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Study of Economic Incentives to Control Photochemically Reactive Organic Compound Emissions from Consumer Products

State of California
AIR RESOURCES BOARD
Research Division

STUDY OF ECONOMIC INCENTIVES TO CONTROL PHOTOCHEMICALLY REACTIVE ORGANIC COMPOUND EMISSIONS FROM CONSUMER PRODUCTS

Prepared for the

California Air Resources Board

Contract A732-150

by

ICF Consulting Associates, Incorporated
10 Universal City Plaza
Suite 2400
Universal City, California 91608

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ABSTRACT

Consumer products are an important and largely uncontrolled source of photochemically reactive organic comound (PROC) emissions in California. These emissions, also referred to as volatile organic compounds (VOCs), are precursors to tropospheric ozone formation commonly known as smog.

There are hundreds of consumer products that emit PROCs. Consumer products packaged in aerosol containers emit the largest volume of PROCs among all consumer products. Aerosol products are used for a variety of purposes, including: insecticides; household cleaning and laundry; shaving cream; underarm deodorants and antiperspirants; hair care and styling; automotive care; and paints.

Because there are numerous consumer products, it may not be practical to use conventional methods for emissions control. Economic incentives can control emissions from consumer products in a more timely and cost effective manner. This study investigates and evaluates two economic incentive systems as potential control strategies for reducing PROC emissions from consumer products.

Based on a review of existing incentive systems, a range of economic incentive systems is described. Two systems, fees and quotas, are evaluated for two consumer products, hair sprays and spray paints. A fee system imposes a fee per pound of PROC that is used in a consumer product. A quota system imposes a total limit on the amount of PROCs that can be used in consumer products in the State of California.

To evaluate the implementation of economic incentives for these two products we defined how the fees and quotas would be implemented. Examples of existing fee and quota systems were examined and the hair spray and spray paint markets were described in order to define fee and quota systems that would be appropriate for these two products. The fee and quota systems were then evaluated in terms of their costs and the likely emissions reduction that could be achieved. To perform this evaluation, the following information was developed:

- based on estimates of product formulations, total sales, and product sizes, we estimated PROC emissions in California in 1987 at 14,000 tons for hair sprays and 6,000 tons for spray paints;

- based on reviews of the trade literature and discussions with industry experts, we identified the currently available and potential future technologies for reducing PROC emissions from the two products, including product reformulation and alternative packaging; and

- using estimates of ingredient and packaging costs and capital costs of upgrading existing product filling equipment, we estimated the costs of implementing the technologies for reducing PROC emissions.

Using the above information and estimates of consumer demand, we estimated the likely reduction in PROC emissions and the costs of achieving those reductions for a range of fee levels. For a range of quota levels we estimated the likely costs of achieving the quota reductions.

The results of the analysis indicate that the ability to reduce PROC emissions from hair sprays is sensitive to assumptions regarding the availability and suitability of various product reformulations, including reformulations that include partially-halogenated chlorofluorocarbon compounds (HCFCs) and mixtures of dimethyl ether (DME) and water. The ability to reduce PROC emissions from spray paints is sensitive to assumptions about the ability to improve consumer awareness about high-solids paint formulations. The marketability of such paints to "average" consumers will be improved by educating consumers on paint performance.

Based on this study, we believe that economic incentives can be used to reduce PROC emissions from hair spray and spray paint products. Because cost is the principal barrier preventing the wide-spread use of most of the PROC-reducing formulations and packaging systems, an incentive fee or quota is appropriate for promoting the use of the desired formulations and packaging systems.

We believe that it will be best to direct the economic incentives to product marketers and to track the performance of the program at this level. Because the expected performance of incentive fees and quotas will always be uncertain, it is preferred to implement economic incentives for a group of products, as opposed to for a single product. This approach reduces the program's reliance on the expected performance of any single emissions-reducing technique and thereby limits the likelihood of inadvertently imposing large costs.

The analysis of the fee and quota systems in this study indicates that fee systems can produce very large government revenues. A quota system may be preferred because it will likely result in smaller near-term impacts for a given level of emissions reduction. However, because fee systems have advantages in terms of long-term economic efficiency, additional work should include analyses of innovative fee systems that can provide adequate incentives while avoiding the generation of large revenues.

Given these results we recommend that further research be undertaken to design economic incentive approaches for groups of products for which cost is the primary factor that currently limits the introduction of low-PROC product formulations.

ACKNOWLEDGEMENTS

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* In the State of California, ICF Incorporated does business as ICF Consulting Associates, Incorporated.

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SUMMARY AND CONCLUSIONS

OBJECTIVE

This study investigates and evaluates two economic incentive systems as potential control strategies for reducing emissions of photochemically reactive organic compounds (PROCs) found in consumer products. The results of this study can help the California Air Resources Board (ARB) assess the feasibility of using economic incentives as non-traditional approaches for controlling PROC emissions.

We addressed the following questions in the study:

- How could economic incentives be designed and how would they work?
- What are current emissions and how large of an emissions reduction can be achieved?
- How much will it cost to reduce emissions?
- How will product prices be affected?

BACKGROUND

Consumer products are an important and largely uncontrolled source of PROC emissions in California. These emissions, also referred to as volatile organic compounds (VOCs), are precursors to tropospheric ozone formation commonly known as smog.

There are hundreds of consumer products that emit PROCs. Consumer products packaged in aerosol containers emit the largest volume of PROCs among all consumer products. Aerosol products are used for a variety of purposes, including: insecticides; household cleaning and laundry; shaving cream; underarm deodorants and antiperspirants; hair care and styling; automotive care; and paints.

Because there are numerous consumer products, it may not be practical to use conventional methods for emissions control. It could take many years to analyze each product category in detail to identify technologies and formulations that would lead to emission reductions. Even with identified alternatives, setting PROC content standards would be complicated by uncertainties regarding consumer acceptance of the reformulated products. The resources necessary to develop conventional standards for each product may not be justified because the emissions from

each product are small, even though the emissions from the entire group of products are significant.

Economic incentives can control emissions from consumer products in a more timely and cost effective manner. Rather than develop rules for each product, economic incentives could be provided to encourage emissions reductions across an entire class of products. Such an approach could result in significant emissions reductions sooner than would developing a rule for each product.

While the theory of economic incentives is relatively well developed, there is little experience in the use of incentives for reducing emissions. Economic incentives are not used extensively for environmental protection in California or the U.S. However, incentives are used throughout the economy for other purposes.

Because there is little experience with economic incentives for environmental protection, this report focuses on how specific incentives could be inplemented for specific products. This report does not review the extensive literature on the concept and theory of using incentives.

ECONOMIC INCENTIVES

Economic incentives can be used to reduce PROC emissions from consumer products by the following mechanism:

- A product or set of products is identified that will be subject to the economic incentives.

- For this product or set of products, an economic incentive is provided that changes the cost of producing and selling the product. For example, a fee may be imposed on the use of PROC ingredients that will be emitted when the product is used. This fee increases the cost of using ingredients that subsequently lead to PROC emissions. Alternatively, a subsidy could be provided for products that have reduced levels of PROC emissions. This subsidy reduces the cost of producing products that have lower PROC emissions. Also, a quota could be established that limits the total statewide PROC emissions for a given product.

- Based on the changes in production costs created by the economic incentives and expectations regarding consumer preferences, product manufacturers will change their products. These changes in the products will result in PROC emissions that are lower than would have occurred in the absence of the incentives. The extent to which emissions are reduced will depend on the type and level of the incentive provided and the costs of producing the products in a manner that both reduces PROC emissions and is responsive to consumer preferences.

Based on a review of existing and potential incentive systems, we describe a range of possible incentive approaches. In conjunction with ARB staff, we chose two systems from this range for detailed study:

- Fee Incentive System: A fee is placed on the use of PROCs that would subsequently be emitted from consumer products sold in California. A fee would be in terms of dollars per amount of PROC used and would be paid by the product manufacturer.

- Quota Incentive System: A quota limits the total use of PROCs in the manufacture of consumer products sold in California. Portions of the quota would be allocated to individual manufacturers. Each manufacturer's use of PROCs in products sold in California would be limited by their portion of the quota. Manufacturers would be allowed to trade their quota allocations.

PRODUCTS SELECTED FOR STUDY

We selected hair sprays and aerosol spray paints for study. One reason for selecting these products was their significant use of PROCs. Both products are formulated with PROC propellants and solvents. Also, they account for a large portion of all aerosol containers filled; nearly 30 percent of the 1987 total.

Another reason for choosing hair sprays and spray paints is that whereas non-aerosol packaging alternatives are available for hair sprays, options to reformulate aerosol spray paints are limited, making PROC control particularly difficult using conventional methods. Thus, we selected hair sprays and spray paints to provide a contrast in the likely ability to reformulate products to reduce PROC emissions.

ESTIMATES FOR HAIR SPRAY PRODUCTS

The Hair Spray Market. About 54 million aerosol and about 5 million pump hair spray packages were sold in California in 1987. There are about 100 marketers of aerosol and pump hair sprays in the U.S., of which about 10 account for 75 percent of the California market. Medium and small regional and local marketers satisfy the remainder of the market.

Hair sprays are marketed using: in-house or contract filling operations; storage and distribution centers; wholesalers; mail order and personal selling operations; hair salons; and retail outlets. No single marketing method dominates the California market.

Hair Spray PROC Emissions. We estimate the 1987 PROC emissions from aerosol and pump hair sprays sold in California at about 14,000 tons. Aerosol hair sprays accounted for 94 percent of these emissions: aerosols account for about 92 percent of the hair spray packages sold; aerosols have

a larger average package size, 8.3 ounces for aerosols versus 6.3 ounces for pumps; and aerosols have a higher average PROC content, 97 percent for aerosols versus 87 percent for pumps, by weight.

Alternative Hair Spray Formulations and Technologies. Opportunities exist to reformulate hair spray ingredients to reduce PROC contents and to repackage hair sprays in containers with delivery systems that require less PROC propellant. Some of the options include the following.

- Partially-halogenated chlorofluorocarbons (HCFCs) are a class of compounds that could help to reduce PROC emissions from hair sprays by 30 to 80 percent. HCFCs are currently marketed as aerosol product ingredients. Promising HCFC-based formulations have not been fully demonstrated. Future HCFC use may be limited due to concerns about their potential to deplete stratospheric ozone. Costs of using the HCFCs would be about $2,000 to $5,000 per ton of PROC emissions avoided.

- Hair spray formulations that include a mixture of dimethyl ether (DME) and water have the potential to reduce PROC emissions by about 15 to 65 percent. One DME/water formulation being marketed by Cosmosol reduces PROC emissions by about 65 percent. Costs of DME/water formulations would be about $400 to $2,000 per ton of PROC emissions avoided.

- Alternative packaging systems that do not require a PROC propellant can reduce PROC emissions by about 45 to 65 percent. These include pump sprays and two innovative systems: the Exxel® system and the Growpak® system. Past experience indicates that consumer acceptance may limit pump use and acceptance has yet to be demonstrated for the innovative packaging systems. The costs of the alternative packaging would be less than $500 per ton of PROC emissions avoided.

A Fee System for Hair Sprays. We estimated emissions reductions for a range of fee levels assuming that the alternative formulations and technologies are available.

- A fee of about $0.45/pound ($1/kilogram) of PROC would produce emissions reductions of about 10 to 15 percent. A fee of about $2.30/pound ($5/kilogram) would reduce emissions by about 20 to 50 percent, and a fee of about $4/pound ($9/kilogram) would reduce emissions by about 35 to 65 percent.

- At the incentive fee levels necessary to reduce emissions by 25 percent or more it is very likely that an incentive fee will produce government revenues of $20 to $60 million per year. The manufacturing cost of hair spray would increase by about $0.55 to $1.60 per can, almost entirely due to the payment of the incentive fee by manufacturers.

A Quota System for Hair Sprays. Our analysis of tradable quotas indicates that:

- Establishing a quota on PROC use in hair sprays will trigger the implementation of formulations and technologies that lead to lower PROC emissions. For emissions reductions of 25 percent or more the costs will be on the order of $2,000 to $4,500 per ton of PROC emissions avoided.

- It is very likely that in the near term the total impacts of achieving a given level of emissions reduction will be lower with a quota system than with a fee because no government revenues are generated under the quota system. However, over the long term the quota system can lead to additional cost impacts if the quota allowances are not allocated efficiently. The magnitude of these potential costs cannot be estimated at this time.

ESTIMATES FOR SPRAY PAINT PRODUCTS

The Spray Paint Market. About 28 million spray paint packages were sold in California in 1987. There are about 125 marketers of aerosol spray paints in the U.S., of which about 10 to 20 account for about 50 to 60 percent of the market. Medium and small regional and local marketers, who generally purchase their ingredients from the large national firms, satisfy the remainder of the market.

Spray paints are marketed using: in-house or contract filling operations; storage and distribution centers; wholesalers; and retail outlets. Because of the variety and limited retail shelf space, retailers often contract with a single spray paint supplier. Some national spray paint marketers have their own retail outlets. No single marketing method dominates the California market.

Spray Paint PROC Emissions. We estimate 1987 PROC emissions from aerosol spray paints sold in California at about 6,000 tons. Two spray paint formulations account for about 93 percent of all aerosol spray paint sold and are about 87 percent PROC by weight. Aerosol spray paints come in a variety of sizes, with an average size of about 8.1 ounces. Packages of about 12 ounces are sold for general purpose use and packages of 3 to 3.5 ounces are sold for hobby uses and automobile touch up.

Alternative Spray Paint Formulations. Opportunities exist to reformulate spray paints to reduce PROC emissions.

- Partially-halogenated chlorofluorocarbons (HCFCs) and dimethyl ether (DME) could be used to reduce PROC emissions from spray paints by about 30 percent. No HCFC/DME spray paint formulations are currently marketed. Future HCFC use may be limited due to concerns about their potential to deplete stratospheric ozone.

Costs of using the HCFC/DME formulation would be about $3,500 per ton of PROC emissions avoided.

- Water and dimethyl ether (DME) could be used to reduce PROC emissions from spray paints by about 30 percent. Some water-based spray paint formulations are currently marketed for limited uses that do not require a high gloss finish. Costs of using the water/DME formulation would be about $3,000 per ton of PROC emissions avoided.

- High-solids paint formulations could be used to reduce PROC emissions from spray paints by about 60 percent. Some high-solids paints are currently marketed, and are less costly per amount of paint delivered to the painted surface. Despite their cost-effective performance, these paints have not achieved significant market share because they are more costly per 12 ounce can. Consumer education and a reliable system for measuring and labeling the performance of spray paint products may be required to promote the acceptance of high-solids spray paint formulations.

A Fee System for Spray Paints. Our assessment of incentive fee systems to encourage the production and use of cost-effective high-solids spray paints indicates the following:

- A PROC incentive fee of about $0.90 per pound ($2/kg) is required to make the original purchase price of high-solids paints equal to the original purchase price of the currently popular paint formulations.

- At a fee of $0.90 per pound emissions would be reduced by about 30 percent, assuming that high-solids paint formulations penetrate half the spray paint market. Higher fees would likely lead to larger emissions reductions.

- A fee of $0.90 per pound would generate government revenues of about $8 million per year. The cost per average-sized can would increase by about $0.35.

- If high-solids paint formulations are not implemented or are found to be unacceptable, higher incentive fee levels and higher costs will be required to reduce spray paint PROC emissions.

A Quota System for Spray Paints. Our analysis of tradable quotas indicates that:

- Establishing a quota on PROC usage in spray paints will trigger the implementation of formulations that lead to lower PROC emissions. If high-solids paints are used extensively in response to the quota, costs will be less than $100 per ton of

emissions avoided because high-solids paint formulations are more cost effective than current formulations per amount of paint transferred to the painted surface.

- If high-solids paints are not used extensively in response to the quota, costs may be much higher, ranging to as high as $3,500 per ton of PROC emissions avoided.

- As described above for hair sprays, it is very likely that in the near term the total impacts of achieving a given level of emissions reduction will be lower with a quota system than with a fee because no government revenues are generated under the quota system. However, over the long term the quota system can lead to additional cost impacts if the quota allowances are not allocated efficiently. The magnitude of these potential costs cannot be estimated at this time.

CONCLUSIONS

Economic incentives can be used to reduce PROC emissions from hair spray and spray paint products. Because cost is the principal barrier preventing the wide-spread use of most of the PROC-reducing formulations and packaging systems, an incentive fee or quota is appropriate for promoting the use of the desired formulations and packaging systems.

The effectiveness of economic incentives is reduced when non-cost barriers, such as inadequate product performance information, prevent the use of emissions-reducing formulations and packaging. In these situations, consumer awareness programs or other steps in conjunction with economic incentives should be considered.

We believe that it will be best to direct the economic incentives to product marketers because: (1) a variety of different distribution channels exist for consumer products; and (2) the marketers are the most centralized portion of the consumer products market. Therefore, directing the incentives to marketers and tracking the performance of the program at this level will help to minimize the burden on the implementing agency and industry. Additionally, this approach is consistent with the fact that the marketer is responsible for the product formulation and package design.

To implement a fee system, the fee should be set to achieve an emissions reduction goal and should be consistent with the costs of controlling emissions from other sources and the value of the emissions reduction in terms of air quality benefits. The PROC emissions reduction that will be achieved using an incentive fee will always be uncertain because it depends not only on the level of the fee, but also on the cost and consumer acceptance of new product formulations and packaging systems and the response of consumers to higher prices. These factors can only be estimated with some uncertainty.

A PROC quota will reliably achieve a given level of emissions reduction. The quota limit should be set to achieve an emissions reduction goal, and the expected costs of achieving the reduction should be consistent with the costs of controlling emissions from other sources and the value of the emissions reduction in terms of air quality benefits. The costs of achieving the emissions reduction with a quota will be uncertain because they depend on the costs and consumer acceptance of new product formulations and packaging systems and the response of consumers to higher prices. These factors can only be estimated with some uncertainty.

Because the expected performance of incentive fees and quotas will always be uncertain, it is preferred to implement economic incentives for a group of products, as opposed to for a single product. This approach reduces the program's reliance on the expected performance of any single emissions-reducing technique and thereby limits the likelihood of inadvertently imposing large costs.

The analysis of the fee and quota systems in this study indicates that fee systems can produce very large government revenues. A quota system may be preferred because it will likely result in smaller near-term impacts for a given level of emissions reduction. However, because fee systems have advantages in terms of long-term economic efficiency, additional work should include analyses of innovative fee systems that can provide adequate incentives while avoiding the generation of large revenues. One such approach may include a "graduated" fee system where the fee level for each manufacturer depends on the emissions reduction he or she achieves relative to a set schedule.

FURTHER STUDY

This study indicates that economic incentives are a promising avenue for controlling PROC emissions from consumer products. Several issues that warrant additional study include:

- Groups of Products. Several groups of products for which economic incentives could be provided for reducing PROC emissions should be identified. Criteria for including products in the groups should be developed and the market structure for the group of products should be assessed. This study should generate concrete proposals for candidate groups of products.

- Quota Allocation. The most challenging aspect of a quota incentive program is designing a system for allocating the quota allowances. Specific allocation schemes should be analyzed in detail, including options for creating set-asides for new entrants to the market with promising low-PROC products. This study should generate several detailed alternatives for allocating quota allowances.

- Innovative Fee Systems. Additional effort may be warranted to identify innovative fee systems that provide adequate incentives without generating unreasonable levels of government revenues.

- Non-cost Barriers. If non-cost barriers exist that will prevent the timely introduction of PROC emission-reducing technologies, strategies for overcoming these barriers should be defined as companions to the economic incentive system. This study should examine specific products and identify non-cost barriers for each.

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1. INTRODUCTION

1.1 OBJECTIVE

The objective of this study is to investigate and evaluate two economic incentive systems as potential control strategies for reducing emissions of photochemically reactive organic compounds (PROCs) found in consumer products. It is well established that consumer products are an important source of PROC emissions in California. These PROC emissions (also referred to as volatile organic compound (VOC) emissions) are largely uncontrolled in the state.

There are hundreds of consumer products that emit PROCs. Consumer products packaged in aerosol containers emit the largest volume of PROCs among all consumer products. Aerosol products are used for a variety of purposes, including: insecticides; household cleaning and laundry; shaving cream; underarm deodorants and antiperspirants; hair care and styling; automotive care; and paints.

Because there are numerous consumer products, it may not be practical to use conventional methods for emissions control. It could take many years to analyze each product category in detail to identify technologies and formulations that would lead to emission reductions. Even with identified alternatives, setting PROC content standards would be complicated by uncertainties regarding consumer acceptance of the reformulated products. The resources necessary to develop conventional standards for each product may not be justified because the emissions from each product are small, even though the emissions from the entire group of products are significant.

Economic incentives can control emissions from consumer products in a more timely and cost effective manner. Rather than develop rules for each product, economic incentives could be provided to encourage emissions reductions across an entire class of products. Such an approach could result in significant emissions reductions sooner than would developing a rule for each product.

While the theory of economic incentives is relatively well developed, there is little experience in the use of incentives for reducing emissions. Economic incentives are not used extensively for environmental protection in California or the U.S. However, incentives are used throughout the economy for other purposes.

Because there is little experience with economic incentives for environmental protection, this report analyzes how two specific economic incentives could be used to reduce PROC emissions from two consumer products. This report does not review the extensive literature on the

concept and theory of using incentives. The results of this analysis can provide input into the ARB's assessment of using non-traditional approaches for improving air quality.

1.2 APPROACH

In considering using economic incentives as an approach for reducing PROC emissions from consumer products, many questions arise, such as:

- How could economic incentives be designed and how would they work?
- To what group within the market for consumer products should the incentive be directed: manufacturers; packagers; wholesalers; retailers; or consumers?
- How large of an emissions reduction can be achieved?
- How much will it cost to reduce emissions?
- How will product prices be affected?

To address these questions, this report analyzes how economic incentive systems could be used to reduce PROC emissions from consumer products. To be useful we made this study specific and detailed by analyzing two well-defined economic incentive systems for two actual consumer products.

The two incentive systems selected for detailed study are fees and quotas:

- Fee Incentive System. A fee is placed on the use of PROCs that would subsequently be emitted from consumer products sold in California. The fee would be in terms of dollars per amount of PROC used and would be paid by the product manufacturer.
- Quota Incentive System. A quota limits the total use of PROCs in the manufacture of consumer products sold in California. Portions of the quota would be allocated to individual manufacturers. Each manufacturer's use of PROCs in products sold in California would be limited by their portion of the quota. Manufacturers would be allowed to trade their quota allocations.

These are the two main types of economic incentives that are often discussed as being applicable to environmental protection. Subsidies are not examined in this study. However, as described below, subsidies could also be used as an economic incentive.

In conjunction with ARB staff we selected hair sprays and aerosol spray paints as the two products for detailed study. One reason for selecting

these products was their significant use of PROCs. Both products are formulated with PROC propellants and solvents. Also, they account for a large portion of all aerosol containers filled; nearly 30 percent of the 1987 total.

Another reason for choosing hair sprays and spray paints is that whereas non-aerosol packaging alternatives are available for hair sprays, options to reformulate aerosol spray paints are limited, making PROC control particularly difficult using conventional methods. Thus, we selected hair sprays and spray paints to provide a contrast in the likely ability to reformulate products to reduce PROC emissions.

Using these two incentive systems and these two products, we then evaluated how the incentive systems could be implemented to reduce PROC emissions. This evaluation of the two economic incentive systems is the main subject of this study, and includes the following:

- data collection to describe the market for the two products being studied and their current PROC emissions;
- a detailed description of how the two economic incentive systems could be implemented given the market for the products;
- data collection and analysis to assess the existing and emerging technologies that could be used to reduce PROC emissions from the two products, including their costs;
- analysis to estimate the levels of economic incentives that would be required in order to induce manufacturers to implement the emissions reduction technologies; and
- analysis to estimate the costs of achieving the emissions reductions using the economic incentive systems.

As described in the main body of the report, to perform this evaluation we collected data from the trade literature and industry experts. Using these data we estimated current PROC emissions and the costs of the individual technologies for reducing emissions from the two products being studied. We then estimated the economic incentives that would need to be provided in order to trigger the use of the emissions reduction technologies. The emissions reductions that could be achieved with varying levels of economic incentives were then estimated. Finally, the costs of achieving the emissions reductions were estimated.

1.3 REPORT ORGANIZATION

This report is organized as follows:

- Chapter 2 discusses the elements of economic incentive systems.

- Chapter 3 describes the market for hair sprays and spray paints in California.

- Chapter 4 presents estimates of 1987 PROC emissions from hair sprays and spray paints in California, and alternatives to reduce the emissions.

- Chapter 5 provides a detailed discussion of the steps necessary to implement fee- and quota-based economic incentives for reducing PROC emissions from hair sprays and spray paints in California.

- Chapter 6 estimates the costs of reducing PROC emissions from hair sprays and spray paints using the economic incentive systems described in chapter 5.

- Chapter 7 presents a synthesis of the results for the two products and recommended future research.

2. ECONOMIC INCENTIVE SYSTEMS FOR CONTROLLING PROC EMISSIONS FROM CONSUMER PRODUCTS

This chapter identifies and describes economic incentive systems that could be used to control emissions of photochemically-reactive organic compounds (PROCs) from consumer products. The purpose of this chapter is to describe and evaluate a range of fee- and quota-based economic incentive systems that may be used. Based on these descriptions, two systems are adopted for more detailed analysis and evaluation with respect to two consumer products.

2.1 WHY USE ECONOMIC INCENTIVES TO CONTROL CONSUMER PRODUCT EMISSIONS?

Because there are hundreds of consumer products that emit PROCs, the control of these emissions by conventional methods may not be practical. For example, it could take many years to analyze each major consumer product in detail and to develop rules that limit emissions. Even if such a process were undertaken, it would be difficult to ensure that the rules provided adequate incentives for innovations that could reduce emissions in the future or that an equitable level of emissions reductions were achieved across the wide variety of products.

Economic incentives have been proposed as one approach for controlling emissions from consumer products in a more timely and cost effective manner. Rather than develop detailed rules for each product, it has been suggested that economic incentives could be provided to encourage emissions reductions across an entire class of products. Such an approach could result in emissions reductions sooner than would developing a rule for each product. Additionally, an economics incentive approach could help assure that products are handled equitably.

Economic incentives are not used extensively for environmental protection in California or the U.S. However, incentives are used throughout the economy for other purposes. Economic incentives can be used to reduce PROC emissions from consumer products by the following mechanism:

- A product or set of products is identified that will be subject to the economic incentives.

- For this product or set of products, an economic incentive is provided that changes the cost of producing and selling the product. For example, a fee may be imposed on the use of PROC ingredients that will be emitted when the product is used. This fee increases the cost of using ingredients that subsequently lead to PROC emissions. Alternatively, a subsidy could be provided for products that have reduced levels of PROC emissions. This subsidy reduces the cost of producing products that have

lower PROC emissions. Also, a quota could be established that limits the total statewide PROC emissions for a given product.

- Based on the changes in production costs created by the economic incentives and expectations regarding consumer preferences, product manufacturers will change their products. These changes in the products will result in PROC emissions that are lower than would have occurred in the absence of the incentives. The extent to which emissions are reduced will depend on the type and level of the incentive provided and the costs of producing the products in a manner that both reduces PROC emissions and is responsive to consumer preferences.

As this description indicates, economic incentives operate by increasing the relative cost of producing products that cause PROC emissions. Products that have lower PROC emissions will have a cost advantage. In response to the incentives, manufacturers are free to modify their products. In general these modifications will result in lower PROC emissions.

Economic incentive systems for environmental protection can be categorized into two broad groups:

- Monetary fees, taxes, or subsidies established for the purpose of influencing the behavior of a target set of decision makers. For example, a fee may be imposed upon the manufacture of products that emit PROCs. If the fee varies with the level of PROC emissions resulting from the product, the fee provides an incentive for reducing PROC emissions.

- Transferable quotas that are used to limit an activity or product to a certain level and to allocate the activity or product to its most highly-valued set of uses. For example, permits that allow a given level of emissions (e.g., 100 tons per year) can be issued or auctioned. If these permits can be bought and sold, then the permits may be traded to the individuals or business entities who value the emissions most. Anyone without a permit would not be allowed to have any emissions. Because they need to purchase permits in order to have emissions, potential emitters have an incentive to limit or avoid emissions.

The advantages of using an economic incentive approach to reduce emissions include:

- Economic incentives provide manufacturers with complete flexibility regarding how best to reduce emissions. Specific technologies or performance criteria need not be specified.

- Economic incentives can provide ongoing incentives to develop technologies for reducing emissions in the future. Technology or

product performance standards do not normally provide this incentive.

- Economic incentives can be implemented for a group of products without analyzing each product in depth. The most cost effective opportunities for reducing emissions within the entire group will be taken as a result of the incentives. Technology or product performance standards would most likely be developed for individual products. With a product-by-product approach it may be difficult to maintain consistency and ensure cost-effectiveness across the rules.

The primary disadvantages of economic incentives are:

- For fee and subsidy incentive systems there is no guarantee that a given level of emissions reduction will be achieved. Consequently, there is uncertainty regarding the level of environmental protection that will be achieved under fee-based systems.

- Fee incentive systems can generate unacceptably large amounts of revenue. Similarly, a subsidy incentive system can require an unacceptably large expenditure of public funds.

- Although a quota incentive system will achieve a given level of emissions reduction with relative certainty, the costs of achieving that emissions reduction will be uncertain. If emissions reduction technologies turn out to be more costly than initially expected, a quota system could impose unacceptably large costs.

There is currently only one major example of an economic incentive system being used for environmental protection in the U.S. The U.S. EPA recently promulgated restrictions on the production and consumption of chlorofluorocarbons (CFCs). The EPA rule relies on a quota being allocated to CFC producers and importers in the U.S.[1] This rule took effect on July 1, 1989.

By restricting the production and consumption of CFCs in the U.S., EPA is affecting the production and use of a wide range of products, including: refrigerators; air conditioners; polyurethane foams used in furniture, carpet backing, and other products; nonurethane insulating foams used in buildings and appliances; foams used in packaging; sterilizers used in hospitals and in other applications; and electronic and metal components currently cleaned with CFC solvents. Rather than promulgate separate rules

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[1] Protection of Stratospheric Ozone, Final Rule, Federal Register, Vol. 53, No. 156, August 12, 1988, pp. 30566-30602. This rule is reproduced as Appendix G.

covering each of these products, EPA's production and consumption quota effectively restricts total CFC use and emissions in the U.S. across all the products at one time.

This economic incentive approach allows the limited quantity of available CFCs to be allocated efficiently among the various manufacturers that want to use CFCs in their products or services. Although there is uncertainty regarding the costs of restricting the CFCs, the diversity of products affected and the large number of existing and potential technologies for reducing CFC use and emissions across these products limits the risk that the costs will be substantially greater than currently expected. It is very likely that some of the key promising technologies for reducing emissions will be feasible and cost effective. Additionally, innovative low cost approaches for reducing emissions will arise that are not currently known. The primary uncertainty exists as to which of the emissions reduction technologies will be best and which of the products will benefit most from them.

Although not used for environmental protection, fee- and quota-based systems are used in other parts of the national, regional, and/or local economies for various reasons. For example, some cities have restrictions on the number of taxicabs that may be in operation. Such restrictions are often enforced with a quota system. As another example, in California, the milk pricing program includes a "base quantity" of milk that dairy farmers own. Dairy farmers are guaranteed a set price for milk produced as part of their base quantity. Production over and above the base amount is not guaranteed the set price. This system is a type of quota, where each farmer's base quantity is his allocation of the quota. The quota is tradeable, and the total quota amount is adjusted periodically.

Fee-based systems have also been used in some areas. For example, time-of-day pricing for electricity provides a monetary incentive for electricity users to modify their electricity consumption. Similarly, in some areas rate reductions are provided as incentives for customers to limit that electricity consumption during peak demand periods. Many subway systems, including the Bay Area Rapid Transit System in San Francisco and the Metro System in Washington, D.C., have peak-time pricing. Airports have also increased landing fees during peak hours as a means of reducing congestion.

The U.S. EPA CFC regulation and the variety of quota- and fee-based systems used in other parts of the U.S. and California economies provide examples of how these economic incentive systems could be used to reduce PROC emissions from consumer products.

2.2 HOW TO DESIGN ECONOMIC INCENTIVES

A variety of options exist for implementing fee- and quota-based economic incentives for reducing PROC emissions from consumer products. In all cases, however, the incentives must change the costs of producing and/or using consumer products that emit PROCs. In general, the incentives should increase the relative costs of continuing to produce or use products that emit PROCs. In response to the incentive-induced change in costs, producers and consumers move away from the PROC-emitting activities. The final result is a reduction in emissions.

To design an economic incentive system, one must define the following:

- The behavior that the incentive will influence. In this study an incentive is desired that will influence the manufacturer's choices of product formulation and delivery (such as aerosol versus pump delivery).

- The products covered. The specific products to be included in the system must be defined.

- The implementing agency. The agency that will provide the incentives must be identified. This agency must have the authority to implement the proposed incentives.

- The form of the incentive and how it will be provided. For example, incentives can be provided in terms of fees/subsidies, quota, or combinations of these. The manner in which the incentive is provided will vary depending on the form of the incentive.

- The steps necessary to track the performance of the incentives and ensure compliance. The activities needed to conduct the incentive program will depend on the form of the incentive.

The first three items on this list are common to all economic incentive programs regardless of the form of the incentive. These three items are discussed next. Following this discussion, separate sections for fee- and quota-based systems address the last two items which deal with the detailed specification of the incentives and how they will be implemented.

The Behavior That the Incentive Will Influence

The incentive should be designed to reduce the emissions of PROCs from consumer products. In this study it is assumed that the primary manner in which this will be achieved will be to provide incentives for manufacturers to formulate and deliver their products so that less PROCs are emitted per amount of product used by the consumer. Other approaches, that are not examined here, could include incentives for manufacturers to perform

research on low-PROC product formulations or incentives for consumers not to purchase PROC-emitting products.

The Products Covered

Common to various economic incentive systems, like all programs for improving environmental quality, is the definition of the specific activity or product that is the subject of the incentives. Separate incentives for every product-type (e.g., aerosol air freshener, aerosol disinfectant, aerosol deodorant, aerosol hair spray, and others), would be time-consuming, burdensome, and difficult to implement and track. Also, even if a series of narrowly-defined, but coordinated incentive systems were implemented, some products (e.g., new products that do not fit into existing product categories) could fall "between the cracks" and remain completely uncontrolled.

An alternative to designing economic incentives to cover individual products is to provide incentives for a broad class of related products. The U.S. EPA CFC regulation is an example of an economic incentive that affects a broad class of products that are related by the fact that they all use CFCs. In terms of this study, a class of products may be defined in terms of their use, such as all personal care aerosol products. Covering a broad class of products such as this could be less burdensome than providing incentives for each individual product.

Additional advantages covering a broad class of related products include:

- o diversity in the products covered reduces the overall cost of achieving a given level of emission reductions by allowing the reductions to take place first in those products that are the least costly to control; and

- o broad coverage puts a group of industries and products on an equal basis, without singling out any individual industry or product for special scrutiny.

Based on these considerations, an incentive system with broad coverage may be preferred. Unfortunately, the economic and air quality impacts of such a system cannot be evaluated fully based on an analysis of two products as called for under this study. Consequently, although the design of the incentives will be focused on a broad-based system, the evaluation of the system will necessarily be based on individual products.

The Implementing Agency

Economic incentives for reducing PROC emissions from consumer products could be implemented at the federal level by the U.S. EPA, at the state level by the ARB, or at the local/regional level by air quality management districts. The choice of the level of implementation should be made based on the nature of the product or activity to be controlled, its impacts on the environment, ease of implementation, and the size and mobility of the market.

The main advantage of using a local/regional-based approach is that it allows the emissions reductions to be achieved using incentives to be tailored to the needs of the individual areas. Because these emissions are primarily local in origin, this approach would be an important advantage if the need to reduce PROC emissions varied significantly among the state's regions. However, seven air quality management districts,[2] covering approximately 80 percent of the current population in the state,[3] currently require that additional steps be taken in order to achieve existing federal and state ambient air quality standards. Therefore, the overwhelming majority of people in the state stand to benefit from improved air quality due to reductions in PROC emissions from consumer products, and emissions reductions for consumer products need not vary for different areas.

Another advantage of using a local/regional-based approach is that it can ensure that emissions reductions are achieved in each individual area. For example, if a statewide quota incentive were implemented, the resulting use of consumer products could shift so that large emissions reductions are achieved in some areas, while no or little emissions reductions are achieved in other areas. While this result is not considered likely for consumer products, implementation at the local/regional level would avoid this potential problem.

Of note is that local/regional level implementation of a quota-based economic incentive system may have an analogue in the emissions reduction credits programs that exist in the districts. For example, under Rule 1303(b) the South Coast District regulates new source emissions, in part by requiring emission reduction credit offsets from existing sources. This system of emissions offsets is analogous to a quota system. Under this program the District:

- o establishes the existence of emissions reduction credits (which are analogous to quota allocations);

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[2] 40 CFR Part 81, §305, amended by 53 FR 34508, September 1988.

[3] U.S. Bureau of the Census, Statistical Abstract of the United States: 1988 (108th Edition), Washington, D.C., 1987.

- o establishes the rules under which the emissions reduction credits can be used (i.e., traded); and

- o tracks the trading of these emissions reduction credits.

State-wide implementation of incentives also has advantages. Because products are marketed state wide,[4] a state-wide system would avoid adding complexity to marketing efforts. For example, a manufacturer or marketer would not have to keep track of inventory or production assigned to individual areas of the state. This is particularly important for consumer products because the majority of them are produced and marketed nationally.

State-wide implementation may also be preferred because products will require reformulation in order to reduce PROC emissions. A state-wide approach would provide the largest target market for the reformulated products. If the target market were too small, the manufacturer may not be able to justify the costs of reformulation. The end result of a fee system, for example, could be little or no change in product characteristics and consequently little or no reduction in PROC emissions.

Finally state-wide requirements allow implementation and compliance efforts to be centralized, thereby reducing the amount of record-keeping required. For example, under a state-wide approach manufacturers would not have to prepare separate tracking reports for products going to individual areas.

2.3 FEE-BASED INCENTIVE SYSTEM

Fee-based incentive systems can be defined broadly to include any system whereby monetary charges (subsidies) are imposed on (provided to) independent decision makers as the result of those decision makers undertaking a clearly defined and monitorable activity. Several aspects of this definition deserve some explanation.

First, the fee-based system involves money or other items of value changing hands in the form of a fee or subsidy. Second, the fee or subsidy is collected or provided by a central authority, such as a government, that can reasonably be anticipated to be able to carry out the program. Third, the fee is imposed on or the subsidy is provided to independent decision makers who have the opportunity to chose whether or not to engage in the activity that triggers the fee or subsidy. Finally, it must be possible to monitor the activity that triggers the fee or subsidy in an unambiguous manner so that all parties can agree as to whether the fee or subsidy is owed.

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[4] Personal communication, Ken Lim, Aerosol Service Company, November 11, 1988.

The principles that form the foundation for the use of fee-based incentives for environmental protection are well established.[5] In general these incentives rely on the assumption that forms the basis for our market-based economy, namely that rational independent decision makers behave in a manner that maximizes their well being.[6] When faced with a fee, decision makers will tend to change their behavior to avoid the fee. Similarly, when faced with a subsidy, decision makers will tend to change their behavior to obtain the subsidy. In this manner the fees and subsidies can be used to modify people's behavior.

This modification of people's behavior is often referred to as inducing substitution among inputs to production. What this means is that if the cost of one input is increased by a fee, producers will tend to substitute another input that costs less, if one is available. In this study the substitution could take the form of avoiding the use of PROCs in the formulation of consumer products in favor of using non-PROC ingredients.

This substitution of inputs induced by the incentive fee is the primary mechanism by which the fee leads to emissions reductions. This substitution would be initiated when the incentive was provided and continue as long as the incentive was in place. Additionally, if the incentive increases the price of a limited set of products, for example by imposing a fee, then consumers will tend to shift away from these products, thereby reducing emissions further.

Fee-based incentives can also have long-term effects on innovation that help to reduce emissions. For example, by increasing the cost of using PROCs in consumer products, an incentive fee makes it more valuable to invest in research aimed at finding non-PROC formulations for consumer products. This research may produce new formulations that enable emissions to be reduced more in the future than is possible today. Although this research incentive exists in theory, it is almost impossible to quantify the effect that it has in particular instances.

While fee-based incentives could include either fees or subsidies, this study focuses on fees for several reasons. First, the objective of these incentives is to discourage PROC emissions from consumer products. This can be done in the most straightforward way by increasing the cost of formulating products that lead to PROC emissions by imposing a fee on PROCs. The basis for providing a subsidy to achieve this objective would

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[5] See for example: Nichols, A.L., Targeting Economic Incentives for Environmental Protection, The MIT Press, Cambridge, Massachusetts, 1984; and Anderson, F.R., et al., Environmental Improvement Through Economic Incentives, The Johns Hopkins University Press, Baltimore, Maryland, 1977.

[6] The conditions for welfare maximization are described in microeconomics texts such as: Nicholson, W., Microeconomic Theory, The Dryden Press, Hinsdale, Illinois, 1978.

necessarily be more complex, potentially involving an estimate of emissions reduction relative to some baseline. Unfortunately, once the subsidy is in place the true baseline level of emissions (i.e., what would have happened in the absence of the subsidy program) cannot be measured, so that the basis for providing the subsidy may be ambiguous.

Second, subsidy incentives will require funding to be implemented. Given current fiscal constraints such funding may not be available. Finally, subsidies will necessarily be economically inefficient. By definition, the subsidy will reduce the cost of producing a low-PROC product to a level that is below its true real resource cost. While in individual circumstances such a situation may not be of any practical significance, the inefficient allocation of resources caused by subsidies indicates that their widespread use for purposes of environmental protection is probably not warranted.

In the following section, we discuss the major components of a fee-based system along with a range of alternative designs for each of the components.

2.3.1 Major Components

A fee-based incentive for reducing PROC emissions from consumer products can take many forms and can be provided in a variety of different ways. The major components that define a fee-based economic incentive system include:

- o what the fee is levied on;
- o the point at which the fee is collected;
- o setting the initial fee, evaluating emissions reductions achieved, and modifying the fee; and
- o use of the revenues.

In addition, the steps necessary to track the performance of the incentives and to ensure compliance must be established. In the five sections below we describe each of these components and the range of alternatives available for each.

What the Fee is Levied On

A fee-based incentive system must impose a fee on some specific product or activity, and it must collect the fee from some specific set of parties or entities. In the case of incentives for reducing PROC emissions from consumer products, a fee could be applied to a range of activities and products, including:

- the manufacture of PROCs that are sold for inclusion in consumer products that are subsequently sold in the state;
- the process of placing the PROC-containing ingredients into consumer products that are subsequently sold in the state, for example the process of filling aerosol containers with ingredients;
- the distribution of consumer products to retail outlets; or
- the retail sale of consumer products.

The choice of the activity or product on which to base a consumer-product-PROC-fee is driven by the ease of monitoring the activity or counting the product as well as the perception of the fee. To minimize the burden of monitoring, the activities that are most centralized are preferred. For this reason, monitoring retail sales of specific products is generally not preferred.

When activities are national in scope, and when all products are distributed through a relative small number of distributors, distribution may be the most centralized activity that is related to state purchases of consumer products. For example, the California State Cigarette Tax is imposed on the activity of "distributing cigarettes."[7] Parties who distribute cigarettes in the state must be licensed with the state and procedures have been established for monitoring and reporting to the state the number of cigarettes that are distributed and the amount of tax owed.[8] This system makes sense for cigarettes because all cigarettes sold in the state are distributed through about 200 distributors. No cigarettes are sold in the state that do not pass through one of the licensed distributors.

Alternatively, when products are distributed through a variety of different ways, manufacturing and/or filling activities are likely to be preferred as the basis for the fee. This appears to be the case for most consumer products because these products can reach consumers in so many different ways that involve manufacturers, in-house or contract filling operations, storage and distribution centers, wholesalers, mail order and personal selling operations, and retail outlets. No single product distribution chain describes the manner in which these products are provided to consumers.

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[7] Revenue and Taxation Code, Part 13 of Division 2, §30101.

[8] Ibid., §30140.

Point at Which the Fee is Collected

The choice of the point at which the fee is collected is related to the choice of the activity that the fee is levied on, and is based on similar considerations. Fees on consumer products that contain PROCs can be collected at several points, including: PROC manufacturers; product manufacturers; product fillers; distributors; or retailers.

For example, as described above, the State Cigarette Tax is based on the number of cigarettes distributed, and is collected from distributors. After manufacture, cigarettes are transferred to approximately 200 distributors within California who distribute them to retail outlets. Distributors purchase a stamp from authorized banks around the state (the purchase price of which is equal to the tax) which is attached to cigarette packages as proof of payment of the tax.[9]

Alternatively, the California Alcoholic Beverage Tax applies to sales of alcoholic beverages to unlicensed persons.[10] Under this system, manufacturers, brewers, distillers, winegrowers, wholesalers, importers, and distributors are recorded with and licensed by the State Department of Alcoholic Beverage Control. The activity that the tax is based on is the transfer of the product from one of these licensed agents to a non-licensed agent (e.g., consumer) or agent with a different type of license (e.g., restaurant or retailer), and is collected from the agent who initiates the transfer. No tax need be paid when the product is transferred among the licensed parties. Under this system, the point of collection can vary depending on the manner in which the product is distributed. Unlike the cigarette tax system, this system is flexible enough to encompass a wide range of alternative chains of distribution. However, it does require the licensing of all entities that participate in the distribution of alcoholic beverages.

Like the choice of the activity upon which the fee is levied, the choice of the point of collection should seek to minimize the reporting and enforcement burden, while maintaining the desired incentives. Consequently, the retail sale level again is not preferred due to its decentralized nature. It may be suggested, however, that although potentially more burdensome, collecting the fee at the retail level will make the fee clearly visible to consumers. This fact could make consumers more aware of the PROC emissions associated with consumer products and could therefore promote additional emissions reductions. The potential value of this effect must be balanced against the difficulty of collecting a special fee at the retail level that will vary by product over time, taking into consideration alternative methods of increasing consumer awareness.

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[9] Revenue and Taxation Code, Part 13 of Division 2.

[10] Revenue and Taxation Code, Part 14 of Division 2, §32151.

Note that the point of collection need not be coincident with the point of monitoring (e.g., at fillers). For example, the number of units filled and their PROC contents could be reported by fillers to manufacturers as well as state authorities for purposes of determining the fee owed.

We would like to emphasize that the incidence of the fee is not the same as the collection of the fee. The incidence refers to the parties that bear the burden of the fee. If the party that pays the fee is able to pass this cost on to a second party (e.g., consumers) then the incidence of the fee actually falls on the second party.

In reality, the incidence of fees placed on the sale of selected products, such as a fee on consumer products associated with PROC emissions, is divided among consumers and manufacturers. The relative burden among the two parties is driven by the specifics of the market, and is not affected by the point at which the fee is collected. If consumers can easily switch to other products that are not subject to the fee then the incidence of the fee will fall principally on the industry that manufactures, fills, and distributes the products.[11] Alternatively, if consumers are not able to switch to other products, and if they do not want to forego the use of the products, then the incidence of the fee will fall primarily on consumers.[12]

Setting the Initial Fee, Evaluating Emissions Reductions Achieved, and Modifying the Fee

As noted, the purpose of the fee-based system is to provide incentives for reducing PROC emissions from consumer products. To achieve a goal of reducing emissions it is necessary to:

- identify an emissions reduction goal;
- predict how manufacturers and consumers would respond to a range of fee levels (e.g., the near-term and long-term changes in production and consumption of consumer products associated with various changes in product prices induced by the fee);

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[11] Technically, in this situation the incidence of the fee falls on the entities that own the inputs that go into producing and distributing the products. These entities include owners of the equipment used (i.e., the owners of capital) and the people employed in the industry (i.e., the owners of labor).

[12] For a review of the incidence of sales taxes (fees) see: Musgrave, R.A. and Peggy B. Musgrave, Public Finance in Theory and Practice, McGraw-Hill Book Company, New York, 1973, pp. 440-458.

- o estimate the levels of PROC emissions associated with the various manufacturer and consumer responses predicted for the fee levels; and

- o select the fee level required to achieve the emissions reduction goal over time.

The prediction of the consumers' and manufacturers' responses to the incentives must take into account the availability and cost of existing and potential future technological options and substitute ingredients, as well as the impact that price increases and other factors[13] would have on consumer demand.

Given this general approach, a fee or fee schedule that changes over time is selected that results in the desired level of PROC emissions reductions being achieved over time. As is often the case, it is preferred to phase-in the incentives over time, for example a fee that phases in gradually over five years. The phase-in is particularly valuable when setting an incentive fee. Because it takes time for manufacturers to develop alternative products with lower PROC emissions and for consumers to adjust to new products, an immediate large fee will have limited influence on PROC emissions. However, a phase-in period allows manufacturers to develop and introduce product modifications that reduce PROC emissions coincident with or in advance of the imposition of the fee. As a consequence, the phase-in period allows the fee to have the desired effect over time while reducing the amount of revenues collected during the phase-in period.

In practice, the factors used to predict the expected emissions reductions for various fee levels can only be estimated imprecisely. For example, the cost and availability of technologies for reducing PROC emissions will not be known with certainty. Because each of the technologies will be uncertain, the fee level needed to achieve a given level of emissions reductions will also be uncertain. As the analysis extends into the future (e.g., five to ten years) the uncertainties will generally increase.

Because there will be much uncertainty about the actual reductions that will be achieved for any given fee level, it is important to monitor and evaluate responses to the incentives over time and adjust the fee as necessary. This process of adjustment must balance off the objective of achieving the desired reductions in emissions with the need to provide clear and dependable incentives to manufacturers. Given that the fee is the incentive to develop new products and formulations with lower PROC emissions, manufacturers, for example, must be assured that the fee will

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[13] To be complete, the evaluation must take into account expected changes in the level of demand associated with: changes in the size and age structure of the population; changes in income; and changes in consumer preferences.

exist at a sufficiently high level over a period of time so as to warrant the introduction of new products and formulations.

One way to structure the overall process of developing, monitoring reactions to, and evaluating the level of the fee is to establish a formula for making regular adjustments to the fee based on the levels of PROC emission reductions achieved. For example, if insufficient emissions reductions are achieved, then the fee is increased by some amount. Making the adjustments automatic (e.g., requiring the adjustments at some interval), provides some certainty to manufacturers regarding the manner in which the fee would be modified. This certainty about the method used to revise the fee over time would help manufacturers plan their responses to the fee.

A second approach is to rely on periodic fee adjustments without specifying a formula for making the adjustments. Such adjustments would presumably be based on the levels of PROC emissions reductions achieved and market conditions, such as activities undertaken, industry trends, and likelihood of future innovation. If this approach is undertaken it would be appropriate to make the fee adjustments relatively infrequent (e.g., once every five years) so that a stable fee level is allowed to persist for a long enough period to allow manufacturers to plan.

This general approach for setting a fee level is driven by a goal of reducing emissions by some amount. It is assumed that the emissions reduction goal can be developed via some mechanism. There are at least two additional approaches for setting the fee level, including:

- o Marginal Costs of Additional Controls. A fee system for reducing PROC emissions for consumer products could be implemented as a companion program to other programs that exist for reducing emissions from automobiles and stationary sources of various types. The fee level for the consumer products economic incentive could be set at the marginal cost of achieving emissions reductions in these other programs. For example, if the existing programs have a marginal cost of additional reduction of $5,000 per ton emissions, the fee could be set at this level. By adopting this fee level, the methods of reducing emissions from consumer products that cost less than the costs of achieving additional reductions in the other programs would be undertaken.

- o Internalization of the Costs of Impacts. A fee system could also be used to increase the costs of consumer products to the point where their market prices reflect their true cost to society. Because the impacts of PROC emissions on the environment are not reflected in the current proces of these products, the current proces do not reflect the full costs of producing and using these products. The fee could be set so that the costs of the

environmental degradation associated with PROC emissions are included in the price of the product.

This approach for setting a fee is the traditional way in which environmental fees have been discussed in the economics literature. In practice the costs of the environmental impacts are not easy to quantify, and in many cases cannot be quantified. Consequently, setting the fee based solely on this consideration is not practical.

As a practical matter the fee level must be set while considering all the factors discussed above. In order to be useful, the fee should be set so that an appropriate amount of emissions reduction can be achieved. This evaluation would include an assessment of technologies that are available to reduce emissions and the potential impacts on industry and consumers. At the same time, care should be taken to ensure that the fee is set in a manner that is consistent with the costs experienced under other emissions reduction programs. Finally, the fee should not be many times larger than the perceived costs of the impacts of the emissions on the environment. Such a fee would be inefficient from a resource allocation perspective.

Use of revenues

A fee-based system will likely generate revenues beyond the cost of administering the program. The manner in which the revenues are used does not affect the incentive provided by the fee.[14] There are, however, several potential dispositions for these revenues. For example, revenues from the California Alcoholic Beverage Tax are used to administer the program, and as necessary, surpluses are transferred into the General Fund of the State. Alternatively, the California Cigarette Tax Fund apportions the balance of its receipts on a yearly basis to cities and counties within the state based on Cigarette Tax revenues from the same.

Several alternative uses of revenue generation from a fee-based system and their benefits include:

- Program Administration. Revenues generated by the fee-based system could be used to offset the cost to the state of operating the program and for the audit and record-keeping functions that the program would require.

- Air Quality Research. Revenues generated may be used to undertake research on methods for improving air quality or reducing emissions. However, if such expenditures were not anticipated to be undertaken in the absence of the fee-based

[14] The incentives will be intact so long as the revenues are not returned directly to the parties that pay the fee.

incentive system, the use of these funds in this manner can be appropriately considered to be a cost of the system.

- o Compensation to Harmed Parties. Funds could be used to compensate parties that are harmed by poor air quality. The benefits of collecting the revenues for this purpose should be evaluated in terms of the merits of making these revenue transfers.

Steps Necessary to Track Performance and Ensure Compliance

An important component of a fee-based incentive system is designing and implementing it to be monitorable, enforceable, and difficult or inconvenient to evade. Ensuring compliance with a fee on PROC-containing consumer products will require measures similar to those used by the Board of Equalization in ensuring compliance with the State Cigarette Tax and the California Alcoholic Beverage Tax. Common elements of such a program include:

- o reporting on a regular and frequent basis (monthly or quarterly) of products received or manufactured and delivered;
- o tracking and documenting information reported on product activities, including quantities of product manufactured and distributed, destinations, and specific recipients; and
- o enforcement against evaders, such as criminal prosecution and/or the imposition of fines.

For example, the State Cigarette Tax, collected by the Board of Equalization, is imposed on over 200 distributors both within and outside of California who distribute cigarettes within the state. Over 3000 agents of the Board throughout the state, while auditing retailers for sales tax compliance, also inspect the cigarette stocks for the required seal or stamp. Reports and remittances are documented through distributors' and manufacturers' invoices, and distributors are audited once a year. Evasion of the tax is subject to financial and criminal penalties.

Alternatively, the State Alcoholic Beverage Tax assumes that products removed from an internal revenue bonded facility by a licensed alcoholic beverage agent will be sold to a non-licensed or retail agent and are thus subject to the tax. All alcoholic beverage agents, therefore, must remit the proper tax with a monthly report, or prove that quantities delivered are not subject to the tax. These reports are audited by the Board, and evasion is a felony offense.

Implementation of such a compliance program will depend largely upon the point at which and the method by which the fee is collected. Specific alternatives for such a compliance program would track closely with the

selected point at which and methods by which a fee is collected and would be similar in form, as appropriate, to the two alternatives outlined above.

2.3.2 Fee-based Incentive System Selected for Detailed Analysis

The previous section describes a wide range of alternatives for each component of a fee-based incentive system. By combining the various alternatives for the components a variety of fee-based systems can be created. Exhibit 2-1 summarizes these alternatives and evaluates them in terms of the following:

- Efficiency: the extent to which resources are allocated efficiently in the economy.
- Equity: the extent to which the system would be perceived as fair.
- Ease of implementation: the relative difficulty of implementing the various alternative approaches.
- Emissions reductions: the reliability of achieving emissions reductions.

The choice of how to design the fee system will depend on the relative weights that are placed on these criteria.

As described in the exhibit, it is both easiest and most equitable to place the fee and collect the fee at the highest level of aggregation in the market. This level will likely be at the product manufacturer. Unfortunately, the act of "manufacturing" a consumer product is often not well defined. Instead, the act of placing ingredients into packages that are intended for sale in California would likely be the preferred "activity" on which to place the fee.

In terms of setting the fee level, the three main approaches each have pros and cons. Efficiency is best achieved when the fee is set to internalize the costs of the air quality impacts caused by the emissions. In practice, these impacts cannot be estimated well. For equity, setting the fee at the marginal cost of other controls is preferred. However, only the approach of setting the fee based on an emissions reduction goal will maximize the likelihood of achieving a given level of emissions reductions with the fee.

In practice all three considerations must be taken into account when setting the fee. For example, the fee level needed to achieve a given emissions reduction goal could be estimated. This fee could then be revised if it is significantly inconsistent with the marginal costs of other controls or if it is many times higher than the perceived costs of the air quality impacts caused by PROC emissions.

EXHIBIT 2-1
MAJOR ALTERNATIVES AND EVALUATION OF FEE-BASED SYSTEM COMPONENTS

Component/Option	Efficiency	Equity	Implementation	Emissions Reduction
<u>What the Fee is Levied on</u> Manufacture of PROCs for use in products sold in the state Manufacture of PROC-containing products Filling of PROC-containing products Distribution of products Retail sale of products	All the options identified will be equally efficient to the extent that they internalize the costs of the PROC emissions that result from the products.	Because manufacturers choose product formulations it will likely be perceived as most equitable if the fee is levied on the manufacture of products. Distributors, fillers, and retail sales outlet merely provide a service.	Implementation will be easiest for those activities that are centralized and easy to monitor. Consequently, distribution and retail sales will be the most difficult to implement. PROC manufacturing will be relatively difficult to implement because PROCs are used for many applications in addition to the manufacture of consumer products. The act of "manufacturing" is ambiguous and is not conducive to quantification and monitoring. Therefore, imposing the fee on the act of filling the product for intended sale in California will be the easiest alternative to implement.	All the alternatives will reduce emissions in approximately the same manner.
<u>Point at Which the Fee is Collected</u> PROC manufacturers PROC-containing product manufacturers Product fillers Distributors Retailers	All the options identified will be equally efficient to the extent that they internalize the costs of the PROC emissions that result from the products.	Because manufacturers choose product formulations it will likely be perceived as most equitable if the fee is collected from the manufacturers of products. Distributors, fillers, and retail sales outlet merely provide a service.	Implementation will be easiest if the fee is collected at a location that is centralized and easy to monitor. Consequently, distribution and retail sales will be the most difficult to implement. PROC manufacturing will be relatively difficult to implement because the PROC manufacturers would need to find out from their customers (the product manufacturers) how much PROC was used to make consumer products. Therefore, collecting fees from manufacturing or filling will be the easiest alternatives to implement.	All the alternatives will reduce emissions in approximately the same manner. Collecting the fee from retail sales establishments may provide additional information to the consumer that can produce additional emissions reduction due to increased consumer awareness.

Continued

EXHIBIT 2-1 (Continued)
MAJOR ALTERNATIVES AND EVALUATION OF FEE-BASED SYSTEM COMPONENTS

Component/Option	Efficiency	Equity	Implementation	Emissions Reduction
Setting the Fee Emissions reduction goal Marginal costs of other controls Costs of air quality impacts	Setting the fee to internalize the costs of air quality impacts will be most efficient, assuming that those costs can be estimated. The fee should not be set to a level that exceeds the likely magnitude of those costs.	Basing the fee on the marginal costs of other controls will likely be most equitable across various industries.	All fee levels pose the same implementation issues.	Setting the fee in a manner that is related to an emissions reduction goal will most likely lead to desired levels of emissions reduction. This goal is presumably set in conjunction with assessments about costs of control and costs of air quality impacts.
Revising the fee Self-adjusting formula Periodic adjustment	A well specified self-adjusting formula will help provide expectations about future incentives, and consequently can reduce uncertainty and the inefficiency that it causes. A discretionary adjustment at frequent intervals would cause the most uncertainty.	The manner in which the fee is revised does not pose equity issues.	A self-adjusting fee requires less intervention and consequently may be easier to implement. However, developing a satisfactory formula that will operate well over an extended period of time may be difficult.	Fee revisions will likely be necessary to ensure that emissions reduction goals are met. Even if a self-adjusting formula is adopted, it will likely require revision periodically to ensure that emissions reductions are achieved.
Use of the Revenues Program administration Air quality research Compensation to harmed parties State General Fund.	Using the revenues for program administration and transferring excess revenues to the General Fund will be most efficient because these revenues can displace other, more inefficient, sources of State revenue.	To be most equitable the revenues could be used for purposes related to the program, principally air quality research related to PROC emissions from consumer products. If fees were used broadly to achieve environmental goals, revenues could be used to compensate harmed parties.	Compensating harmed parties will be difficult to implement because it requires defining criteria for demonstrating harm, and requires administration of a program. Transferring revenues to the General Fund would be easiest to implement.	Performing research on PROC emissions from consumer products could help reduce emissions further in the future.

Continued

EXHIBIT 2-1 (Continued)
MAJOR ALTERNATIVES AND EVALUATION OF FEE-BASED SYSTEM COMPONENTS

Component/Option	Efficiency	Equity	Implementation	Emissions Reduction
Tracking and Compliance Reporting, tracking and documenting, and enforcement mechanisms appropriate for the manner in which fee is collected.	The manner in which tracking and compliance are performed does not pose efficiency issues.	Because manufacturers choose product formulations it will likely be perceived as most equitable if the tracking and compliance burden falls upon the manufacturer. Distributors, fillers, and retail sales outlets merely provide a service. In order to be equitable, the compliance program must ensure that the fee cannot be evaded with impunity.	The tracking and compliance efforts must be focused on those parties that are responsible for paying the fee and moving the products to market.	If inadequate tracking and compliance activities are undertaken, emissions reduction may be jeopardized.

In terms of revising the fee over time, some revisions will likely be required. While a formula for adjustment may reduce uncertainty and improve efficiency by establishing expectations, we believe that developing a formula that will achieve these benefits will be difficult. Consequently, it is our judgment that the fee should be revised periodically as part of a public process. The revisions should not be too frequent, because frequent adjustment will create uncertainty, and the downward adjustments should not be too large, because the possibility of future downward adjustments will make investments in new technologies less attractive.

Finally, to be most efficient it is recommended that the revenue from the program that exceeds the cost of running the program be transferred to the State's General Fund. Research and compensation programs that are related to air quality should be evaluated on their own merits and need not be linked to the incentive program.

Based on these assessment a fee-based incentive system with the following components is evaluated in detail in this study:

- fee levied upon the activity of placing ingredients into packages that are intended to be sold in the state (e.g., aerosol containers), with the fee payment equal to the fee level times the amount of PROCs placed in the packages;
- collection of the fee from product manufacturers;
- phased in fee set to achieve an emissions reduction goal, with assessment of market activity and further adjustments after a moderate predetermined time (e.g., 5 years);
- revenues to be used for operation of the program, with the balance of revenues transferred to the State General Fund, as necessary; and
- compliance program that includes quarterly reporting and tracking, with spot-checking and yearly audits.

2.4 QUOTA-BASED INCENTIVE SYSTEM

Unlike a fee-based system, a quota-based incentive system would impose a limit on the level of PROC emissions that are allowed from consumer products. A quota-based incentive system can be defined broadly to include any system whereby a central authority establishes a firm overall limit for a clearly defined and monitorable product or activity. Independent decision makers are given flexibility in deciding how best to operate within the constraints of the quota limit.

The principles that form the foundation for the use of quota-based incentives for environmental protection are the same as those discussed above for fees. The key attribute of this incentive system is the limit that is established by a central authority. In this study the limit relates to PROC emissions from consumer products. In practice, a quota system aimed at reducing PROC emissions would likely limit the use of PROCs in products, as opposed to limiting the emissions of PROCs by consumers.

A quota incentive system works best when the quota is allocated to its most highly valued uses. In this case such an allocation would mean that the PROCs that are allowed to be used and emitted are in fact used in the products that "need them most." In the field of economics, these products are defined as those products for which consumers are most willing to pay. As discussed below, there are several alternatives for allocating the quota among products and companies.

The quota-based system provides incentives for manufacturers to change their products so that they do not require PROCs because the availability of PROCs is limited. As with the fee incentive, this limitation on the use of PROCs causes manufacturers to change their inputs to production, and also provides incentives for developing new technologies that do not rely on PROCs.

The primary difference between a quota and a fee is that a quota sets a firm limit on the use and emissions of PROCs, whereas a fee does not. Because the quota is firm, the cost of the program is uncertain. For example, if low cost options for reducing the emissions turn out not to be practical, the cost of attaining the quota may be larger than expected. This is result is contrasted with a fee where the costs are fairly well known but the level of emissions reduction achieved is uncertain.

In the following section, the major components of a quota-based system are discussed along with a range of alternative designs for each of the components.

2.4.1 Major Components

The major components of an economic incentive system that operates through a quota on an activity or product include:

- what the quota is placed upon;
- initial allocation of the quota and the level of the quota;
- trading the quota; and
- evaluating emissions reductions and revising the quota.

In addition, the steps necessary to track the performance of the incentives and to ensure compliance must be established. In the five sections below we describe each of these components and the range of alternatives available for each.

What the Quota is Placed On

A quota-based incentive system imposes a limit on some specific product or activity. In the case of incentives for reducing PROC emissions from consumer products, the quota could be applied to a range of products and activities, including:

- o the manufacture of PROCs that are sold for inclusion in consumer products that are subsequently sold in the state;
- o the amount of PROCs placed in packages as consumer products for sale in the state;
- o the distribution of consumer products to retail outlets; or
- o the retail sale of consumer products.

As with the fee, the choice of the activity or product on which to base a consumer-product-PROC-quota is driven, in part, by the ease of monitoring the activity or counting the product. Consequently, retail sale is not likely to be preferred. Because the quota relates to the amount of PROCs placed in products, the placing of PROCs in packages as consumer products may be the most appropriate activity for the quota. This activity may be preferred to the manufacture of PROCs (which are used for purposes other than consumer products) and the distribution of products (which may be less centralized than packaging).

Quota Allocation and Level

The objective of a quota-based incentive system is to allocate the quota to its most highly valued uses. In practice this is done by distributing pieces of the quota, or allowances, to entities who would use their allowances to meet the mostly highly desired consumer demands for products. The manner in which the allowances are allocated initially will influence how consumer demands are met in the short term. However, if the allowances can be traded among parties, then in the long run the allocation of allowances should move toward their most highly valued uses.

In allocating the allowances, one must identify the entities required to hold allowances, and the manner for distributing them. The choice of which entities are required to hold allowances is related to the activity on which the quota is placed. If the quota is placed on retail sales, then retailers may be required to hold quota allowances in order to sell the products. Similarly, distributors may be required to hold allowances if the quota applies to the distribution of products. If the quota applies to

placing ingredients in packages, then the allowances may be required by either packagers or manufacturers. Given that the manufacturers are responsible for product formulations, it may be preferred to require the allowances of the manufacturers.

There are two main methods by which the allowances may be allocated initially:

- Allocation Based on Historical Patterns. Using this approach, allowances are allocated based on historical activities. To perform this allocation, definitive data on past activities must be collected, for example, by requiring all parties who feel that they should receive an allowance to report on past levels of activity. Based on these reports (and verifications of them), allowances are allocated in proportion to levels of historical activities.

  Setting the allocation based on some prior level minimizes the opportunity for firms to benefit from "strategic behavior" prior to implementation of the system. Additionally, it does not generate revenues from firms unless a "processing fee" is charged for the entities that receive the allowances. This alternative does, however, make entry into the market difficult for new firms, and does not account for recent changes or trends in the industry.

  Trends in the industry can be accounted for by collecting data on several years of product sales, and allocating allowances in a manner that reflects the observed trends. It may be more difficult to reduce the barriers that allocation based on historical sales creates for new entries into the market. One way to do so would be to set aside a portion of the allowances for new entities. These allowances could be allocated to new entities that demonstrate that they have a competitive product with reduced levels of PROC emissions. If applications for these set aside allowances grew, the quota could be modified so that a larger fraction was provided for these set asides. Given the manner in which consumer products are manufactured and marketed nationally and regionally in the U.S., it is unlikely that a very larger portion of the PROC quota would need to be set aside in this manner.

- Auction. Initial allocation of allowances through an auction requires entities that desire allowances to bid for them. Various auction schemes are possible, including: sealed bid auction; ascending price public or secret auction; and descending price public or secret auction. Additionally, there are a variety of options for structuring the auction, including:

-- establishing auction participation limitations, such as restricting participation to those entities that would require allowances;

-- setting minimum bid requirements;

-- setting aside portions of the allowances to be made available to small businesses at the average auction price;

-- choosing the method of conducting the auction, such as in person, electronically, or by mail.

The primary advantage of an auction is that it may allocate the allowances more efficiently than would an allocation based on historical patterns. This efficient allocation would be of particular concern if an aftermarket for trading the allowances was not anticipated (see below).

An auction, however, collects revenue and requires an administrative procedure. Additionally, it can create uncertainty among industry because the availability of allowances will be contingent on bidding successfully in the auction.

Given the potential uncertainties created by an auction, initial allocation based on historical patterns may be most appropriate. This initial allocation may be the only time that the allowances are distributed by the state. In this case, revisions to the quota would be implemented by changing the value of the initial allowances, for example each pound of PROC emissions would be reduced to 0.5 pounds as of a given date. Such changes can be planned in advance, for example at the time the allowances are initially allocated.

The initial level of the quota should be set based on the level of emissions reduction desired and the costs and technical feasibility of achieving those reductions. For a range of potential quota levels, data should be collected to predict the way manufacturers and consumers would respond to restrictions on the availability of PROCs. This prediction, which will necessarily be somewhat uncertain, would describe the feasibility of reducing emissions and the costs of implementing the emissions reducing technologies.

To be efficient, the quota should be set so that the marginal costs of reducing emissions equals the marginal cost of the air quality impacts caused by the emissions. As described above for fees, in practice it is not possible to estimate the marginal cost of the air quality impacts. In this case there is also uncertainty surrounding the marginal cost of reducing emissions to any given level.

Given that it is not possible to equate marginal costs precisely, the initial level of the quota could also be based on estimates of the

technical feasibility of achieving reductions and/or by equating the marginal cost of emissions reductions with the marginal cost of reducing emissions from other sources such as stationary sources and automobiles. As with fee, in practice the quota level would be set to some extent based on all of these considerations.

The recently implemented restrictions on chlorofluorocarbon (CFC) production in the U.S. uses a quota mechanism with initial allocation based on historical patterns of production.[15] Under this program, CFC producers reported their 1986 production confidentially to the U.S. Environmental Protection Agency. The production quota was allocated to the existing producers based on these reported amounts, along with a schedule of how the quota would be reduced over time.

Initially, the CFC allocations are set at 100 percent of 1986 production and imports. In the future the quota drops to 80 percent and then 50 percent of the initial allocation. The initial level of this quota, and the subsequent reduction in the quota was adopted through international negotiations in 1987. Since that time discussions have been initiated that will likely lead to a downward revision in the CFC quota.

Trading Quota Allocations

The trading of quota allowances among parties is referred to as the "aftermarket." A working aftermarket helps to ensure that the quota is used in the most efficient manner, i.e., that the PROC emissions that are allowed under the quota are used in their most highly valued uses. Alternative "aftermarket" designs include: allowances transferable with no restrictions; allowances transferable only at specified times and/or with limited restrictions; or allowances not transferable or only under exceptional circumstances, as allowed by the administering agency.

The ability of an aftermarket for the allowances to facilitate transfer of the allowances effectively and efficiently is affected by several factors, including: the availability of information to the participants; the cost of transferring the allowances; market concentration; and the rate of technological change. If the information on who holds allowances is not well known, then an aftermarket will not work well. Similarly, automatic devaluations of the allowances that are triggered by transfers among parties introduce a transactions cost that may hinder the working if the aftermarket.[16] If a small number of parties has significant market power

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[15] Protection of Stratospheric Ozone, Final Rule, Federal Register, Vol. 53, No. 156, August 12, 1988, pp. 30566-30602. See Appendix G.

[16] For example, the South Coast District guidelines for point source emissions of Reactive Organic Gases (ROGs) discount by 10 to 50 percent the credits (emissions offsets) transferred from one permitted holder to another. These discounts reduce the value of the permit: (1) because it has been

the aftermarket may not work well. Finally, if the technical options for reducing PROC emissions change quickly, the aftermarket may not allocate the quota quickly enough to enable the PROC emissions to be used most efficiently.

Generally, the greater the flexibility manufacturers have in transferring the allowances, the better the aftermarket. For this reason, alternative designs that provide greater freedom in transferring allowances are generally preferred. However, allowing transfer of allowances only at specified times (e.g., January of each year) would institutionalize a planning time frame that would likely encourage firms to analyze once a year the advantages of buying or selling allowances. Such an approach would, therefore, likely reduce some of the information barriers of allowance transfers by creating a market of buyers and sellers at the same time each year.

Evaluation and Revisions of the Quota

Unlike a fee-based system, a quota ensures that a given emissions reduction goal will be achieved. Consequently, the evaluation of the incentive system would instead focus on impacts on consumers and the industry. If the impacts were too large to be justified, a loosening of the quota may be warranted. Alternatively, a tightening of the quota may be appropriate if additional emissions reductions are required, and if impacts are not large.

Such adjustments could be precipitated by unforeseen impacts on industry or the environment, emergence of a new technology or alternative, or new information about PROCs or their impacts. Such adjustments would require further analysis of the market impacts of the quota, and would likely require analysis of the specific firms and applications to which the allowances are allocated. It is likely that much of the information necessary for such analysis could come from information reported by the firms for compliance purposes.

Steps Necessary to Track Performance and Ensure Compliance

An important component of a quota-based incentive system is designing and implementing it to be monitorable and enforceable. As with the fee-based incentive system, ensuring compliance with a quota on the use of PROCs in consumer products will require a program that includes:

- monitoring and reporting PROC ingredients manufactured, received, packaged, or used in consumer products to ensure that those holding allowances use no more than allowed;

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transferred to another party; (2) to account for the distance the emissions offset credit is moved from the location of the original holder; and (3) to account for degradation over time.

- o tracking and documenting information reported on product activities; and

- o enforcement against violators for exceeding their allowed usage of PROCs in consumer products.

Implementation of a compliance program will depend largely upon the design of the quota system. Regular reporting, auditing, and inspection will likely be required.

2.4.2 Quota-based Incentive System Selected For Detailed Analysis

The previous section describes a wide range of alternatives for each component of a quota-based incentive system. By combining the various alternatives for the components a variety of quota-based systems can be created. As described above for fee-based incentives, Exhibit 2-2 summarizes these alternatives and evaluates them in terms of efficiency, equity, ease of implementation, and emissions reduction. The choice of how to design the quota system will depend on the relative weights that are placed on these evaluation criteria.

As described in the exhibit, it is easiest to base the quota on the filling of packages with ingredients that intend to be sold in California. The manufacturer would be require to hold the quota allowances in order to fill, or contract to fill, packages of products that were intended for sale in California.

The initial allocation of the quota will require close attention regardless of which approach is taken. The primary drawback of allocation based on historical patterns is the potential inefficiency and inequity caused. In particular, the barriers to potential new entrants to the market caused by this approach could be very important. To ameliorate these problems, set asides could be established for allocation to new entrants with promising low-PROC products. This approach increases the burden of implementing the program, however.

The improved efficiency that may be realized by allocating quota allowances with auctions may not be realized if there is a lot of uncertainty regarding the value of the quota or if a small number of firms dominate the auction. The uncertainty is likely to be important because there currently is no market experience for these quota allocations.

As described in the exhibit, it is important to encourage a well operating aftermarket for trading the quota allocations. Nevertheless, it will be necessary to track the ownership of the allowances for tracking and enforcement purposes.

EXHIBIT 2-2
MAJOR ALTERNATIVES AND EVALUATION OF QUOTA-BASED SYSTEM COMPONENTS

Component/Option	Efficiency	Equity	Implementation	Emissions Reduction
<u>What the Quota is Placed Upon</u> Manufacture of PROCs for use in products sold in the state Manufacture of PROC-containing products Filling of PROC-containing products Distribution of products Retail sale of products	All the options identified will be equally efficient to the extent that they allow the PROCs to be allocated to their most highly valued uses. This efficiency will depend on a well operating aftermarket (see below).	Because manufacturers choose product formulations it will likely be perceived as most equitable if the quota restricts the manufacturers. Distributors, fillers, and retail sales outlet merely provide a service.	Implementation will be easiest for those activities that are centralized and easy to monitor. Consequently, distribution and retail sales will be the most difficult to implement. PROC manufacturing will be relatively difficult to implement because PROCs are used for many applications in addition to the manufacture of consumer products. The act of "manufacturing" is ambiguous and is not conducive to quantification and monitoring. Therefore, imposing the quota on the act of filling the product for intended sale in California will be the easiest alternative to implement.	All the alternatives will reduce emissions in approximately the same manner.
<u>Initial Allocation of the Quota</u> Based on historical patterns Auction Set asides	Assuming that a competitive auction can be held, an auction will be more efficient than allocation based on historical patterns. However, uncertainties will limit the efficient workings of the auction. Set asides for new entrants can help alleviate the barriers to entry caused by allocating the quota based on historical patterns.	Allocation based solely on historical patterns will be inequitable to potential new entrants with good low-PROC products. Set aside programs may also be inequitable if they are perceived as providing an unfair advantage to some groups. Auctions may be perceived as unfair if large national producers are able to outbid local and regional producers due to their larger financial resources.	Each method has its pros and cons. Allocation based on historical patterns requires collecting definitive data on past sales. Such data can be reported by manufacturers, but will require close scrutiny and verification. An auction system will require a bidding system and, because it involves obtaining revenues, will likely require close attention. Set aside programs will require developing criteria for distributing the set aside and will require an approval system.	All the alternatives will reduce emissions in approximately the same manner. A set aside program could potentially spur innovation from new entrants, thereby creating techniques for reducing emissions at lower cost.

Continued

EXHIBIT 2-2 (Continued)
MAJOR ALTERNATIVES AND EVALUATION OF QUOTA-BASED SYSTEM COMPONENTS

Component/Option	Efficiency	Equity	Implementation	Emissions Reduction
Setting the Quota Emissions reduction goal Expected costs equal to marginal costs of other controls Expected costs equal to costs of air quality impacts	Setting the quota to equate marginal costs with the costs of air quality impacts will be most efficient, assuming that those costs can be estimated. The quota should not be set to a level such that the costs of reducing emissions exceeds significantly the likely magnitude of the costs of the air quality impacts.	Setting a quota so that the marginal costs of reducing emissions are expected to equal the marginal costs of other controls will likely be most equitable across various industries.	All quota levels pose the same implementation issues.	Each quota level will lead to its stated reductions. If costs of control turn out to be unexpectedly excessively high, subsequent revisions to the quota may be needed.
Trading of the Quota Transferable with no restrictions Transferable at specific times and/or limited restrictions Not transferable, or under exceptional circumstances	A well working aftermarket is important for efficiency. Consequently, the fewer restrictions on transfers the better.	Making the quota allocations transferable improves the equity of the program. Prohibiting all transfers after basing the initial allocations on historical patterns would be most inequitable.	At a minimum it will be important to track the ownership of the quota allowances. Therefore, it will be important to track all transfers of the allowances. Requiring prior approval for transfers will increase the burden for implementing the program.	Trading in the aftermarket will not affect the emissions reduction achieved, but will influence the cost of achieving the emissions reduction.
Revising the Quota Evaluation based on industry and environmental impacts	If inefficient resource allocations are being made then the quota or the quota system could be revised; for example, if a small number of manufacturers dominate the aftermarket and the market is not competitive. Revisions to the quota system should take into account people's expectations that have developed under the quota system.	If the set aside programs do not allow promising entrants to enter the market with good products, then the system could be revised.	Revisions to the system have the same implementation issues as the original system.	Revisions to the level of the quota will influence the emissions reductions directly.

Continued

EXHIBIT 2-2 (Continued)
MAJOR ALTERNATIVES AND EVALUATION OF QUOTA-BASED SYSTEM COMPONENTS

Component/Option	Efficiency	Equity	Implementation	Emissions Reduction
Tracking and Compliance Reporting, tracking and documenting, and enforcement mechanisms appropriate for the manner in which fee is collected.	The manner in which tracking and compliance are performed does not pose efficiency issues.	Because manufacturers choose product formulations it will likely be perceived as most equitable if the tracking and compliance burden falls upon the manufacturer. Distributors, fillers, and retail sales outlets merely provide a service. In order to be equitable, the compliance program must ensure that the quota cannot be evaded with impunity.	The tracking and compliance efforts must be focused on those parties that are responsible for holding quota allowances and moving the products to market.	If inadequate tracking and compliance activities are undertaken, emissions reduction may be jeopardized.

Based on these considerations, a quota-based system with the following components is evaluated in detail in this study:

- quota placed upon the activity of placing ingredients into packages that are intended to be sold at the retail level in the state (e.g., aerosol containers) with the level of the quota set to the desired level of PROC emissions (presumably, declining over time);

- initial allocation of the allowances to product manufacturers based on historical usage of PROCs in consumer products, estimated from confidential reports from industry to the state, with a portion set aside for new entrants with promising low-PROC products;

- an aftermarket for the allowances that allows free transfer of the allowances at any time among manufacturers of the covered consumer products, with reports of the transfers provided to the implementing agency;

- monitoring of industry activities through a self-reporting program, with certification of product contents at time of packaging and annual audits; and

- evaluation of the effects of the quota allocation at some pre-specified interval after initial allocation with further reductions and revisions, as appropriate.

3. HAIR SPRAY AND SPRAY PAINT MARKETS IN CALIFORNIA

This section describes the structure of the markets for hair sprays and spray paints in California. For purposes of this analysis the market structure includes:

- the manner in which organizations perform the necessary activities to bring these two consumer products to market; and
- the "market power" the major players in these markets may exert over the sales and pricing of these products.

The structure of these markets will, in part, dictate the feasibility and effectiveness of alternative economic incentive systems for reducing PROC emissions from the products.

First, a general overview, with specific examples outlined, of the market structure for aerosol and pump spray consumer products is provided. Then the California markets for hair sprays and spray paints are described.

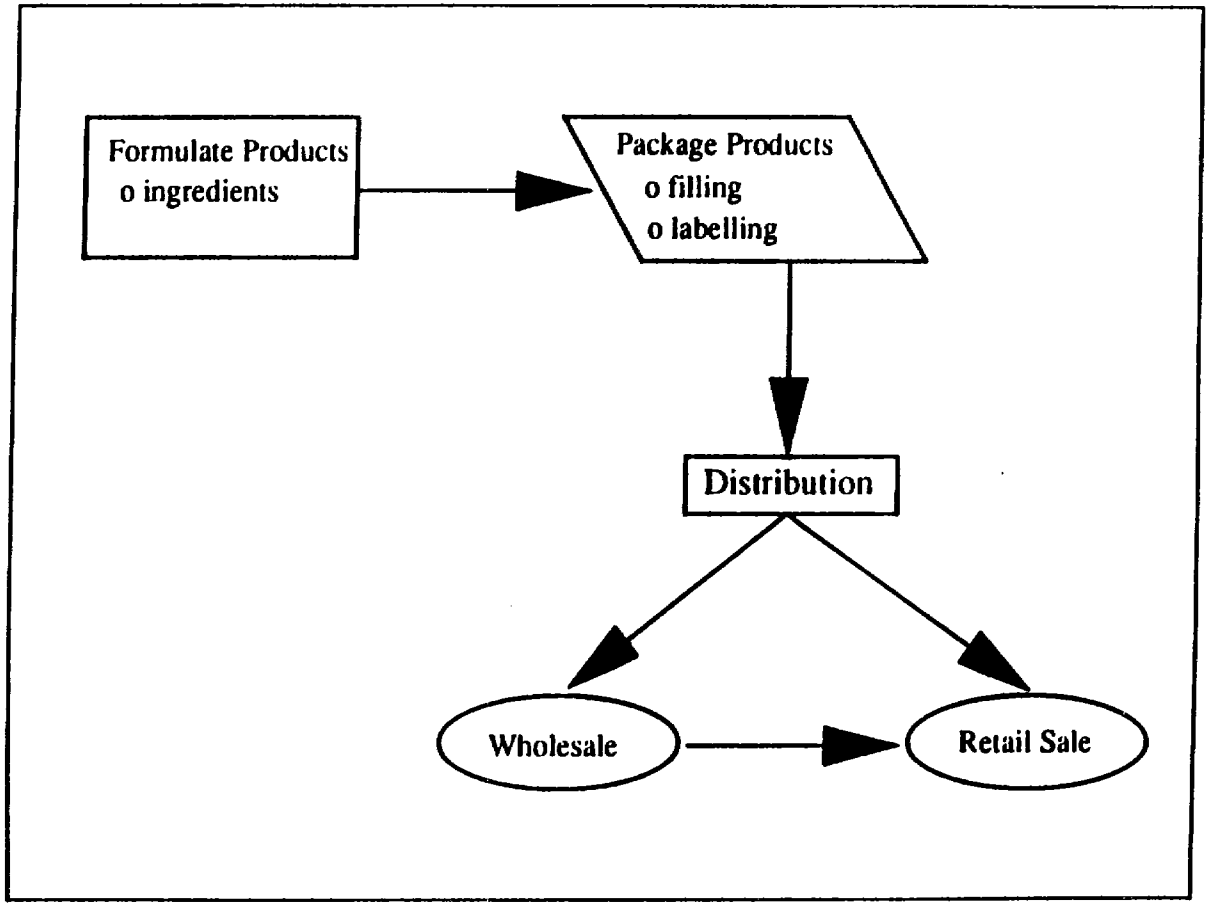
3.1 MARKET STRUCTURE

Market structure refers the way in which products are produced, packaged, labeled, distributed, and sold to consumers. The major market activities in this process (Exhibit 3-1) for aerosol and pump spray products include:

- formulating products, including development of active ingredients, product formulas, and delivery systems;
- packaging products, including filling pressurized and non-pressurized containers with product formula, labelling containers, and packaging individual containers for shipment and distribution;
- distributing products to regional and local distributors, wholesalers, and retail establishments; and
- wholesale and retail sale of products to institutional and consumer users.

EXHIBIT 3-1

ACTIVITIES IN PUMP SPRAY AND AEROSOL PRODUCT MARKETING PROCESS



Each of these activities is undertaken by organizations of various types and sizes, including:

- o marketers who formulate and develop products for sale to consumers (e.g., Clairol, Revlon);
- o fillers who mix product formulas and/or fill containers for marketers;
- o shippers, distributors, and wholesalers who transfer products in various forms to retail establishments; and
- o retailers who are the final point of distribution to most consumer users.

Of note is that some marketers also do filling, distribution, and in some cases, retail sales. Often fillers are involved in shipping and distributing as well.

Market structure also refers to the degree of concentration of these activities in a small number of organizations. If the market is highly concentrated, then there may be one or several major manufacturers that exercise considerable influence over market prices (e.g., that may act as "price leaders"). Where a relatively large number of firms exist that each sell a relatively small share of a generally homogenous product, the market is often referred to as a competitive market. In a competitive market, no one firm has significant market power, i.e., no single firm can successfully raise the price of their product relative to their competitors. In such cases, each firm must price its products competitively due to the availability of comparable substitutes from other firms.

Aerosol paints and hair sprays have similar market structures in California which appear to be highly competitive. The market for these products can generally be divided into the following three segments:

- o Large National Marketers. There are large marketers throughout the U.S. that develop, fill, and market their own hair spray and spray paint consumer products under nationally recognized brand names. As a group these companies generally hold a large share of the national market and sell their products in all regions. Individually, no single firm has a large share of the national market or of the California market. Some of these firms perform several roles, acting as manufacturer, filler, and distributor. Other firms focus on formulating products and use independent (i.e., contract) fillers and distributors.
- o Medium Sized National and Regional Marketers. A larger number of medium sized firms exist nationally and regionally. These firms

generally perform the same activities as the large national marketers, but may not market all their products nationally or in as wide a range of retail locations. The products produced by these firms may also serve a specific retailer as a "store brand" (e.g., K-Mart, Super-Value). In this case these products are not wholesaled or distributed to other retail outlets.

- o Specialty Products. Finally, a product may be of a specialty variety, formulated and marketed by smaller firms to serve a select market or location. These products are usually destined for a small number of specific retail or institutional outlets.

3.1.1 Market Activities in California

Marketing/Manufacturing

An estimated 80 to 85 percent of all spray paints and 70 to 80 percent of all hair sprays sold in the U.S. are manufactured east of the Mississippi River. Large national marketers usually truck or otherwise ship a fraction of their products from the east coast to the west coast for final distribution. For example, Revlon manufactures and fills all of its own products at a plant in Edison, New Jersey that also serves as Revlon's distribution headquarters. The products are packaged and sold directly from New Jersey to outside vendors, retail outlets, salons, and wholesalers.

Manufacture of both hair sprays and spray paints does occur in California, mostly for distribution in the nine western region states[17]. There are approximately 30 marketers/manufacturers of spray paint and hair spray products in California, most of which are medium and smaller firms. Based on discussions with industry representatives, these firms account for roughly 30 percent of the hair sprays and spray paints sold in California.

Filling and Packaging

Currently, there are only about 19 filling operations in California that fill hair sprays and spray paints.[18] Of these, only 6 are contract fillers. Contract fillers mix, pressurize, fill, and package products for manufacturers who have contracted with them. The marketer will send the

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[17] The western region is composed of Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.

[18] There are approximately 20 aerosol fillers in the state. However, based on discussions with representatives of the filling industry, only about 12 fillers have recently filled hair sprays or spray paints. Other products filled may include pesticides, household cleaning products, and automotive cleaners and accessories.

formula (mixed or unmixed) to the filler who fills an agreed upon number of containers with the product. The process of filling the containers is often referred to as a production run. Such production runs, depending on the product, can account for between one month and one year worth of sales for the marketer. For example, National Aerosol Products, a contract filler located in Los Angeles, receives a dispersion of a half completed product (e.g., spray paints or hair sprays) from the manufacturer, tints the product as needed, adds the aerosolizing ingredients, fills the containers, packages the products, and ships them to the distributor that the marketer has chosen.

The other 13 filling operations that fill hair sprays and spray paints in California are owned by marketers/manufacturers for filling their own products. These filling lines operate in the same manner as contract fillers, and most of these marketers also fill products for other firms that do not have their own filling operations on a contract basis in the same manner as contract fillers.

Distribution

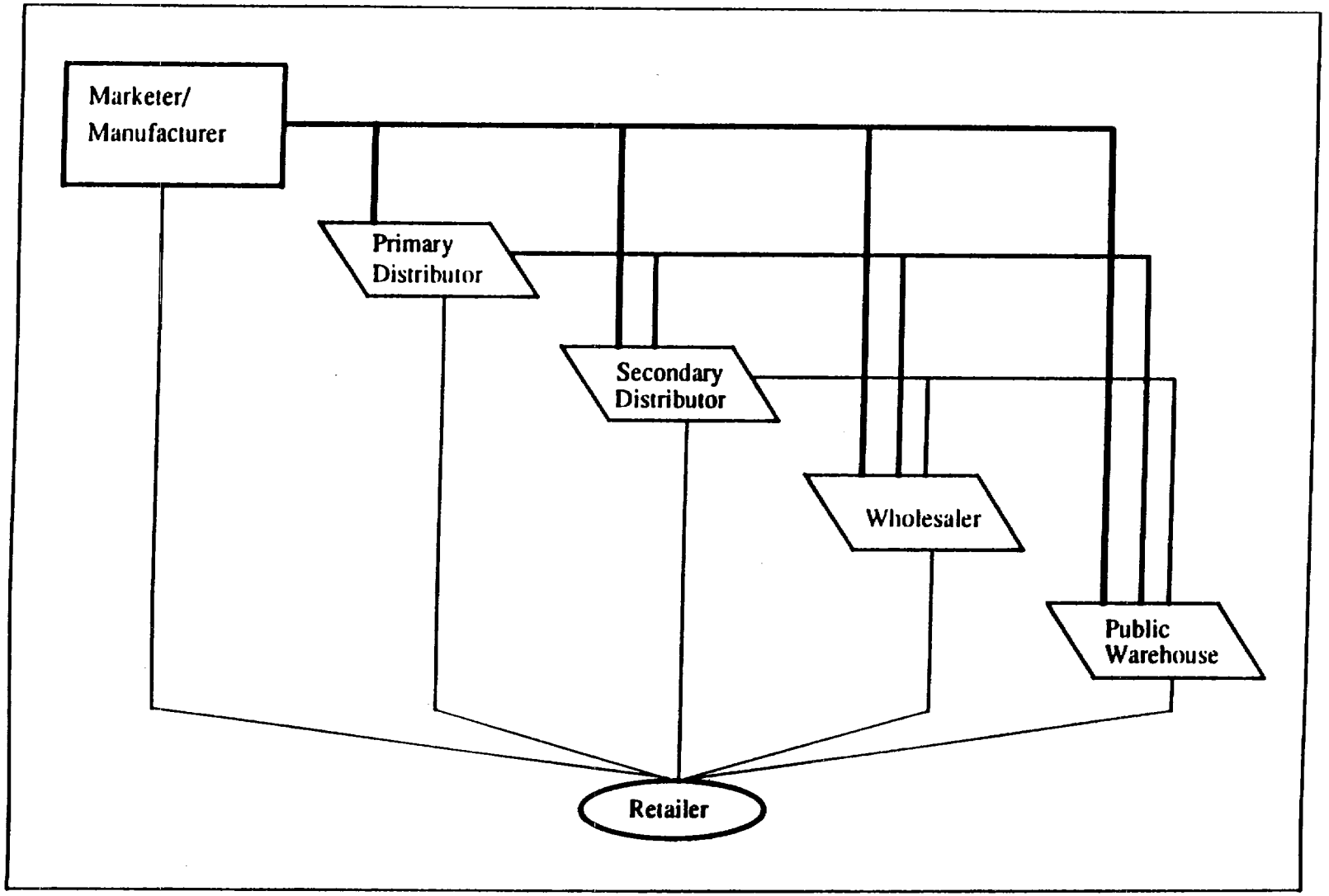
Distribution is an intermediary step in the product marketing process that may be performed by any organization in the marketing process, and is often performed several times before a product reaches a retail shelf. A conceptual flow diagram of the distribution process is presented in Exhibit 3-2. Generally, if a marketer fills its own containers, then the marketer initiates the primary distribution, and products are shipped from the marketer to distribution centers or directly to wholesalers and retailers. If a marketer employs a contract filler, then either: (1) the products will be shipped by the filler to the distributor that the marketer requests; or (2) the marketer will engage a distributor to pick up the products from the filler.

Once primary distribution is initiated, the product may be shipped directly to a retail outlet, sold to a warehouse or wholesaler who would then complete the final sale to retailers, or shipped to a regional distribution center that may distribute it directly to retailers or to other territory distributors and wholesalers.

Large marketers often own their own distribution centers, but portions are often leased out to other marketers for maximum efficiency and cost savings. Some distribution centers are operated by retailers (such as K-Mart, Kresgee stores, A&S). Some marketers do not own distribution centers, and instead ship directly to public warehouses from which retailers' trucks transfer goods to stores. Medium- and smaller-sized firms sometimes ship directly to retail outlets, without using a wholesaler.

EXHIBIT 3-2

CONCEPTUAL FLOW OF DISTRIBUTION PROCESS



Other distribution centers include public warehouses where retailers can pick up products, and wholesale/rack-jobbers[19] who purchase products from marketers and distribute directly to retailers. Marketers also ship truckloads (one product or a mix of products) directly to warehouses owned by retailers. Marketers of national brand name products generally do not make direct deliveries to retail outlets, using some form of distributor or wholesaler instead. Three examples of varying distribution structure are as follows:

- Alberto Culver Company, the marketer of VO-5 hair spray products, has a large distribution center (semi-private warehouse) in Sparks, Nevada from which they make subsidiary distributions to locations in the nine western states. A typical shipment might consist of 21 different products in one truckload, directed toward the Super-Value warehouse in Los Angeles, which supplies Super-Value stores in Southern California.

- Amway Corporation maintains a central warehouse and distribution center in Ada, Michigan, and seven satellite distribution centers around the U.S. (which they own). One of these is located in Orange County. Amway sends products to the California distribution center via rail, and sometimes truck. Mixed truckloads of products are shipped from the distribution center to subsidiary distribution points, which also house special packaging facilities so that products can be collected and boxed and mailed to retail customers. Amway products are not sold directly in retail outlets.

- Carter-Wallace Products Corporation, based in Cranberry New Jersey, ships aerosol products to their Obispo Beach distribution center via ship. These are then trucked 6 miles from the dock to the California distribution center (235,000 square feet), where other non-Carter-Wallace products are also stored. Mixed truckloads of Carter-Wallace and non-Carter-Wallace products are then transported to supermarket warehouses, drug stores, small independent stores, and other outlets.

The number of distribution centers in california that distribute hair sprays and spray paints is approximately 135, most of which also distribute many other products. Distributors that serve a specific retail chain are likely to have many products, including non-aerosol products. Few distributors carry only one product from one marketer/manufacturer. Distribution centers typically range from 40,000 to 500,000 square feet.

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[19] Rack-jobbers are responsible for making sure that a store's shelves are adequately stocked with a particular product.

Wholesalers and Retailers

Wholesalers make the final link between the marketer (distributor) and the chain or outlet that generally sells products to the consumer. As discussed above, not all products utilize wholesalers in the distribution process. Wholesalers generally buy products directly from the marketer/manufacturer, eliminating other levels of distribution to cut distribution cost. Wholesalers distribute mostly to smaller and non-chain outlets that would not normally be able to get a direct delivery from the manufacturer. By cutting out other levels of distribution, a wholesaler can often charge a lower price than these outlets would have otherwise paid.

As noted above, some wholesalers also perform a rack-jobber function, but this is not as common with hair sprays and spray paints as it is with other consumer products. Because of the competitive nature of the market for these products and the extra cost that rack-jobbing adds to the purchase price of the product, most retailers avoid this activity. In addition, the use of Universal Product codes (UPC), now available on most retail products, and UPC scanners has reduced the need for rack-jobber activities by automating the inventory processes.

3.1.2 Market Activity Costs

The cost of moving an aerosol product through the distribution system to the store shelf depends upon the volume of containers shipped, the distance shipped, and the number of activities or handlers involved. Because aerosol paints and hair sprays are handled very similarly, the example of market activity costs presented in Exhibit 3-3 can be applied to both hair sprays and spray paints.

If a can of aerosol paint has a factory cost of $0.65, the cost to get that can through the distribution system to the store shelf is reported to be between $0.25 and $.60, depending upon the number of trips through the system, the distance traveled, and (most importantly) the number of cans (volume) in the transfer (Johnsen, 1989). Typically, larger shipments spread the fixed cost of transport vehicle costs over more products, lowering the average cost per container transferred. Shipping and distributing is typically considered to have a high profit-margin for individual shipments, with direct costs being about 40 to 75 percent of income.[20] Manufacturers are generally willing to pay a premium for the services of the existing distribution network because it would be costly for a manufacturer to set up filling, packaging, and distribution operations in all locations where a product is finally marketed.

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[20] This is not to imply that competition does not maintain appropriate prices for shipping and distribution. Instead, there are indirect costs of maintaining a shipping and distribution system that are recovered through relatively high profit margins on direct costs of individual shipments.

EXHIBIT 3-3

EXAMPLE OF MARKET ACTIVITY COSTS

	Activity	Cost ($/can)
a.	Manufacturer's cost (factory cost, including ingredients, packaging, and filling)	$0.65
b.	Manufacturer's gross profit (20 to 30 percent)	$0.20
c.	Distributor's costs ($0.15 to $0.25 per can)	$0.20
d.	Distributor's gross profit (25 to 30 percent of total cost)	$0.25
e.	Retail markup (90 to 100 percent)	$1.19
	Final selling price to consumer	$2.49

Source: Johnsen (1989).

If a distributor is required to do rack-jobber functions (keeping the store shelves supplied with the products he handles) then the distribution costs increase considerably (50 to 100 percent). If the initial distributor is obliged to pass a product through a secondary distributor, costs increase as the second firm takes their piece of the valuation (another $0.35 to $0.60 per can). This happens more for hair sprays than for paints, and is increasingly rare as many specialized distribution organizations have developed for delivering products directly to retail outlets from manufacturers.

3.2 HAIR SPRAYS

For purposes of this analysis, hair sprays are defined as products delivered as an atomized mist that are generally applied to dry hair to provide hold to a specific hair style. Both pressurized aerosol cans and plastic pumps fall into this definition. Foams, also known as styling mousses, are not included in this definition of hair sprays as they are usually applied to wet hair to aid the styling process (CSMA 1986). This analysis, therefore, focuses on hair spray products packaged as either aerosols or pumps.

3.2.1 Market Size

In 1987, over 487.9 million aerosol containers of hair spray products were filled nationally, accounting for 18 percent of the total market for aerosol products in the U.S. in 1987 (CSMA, 1988). In interviews with ICF, industry representatives (e.g., Chemical Specialties Manufacturers Association (CSMA), Western Aerosol Information Bureau (WAIB)) agreed that the California market for aerosol hair sprays does not differ significantly from the national market for these products, and consumption can be accurately estimated on a percentage of population basis. Based on national and state population figures from 1985 Bureau of Census data[21], an 11 percent factor can be used to estimate California percentages from national data.[22] Consequently, as shown in Exhibit 3-4, the California market for aerosol hair sprays is approximately 11 percent of the national market, or about 53.7 million cans. Industry representatives also

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[21] The total U.S. population, according to Bureau of Census data, was 238,741,000 -- the California population was 26,358,000.

[22] CSMA agreed in a letter to the ARB (May 1986), that this factor is appropriate to use as an alternative to the 10 percent factor that had previously been applied.

EXHIBIT 3-4

MARKET SHARE AND UNITS SOLD FOR HAIR SPRAY PRODUCTS

Product Type	Market share (National)	Number of Units Sold in California (millions of cans)
Aerosol Spray	91.5%	53.7
Pump Spray	8.5%	5.0
TOTAL	100.0%	58.7

Source: Data based on CSMA (1988) and Johnsen (1989).

indicated that individual national brand market shares, prices, and consumption rates should likewise be similar to national figures, although some variations may exist. This approach of estimating the California market based on population has been used previously in analyses of PROC emissions from these products. See, for example, ARB (1987) and SAI (1986).

The size and characteristics of the market for pump hair sprays are less well quantified because there is little published information on this alternative form of hair spray package. Previous ARB analyses (e.g., ARB 1987) estimated the pump hair spray market based on its reported 1980 share of the total hair spray market. Johnsen (1982) reports that pump products achieved significant market share in 1980 (approximately 37 percent) due to consumer concerns over chlorofluorocarbon (CFC) use in aerosol products. Similar data are reported for the pump hair spray national market share in ARTI (1988) based on data from 1984 and 1986. Using the 37 percent estimate of the pump market share, approximately 32 million pump units would be anticipated for 1987 in California based on the estimate of 53.7 million aerosol units.

More recently, Johnsen (1989) has indicated that pump sales in California ranged between 4 and 6 million units in 1987. Assuming that California is representative of national trends, this estimate implies a substantial increase in aerosol market share for hair sprays, with a share of about 90 to 93 percent. Johnsen (1982) reported that this aerosol market share was last achieved in the mid-1970s prior to the promotion of pump packaging in response to consumer concerns regarding CFCs.

These widely divergent estimates of pump market share cannot be resolved at this time. For purposes of this analysis, an estimate of 5 million units of pump hair sprays is assumed for 1987. The lower estimate of the pump market share is used because if one assumes that pumps make up 37 percent of the total market, then the total market for hair sprays in California amounts to 53.7 million aerosol units and 32 million pump units. Johnsen (1982) indicates that the amount of active ingredient in pumps is about 1.7 to 1.8 times the amount present in aerosols. Thus, a factor of about 1.8 is considered an aerosol equivalent for each pump unit. Using this conversion factor, this market size implies the equivalent of 53.7 + 1.8*(32), or about 111 million aerosol-equivalent units of hair spray in California in 1987. These 111 million units amount to over 4 units per capita in California, which is far in excess of the historical national levels, which were on the order of 2.2 per capita. Assuming a pump hair spray market of 5 million units implies a total of 2.4 units per capita for the state, which is more in line with historical data.

Also of note is that the higher market share for pump sprays may also reflect hair care products that are not hair sprays as defined above. Hair "spritzers" are often marketed in pump spray form. These products are not considered in this analysis.

3.2.2 Market Activities

Marketing/Manufacturing

Marketers of various types and sizes account for different fractions of the California market for hair sprays. Hair spray products are generally manufactured and marketed nationally (accounting for 70 to 80 percent of the marketers doing business in California), but some house brands and specialty products are formulated and marketed regionally and in isolated specialty markets. Some such specialty markets do exist in California, especially in the Los Angeles area.

For example, Sebastian International markets a hair spray product line that is sold exclusively through hair salons, and is not available in retail stores. With such exceptions (about 2 to 3 percent of California market) all hair spray products available in the national market are also available in California, and specialty products do not affect greatly the overall market shares in California (ARTI, March 1988).

An estimated 100 manufacturers (both in state and out of state) market hair spray products in California. Of these, approximately 14 have operations located in California to serve the California and western region market. These operations account for about 17 million containers of hair spray annually, or 25 to 30 percent of the hair sprays sold in California. These operations also produce an additional 10 to 15 million containers of hair spray in California for distribution to other western region states.

A breakdown of the marketing/manufacturing activities in California is presented in Exhibit 3-5. A list of marketers/manufacturers with operations in California are presented in Appendix A. Specific examples of hair spray marketers/manufacturers in California are as follows:

- Vidal Sassoon, Inc., a large national brand manufacturer is one of four health and beauty aid divisions of Proctor and Gamble. The company manufactures its hair spray products in Greensborough, North Carolina. However, Vidal Sassoon maintained offices and distribution centers in California. The majority of Vidal Sassoon products are sold in retail stores, however, a small percentage (less than 5 percent) of its product is sold in Vidal Sassoon hair salons.

- Duart Manufacturing Co., a division of Clairol, conducts research, development, and design of Clairol products. Duart is also a west coast manufacturing operation for Clairol, packaging and selling Clairol products to distributors in California and the western region.

EXHIBIT 3-5

MARKETERS/MANUFACTURERS OF HAIR SPRAY SOLD IN CALIFORNIA

Marketers/Manufacturers	In State	Out Of State
Large, national	5	10-20
Medium, store brand	6	50-70
Small, specialty	3	5-10
TOTAL	14	80-86

Source: Based on data from CSMA and interviews with industry representatives.

- Sebastian International, a marketer/manufacturer in Southern California, sells its hair spray product exclusively through hair salons. While this product does not account for a significant share of the overall product market, the product, generally considered a specialty hair spray, generates significant volumes of sales within large metropolitan areas in California.

Filling

Currently, there are approximately eight hair spray fillers in California, only three of which are contract fillers -- the others are self-filling manufacturers. Two contract fillers currently in operation are both large multi-purpose fillers, and generate most of their current revenue from other types of filling. In addition, excess capacity from manufacturing/self-fillers is adequate to absorb any excess demand that may exist for filling services. One of the contract fillers, Aerosol Services, Inc., located in City of Industry, also maintains its own distribution center.

The volume of hair sprays filled in California, as noted above, accounts for approximately 25 to 30 percent of the state consumption (17 million containers), with an equal amount shipped to the nine western region states. Pump action hair sprays account for less than 10 percent of the containers filled in California. Fillers with operations in California are presented in Appendix B.

Distribution

Distribution of hair spray products in California follows all of the examples described above. In total, 135 distributors in California distribute hair sprays and/or spray paints. Of these, approximately 30 are large distribution centers, which account for greater than 50 percent of the hair sprays distributed in California. In addition, between 50 and 150 out of state distributors distribute into the state, and are equally divided between primary distribution and final distribution to retail outlets. Firms that have distribution centers in California are presented in Appendix C.

Retail

Retailers of hair sprays in California number in the thousands, and include supermarkets, drug stores, small independent stores, and commercial hair salons. A small percentage of hair sprays are also sold via mail order and to salons for institutional use.

3.2.3 Market Structure

The market for hair sprays is generally considered to be highly competitive, with name recognition and perception of product quality being highly important. While as many as 100 different firms nationwide market hair spray products, the top 10 marketers/manufacturers account for 88 percent of the national hair spray market, each with a market share ranging from 3 to 14 percent (Exhibit 3-6). However, no one marketer/manufacturer is considered a price leader, and it can therefore be assumed that competitive supply conditions exist.

On the demand side, the price of a hair spray product appears to be associated with brand loyalty and a perception of quality. While hair spray formulas are generally quite similar, except for formulas containing higher resin contents specifically for hard to hold hair, there is wide divergence in the retail price per ounce, even among the top ten products (Exhibit 3-7), and specialty hair spray products of comparable formula generally sell for 50 to 150 percent higher per ounce.

To evaluate the potential impacts of economic incentives for reducing PROC emissions from consumer products, the potential behavior of consumers in response to increased product prices is required. Such consumer response is referred to as the price elasticity of demand, which describes the anticipated change in demand associated with unit (i.e., one percent) increases in product prices. Several industry representatives believe that the demand for hair spray products is relatively price-inelastic, meaning that a one percent increase in price will result in less than a one percent decrease in sales. Published estimates of demand elasticities for hair sprays are not available. However, because brand loyalty is known to be important, an assumption of price-inelastic demand is reasonable.

3.3 SPRAY PAINTS

For the purposes of this analysis spray paints are considered to be one portion of a class of products commonly referred to as aerosol coatings. Aerosol coatings are classified into four main product categories: spray paints, clear coatings, primers, and other related products such as metallic paints, wood stains, paint strippers, and rust removers. This study focuses on spray paints which account for about 81.4 percent of the total U.S. market for aerosol coatings.

All surface coatings are typically composed of three basic components: the film-forming binder, the pigment system, and solvents. Surface coatings packaged as aerosols contain a fourth component, propellants. The amount and composition of the film-forming binder and pigment system define whether a product is a spray paint, a clear coating, or a primer. The presence of pigments/colorants is typical in all spray paints; in contrast, clear coatings do not contain pigments (Johnsen 1987b, Rehm 1982). Primers

EXHIBIT 3-6

TOP TEN HAIR SPRAY BRANDS AND MARKET SHARES

Brand Name	Typical Can Size (in weight)	Marketer/ Manufacturer	Market Share (percent)
Final Net	8 oz.	Clairol Division	14
Aqua-Net	9 oz.	Rayette-Faberge	14
Adorn	9 oz.	Gillette (10%)	13[a]
White Rain	7.5 oz.	Gillette (3%)	
Permasoft	7 oz.	LaMur, Inc.	13
Miss Breck	7 oz.	John H. Breck Div.	12
VO-5	11 oz.	Alberto Culver Co.	9
Protein 21	9 oz.	Mennen Co.	6
Rave	7 oz.	Chesebrough-Pond	4
Finesse	7 oz.	Helene Curtis Inds.	3
			88 percent

[a] Total Gillette market share for Adorn and White Rain.

Source: Johnsen 1987a.

EXHIBIT 3-7

SELECTED HAIR SPRAY RETAIL PRICES

JUNE 1987

Trade Name	Marketer	Can Size*	Net Weight	Price	Retail $/oz.
Conair	Conair Corp.	207.5x708	9.3-oz.	$0.99	0.106
Hook's	Hook Drug Stores	211x713	14-oz.	$1.79	0.128
Aqua-Net	Rayette-Faberge	211x604	9-oz.	$1.59	0.177
C. Richards	Rayette-Faberge	211x604	9-oz.	$1.89	0.210
White Rain	Gillette	207.5x605	7.5-oz.	$1.59	0.212
Miss Breck	John H. Breck Div.	207.5x605	7-oz.	$1.69	0.241
Final Net	Clairol Division	207.5x708	8-oz.	$1.99	0.249
Rave	Chesebrough-Pond	207.5x708	7-oz.	$1.99	0.284
Matrix Ess.	Matrix Essentials	112x214	2-oz.	$0.59	0.295
Oil Sheen	M&M Products Inc.	211x604	9.5-oz.	$2.99	0.315
VO-5	Alberto-Culver Co.	207.5x708	11-oz.	$3.64	0.331
Protein 21	Mennen Company	211x604	9-oz.	$2.99	0.332
Adorn	Gillette	207.5x708	9-oz.	$2.99	0.332
Permasoft	LaMur, Inc.	202x708	7-oz.	$2.39	0.341
Finisheen	Revlon/Realistic	211x713	14-oz.	$4.89	0.349
Allercreme	Dermalogical Prods.	211x604	11-oz.	$3.99	0.363
Jhirmack	Internat. Playtex	207.5x605	8-oz.	$2.99	0.374
Vital Control	Matrix Essentials	112x214	2-oz.	$0.79	0.395
Sassoon	Vidal Sassoon Div.	205x708	7-oz.	$2.79	0.399
Finesse	Helene Curtis, Inc.	208.9x675	7-oz.	$3.19	0.456
Spraze	The Nestlemur Co.	202x406	3.5-oz.	$2.99	0.854

Source: Johnsen (1987a).

* The can size is reported in millimeters. The first number is the circumference of the base and the second number is the height.

use larger amounts of pigment and binder solids to provide an initial protective coating. The typical spray paint provides a glossy or semi-glossy colored finish that is usually referred to as an enamel. Flat (low gloss) paints are also available and their applications include the protection of outdoor surfaces, tools, etc.

3.3.1 Market Size

In 1987, over 317 million tin-plate containers of spray paints, primers, and finishes were filled (CSMA, 1988), accounting for 11.6 percent of the total aerosol market in the U.S. in 1987 (Johnsen, 1987a). The estimated size of the California market for spray coatings is presented in Exhibit 3-8. There are no spray paints packaged in pumps.

3.3.2 Market Activities

Marketing/Manufacturing

Spray paints, like hair sprays, are generally manufactured and marketed nationally. However, much of this activity is for the raw materials (pigments, solvents, formulas) that are marketed nationally, accounting for 60 to 70 percent of the marketers doing business in California. According to industry representatives, approximately 10 to 20 large national brand firms marketing/manufacturing spray coating products account for 50 to 60 percent of the formula used in the national market for spray coatings.

Another 105 to 115 smaller and regional firms compete respectfully on the local and regional level for the other 30 to 40 percent of the market. These firms generally buy the ingredients and formulas from national firms and suppliers and produce a similar paint product under their own name. While no one manufacturer or product can be considered dominant nationally, several companies (e.g., New York Bronze, Illinois Bronze, Standard Brands, Rustoleum, Flecto) do have relatively large national market shares both for spray paints and for their ingredients, and are generally well known in the spray paint market. This brand recognition provides the large firms with somewhat of an advantage in contracting with retail outlets over the numerous smaller firms that also compete in the market.

Many of the smaller manufacturers produce products under the name of the larger manufacturers. Because the number of paint shades and specific applications for paints is large, the size of any one production run is apt to be quite small. These operations, then are more easily produced by smaller firms. However, many of the spray paint marketers fill their own products, and often fill for others as well.

Of an estimated 125 spray paint manufacturers in the U.S., approximately 55 marketers/manufacturers (both in state and out of state) sell spray paints in California. Of these, approximately 20 have

EXHIBIT 3-8

SPRAY COATINGS AND RELATED PRODUCTS FILLED IN 1987

Product Category	Percent of Aerosol Coatings Market (national)	Number of Units Sold in California (millions of cans)
Spray Paints	81.4%	28.40
Clear Coatings		
Varnishes/Lacquers	2.9%	1.01
Polyurethanes	3.2%	1.12
Shellacs	0.1%	0.03
Primers		
Rust Preventive	3.2%	1.12
Standard	1.5%	0.51
Marine	1.1%	0.40
Wood Stains		
Oil-Base	0.1%	0.03
Varnish-Base	0.8%	0.29
Paint Strippers	2.2%	0.77
Rust Removers	0.2%	0.08
Metallic paints	3.3%	1.16
Total	100.0%	34.90

Sources: Johnsen 1987a and CSMA 1988.

operations located in California to serve California and western region markets. These in-state operations account for about 10 million containers of spray paint and coatings annually, or 30 to 35 percent of the spray coatings sold in California. In most of the smaller markets, spray paints produced locally are sold locally. Another 5 to 10 million containers are manufactured in California for distribution to other western region states.

A breakdown of the marketing/manufacturing activities in California is presented in Exhibit 3-9. A list of marketers/manufacturers with operations in California is presented in Appendix A. Specific examples of spray paint marketers/manufacturers in California are as follows:

- Ace Hardware, located in Chicago, Illinois is representative of the group of manufacturers that generally carry a product from its development to the retail market, through its own retail outlets. While Ace Hardware manufactures its own line of nonaerosol paint products, it purchases all of its spray paints from Illinois Bronze, also located in Chicago, to be marketed as the Ace Hardware store brand.

- Grow Group, Inc., a self-filling marketer located in City of Commerce, sells spray paints to large chain outlets and distributors in California, but not to retail outlets. Grow group buys the products from another manufacturer, fills and labels containers, and then sells the brand as their product to outlets with which they have contracts.

- Zynolyte Products Co., located in Compton, is one of the largest spray paint marketing and filling firms in California. Zynolyte fills and markets a wide variety of spray paint products in local hardware and utility stores.

Filling

Currently, there are approximately 11 spray paint fillers in California, at least 5 of which are contract fillers -- the other 6 are self-filling manufacturers, associated with in-state medium to large sized paint manufacturers. All of the contract fillers are large multi-purpose fillers. Several of the paint manufacturer and marketers, such as Zynolyte Products Company (Compton) who fill their own products fill paints for other marketers as well.

Because, as noted, many shades and variations of paints are available, filling runs are generally small, and usually use transfer labels or color coded caps, rather than having the color printed directly on the container. Some products also have paper labels.

EXHIBIT 3-9

SPRAY COATING MARKETERS/MANUFACTURERS IN CALIFORNIA

Marketers/Manufacturers	In State	Out Of State
Large, national	4	15-20
Medium, store brand	11	20-30
Small, specialty	5	5-10
TOTAL	20	30-40

Source: Based on data from CSMA and interviews with industry representatives.

The volume of spray paints filled in California, as noted above, accounts for approximately 30 to 35 percent of the state consumption (10 million containers), with an equal amount shipped to the nine western region states. Fillers with operations in California are presented in Appendix B.

Distribution

As with hair sprays, distribution of spray paints in California follows all of the examples described above. However, there is somewhat less overall manufacture on the national level. Overall, a smaller percentage of spray paints are initially distributed in California from out of state than for hair sprays. In total, 135 distributors in California distribute hair spray and/or spray paints. Approximately 30 of these are large distribution centers that account for greater than 70 percent of the spray paints distributed in California. Out-of-state distributors, mostly regional, and smaller in-state distributors account for the other 30 percent. Firms that have distribution centers in California are presented in Appendix C.

Retail

Retailers of spray paints in California number in the thousands, and include drug stores, hardware stores, automotive supply stores, department stores, and small independent stores. An important aspect of the retail side of the spray paints market is that because of the wide variety in types and numerous shades of paint, many retailers cannot afford to shelf more than one specific supplier/manufacturer and will carry only that one brand. Because the expense of shelf space and difficulty for users to be informed about the quality of the products, retailers usually contract with the supplier that provides the best price and perceived level of quality.

3.3.3 Market Structure

There are a large number of marketers nationally, and the market for spray paints is considered highly competitive. No one firm appears to exert a monopoly or price leader power in this market. Because of the ease with which manufacturers and fillers can respond to fluctuations in demand in the spray paint market, relatively competitive supply conditions are assumed to exist.

On the demand side, because retail outlets usually only stock one brand and the information costs are high for consumers to distinguish between the brands, casual users of spray paint are generally not able to incorporate price or quality considerations into their product choices. It can therefore be assumed that where use of such a product is necessary for one-time or small jobs, it is probably price-inelastic. Where use is more regular or for a larger one-time application, it would be expected that other brands and alternative methods of applying paints (e.g., using a

compressor) would become more attractive and the demand could be more price-elastic with respect to substitutes.

3.4 REFERENCES

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4. ANALYSIS OF HAIR SPRAYS AND SPRAY PAINTS

This section presents the chemical formulations, emissions, and technical emissions reduction options for hair sprays and spray paints. The data describing the technical emissions reduction options are used below to evaluate the likely impacts of proposed economic incentive systems for reducing PROC emissions.

4.1 PROC DEFINITION

In order to evaluate alternative approaches for reducing PROCs from hair sprays and spray paints, a precise definition of PROCs is required. For purposes of this analysis PROCs are defined as any compound containing at least one atom of carbon, excluding the following: carbon dioxide; carbon monoxide, methane, carbonic acid, metallic carbides or carbonates, ammonium carbonate, 1,1,1-trichloroethane (methyl chloroform); methylene chloride; fully-halogenated chlorofluorocarbons (CFC-11, CFC-12, CFC-23, CFC-113, CFC-114, and CFC-115); and partially-halogenated chlorofluorocarbons and fluorocarbons (HCFC-22, HCFC-123, HFC-134a, HCFC-141b, and HCFC-142b).

The compounds that are considered PROCs are also commonly referred to as the reactive volatile organic compounds, or VOCs. However, VOCs can include any volatile carbon-based compound regardless of whether it is photochemically reactive, such as methane. Therefore, the use of the PROC definition in this study limits the compounds of concern to those that are photochemically reactive.

Although various PROCs have different reactivities, all PROCs are treated equally in this analysis. If reactivities of the PROCs are subsequently considered to be important, both fee and quota incentives could be modified to reflect the varying values across compounds.

It has also been suggested that the definition include a cut off for volatility, which could be measured in terms of vapor pressure. Compounds that have very low vapor pressures (i.e., are not very volatile) may be excluded from concern in terms of emissions. In this study, hair sprays and spray paints both contain large amounts of very volatile PROCs, and the volatility criterion is not important. Such a criterion may be more important for other consumer products, such as creams and gels.

4.2 HAIR SPRAYS

As described above, for purposes of this analysis, hair sprays are defined as products delivered as an atomized mist that are generally

applied to dry hair to provide hold to a specific hair style. Both pressurized aerosol cans and plastic pumps fall into this definition. Foams, also known as styling mousses, and spritzers, often sold in pump containers, are not included in this definition of hair sprays as they are usually applied to wet hair to aid the styling process (CSMA 1986). This analysis, therefore, focuses on hair sprays packaged as either aerosols or pumps.

Aerosol hair sprays constitute the largest fraction of the personal products category of the U.S. aerosol market. Of the total 964 million unit aerosol personal products market in 1987, hair sprays account for 51 percent (CSMA 1988). Chapter 3 above presents the estimated size of the hair spray market for both aerosols and pump sprays. In California it is estimated that there were about 53.7 million aerosol cans and about 5 million pump spray containers sold in 1987.

4.2.1 Formulations

Aerosol Hair Sprays

Aerosol hair sprays contain a film-forming resin, a solvent, various additives, and a propellent. The film-forming or fixative resin is the active ingredient because it provides the "hair-holding power" of the product. The resin, a water soluble polymeric material that can be removed by washing (Johnsen 1982), generally represents 1.5 to 4 weight percent of the formulation and is usually solubilized in ethanol. The concentration of the resin determines whether the product is classified as a "soft", "regular", "hard-to-hold", or "super hold" hair spray (with more resin providing more holding power). For this analysis, a "regular" hold hair spray containing 1.8 to 2 percent film-forming resin is assumed to be the average product available on the market.

Exhibit 4-1 presents four prototype formulations of aerosol hair sprays currently available in California. The photochemically reactive ingredients in these formulations are highlighted in bold. Formulation I, by far the most popular product, accounting for 86 percent of the market, has a total PROC content of 97.8 weight percent.[23]

Formulation II has similar ingredients except that 6.5 percent of the propellant and ethanol used is replaced with de-ionized water, which acts as a co-solvent. In Formulation II, PROCs account for 91.1 percent of the product weight and its market share is estimated to be 12 percent. (The presence of water in hair spray formulations is discussed in further detail below.)

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[23] All ingredient percentages reported here are weight percentages (as opposed to volumetric percentages).

EXHIBIT 4-1

FORMULATION DATA FOR AEROSOL HAIR SPRAYS

Ingredients	Formulations (%) w/w I	II	III	IV
Film Former[a]	1.8	2.0	1.8	2.0
Plasticizer[b]	0.2	0.3	0.2	0.3
Additives[c]	0.2	0.1	0.2	0.2
Fragrance	0.1	0.1	0.1	0.1
Colorant/Tint	-	-	-	0.2
Methylene Chloride-S	-	-	12.0	-
S.D. Ethanol (200 Proof)	65.7	63.5	60.7	65.8
De-Ionized Water	-	6.5	-	-
Hydrocarbon Propellant (Isobutane/propane, A-40)	32.0	27.5	25.0	31.4
Total	100.0	100.0	100.0	100.0
PROC Content• (%w/w)	97.8	91.1	85.8	97.3
Market Share[d]	86.0	12.0	1.0	1.0

[a] Non-PROC resins such as esters of PVM/MA copolymer.

[b] Non-PROC resins such as tri-isopropanolamine.

[c] Non-PROC solid resins, such as cetyl-alcohol, d-Panthenol, etc.

[d] Aerosol hair spray market in California: 53.7 million cans/year.

• PROCs are highlighted in bold.

Source: Based Johnsen 1987a, Johnsen 1989, and CSMA 1988.

Note: All formulations discussed are prototypes and only representative of what may finally be available in the marketplace. The relative proportions of ingredients should therefore be read as indicative rather than absolute numbers.

Formulation III represents the very small portion of the hair spray market still using methylene chloride (a non-PROC). Since the late 1970s, methylene chloride has played a significant role in aerosol hair spray compositions (Oteri 1985). The Food and Drug Administration (FDA) proposed to ban the use of this chemical in personal products (primarily hair sprays) because of toxicity concerns (FDA 1985). The industry responded with a quick reformulation effort that lead to a significant reduction of methylene chloride use in hair sprays. In 1989 the FDA banned the use of methylene chloride in products under FDA jurisdiction (food, pharmaceutical, and cosmetic products). Although hair spray formulations containing methylene chloride may no longer be used in the future, Formulation III in Exhibit 4-1 is used to represent the composition of the market in 1987.

Methylene chloride was used because it enhances resin solubility, reduces the flammability of the product, and contributes to product weight at low cost (Johnsen 1982). Formulation III has 12 percent methylene chloride and a total PROC content of 85.8 percent.

Formulation IV is essentially the same as Formulation I, except that it has a colorant or tint agent added. It represents a very small portion of the market and its PROC content is 97.3 percent.

Of the ten largest selling hair spray brands, representing 88 percent of the aerosol hair spray market, nine have formulations similar to Formulation I and one has a formulation similar to Formulation II (Johnsen 1987a).

Pump Hair Sprays

An alternative to the aerosol dispenser system is a pump. A pump hair spray formulation essentially has the same ingredients as the aerosol, but contains no propellent. The finger depression of the valve generates the pressure necessary to expel the product. Because the contents of pump hair sprays are not pressurized, plastic containers are commonly used.

Exhibit 4-2 shows representative pump hair spray formulations. The amount of film-forming resin corresponds to the "regular" hold category, therefore, these formulations are comparable to the aerosol counterparts shown above in Exhibit 4-1. These formulations differ from aerosol hair spray formulations in two main aspects: (1) they contain approximately 1.7 to 1.8 times the amount of film-forming resin (based on the percentage of the weight of the product formulation); and (2) on average they contain a lower PROC content than aerosols. The formulations shown in Exhibit 4-2 are based on communications with industry representatives (Johnsen 1989).

EXHIBIT 4-2

FORMULATION DATA FOR PUMP HAIR SPRAYS

Ingredients	Prototype Formulations (%) w/w I	II
Film Former	3.2	3.2
Plasticizer	0.4	0.4
Additives	0.4	0.4
Fragrance	0.2	0.2
S.D. Ethanol (200 Proof)	90.8	55.8
1,1,1-trichloroethane	--	35.0
De-Ionized Water	5.0	5.0
Total	100.0	100.0
PROC Content (%w/w)	91.0	56.0
Market Share[a]	88.0	12.0

[a] Pump hair spray market in California: 5 million units/year. Average Container Weight: 6.3 wt. ounces.

Source: Based ICF 1987a and Johnsen 1989.

Note: All formulations discussed are prototypes and only representative of what may finally be available in the marketplace. The relative proportions of ingredients should therefore be read as indicative rather than absolute numbers.

4.2.2 PROC Emissions

Aerosol and pump hair sprays are sources of PROC emissions during three main stages: product manufacture; product use; and disposal of the product package. The amount of PROCs emitted during product manufacture depends primarily on the volatility of specific chemicals used. Because the PROCs are flammable, uncontrolled emissions of the compounds are not desired during product filling operations. Additionally, in California fillers are responsible for fees associated with PROC emissions. PROC emissions associated with product manufacture are not included in this analysis.

PROCs are obviously emitted during use as the consumer applies the product to his or her hair. It is assumed that consumers use the full amount of the product contained in the pump and aerosol containers that can be expelled from the packages. However, for both the aerosol and the pump package, there is a small portion of the product that remains in the container after use that cannot be expelled. This amount is known as "overfill," i.e., the additional product that the manufacturer is required to include in the package to allow the extraction of the net weight reported on the product label. It is assumed in this analysis that when used packages are disposed of, the PROCs contained in this residual amount are also emitted to the atmosphere. This assumption is reasonable considering that both aerosol cans and plastic pump containers are often crushed prior to disposal.

Of note is that industry sources indicate that plastic pump containers may be incinerated as a means of disposal. It has been suggested that such incineration could also contribute to PROC emissions (CSMA 1986). This potential contribution to emissions is not considered in this analysis.

The estimates of PROC emissions for the state of California are therefore based on the assumption that emissions are equal to 100 percent of the PROCs contained in the product packages. Thus, these estimates account for PROCs emitted during actual product use and for PROCs remaining in the package at disposal. Exhibit 4-3 presents estimates of PROC emissions from aerosol and pump hair sprays used in the state of California in 1987. Aerosol hair sprays generated an average of about 13,500 tons of PROC emissions during 1987 with a high or upper bound estimate of about 16,000 tons. Similarly, a total of about 850 tons are estimated to be released from pump hair sprays with an upper bound estimate of 950 tons.

The data used to compute these estimate include:

- the PROC contents of the prototype formulations reported in Exhibits 4-1 and 4-2;
- the estimated market shares of these formulations (also reported in Exhibits 4-1 and 4-2);

EXHIBIT 4-3

PROC EMISSIONS FROM HAIR SPRAYS

(1) Product Category / Formulation, PROC % (w/w)	(2) Average Container Size (Upper Bound Container Size) (wt. oz.)	(3) Market Share of Formulation	(4) Units Consumed in California in 1987	(5) = (4) * (1) * (2) * [16 oz/lb X 1 ton/2000lb] PROC EMISSIONS (tons) Average	Upper Bound
Aerosol Hair Sprays	8.3 (9.9)				
I 97.8%		86.0%	46,182,000	11,715	13,973
II 91.1%		12.0%	6,444,000	1,523	1,816
III 85.8%		1.0%	537,000	120	143
IV 97.3%		1.0%	537,000	136	162
		100.0%	53,700,000 (a)	13,493	16,094
Pump Hair Sprays	6.3 (7.0)				
I 91.0%		88.0%	4,400,000	788	876
II 56.0%		12.0%	600,000	66	74
		100.0%	5,000,000 (b)	854	949

TOTAL PROC EMISSIONS	Average	Upper Bound
AEROSOLS	13,493	16,094
PUMPS	854	949
TOTAL (c)	14,347	17,043

Source: Data based on CSHA 1988, Johnsen 1989, and formulation data provided above.

(a) Eleven percent of the national hair spray production estimated at 487.9 million units (CSHA 1988).
(b) Based on industry estimate of 4 to 6 million pumps consumed in California in 1987.
(c) Totals may not add due to rounding.

- o the estimated number of containers consumed in California; and
- o estimates of the average container sizes.

Average container sizes for these products are uncertain because of the multiplicity of container sizes available in the market. Based on the container sizes of the major representative brand names, however, it is possible to define a "best guess" of an average container size and a large or "upper bound" can size. Appendix D presents an explanation of average and large container sizes used in Exhibit 4-3 to estimate annual emissions.

Of note is that the total PROC emissions of about 14,000 tons per year is larger than the 1983 VOC (volatile organic compound) emissions estimated by ARB (1987) which was about 7,200 tons for aerosol hair sprays and about 2,400 tons for pump hair sprays, for a total of about 9,600 tons. Similarly, SAI (1986) estimated California PROC emissions from aerosol hair sprays at 6,400 to 8,500 tons per year based on estimates of fillings in 1983 and 1984 and formulation data from the same period or earlier. This estimate, however, was prepared prior to the significant shift away from methylene chloride in hair sprays. The phasing out of methylene chloride and its general replacement with PROCs increases PROC emissions from this source by about 10 to 15 percent.

When compared to these two previously published estimates of emissions from hair sprays, the estimate presented in this analysis is larger than the others for aerosols and smaller for pumps, with an overall larger estimate for hair sprays. The larger overall estimate is driven in part by the apparent increased market share of aerosol hair spays nationally since the early 1980s (aerosol personal product fillings have increased by nearly 30 percent in the U.S. between 1983 and 1987) and the replacement of methylene chloride (a non-PROC) with PROCs in most formulations.

4.2.3 Options for Reducing PROC Emissions

Two main technical options exist to reduce PROCs emissions from hair sprays: (1) alternate aerosol formulations with lower PROC contents; and (2) alternate delivery systems where either the PROC content and/or the PROC application rate are lower. These options are described in turn.

Alternate Aerosol Formulations

PROC emissions could be reduced by replacing portions of the propellants and/or ethanol solvent of the formulation with non-PROCs. Exhibit 4-4 presents five alternate formulations with reduced PROC contents. These systems are discussed below.

EXHIBIT 4-4

ALTERNATE FORMULATIONS FOR AEROSOL HAIR SPRAYS

Ingredients	Formulations (%) w/w					
	DME/Water I[a]	HCFC Systems II[b]	HCFC Systems III[c]	HCFC Systems IV[c]	CO_2 System V[d]	High H_2O No Alcohol VI[e]
Film Former	2.2	1.5	1.8	1.8	2.1	--
Plasticizer	0.3	0.2	0.3	0.2	0.3	--
Additives	0.2	0.2	0.3	0.2	0.3	--
Fragrance	0.3	0.1	0.2	0.2	0.2	--
S.D. Ethanol (200 Proof)	40-50	18.0	67.4	37.6	81.6	--
DME 32-47	--	--	30.0	--	--	30-35
De-Ionized Water	10-15	2.0	--	10.0	--	60
HCFC-142b	--	78.0	--	--	--	--
HCFC-22	--	--	30.0	20.0	--	--
Carbon Dioxide (CO_2)	--	--	--	--	5.5	--
Iso-Pentane	--	--	--	--	10.0	--
Proprietary[f]	--	--	--	--	--	5-10
Total	100.0	100.0	100.0	100.0	100.0	100.0
PROC Content (%w/w)	82.3-87.3	18.1	67.6	67.8	91.8	35.0

[a] Based on Bohnenn 1983, Nowak 1985, and DuPont 1989.

[b] Johnsen 1989.

[c] Based on Dupont 1989.

[d] Based on ICF 1987.

[e] Based on Saferstein 1990 and Johnsen 1989.

[f] Proprietary ingredients that include the film former, plasticizer, fragrance, and additives. Some portion of these ingredients may include PROCs.

Note: Some of the above formulations have not been tested and developed for final use. All formulations discussed are prototypes and only indicative of what may become available in the marketplace.

Water as a Solvent. Water could be used to replace ethanol in aerosol hair spray formulations. Water is currently being used in one representative formulation at 6.5 percent. This formulation has a PROC content of 91.1 percent and represents 12 percent of the market (see Exhibit 4-1). If all aerosol hair sprays used water to this extent, PROC emissions could be reduced by about 6 percent.

Assuming that current manufacturers of aerosol hair sprays not using water in their formulations decided to switch, there would be certain costs associated with package modifications and product stability testing (can corrosion, shelf life, etc.) that would be incurred. Specific cost data are provided below in Section 4.4.

Some experts believe that there is a technical limit to the amount of water that can be added to a hair spray formulation. Some background on the introduction of water in hair spray formulations and potential limits on its use is provided by Johnsen (1982). When aerosol hair spray formulators opted to replace methylene chloride from their formulations, water was found to be an effective substitute. Methylene chloride had been originally introduced to aid the solubility and dispersion of the film-forming resin in the ethanol/propellent system and to prevent the resins from separating at storage temperatures below 55°F. Water achieved the same result, although no more than 10 to 15 percent could be added without incurring phase separation (Johnsen 1989). In addition, CSMA (1986) indicates that if more that 10 to 15 percent water is added to hydrocarbon propelled formulations, the spray becomes wetter, hair becomes more flexible (less hold) and the original hair configuration is destroyed.

Water is also reported to promote corrosion of the aerosol container (Oteri 1985) and, therefore, requires internal linings. According to Johnsen (1982), can corrosion can be controlled using an amine based resin neutralizer in conjunction with extremely pure water and a double lined can. Data on the costs of this modification are provided below in Section 4.4.

Another problem associated with higher water content is increased drying time. Water evaporates more slowly than ethanol and methylene chloride, thereby increasing the time required for the hair spray to dry and set. This increased drying time may pose an effective limit on the possible water content of alternative hair spray formulations.

It has been reported, however, that the use of highly volatile dimethyl ether (DME) in place of a portion of the ethanol allows the fraction of water in the formulation to be increased to 10 to 15 percent without experiencing increases in drying time (Oteri 1985). Formulation I in Exhibit 4-4 presents a sample DME/Water formulation reported in the literature. PROCs in this formulation have a weight concentration of 82.3 to 87.3 percent. If all aerosol hair sprays used water to this extent, PROC emissions could be reduced by about 10 to 15 percent. These systems

are reported to be widely used in Europe, however, market penetration in the U.S. has been limited due to DME's high flammability and cost (Johnsen 1982). DME is an extremely flammable and strong solvent which requires certain changes in the aerosol line to accommodate its use. Cost estimates for adapting aerosol equipment to handle DME are discussed below.

In 1989 a new aerosol hair spray product was introduced that contains very high levels of water (up to 60 percent) and no alcohol (Saferstein, 1990). DME is used as the solvent and proprietary materials are used for the resin. An example of this formulation is listed as Formulation VI in Exhibit 4-4. Based solely on the composition of the product, this formulation represents a PROC reduction of about 65 percent from the most popular aerosol hair spray formulation used today. It has also been indicated that the formulation provides more active ingredient per ounce of product than do current formulations, so that the emissions per effective product delivered to the hair are actually reduced by over 80 percent.

Because this product is new, consumer acceptance in the marketplace has not been fully tested. However, product representatives report that focus group and market testing indicate very positive results, indicating that consumer acceptance and product performance may be quite high. If this product is successful, it will provide an opportunity to reduce PROC emissions significantly from hair sprays.

Other industry experts have expressed reservations about the high water content of this formulation, indicating that additional research may be needed to evaluate fully its potential market acceptance. Economic incentives or other restrictions to limit PROC emissions from hair sprays would help to spur this needed research. Because of this uncertainty regarding the acceptance of this high water, no alcohol formulation, scenarios are analyzed below with and without the use of this formulation.

CO_2 Propellant Systems. Exhibit 4-4 presents a system with a CO_2/iso-pentane propellent system resulting in a PROC content of 91.8 percent. If all aerosol hair sprays consumed in California used this formulation the amount of PROC emissions would be reduced by about 5 percent.

Some technical drawbacks of this system have been reported. The product is initially delivered with too much force due to the 100 pounds per square inch (psi) initial pressure at 77°F (Johnsen 1982) then, pressure decreases during product life resulting in variable spray performance. Thus, the initial spray droplets are small, but eventually the spray droplets become larger resulting in a wetter spray. This may create distortion of the set-fixed coiffure upon application of the spray.

CO_2 is considered a "compressed gas" by the aerosol industry, which indicates that high pressure is required to inject this propellant into the aerosol container. In contrast with other propellants which are handled as liquified gases, CO_2 requires special handling and filling equipment. This propellant, however, was one of the first gases used in the aerosol

industry and is currently used for various products such as food products, starting fluids, stain repellents, and engine cleaners (Johnsen 1982). Special filling technology and an adequate bulk storage facility are required to handle CO_2. The investment associated with this equipment is presented below.

Use of Partially-halogenated Chlorofluorocarbons (HCFCs) and Fluorocarbons (HFCs). Existing HCFCs such as HCFC-142b, HFC-152a, and HCFC-22 are feasible propellent and solvent substitutes. DuPont currently markets the Dymel® series of propellants that includes these three compounds and DME (dimethyl ether). Additionally, compounds currently under development as replacements for fully-halogenated CFCs in various applications, such as HCFC-123 and HFC-134a, may also be applicable PROC substitutes in aerosol formulations in the future. It is expected that HCFCs and HFCs would be considered as non-PROCs based on the discussion presented on assessment of PROC emissions from underarm products (ARB 1987). Thus, these compounds may be considered as viable options for reducing PROC emissions from hair sprays, although as discussed below their use may be limited due to concerns regarding their ozone depleting and global warming impacts. To review the technical feasibility of HFCs and HCFCs as aerosol propellants, it is useful to review the main properties that govern the selection of aerosol propellants.

An aerosol propellant is defined as a non-toxic fluid capable of exerting pressure when held in a sealed container at room temperature (Johnsen 1982). As the valve is depressed, a portion of the propellant vaporizes from the liquid phase carrying the concentrate out of the container. The resulting empty space is filled with gaseous propellant, thereby reestablishing the equilibrium pressure in the container. Given this definition, an aerosol propellant performs two main functions: expelling the liquid concentrate and producing the proper type of spray. Almost all aerosol propellants are present in the container as liquified gases forming part of the liquid concentrate. Depending on the solvency properties of the liquified propellant, it may also act as the solvent of the other ingredients in the container.

Industry considers any fluid that boils at or below 105°F (40.6°C) at normal atmospheric conditions to be a candidate propellant (Johnsen 1982), i.e., a propellant is a liquified gas with a vapor pressure greater than atmospheric pressure (14.7 psi) at a temperature of 105°F. Exhibit 4-5 presents the physical properties of three groups of propellants: CFCs; hydrocarbon propellants (propane, isobutane, and butane); and HCFC/HFCs. A propellant's vapor pressure, density, flammability, solvency, and miscibility with other solvents influence its ability to meet the desired performance. Before the Federal restriction in 1979 on the use of CFCs as aerosol propellants, industry preferred CFCs over hydrocarbons because of their non-flammability, high solvency, and high stability (non-reactivity). The most popular CFC was CFC-12 because of its medium vapor pressure and

EXHIBIT 4-5

AEROSOL PROPELLANTS AND THEIR PROPERTIES

Propellant	CFC-12	CFC-114	CFC-11	Propane	Isobutane	n-Butane	HCFC-22	HCFC-142b	HFC-152a	DME
Formula	CCl_2F_2	$CCLF_2$-$CClF_2$	CCl_2	C_3H_8	i-C_4H_{10}	n-C_4H_{10}	$CHClF_2$	CH_3-$CClF_2$	CH_3-CHF_2	CH_3-O-CH_3
Molecular Weight	120.9	170.9	137.4	44.1	58.1	58.1	86.5	100.5	66.1	46.1
Boiling Point, F	-21.6	38.8	74.9	-43.7	10.9	31.1	-41.4	14.4	-11.2	-12.7
Vapor Pressure, psi*										
(70 F)	70.2	12.9 (13.4 psia)		109.0	31.0	17.0	121.0	29.0	62.0	63.0
(130 F)	181.2	58.8	24.3	257.0	97.0	67.0	297.0	97.0	176.0	174.0
Liquid Density @ 70 F (g/ml)	1.33	1.47	1.49	0.50	0.56	0.58	1.21	1.12	0.91	0.66
Solubility in Water (weight %)	0.030	0.010	0.110	15.0	17.0	20.0	3.0	0.5	1.7	34.0
Kauri-Butanol Value	18	12	60	15	17	20	25	20	11	60
Flammability Limits	Non-Flam.	Non-Flam.	Non-Flam.	2.2-9.5	1.8-8.4	1.8-8.5	Non-Flam.	6.3-14.8	3.9-16.9	3.4-18
LEL (% Vol. in Air)										
Flash Point, F	0	0	0	-156	-117	-101	0	0	0	-42
Vapor Density (g/l) at boiling point	6.26	7.83	5.86	N.A.	N.A.	N.A.	4.83	4.84	3.38	N.A.

Source: Daly 1986

* Vapor pressures are reported in pounds per square inch (psi) above atmospheric pressure with the exception of CFC-11 at 70 F which is reported in absolute pressure.

relatively high density. Because of its relatively low solvency power it was frequently mixed with CFC-11 which adds solvency and density while reducing internal pressure (Johnsen 1982).

As hydrocarbon propellants replaced CFCs, the aerosol industry upgraded filling lines to safely handle flammable propellants. Although combinations of propane, isobutane, and n-butane achieved the required vapor pressures for aerosol applications, the extremely low density and relatively low solvency power of these hydrocarbons required the use of organic solvents (e.g., methylene chloride, ethanol, 1,1,1-trichloroethane) that provided a higher contribution to container weight and aided the solubility of the active ingredient. One benefit of hydrocarbon propellants is their high solubility in water, a property desired in high-water content products, such as cleaners, room fresheners, and foams.

HCFCs and HFCs mimic many of the properties of CFCs, as shown in Exhibit 4-5. As mentioned earlier, DuPont markets HCFC-22, HCFC-142b, and HFC-152a for aerosol applications (Strobach 1989a, McCain 1989). HCFC-22, for instance, is used in pressurized glass bottles of over one ounce (Strobach 1989b, CMR 1989). HCFC-152a is reported to be used with hydrocarbons in hair mousses (CMR 1989). The HCFCs have low to no flammability, while HFC-152a is flammable. Given that the aerosol industry already handles flammable hydrocarbons, the flammability of HFC-152a may be unimportant. Although HCFCs are slightly better solvents than the hydrocarbons, they remain relatively poor solvents with low solubility in water. As in the case of hydrocarbon propellants, the use of other solvents is sometimes needed. DuPont suggests that DME provides the desired solvency power to HCFC formulations.

HCFCs and HFCs could potentially replace the current ethanol-hydrocarbon propellant systems used in hair sprays. As an illustration, an industry source suggested Formulation II in Exhibit 4-4 containing 78 percent HCFC-142b and 18.1 percent PROCs (Johnsen 1989). The amount of PROCs emissions that would be reduced assuming that all hair sprays used this HCFC formulation is large: 81.3 percent. This reduction should be considered an upper bound because the amount of HCFC-142b in this formulation is unusually high. Strobach (1989b) from DuPont estimated that although HCFC-142b has a low vapor pressure that may allow its use at high concentrations, the resulting spray would be extremely "dry," i.e., the propellant to concentrate ratio would be so high that the resin could be visible as plastic beads deposited on the hair. Testing is required to prove the feasibility of this formulation; therefore, its reduction potential should be regarded as preliminary.

An alternative option is to use HCFC-22, as shown in Formulation III of Exhibit 4-4. This formulation is based on a prototype "hard-hold" formulation provided by DuPont (1989). The concentration of active ingredient and ethanol was adjusted to make this formulation comparable to the regular-hold hair sprays discussed earlier. The PROC content of this formulation is 67.6 percent, which represents a PROCs emissions reduction

of 30.2 percent. Formulation IV combines the use of HCFC-22, DME, and water and its PROCs content is 67.8 percent. DME facilitates the use of additional water (increases evaporation rate) and HCFC-22 decreases the PROCs content of the formulation. The PROCs reduction potential of this formulation is also about 30 percent. No data on formulations containing HCFC-152a are available at this time.

The cost of HCFCs and HFCs is a major drawback of the proposed formulations presented in Exhibit 4-4. The prices of these compounds at the distributor level are: $1.00/lb for HCFC-22, $ 1.65/lb for HFC-152a, and $2.30/lb for HCFC-142b (Nathan 1989, McCain 1989, Basel 1989). Ethanol and a typical hydrocarbon propellant cost approximately $.34/lb and $0.16/lb, respectively. The raw material costs of these HCFC formulations compared to the costs of the standard formulations are presented below. Capital conversion costs and reformulation costs (such as ingredient compatibility tests and shelf life tests) are also likely to be incurred by industry when switching to HCFCs, and are also presented below.

Another potential limitation on the use of HCFCs and HFCs is their potential impact on stratospheric ozone and global climate. Like the CFCs, the HCFCs contain chlorine, which when released into the stratosphere is believed to deplete stratospheric ozone. However, due to their much shorter atmospheric lifetimes, and the manner in which the HCFCs break down in the atmosphere, the HCFCs are only 5 to 10 percent as potent as the CFCs at depleting stratospheric ozone. Consequently, in the near term the HCFCs are considered desirable replacements for CFCs in many applications.

Like the CFCs, the HCFCs and HFCs also absorb infrared radiation, and consequently have the potential to contribute to the greenhouse effect. Again, because the lifetimes of the HCFCs and HFCs are much shorter than the lifetimes of the CFCs, their contribution to the greenhouse effect is also smaller and they are considered good near term substitutes for CFCs.

Despite the fact that HCFCs and HFCs are much less potent ozone depleters and greenhouse gases than the CFCs, concern over these effects may lead to limitations on their future use. In particular, it may be decided that the use of HCFCs and HFCs should be limited to specific high-valued uses, such as refrigeration and hospital-equipment sterilization. Under such a scenario, HCFCs and HFCs may not be available for use in consumer products.

Despite this speculation about potential future limits on the use of these compounds, as described above some companies are actively marketing existing HCFCs and HFCs as aerosol propellants. Consequently, in the analysis below scenarios are analyzed both with and without the availability of HCFCs and HFCs as alternatives for reducing PROC emissions from consumer products.

Alternate Delivery Systems

Switch to Pumps. As shown in Exhibits 4-1 and 4-2, aerosol hair sprays contain larger proportions of PROCs than pump hair sprays. Using the market shares of the prototype formulations, the weighted average PROC content in aerosol and pump hair sprays is 96.9 and 86.8 percent, respectively. Other studies generally agree with these estimates of PROC content in aerosol and pump hair sprays. ARTI (1988) reports 96.2 and 86.0 percent, respectively. Based on these data, a policy that promotes a switch from aerosols to pumps would achieve a reduction in PROC emissions of 10.4 percent if consumers use the same amount of product from pumps as from aerosols. However, such reductions would be offset, possibly entirely, if consumers use larger amounts of the product per application with pumps to obtain the same results. Quantifying this reduction or increase in PROC emissions is difficult because of the many factors involved in consumer hair spray use patterns, such as the efficiency of the delivery system,[24] the effect of higher active ingredient concentrations on use frequency, and subjective factors, such as hair stiffness and appearance.

A recent study indicates that pump users require less product per application than aerosol users. American Research and Testing Incorporated (ARTI, 1988) reports the results of a survey in which the amount of PROCs emitted from aerosol and pump hair spray per application was weighted for various user groups. Exhibit 4-6 presents a summary of the results. For all user groups, the amount of PROCs (in grams) emitted per application was higher for aerosol hair sprays than for pump hair sprays. Although the significance of the absolute values for the teen user groups reported in the exhibit is questionable due to the small sample sizes used in the study, the results point to the conclusion that on average consumers tend to emit less PROCs from pumps than from aerosols. Based on the ratio of PROC emissions shown in Exhibit 4-6 and assuming that the adult female user group is the largest in California (for which the sample size is the largest), it can be concluded that if pumps replaced aerosols, PROC emissions would be 1/1.33 of the amount currently emitted. This would represents an approximate 25 percent reduction in the amount of PROCs emitted to the atmosphere.

This general conclusion that switching to pumps yields a reduction in PROC emissions is expected based on the product composition. The higher weight concentration of active ingredient (the film-forming resin) in pump hair sprays allows consumers to achieve satisfactory hair-holding results with less PROC emissions per application. Thus, a switch to pumps from aerosols would reduce the amount of PROCs emitted to atmosphere.

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[24] Efficiency refers here to the amount of product released that actually reaches the target, in this case the consumer's hair.

EXHIBIT 4-6

PROC EMISSION PER APPLICATION: AEROSOL VS. PUMP HAIR SPRAYS

User Group (sample size Aerosol/Pump)	Grams of PROCs Emitted per Application (standard deviation) Aerosol	Pump	Ratio Aerosol/Pump
Female Adult (156/153)	5.0 (4.0)	3.4 (2.8)	1.33[a]
Female Teen (23/23)	4.0 (3.9)	3.0 (2.5)	1.33
Male Adult (57/57)	5.5 (4.6)	2.7 (1.8)	2.04
Male Teen (12/11)	5.0 (4.2)	4.4 (4.2)	1.14

Source: Based on ARTI 1988.

[a] ICF examined the method used by ARTI (1988) to determine PROC emissions per application for pump and aerosol hair sprays. It is concluded that on average the ratio of aerosol to pump PROC emissions in female adults, which is the group with the largest sample size in the survey, is 1.33 and not 1.47 as reported by ARTI (1988). This correction is based on two adjustments made to ARTI's data: (1) the elimination of two pump brands with zero PROC contents that do not meet the definition of a hair spray, and (2) the comparison of the absolute amount of PROCs emitted from aerosols and pumps rather than the PROC application rates. The first adjustment resulted in the reduction of the pump user sample from 153 to 141 because 12 users of the two brands (Sebastian Spritz and Sta-So-Fro) containing high water content and no PROCs were eliminated. A high water content is not typical of hair sprays, but of conditioning or styling products, such as spritzers and styling lotions (Wells 1989). The second adjustment is based on the fact that ARTI (1988) does not clearly define what users reported as an "application." For instance, for one user an application could mean an actual depression of the valve, whereas for other user it could represent a styling session regardless of the number of times the valve was depressed. In a test period of 14 days most users reported 10 to 20 applications; however, several users reported more than 40 applications with one user reporting up to 59 applications. Thus this discrepancy in the definition of "application" for each user is believed to bias the results. Appendix E presents the calculations made to arrive at the 1.33 ratio reported above.

The quantitative results from the ARTI study, however, do not correspond to the results expected based on the product composition. As described above, one pump container is considered to be equivalent to about 1.6 to 1.7 aerosol containers based on the concentration of active ingredients in the popular formulations. Assuming that consumers apply the same amount of active ingredients to their hair regardless of the package type, the pump hair spray should reduce emissions by a minimum of about 40 percent (1 - 1/1.68). Given that pump hair sprays also have lower PROC concentrations, the total emissions reduction associated with switching to pumps should be on the order of 45 to 66 percent, depending of the pump formulation.

The cause of the deviation between the ARTI test results and the results expected based on representative aerosol and pump formulations is not known. As shown in Exhibit 4-6, the results for adult men show emissions reductions of about 50 percent, which is larger than the reduction for adult women. One possible explanation for why the results for adult women do not correspond to expectations is that the consumers that switched delivery systems did not have enough time to adjust their usage patterns during the test. It is possible that over time the consumers would adjust their application rates so that the same amounts of active ingredients would be delivered to their hair.

This hypothesis, however, cannot be proved conclusively at this time with the available data. Of note is that in examining the ARTI test data it appears that those consumers that applied the pump spray 20 or more times during the test period achieved, on average, a larger reduction in PROC emissions than did consumers that applied the pump spray fewer than 20 times. This result suggests that consumer behavior was still adapting to the alternative product formulation and delivery at the time the test ended. Although additional analysis of the data can be performed, the large variability in the results among individual participants prevents firm conclusions from being drawn.

Other Delivery Systems. Alternative delivery systems that do not fall into the definition of pumps include barrier packages, such as the Exxel® system and the Growpak® system. These systems are characterized by the elimination of the hydrocarbon propellants (e.g., isobutane, propane) as the pressurizing media that forces the product out of the can. The Exxel package consists of a plastic container with an inner bottle that is inserted into a rubber sleeve and crimped to a valve. The system is filled by injecting the product through the valve under pressure, thereby expanding the rubber sleeve. As the valve is depressed the product is expelled by the natural contraction of the expanded rubber sleeve which tends to return to its original shape.

A hair spray product formulated for the Exxel package was market tested and introduced by Clairol under the brand name of "Patterns" (ARTI 1988). Complete information on this product's formulation is not available; however, its PROC content is reported at 96 percent (ARTI 1988). Although

the referenced market survey reports that users were generally satisfied with "Patterns," the product was withdrawn from the market after one and a half years due to two technical problems. First, the polyethylene barrier pack stresses at temperatures above 118°F and thus container leakage became a problem in warm climates such as in warehouses in Texas (Gould 1989).[25] Second, the alcohols and solvents used in the formulation were not compatible with the polyethylene barrier pack and stress cracks occurred at the neck of the bottle (Gould 1989). In addition, Pereira (1989) reports that the last 30 percent of the product had poor delivery rate because the pressure in the package dropped to 23 psi. According to this source, the minimal pressure required in a hair spray is 35 psi (Pereira 1989).

At present, a representative of Exxel believes that using a formulation similar to one used in a pump (i.e, with a lower alcohol content than "Patterns") would probably be compatible with a polyethylene pack or with a new resin pack now under development by Exxel (Gould 1989). This source reports that one hair spray formulator is currently evaluating a formulation for the European market thought to be compatible with the current Exxel system. Although the formulation is not known, it is thought to have a PROC content equivalent to the content found in a typical pump formulation (Gould 1989). A contact at Clairol also believed that future formulations for the Exxel package would resemble current pump formulations (Pereira 1989). If this formulation does prove to be compatible with the Exxel package, switching to an Exxel system would not reduce PROC emissions anymore than would switching to a pump system. However, if the Exxel system has spray characteristics that are similar to those from an aerosol package, its consumer acceptance may be higher than for other pump products.

Another alternative delivery system, the Growpak, manufactured by Enviro-Spray, consists of an inflatable barrier pouch that is surrounded by the product. The pressurization and consequent dispensing of the product is achieved by the gradual formation of CO_2 inside the pouch. To generate the CO_2, the pouch is equipped with a system that allows the gradual reaction of sodium bicarbonate with citric acid. With respect to dispensing pressure, two systems exist - one that maintains a relatively constant pressure through the product life and one that declines in pressure as the product ages.

Modall®, a hair spray manufactured in Europe, uses the latter Growpak system and has been on the market since 1989 (Banks 1989). At this time, no technical problems have arisen with the product; however, the drying time is longer compared to CFC or hydrocarbon-propelled aerosols (Banks 1989). It is believed that the product has a formulation similar to one found in a pump (i.e, with similar PROC content) (Banks 1989); thus, this Growpak system offers similar PROC reduction as pumps and the Exxel system.

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[25] Exxel now reports that they have developed a barrier pack capable of sustaining temperatures above 120°F.

4.3 SPRAY PAINTS

Consumers use different methods to apply paint to household goods depending on the size, shape, and other physical characteristics of the item being painted. These painting methods include the use of a common brush, a roller, an aerosol coating, and a compressor system. Aerosol coatings possess specific advantages that differentiate them from other methods of applying paint, such as, ease of use, fast drying, effective application on intricate surfaces, uniform application (no runs or drips in vertical surfaces), convenience for small touch-up jobs, and reduced cleaning after use. Typically aerosol coatings are used to protect, touch-up and/or decorate a variety of objects, such as automobiles, bicycles, mail boxes, outdoor and indoor furniture, barbecues, tools and machinery, and hobby items.

With respect to the entire coatings industry in the U.S. which in 1986 shipped 967 million gallons of paints valued at $9.68 billion (Chemical Marketing Reporter 1987a), aerosol coatings represent a small sub-segment within the so-called "special-purpose coatings". The types of paints used in aerosol coatings are generally defined as "air-drying," in contrast to industrial paints that are factory applied to industrial products and oven-dried ("baked" paints) (Kirk Othmer 1984).

There is no simple classification for all kinds of paint products packaged as aerosols because of the complexity of these products' composition. For the purposes of this analysis and according to the available production data, aerosol coatings are classified into four main product categories: spray paints, clear coatings, primers, and other related products such as metallic paints, wood stains, paint strippers, and rust removers. Exhibit 4-7 presents a list of these categories and an estimate of the number of aerosol cans filled in 1987 in the U.S. This study focuses on the spray paints category, which represents about 81.4 percent of the total U.S. market for aerosol coatings.

All surface coatings are typically composed of three basic components: the film-forming binder, the pigment system, and solvents. Surface coatings packaged as aerosols also contain propellants. The film-forming binder consists of resins or drying oils. The pigment system contains coloring and opacifying materials and various extenders. Volatile solvents (or water) act as the dispersion medium[26] and maintain fluidity.[27] When a

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[26] The solvent disseminates the aerosol ingredients and correspondingly influences the rate of spray and droplet size of the dispersed product.

[27] The solvent solubilizes the compressed gas propellants and brings the other ingredients into a homogeneous solution with the propellant.

EXHIBIT 4-7

AEROSOL COATINGS AND RELATED PRODUCTS FILLED IN 1987 IN THE U.S.

Product Category	Units Filled in 1987 (millions)	Percent of Aerosol Coatings Market (%)
Spray Paints	258.2	81.4%
Clear Coatings		
Varnishes/Lacquers	9.2	2.9%
Polyurethanes	10.1	3.2%
Shellacs	0.3	0.1%
Primers		
Rust Preventive	10.1	3.2%
Standard	4.8	1.5%
Marine	3.5	1.1%
Wood Stains		
Oil-Base	0.3	0.1%
Varnish-Base	2.6	0.8%
Paint Strippers	7.0	2.2%
Rust Removers	0.7	0.2%
Metallic Paints	10.5	3.3%
Total	317.3	100.0%

Sources: Johnsen 1987a and CSMA 1988.

coating is applied to a surface, the volatile solvent evaporates, leaving the binder and pigment to form an adherent film (Rehm 1982).

The properties of the propellant systems currently used explain, to some extent, the high concentrations of PROCs present in aerosol coating formulations. When the chlorofluorocarbon (CFC) propellants were phased out in the late 1970s, aerosol coatings formulations required substitute chemicals with adequate solvency, atomization, and evaporation characteristics. Low molecular weight hydrocarbons such as propane, isopropane, butane, and isobutane met the evaporation requirements and eventually replaced CFCs. These hydrocarbons, however, have lower solvency and poorer atomization properties than the original CFCs (Spechts 1987). Thus, a solvent is needed in the hydrocarbon-propelled aerosol to increase solvency, improve atomization, and improve polymer compatibility with the propellant.

Since the ban on CFC propellants (i.e., fully halogenated fluorocarbons used as propellants, such as CFC-11, CFC-12, and CFC-114 (Reed 1987)), a wide variety of solvent/dispersion media have been used by formulators to achieve cost-performance objectives (SRI 1985b):

- aliphatic hydrocarbons (e.g., naphtha, mineral spirits, hexane);
- aromatic hydrocarbons (e.g., toluene, xylene);
- alcohols (e.g., methanol, isopropanol);
- ketones (e.g., acetone, methyl ethyl ketone);
- esters (e.g., ethyl acetate, n-butyl acetate);
- ethers (e.g., dioxane);
- chlorinated hydrocarbons (e.g., methylene chloride, 1,1,1-trichloroethane); and
- water.

All of these solvents, except for the last two, fall into the definition of PROCs. The aliphatic and aromatic solvents and the ketones are generally used as primary solvents. The chlorinated hydrocarbons are often defined as co-solvents (Rehm 1982), meaning that they act as a propellant co-solvent blend to improve polymer compatibility with the propellant.

4.3.1 Spray Paint Formulations

As mentioned earlier, aerosol coatings consist of four components: the film-forming binder, the pigment system, solvents, and propellants. In most cases, the amount and composition film-forming binder and pigment system define whether a product is a spray paint, a clear coating, or a primer. The presence of pigments/colorants is typical in all spray paints; in contrast, clear coatings do not contain pigments (Johnsen 1987b, Rehm 1982). Primers use larger amounts of pigment and binder solids to provide an initial protective coating (clear coatings and primers are discussed separately in further detail).

The typical spray paint provides a glossy or semi-glossy colored finish that is usually referred to as an enamel (Kirk Othmer 1984). Flat (low gloss) paints are also available and their applications include the protection of outdoor surfaces, tools, etc. Regarding chemical composition, the film-forming binder is responsible for most of the product's functionality; thus, the binder is used to differentiate between different types of paints. For example, a polyurethane binder provides a highly weather and impact-resistant finish desirable for outdoor applications. These aerosol coatings are designated as "polyurethane spray paints."

Within each type of binder system, different pigment systems can be added to obtain different colors. A typical general-purpose spray paint is based on an air-dry alkyd system as the film-forming binder (SRI 1985); however, many other resins, such as acrylic and epoxy ester polymer-based systems are gaining popularity for auto refinishing and appliance touch-up spray paint applications. These emerging binder systems provide special properties, such as moisture and abrasion resistance, and rust prevention.

Exhibit 4-8 presents five prototype spray paint formulations. Formulation I is a pigmented varnish[28] that uses an alkyd resin as the binder and represents the most popular type of spray paint. Formulation II is the same except that the resins are replaced with nitrocellulose, thus making it a lacquer-type spray paint. It accounts for 12 percent of the market. The PROC content of these formulations are 87.8 and 85.8 percent, respectively.

Until a few years ago, Formulation III represented the standard varnish-type product, which contained methylene chloride. Because methylene chloride is not classified as a PROC, Formulation III contains a

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[28] A varnish is a resin-based coating that cures through a polymeric reaction of the binder with oxygen after evaporation of the solvent. A varnish may be pigmented/colored or clear. For this analysis, pigmented varnishes, lacquers, and polyurethanes are considered a type of spray paint. Varnishes, lacquers, and polyurethanes without pigment are categorized as clear coatings and are discussed below.

EXHIBIT 4-8

FORMULATION DATA FOR SPRAY PAINTS

Ingredients	Formulation (%) w/w I	II	III	IV	V[a]
Pigment/Colorant	6.0	6.0	6.0	--	5.0
Resin[b]	6.0	--	6.0	15.0	10.0[c]
Nitrocellulose	--	8.0	--	--	--
Metallic Additive	--	--	--	3.0	--
Plasticizer/Additives	0.2	0.2	0.2	0.3	--
Surfactants and Other[g]	--	--	--	--	0.8
Methylene Chloride	--	--	28.0	--	--
PROC Solvents[d]	**58.8**	**55.8**	**32.0**	**53.7**	**14.2[e]**
Water	--	--	--	--	25.0
Propellant A-70 or A-85	**29.0**	**30.0**	**27.8**	**28.0**	**45.0[f]**
Total	100.0	100.0	100.0	100.0	100.0
PROC Content (%w/w)	**87.8**	**85.8**	**59.8**	**81.7**	**59.2**
Market Share (%)[h]	81	12	3	3	1

[a] This is a high gloss red acrylic paint representative of dimethyl ether/water-based spray paints.

[b] Vinyl-toluene modified alkyd resin or short oil chain-stopped alkyd resin.

[c] Acrylic resin formulated at 40 percent in water (Goodrich 1989). Resin and water contents have been adjusted accordingly.

[d] These PROC solvents include acetone, methylethyl ketone, n-butylmethyl ketone, toluene, mixed isomeric xylenes, durene, light aromatic blends (e.g., containing ethylbenzene), alcohols, and esters (e.g., n-butyl acetate).

[e] Isopropyl alcohol (9 percent) as volatile solvent and propylene glycol (5.2 percent) as coalescing solvent.

Continued

EXHIBIT 4-8 (Continued)

FORMULATION DATA FOR SPRAY PAINTS

[f] Dimethylether.

[g] Includes nonylphenoxy polyethoxy ethanol (0.36 percent), fluorosurfactant (0.02 percent), colloidal silica (0.14 percent), and magnesium aluminum silicate (0.30 percent).

[h] Spray paints market for California: 28.4 million cans (8.1 oz.) (Johnsen 1989).

Sources: Formulations I through IV are from Johnsen (1987a), formulation V from Aerosol Age (1986a).

Note: All formulations discussed are prototypes and only representative of what may finally be available in the marketplace. The relative proportions of ingredients should therefore be read as indicative rather than absolute numbers.

relatively low PROC content of 59.8 percent. Methylene chloride was used in aerosol coatings because of its rapid rate of evaporation, excellent solvency, low flammability, high specific gravity (i.e., high contribution to the formulation's weight), excellent vapor pressure depressant properties (SRI 1985b), and low cost (Mallarnee 1987).

In March 1985, the National Toxicology Program (NTP) released results indicating evidence of the carcinogenicity of methylene chloride in laboratory animals. The regulatory review process by EPA (as required by the Toxic Substances Control Act), The Food and Drug Administration (FDA), the Consumer Product Safety Commission (CPSC), and to some extent, the Occupational Safety and Health Administration (OSHA) has led to increased pressure to reduce the use of methylene chloride in aerosol products.

ICF estimates that between 1984 and 1987, the consumption of methylene chloride in aerosol products declined from 100 million pounds to an upper bound estimate of 57 million pounds, which represents an annual drop of 17 percent over the three-year period (ICF 1988). Aerosol coatings account for the largest share (51 percent) of methylene chloride consumed in aerosols. This three-year transition has been dramatic for the case of aerosol coatings. According to industry sources, California has led the nation in the use of aerosol coatings without methylene chloride. Whereas methylene chloride-based products account for 30 to 40 percent of the nation's aerosol coatings, in California they account for only about 3 percent of the market (Johnsen 1989).

Methylene chloride has been replaced with PROCs, primarily acetone, in the older and simpler formulations (Johnsen 1987b). In the more complex formulations, methylene chloride is being replaced by a combination of acetone and certain simple esters (Johnsen 1987b). This results in a slightly "runnier" product of lighter density, so that only approximately 85 percent of the original maximum weight can be filled into the same can size. Furthermore, an industry source indicated a general trend towards smaller aerosol cans due to the replacement of methylene chloride with lighter solvents (Mallarnee 1987).

Formulation IV represents a metallic version of Formulation I; it has neither methylene chloride nor pigment/colorant, although it contains metallic ingredients. Its PROC content is 81.7 percent.

Formulation V represents a dimethyl ether/water-based spray paint (Aerosol Age 1986). Although water-based spray paints can be formulated with hydrocarbon propellant blends, this specific example contains dimethyl ether (DME). In past years, DME-based formulations have generally been reported to be a future spray paint option (Leep 1985, ICF 1985); thus, its current market share is very small. Formulation V has a PROC content of 59.2 percent.

All formulations, except V, contain small concentrations of plasticizer. This additive makes the painted surface less brittle, so that

sitting down in a painted cane chair, for example, will not cause the paint to crack off (Johnsen 1987b). Esters are commonly used as plasticizers.

As a comparison to the data on spray paints, Exhibit 4-9 and 4-10 present formulation information for clear coatings and primers. Aerosol clear coatings do not contain pigments and include polyurethanes, lacquers, and varnishes. Polyurethanes account for the largest portion of the market (81 percent), followed by lacquers (15 percent), and varnishes (4 percent). (Shellacs, also considered clear coatings, are not described here and represent approximately one percent of the clear coatings market).

Exhibit 4-9 presents six formulations for aerosol clear coatings. Formulations I and II represent varnishes and contain vinyl-toluene resin. The PROC content in these formulations is 68.7 and 88.7 percent, respectively.

Formulations III and IV represent the lacquer-type coatings and, thus, are formulated with nitrocellulose/acrylic resin. The PROC content in these formulations is 64.8 and 92.8 percent, respectively. Formulation III has a lower PROC content because of the presence of methylene chloride as the solvent.

The polyurethanes are exemplified by Formulations V and VI, which contain linseed-oil-modified polyurethane resin. PROCs account for 54.0 and 85.0 percent of these formulations, respectively.

As shown, Formulations II, IV, and VI are the equivalent of Formulations I, III, and V with the methylene chloride removed and replaced with other PROC solvents (e.g., acetone). The formulations without methylene chloride represent the majority of the clear coatings market.

Shellacs are also classified as clear coatings and are based on a resin manufactured from the lac bug of India. No formulation data are available on these products. Shellacs represent one percent of the clear coatings market, thus, the effect on the overall PROC emissions estimate is considered insignificant.

Primers are paints heavy in pigments/colorants for hiding power. These products are applied to a raw surface as the first coat. They provide two-sided bonding, crevice fitting, and hiding power and function to seal the surface (e.g., wood, composite). Primers give protection from the elements and allow the final coating to go on smoothly for lasting beauty or functionality. A rust preventive type primer contains corrosion inhibitors in the formulation. A standard primer has no special additives. A marine primer has both a corrosion inhibitor as well as a copper organic salt to fight off barnacles and sea plant life. Rust preventive, standard and marine primers account for 54, 28, and 18 percent of the market, respectively.

EXHIBIT 4-9

FORMULATION DATA FOR CLEAR COATINGS

Ingredients	Formulation (%) (w/w) I	II	III	IV	V	VI
Vinyl-Toluene Resin	11.0	11.0	--	--	--	--
Nitrocellulose/Acrylic Resin	--	--	7.0	7.0	--	--
Linseed-Oil-Modified Polyurethane Resin	--	--	--	--	15.0	15.0
Plasticizer/Additives	0.3	0.3	0.2	0.2	--	--
Methylene Chloride	20.0	--	28.0	--	31.0	--
Other Solvents[a]	41.7	61.7	37.8	65.8	27.0	58.0
Propellant A-70 or A-85	27.0	27.0	27.0	27.0	27.0	27.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
PROC Content (%w/w)	68.7	88.7	64.8	92.8	54.0	85.0
Market Share (%)[b]	1	3	2	13	33	48

Source: Johnsen 1987a, Johnsen 1989.

[a] These other solvents include acetone, methylethyl ketone, n-butylmethyl ketone, toluene, mixed isomeric xylenes, durene, light aromatic blends (e.g., containing ethylbenzene), alcohols, and esters (e.g., n-butyl acetate).

[b] Clear coatings market in California: 1.8 million (8.1 oz.) (Johnsen 1989).

Note: All formulations discussed are prototypes and only representative of what may finally be available in the marketplace. The relative proportions of ingredients should therefore be read as indicative rather than absolute numbers.

EXHIBIT 4-10

FORMULATION DATA FOR PRIMERS

Ingredients	Formulation (%) (w/w) I	II	III	IV	V	VI
Pigment/Colorant	15.0	15.0	15.0	15.0	15.0	15.0
Silicone-Modified Alkyd Resin	16.0	16.0	--	--	--	-
Epoxy-Ester Resin	--	--	20.0	20.0	--	-
Chain-Stopped Alkyd Resin	--	--	--	--	18.0	18.0
Plasticizer	0.5	0.5	0.5	0.5	0.5	0.5
Methylene Chloride	30.0	--	30.0	--	28.0	-
Other Solvents[a]	8.5	38.5	4.5	34.5	11.5	39.5
Propellant A-70 or A-85	30.0	30.0	30.0	30.0	27.0	27.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
PROC Content (% w/w)	38.5	68.5	34.5	64.5	38.5	66.5
Market Share (%)[b]	4	50	1	27	2	16

[a] These other solvents include acetone, methylethyl ketone, n-butylmethyl ketone, toluene, mixed isomeric xylenes, durene, light aromatic blends (e.g., containing ethylbenzene), alcohols, and esters (e.g., n-butyl acetate).

[b] Primer market in California: 1.9 million cans (8.1 oz.) (Johnsen 1989).

Source: Johnsen 1987b, Johnsen 1989.

Note: All formulations discussed are prototypes and only representative of what may finally be available in the marketplace. The relative proportions of ingredients should therefore be read as indicative rather than absolute numbers.

Exhibit 4-10 presents prototype formulations of aerosol primers. As shown, these products usually contain a higher concentration of paint solids and methylene chloride than exists in spray paints; thus the PROC content in these products is relatively lower.

The six formulations represent the three types of primer products mentioned above. Formulations I and II depict rust preventive primers; these products contain silicone-modified alkyd resin. The PROC content in these formulations is 38.5 and 68.5 percent, respectively. Formulations III and IV are standard-type primer formulations with epoxy-ester resin. The PROC content in these formulations is 34.5 and 64.5 percent, respectively.

Formulations V and VI represent marine-type primers, which contain chain-stopped alkyd resin formulated with a copper salt that attacks marine life. PROCs in these formulations account for 38.5 and 66.5 percent of the total formulation weight.

As with clear coatings, formulations II, IV, and VI are the equivalent of Formulations I, III, and V with the methylene chloride removed and replaced with other PROC solvents (e.g., acetone). The formulations without methylene chloride represent the majority of the primer market.

4.3.2 PROC Emissions

Exhibit 4-11 presents estimates of PROC emissions from spray paints, clear coatings, and primers in 1987. As for hair spray products, these estimates account for emissions associated with 100 percent of the product's contents, i.e., declared contents plus overfill (see Appendix D for explanation of overfill). These aerosols generated between 6,815 (average) and 8,544 (upper bound) tons of PROC emissions during 1987.

These emission estimates are based on the PROC contents of the formulations reported in Exhibits 4-8, 4-9, and 4-10, the estimated average and upper bound container sizes, and the estimated size of the market for these products in California. An explanation of average and upper bound can sizes is presented in Appendix D.

Of note is that these estimates of PROC emissions are smaller than the 1983 VOC emissions estimates presented in ARB (1987) of about 9,070 metric tons. The ARB estimates include methylene chloride (a VOC), which may account for a portion of the differences in the estimates.

SAI (1986) also reports larger emissions rates for these products, 8,667 to 11,240 metric tons. The SAI estimates differ from the estimates presented here because:

- SAI estimates an average weight of 12 ounces (0.75 lbs.) while the estimates presented here are based on an average product

EXHIBIT 4-11

PROC EMISSIONS FROM AEROSOL COATINGS

(1) Product Category Formulation, PROC % (w/w)	(2) Average Can Size (Upper Bound Can Size) (oz.) (a)	(3) Market Share of Formulation	(4) Units Filled in the Category	(5) = (4) X [(2)/16 oz/lb X 1 ton/2000lb] PROC Emissions (Tons)	
				Average	Upper Bound
Spray Paints	8.1				
I 87.8%	7.69 (10.1)	81%(c)	23,004,000	4,854	6,375
II 85.8%	9.72	12%	3,408,000	888	923
III 59.8%	9.72	3%	852,000	155	161
IV 81.7%	9.72	3%	852,000	211	220
V 59.2%	9.72	1%	284,000	51	53
SUB TOTAL		100%	28,400,000	6,159	7,731
Clear Coatings	8.1				
Varnishes	(10.1)				
I 68.7%		1%	18,000	3	4
II 88.7%		3%	54,000	12	15
Lacquers					
III 64.8%		2%	36,000	6	7
IV 92.8%		13%	234,000	55	69
Polyurethanes					
V 54.0%		33%	594,000	81	101
VI 85.0%		48%	864,000	186	232
SUB TOTAL		100%	1,800,000	343	428
Primers	8.1				
Rust Preventive	(10.1)				
I 38.5%		4%	76,000	7	9
II 68.5%		50%	950,000	165	205
Standard					
III 34.5%		1%	19,000	2	2
IV 64.5%		27%	513,000	84	104
Marine					
V 38.5%		2%	38,000	4	5
VI 66.5%		16%	304,000	51	64
SUB TOTAL		100%	1,900,000	312	390
TOTAL PROC EMISSIONS (b)				6,815	8,549

Source: Data based on Johnsen 1987a, Johnsen 1987b, Johnsen 1989 (except where noted otherwise).
(a) ICF estimates based on Johnsen 1987b and Westat 1987. See Appendix A for explanation.
(b) Totals may not add due to rounding.
(c) Formula I includes car touch up paints which account for approximately 25 percent of the spray paint market. Average can size includes 9.72 oz./can for non-car touch up and 3.15 oz./can for car touch up.

size of 8.1 ounces. In light of the large share of automobile touch up and hobby paint 3 ounce containers in the overall spray paint category, the average weight is unlikely to be as high as 12 ounces (see Appendix D).

- o SAI uses a geographic multiplier of 1.15 to represent the spray paint market in California (i.e., the California use of these products is estimated as 1.15 x 11% or 12.65% of the national total).

- o SAI estimates that the PROC content of aerosol paints ranges from 67 to 87 percent. The estimates presented here have a weighted average PROC content of about 83 percent.

Assuming that the geographic multiplier used by SAI is valid, the emissions estimates presented here may be biased downward by 15 percent. However, in our opinion it is unlikely that the overall average size of spray paint containers is as high as 12 ounces.

4.3.3 Options for Reducing PROC Emissions

The concentration of PROCs (i.e., primarily solvents and propellants) employed in a given formulation is determined by several factors, all of which are influenced by the specific paint product and the formulator's technical and economic objectives. Important factors include: type of coating resin, amount of paint solids, and the desired weight of the container. Each of these factors is discussed in turn.

Coating Resin. The properties of the coating resin control the selection of solvents (Spechts 1987). The coating resin is the bonding agent, such as alkyd, acrylic or polyurethane resins. Each type of solvent, for example, chlorinated solvents, toluene, mineral spirits, and water, has a distinct solvency strength. Therefore, the solvent choice depends on its ability to dissolve a specific coating resin and provide homogeneity to the aerosol system (Johnsen 1987b).

An acrylic resin, for example, is dissolved by glycol ethers, ethyl acetate, methyl ethyl ketone, and various alcohols among others (DuPont 1987) because specific molecular interactions allow the diffusion of the resin in the solvent phase. In general, polar solvents dissolve polar resins. For example, an alcohol with strong hydrogen bonding dissolves a polar acrylic resin. Similarly, non-polar solvents dissolve non-polar resins.

Water is a highly polar molecule that has limited affinity with mostly non-polar polymers employed in aerosol paint formulation. Thus, when water is used it is usually combined with other organic solvents to achieve the desired solubility strength.

Paint Solids. The concentration of paint solids in the formulation determines the gloss of a particular paint. Flat paints, formulated with a high pigment content (i.e., solids), typically have lower amounts of solvents. These paints have less shine than gloss or "enamel" paints. Gloss paints, on the other hand, usually contain more solvents (up to 35 or 40 percent) because of the lower amounts of pigment in these formulations (Spechts 1987).

Product Weight. The desired weight of a particular formulation also affects the selection of solvents. Assuming that several solvents meet all the solubility criteria, each solvent's density (the weight of each unit of volume) and cost determines the relative desirability of the options. In general, formulators prefer effective solvents of low cost that contribute the most to the product weight.

Considering the particular characteristics of aerosol coating systems discussed above, there are few opportunities to significantly reduce the use of PROCs and still achieve the same product performance and cost. These include alternate formulations and possibly a switch to alternate delivery systems. The next sections discuss the options for reducing PROC emissions from spray paints.

Alternate Formulations

Switch to Water-Based Spray Paints. Water-based spray paints allow for a partial reduction of PROC contents in aerosol spray paints. Water based paints in the U.S. are made by two companies: Seymour of Sycamore (Seymour, IL) and DAP, Inc. (Tipp City, OH) (Simon 1989, Leep 1989). Water-based paints are also produced in Canada by ICI and custom filled by KG Packaging (Leep 1989). The amount of water that can be used ranges from 10 to 35 percent.

Formulation I in Exhibit 4-12 represents an example of a water-based spray paint containing 21.2 percent water and 66.5 percent PROCs (Johnsen 1987b). The product sold by Seymour of Sycamore is similar to this formulation. Formulation II in Exhibit 4-12 is the water-based spray paint presented earlier containing 25 percent water and 45 percent DME (see Formulation V in Exhibit 4-8). The formulations sold by DAP and the Canadian firm are believed to be very similar to this formulation (Leep 1989, Bartlett 1986, DAP 1989).

The major differences between the two water-based formulations shown in Exhibit 4-12 are the gloss of the finish and price. Patent and trade literature indicate that the use of water-insoluble hydrocarbon propellants in spray paint formulations render emulsions which lead to a matte or dull finish (Bartlett 1986). In fact, the product marketed by Seymour of Sycamore propelled with hydrocarbons uses an acrylic resin and is considered a flat paint (low gloss) targeted for road marking jobs (Leep 1989).

EXHIBIT 4-12

ALTERNATE FORMULATIONS FOR SPRAY PAINTS

Ingredients	Formulation (%) w/w				
	Water-based Hydrocarbon I	Water-based DME II	HCFC/DME III	High-solids IV	MC-based V
Pigment/Colorant	6.0	5.0	6.0	10.0	6.0
Resin	6.0	10.0	6.0	15.0	--
Nitrocellulose	--	--	--	--	8.0
Plasticizer/Additives	0.3	--	0.2	--	0.3
Surfactants and Other	--	0.8	--	--	--
Methylene Chloride	--	--	--	--	29.0
PROC Solvents[a]	**35.5[b]**	**14.2**	**58.8**	**48.0**	**29.7**
Water	21.2	25.0	--	--	--
Propellant[c] HCFC-22/	--	--	11.6	--	--
DME	--	**45.0**	**17.4**	--	--
Hydrocarbon Propellant (A-70)	**31.0**	--	--	**27.0**	**27.0**
Total	99.2	100.0	100.0	100.0	100.0
PROC Content (%w/w)	**66.5**	**59.2**	**76.2**	**75.0**	**56.7**

[a] These PROCs include acetone, methylethyl ketone, n-butylmethyl ketone, toluene, mixed isomeric xylenes, durene, light aromatic blends (e.g., containing ethylbenzene), alcohols, VM&P Naphtha, and esters (e.g., n-butyl acetate).

[b] Mixed xylenes (25 percent), toluene (5 percent), n-butylmethyl ketone (5 percent), and morpholine (0.5 percent).

[c] Propellent mixture consisting of 40 percent HCFC-22 and 60 percent DME.

Sources: Formulations I and V: Johnsen 1987a; formulation II (same as V in Exhibit 5-10); Aerosol Age 1986a; formulations III and IV: ICF estimates based on Strobach 1989b, DuPont 1989, and Leep 1989.

Note: None of the above formulations have been tested and developed for final use. All formulations discussed are prototypes and only indicative of what may finally become available in the marketplace.

The lack of gloss appears to be solved in DME-propelled water-based formulations. DME is suited for use in water-based paints because of its water solubility (35 percent weight) and high resin solvency power (Kauri Butanol No.= 60). DME assists in water evaporation and acts as the propellant. Other water-soluble solvents used include a coalescing organic solvent (a PROC), such as propylene glycol monomethyl ether, which assists in the formation of the paint film and acts as an agent to provide a single phase solution, i.e., resists the separation of two different liquid phases upon standing. In contrast with the water emulsion formed with the hydrocarbon-propelled formulation, DME formulations form a solution. A single phase propellant-solvent solution enables a film-forming polymer dissolved therein to be readily dispensed from the aerosol container without significant agitation.

The substitution potential of water-based formulations for PROC-based paints appears to be limited to certain resin systems. Nitrocellulose lacquers (a clear coating) and other basic forms have not been able to convert to water-based and some sources doubt this will be possible (Johnsen 1987b). Industry sources indicate that not all R&D avenues have been exhausted, however, and that inroads in other systems may be possible. To convert to the water-based types requires significant reformulation with parameters highly specific to the product being changed over. Also, there are patents that limit some options for both straight water and DME/water options. Lengthy shelf-life testing of 1 to 2 years must be performed to ensure that container corrosion does not occur.

Among the performance parameters that must be considered when reformulating an aerosol coating to include water is the evaporation rate. Evaporation rate influences the ability of the spray paint to dry and form a tack-free film (Rehm 1982, Bartlett 1986). The evaporation rate of a solvent from a coating depends on several factors including solvent vapor pressure and solvent-resin interactions. Solvent-based spray paints dry by a combination of oxidation and polymerization of the binder after evaporation of the solvent. Water-based spray paints, alternatively, dry by coalescence of the binders and pigments as the water evaporates, a process that requires a longer period of time.

An economic benefit of using water instead of solvents exists, but it is not highly significant. The PROCs emissions reduction associated with water-based spray paints is estimated at 27 percent.[29]

High Solids Aerosol Spray Paints. As mentioned earlier, aerosol paints consists of four major components: pigments,[30] resin, solvent, and

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[29] Computed using the average of the PROC contents of formulations I and II in Exhibit 4-12.

[30] Except for aerosol clear coatings, most aerosol paints have pigments.

propellant. Solvent and propellant evaporate leaving behind a coating of pigment and resin. These two components are known as "paint solids" or "solids". These solids are the active ingredient in an aerosol paint because they provide the color and protection of the surface to which the spray is applied. Formulation III in Exhibit 4-12 presents an example of a high solids spray paint formulation.

The higher the amount of solids, the larger the surface that can be painted per can. Although there is a technical limit to solids content estimated at approximately 20 to 25 percent[31] (Leep 1989), the amount of PROC solvents and propellants emitted could be reduced by increasing the solids content in spray paints. For example, based on a 12 oz. can the "low-end" of the spray paint market uses a solids content of 7 percent, whereas the "high-end" of the market uses 17 percent solids[32] (Leep 1988). PROCs account for the rest of these formulations. One can of the high solids paint could replace 2.4 cans (17/7) of the "low-end" and PROC emissions would be reduced by 63 percent.[33] This 63 percent reduction is much larger than the reduction in PROC content of the spray paint cans themselves.

As described below, a high solids paint will have higher raw material costs per can. Because the cost of the resins and pigments drive the cost of the formulation, for example, a formulation containing 25 percent solids would have much higher ingredient costs than a standard formulation containing 12 percent solids. No capital investment in equipment would be required to produce high solids paints, however.

Although high solids paints would have higher costs per can they would actually have lower costs per amount of paint delivered. Although such paints would be more cost effective, an industry source indicated that the success of high solids paints would require consumer re-education that may involve labelling changes and communications programs (Leep 1989). In particular, a reliable method of rating the performance of spray paints would be required so that consumers could see that the high solids paints actually cost less per amount of paint delivered. No specific estimates of the costs of such a consumer education and performance testing program are available at this time.

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[31] Seymour of Sycamore sells a commercial spray paint for industrial uses ("MRO"®) with approximately 25 percent solids (Leep 1989).

[32] Solids weight varies depending on the color and nature of the resin used. These percentages are believed to be indicative of an "average" solid content across resins and colors.

[33] PROCs in 2.4 cans = 93 parts * 2.4 = 223.2 parts; PROCs in high solids paint = 83 parts. Percent reduction = (223.2 - 83)/223.2 = 62.8 percent.

Return to Methylene Chloride-based Aerosol Coatings. Formulation V in Exhibit 4-12 shows a representative methylene chloride formulation that is very similar to Formulation III in Exhibit 4-8 that is still on the market. If the toxicity of methylene chloride were not a concern and spray paint formulators decided to switch back to this product with 56.7 percent PROCs, emissions from spray paints would decrease by about 31 percent.

HCFC-based Aerosol Coatings. As with hair sprays, partially-halogenated chlorofluorocarbons (HCFCs) and fluorocarbons (HFCs) may provide an opportunity for reducing PROC emissions significantly. None of the industry sources contacted including representatives from DuPont could report any development work done on spray paint formulations containing HCFCs and HFCs. This does not mean that the use of these compounds is not feasible.

A representative from DuPont agreed that a propellant mixture containing of 40 percent HCFC-22 and 60 percent DME could render an effective blend for an spray paint (Strobach 1989b). Compared with the use of pure HCFC-22, the mixture of HCFC-22 with DME is necessary for two reasons: to decrease the high vapor pressure of HCFC-22 and to enhance the solubility of HCFC-22 (Strobach 1989b). At 70°F, a 40/60 mixture of HCFC-22 and DME has a vapor of 70 psi (DuPont 1989), which is the vapor pressure of propellant A-70[34] commonly used for spray paints. Hence, it is estimated that the HCFC-22/DME blend would be a feasible replacement for hydrocarbon propellants from the vapor pressure standpoint and Formulation III in Exhibit 4-12 shows the estimated composition of a sample formula.

The HCFC-22/DME blend has a higher density than propellant A-70 that may result in a higher contribution to container weight. For the purposes of estimating PROC emissions reductions, however, the HCFC-22/DME mixture in Formulation III (Exhibit 4-12) is assumed to be a one-to-one replacement for propellant A-70 on a percent weight basis. If all spray paints were to replace hydrocarbon propellants with the system depicted in Formulation III, PROCs emissions from spray paints would be reduced by 32 percent.

Alternate Delivery Systems

Airless Paint Sprayers. Alternative delivery systems such as a hand-held paint atomizer or airless sprayer use an electromagnetic or electric motor along with any of three pumping systems - piston, rotary, or diaphragm - to achieve the necessary pressure to dispense the product. Literature indicates that airless sprayers are most effective where the brush is not, such as in painting "textured" surfaces or "hard-to-get-at recesses" (Practical Homeowner 1985). Krebs Incorporated manufactures several sizes of sprayers; the smallest sprayer (Krebs 070) can hold 12

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[34] Propellant A-70 is a mixture of 42 percent weight propane and 51 percent isobutane. The "A" stands for Aerosol Grade and the "70" for the vapor pressure of the mixture (Johnsen 1982).

fluid ounces of product and sells for about $70. A brochure on this sprayer indicates that it can be used with various types of paints such as, metallic, lacquer, enamel stain, polyurethane, and primer (Krebs 1989). Typical applications where this sprayer is useful includes painting of bicycles, furniture, radiators, window screens, auto touch-ups, and hobby projects (Practical Homeowner 1985).

An evaluation of airless sprayers conducted by the product testing laboratory of a publishing firm noted little difference between different brands of airless sprayers, although none of them "produced surfaces as smooth and uniform as surfaces sprayed with compressed air" (Practical Homeowner 1985). Although the study did not compare airless sprayers with aerosols, it is believed that aerosols produce finished surfaces as smooth and uniform as compressor systems, thus, airless sprayers may be at a disadvantage in this aspect. Another disadvantage of airless sprayers is that they are noisy and require clean-up. Over spray (i.e, paint lost due to misting), however, is lower with airless sprayers compared to compressed air systems and aerosols (Practical Homeowner 1985). Overall it is believed for the majority of consumer painting jobs airless sprayers will be as effective as aerosols.

Assuming that all spray paints were replaced by airless sprayers the amount of PROCs emitted to the atmosphere would be reduced by 80 percent. To arrive at this estimate, the amounts of solids (i.e., pigments and resins) of the paint is assumed to be directly proportional to the surface area that can be coated, i.e., the higher the solids, the larger the surface area that can be painted. Determining the amount of solids that can be delivered with the airless sprayer and comparing this with the solids delivered from a can of spray paint provides an estimate of the number of "aerosol equivalent" units required to complete the same painting job. The amount of PROCs emitted from the airless sprayer and from the number of aerosol equivalent units are then compared.

The airless sprayer requires the use of thinned paint with a viscosity that allows efficient delivery.[35] The system analyzed here has a capacity of 12 fluid ounces of thinned paint. To estimate the amount of paint solids contained in 12 fluid ounces of thinned paint the following procedure is used: (1) select a commercial paint recommended for airless sprayers and determine its solid weight content, (2) determine the number of fluid ounces of thinner recommended for airless sprayers, and (3) compute the solid content of the thinned paint.

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[35] The sprayer comes with a funnel for testing paint viscosity. For effective use, paint must be diluted with thinner so that it passes through the funnel in a specified period of time (Brewster 1989). Thinners are 100 percent PROC solvents, such as methyl ethyl ketone and xylene.

Sherwin-Williams (1986) recommends an acrylic enamel (F79 series) with 49 percent weight solids for use with airless paint sprayers.[36] For each fluid ounce of paint used, 0.25 fluid ounces of thinner must be added to achieve the adequate paint viscosity. Since the total volume of the paint container is 12 fluid ounces, the amount of paint and thinner used is 9.6 and 2.4, respectively.[37] Using the paint density of 1.093 wt.oz./fl.oz. the weight of the paint is calculated at 10.49 wt.oz. Forty nine percent of this amount is 5.14 wt.oz., which accounts for the solids that remain on the substrate after all solvents evaporate.

For aerosols, the spray paint formulation with the largest market share that contains 12.2 percent weight solids is used as the basis for comparison. Using an average can of 8.1 wt.oz., the amount of solids in the spray can is 0.988 wt. oz. Assuming that transfer efficiency is the same for airless sprayers and for aerosols, the ratio of solid content determines the number of aerosol cans required to paint the same surface area.[38] On average, then, 5.2 cans of aerosols (5.14/0.988 = 5.2) would be required for the same job.

The amount of PROCs contained in 5.2 aerosol cans is 36.98 wt.oz.[39] The amount of PROCs contained in 12 fl.oz. of thinned paint is 7.37 wt.oz. (5.35 wt.oz. for PROCs contained in the paint before dilution and 2.02 wt.oz. for PROCs in the thinner[40]). The amount of PROCs avoided is 29.61 wt.oz., thus, it is estimated that an approximate 80 percent reduction in PROC emissions is achieved when switching from aerosols to airless sprayers.

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[36] Sherwin-Williams (1986) reports that for this acrylic enamel (F79 series) to be compatible with an airless sprayer, the sprayer must generate pressures from 1500 to 2500 psi and have a jet nozzle orifice of 0.011 to 0.013 inches. Although the jet nozzle orifice size of the Krebs 070 is not known, the pressure generated by the Krebs 070 was given by Brewster (1989) to be 2000 psi. Since a Krebs (1989) brochure lists several different sized jet nozzles, it can be assumed that one would be compatible with the Krebs 070. Thus, it is assumed that the acrylic enamel (F79 series) could be used with the Krebs 070.

[37] These figures are obtained from solving the following equation: $X + 0.25*X = 12$, where X is the number of fluid ounces of paint.

[38] For convenience, it is assumed that 100 percent of the airless sprayer capacity is used. Different usage assumptions would yield similar results.

[39] Computed as: 5.2 cans * 8.1 wt.oz./can * .878 PROC wt. oz. = 36.98 wt. oz. (see Exhibit 4-8).

[40] The thinner has a density of 0.84 fl.oz./wt.oz.; 2.4 * 0.84 = 2.02 wt.oz.

Of note is that airless sprayers can use water- and oil-based paints. The above acrylic paint used to derive the PROC emissions estimates is an oil-based paint diluted with PROC solvents. Because the proportion of water-based vs. oil-based paints is unknown, the analysis has assumed the extreme case scenario, i.e., all airless sprayers would use PROC-based paints. Presumably the PROC emissions reduction can be higher.

The major obstacle in the use of airless sprayers is their cost. As described below, the use of such sprayers is cost effective for only those consumers that use many cans of spray paint per year.

4.4 COSTS OF OPTIONS FOR REDUCING PROC EMISSIONS

Most of the options for reducing PROCs emissions reviewed in this analysis lead to changes in current aerosol manufacturing costs in four major areas:

- o the costs of the package (e.g., the cost of a tinplate can versus a plastic pump);
- o the costs of the chemical ingredients (i.e., the raw material costs of the alternate formulations);
- o capital costs required to adapt or acquire equipment capable of handling the new chemical materials (e.g., DME, HCFCs); and
- o R&D costs associated with the development and testing of the new formulations.

Each of these costs is discussed in turn.

Exhibit 4-13 presents estimates of the costs of using alternative packages, including: the standard tinplate aerosol container; a pump spray; the Exxel package; and the Growpak package. These alternative appear to be feasible for hair sprays. No alternate packages are considered for spray paints.

As shown in the exhibit, the costs per unit of pump sprays is higher than the cost per unit of aerosols. As described above, however, the pump sprays deliver more applications per weight of product than aerosols, so that the package cost per effective application is comparable for the two types of packages.

For the Exxel package a filling fee was not available. For purposes of the analysis below, the capital cost of the equipment is used to estimate the effective filling fee. It is assumed that the capital costs of the

EXHIBIT 4-13

PACKAGE COST DATA
($ per can)

	AEROSOLS	PUMPS	EXXEL	GROWPAK
Package[a]	$0.36	$0.50	$0.479	$0.565
Filling Fee[b]	$0.10-$0.11	$0.15-$0.18	N/A	$0.40
New Equipment[c]	None	None	$88,550	N/A

[a] Package includes all components of the container except the ingredients.

[b] Fees quoted by contract fillers.

[c] It is assumed that there is enough capacity to increase pump production. The Exxel machine quoted has a capacity of 100 cans per minute.

N/A: Not available.

Sources: Peterson Puritan (1989), Sun Labs (1989), Exxel (1989), ASM-Switzerland (1989), Speer Products (1989), and Terco (1989).

Note: The above costs are highly dependent on the ordering volume when the order is below 100,000 units. For orders between 100,000 and 1,000,000 units costs may vary by between 1 or 2 cents. The above quotes are based on ordering volumes of over 100,000.

equipment would have to be recovered across various numbers of products filled. Like the Growpak packaging costs shown in the exhibit, the costs of the Exxel packaging are estimated to be higher than the costs of the current aerosol and pump spray packages.

Exhibits 4-14, 4-15, and 4-16 present the costs of the chemical ingredients of the current aerosol formulations, the alternate aerosol formulations, and the pump hair spray formulations. Similarly, Exhibits 4-17 and 4-18 present similar costs for current and alternate spray paint formulations. The information used to develop these estimates includes the formulation data presented above, ingredient prices, and manufacturing loss allowance factors reported by industry sources.

It is important to note that chemical prices depend on host of factors, such as ordering quantity (i.e., bulk vs. drums), purity, location, supplier, etc. Most of the prices used here are prices reported by California distributors and the rest were based on chemical trade literature (Chemical Marketing Reporter 1987). In addition, the assumed manufacturing loss allowance represents the portion of the chemical ingredient that is lost during the manufacturing process (e.g., evaporation) and was provided by an industry source (Johnsen 1987b).

As shown in the exhibits, the ingredient costs of the current aerosol hair spray formulations are all very similar, approximately $0.18 per can. The ingredient costs for pumps are slightly smaller. The alternative formulations have higher ingredient costs, with the HCFCs being the highest. The HCFC-142b formulation is many times more costly than the current formulations, and costs about $1.00 per can more than the currently used formulations.

The High H_2O, No Alcohol alternative has ingredient costs that are estimated to be only slightly higher than current formulations in use. The estimate of these ingredient costs are somewhat uncertain because the precise costs of the proprietary ingredients are not known. For this analysis the costs of film former, plasticizer, additives, and fragrance are used.

The ingredient costs for spray paints vary from about $0.14 to $0.27 per can. The formulations with ingredient costs in the $0.15 to $0.19 range have the largest market share. The ingredient costs for the substitute formulations are slightly higher than the current formulation costs.

Some of the technical options to reduce PROC emissions from hair spray and spray paints require capital investment in new equipment and/or conversion of existing equipment. The additional investment is necessary due to the properties of some of the new chemical ingredients considered in the alternate formulations. In particular, the costs presented in Exhibit 4-19 are estimates of the costs associated with the equipment for handling and storing DME, HCFCs, and CO_2.

EXHIBIT 4-14

INGREDIENT COST DATA FOR AEROSOL HAIR SPRAYS

[1] Ingredient	[2] Ingredient Cost ($/lb)	[3] Manufacturing Loss Allowance	[4] Ingredient Concentration (%) Representative Formulation I	II	III	IV
Film Former (*)	2.08	1.02	1.8%	2.0%	1.8%	2.0%
Plasticizer (*)	2.08	1.02	0.2%	0.3%	0.2%	0.3%
Additives (*)	2.08	1.02	0.2%	0.1%	0.2%	0.2%
Fragrance (+)	6.00	1.03	0.1%	0.1%	0.1%	0.1%
Colorant/Tint	0.78	1.02	--	--	--	0.2%
Methylene Chloride-S	0.30	1.10	--	--	12.0%	--
S.D. Ethanol (200 Proof)	0.34	1.03	65.7%	63.5%	60.7%	65.8%
De-Ionized Water	0.01	1.03	--	6.5%	--	--
Hydrocarbon Propellant (Isobutane, A-40)	0.16	1.25	32.0%	27.5%	25.0%	31.4%
Total			100.0%	100.0%	100.0%	100.0%
Cost Per Pound (a)			$0.347	$0.335	$0.355	$0.354
Cost Per Can (weighted ave. can size = 8.3 oz.) (a)			$0.180	$0.174	$0.184	$0.184
Ingredient Cost Rating (b)			100	97	102	102

a) The chemical component costs per pound and per can are shown to the third decimal place in order to suggest that the cost differences may be substantial on a bulk production basis (i.e., the filling of several million aerosol containers), although they seem insignificant on an individual can basis.

b) The ingredient cost rating is based on a standard of "100" for the PROC-based formulation that has the largest market share. These values indicate the relative ingredient costs of each formulation with respect to the standard.

*) The cost of the film former represents the bulk cost of PVP-VA in 50% Ethanol (GAF 1989). The cost of the plasticizer and the additives are assumed to equal the cost of the film former.

+) The cost of the fragrance is based on the lower bound estimate of a typical hair spray fragrance (Felton Worldwide Inc 1989). More specific data were not available.

EXHIBIT 4-15

INGREDIENT COSTS FOR AEROSOL HAIR SPRAY ALTERNATIVE FORMULATIONS

Ingredient	Ingredient Cost ($/lb)	Manufacturing Loss Allowance	Ingredient Concentration (%)					
			DME/Water I (a)	HCFC Systems II	HCFC Systems III	HCFC Systems IV	CO2 System V	High H2O No Alcohol VI
Film Former (b)	2.08	1.02	2.2%	1.5%	1.8%	1.8%	2.1%	--
Plasticizer (b)	2.08	1.02	0.3%	0.2%	0.3%	0.2%	0.3%	--
Additives (b)	2.08	1.02	0.2%	0.2%	0.3%	0.2%	0.3%	--
Fragrance (c)	6.00	1.03	0.3%	0.1%	0.2%	0.2%	0.2%	--
S.D. Ethanol (200 Proof)	0.34	1.03	45.0%	18.0%	67.4%	37.6%	81.6%	--
Dimethyl Ether (DME)	0.41	1.25	39.5%	--	--	30.0%	--	30.0%
De-Ionized Water	0.01	1.03	12.5%	2.0%	--	10.0%	--	60.0%
HCFC-142b	2.30	1.25	--	78.0%	--	--	--	--
HCFC-22	1.00	1.25	--	--	30.0%	20.0%	--	--
Carbon Dioxide	0.30	1.25	--	--	--	--	5.5%	
Iso-Pentane	0.19	1.25	--	--	--	--	10.0%	
Proprietary Ingredients (d)								10.0%
Total			100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Cost Per Pound (e)			$0.437	$2.352	$0.674	$0.595	$0.400	$0.384
Cost Per Can (weighted ave. can size = 8.3 oz.) (e)			$0.227	$1.220	$0.350	$0.309	$0.207	$0.199

a) To compute raw material costs, the mid-point of the concentration ranges reported for the prototype DME/water based hair spray is used.

b) The cost of the film former represents the bulk cost of PVP-VA in 50% Ethanol (GAF 1989). The cost of the plasticizer and the additives are assumed to equal the cost of the film former.

c) The cost of the fragrance is based on the lower bound estimate of a typical hair spray fragrance (Felton Worldwide Inc 1989). More specific data were not available.

d) The cost of the proprietary ingredients is assumed to be the weighted average cost of film former, plasticizer, fragrance, and additives, with additives being 3 percent of this total.

e) The chemical component costs per pound and per can are shown to the third decimal place in order to suggest that the cost differences may be substantial on a bulk production basis (i.e., the filling of several million aerosol containers), although they seem insignificant on an individual can basis.

EXHIBIT 4-16

INGREDIENT COST DATA FOR PUMP HAIR SPRAYS

[1] Ingredient	[2] Ingredient Cost ($/lb)	[3] Manufacturing Loss Allowance	[4] Ingredient Concentration (%w/w) Representative Formulations I	II
Film Former (*)	2.08	1.02	3.2%	3.2%
Plasticizer (*)	2.08	1.02	0.4%	0.4%
Additives (*)	2.08	1.02	0.4%	0.4%
Fragrance (+)	6.00	1.03	0.2%	0.2%
S.D. Ethanol (200 Proof)	0.34	1.03	90.8%	55.8%
De-Ionized Water	0.01	1.03	5.0%	5.0%
1,1,1-Trichloroethane	0.42	1.10	--	35.0%
Total			100.0%	100.0%
Cost Per Pound (a)			$0.416	$0.455
Cost Per Can (weighted ave. can size = 6.3 oz.) (a)			$0.164	$0.179
Ingredient Cost Rating (b)			100	109

a) The chemical component costs per pound and per can are shown to the third decimal place in order to suggest that the cost differences may be substantial on a bulk production basis (i.e., the filling of several million aerosol containers), although they seem insignificant on an individual can basis.

b) The ingredient cost rating is based on a standard of "100" for the PROC-based formulation that has the largest market share. These values indicate the relative ingredient costs of each formulation with respect to the standard.

*) The cost of the film former represents the bulk cost of PVP-VA in 50% Ethanol (GAF 1989). The cost of the plasticizer and the additives are assumed to equal the cost of the film former.

+) The cost of the fragrance is based on the lower bound estimate of a typical hair spray fragrance (Felton Worldwide Inc 1989). More specific data were not available.

EXHIBIT 4-17

INGREDIENT COST DATA FOR SPRAY PAINTS

[1]	[2]	[3]	[4] Ingredient Concentration (%)				
Ingredient	Ingredient Cost ($/lb)	Manufacturing Loss Allowance	Representative Formulation I	II	III	IV	V
Pigment/Colorant	1.16	1.02	6.0%	6.0%	6.0%	--	5.0%
Vinyltoluene Alkyd Resin	0.65	1.02	6.0%	--	6.0%	15.0%	--
Acrylic Resin	1.74	1.02 (f)	--	--	--	--	10.0%
Nitrocellulose	1.48	1.02 (f)	--	8.0%	--	--	--
Metallic Additive	0.22	1.02	--	--	--	3.0%	--
Plasticizer/Additives	0.67	1.02 (f)	0.2%	0.2%	0.2%	0.3%	--
Methylene Chloride	0.30	1.10	--	--	28.0%	--	--
Other Solvents (c)	0.22 (d)	1.02	58.8%	55.8%	32.0%	53.7%	--
Isopropyl Alcohol	0.27	1.03	--	--	--	--	9.0%
Propylene Glycol Monomethyl Ether	0.68	1.03 (f)	--	--	--	--	5.2%
Water	0.01	1.03	--	--	--	--	25.0%
Other Additives	0.99 (e)	1.02	--	--	--	--	0.8%(e)
Propellant (A-70 or A-85)	0.15	1.25	29.0%	30.0%	27.8%	28.0%	--
Dimethyl Ether	0.41	1.25	--	--	--	--	45.0%
Total			100.0%	100.0%	100.0%	100.0%	100.0%
Cost Per Pound (a)			$0.298	$0.375	$0.328	$0.281	$0.539
Cost Per Can (weighted ave. can size = 8.1 oz.) (a)			$0.151	$0.190	$0.166	$0.142	$0.273
Ingredient Cost Rating (b)			100	126	110	94	181

a) The chemical component costs per pound and per can are shown to the third decimal place in order to suggest that the cost differences may be substantial on a bulk production basis (i.e., the filling of several million aerosol containers), although they seem insignificant on an individual can basis.

b) The ingredient cost rating is based on a standard of "100" for the PROC-based formulation that has the largest market share. These values indicate the relative ingredient costs of each formulation with respect to the standard.

c) Ketones (e.g., acetone), xylenes, aromatics, aliphatics, alcohols, esters, etc.

d) Cost of toluene (can also use acetone)

e) Formulation V also contains nonylphenoxy polyethoxy ethanol (0.36%), a fluorosurfactant (0.02%), colloidal silica (0.16%), and magnesium aluminum silicate (0.30%). The price of this mixture of additives is estimated at $0.99/lb based on weighted average of the price of the first and last ingredients of the mixture (Rohm & Haas 1989, PPG Industries 1989).

f) Estimated manufacturing loss allowance based on similar chemical.

EXHIBIT 4-18

INGREDIENT COST DATA FOR ALTERNATIVE SPRAY PAINT FORMULATIONS

[1] Ingredient	[2] Ingredient Cost ($/lb)	[3] Manufacturing Loss Allowance	[4] Ingredient Concentration (%) Representative Formulation I Water-based(g)	III HCFC/DME	IV High solids	V Methylene Chloride
Pigment/Colorant	1.16	1.02	6.0%	6.0%	10.0%	6.0%
Vinyltoluene Alkyd Resin	0.65	1.02	6.0%	6.0%	15.0%	--
Nitrocellulose	1.48	1.02 (a)	--	--	--	8.0%
Metallic Additive	0.22	1.02	--	--	--	--
Plasticizer/Additives	0.67	1.02 (a)	0.3%	0.2%	--	0.3%
Methylene Chloride	0.30	1.10	--	--	--	29.0%
Other Solvents (b)	0.22 (c)	1.02	5.0%	58.8%	20.0%	29.7%
Water	0.01	1.03	21.2%	--	--	--
xylenes	0.27	1.02	25.0%	--	--	--
n-butylmethylketone	0.70	1.02 (a)	5.0%	--	--	--
VM&P Naphtha	0.32	1.03 (a)	--	--	13.0%	--
mineral spirits	0.23	1.03 (a)	--	--	15.0%	--
Morpholine	1.08 (d)	1.03	0.5%	--	--	--
Hydrocarbon Propellant (A-70 or A-85)	0.15	1.25	31.0%	--	27.0%	27.0%
HCFC-22/DME (40/60) (e)	0.65	1.25	--	29.0%	--	--
Total			100.0%	100.0%	100.0%	100.0%
Cost Per Pound (f)			$0.294	$0.480	$0.392	$0.407
Cost Per Can (weighted ave. can size = 8.1 oz.) (f)			$0.149	$0.243	$0.198	$0.206

a) Estimated manufacturing loss allowance based on similar chemical.
b) Ketones (e.g., acetone), xylenes, aromatics, aliphatics, alcohols, esters, etc.
c) Cost of toluene (can also use acetone).
d) Price based on CMR 1989.
e) Propellant mixture consisting of 40 percent HCFC-22 and 60 percent DME costing $1/lb and $0.41/lb, respectively.
f) The chemical component costs per pound and per can are shown to the third decimal place in order to suggest that the cost differences may be substantial on a bulk production basis (i.e., the filling of several million aerosol containers), although they seem insignificant on an individual can basis.
g) The water-DME alternative is shown as formulation V on Exhibit 4-17.

EXHIBIT 4-19

CAPITAL, R&D, AND OTHER NON-RECURRING COSTS OF REDUCING PROC EMISSIONS

COSTS	DME	HCFC Systems	CO_2
Bulk Storage Conversion	8,900[a]	8,200[a]	30,000[b]
Filling Line Conversion			
Small Plant	15,000[c]	15,000[c]	3,000[b]
Large Plant	27,000[c]	27,000[c]	3,000[b]
R&D and Non-Recurring Costs per formulation[d]	17,500	17,500	17,500

Note: Small = 2 slow speed lines; large = 1 slow and 1 high-speed

[a] Phillips 1989.

[b] Cull 1989.

[c] Based on ICF 1987.

[d] Based on estimated R&D and shelf life testing costs per formulation (ICF 1987).

DME is a very strong solvent that attacks certain materials used in seals and valves, and it is classified as a class C flammable material according to the National Electric Code (most hydrocarbons are class D materials, i.e., a less stringent flammability classification). To safely handle DME in an aerosol manufacturing line additional capital investment of $15,000 to $27,000 is required to convert certain electric motors and switches to "explosion-proof" class as well as to replace the material used in valves and seals. The magnitude of the costs will depend on the size of the filling line.

In addition to these filling line conversion costs, DME bulk storage conversion costs will be incurred. These costs are on the order of $8,900 per filling location.

The use of CO_2 as a propellant has been known for many years, however, the problem of pressure stabilization appears to limit its widespread use. Impact gassing is a filling technique used to inject CO_2 and create turbulence inside the container. The objective is to create large surface area (contact area) and achieve the adsorption of CO_2 into the concentrate. As for all compressed gases, the pressure of a CO_2 system is a function of concentration. To expel 100 percent of the product, the maximum concentration of CO_2 in the concentrate (i.e., saturation) should be sought.

Impact gassing is not a universal solution because its effectiveness depends on the viscosity and composition of the product (gels may not be impact gassed). In addition, the formulation must be capable of adsorbing CO_2 to the maximum extent possible. For this analysis a CO_2 hair spray formulation is assumed to be technically feasible.

Very few contract fillers have bulk storage facilities for CO_2. Such installations would require an investment of approximately $30,000 to handle large quantities of CO_2 (including the cost of a refrigerated chiller for the tank). Regarding the filling equipment, retrofit equipment worth about $3,000 is required.

In the analysis of economic incentives below it is assumed that investments at filling locations will be needed in order to implement several of these emissions reduction options. These costs are counted as part of the cost of reducing emissions. To the extent that fillers already have adequate equipment for handling these various alternative formulations, the costs presented below for achieving emissions reduction may be overstated.

In addition to the costs described above, aerosol product formulators will incur reformulation costs. Reformulation costs include the costs of personnel to select product ingredients, as well as market and shelf-life testing to assess performance. Most formulators have experience in this area due to recent reformulations undertaken as the result of CFC controls and concerns about methylene chloride.

The selection of ingredients and a shelf-life test is estimated to cost approximately $15,000 to $20,000 per individual formulation based on a rough estimate provided by a source based on the time that a research chemist would have to dedicate to develop a new formulation (Klater 1989). This cost applies to each "basic" formulation, i.e., to a generic type of product. For example, from the development standpoint a generic type refers to resin types whereas various colors of each resin would not necessarily additional development work.

Each aerosol manufacturer is likely to produce more than one basic formulation; therefore, the average estimate of $17,500 development cost must be multiplied by the number of formulations to be changed. For example if a paint manufacturer has 8 basic formulations, these costs would amount to $140,000.

In addition to these costs, market testing costs will be incurred. The extent of these tests will depend on how significantly the formulations are being changed, and how much testing has been performed by others. Minor formulation changes will require little or no testing. For purposes of this analysis it is assumed that large brands require about $16,200 of market testing per brand, and that small brands perform $8,100 of market testing per brand.

As described above, an airless sprayer is also an option for reducing PROC emissions from spray paints. The costs of this option include:

- The consumer would incur the costs of purchasing the sprayer, at about $70 per sprayer. It is assumed that the sprayer would be used over a five year period.

- The cost of ingredients for the sprayer include the paint and thinner,[41] which were estimated based on $2.03 for 9.6 fl. oz. of paint and $0.20 for 2.4 fl.oz. of thinner.[42]

To analyze the costs to the consumer it is assumed that there are no tax effects in the calculation (i.e., the consumer cannot depreciate the investment in the sprayer).

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[41] Energy used to operate the airless sprayer is 30 watts per minute. Brewster (1989) reports that the Krebs 070 can dispense product at a rate of 2 fluid ounces per minute. Given that in 6 minutes all of the 12 fl.oz. of paint will be expelled, the total energy consumption is 180 watts or 0.003 kilowatt-hours. The cost of this energy consumption is negligible given that utility costs are approximately $0.08 per kilowatt-hour.

[42] The paint costs $27 per gallon and the thinner costs $10.50 per gallon (Miller 1989). A gallon contains 128 fluid ounces.

The use of an airless sprayer becomes cost effective if the consumer would have used a large number of cans of spray paint per year. Using an average cost per can of spray paint at $2.67, the consumer would have to replace about 7 cans of spray paint per year with the airless sprayer. Given that most spray paint users are infrequent users for one-time applications, it is unlikely that airless sprayers would penetrate the market for spray paints based solely on economic considerations.

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