0%
1,2	High performance	144,958	$2.51	$363,844	12	8	$116,560	$0.80	**32.0%**
12	Swimming pool coatings	126,358	$4.10	$518,070	0	0	$0	$0.00	0.0%
13	Sanding sealers	80,170	$3.45	$276,587	1	1	$9,713	$0.12	3.5%
5,6	Undercoaters	66,427	$2.44	$162,081	3	2	$29,140	$0.44	**18.0%**
12	Dry fog coatings	63,187	$4.10	$259,066	6	4	$58,280	$0.92	**22.5%**
12	Antigraffiti coatings	40,060	$4.10	$164,248	1	1	$9,713	$0.24	5.9%
7,8	Stains, opaque	38,668	$2.66	$102,856	6	4	$58,280	$1.51	**56.7%**
7,8	Waterproofing sealers, opaque	16,726	$2.66	$44,491	2	1	$19,427	$1.16	**43.7%**
12	Pretreatment wash primers	11,272	$4.10	$46,214	4	3	$38,853	$3.45	**84.1%**
13	High-temperature coatings	4,383	$3.45	$15,121	0	0	$0	$0.00	0.0%

(continued)

TABLE 6-4. SMALL BUSINESS COSTS BY MARKET SEGMENT: REFORMULATION OPTION ONLY[a] (CONTINUED)

Market Segment Number	Regulation Category	Sales (L)	Average Price[b] ($/L)	Imputed Revenues ($1991)	Number of Products over VOC Limit	Number of Constrained Products[c]	Total Cost of Reformulating Constrained Products[d] ($1991)	Reform Cost per Unit ($/L)	Reformulation Cost/Revenues (%)
10	Below ground wood preservatives	0	$1.45	$0	0	0	$0	$0.00	0.0%
10	Clear wood preservatives	0	$1.45	$0	0	0	$0	$0.00	0.0%
10	Opaque wood preservatives	0	$1.45	$0	0	0	$0	$0.00	0.0%
10	Semitransparent wood preservatives	0	$1.45	$0	0	0	$0	$0.00	0.0%
12	Form release compounds	0	$4.10	$0	0	0	$0	$0.00	0.0%
12	Multicolor coatings	0	$4.10	$0	0	0	$0	$0.00	0.0%
13	Fire-resistant/retardant coatings	0	$3.45	$0	0	0	$0	$0.00	0.0%
13	Magnesite coatings	0	$3.45	$0	0	0	$0	$0.00	0.0%
5,6	Quick dry primers, undercoaters	0	$2.44	$0	0	0	$0	$0.00	0.0%
	Total/Average	65,914,429	$2.52	$166,022,123	421	281	$4,089,313	$0.06	2.5%

NA = not available

[a] Small businesses are defined as producing less than $10 million in architectural coatings products or less than $50 million in total sales.

[b] Average prices are taken from Section 2, and a weighted average is used when the product category belongs in two market segments.

[c] Number of products over the limit multiplied by two-thirds to represent the portion that potentially undergo major reformulation. Numbers in table are rounded.

[d] Annualized cost of reformulations is the number of products facing reformulation multiplied by the annualized major reformulation cost estimate per product of $14,573 (details in Section 2).

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

Less than 10 percent of the small business products in the sanding sealers, mastic texture coatings, and bituminous categories will be constrained by the regulation. Swimming pool coatings, shellacs, and high-temperature coatings produced by the small business sector will require no reformulations. Traffic paints, roof coatings, and varnishes are all relatively high-volume categories in which over 40 percent of the surveyed small business products are constrained by the VOC limits.

6.2.4.1 Small Business Impacts Under "Reformulation-Only" Option. In this section, the estimation of the total and per-unit annualized compliance costs for small producers in each product category with reformulation as the only compliance option is described. As with the impacts presented in Section 2, the "reformulation-only" scenario gives the upper bound of regulatory costs. The effect of cost-reducing strategies (fee and withdrawal) is considered in the next subsection.

The annualized $14,573 estimate of the cost per reformulation was multiplied by the number of products constrained by the regulation (all products over the limit less the one-third that can costlessly comply). Table 6-4 lists the cost estimates. These costs can be compared with revenue information to gauge the relative impact of the regulation on small businesses.

To compute product revenue, the analysis uses average price per liter for each category (see Sections 2 and 3) for the market segment in which the category is classified.[g] The cost of reformulation as a percentage of revenues was computed using the estimated cost of reformulation divided by the

[g]Where a coating category could not be separated into waterborne and solventborne market segments (categories in market segments 1 through 8), a weighted average of the two prices was used.

imputed revenues for each product category. Ideally, costs would be calculated for each firm affected by the regulation and compared to the firm's revenues as a firm-specific measure of impacts. Then, these measures could be used to determine the number and percentage of firms exceeding certain cost/revenue threshold values, e.g., 1 percent or 3 percent. What constitutes a significant impact varies, depending on typical profit rates and other industry-specific factors.

Unfortunately, the product-level survey data used to estimate costs did not identify the firms that produced each surveyed product. Therefore, it was not possible to estimate costs at the firm level. In lieu of the firm-level measures, the analysis calculated cost/revenue affects per market segment (in Table 6-4) and the average cost/revenue ratio per small company using summary totals from the small business component of the survey (in Table 3-5).

6.2.5 Cost Impacts Across Market Segments

The data presented in Table 6-4 illustrate a number of scenarios pertaining to potential small business impacts of the regulation under a reformulation-only response scenario. Key phenomena indicated by the data are examined below.

Based on the survey data, roof coatings is the largest quantity and highest revenue category for small businesses. For small business roof coatings, 43 percent of the individual products will be constrained; however, the cost of reformulation as a percentage of sales is relatively small, less than 1 percent.

Categories with cost/revenue ratios in excess of 10 percent are highlighted in bold in Table 6-4. The three highest impact categories are opaque waterproofing sealers (43.7 percent), opaque stains (56.7 percent), and pretreatment wash primers (84.1 percent).[h] In each case, the large impacts result from the fact that the average product volumes are very small (e.g., just 2,800 liters per product in pretreatment wash primers). This provides further evidence of the point made throughout the report that the impact on small volume products is potentially large because of the fixed cost nature of reformulation. Obviously the impacts would be dramatic *if these products were forced to reformulate*. However, the fee option provides relief from these high impacts. Therefore, the highest proportional impacts estimated in Table 6-4 would not occur with the fee as a compliance option. If, for instance, an average size pretreatment wash primer (2,800 liters) were 100 g/L over the limit for the category, then the total fee payment would be (100 g/L) • $0.0022/g • 2,800 l = $616. Clearly the producer's cost-minimizing compliance option would be to choose the fee rather than incur the annualized reformulation cost of almost $15,000. As a result, the 84.1 percent figure greatly overstates the true cost impact for the prototypical pretreatment wash primer product. Given the fee amount just computed, the figure would be closer to 5 percent of revenues for that category. Similar arguments can be made for the other categories representing the highest impacts in Table 6-4. Further quantitative evidence of the cost savings from the fee (and withdrawal) compliance options is presented below.

Antigraffiti coatings present quite a different small business impact outcome. Small businesses represent almost the entire market but produce small quantities in relation to other coating categories and generate lower revenues. Only one product requires reformulation under the VOC limits, but

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[h]This analysis is based on the interim standards presented in Section 2. As indicated in Section 7, the content limit for opaque waterproofing was raised in the final standards. Thus, the cost impact for that category would likely be lower than indicated here.

the cost of reformulating that product would represent about 6 percent of revenues in the category.

6.2.6 Average Cost Impacts for Small Company

For the small business segment of the architectural coatings industry overall, 42 percent of the products are over the VOC content limits, and 28 percent are expected to undergo reformulation, pay an exceedance fee, or exit. The total annualized cost for the sample of small businesses in the survey under the reformulation-only scenario is $4.1 million. The average cost per unit is $0.06 per liter.

Table 6-5 compares small firm and industry averages for revenues, number of products, and reformulation costs.[75] Small businesses on average manufacture approximately one-third fewer products than the industry average. On average, small firms have fewer constrained products than the industry average, but they comprise a slightly larger percentage of total number of products, 28 percent, as compared to 23 percent for the industry. Similarly, small business reformulation costs as a percentage of revenues are higher at 2.5 percent than the industry at roughly 0.4 percent.

In response to concerns expressed in the public comment period about the limited coverage of firms used to assess small business impacts, EPA obtained a list identifying small businesses in the industry and gathered data on total revenues and employment for these firms. However, without specific information on the number of products produced and their VOC content, there is no method to determine the number of products for each firm that would incur reformulation costs. Unfortunately, assigning the average costs for a small firm presented here (based on 7.8 noncompliant products) cannot produce a meaningful evaluation of the distribution of small firms' impacts. This occurs because the calculation of cost/revenue ratios for these firms varies the denominator

TABLE 6-5. AVERAGE REGULATORY IMPACT BY FIRM SIZE—"REFORMULATION-ONLY" SCENARIO[a]

	Industry Average	Small Firm Average
Revenue[b] ($1991)	38,990,000	4,614,000
Number of products[b]	42.4	27.5
Number of products facing major reformulation[c]	9.9	7.8
Annualized reformulation cost[d] ($1991)	144,272	113,669
Ratio of annualized reformulation cost to revenues (percent)	0.4	2.5

[a] The survey has 116 respondents and 36 of those identified themselves as having under $10 million in annual sales. Twelve survey respondents did not report company size.
[b] Data for revenues and products per firm were based on data reported in Table 6-1. The number of products per firm is based on the total number of products for which quantity data are available.
[c] This number represents two-thirds of the products over the 1998 TOS. Industry experts estimate that approximately two-thirds of the products with VOC contents exceeding the TOS limits face a "major" reformulation.
[d] Annualized cost of reformulation is the number of major reformulations multiplied by the annualized reformulation cost estimate per product of $14,573 ($1991).

Source: Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final Draft Report. 1993.

(revenues) by firm, but the numerator (compliance costs) remain fixed as those represented by the model (average) firm. Using this method, the estimated impacts would, by definition, be relatively larger for firms with smaller revenues. However, it does not necessarily follow that a firm with low revenues would have the same level of reformulation costs as a firm with larger revenues; such an analysis would therefore overstate impacts on the smallest firms. Therefore, for the final rule EPA uses the data from the 36 firms in the survey to provide a representative look at model company small business impacts as described above.

6.2.7 Potential Factors Mitigating Small Business Impacts: Exceedance Fee, Withdrawal, and Tonnage Exemption

6.2.7.1 Fee and Withdrawal Options. As discussed in Section 2, a product's output level affects the choice between reformulating the product and paying an exceedance fee. Since the cost of reformulation is a fixed cost (i.e., it is independent of output level), the average reformulation cost per unit of output falls as output levels increase. However, the exceedance fee per unit of output is constant with respect to the output levels and the fixed costs of the fee (recordkeeping) are relatively small. Thus, the fee is more likely to be chosen by small-volume producers, all else equal. Because the fee will be more cost-effective only for lower-volume products and lower-excess VOC categories, allowing the fee option should have a relatively small impact on variation from the aggregate emissions reduction targets as long as the fee assessment rate is not set at an inappropriately low level. The results presented in Section 2 support this point. Therefore, the fee option provides increased flexibility for small businesses by placing an upper limit on the per-unit costs of complying with the regulation, without significantly jeopardizing VOC emissions reduction targets.

It is not possible to directly conduct a best-response (least-cost) analysis of the fee/reformulation decisions for the small business segment of the survey because of insufficiently detailed VOC data on small businesses. However, the results of the best-response analysis in Section 2 can be employed to indirectly measure the effect of alternative compliance strategies on the relative size of small business impacts.

Based on survey data for the small business segment, the average small firm has 27.5 products, 7.8 of which would be constrained by the regulation. Table 6-6 divides the average small company's number of constrained products into three compliance categories: reformulation, fee, and withdrawal. The average number of products selecting each strategy is based on the average percentage of all constrained products in the survey (small company and large) that select each option.

TABLE 6-6. AVERAGE REGULATORY IMPACT FOR SMALL COMPANIES—"BEST-RESPONSE" SCENARIO

Compliance Strategy	Percent of All Constrained Survey Products Selecting Option	"Expected" Number of Products Selecting Strategy[a]	Average Compliance Cost per Product (1991 $)	Compliance Cost (1991 $)
Reformulate	60.5%	4.7	14,573	68,767
Fee	35.5%	2.8	7,197[b]	19,936
Withdrawal	4.0%	0.3	12,705[c]	3,955
Total	100.0%	7.8	11,879	92,658
Average percent of sales				2.0%

[a] Equals average number of constrained products for small companies (7.8) multiplied by percentage of all constrained products in the survey selecting each strategy.
[b] Average fee cost computed by taking the average fee rate ($0.084/L), multiplying by the average size per small company product (65,914 L), and adding the recordkeeping cost per product of $590.
[c] Equals the average value of foregone profits for the 46 surveyed products that select the fee as the best-response strategy.

This is expected to be a conservative assumption because small volume products produced by small businesses are more likely to select the fee option to reduce regulation costs. Compliance costs were estimated by multiplying the number of products in each category by the per-product cost of that strategy. Summed across all products, the per-company compliance costs fall to about $88,000, which is about 23 percent less than the cost per company under the reformulation-only scenario. The average cost ratio under the best-response scenario is 2.0 percent. Considering that small companies may be even more likely to select the fee than the survey population at large, the cost reductions may be even greater than those estimated in Table 6-6.

The results presented in Tables 6-5 and 6-6 together indicate that, while the average impact on small companies is expected to be larger than the average impact on all producers, the alternative strategies to reformulation, particularly the fee option, can reduce the small company impacts substantially.

6.2.7.2 Tonnage Exemption. As an alternative to the fee options of reformulation, fee, or withdrawal, the EPA will allow a phased tonnage exemption for architectural producers. Affected firms will be allowed to exempt a total of 23 Mg of VOC emissions from control responsibilities through December 31, 2000, 18 Mg in 2001, and 9 Mg in 2002 and beyond. These tonnage exemption levels differ from the fee in two ways. First, the exempt emissions can be applied across all noncompliant products a firm produces, whereas the fee is assessed individually for each noncompliant product for which the fee is selected. Second, the exempt emissions that are granted are the total emissions of the product rather than just those in excess of the content limit. Thus, a firm must coordinate the VOC levels and requirements of all facilities and products to determine which ones will be produced under the tonnage exemption.

The tonnage exemption allows some low-volume products relief from reformulation costs that can be difficult to recover from the small amount of revenue generated by a low-volume product. Both the exceedance fee alternative and the tonnage exemption are compliance options aimed at addressing the potential issue of "niche markets" in which low-volume products exist for which it may not be cost-effective for either the manufacturer or resin supplier to develop a lower VOC formulation.

The EPA lacks data to directly evaluate the economic impact of the tonnage exemption. It is likely, however, that many of the products covered under the tonnage exemption might otherwise be subject to the exceedance fee because both provisions are most applicable to the smallest volume products[1]. Therefore, the tonnage exemption provision is not likely to further curtail emissions reductions much beyond what is curtailed by the fee option. However, to the extent that it supplants the fee as a firm's compliance option, it will reduce the financial impact of the regulation on that firm. For example, if 9 Mg of VOCs exempted from regulation represents 3.6 Mg of exceedance (assuming an exceedance rate on over-limit products of 40 percent), then the firm subject to the tonnage exemption can forego 3.6 Mg worth of fee payments which, at $2,200 per MG (in 1991 dollars), translates to an impact reduction of $7,920 per firm. If this is applied to the roughly 500 firms in the architectural coatings industry, the maximum potential reduction in aggregate producer impacts is estimated to be about $4 million. However, it cannot be directly determined whether each firm would be able to take advantage of the tonnage exemption and incur these savings. One should also note that, while these represent potential savings to producers, these are offset by reductions in fee receipts by the government sector. Thus, to the extent that the tonnage exemption merely substitutes for the fee, the substitution has not affected the net social cost of the regulation.

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[1] EPA recognizes that a few products on the margin that would be reformulated if the fee was the only alternative option, may now use a combination of the tonnage exemption and fee if it is determined to be the firm's least-cost compliance option. To the extent that this will occur, there will be a minimal effect on additional foregone emission reductions when the exemption is considered as a compliance strategy.

The tonnage exemption may also serve in lieu of small product withdrawals. In this case, the tonnage exemption would curtail some emission reductions. However, given the relatively few products projected for withdrawal and the small volumes involved, the effect on VOC emissions would likely be small.

While seeking ways to mitigate the impacts of the regulation for small manufacturers, the EPA recognizes that the two different approaches discussed here, the fee option and small product tonnage exemption, have different implications for the marginal incentives for VOC reductions. Although the fee option continues to provide incentive to reformulate the small niche products because marginal reductions in VOC content will reduce the per- unit fee paid, a tonnage exemption would provide no such incentive.

6.3 REGULATORY ALTERNATIVES TO REDUCE IMPACTS

The Agency has engaged in extensive dialogue with both large and small businesses over the 8-year period of development of the final rule. The Agency has sought input from small businesses through a regulatory negotiation, meetings between EPA and small businesses, and SBA review of the proposal. Based on this involvement, the EPA incorporated many of the suggested changes and designed the proposed rule to address concerns about potential impacts on small businesses. Specifically, coating categories and VOC content limits were selected to account for niche products in which smaller manufacturers have a disproportionate presence. In addition, to evaluate whether further steps were still needed to accommodate niche market coatings, the Agency requested that commenters identify any additional specialty coatings that could not comply with the proposed VOC content requirements. The Agency also requested comment on whether to include several other compliance options to provide flexibility and reduce the burden for small businesses. This section presents a summary of significant issues raised by public comment on those compliance options and the Agency's consideration of those compliance options as well as other provisions in the rule to mitigate rule impacts on small businesses and preservation of niche markets. The response to comments document entitled "National Volatile Organic Compound Emission Standards for Architectural Coatings—Background for Promulgated Standards," EPA-453/R-95-009b, contains more detailed summaries of the comments and the EPA's response.

The EPA considered the following compliance options and other measures to mitigate impacts of the rule on small businesses:

- selection of VOC content limits and coating categories;
- low-volume exemption option;
- exceedance fee compliance option;
- extended compliance time for small businesses;
- compliance variance for cases where compliance would result in economic hardship; and
- selection of recordkeeping and reporting requirements.

Based on review of comments and further analysis of the effects of the rule, the EPA has elected to incorporate a number of the above compliance options and other measures into the final rule to avoid unnecessary impacts on small businesses. This section presents the results of the EPA's final regulatory flexibility analysis, which evaluates the alternative measures considered to mitigate the impacts of the rule on small businesses. This discussion incorporates the results of the economic impact analysis presented earlier in this section as well as the Agency's policy considerations and other information used in selecting the compliance options and other measures to mitigate the impacts of the rule on small businesses.

6.3.1 Selection of VOC Content Limits and Coating Categories

In developing the proposed rule, the EPA recognized that it may not be economical for some manufacturers to reformulate certain lower-volume products. Rather than exempting these lower-volume products, the EPA proposed the VOC content limits in the upper range of VOC content limits in existing state rules for these categories. For categories for which no state standards exist, the EPA included the categories in the architectural coating rule based on discussions with industry representatives and end-user groups, petitions from stakeholders prior to proposal, and public comments from companies providing support for inclusion of the categories and a suggested VOC content limit. In discussion of the proposed low-volume exemption, the EPA also requested that commenters submit detailed information on any specialty coatings that would not comply with the proposed VOC content limits and that cannot be cost-effectively reformulated. The proposal indicated that the EPA would consider whether to develop additional categories for newly identified niche categories or to provide a categorical exemption for the specialty coating.[76,77]

As a result of information submitted by commenters, the Agency has added seven new categories to the final rule to address specific groups of specialty coatings that were identified through public comment. Also, based on new information the VOC content limits were increased in the final rule for four categories. Available information indicates that the final rule includes VOC content limits at levels that recognize the limited potential for reformulation of specialty niche products and sets VOC contents at the upper range for the particular type of product. The EPA established special categories and limits for niche products and established higher-than-proposed VOC content limits for niche product categories where commenters submitted sufficient supporting information. As a result, the final VOC limits for these categories are unlikely to require manufacturers to reformulate many products. The specific changes are identified in Section 7 of this document.

6.3.2 <u>Low-Volume Exemption Option</u>

The Agency requested comment on the concept of a low-volume compliance exemption option.[78] In the proposal preamble this exemption was described as a compliance option under which "any manufacturer or importer may request an exemption from the VOC levels in table 1 for specialized coating products that are manufactured or imported in quantities less than a specified number of gallons per year." The Agency specifically requested comment on exemptions ranging from 1,000 to 5,000 gallons of product per year. The exemption, as described in the proposal, could be used by a manufacturer for multiple products, provided that each product was manufactured in quantities less than the cutoff level. As described in the proposal preamble, the manufacturer would be required to submit a request for the exemption and document that the product(s) for which the exemption was requested "served a specialized use which cannot be cost-effectively replaced with another, lower VOC product." The EPA recognizes that small businesses who produce products with limited volume will benefit most from an exemption of this type.

Seventeen commenters supported some form of a low-volume exemption, and four commenters opposed such an exemption. Commenters supporting the low-volume exemption suggested cutoffs ranging from 100,000 gallons per product down to 1,000 gallons per product. Commenters opposed to the low-volume exemption argued that it was subject to abuse because of difficulty in defining what is a "product." These commenters believed that this compliance option would provide an incentive for companies to develop purportedly "new" specialty products to keep selling noncompliant coatings.

Based on the arguments presented by commenters about the need for some type of exemption for very low-volume specialty products for which it is not cost-effective for either the manufacturer or the resin supplier to devote time and resources to reformulation, an exemption is included in the final rule to accommodate these types of products. Although in the proposal preamble, the exemption was described in terms of a per-product exemption at a level between 1,000 and 5,000 gallons annually, commenters highlighted the potential problems with this type of provision. Therefore, the final rule contains a variation on the low-volume exemption approach described at proposal. Specifically, a VOC tonnage exemption is provided in the final rule. This approach continues to accommodate the needs of small businesses, niche markets, and specialty products, as did the proposed low-volume exemption; but it more effectively limits the VOC emissions resulting from the exemption. It is expected that this provision will provide more benefit to small businesses than large businesses.

Under the VOC tonnage exemption, each manufacturer can exempt a total of 23 megagrams (25 tons) of VOC in the period of time from the compliance date through December 31, 2000; 18 megagrams (20 tons) in the year 2001, and 9 megagrams (10 tons) for the year 2002 and for each year thereafter. Since some corporations have multiple companies and/or divisions, an architectural coatings manufacturer or importer is defined in the rule to mean the parent company and not each individual company, subsidiary, or division. Thus, if a corporation (parent company) has several subsidiaries or divisions that manufacture coatings, only one exemption per parent company will be allowed annually. This provision is structured in this manner to avoid sacrificing VOC emission reductions and to be equitable to manufacturers. For the purposes of the tonnage exemption, the manufacturer or importer calculates VOC tonnage by multiplying the total sales volume in liters by the "in the can" VOC content of the coating in grams per liter of coating *including* any water or exempt compounds. The "in the can" VOC content must include consideration of the maximum thinning recommended by the manufacturer. In the following examples, g/L (or lb/gal) is an abbreviation for grams (or pounds) of VOC per liter (or gallon) of coating, including water and exempt compounds at the manufacturer's maximum recommendation for thinning. For example, under this exemption in the second year a manufacturer could exempt 38,300 liters (8,000 gallons) of a 600 g/L (5 lb/gal) coating.

5lbs/gallon * 8,000 gallons = 40,000 lbs or 20 tons

Alternatively, a manufacturer could exempt 18,939 liters (4,000 gallons) of an 800 g/L (6.67 lb/gal) coating plus 13,731 liters (3,625 gallons) of a 550 g/L (4.58 lb/gal) coating.

[(6.67 lbs/gal * 4,000)+(4.58 lbs/gal * 2,900)] =
40,000 lbs or 20 tons

A manufacturer can exempt any combination of coatings and volumes as long as the total emissions from these products do not exceed 23 Mg (25 tons) from the compliance date through

December 31, 2000; 18 Mg (20 tons) in the year 2001; and 9 Mg (10 tons) in the year 2002 and each year thereafter.

The tonnage limits would exempt no more than 1.5 to 2 percent of the total expected emission reductions from architectural coatings in the first year the standard is in effect. The 9 Mg (10 ton) per-year exemption that goes into effect in the year 2002 will provide adequate flexibility for future needs, while effectively limiting emissions due to the exemption. For firms with VOC content around 600 g/l (5 lb/gal), the exemption could apply to 4,000 gallons total across all of the firm's products. As is demonstrated in the calculation of potential cost savings, the exemption can provide significant relief to small firms or niche market products by reducing prossible fee payments. However, since it applies to all products of a firms, it is substantially lower than the 1,000 to 5,000 gallon per product exemption considered at proposal.

This exemption differs from the low-volume exemption in the proposal preamble in the following ways:

(1) The EPA changed the exemption from a per-product basis to a per-manufacturer basis. This was done to avoid the difficulty of defining a "product" and to avoid the related potential for abuse by manufacturers in designating products for exemption.

(2) The EPA changed the exemption level from gallons of coating to tons of VOC. This change was made for two primary reasons. First, it provides an incentive for manufacturers to reduce the VOC content of the coatings for which they claim this exemption. For example, with a 5,000 *gallon* exemption, the manufacturer could exempt 5,000 gallons whether the product was 850 g/L or 200 g/L. With a *tonnage* exemption, however, the VOC content in each can of coating counts toward the allotted exemption. Therefore, if the manufacturer reduces the VOC content of the coating it wishes to exempt, more gallons of that coating could be sold under the exemption. Second, the choice of VOC tonnage instead of gallons of coating for the exemption

alters the exemption from an unknown loss of emission reductions to a cap on tons exempted per manufacturer. Therefore, this change serves to place an upper bound on the emission reductions that are lost through this exemption, which allows the Agency to better estimate its anticipated impact.

(3) The exemption is reduced over time. The ratcheting down of the tonnage exemption from 23 Mg (25 tons), to 18 Mg (20 tons), and then to 9 Mg (10 tons) provides a strong incentive to manufacturers using the exemption to continue to seek ways to reduce the VOC content of their coatings. This exemption is intended to provide additional time for manufacturers to reformulate coatings, and provide some relief in the long run for small volume producers.

6.3.3 Exceedance Fee Compliance Option

The EPA requested comment on whether to include an exceedance fee option for use as a compliance alternative to meeting the VOC content limits in the proposed rule.[79] This option was designed to provide compliance flexibility and set the fee rate high enough to provide an economic incentive for reformulation. The proposed fee rate was $0.0028 per gram ($2,500 per ton) of VOC in excess of the applicable VOC content limit multiplied by the amount of coating produced. The EPA also requested comment on the appropriateness of the proposed fee rate and the recordkeeping and reporting requirements associated with the exceedance fee compliance option.

Public comment on the concept of this option varied widely. Some commenters, including small businesses and national coating manufacturers trade associations, were supportive of the concept because it provided compliance flexibility. Some of these commenters supported the concept under the condition that the option would not be accompanied by burdensome recordkeeping requirements. Other groups of commenters opposed inclusion of this option because they thought that it could disrupt the market (increase prices), that it would be difficult to enforce, or that it was unnecessary because the proposed limits were not hard to achieve. For a more complete description of the comments on this option, see Section 2.4.1 of the Architectural Coating Regulation BID.

Careful evaluation of all of the comments and discussions with the SBA led the Agency to include the exceedance fee option in the final rule. Under this approach, manufacturers and importers have the option of paying a fee, based on the extent to which VOC content limits are exceeded, instead of achieving the VOC content limits in the rule. The fee is calculated at a rate of $0.0028 per gram ($2,500 per ton), in 1996 dollars, of VOC in excess of the applicable VOC content limit, multiplied by the volume of coating produced. This option is included in the rule for several reasons. The exceedance fee option will provide transition time for those manufacturers that need additional time to obtain lower-VOC technologies. The exceedance fee option provides long-term flexibility and a less costly compliance option than reformulation for both small and large manufacturers selling very low-volume specialty coatings where the cost of reformulation may be prohibitive compared to the potential profit, thus enabling manufacturers to continue to make these products available to consumers. The exceedance fee option is significantly less burdensome for manufacturers than the proposed compliance variance provision, which has not been retained in the final rule. However, contrary to some comments received, costs resulting from the exceedance fees will likely generally motivate manufacturers over time to develop high performance products with low-VOC content.

Some commenters believed that the exceedance fee will disrupt the marketplace, shifting business among companies.

However, since the fee will probably be used primarily for the manufacture of low-volume specialty coatings, which are driven by demand from consumers, it is not likely that the demand from these markets would be significant enough to provide any incentive for manufacturers to shift to these products. The impacts to the market are lower with the fee than they would be if reformulation was the only option available for producers, because the fee reduces the number of potential product withdrawals and reduces the net social cost. Raising the VOC content limits, as suggested by some of the commenters, in lieu of offering the fee could significantly undermine the emissions reduction objectives of the rule. The fee provides some flexibility to producers of low-volume products, or products that are only slightly above the VOC content limit of the standard, who may find it prohibitive to incur the largely fixed cost of reformulation. Because products for which manufacturers will choose to pay the fee would tend to represent a small portion of the national VOC emissions from architectural coatings, the fee option itself would not significantly undermine emission reduction objectives. However, raising the VOC content limits in the rule to accommodate all low-volume products would negate the VOC emission reductions from all these products. The fee also provides continued incentive for producers to reduce VOC content until they achieve the VOC content limits in the rule.

With regard to concerns about enforcement of the exceedance fee, the recordkeeping and reporting requirements are designed to ensure compliance with this option. Any violations of the recordkeeping and reporting or any other requirements could result in enforcement actions and the possibility of penalties.

The estimated cost for reporting and recordkeeping of the fee provision at a small company using the exceedance fee provisions for eight products is approximately $5,000 per year (see Table 6-5). This cost represents the cost to maintain the records of the VOC content and the total volume manufactured or imported for which the exceedance fee option is used as well as the preparation of the annual report for payment of the exceedance fee. Assuming $5 million of sales revenue as a midpoint estimate for small companies in the $0 to 10 million range, fee recordkeeping costs would be approximately 0.1 percent of sales revenue, which is not a significant burden.

Price increases on fee-paying products will cause some consumer substitution to nonfee-paying (lower-VOC) products. For some products, it may not be profitable to reformulate or pay the fee, so firms may consider withdrawing the product from the market. These phenomena are explicitly modeled elsewhere in this document. However, the premise of the fee is that it internalizes the (public) environmental cost of VOC emissions into the private cost of the good. Therefore, if some consumers substitute away from the now higher-priced fee-paying product, it reflects the fact that they are not willing to pay the "full" cost of consuming the higher—VOC products. This is the fundamental purpose of market-based incentives for environmental protection.

6.3.3.1 Exceedance Fee Rate. Several commenters also submitted comments on the proposed exceedance fee rate of $0.0028 per gram of VOC in excess of the applicable VOC content limit. Some of these commenters thought that the fee rate was too low to encourage development of compliant coatings. Other commenters thought that it was too high relative to the price of some products or in light of the additional costs associated with recordkeeping for this option. One commenter suggested a phase-in of the fee. For a more complete description of the comments on this option, see Section 2.4.2 of the Architectural Coatings Regulation BID.

Several factors affected the selection of fee level, including the benefit per ton of VOC reductions value historically used in analyses under the Clean Air Act, the historical range of acceptable cost-effectiveness values for VOC, the magnitude of the loss in emission reductions, and the effect on the market model (price and output adjustments, distribution of welfare impacts across consumers and producers, and changes in social cost) as well as the effect of different exceedance fee rates on the industry cost-to-revenues ratio.

More specifically, the value chosen for analysis at proposal is slightly higher than the benefit transfer value (i.e., the benefit value per ton of VOC reduced) historically used in EPA analyses and is also slightly higher than historical cost-effectiveness values for VOCs. This was intended to provide incentive for manufacturers to continue to strive to find low-cost methods of reducing the VOC content in their products. Therefore, manufacturers that find the fee to be the lowest-cost option of compliance with the regulation (in comparison to reformulation or losing profits from product withdrawal) would pay the fee, but be encouraged to find an even lower-cost solution to reduce total production costs in the long run.

Another consideration was the amount of emission reductions lost at the selected fee level. This level also proved to provide only minor adjustments in market price and quantity in comparison to reformulation by itself, while providing substantial flexibility to manufacturers of small-volume products or products that exceed the standards by a small amount. The Agency also evaluated a higher fee rate prior to proposal and found that social cost increased with a relatively small change in lost emission reductions (as compared to the lower fee rate). The selected fee rate was thus set high enough to make reformulation attractive for the majority of producers, but low enough to allow a small sector of products to remain on the market in lieu of withdrawal. Also, the lost emission reductions will be limited and the impact on the markets will be minor. The Agency also examined the effect of varying the fee rate on the fee adoption rates, social cost impacts, foregone emission reduction, and small business impacts. This analysis showed that at lower fee rates (e.g., $1,500/ton and $1,000/ton) there was a significant increase in the amount of foregone emission reductions and only a small decrease in the average cost-to-revenues ratio for small businesses.[80]

Based on the economic analysis, the EPA believes that the fee is set at an appropriate level. The economic model compares the cost of paying the fee to the cost of reformulation for surveyed products. While many products are projected to opt for the fee, these products are uniformly small in volume; thus, their contribution to total market output (and emission reduction) is relatively small. It generally would not be advantageous for producers of large-volume products, which generate a disproportionately large share of emissions, to opt for the fee over reformulation. Furthermore, the existence of the fee provides continued incentive for fee-paying firms to reduce VOC contents on the margin, because this will reduce the amount of fee they must pay.

Some commenters suggested that the EPA should base the fee on price, rather than the quantity of VOC emitted by the product. The premise is that only a large proportional price effect will induce large changes in behavior. The objective of a pollution fee, however, is to "charge" for the pollution generated. The only consistent way to accomplish this is to have the fee payment depend on the amount of pollution generated. It is not clear how a price-based fee would be tied to the amount of VOC emitted. For instance, a low-priced high-VOC product could have a fee per unit that is much lower than a high-priced lower-VOC product. In this case, the fee mechanism would not work to ensure enough incentive for the higher-VOC product to reduce VOC content. In other words, a ton of extra emissions from one product would incur less of a fee than a ton of extra emissions from the other. For example, such a mechanism would favor very high-VOC content products that are very inexpensive. Alternatively, having one ton of exceeded emissions face the same fee, regardless of source is more efficient, and seemingly more fair.

The combination of the compliance options in the final rule provides the phase-in of the fee suggested by some commenters. Specifically, the phasing of the tonnage exemption in combination with the exceedance fee provision will operate to increase the fee for products that exceed the VOC content limits in the rule. In the time period from the compliance deadline through the year 2000, manufacturers may exempt from regulation 25 tons (23 Mg) of VOC, so total fee payments would be lower than in the second year. The following year, 2001, has a lower exemption level of 12 tons (11 Mg) of VOC, so fee payments would be slightly greater for those manufacturers who choose not to reformulate or otherwise reduce the VOC content of their products. In the next year and any subsequent year of compliance, the fee rate would become level because the exemption level remains the same at 5 tons (4.5 Mg) per year. The fee payments would also provide incentive for manufacturers to find lower-cost VOC technology to meet the standard and eliminate or reduce their fee payments.

6.3.4 Extended Compliance Time for Small Businesses

At proposal the Agency requested comment on whether the final rule should include a compliance extension for small businesses.[81] In effect, this extension would have allowed small businesses 12 additional months to comply. Thirteen commenters commented on the small business compliance extension concept. Two-thirds of the commenters providing comments on this provision were against special treatment for small businesses. The primary concern was that this provision would provide small businesses an unfair advantage in the marketplace. Some of the commenters opposing the extension noted that an extension should not be necessary because of the specialized coating categories and the VOC content limits for these categories, small volume exemption, the potential exceedance fee compliance option, and the variance provision.

After careful evaluation of the comments, the Agency has decided not to include a compliance extension specific to small businesses but has instead lengthened the compliance period for all regulated entities to 12 months. This time period was selected to balance the needs of the regulated entities, both large and small businesses, against the need for rapid implementation of the rule to achieve the required reductions of VOC emissions.

6.3.5 Compliance Variances

In the proposal preamble the Agency requested comments from small businesses on their expected use of a compliance variance provision.[82] The proposed compliance variance provision would have allowed manufacturers and importers of architectural coatings to submit a written application to the Administrator requesting a variance if, for reasons beyond their reasonable control, they could not comply with the requirements of the proposed rule. In particular, the proposed variance provision allowed additional compliance time and was developed especially for small businesses, but would have been available to any size business.

Of the 22 commenters on this provision, only eight commenters supported the concept. The 14 commenters opposing the concept included some small businesses. Concerns expressed by those commenters included concerns that it would impose such a heavy burden that businesses would choose to shut down rather than use the variance and that the variance requirements as proposed are unduly difficult to achieve. For example, one commenter noted that the variance provision as proposed required significant expense with little or no guarantee of approval. The commenter recommended an extended compliance period as a more effective option to alleviate the heavy burden upon small businesses.

Based on the comments received, the Agency concluded that the variance provision may not provide the intended additional compliance flexibility, especially for small businesses. Therefore, the variance provision has not been included in the final rule. Even though the proposed variance requirements were intended to be the minimum necessary to approve a coating variance, the requirements may have been burdensome, particularly for small businesses with limited or no regulatory compliance staff. It is also possible that the variance provision could create an uneven playing field because small businesses would not have the resources needed to pursue this option, thereby putting small businesses at a disadvantage compared to large businesses. Also, as one commenter pointed out, even with the investment of time and money, the Agency cannot guarantee approval of the variance application. In addition, review and approval of numerous variance applications would place a heavy burden on EPA's staff, thereby delaying implementation of the intended flexibility to the disadvantage of regulated entities.

Nevertheless, there is still value in providing additional compliance flexibility; therefore, new provisions have been incorporated into the final rule (i.e., the tonnage exemption that phases down over time and the exceedance fee option). These provisions provide even greater flexibility than the variance provision and are less burdensome. Both of these compliance options are automatically available to all regulated entities and, thus, do not involve complex application and approval processes. However, these compliance options do require some minimal recordkeeping and reporting.

The tonnage exemption will allow each regulated entity to exempt from the VOC content limit anywhere from 7,000 to 30,000 gallons of coatings the first 15 months; 3,400 to 14,400 gallons the second year; and 1,400 to 6,000 gallons the third year and beyond (the actual amount exempted depends on the VOC content of the product(s)). Therefore, this exemption is ideal for low-volume products that cannot be reformulated in the foreseeable future.

The exceedance fee option is designed to give manufacturers additional time to develop lower-VOC technologies, if necessary. This option allows regulated entities to continue to sell coatings that exceed the VOC content limits in addition to the coatings for which they are claiming the low-volume exemption, provided they pay an exceedance fee. The amount of the fee is based on the volume of the product sold, the VOC content of the product, the VOC content applicable to the product, and the fee rate.

In addition to these provisions, the compliance time, which concerned some commenters, has been extended to 12 months, and the EPA added seven new specialty coatings categories (e.g., zone markings, concrete curing and sealing, conversion varnishes) to the final rule and increased the VOC content limits for four coating categories.

6.3.6 Selection of Recordkeeping and Reporting Requirements

The EPA also selected the recordkeeping and reporting requirements of the rule, taking into consideration the impacts of the rule on small businesses. The EPA designed the proposed rule to require only those recordkeeping and reporting requirements necessary to allow determination of compliance and enforcement, if necessary. The proposed rule required an initial report and labeling of containers for manufacturers who choose to demonstrate compliance by meeting the VOC content limits in the standard. There were no additional reports or records required from these manufacturers. Additional recordkeeping and reporting requirements were proposed for the recycled coatings option, the exceedance fee option, and the low-volume exemption option.

Two industry commenters requested even more limited recordkeeping and reporting requirements in the rule and several industry commenters noted the need to correct dates and clarify some of the labeling requirements in the proposed rule. In the final rule, the EPA has maintained the proposed recordkeeping and reporting requirements for manufacturers who choose to demonstrate compliance by meeting the VOC content limit in the standard. The EPA has also clarified the container labeling requirements and provided additional flexibility for labeling of VOC content of the coating as well as for placement of the date codes. In the final rule, the EPA required only those records and information necessary to determine compliance with the compliance alternatives of the exceedance fee, the tonnage exemption, and the credit for recycling of coatings. Specifically, the final rule only requires semiannual reporting from manufacturers who elect to use the exceedance fee compliance option and annual reporting from manufacturers who elect to use the tonnage exemption or the recycled coatings provision. These records and reports are essential for enforcing these provisions and the EPA believes that these records and reports do not represent an undue burden on manufacturers or importers who elect to use these optional compliance provisions. For example, as noted earlier, the estimated cost for reporting and recordkeeping of the exceedance fee provision at a company with an average of eight reformulations would be approximately 0.1 percent of sales revenue, which is not a significant burden.

6.4 SMALL BUSINESS IMPACT SUMMARY

The potential for significant impacts on small businesses of the regulation arise from two primary sources:

- Products made by small producers, on average, have a higher VOC content than the industry average.
- The costs of reformulating products to comply with the regulation are independent of product volume and thereby impose higher average costs per unit of product on small volume coatings.

The first problem is related to small producers' tendency to specialize in coatings categories that are naturally higher in VOC content and to their tendency to concentrate in the "high-VOC" end of the distribution of products within a given category. Thus the potential for disproportionate impacts of VOC reduction regulation on small businesses follows partly from the fact that small businesses contribute a disproportionate amount of the aggregate VOC emissions that are targeted for reduction.

The second problem follows from the nature of reformulation costs. A coating's formula is the product of an intellectual capital investment, much like the development of a drug or a computer software product. The cost of the investment follows directly from the level of effort necessary to revise the formula to meet both the VOC standards imposed by the regulation and performance standards imposed by the marketplace. This level of effort is essentially independent of the quantity of the product that is eventually sold. Therefore, the relative impacts on smaller volume products is, by definition, greater.

The data used in this analysis suggest that these two primary factors are relevant in the case of small architectural coatings producers. The average VOC content of the products made by the small business producers in the survey is 75 percent higher than the average VOC content of all products combined. A little over half of the difference in the averages is attributed to the specialization of small producers in high-VOC content product categories, with the remainder attributed to the tendency for small businesses to produce higher VOC products within each product group. Moreover, the average product volume of products made by small businesses is less than 20 percent of the average product volume for the entire survey population, implying much larger average reformulation costs. Thus, without mitigating factors, the impacts on small businesses are potentially significant.

The regulation has been designed to mitigate small business impacts. Despite their inherently higher VOC content, the proportion of small business products exceeding the regulatory standards is not much higher than the corresponding proportion for the survey population at large (42 percent vs. 36 percent). In addition, the availability of the exceedance fee option is beneficial to small business producers because it places an upper bound on the per-unit costs of compliance. Data analyzed in this study indicate that small business producer costs are reduced by nearly one-quarter when the exceedance fee is introduced and the possibility of product withdrawal is considered in lieu of reformulation. The cost/revenue ratio exemplifies the advantages of the lower-cost compliance options (the fee and withdrawal) in that the ratio for small businesses drops from 2.5 percent to 2.0 percent.

In addition to adding the exceedance fee and the tonnage exemption to the final rule, the EPA also increased the compliance time to 12 months and added seven new product categories and increased the VOC content limits for four categories. These changes were made in response to public comments to further mitigate the rule's small business impacts. The analysis of the impacts of the final rule shows that these provisions are likely to be used by small entities and the impact on a typical small firm is reduced without significant reduction in the emission reductions achieved by the rule. The EPA believes that these measures adopted in the final rule represent a significant mitigation of the economic impacts on small businesses compared to the impacts that might otherwise have occurred.

SECTION 7
EPILOGUE

Because regulatory development is an evolving process, the final Table of Standards for VOC content limits differs slightly from the interim Table of Standards used in the analysis reported here. The main difference between the two sets of standards (see Table 7-1) is the addition of new categories in the final standards and the revision of content limits for other categories. These two dimensions of change are evaluated in turn below.

7.1 NEW PRODUCT CATEGORIES

The final standards added seven product categories not included in the interim standards. These are:

- calcimine recoaters
- concrete curing and sealing compounds
- concrete surface retarders
- conversion varnish
- faux finish/glazing
- stain controllers
- zone marking coatings

TABLE 7-1. TABLE OF STANDARDS: INTERIM VS. FINAL

Architectural Coatings Category	VOC Content Limit (g/L) Interim (see Table 2-1)	VOC Content Limit (g/L) Final	Difference
Antenna coatings	500	530	Limit increased
Antifouling coatings	450	450	
Antigraffiti coatings	600	600	
Bituminous coatings and mastics	500	500	
Bond breakers	600	600	
Calcimine recoater	NA	475	New category
Chalkboard resurfacers	450	450	
Concrete curing compounds	350	350	
Concrete curing and sealing compounds	NA	700	New category
Concrete protective coatings	400	400	
Concrete surface retarders	NA	780	New category
Conversion varnish	NA	725	New category
Dry fog coatings	400	400	
Extreme high-durability coatings	800	800	
Faux finishing/glazing	NA	700	New category
Fire-retardant/resistive coatings			
Clear	850	850	
Opaque	450	450	
Flat coatings, N.O.S.			
Exterior	250	250	
Interior	250	250	
Floor coatings	400	400	
Flow coatings	650	650	
Form release compounds	450	450	
Graphic arts coatings (sign paints)	500	500	
Heat reactive coatings	420	420	
High-temperature coatings	650	650	
Impacted immersion coatings	780	780	
Industrial maintenance coatings	450	450	

(continued)

TABLE 7-1. TABLE OF STANDARDS: INTERIM VS. FINAL (CONTINUED)

Architectural Coatings Category	VOC Content Limit (g/L)		Difference
	Interim (see Table 2-1)	Final	
Lacquers (including lacquer sanding sealers)	680	680	
Magnesite cement coatings	600	600	
Mastic texture coatings	300	300	
Metallic pigmented coatings	500	500	
Multicolor coatings	580	580	
Nonferrous ornamental metal lacquers	870	870	
Nonflat coatings, N.O.S.			
Exterior	380	380	
Interior	380	380	
Nuclear coatings	450	450	
Pretreatment wash primers	780	780	
Primers and undercoaters, N.O.S.	350	350	
Quick dry coatings			
Enamels	450	450	
Primers, sealers, and undercoaters	450	450	
Repair and maintenance thermoplastic coatings	650	650	
Roof coatings	250	250	
Rust preventive coatings	400	400	
Sanding sealers	550	550	
Sealers	400	400	
Shellacs			
Clear	650	730	Limit increased
Opaque	550	550	
Stains			
Clear and semitransparent	550	550	
Opaque	350	350	
Waterborne low solids	120	120	
Stain controllers	NA	720	New category

(continued)

TABLE 7-1. TABLE OF STANDARDS: INTERIM VS. FINAL (CONTINUED)

Architectural Coatings Category	VOC Content Limit (g/L) Interim (see Table 2-1)	Final	Difference
Swimming pool coatings	600	600	
Thermoplastic rubber coatings and mastics	550	550	
Traffic marking paints	150	150	
Varnishes	450	450	
Waterproofing sealers and treatments			
Clear	600	600	
Opaque	400	600	Limit increased
Wood preservatives			
Below ground	550	550	
Clear and semitransparent	550	550	
Opaque	350	350	
Low solids	NA	120	
Zone marking coatings	NA	450	New category
Total New Categories	7		
Total Limit Changes	4		

By and large, new categories were added to accommodate specialty products that were previously included in other categories with lower (more stringent) VOC limits. As a result, some products that would be over the limit in the previous category, thereby necessitating a compliance action (reformulate, fee payment, withdrawal), are no longer constrained by the regulation. In these cases, the addition of the new categories reduces the number of required compliance actions, as a result, also cuts compliance costs and the quantity of emission reductions.

However, one of the new product categories, concrete curing and sealing (CCS) compounds, applies to products that were considered outside of the regulated universe in the economic analysis presented in this report. Therefore, the compliance actions required for those products are not estimated in this analysis. The potential cost implications of that omission are discussed below.

Supplemental data could be obtained for only two of the seven new product categories. These data were gathered after proposal and are used here to estimate the likely impact of these new categories on regulatory costs.

One of the categories for which supplemental data were obtained is the zone markings category. First, we note that 46 products from the original survey data in the traffic paints category have VOC contents that are greater than 150 g/L (the final traffic marking paints content limit) and 450 g/L (the zone markings limit). These 46 products constitute the entire list of surveyed products that could potentially be relieved from compliance by the addition of the higher zone markings limit. According to data from the state of Texas, zone markings constitute approximately 9 percent of all traffic coatings.[83] We use this percentage to estimate the number of those 46 products that are zone markings, yielding an estimate of 4.1 (decimals are used to reflect an averaging effect). Using an expansion factor of 3.0 to reflect the scale of the national estimate of traffic coatings to the survey estimate, we estimate that 12.3 products nationwide can avoid compliance action due to the addition of the new zone markings category.

Data were gathered for 77 CCS products with a total product volume of 11.2 million liters.[84] Of these 77 products, 38 were determined to exceed the content limit of 700 g/L. As described in Section 2 of this report, the number of noncompliant coatings is reduced by a factor of one-third to estimate the total number of noncompliant coatings needing a compliance action (reformulation, fee, or withdrawal). After this adjustment, 25 of the 77 CCS products surveyed are estimated to require compliance action. The CCS data also indicate an estimate of 37.8 million liters of CCS products nationwide. Taking the ratio of national CCS volume to the volume captured in the supplemental data collection (37.8/11.2) and multiplying by the 25 surveyed products needing compliance action yields a national estimate of CCS compliance actions of 85.6 products.

Taking the 85.6 additional compliance actions due to the new CCS category together with the 12.3 fewer compliance actions due to the zone markings category yields a net increase of 73.3 compliance actions. To approximate the social cost implications, we take the ratio of the total social costs from the architectural coatings market analysis ($20.2 million in Table 3-2) and divide by the total number of compliance actions in the analysis (2,345 products in Table 2-2) to get a social cost per compliance action of approximately $8,600. Multiplying this number by 74 compliance actions gives a social cost estimate of approximately $632,000 ($1991).

7.2 CATEGORIES WITH HIGHER VOC CONTENT LIMITS

Besides the additional categories, VOC content limits were higher (less stringent) in the final standards than in the interim standards for the following categories:

- antenna coatings
- shellacs, clear
- waterproofing sealers and treatments, opaque

The survey data indicate that nine products in these three product categories would have been noncompliant under the interim standards but are compliant under the final standards. Reducing the nine otherwise noncompliant products by one-third yields an estimate of six compliance actions within the survey population that are avoided by the higher content limit in the final standards. Because the volume of surveyed products in these categories roughly equals the national sales estimates, the estimated number of avoided compliance actions nationwide is also six. Multiplying this number by the social cost estimate of $8,600 yields an estimate for the reduction of social costs caused by the new content limits of approximately $52,000. Subtracting this from the net cost increase quantified for the new product categories reduces the cost estimate to about $580,000 ($1991).

7.3 SUMMARY

The VOC content standards included in the final rule differ from the limits analyzed in this report. The difference between the two sets of standards are the inclusion of seven new product categories and an increase in the content limits (reduction in stringency) for three product categories.

Because of data limitations, only a subset of these changes lend themselves to quantification of potential costs impacts. The net quantified effect is a $580,000 increase in the estimate of annual social costs. However, this increase in cost must be considered against the unquantified decrease in costs from the expected fall in compliance due to the five other new categories. Without additional data, it is difficult to conclude whether the cost reductions from those categories will together outweigh the net cost increases quantified. Given that the social cost effects quantified here are less than 3 percent of the total estimated social costs of the regulation, factors that reduce (or reverse the sign) of these costs lead to the conclusion that the total social cost estimate is not greatly affected by the differences between the interim standards used in the analysis and the final standards issued in the rule.

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APPENDIX A

MARKET DEFINITION, DEMAND ESTIMATION, AND DATA

A.1 PRODUCT/MARKET CROSS-REFERENCE METHOD

Data on coating prices, quantities, average VOC contents, and VOC content limits are necessary to estimate the effect of VOC content limits on architectural coatings products. Price and quantity data were taken from the 1991 Current Industrial Reports: Paint and Allied Products.[1] The Architectural and Industrial Maintenance Surface Coatings Survey (the survey)[2] provided the sales-weighted average VOC emissions, which represent VOC content. VOC content limits were from the TOS developed by EPA.

Census data are organized according to product codes, which define product categories; however, these Census product categories differ from the product categories in the survey. Furthermore, the TOS (see Table 2-1) gives VOC content limits for product categories that differ slightly from those categories for which data are provided in the survey. Data from all three sources are necessary to conduct the economic impact analysis. Therefore, a fourth product categorization was constructed, which is called market segments, that aggregates the categories so that data may be used from all three sources to provide the necessary level of resolution for market analysis. Table A-1 illustrates the individual product categories represented by each data source and how they map into the market segments used in the analysis.[3,4]

The mapping in Table A-1 proceeds from the most aggregated category to the least aggregated category. In some cases, however, the survey provides more detail than the TOS.

TABLE A-1. PRODUCT/MARKET CROSS-REFERENCE

Market Segment	Current Industrial Report Census Category	Census Product Code	VOC Emission Inventory Survey Category	Table of Standards Proposed Regulation Limits Category
Exterior solventborne	Exterior solvent paints and tinting bases, including barn and roof paints	2851112	Roof coatings--solventborne	Roof coatings[a]
	Exterior solvent enamels and tint, including ex.-in floor enamels	2851115	Flat, exterior, solventborne	Flat, exterior[a]
	Other exterior solvent coatings, including bituminous paints	2851139	High performance arch. coatings--solvent	High performance, floor coatings[a]
			Bituminous coatings--solvent	Bituminous coatings and mastics[a] High performance, rust preventive[a] High performance, concrete protective[a]
			Nonflat, exterior--solvent	Nonflat, exterior[a]
Exterior waterborne	Exterior water paints and tinting bases, including barn and roof paints	2851141	Flat, exterior, waterborne	Flat, exterior[a]
	Exterior water exterior--interior deck and floor enamels	2851142	Roof coatings--waterborne	Roof coatings[a]
			Nonflat, exterior--waterborne	Nonflat, exterior[a]
	Other exterior water coatings	2851155	High performance arch. coatings--water	High performance, floor coatings[a]
			Bituminous coatings--water	Bituminous coatings and mastics[a] High performance, rust preventive[a] High performance, concrete protective[a]
Interior solventborne	Interior flat solvent wall paints and tinting bases	2851163	Flat, interior--solventborne	Flat, interior[a]
	Interior solvent gloss and quick dry enamels and other solvent paints and tint	2851165	Nonflat, interior--solventborne	Nonflat, interior[a]
	Interior semigloss, eggshell, satin solvent paints and tinting bases	2851169	Quick dry enamels	Quick dry enamels
Interior waterborne	Interior flat water paints and tinting bases	2851181	Flat, interior--waterborne	Flat, interior[a]
	Interior semigloss, eggshell, satin and other water paints and tints	2851183	Nonflat, interior--waterborne	Nonflat, interior[a]
Solventborne primers and undercoaters group	Exterior solvent undercoaters and primers	2851125	Primers, solventborne	Primers and undercoaters[a]
	Interior solvent undercoaters and primers	2851171	Undercoaters, solventborne	
			Q.D. primers, sealers, undercoaters--solvent	Quick dry primers, sealers, undercoaters[a]

See notes at end of table. (continued)

TABLE A-1. PRODUCT/MARKET CROSS-REFERENCE (CONTINUED)

Market Segment	Current Industrial Report Census Category	Census Product Code	VOC Emission Inventory Survey Category	Table of Standards Proposed Regulation Limits Category
Waterborne primers and undercoaters group	Exterior water undercoaters and primers	2851144	Primers, waterborne	Primers and undercoaters*
	Interior water undercoaters and primers	2851186	Undercoaters, waterborne	
			Q.D. primers, sealers, undercoaters--water	Quick dry primers, sealers, undercoaters*
Solventborne clear coating, sealer, and stain	Exterior solvent clear finishes and sealers	2851135	Sealers, solventborne	Sealers*
	Interior solvent clear finishes and sealers	2851175	Shellacs	Sealers--shellacs, clear
	Exterior solvent stains	1851137		Sealers--shellacs, opaque
	Interior solvent stains	1851177		
			Waterproofing sealers w/pigment, solvent	Waterproofing sealers, opaque*
			Waterproofing sealers--clear, solvent	Waterproofing sealers, clear*
			Varnishes, solventborne	Varnishes*
			Stains, opaque, solventborne	Stains, opaque*
			Stains, semitransparent, solventborne	Stains, clear and semitransparent*
Waterborne clear coatings and stains group	Exterior water stains and sealers	2851149	Stains, opaque, waterborne	Stains, opaque*
			Sealers, waterborne	Sealers*
			Stains, semitransparent, waterborne	Stains, clear, and semitransparent*
	Other interior water coatings, stains, and sealers	2851188	Waterproofing sealers w/pigment, water	Waterproofing sealers, opaque*
			Waterproofing sealers--clear, water	Waterproofing sealers, clear*
			Varnishes, waterborne	Varnishes*
				Stains, low solids
Lacquers	Architectural lacquers	2851193	Lacquers	Lacquers
Wood preservatives group	Other miscellaneous allied paint products, including brush cleaners, nonpressure wood preservatives, putty, and glazing compounds, etc.	2851598	Wood preservatives, below-ground	Wood preservatives, below-ground
			Clear wood preservatives	Wood preservatives, clear, and semitransparent
			Semitransparent wood preservatives	
			Wood preservatives, opaque	Wood preservatives, opaque
Traffic marking paints	Traffic marking paints	2851311	Traffic paints	Traffic marking paints

See notes at end of table.

(continued)

TABLE A-1. PRODUCT/MARKET CROSS-REFERENCE (CONTINUED)

Market Segment	Current Industrial Report Census Category	Census Product Code	VOC Emission Inventory Survey Category	Table of Standards Proposed Regulation Limits Category
Special purpose group	Special purpose coatings, n.s.k.	2851300	Dry fog coatings	Dry fog coatings
			Metallic pigmented coatings	Metallic pigmented coatings
				Antifouling coatings
			Antigraffiti coatings	Antigraffiti coatings
				Bond breakers
				Chalkboard resurfacers
			Concrete curing compounds	Concrete curing compounds
			Form release compounds	Form release compounds
			Graphic arts coatings	Graphic arts coatings
				Impacted immersion coatings
			Multicolor coatings	Multicolor coatings
			Pretreatment wash primers	Pretreatment wash primers
			Swimming pool coatings	Swimming pool coatings
				Flow coatings
Industrial maintenance group	Interior industrial new construction and maintenance paints	2851301		Antenna coatings
	Exterior industrial new construction and maintenance paints	2851305		Extreme high durability coatings
			Fire-retardant/resistive coatings	Fire-retardant/resistive coatings
			High temperature coatings	High temperature coatings
			Magnesite cement coatings	Magnesite cement coatings
			Mastic texture coatings	Mastic texture coatings
				Nonferrous ornamental metal lacquer and surface protectants
				Nuclear power plant coatings
				Repair and maintenance thermoplastic
			Sanding sealers	Sanding sealers
				Thermoplastic rubber coatings and mastics
			Industrial maintenance coatings	Industrial maintenance coatings
			Appurtenances	Heat reactive coatings

* In the TOS, only one limit for both solvent and waterbornes is given; for presentation the product is listed under both.

Sources: U.S. Department of Commerce. Current Industrial Reports: Paint and Allied Products, 1991. Washington, D.C. Government Printing Office. 1992.
Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for the National Paint and Coatings Association in cooperation with the AIM Regulatory Negotiation Industry Caucus. Final draft report. 1993.

Where possible, the market segments were paired as solvent borne and waterborne coating categories. Separate market segments could not be created for flat and nonflat coatings in the interior and exterior segments because the Census data do not differentiate between exterior flats and nonflats.

The necessary data were developed for each of the 13 market segments using the mapping scheme presented in Table A-1. Data for individual Census product codes were summed where necessary to compute prices and quantities.

A.2 ESTIMATING DEMAND ELASTICITIES FOR COATINGS

To perform the market analysis, own- and cross-price elasticities of demand were estimated for four broad coating categories: exterior solventborne and interior solventborne and their two respective substitutes, exterior waterborne and interior waterborne. The variables used in estimation are domestic consumption quantity; real value of domestic consumption; real consumption price; national income; a housing variable; and the real price of alkyd resins, acrylic resins, and titanium dioxide. Complete data for these variables were collected for the years 1981 through 1991. Justification of these variables and their data sources is given below.

A.2.1 Estimation Procedure and Results

Econometric estimation of the interrelated demand system for interior solventborne, interior waterborne, exterior solventborne, and exterior waterborne architectural coatings generated estimates of own-price demand elasticities for each of the four groups and cross-price demand elasticities between the solventborne and waterborne segments of each interior (exterior) pair.

The quantity demanded of a commodity is a function of its price, the price of any substitutes and other factors, such as income, that affect aggregate demand. Estimating the demand function, however, is more complicated than just running regressions of observed market quantities on observed market prices and other demand variables. One must account for the fact that the observed prices and quantities are equilibrium values, which are simultaneously determined by both demand and supply factors.

Variables that are determined within a system (such as prices and quantities in a market equilibrium system) are endogenous to that system, whereas those variables determined outside of the particular system (e.g., income, housing activity) are termed exogenous. In simultaneous equations models, endogenous variables are correlated with the error terms through solution of the system. As a result of the interdependence of the endogenous variables and the error terms, the application of standard regression techniques is modified to estimate the effect of an endogenous right-hand side variable (i.e., equilibrium price) on the endogenous left-hand dependent variable (equilibrium quantity). In general, ordinary least squares estimation of the individual demand equations leads to biased and inconsistent parameter estimates when a regressor is endogenous.

Endogeneity bias is corrected by applying the two-stage least squares (2SLS) regression procedure for each estimated equation (see, for example, Pindyck and Rubinfield[5]). In the first stage of the 2SLS method, the price observations were regressed against all exogenous demand and supply variables in the system. This regression produced fitted (predicted) values for the price variables that are, by definition, highly correlated with the true endogenous variable (the observed equilibrium price) and uncorrelated with the error term. In the second stage, these fitted values were employed as observations of the right-hand side price variables in the demand equations. This procedure can also be used to estimate the underlying structural supply equations; however, because of the poor performance of various specifications in the supply estimations, only demand estimates are reported here.

The 2SLS procedure was used to estimate the four demand functions. Both linear and double-log regressions were estimated. The double-log specifications are presented here because of slightly better statistical fit and because the parameter estimates are directly interpretable as point elasticities.

For the two exterior categories, housing completions are included as an exogenous demand determinant. Exogenous supply factors incorporated into the first-stage regressions include the prices of various raw material inputs and a price index for substitute outputs, which captures the effect of non-exterior coatings prices on the supply of exterior coatings. For the two interior categories, U.S. domestic GNP is included as a proxy for the exogenous effect of aggregate income on the demand for interior coatings. Exogenous supply factors incorporated into the first-stage regressions also include the prices of various raw material inputs and a price index for substitute outputs, which in this case captures the effect of noninterior coatings prices on the supply of interior coatings. The results of the demand estimations are shown in Table A-2.

Unfortunately, sufficient data to estimate the demand parameters for the other market segments were unavailable. For the other two solvent/water-paired segments—clear coatings and primers/undercoaters—the mean of the respective own- and

TABLE A-2. DEMAND CURVE ESTIMATES

Variable	Adjustable R^2	F-Value	Elasticity Estimate	t-statistic
Exterior solventborne demand	0.94	50.52		
Log-housing completions			0.17	3.30
Log exterior solventborne price			-1.43	-1.89
Log exterior waterborne price			0.20	0.36
Exterior waterborne demand	0.92	39.36		
Log-housing completions			-0.05	-0.62
Log exterior solventborne price			0.51	0.42
Log exterior waterborne price			-1.89	-2.17
Interior solventborne demand	0.69	8.49		
Log GNP			1.01	1.67
Log interior solventborne price			-1.50	-1.74
Log interior waterborne price			1.43	1.28
Interior waterborne demand	0.99	588.90		
Log GNP			1.00	5.07
Log interior solventborne price			0.36	1.28
Log interior waterborne price			-1.39	-3.80

cross-price elasticities from the interior and exterior estimation process were used as proxies for the elasticities. The other five segments—special purpose, industrial maintenance group, traffic marking paints, lacquers, and wood preservatives—are specialty groups whose demand is assumed to be fairly inelastic and not dependent on prices in the other segments. Therefore, a value of -0.5 for the own-price demand elasticity and zero for all cross-price elasticities were assigned to each of these categories. Table A-3 provides the matrix of own- and cross-price elasticities for all 13 market segments.

A.2.2 <u>Data Used in Demand Estimation</u>

Domestic consumption quantities and values were calculated using data from U.S. Department of Commerce publications Current Industrial Reports: Paint and Allied Products[6,7,8,9,10,11,12,13,14] and U.S. Exports Schedule B Commodity by Country.[15,16,17,18,19,20,21,22] Domestic quantity and value of shipments figures were used, which include exports. Exports were then subtracted to estimate domestic consumption (architectural coatings imports are negligible and are not included in the consumption variable). Consumer price indexes from the U.S. Department of Labor's Handbook of Labor Statistics[23] and the U.S. Department of Commerce's Survey of Current Business[24,25,26] are used to adjust the current figures to real values. Real consumption price was imputed for each product by dividing real value of domestic consumption by the quantity of domestic consumption.

TABLE A-3. DEMAND ELASTICITY MATRIX FOR ARCHITECTURAL COATINGS MARKET SEGMENTS

Percentage Change in Quantity Demand of Product	With Respect to Percentage Change in Price of Product												
Market segment	1	2	3	4	5	6	7	8	9	10	11	12	13
1	-1.43	0.20	0	0	0	0	0	0	0	0	0	0	0
2	0.51	-1.89	0	0	0	0	0	0	0	0	0	0	0
3	0	0	-1.50	1.43	0	0	0	0	0	0	0	0	0
4	0	0	0.36	-1.39	0	0	0	0	0	0	0	0	0
5	0	0	0	0	-1.47	0.82	0	0	0	0	0	0	0
6	0	0	0	0	0.44	-1.64	0	0	0	0	0	0	0
7	0	0	0	0	0	0	-1.47	0.82	0	0	0	0	0
8	0	0	0	0	0	0	0.44	-1.64	0	0	0	0	0
9	0	0	0	0	0	0	0	0	-0.50	0	0	0	0
10	0	0	0	0	0	0	0	0	0	-0.50	0	0	0
11	0	0	0	0	0	0	0	0	0	0	-0.50	60	0
12	0	0	0	0	0	0	0	0	0	0	0	-0.50	0
13	0	0	0	0	0	0	0	0	0	0	0	0	-0.50

The GNP in constant 1987 dollars from 1981 through 1991 was used as an aggregate income measure.[a,27,28,29] Housing completions for 1981 through 1991 were obtained from the U.S. Department of Commerce's Current Construction Reports.[30] Prices for alkyd and acrylic resins are obtained from the U.S. International Trade Commission publication Synthetic Organic Chemicals, U.S. Production and Sales.[31,32,33,34,35,36,37,38,39,40] Prices for titanium dioxide were imputed using quantity and value of shipment data for U.S. production from the Current Industrial Reports, Inorganic Chemicals.[41] Real prices for these raw materials were calculated by deflating normal values using CPIs. Alkyd and acrylic resins were used to represent raw materials for the nonvolatile vehicle portion of the coatings, which are found mainly in solventborne and waterborne coatings, respectively. Titanium dioxide was used to represent a raw material in the pigment portion of the coating, which is found in both types of coatings. A Laspeyres price index was constructed to incorporate the price of substitute outputs as a supply-side effect in the first stage regressions of the 2SLS procedure. Let the price and quantity of commodity *n* in period *t* be p_n^t and q_n^t, respectively for $n = 1, \ldots, N$ and $t = 0, 1, \ldots, T$. Then the Laspeyres price index of the *N* commodities for period *t* (relative to the base period 0) is defined as

$$P_L \equiv \sum_{N=1}^{N} p_n^t q_n^0 \Big/ \sum_{N=1}^{N} p_n^0 q_n^0 . \qquad \text{(A-1)}$$

[a]All constant values were converted to 1982-1984 dollars for the analysis to be consistent with the consumer price index (CPI), which has 1982-1984 as a base.

Real domestic prices and quantities of nonexterior coatings were used to construct the price index for the exterior coatings equations and real domestic prices, and quantities of noninterior coatings were used to construct the index for the interior coatings equations. Each index is computed for the years 1981 through 1991, with 1981 serving as the base year.

A.3 EVALUATION OF DATA QUALITY

The Current Industrial Report series is generally considered a reliable source for quantities and values of products shipped. Monthly and annual data were estimated from a sample designed to measure activities of the entire paints and allied products industries. Each annual report provides data for 2 years, and figures from the 1991 report were used for the coatings analyses. In addition to the four representative coatings products, the architectural coatings Census category includes two other products: architectural lacquers and architectural coatings, not elsewhere classified. These categories were not included in the estimates because of insufficient data. However, in 1991, these two product categories combined represented only 1.3 percent of the total value of shipments for the architectural coatings market.[42] Statistics reported in the Current Industrial Reports at the seven-digit SIC product level are based on Annual Surveys of Manufactures and represent about 95 percent of total shipments in the paint industry (SIC 2851).[43] To produce estimates for the entire industry, the Census Bureau inflates the quantity and value figures reported in the annual survey by a factor based on data reported by all establishments in the 1987 Census of Manufactures.[b] The inflation factors for architectural coating product categories are as follows: 1987 through 1991, 1.00; 1982 through 1986, 1.004; and for 1981, 1.04.[c] Quantity and value figures for the four product categories used in the demand estimation are inflated using these factors. Prior to 1981, data were not collected at the more specific seven-digit SIC level. Using the longer time series would provide more data points but would also preclude analysis of the individual product categories, and representativeness would be lost.

The export data used are the best publicly available; however, combining export and domestic data to estimate domestic consumption poses some problems. The classification systems used to gather both types of data are different, and the corresponding product categories used cannot always be compared. For example, data from the U.S. Department of Commerce publication U.S. Imports for Consumption and General Imports, TSUSA Commodity by Country of Origin were not used because the imported commodity classifications had no comparable domestic output classification. Exclusion of imports from the estimate of domestic consumption does not pose a problem because in 1991 the value of imports for architectural, OEM, and special purpose coatings (SIC 28511, 28512, 28513) combined represented less than 0.9 percent of the total domestic value of shipments.[44] Data from U.S. Exports Schedule B Commodity by Country were available for 1981 through 1991, and the export categories correspond well

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[b]The inflation factor for 1981 is based on 1977 Census relationships and for 1982 through 1986 on 1982 Census relationships.

[c]The 1991 quantities and values used in the model (values to impute price) also include products in the special purpose and miscellaneous allied paint products categories. The special purpose inflator for 1991 is 1.06, and the miscellaneous inflator in 1991 is 1.18.

with the four domestic product categories except for 1989 through 1991.[45,46,47,48,49,50,51,52] In 1989, the export codes and categories changed and are no longer compatible with the domestic categories. In addition, quantities are reported in kilograms rather than gallons, as they were in previous years. For these reasons, export data were not used to adjust domestic consumption after 1988. The GNP data typically represent income for the entire nation including income generated from American businesses located overseas. The current price data for the paint products and raw materials should be considered reliable, though their accuracy may be affected by the exclusion of imports for the coatings products and of exports and imports for the raw materials prices. CPIs for all urban consumers with a base of 1982 through 1984 were used in calculating real prices.

The raw material prices used are representative of the entire U.S. and export market for these products, rather than just the U.S. supply to the paints and coatings industry. The alkyd resins were used in this estimation to represent an input found only in solventborne coatings and acrylic resins to represent an input found only in waterborne coatings. However, some acrylic resin materials are used in some solventborne coatings and alkyd resins are used as modifiers in waterbornes. Exports and imports were not considered when computing raw material supply prices because foreign trade data were not available for alkyd and acrylic resins. In 1991, exports of titanium dioxide represented 17.9 percent of the total domestic value shipped and imports were 10.9 percent.[53]

A.4 REFERENCES

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APPENDIX B

SUMMARY OF REFORMULATION COST ESTIMATES FROM PUBLIC COMMENTS

At proposal, EPA's estimate for per product reformulation cost was based on an estimate for a hypothetical new coating included in a presentation to the Regulatory Negotiation committee (July 28, 1993). This lump-sum cost estimate was $250,000, implemented over three years at $83,333 per year.

During the public comment period, EPA solicited public input regarding the size and nature of reformulation costs to gauge the reasonableness of (and potentially modify) the estimate used in the EIA. The public comments on costs were reviewed for this purpose. Costs were organized along the following dimensions:

- technical staff training
- prioritization of products needing reformulation
- survey available materials
- reformulate to desired properties
- performance tests
- field tests
- marketing costs
- production costs (labels)
- sales training
- executive expenses

Upon review of the public comments on costs, eleven of the responses appeared to provide comparable information for estimating lump-sum reformulation costs per product. Other responses presented costs for all of the company's products, but did not provide information on the number of products to enable computation of cost per product. Other responses could not be used either because of incompleteness or lack of clarity about the information provided. A list of and summary statistics for the eleven potentially comparable responses plus the original Regulatory Negotiation committee estimate are presented in Table B-1. Note that two of the estimates are alternative interpretations of the same estimate. One interpretation estimates per-product cost by dividing the company's total cost estimate by all noncompliant formulas. The other interpretation is that the total cost number is divided by the subset of formulas that are most feasible to reformulate. It was unclear from the comment, which number the company used to estimate its total compliance costs, so both interpretations were used to provide a range.

Cost per product estimates (in 1991 dollars) range from $576 to $272,000, with a mean value of $86,326. The mean value was rounded up to $87,000 to provide the model product cost estimate used throughout the analysis. As the summary statistics in Table 2-1 indicate, the central tendency cost estimates (mean and median) are well-below the $250,000 lump-sum cost per product estimate used in the EIA at proposal, ranging anywhere from 20 to 35 percent of that estimate.

In summary, a review of the public comments related to reformulation costs suggests that EPA may have significantly overestimated the per-product costs by a factor of three to five times at proposal. Because it is based on information

TABLE B-1. REFORMULATION-RELATED COST ESTIMATES

Public Comment Docket Number	Estimated Cost per Product (current $)	Estimated Cost per Product ($ 1991)[a]
IV-D-217 (Interpretation 1, Total cost divided by all noncompliant products)	15,764	13,832
IV-D-217 (Interpretation 2, Total cost divided by most feasible reformulations)	48,220	42,311
IV-D-108	63,500	55,719
IV-D-110	13,000	11,407
IV-D-130	20,300	17,812
IV-D-93	656	576
IV-D-152	122,417	107,416
IV-D-36	51,210	44,935
IV-D-38	310,000	272,013
IV-F-1e	150,000	131,619
IV-D-182	96,000	84,236
II-E-52	267,000	254,038
Summary statistics		
N =		12
Min		576
Max		272,013
Mean		86,326
Median		50,327

[a] Converted from year in which estimate is given (usually 1996) to 1991 using the Gross Domestic Product Price Deflator.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, August 1997.

provided in the public comment period, the revised estimate used in this analysis should provide a more valid estimate of reformulation-related costs than the estimate used at proposal. Alternative methods for annualizing the lump-sum cost estimate of $87,000 are presented in the main text.

APPENDIX C

CALCULATION OF REGULATION-INDUCED COSTS WHEN REFORMULATION NORMALLY OCCURS AT FIXED TIME INTERVALS

One complicating factor in estimating the cost of the regulation is the fact that product reformulation is a normal business activity in the architectural coatings industry. Therefore, rather than viewing the regulation as creating reformulation responsibilities (the maintained assumption throughout the analysis), one might take the alternative view that a different time pattern of reformulation is created, thereby leading to a lower estimate of regulatory costs. This appendix presents the issue analytically and develops a numerical example to quantify the difference in costs under the alternative assumptions.

Suppose a company routinely reformulates products every eight years. If the average product is product midway through its reformulation cycle, it will be reformulated four years in the future in the absence of the regulation. However, the regulation requires them to do the reformulation now rather than four years in the future and this acceleration imposes costs on the firm. To estimate the costs of this acceleration, assume the initial reformulation cost of \$87,000 occurs in the first year. Then the net present value, today, of a cost otherwise deferred four years into the future is

$$NPV(-4) = \$87,000/1.07^4 = \$66,372$$

Instead, the company is required to reformulate today at a cost of

$$NPV(0) = \$87,000$$

The net effect on the company of accelerating the next formulation is then

$$\text{Initial Net effect} = NPV(-4) - NPV(0) = -\$20,628$$

Thus, if the regulation just accelerates the next reformulation, the one-time cost of that acceleration is approximately $20,000. This is substantially below the one-time cost of $87,000 currently assumed in the EIA. However, if it is assumed that this requirement also forces *all future reformulations to be moved up four years,* then the computation must be expanded to measure the present value of the current and all future adjustments. To start, the present value of an initial $87,000 cash expenditure repeated every eight years thereafter can be written

$$\begin{aligned} V(0) &= \$87,000 + \$87,000*(1/((1.07)^8 - 1)) \\ &= \$208,\ 139 \end{aligned}$$

Without the regulation, this stream of costs would be deferred four years into the future. Evaluating this in present value terms gives

$$V(-4) = V(0)/1.07^4 = \$158,788$$

Thus, the difference in present value between the two reformulation cost streams is the total net effect of accelerating this and all future reformulations.

$$\text{Total net effect} = V(-4) - V(0) = \$49,351$$

This can be viewed as conceptually equivalent to a *one-time cost* of the regulation for an average product that is over-the-limit. This explicitly accounts for the net present value of the regulation's affect on all future formulations. This one-time cost is substantially below the $87,000 one-time cost assumed in the analysis.

By comparison, if the product were otherwise to be reformulated one year in the future without the regulation, the present value of this cost acceleration can be computed is a similar fashion as $13,617 (16 percent of $87,000). If the previous reformulation had been implemented just one year before the regulation, then the present value of accelerating the future reformulation cycle by seven years would be $78,520 (90 percent of $87,000).

In summary, the one-time cost estimate of an accelerated reformulation schedule ranges from a small fraction to a large fraction of the reformulation cost estimate used in the EIA. In this example, the average product's one-time cost equivalent is less than 60 percent of the estimate used in the EIA. Thus, EPA contends that it has provided a conservatively high estimate of the true incremental cost of reformulating a product subject to the regulation.

APPENDIX D

METHODOLOGY FOR COMPUTING MARKET AND WELFARE ADJUSTMENTS

D.1 METHODOLOGY FOR COMPUTING SUPPLY EFFECTS

For the purposes of modeling the regulatory effects in each market, products are separated into four categories, based on their producers' response to the regulation:

- products slated for withdrawal,
- products on which exceedance fees are paid,
- products slated for reformulation, and
- products unconstrained by the regulation.

The baseline (preregulatory) quantities from these groups are denoted as follows: Q^X, Q^F, Q^R, and Q^U for groups 1, 2, 3, and 4, respectively. Total baseline market output equals the sum of the four components:

$$Q = Q^X + Q^F + Q^R + Q^U. \tag{D.1}$$

Figure D-1 depicts the aggregation of these subgroups into a market supply function. The regulation causes a shift in the aggregate supply function depicted in Figure D-1 as a result of two phenomena: an inward supply shift due to eliminating Group 1 through product withdrawals (e.g., the shift from S^0 to S^1), and an upward supply shift due to imposing per-unit fees on the products from Group 2 (the shift from S^1 to $S^{1'}$). There is no supply shift emanating from

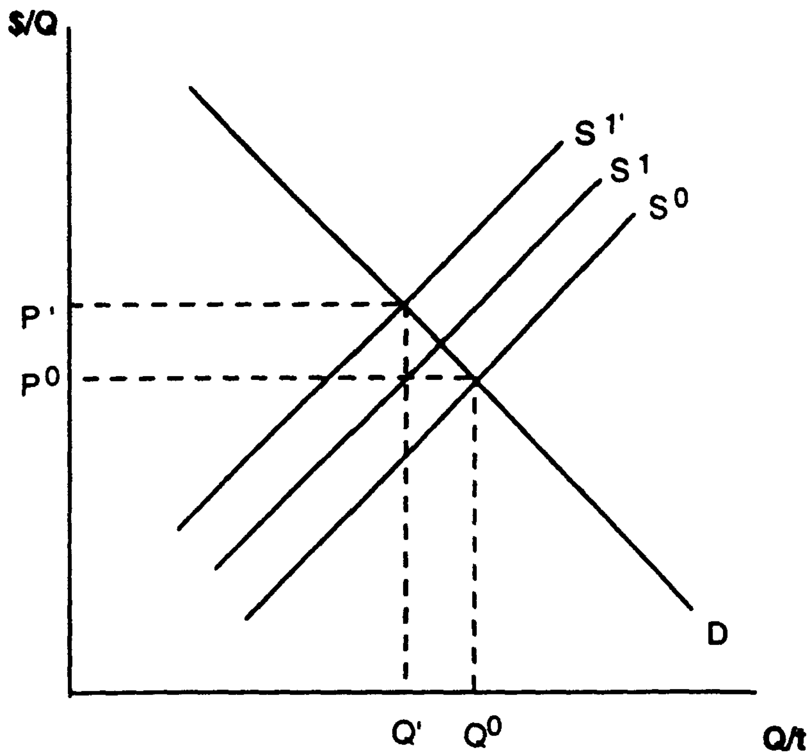

Figure D-1. Single market effects of VOC content regulation.

Group 3 because the reformulation is assumed not to affect marginal production costs, and there is no shift from Group 4 because the unconstrained products experience no regulation-induced change in their cost structure. So the full regulation-related shift is from S^0 to $S^{1'}$, which leads to a new market equilibrium. At the new equilibrium, price rises to P' and quantity falls to Q'.[a]

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[a]This graphical analysis demonstrates that the post-regulatory market effects are uncertain if the analysis were to consider the possibility that the reformulation process changes the marginal cost of producing the coating as a result of changes in material or labor costs, for example. This empirical issue can be resolved given sufficient data on the effect of VOC content on production costs for all affected products. Unfortunately, these data were not available for this study, so the appropriate empirical analysis could not be conducted to draw such conclusions.

D.2 DEMAND EFFECTS

Figure D-1 depicts a partial equilibrium view of the short-run effect of imposing content limits in one market. One must also consider the role of substitute products in determining the equilibrium adjustments, which suggests a multimarket perspective. Figure D-2 depicts the markets for two products (A and B) that are demand substitutes. The price of product B factors into product A's demand function and vice versa:

$$D_A = D_A(P_A, P_B) \quad (D.2)$$

$$D_B = D_B(P_B, P_A). \quad (D.3)$$

Given that A and B are substitutes implies

$$\delta D_A / \delta P_B > 0 \quad (D.4)$$

$$\delta D_B / \delta P_A > 0 . \quad (D.5)$$

Suppose the supply of A is affected by the content limits in the manner described above, but that the supply of B is unaffected. This initiates a supply shift in market A from S_A^0 to S_A^R. Holding the initial demand function constant, this shift would generate an equilibrium quantity of Q_A'' and price of PA". However, the associated price increase in market A induces an outward shift in the demand for product B, which raises the price of product B. Likewise, the increase in B's price leads to an outward shift in the demand for product A, which raises its price and so on. This interaction continues until post-regulatory equilibrium is established at (P_A^R, Q_A^R), (P_B^R, Q_B^R).

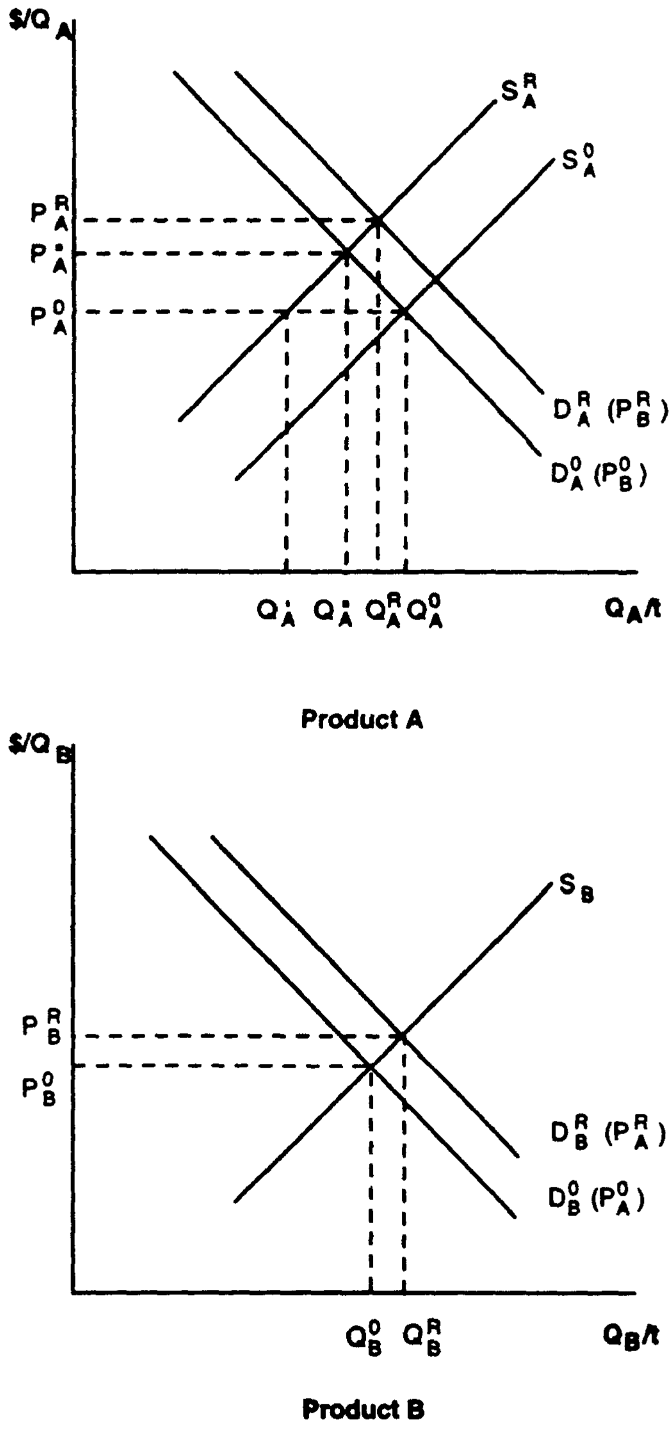

Figure D-2. Multiple market effects of VOC regulations.

D.3 COMPUTING CHANGES IN EQUILIBRIUM PRICES AND QUANTITIES

The change in equilibrium prices and quantities for the products affected by the content limits and their substitutes can be numerically computed by adjusting the equations in the multimarket supply and demand system to reflect the imposition of these limits. For each market, i, the equilibrium change in quantity supplied of each product affected by the regulations equals the sum of the supply changes from each of the producer subgroups:

$$\Delta Q_i^S = \Delta Q_i^X + \Delta Q_i^F + \Delta Q_i^R + \Delta Q_i^U. \quad (D.6)$$

The change (from baseline) in quantity supplied by the withdrawal sector is simply the negative of the quantity originally supplied by that group:

$$\Delta Q_i^X = - Q_i^X. \quad (D.7)$$

The change in quantity supplied from the fee-paying sector is specified as follows:

$$\Delta Q_i^F = e_i^F (Q_i^F / P_i)(\Delta P_i - F_i) \quad (D.8)$$

where e_i^F is the supply elasticity of the fee producers in market i, ΔP_i is the change in equilibrium market price, and other terms are as previously defined (without the subscripts). $\Delta P_i - F_i$ is the change in "net price" for the fee-paying producers (i.e., the change in unit process less the unit fee).

The changes in quantity supplied from the reformulating group and unconstrained groups, respectively, are

$$\Delta Q_i^R = e_i^R (Q_i^R / P_i) \Delta P_i \qquad (D.9)$$

$$\Delta Q_i^U = e_i^U (Q_i^U / P) \Delta P_i . \qquad (D.10)$$

These producers respond to the increase in price with no counteracting effect on costs. Given the higher price in the post-regulatory equilibrium, output will increase from these two groups of producers.

The aggregate change in equilibrium supply quantity can now be restated by combining the preceding five equations:

$$\Delta Q_i^S = - Q_i^X + e_i^F (Q_i^F / P_i)(\Delta P_i - F_i) + e_i^R (Q_i^R / P_i) \Delta P_i$$
$$+ e^U_i (Q^U_i / P)_i \Delta P_i \ . \qquad (D.11)$$

The change in market demand for each product is given by

$$\Delta Q_i^D = E_{ii} (Q_i / P_i) \Delta P_i + E_{ij} (Q_i / P_j) \Delta P_j \qquad (D.12)$$

where E_{ii} is the own-price demand elasticity for product, i and E_{ij} is the associated cross-price demand elasticity between products i and j. Consumer demand theory supports the assertion that own-price elasticities are negative and that cross-price elasticities of substitutes are positive. To attain equilibrium, the change in quantity demanded must equal the change in quantity supplied in both markets:

$$\Delta Q_i^D = \Delta Q_i^S . \qquad (D.13)$$

This provides a system of M*3 equations in M*3 unknowns, where M equals the number of markets affected by the regulation. This can be reduced to an M*2 equation system, simply by substituting $\Delta Q_i^D = \Delta Q_i^S = \Delta Q_i$. This system can be solved simultaneously to compute the change in equilibrium price and change in equilibrium quantity for each market. To do this, baseline market data, model parameters (supply and demand elasticities), and an empirical characterization of the various supply shocks alluded to above are needed.

D.4 COMPUTING WELFARE EFFECTS

Changes in the market equilibrium cause changes in resource allocation, which, when quantified, provide measures of how the welfare costs of the regulation are distributed across groups affected by the regulation. The groups focused upon here are architectural coatings producers and consumers, because the changes in prices and quantities directly affect their welfare. Since fee payments are considered, the government sector is also included in the welfare analysis because they collect the fee revenues. This study does not measure the welfare benefits of reductions in VOC emissions, a value against which these costs may be measured to determine the net value to society of the proposed regulatory structure.

D.4.1 Effects on Architectural Coatings Producers

The profits earned at the new equilibrium to the profits earned at the old equilibrium can be compared as a measure of effects of the regulation on the individual producer. Foregone baseline profits (π^0) provide a measure of the loss to producers that choose to exit rather than reformulate:

$$\Delta\pi = \pi^{R*} - \pi^0 = -\pi^0. \qquad \text{(D.14)}$$

For the remaining producers, the change in profits is affected by several factors, including the incurrence of the fixed reformulation cost and any associated changes in price, quantity, and marginal cost.

The remaining firms' costs may be affected through either the reformulation cost or the fee payment. The effect of the content limit on producers is generally not uniform and thus raises some distributional considerations. As indicated above, shifts in the aggregate supply function will cause the market price to rise. For some producers, the benefits of the price increase may outweigh the net costs of compliance. This is certainly the case for producers of coatings with VOC content below the regulatory standards, because they incur no reformulation costs but would gain from the rise in market price sparked by the compliance costs and/or product withdrawals incurred by their competitors. Alternatively, fixed reformulation costs may be substantial for some producers, outweighing the positive price effect. The profit effect will be negative for those producers. Other producers may fall in the midrange, where the price benefits and cost effects essentially offset each other.

Changes in producer welfare are generally reported as changes in producer surplus. The aggregate change in producer surplus for the withdrawn-product producers equals the sum of forgone profits from all withdrawn products in market i:

$$\Delta PS_i^X = -\sum_{j=1}^{N_i^X} \pi_{ij} \ . \tag{D.15}$$

The j subscript indicates forgone profits from the j'th product in market i. N_i^A is the number of withdrawn products in market i. The change in producer surplus from the reformulating sector can be approximated as follows:

$$\Delta PS_i^R = \Delta P_i \bullet Q_i^R + 0.5 \bullet \Delta Q_i^R \bullet \Delta P_i - (R_{ac} \bullet N_i^R) . \tag{D.16}$$

ΔP_i is the change in equilibrium price, ΔQ_i^R is the change in equilibrium quantity from the reformulating producers, Q_i^R is the initial quantity of the reformulating producers, R_{ac} is the annualized reformulation costs, and N_i^R is the number of products needing reformulation.

The change in producer surplus for the fee-paying producers is initially computed as follows:

$$\Delta PS_i^{F1} = (\Delta P_i - F_i) \bullet (Q_i^F + \Delta Q_i^F) - 0.5 \bullet \Delta Q_i^F \bullet (\Delta P_i - F_i). \qquad (D.17)$$

The first term reflects the net revenue effects of the price rise less the fee payment and the second term reflects changes in deadweight loss. To this term we must add the fixed cost (per product) associated with fee recordkeeping requirements so that the full welfare effect is

$$\Delta PS_i^F = \Delta PS_i^{F1} - FF \bullet N_i \qquad (D.18)$$

where FF is the fixed cost per product of fee recordkeeping and N_i equals the number of products subject to the fee in market i.

Finally, the change in producer surplus for unconstrained producers is

$$\Delta PS_i^U = \Delta P_i \bullet Q_i^U + 0.5 \bullet \Delta Q_i^U \bullet \Delta P_i \qquad (D.19)$$

with the Q_i^U reflecting the quantity supplied by these producers. Total (net) producer surplus effects is simply the sum of the terms above:

$$\Delta PS_i = \Delta PS_i^X + \Delta PS_i^R + PS_i^F + \Delta PS_i^U. \qquad (D.20)$$

D.4.2 Effects on Architectural Coatings Consumers

Changes in consumer welfare are measured by the change in consumer surplus, which quantifies losses due to a combination of the higher price and reduced consumption quantity. This change can be approximated as follows:

$$\Delta CS_i = -\Delta P_i \bullet (Q_i + \Delta Q_i) + 0.5 \bullet \Delta P_i \bullet \Delta Q_i. \qquad (D.21)$$

D.4.3 Effects on the Government Sector

The transfer of fees from the fee-paying producers to the recipient of those fees must be considered. For the purposes of the welfare analysis, the government is identified as the "recipient" of the fees.

$$\Delta GS_i = F_i \bullet (Q_i^F + \Delta Q_i^F). \qquad (D.22)$$

Ultimately, the government may choose to redistribute those fees back to affected producers or consumers or back to other members of society via the Treasury; however, for purposes of quantifying these distributional flows, they are assigned as gains to the government sector.

D.4.4 Net Welfare Effects

The net welfare effects are computed by taking the sum of producer, consumer, and government surplus:

$$\Delta WF_i = \Delta PS_i + \Delta CS_i + \Delta GS_i. \qquad (D.23)$$

This calculation nets out any transfers from one group to another within society (e.g., transfers from consumers to producers through higher prices and transfers of fee revenues from producers to the government) because these transfers do not affect the total sum of resource costs, just how they are distributed within society. ΔWF_i provides an estimate of the net social costs of the regulation.