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ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES IN THE STATE OF OHIO

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Region V
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FINAL REPORT

ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES IN THE STATE OF OHIO

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RESEARCH AND DEVELOPMENT SERVICES FOR ASSISTANCE TO STATES AND EPA CARRYING OUT REQUIREMENTS OF CLEAN AIR ACT AND APPLICABLE FEDERAL AND STATE REGULATIONS

Prepared for:

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From:

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1. EXECUTIVE SUMMARY

This chapter summarizes the major elements and most significant findings of the study to determine the economic impact of implementing Reasonably Available Control Technology (RACT) guidelines in the state of Ohio. Further discussion and data are presented in detail in the subsequent chapters of the report. This Executive Summary is divided into three sections:

- Objectives, Scope and Approach
- Statewide Aggregate Economic Impact for the Fifteen RACT Guidelines
- Economic Implications of Each RACT Guideline.

1.1 OBJECTIVES, SCOPE AND APPROACH

1.1 OBJECTIVES, SCOPE AND APPROACH

The Clean Air Act Amendments of 1977 required the states to revise their State Implementation Plans (SIPs) to provide for the attainment and maintenance of national ambient air quality standards in areas designated as nonattainment. The Amendments require that each state submit the SIP revisions to the U.S. Environmental Protection Agency (EPA) by January 1, 1979. These proposed regulations should contain an oxidant plan submission for major urban areas to reflect the application of Reasonably Available Control Technology (RACT) to stationary sources for which the EPA has published guidelines. The Amendments also require that the states identify and analyze the air quality, health, welfare, economic, energy and social effects of the plan provisions.

1.1.1 Objectives

The major objective of the contract effort was to determine the direct economic impact of implementing RACT standards for industrial categories in four states (Illinois, Wisconsin, Ohio and Michigan) of Region V of the U.S. Environmental Protection Agency. These studies will be used primarily to assist EPA and state decisions on achieving the emission limitations of the RACT standards.

1.1.2 Scope

The scope of this project was to determine the costs and direct impacts of control to achieve RACT guideline limitations. The impact was addressed for each industry and for each state so that the respective studies are applicable to individual state regulations. Direct economic costs and benefits from the implementation of the RACT guidelines were identified and quantified. While secondary (social, energy, employment, etc.) impacts were addressed, they were not a major emphasis in the study. In summary, direct economic impact analysis of each industrial category was aggregated on a statewide basis for the RACT categories studied.

- In Ohio, the economic impact was assessed for the following 15 RACT industrial categories:
  - Surface coating of cans
  - Surface coating of coils
  - Surface coating of paper
  - Surface coating of fabrics

- Surface coating of automobiles and light duty trucks

- Surface coating of metal furniture

- Surface coating for insulation of magnet wire

- Surface coating of large appliances

- Solvent metal cleaning

- Bulk gasoline terminals

- Refinery vacuum producing systems, wastewater separators and process unit turnarounds

- Bulk gasoline plants

- Storage of petroleum liquids in fixed roof tanks

- Service stations--Stage I

- Use of cutback asphalt.

In the determination of the economic impact of the RACT limitations, the following are the major study guidelines:

- The emission limitations for each industrial category were studied at the control level established by the RACT guidelines. These are presented in Exhibit 1-1, at the end of this section. (In addition an alternate scenario for the surface coating of automobiles is presented in this report.)

- The timing requirement for implementation of controls to meet RACT emission limitations was January 1, 1982.

- All costs and emission data were presented for 1977.

- Emission sources included were existing stationary point sources in most of the applicable industrial categories with VOC emissions greater than 3 pounds in any hour or 15 pounds in any day.[1]

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1 For some industrial categories (i.e., solvent metal cleaning and fixed roof tanks) size characteristics are used as the basis for inclusion, rather than emissions.

- The guidelines were assumed to be adopted statewide (including all nonclassified and attainment ozone areas as well as rural areas).

- The following volatile organic compounds were exempted:

  - Methane
  - Ethane
  - Trichlorotrifluorethane (Freon 113)
  - 1,1,1-trichloroethane (methyl chloroform).[1]

- The cost of compliance was determined from the current level of control (i.e., if an affected facility already had control in place, the cost of compliance and the resulting VOC emissions reduction are not included in this analysis).

1.1.3 Approach

The approach applied to the overall study was: a study team with technology and economic backgrounds utilized available secondary sources to estimate the emissions, statistics and costs for each RACT industrial category; then, the study team completed, calibrated and refined these estimates based on approximately 60 interviews with a cross-section of industry representatives in the four states. Because of the number of point sources and the data available in the state emission inventory, the methodology was specific for each RACT industrial category studied. However, the general methodology applied for two major classes of industrial categories was:

- Surface coating RACT industrial categories (cans, coils, fabrics, paper, automobiles and light duty trucks, metal furniture, magnet wire and large appliances)--the potentially affected facilities, emissions and emission characteristics were studied by Booz, Allen with assistance from the Ohio EPA. Therefore, the following generalized methodology was applied:

  - A list of potentially affected facilities was compiled from secondary reference sources.

  - Data from the emission inventory was categorized and compiled for some of the affected facilities in each RACT industrial category by the Ohio EPA.

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1 The exemption status of methyl chloroform under these guidelines may be subject to change.

- Firms not substantiated in the emission inventory were identified. A sampling of these facilities were then interviewed by telephone when there was doubt concerning their inclusion.

- Emissions, emission characteristics, control options and control costs were studied for relevant firms.

- Interviews were conducted to determine applicable control options and potential control costs.

- The study team then evaluated the control cost to meet the RACT requirements and the potential emission reduction.

. Nonsurface coating RACT industrial categories (bulk gasoline plants, bulk gasoline terminals and refineries service stations, fixed roof tanks and solvent metal cleaning)--each category either represented an exhaustive list of potentially affected facilities or emissions data were not available (or categorized) for these types of sources. Therefore, the following generalized methodology was applied:

  - Industry statistical data were collected from secondary reference sources.

  - Statewide emissions were estimated by applying relevant factors (e.g., emissions per facility or throughput).

  - Control options and estimated costs to meet the RACT guidelines were reviewed.

  - Interviews were conducted to determine applicable associated control options and the cost of control.

1.1.4 Quality of Estimates

The quality of the estimates that are presented in this report can be judged by evaluating the basis for estimates of the individual study components. In each of the chapters that deal with the development of estimated compliance cost, the sources of information are fully documented.

In the determination of the economic impact for each industrial category studied, the estimated compliance cost is subject to variations due to inherent variations in procedures for estimating:

- Engineering costs
- The number of sources affected.

Engineering cost estimates, when performed for an individual modification with specific equipment sized at the desired capacity, are typically subject to variations of 25 percent. When engineering cost estimates are performed on technologies not commercially proven for a specific facility, the variations are much greater, many times over 100 percent.

Many of the RACT categories studied (such as solvent metal cleaning) represent an exhaustive list of potentially affected facilities that have not been previously identified or categorized. Therefore, the actual number of facilities affected by a given RACT industrial category had to be estimated from available data sources.

If a study with unlimited resources were performed, to estimate the specific cost to each individual facility affected within the state, the study would be subject to a 25 percent to 50 percent variation because of the inherent variability of engineering estimates and the uncertainty involved in the selection and demonstrated capabilities of the control alternatives. Furthermore, a study of this type would take years to perform.

Therefore, to put a perspective on the estimates presented in this report, the study team has categorically ranked by qualitative judgment the overall data quality of the major sources and, therefore, of the outcomes. These data quality estimates were ranked into three categories:

- High quality ("hard data")--study inputs with variation of not more than ± 25 percent.
- Medium quality ("extrapolated data")--study inputs with variation of ± 25 to ± 75 percent.
- Low quality ("rough data")--study inputs with variation of ± 50 to ± 150 percent.

Each of these data quality estimates is presented in the individual chapters. The overall quality ranking of the study inputs for each RACT industrial category was generally in the medium quality range.

EXHIBIT 1-1(1)
U.S. Environmental Protection Agency
LISTING OF EMISSION LIMITATIONS THAT REPRESENT
THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH
APPLICATION OF RACT FOR FIFTEEN INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvent Coatings (lbs. solvent per gallon of coating, minus water)
Surface Coating Of:	
Cans	2.8
. Sheet basecoat (exterior and interior) Overvarnish Two-piece can exterior (basecoat and overvarnish)	
. Two and three-piece can interior body spray Two-piece can exterior end (spray or rollcoat)	4.2
. Three-piece can side-seam spray	5.5
. End sealing compound	3.7
Coils	
. Prime and topcoat or single coat	2.6
Paper	2.9
Fabrics and vinyl coating	
. Fabric	2.9
. Vinyl	3.8
Automobiles and Light Duty Trucks	
. Prime application, flashoff and oven	1.9
. Topcoat application, flashoff and oven	2.8
. Final repair application, flashoff and oven	4.8
Metal Furniture	
. Prime and topcoat or single coat	3.0
Magnet Wire	1.7
Large appliance	
. Prime, single or topcoat	2.8
Solvent Metal Cleaning	
. Cold cleaning	Provide cleaners with: cover; facility to drain clean parts; additional freeboard; chiller or carbon absorber. Follow suggested procedures to minimize carryout.
. Conveyorized degreaser	Provide cleaners with: refrigerated chiller or carbon adsorption system; drying tunnel or rotating basket; safety switches; covers. Follow suggested procedures to minimize carryout.
. Open top degreaser	Provide cleaner with: safety switches; powered cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout.
Petroleum Refinery Sources	
. Vacuum producing systems	No emissions of any noncondensible VOC from condensers, hot wells or accumulators to a firebox, incinerator or boiler.

EXHIBIT 1-1(2)
U.S. Environmental Protection Agency

Category	RACT Guidelines Emission Limitations[a]
. Wastewater separators	Minimize emissions of VOC by providing covers and seals on all separators and forebays and following suggested operating procedures to minimize emissions
. Process unit turnaround	Minimize emissions of VOC by depressurizatic venting to vapor recovery, flare or firebox. No emissions of VOC from a process unit or vessel until it's internal pressure is 136 kilo pascals (17.7 psia) or less
Bulk Gasoline Terminals	Equipment such as vapor control system to prevent mass emissions of VOC from control equipment to exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Bulk Gasoline Plants	Provide submerged filling and vapor balancing so that VOC emissions from control equipment do not exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Storage of Petroleum Liquids in Fixed Roof Tanks	Provide single seal and internal floating roof to all fixed roof storage vessels with capacities greater than 150,000 liters (39,000 gal.) containing volatile petroleum liquids for which true vapor pressure is greater than 10.5 kilo Pascals (1.52 psia)
Service Stations (Stage I)	Provide submerged fill and vapor balance for any stationary storage tank located at a gasoline dispensing facility
Use of Cutback Asphalt	The manufacture, mixing, storage, use or application may be approved where: long-life stockpile storage is necessary; the use or application is an ambient temperature less than 10°C (50°F) is necessary; or it is to be used solely as a penetrating prime coat

Note: An alternative scenario to the recommended RACT guidelines for surface coating of automobiles is also studied. It assumes that requirements are modified to meet specific technologies.

a. Annotated description of RACT guidelines

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, U.S. Environmental Protection Agency, EPA-90512-78-001, April 1978.

1.2 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE FIFTEEN GUIDELINES

1.2 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE FIFTEEN RACT GUIDELINES

The implementation of RACT emission limitations for fifteen industrial categories in Ohio involves an estimated $383 million capital cost and $63 million annualized cost per year. The net VOC emission reduction is estimated to be 186,000 tons annually. Exhibit 1-2, on the following page, presents a quantitative summary of the emissions, estimated cost of control, cost indicators and cost effectiveness of implementing RACT guidelines for fifteen industrial categories.[1]

- Approximately 43,440 facilities are potentially affected by the fifteen RACT guidelines in Ohio.
  - Approximately 98 percent of the potentially affected facilities are represented by the solvent metal cleaning 20,000 facilities and service station (22,600 facilities) industrial categories.
  - Less than 1 percent (108 facilities) of the potentially affected facilities are represented by the eight surface coating industrial categories (cans, coils, paper, fabrics, automobiles, metal furniture, magnet wire and large appliances).
- In 1977, the estimated annual VOC emissions (including those already controlled) for the fifteen RACT industrial categories totalled approximately 264,000 tons.
  - Three gas marketing categories (tank truck loading terminals, bulk gas plants and service stations) represented 31 percent of the total VOC emissions.
  - Eight surface coating categories represented 24 percent of the total VOC emissions.
  - Use of cutback asphalt represented 20 percent of the total VOC emissions.

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1. An alternative scenario for the surface coating of automobiles is also presented in the text of the next section. The EPA recommended RACT limitations for automobile assembly plants represent a waterborne topcoat system which would require extensive modification of the current production lines. Under the alternate scenario it is assumed that RACT requirements are modified to meet specific technologies that are more cost and energy effective.

EXHIBIT 1-2
U.S. Environmental Protection Agency
SUMMARY OF IMPACT OF IMPLEMENTING RACT GUIDELINES IN 15 INDUSTRIAL CATEGORIES--OHIO

Industry Category	Number of Facilities Potentially Affected	Emissions: 1977 VOC Emissions (tons/yr.)	Emissions: Estimated VOC Emissions After Implementing RACT (tons/yr.)	Emissions: Net VOC Emission Reductions (tons/yr.)	Cost of RACT Control: Capital Cost[a] ($ millions)	Cost of RACT Control: Annualized Cost (credit) ($ millions)	Cost Indicators: Annualized Cost as Percent of Value of Shipments[b] (percent)	Cost Indicators: Annualized Cost Per Unit Shipment (cost per unit)	Cost Effectiveness: Annualized Cost (credit) Per Ton of VOC Reduction ($ per tons/yr.)
Surface coating of cans	23	3,400	1,100	2,300	2.7	(0.11)[g]	0	0	247
Surface coating of coils	16	4,400	785	3,615	2.5	0.75	NA	NA	207
Surface coating of paper	30	30,000	6,000	24,000	25.0	9	1.3	Increase of 1.3%	300
Surface coating of fabrics	6	7,500	1,500	6,000	10	1	0.3	-	170
Surface coating of automobiles	5	13,700	2,800	10,900	280	44	0.8	$38/Vehicle	4,040
Surface coating of metal furniture	16	1,500	1,300	200	0.93	0.04	0.014	-	32
Surface coating for insulation of magnet wire[c]	2	218	118	100	0	0	0	-	0
Surface coating of large appliances	10	3,500	1,000	2,500	4.0	0.92	0.04	$0.2/Household Appliance	374
Solvent metal cleaning	20,000	48,000	36,700	11,400	9.2	1.1	0.002	0.01%	105
Refinery vacuum wastewater separators and turnarounds	7	15,000	700	14,300	0.6	(0.4)	0	0	(26)
Tank truck gasoline loading terminals	50	17,400	1,700	15,700	15.3	(1.4)	(0.1)	-	(32)
Bulk gasoline plants	670	19,400	5,300	14,100	10.0	2.6	0.7	$0.0014/gallon[d]	188
Storage of petroleum liquids in fixed roof tanks	6	1,200	120	1,080	0.78	0.007	NA	0	64
Service stations (Stage I)	22,600	45,500	19,000	26,500	21.5	5.2	0.2	$0.002/gallon	195
Cutback Asphalt	e	53,100	0	53,100[f]	0.2	0	0	0	0
Total	43,440	264,000	78,000	186,000	383	63			

Note Figures presented in this exhibit are rounded and approximated for comparison purposes.

a. Includes one time costs
b Value of shipments represents the total value in the specific industry category for the state being studied.
c. All magnet wire coating facilities have implemented controls prior to the RACT guidelines and are assumed with compliance.
d. This represents the industrywide increase: small operations will be subject to a $0.003 gallon increase
e. Estimate use of cutback asphalt in 1977 was 265,000 tons.
f. Based on replacing all cutback asphalt with emulsions.
g. This credit includes an anticipated savings of $900,000 that is attributable to materials savings from fewer coatings on two-piece cans. Excluding this credit the annualized cost is estimated to be $785,000.

Source· Booz, Allen & Hamilton Inc.

- Solvent metal cleaning represented 18 percent of the total VOC emissions (from the fifteen RACT categories studied).

- Fixed roof tanks represented less than one percent of the total VOC emissions.

. The net emission reduction achievable by implementing the fifteen RACT guidelines is estimated to be 186,000 tons annually. The approximate percent of the total VOC emissions reduced by implementing RACT by industrial category group is:

  - Gas marketing categories--30 percent of VOC emission reduction

  - Use of cutback asphalt--29 percent of VOC emission reduction

  - Surface coating categories--27 percent of VOC emission reduction

  - Refinery vacuum systems--8 percent of VOC emission reduction

  - Solvent metal cleaning category--6 percent of VOC emission reduction

  - Fixed roof tanks--less than 1 percent of VOC emission reduction

. The capital cost for the fifteen industrial categories to achieve the RACT guidelines is estimated to be $383 million. Approximately 73 percent of the total estimated capital cost is for control of automobile assembly plants.

  - The capital required to meet RACT guidelines for automobile surface coating is estimated to be $280 million. (An alternative scenario to the recommended RACT limitations for automobiles is also developed. This alternative scenario would represent an estimated capital cost of $34 million.)

  - The four industrial categories dealing with petroleum (bulk gasoline plants, bulk gasoline terminals, service stations and fixed roof tanks) account for approximately $48 million (or 13 percent of the total) of the estimated capital cost.

- The paper coating category is estimated to require $25 million in capital (or 7 percent of the total).

- The solvent metal cleaning category is estimated to require $9.2 million in capital (or 2 percent of the total).

- The fabric coating category is estimated to require $10 million in capital (or 3 percent of the total).

- The other seven RACT categories collectively represent a estimated capital cost of $10.9 million (or 3 percent of the total).

. The annualized cost of the fifteen RACT industrial categories to achieve the RACT guidelines is estimated to be $63 million. The control of automobile assembly plants is estimated to be $44 million annualized cost (the alternate scenario for auto assembly has an estimated annualized cost of $5 million). In terms of cost indicators, the annualized compliance cost per value of shipments will have the largest effect on the following industrial categories:

  - Paper coating--The annualized costs represent approximately 1.3 percent of the 1977 statewide value of shipments.

  - Bulk gasoline plants--The annualized compliance costs represent approximately 0.7 percent of the 1977 statewide value of shipments.

. Technology developments and delivery of equipment could present problems in achieving the 1982 timing requirements of the RACT guidelines.

  - The recommended RACT guidelines for automobile assembly plants would require a waterborne top coating. Manufacturers could not convert facilities on a nationwide basis to waterborne top coat systems.

  - Low solvent coating technology requires further development for cost- and energy-effective implementation of the RACT guidelines in the following industrial categories:

        - Surface coating of automobiles
        - Surface coating of large appliances
        - Surface coating of cans (end sealing compound).
    - Equipment delivery and installation of control equipment were identified as potential problems in the following industrial categories:
        - Surface coating of paper
        - Solvent metal degreasing
        - Tank truck gasoline loading terminals
        - Bulk gasoline plants
        - Surface coating of fabrics
        - Gasoline service stations.

- With the exception of bulk gasoline plants the implementation of the RACT guidelines are not expected to have major impact on statewide productivity or employment. Capital cost requirements for bulk gasoline plants could further concentrate a declining industry. Many small bulk plants today are marginal operations and further cost increases may result in additional plant closings.

- The implementation of the RACT guidelines is expected to create further concentration for some industrial sectors requiring major capital and annualized cost increases for compliance. RACT requirements may have an impact on the market structure and trends of the following RACT industrial categories:
    - Bulk gasoline plants
    - Service stations
    - Surface coating of paper.

- The implementation of the RACT guidelines for the fifteen industrial categories is estimated to represent a net energy savings of approximately 38,000 equivalent barrels of oil annually; or 0.03 percent of the statewide energy demand for all manufacturing. Assuming a value of oil at $13 per barrel, this is an equivalent energy savings of $0.5 million annually. Exhibit 1-3, following the next page, presents the estimated change in energy demand from implementation of the RACT guidelines in Ohio.

- RACT compliance requirement for the eight surface coating industrial categories (cans, soil, paper, fabrics, automobiles, metal furniture, insulation of magnet wire and large appliances) represent a net energy demand of approximately 456,000 equivalent barrels of oil annually.

- RACT compliance requirements for refinery systems represent a net energy savings of approximately 102,000 equivalent barrels of oil annually.

- RACT compliance requirements for the four industrial categories dealing with petroleum marketing (service stations, fixed roof tanks bulk gasoline terminals, bulk gasoline plants) represent a net energy savings of approximately 392,000 barrels of oil annually. However, the control efficiency has not been fully demonstrated and these estimates are likely to overstate the achievable energy savings for bulk gasoline plants and service stations.

In 1977, the statewide value of shipments of the fifteen industrial categories potentially affected by RACT was $16.1 billion, which represents approximately 18 percent of Ohio's total value of shipment of manufacturing goods. The estimated annualized cost of implementing the RACT guidelines ($63 million) represents 0.3 percent of the value of shipments for the fifteen RACT industrial categories affected. The annualized cost represents 0.06 percent of the statewide total value of shipment of all manufactured goods.

EXHIBIT 1-3
U.S. Environmental Protection Agency
ESTIMATED CHANGE IN ENERGY DEMAND RESULTING FROM IMPLEMENTATION OF RACT GUIDELINES IN OHIO

Industry Category	Energy Demand Change Increased (Decrease) (Equivalent barrels of oil)	Energy Demand Change Cost/(Savings)[a] ($ million)
Surface coating of cans	5,000	0.07
Surface coating of coils	NA	NA
Surface coating of paper	175,000	2.3
Surface coating of fabrics	34,000	0.40
Surface coating of automobiles	250,000	3.2
Surface coating of metal furniture	None	None
Surface coating for insulation of magnet wire	None	None
Surface coating of large appliances	(8,000)	(0.10)
Solvent metal cleaning	Negligible	Negligible
Refinery systems	(102,000)	(1.3)
Tank truck gasoline loading terminals	(107,000)	(1.4)
Bulk gasoline plants	(97,000)	(1.3)
Storage of petroleum liquids in fixed roof tanks	(7,500)	(0.10)
Service stations (STAGE I)	(181,000)	
Use of cutbaks asphalt	None[b]	None
TOTAL	(38,500)	(0.5)

NA = Not available

a. Based on the assumption that the cost of oil is $13 per barrel.
b. There is not anticipated to be any energy demand change at the user level. However, if all cutback asphalt was replaced with emulsions a maximum energy savings could be over 500,000 barrels per year. This savings would accrue to manufacterers (not users) and this represents the difference in total energy associated with the manufacturing, processing and laying of cutback asphalt (50,200 BTU/gallon) versus emulsions (2,830 BTU/gallon).

Source: Booz, Allen & Hamilton Inc.

1.3 ECONOMIC IMPLICATIONS OF EACH RACT GUIDELINE

1.3 ECONOMIC IMPLICATIONS OF EACH RACT GUIDELINE

This section presents a summary of the economic impact for each of the fifteen RACT industrial categories studied. Following this section is a series of summary exhibits which highlight the study findings for each industrial category.

1.3.1 Surface Coating of Cans

Currently there are 23 major can coaters in the state of Ohio. The industry-preferred method of control to meet the RACT requirements is to convert to low solvent (water-borne) coatings. However, low solvent coatings for end sealing compounds are presently not available and may not be available by 1982. To meet the RACT requirements, can manufacturers may convert some facilities to waterborne two-piece can lines (where commercially feasible) and install thermal incineration for controlling high solvent coatings. It is possible that some precoated stock will be manufactured out of state for cost-effectiveness, in addition to meeting RACT requirements. Emission controls are expected to cost $2.7 million in capital and represent a savings of $150,000 in annualized costs in meeting the RACT guidelines. This savings includes a credit of $900,000 for reduced material and energy savings that are anticipated from reducing the number of coatings on two piece cans. Excluding this credit, the annualized cost of compliance is estimated to be $785,000.

1.3.2 Surface Coating of Coils

Currently there are an estimated 23 coil coating facilities in the state of Ohio. Most of those firms currently control VOC emissions and for purposes of this study are assumed to require minimal cost to meet the RACT guidelines. For those firms requiring VOC control, the capital requirements is estimated to be $2.5 million and the annualized costs is approximately $750,000. No major market structure, employment or productivity impacts are anticipated.

1.3.3 Surface Coating of Paper

This study covered 25-30 plants expected to be affected by the RACT guideline. Excluded from this study are facilities engaged in publishing, who may coat paper as a segment of the processing line. The study assumes that these facilities would fall under other RACT guidelines currently being developed, such as Graphic Arts. Further definition of the paper coating category needs to be established prior to regulatory implementation.

The retrofit situations and installation costs for add-on controls are highly variable. Based on these variations, the estimated capital cost to the industry is between $18 million and $33 million, with an annual operating cost of $6 million to $11 million (approximately 1.3 percent of the statewide value of shipments).

The smaller firms have indicated they may not be able to secure the necessary capital funding for add-on systems. The effect on employment will be a function of the number of firms that may opt to cease production rather than invest in retrofit equipment for control.

Assuming 70 percent heat recovery, the annual energy requirements are expected to increase by approximately 175,000 equivalent barrels of oil per year. Energy consumption may decrease if further efficient recovery of incinerator heat is possible.

Incinerator equipment manufacturers have stated that there may be significant problems in meeting the anticipated demand for high heat recovery incinerators on a nationwide basis.

1.3.4 Surface Coating of Fabrics

There are six firms in Ohio identified as coaters of fabric and affected by the proposed RACT guidelines. Most of these firms potentially affected by the proposed guidelines were not fully aware of their inclusion in this category. These facilities will be required to invest an estimated $10 million in capital and approximately $1.0 million in annualized cost to meet RACT limitations.

No significant productivity, employment or market structure dislocations should be associated with the implementation of the RACT guideline.

Assuming a 70 percent heat recovery, about 34,000 barrels of additional fuel oil per year would be required to operate the control equipment.

1.3.5 Surface Coating of Automobiles

There are three major companies operating five automobile assembly plants in Ohio. Ohio is the third largest state in terms of automobile production in the U.S. and the value of shipments of automobiles represents approximately 6 percent of the statewide value of manufacturing shipments. The EPA recommended RACT guidelines would require conversion to waterborne paints. However, the EPA is currently considering some modifications of the RACT requirements for automobile assembly plants. Therefore, there are two scenarios of RACT guidelines studied:

Scenario I--Current RACT limitations implemented by 1982. Under this scenario, it is assumed that automobile assembly plants will convert facilities to the following available paint technologies to meet the RACT requirements:

- Cathodic electrodeposition for prime coat
- Waterborne enamels for topcoat
- High solids enamels for final repair.

The implementation of these technologies would require extensive modification to all five facilities in Ohio. The capital required would be approximately $280 million or 340 percent of the estimated current annual capital appropriations. The estimated annualized compliance cost is $44 million and would represent an increased energy demand of approximately 250,000 barrels of oil annually. If this increased cost were passed on directly it would represent an increase in price of $38 per automobile manufactured. These major modifications would require approximately three to four years for completion and although possibly achievable in Ohio, all assembly plants in the U.S. could not convert to these technologies by 1982.

Scenario II--RACT requirements are modified to meet specific technologies. Under this scenario it is assumed that automobile assembly plants will develop and apply the following paint technologies:

- Cathodic electrodeposition for prime coat

- High solids enamels, urethane enamels, powder coating or equivalent technologies for topcoat

- High solids enamels for final repair.

The major area of modification in this scenario is the technology applied for topcoat paints. It is assumed that manufacturers currently using enamel paints would develop higher solids enamels that would approach or achieve the emission reduction of waterborne paints. At General Motor's facilities (which use lacquer paints) the conversion to other technology developments is still likely to require major plant modifications. The capital requirements for Scenario II are estimated to be $34 million or 40 percent of the current annual capital appropriations in the state. The estimated annualized compliance cost is $5 million. If this increased cost were passed on directly, it would represent an increase in price of $4 to $5 per vehicle manufactured.

1.3.6 Surface Coating of Metal Furniture

There are 16 facilities in Ohio identified as manufacturers and coaters of metal furniture and potentially affected by the proposed RACT guidelines. These facilities will be required to invest an estimated $1 million in capital and approximately $40,000 in annualized costs (approximately 0.01 percent of the value of shipment) to meet the RACT limitations.

No significant productivity, employment or market structure dislocations should be associated with the implementation of the RACT guideline.

1.3.7 Surface Coating for Insulation of Magnet Wire

This study has identified two facilities currently coating magnet wire for insulation in the state of Ohio. Both of these facilities have already implemented controls which for the purpose of this study are assumed to be in accordance with the RACT guidelines. Therefore, in Ohio, the implementation of RACT guidelines for magnet wire coating is not expected to have any substantial economic impact or to reduce emissions.

1.3.8 Surface Coating of Large Appliances

There are ten facilities identified as major coaters of large appliances in Ohio. The industry statewide is estimated to invest approximately $4.0 million in capital and incur additional annualized cost of $920,000 (approximately 0.04 percent of industry statewide value of shipments) to meet the emission limitations.

Assuming a "direct cost pass-through," the cost increase for household appliances relates to a price increase of approximately $0.2 per unit. Certain manufacturers could incur disproportionate compliance costs, which could further deteriorate the profit position of a marginally profitable operation. Of the firms with marginally profitable operations that may be affected, none of the companies contacted indicated that they might be forced out of business. No major productivity, employment or market structure dislocations appear to be associated with implementation of the RACT guidelines.

The high solids (greater than 62 percent by volume) topcoat application technique preferred by the industry has not been proven under normal operating conditions, although it appears to be technically feasible.

1.3.9 Solvent Metal Cleaning

This category includes equipment to clean the surface for removing oil, dirt, grease and other foreign material by immersing the article in a vaporized or liquid organic solvent. The cleaning is done in one of three devices: a cold cleaner, an open top vapor degreaser or a conveyorized degreaser. This type of cleaning is done by many firms in many different types of industries.

Implementation of the proposed RACT guidelines for an estimated 20,000 facilities is expected to have a negligible economic effect on industry because of the relatively minor changes required. Statewide, the many facilities potentially affected represent a capital cost of $9.2 million and an annualized cost of $1.1 million (less than 0.01 percent of industry value of shipments).

Because of the large number of degreasers that require retrofit to meet RACT and the inability of manufacturers to provide equipment on such a large scale, it is doubtful if all degreasers nationwide can be retrofitted within the 1982 timeframe.

No major productivity, employment and market structure dislocations will result from RACT implementation.

1.3.10 Refinery Vacuum Systems, Wastewater Separators and Process Unit Turnarounds

There are seven refinery facilities in the state of Ohio, potentially affected by the proposed RACT guidelines. All the refinery operations were reported to have systems that are compatible with the RACT requirements except for five uncovered wastewater separators and ten process units. Achieving the equipment requirements represents a capital investment of approximately $600,000 and an annualized credit of approximately $400,000. The annualized credit is due to the projected recovery of gasoline equivalent to approximately 100,000 barrels annually.

No significant productivity, employment or market structure dislocations should be associated with the implementation of the RACT guideline.

1.3.11 Tank Truck Gasoline Loading Terminals

There are 50 facilities identified in the state of Ohio as tank truck gasoline loading terminals. Emission control of these facilities is expected to require a capital investment of $15.3 million. Product recovery of gasoline will be accrued to bulk terminal operations, not only from bulk terminal emission control installations, but also from the recovery of vapors from service stations and bulk gasoline plants. This recovery represents approximately 46,000 tons of emissions. Based on this savings, the annualized credit for implementation of RACT for bulk gasoline loading terminals is estimated to be $1.4 million.

No significant productivity, employment or market structure dislocations should be associated with implementing the RACT guidelines.

1.3.12 Bulk Gasoline Plants

This industry is characterized by many small plants. Of these plants, only a few percent are either new or modernized. The majority of the plants are over 20 years old. Most bulk plants are located in rural areas where implementation of RACT to stationary sources may not be required. However, the economic analysis presented includes all bulk gas plant facilities, regardless of location.

To meet the RACT requirements, bulk gas plants must be equipped with vapor balance and submerged fill systems. This recommended control system is not cost-effective for the bulk plant operator as most of the economic credit (for recovered vapors) would be accrued to a bulk terminal or refinery.

The estimated capital cost and annualized cost to meet compliance requirements for the 670 facilities in the state of Ohio represent $10 million and $2.6 million (approximately 0.7 percent of industry statewide value of shipments), respectively. Industrywide, the price of gasoline (assuming a "direct cost pass-through") would be increased $0.0014 per gallon, but the smaller volume operators would be more severely affected, with costs increasing between $0.005 per gallon and $0.01 per gallon. Because of the competitiveness and low profit structure in the industry, further cost increases could force some marginal operations out of the business, thus further concentrating the market structure. In urban areas, the bulk gasoline plant markets have been declining because of competition from retailers and tank truck terminals, and are expected to continue to decline regardless of the RACT guidelines.

Those bulk gas plants that close would represent an average loss of 4.6 jobs per plant.

The implementation of the RACT alternatives of bottom filling and vapor balancing could produce an energy saving equivalent to 97,000 barrels of oil per year assuming a control efficiency as defined by the RACT guidelines. This assumed control efficiency has not been fully demonstrated.

1.3.13 Storage of Petroleum Liquids in Fixed Roof Tanks

There are approximately 100 fixed roof tanks, each of which is greater than 40,000 gallons and used for storing petroleum liquids. With the exception of six tanks, all are located in priority I areas and are reportedly equipped with floating roof tanks because of current regulations.

These tanks are owned by major oil companies, large petrochemical firms and bulk gasoline tank terminal companies. The capital cost to equip these six fixed roof tanks with a single-seal floating roof is estimated to be $0.8 million. The estimated annualized cost is approximately $7,000.

No significant productivity, employment or market structure dislocations will be associated with the implementation of the RACT guidelines.

1.3.14 Service Stations

Of the estimated 22,000 gasoline disposing facilities located in Ohio, 5 percent are considered small gasoline stations (throughput less than 10,000 gallons per month). These stations will experience a cost increase less than $0.0046 per gallon to implement RACT; larger stations will experience a much smaller unit cost increase. Statewide, the industry capital cost is $21.5 million and annualized cost is $5.2 million (approximately 0.2 percent of the statewide value of gasoline sold) for implementing submerged fill and vapor balancing. The service stations could experience some loss of business while vapor control systems are being installed.

Implementation of the RACT guidelines may accelerate the trend to high throughput stations because of the increasing overhead costs. However, the RACT guidelines will not cause major productivity and employment dislocations to the industry as a whole.

It is estimated that implementing RACT guidelines for service stations in Ohio will result in a net energy savings equivalent to 181,000 barrels of oil per year. The assumed control efficiency has not been fully proven. The economic benefit of the recovered gasoline vapors will not accrue to the service stations.

1.3.15 Use of Cutback Asphalt

In 1977, it is estimated that 265,000 tons of cutback asphalt was utilized in the state of Ohio. Replacement of the solvent based asphalt with asphalt emulsion will cause no dislocation in employment or worker productivity. Capital investment is estimated at $200,000.

It is anticipated that sufficient lead time is available to assure an adequate supply of asphalt emulsion to meet the increased demand and provide training for municipal employees.

* * * *

A summary of the direct economic implications of implementing RACT in each of the 15 industrial categories studied is presented in Exhibits 1-4 through 1-18, on the following pages.

EXHIBIT 1-4
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are about 23 can manufacturing facilities
Indication of relative importance of industrial section to state economy	The 1977 value of shipments was about $360 million
Current industry technology trends	Beer and beverage containers rapidly changing to two-piece construction
VOC emissions	3,400 tons per year (Booz, Allen estimate); theoretical uncontrolled level is 4,600 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Low solvent coatings (waterborne)
Assumed method of control to meet RACT guidelines	Low solvent coatings (waterborne)
Affected Areas in Meeting RACT	
Capital investment (statewide)	$2.7 million from uncontrolled state (0.4 million above 19__ in-place level). Current investments are $15 million to $30 million
Annualized credit (statewide)	$0.15 million credit--less than 0.1 percent of current direct annual operating costs[1]
Price	No price increase
Energy	Increase of 5,200 equivalent barrels of oil annually to operate incinerators (virtually no increase from 1977 level)
Productivity	No major impact
Employment	No major impact
Market structure	Accelerated technology conversion to two-piece cans
	Further concentration of sheet coating operations into larger facilities
Problem area	Low solvent coating technology for end sealing compound
VOC emission after RACT control	1,100 tons per year (29 percent of current emission level)
Cost effectiveness of RACT control	$247 annualized cost/annual ton of VOC reduction from theoretical level attributed to implementation of RACT

[1]This savings includes a credit of $900,000 for reduced material and energy costs that arise from reducing the number of coatings on two-piece cans. Excluding this credit, meeting the RACT limitations would represent an annualized cost of $785,000 (approximately 0.2 percent of the value of shipments).

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-5

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR COIL COATING FACILITIES IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are 16 coil coating facilities potentially affected by the coil coating RACT guideline in Ohio. Five firms currently meet RACT emission limitations
Current industry technology trends	Due to the pressures of energy availability as well as environmental protection, most firms have or are installing regenerative type incinerators
1975 VOC emissions (actual)	4,400 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Regenerative thermal incineration
Assumed method of control to most RACT guidelines	Regenerative thermal incineration

Affected Areas in Meeting RACT	Discussion
Capital Investment (statewide)	$2.5 million incremental capital required by eight firms if they were to install controls on 10 processing lines
Annualized cost (statewide)	$.75 mi[illegible]
Energy	Small increased fuel consumption for regenerative incineration
Productivity	No major impact
Employment	No major impact
Market structure	The captive coil coating operations not meeting the RACT limitation may opt to purchase coated material in lieu of investing significant capital requirements
RACT timing requirements (1982)	Since most coil coating facilities in Ohio meet the RACT limitations, timing requirements should be met
Problem area	Low solvent coating technology is currently inadequate to meet product requirements
VOC emission after control	785 tons per year (18 percent of 1975 VOC emission level)
Cost effectiveness of control	$207 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-6(1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR PAPER COATERS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	Approximately 25-30 plants in the state are expected to be affected by these regulations. However, if this category is interpreted to include all types of paper coating, including publishing, far more firms would be affected
Indication of relative importance of	The 1977 value of shipments of these is estimated to be $600 million. These plants are estimated to employ 8,000-10,000 employees
Current industry technology trends	Gravure coating replacing older systems
1977 VOC emissions (actual)	Approximately 28,000-35,000 tons per year were identified from the emission inventory. Actual emissions are expected to be higher
Industry preferred method of VOC control to meet RACT guidelines	Though low solvent coating use is increasing, progress is slow. Add-on control systems will probably be used
Assumed method of control to meet RACT guidelines	Thermal incineration with primary and secondary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $18 million to $33 million depending on retrofit situations. This is likely to be more than 100 percent of normal expenditures for the affected paper coaters
Annualized cost (statewide)	$6.0 million to $11.0 million annually. This may represent 1.1 to 1.6 percent of the 1977 annual sales for the affected paper coaters
Price	Assuming a "direct cost pass-through"--1.1 to 1. percent
Energy	Assuming 70 percent heat recovery, annual energy requirements would increase by approximately 175,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	Smaller firms may be unable to secure capital funding for add-on systems
RACT timing requirements (1982)	RACT guideline needs clear definition for rule making Equipment deliverables and installation of incineration systems prior to 1982 may present problems
Problem areas	Retrofit situations and installation costs are highly variable

EXHIBIT 1-6(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
VOC emissions after control	5,000-7,000 tons/year (20 percent of 1977 VOC emission level)
Cost effectiveness of control	$250 - $350 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-7
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR FABRIC COATERS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	Six firms were identified as being affected by the proposed regulation
Indication of relative importance of industrial section to state economy	Total value of shipments by the plants identified could not be determined. These plants employ about 2,600 persons
Current industry technology trends	Newer plants are built with integrated coating and emission control systems; older plants are only marginally competitive now
1977 VOC emissions (actual)	Current emissions are estimated at about 7,500 tons/year
Industry preferred method of VOC control to meet RACT guidelines	Direct fired incineration or carbon adsorption for short range; low solvent coatings are a long range goal
Assumed method of VOC control to meet RACT guidelines	Direct fired incineration with primary and secondary heat recovery and carbon adsorption with distillation

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Study team estimate is about $10 million
Annualized operating cost (statewide)	Approximately $1.0 million
Price	Assuming a "direct pass-through of costs" prices of coated fabrics will increase by abou 0.3 percent
Energy	Assuming 70 percent heat recovery about 34,000 equivalent barrels of additional fuel oil woul be required per year
Productivity	No major impact
Employment	No major impact
Market Structure	No change in market structure within the state is anticipated; firms affected have different product lines or are about the same size
RACT timing requirements (1982)	Plants may have problem in control equipment deliveries
Problem areas	Additional capital and operating costs may mak the plants uncompetitive with more modern and efficient ones Capital and operating costs can only be approx mated because of unknown retrofit situations
VOC emissions after RACT control	1,500 tons/year (20 percent of 1977 VOC emissi
Cost effectiveness of RACT control	$170 annualized cost/annual ton of VOC reducti

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-8(1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT SCENARIO I FOR
AUTOMOBILE ASSEMBLY PLANTS IN THE
STATE OF OHIO

SCENARIO I
(RACT Limitations
Implemented By 1982)

Current Situation	Discussion
Number of potentially affected facilities	Three companies operating five assembly plants
Indication of relative importance of industrial section to state enconomy	1977 value of shipments was approximately $5.6 billion which represents approximately 6.2 percent of the state's manufacturing industry. Of all states, Ohio ranks third in automobile production
Current industry technology trends	Prime coat--cathodic electrodeposition Topcoats--high solids enamels for manufacturers using enamel systems
1977 VOC emissions (actual)	Approximately 13,700 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Cathodic electrodeposition for prime coat. High solids enamel for topcoat.
Assumed method of control to meet RACT guidelines	Cathodic electrodeposition for prime coat Waterborne enamels for topcoat High solids enamels for final repair

Affected Areas in Meeting RACT Scenario I	Discussion
Capital investment (statewide)	$280 million (approximately 340 percent of current annual capital expenditures for the industry in the state)
Annualized cost (statewide)	$44 million (approximately 0.8 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass-through" approximately $38 per automobile manufactured
Energy	Increase of 250,000 equivalent barrels of oil annually primarily for operation of waterborne topcoating systems
Productivity and employment	Conversion to waterborne systems would require total rework of existing processing lines. Major modifications would probably increase efficiency and line speed in some facilities.

SCENARIO I
(RACT Limitations
Implemented By 1982)

Current Situation	Discussion
Market structure	No major effect
RACT timing requirements (1982)	Conversion of all automobile assembly plants to topcoating waterborne systems cannot be achieved by 1982
Problem areas	Prime coat RACT limitations are based on anodic electrodeposition systems and need to be modified to reflect cathodic processing. Topcoat RACT limitations are based on waterborne coatings, which is not a cost or energy effective alternative. Final repair RACT limitations are based on high solids enamel technology which would require major modifications for manufacturer's using lacquer systems
VOC emission after RACT control	2,750 tons per year (20 percent of 1977 emission level)
Cost effectiveness of RACT control	$4,040 annualized cost/annual ton of VOC reduction

EXHIBIT 1-9(1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT SCENARIO II FOR
AUTOMOBILE ASSEMBLY PLANTS IN THE
STATE OF OHIO

SCENARIO II
RACT Requirements Are
Modified To Meet Specific
Technologies

Current Situation	Discussion
Number of potentially affected facilities	Three companies operating five assembly plants.
Indication of relative importance of industrial section to state economy	1977 value of shipments was approximately $5.6 billion which represents approximately 6.2 percent of the state's manufacturing industry. Of all states, Ohio ranks third in automobile production
Current industry technology trends	Prime coat--cathodic electrodeposition Topcoats--high solids enamels for manufacturers using enamel systems
1977 VOC emissions (actual)	Approximately 13,700 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Cathodic electrodeposition for prime coat. High solids enamel for topcoat.
Assumed method of control to meet RACT guidelines	Cathodic electrodeposition for prime coat High solids enamels for topcoat. High solids enamel for final repair.

Affected Areas in Meeting RACT Scenario II	Discussion
Capital investment (statewide)	$34 million (approximately 40 percent of current annual capital appropriations for the industry in the state)
Annualized cost (statewide)	$5 million (approximately 0.1 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass-through" approximately $4 to $5 per automobile manufactured
Energy	Dependent on technology applied
Productivity and employment	No major effect

SCENARIO II

Current Situation	Discussion
Market structure	No major effect
RACT timing requirements	Primer and final repair limitations could be implemented at most facilities by 1982 Topcoat limitations could be set at a 40 percent to 62 percent solids by 1985 dependent on technology developments
Problem area	Limitations for topcoat are dependent on technology development
VOC emission after RACT control	2,750-5,000 tons per year (20 percent to 37 percent of 1977 emission levels dependent on limitations)
Cost effectiveness for RACT control	$460-$580 annualized cost/annual ton for VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-10

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are 16 metal furniture manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was $284 million
Current industry technology trends	Trend is towards the use of a variety of colors
1977 VOC emissions (actual)	1,532 tons per year
Industry preferred method of VOC control	Low solvent coatings
Assumed method of control to meet RACT guidelines	Low solvent coatings

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$929,000
Annualized cost (statewide)	$41,000 (approximately 0.014 percent of current value of shipments)
Price	Varies from a few cents to more than $1 per unit of furniture depending upon surface area coated
Energy	No major impact
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirement (1982)	Companies using a variety of colors may face a problem
Problem area	Low solvent coating in a variety of colors providing acceptable quality needs to be developed
VOC emissions after RACT	249 tons per year (16 percent of current emissions level)
Cost effectiveness of RACT	$32 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-11
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are ten major large appliance manufacturer and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $2.4 billion and represents 10 percent of the estimated $15 billion U.S. value of shipment of the major appliance industry
1977 VOC emissions (actual)	3,500 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat
Assumed method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$4.0 million
Annualized cost (statewide)	$920,000 which represents 0.038 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.21/unit for household appliances (based on a price of $230 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 8,000 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	Possible problems meeting equipment deliveries and installation are anticipated
Problem area	Commercial application of high solids (greater than 62% by volume) has not been proven
VOC emission after RACT control	1,050 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$374 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 1-12
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	About 20,000 plants
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is in the range of $55 billion, about one-half of the state's 1977 value of shipments.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents
1977 VOC emissions (actual)	48,100 tons/year (of which 20,000 tons are subject to RACT)
Industry preferred method of VOC control to meet RACT guidelines	Substitution. Otherwise lowest cost option as specified by EPA will be used.
Assumed method of VOC control meet RACT guidelines	Equipment modifications as specified by the RACT guidelines

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$9.2 million
Annualized operating cost (statewide)	$1.1 million, (less than 0.002 percent of the 1977 statewide value of shipments)
Price	Metal cleaning is only a fraction of manufacturing costs; price affect expected to be less than 0.01 percent
Energy	Less than a 1500 equivalent barrels of oil per year in reduction
Productivity	5-10 percent decrease for manually operated degreasers. Will probably not affect conveyorize cleaners.
Employment	No effect except a possible slight decrease in firms supplying metal degreasing solvents
Market Structure	No change
RACT timing requirements (1982)	Equipment availability--only a few companies now supply the recommended control modifications
Problem Areas	No significant problem areas seen. Most firms will be able to absorb cost.
VOC emission after RACT control	36,700 tons/year (76 percent of 1977 VOC emission level--however, this does not include emission controls for exempt solvents)
Cost effectiveness of RACT control	$105 annualized cost per ton of emissions reduced

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-13

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTI
RACT FOR REFINERY VACUUM PRODUCING SYSTEMS, WASTEWAT
SEPARATORS AND PROCESS UNIT TURNAROUNDS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	7
Indication of relative importance of industrial section to state economy	1977 industry sales were $3 billion. The estimated annual crude oil throughput was 215million barrels
Current industry technology trends	Most refineries have installed controls equi alent to RACT with the exception of 5 uncove wastewater separators and 10 uncontrolled process units
1977 VOC actual emissions	15,000 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Vapor recovery of emissions by piping emissions to refinery fuel gas system or flare and by covering wastewater separators
Estimated method of VOC control to meet RACT guidelines	Vapor recovery of emissions from process unit to refinery fuel gas system, cover wastewaster separators and piping emissions from process units to flare

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$571,000
Annualized credit (statewide)	$383,000
Price	No major impact
Energy	Assuming full recovery of emissions —net savings of 101,600 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	764 tons per year
Cost effectiveness of control	$26 annualized credit/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-14
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR TANK TRUCK GASOLINE
LOADING TERMINALS IN OHIO

Current Situation	Discussion
Number of potentially affected facilities	50
Indication of relative importance of industrial section to state economy	1977 industry sales were $1,480 million, with annual throughput of 3.484 billion gallons. The primary market is rural accounts.
Current industry technology trends	New terminals will be designed with vapor recovery equipment
1977 VOC actual emissions	17,378 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Bottom or submerge fill and vapor recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$15.3 million
Annualized credit (statewide)	$1.494 million (approximately 0.1 percent of value of shipments)
Price	No change in price
Energy	Assuming full recovery of gasoline from terminal emissions only—net savings of 106,830 barrels annually from terminal emissions
Productivity	No major impact
Employment	No direct impact
Market structure	No direct impact
Problem area	Gasoline credit from vapors from bulk gasoline plants and gasoline service stations require uniform RACT requirements throughout the state
VOC emissions after control from terminal operations only	1,738 tons per year
Cost effectiveness of control	$32 annualized credit/annual ton of VOC controlled from terminals, and emissions returned from bulk gasoline plants and gasoline service stations (i.e., 46,308 tons per year).

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-15
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS C
IMPLEMENTING RACT FOR
BULK GASOLINE PLANTS IN OHIO

Current Situation	Discussion
Number of potentially affected facilities	670
Indication of relative importance of industrial section to state economy	1977 industry sales were $693 million, wit annual throughput of 1.631 billion gallons The primary market is rural accounts
Current industry technology trends	Only small percent of industry has new/ modernized plants
1977 VOC actual emissions	19,440 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Top submerge or bottom fill and vapor balancing (cost analysis reflects top submerge fill, not bottom fill)

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$10.1 million
Annualized cost (statewide)	$2.66 million (approximately 0.36 percent of value of shipment)
Price	Assuming a "direct cost passthrough" . Industrywide—$.0014 per gallon incre . Small operations—$.003 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 96,800 barrels annually
Productivity	No major impact
Employment	No direct impact; however for plants closi potential average of 4.6 jobs lost per plant closed
Market structure	Regulation could further concentrate a declining industry. Many small bulk gas plar today are marginal operations; further cost increases could result in some plant closir
Problem area	Severe economic impact for small bulk plan operations. Regulation could cause further market imbalances. Emission control efficiency of cost effective alternatives has not been fully demonstrated
VOC emission after control	5,263 tons per year (27 percent of current level)
Cost effectiveness	$188 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 1-16
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected storage tanks	Six
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 214 million gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
VOC emissions	1,217 tons per year
Preferred method of VOC control to meet RACT guidelines	Single seal and internal floating roof
Affected Areas in Meeting RACT	
Capital investment (statewide)	$780,000
Annualized cost (statewide)	$70,000
Price	No change in price anticipated
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 7,479 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	No problems anticipated
VOC emission after control	122 tons per year
Cost effectiveness of control	$64 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-17
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR GASOLINE DISPENSING FACILITIES IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	22,600
Indication of relative importance of industrial sector to state economy	Industry sales are $2.6 billion with a yearly throughput of 5.116 billion gallons
Current industry technology trends	Number of stations has been declining and throughput per station has been increasing. By 1980, one-half of facilities in U.S. will be totally self-service
1977 VOC actual emissions	45,506 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACT guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$21.46 million
Annualized cost (statewide)	$5.189 million (approximately 0.2 percent of the value of gasoline sold)
Price	Assuming a "direct cost pass-through"—less than $0.002 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 181,000 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	Compliance requirements may accelerate the industry trend towards high throughput stations (i.e., marginal operations may opt to stop operations)
Problem area	Older facilities face higher retrofit costs—potential concerns are dislocations during installation
VOC emissions after control	18,983 tons per year from tank loading operation tank breathing, vehicle refueling and spillage
Cost effectiveness of control	$195 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-18
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTATING RACT FOR USE OF CUTBACK ASPHALT
IN THE STATE OF OHIO

Current Situation	Discussion
Use potentially affected	In 1977, estimated use of cutback asphalt was 265,000 tons[a]
Indication of relative importance of industrial section to state economy	1977 sales of cutback asphalt were estimated to be $24.3 million
Current industry technology trends	Nationally, use of cutback asphalt has been declining
1977 VOC actual emissions	53,100 tons annually
Industry preferred method of VOC control to meet RACT guidelines	Replace with asphalt emulsions

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$0.2 million
Annualized cost (statewide)	No change in paving costs are expected
Price	No change in pavings costs are expected
Energy	No major impact to the user[b]
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	Winter paving Short range supply of asphalt emulsions
VOC emission after control	Net VOC emission reduction is estimated to be up to a maximum of 53,100 tons annually[c]
Cost effectiveness of control	$0 annualized cost/annual ton of VOC reduction

a. All of this use may not be affected by the regulations because of likely exemptions.

b. If all cutback asphalt were replaced with emulsions, up to 530,000 equivalent barrels of oil savings might accrue to the manufacturer, not user. This is based on the difference in total energy associated with manufacturing, processing and laying of cutback asphalt (50,200 BTU per gallon) and emulsions (2,830 BTU per gallon). One ton of cutback asphalt or emulsion contains 256 gallons and one barrel of oil contains 6.05 million BTUs.

c. Based on replacing all cutback asphalt with emulsions.

Source: Booz Allen & Hamilton Inc.

2.0 INTRODUCTION AND APPROACH

2.0 INTRODUCTION AND OVERALL STUDY APPROACH

This chapter presents an overview of the study's purpose, scope, methodology and quality of estimates. This chapter is divided into six sections:

- Background
- Purpose of the contract effort
- Scope
- Approach
- Quality of estimates
- Definitions of terms used.

The approach and quality of the estimates are discussed in detail in the respective chapters dealing with the specific RACT industrial categories (Chapters 3 through 18).

2.1 BACKGROUND

To reduce volatile organic compound (VOC) emissions from stationary sources, the U.S. Environmental Protection Agency (EPA) is developing a series of emission limitations based on application of control technology. These regulations are meant to guide the states in revising their State Implementation Plan (SIP) to achieve the mandated National Ambient Air Quality Standards for oxidants. The Clean Air Act Amendments of 1977 require that each state submit a SIP revision to EPA by January 1, 1979 for approval by July 1, 1979.

Specifically, the EPA requires that the oxidant plan submissions for major urban areas should contain regulations to reflect the application of Reasonably Available Control Technology (RACT) to stationary sources for which the EPA has published guidelines. Recommended VOC limitations representative of RACT have been prepared for the following industrial categories.

- Control Of Volatile Organic Emissions From Existing Stationary Sources--Surface Coating Of:
  - Cans
  - Coils
  - Paper
  - Fabrics
  - Automobiles
  - Light-Duty Trucks
  - Metal Furniture
  - Insulation Of Magnet Wire
  - Large Appliances
- Control Of Volatile Organic Emissions From Solvent Metal Cleaning
- Control Of Refinery Vacuum Producing Systems, Wastewater Separators And Process Unit Turnarounds
- Gasoline Marketing--Control Of:
  - Tank Truck Gasoline Loading Terminals
  - Volatile Organic Emissions From Bulk Gasoline Plants
  - Volatile Organic Emissions From Storage Of Petroleum Liquids In Fixed-Roof Tanks
  - Service Stations--Stage I
- Control Of Volatile Organic Compounds From Use Of Cutback Asphalt.

Under the direction of Region V, the EPA commissioned Booz, Allen and Hamilton Inc. (Booz, Allen) to determine the economic impact of implementing RACT standards in four states:

- Illinois
- Michigan
- Ohio
- Wisconsin.

The assignment was initiated on June 1, 1978, and the research stage of the project was completed over a three-month to four-month period, depending on the individual state requirements. A report was issued for each of the four states being studied.

2.2 PURPOSE OF THE CONTRACT EFFORT

To determine the economic impact of implementing RACT standards for industrial categories in four states (Illinois, Michigan, Ohio and Wisconsin) of Region V of the U.S. Environmental Protection Agency. These studies will be used primarily to assist EPA and state decisions on achieving the emission limitations of the RACT standards.

2.3 SCOPE

The primary task of this project is to determine the costs and impact of control to achieve RACT guideline limitations. The impact must be addressed for each industry and for each state so that the respective studies are applicable to individual state regulations. Direct economic costs and benefits that can be realized from RACT implementation shall be identified and quantified. While secondary (social, energy and employment) impacts are to be addressed, they are not to be the major emphasis in the study. In summary, an economic impact will be analyzed for each of the industry categories in each state and the economic impact of the RACT guidelines will be aggregated statewide.

In Ohio, the economic impact is assessed for the following fifteen RACT industrial categories:

- Surface coating of cans
- Surface coating of coils
- Surface coating of paper
- Surface coating of fabrics
- Surface coating of automobiles and light duty trucks
- Surface coating of metal furniture
- Surface coating for insulation of magnet wire
- Surface coating of large appliances
- Solvent metal cleaning
- Refinery vacuum producing systems, wastewater separators and process unit turnarounds
- Bulk gasoline terminals
- Bulk gasoline plants
- Storage of petroleum liquids in fixed roof tanks
- Service Stations--Stage I
- Use of cutback asphalt.

In the determination of the economic impact of the RACT guidelines, the following are the major study guidelines:

- The emission limitations for each industrial category were studied at the control level established by the RACT guidelines. These are presented in Exhibit 2-1, on the following page.

EXHIBIT 2-1(1)
U.S. Environmental Protection Agency
LISTING OF EMISSION LIMITATIONS THAT REPRESENT THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH APPLICATION OF RACT FOR FIFTEEN INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvent Coatings (lbs. solvent per gallon of coating, minus water)
Surface Coating Of:	
Cans	2.8
. Sheet basecoat (exterior and interior) Overvarnish Two-piece can exterior (basecoat and overvarnish)	
. Two and three-piece can interior body spray Two-piece can exterior end (spray or rollcoat)	4.2
. Three-piece can side-seam spray	5.5
. End sealing compound	3.7
Coils	
. Prime and topcoat or single coat	2.6
Paper	2.9
Fabrics and vinyl coating	
. Fabric	2.9
. Vinyl	3.8
Automobiles and Light Duty Trucks	
. Prime application, flashoff and oven	1.9
. Topcoat application, flashoff and oven	2.8
. Final repair application, flashoff and oven	4.8
Metal Furniture	
. Prime and topcoat or single coat	3.0
Magnet Wire	1.7
Large appliance	
. Prime, single or topcoat	2.8
Solvent Metal Cleaning	
. Cold cleaning	Provide cleaners with: cover; facility to drain clean parts; additional free-board; chiller or carbon absorber. Follow suggested procedures to minimize carryout.
. Conveyorized degreaser	Provide cleaners with: refrigerated chillers; or carbon adsorption system; drying tunnel or rotating basket; safety switches; covers. Follow suggested procedures to minimize carryout.
. Open top degreaser	Provide cleaner with: safety switches; powered cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout.
Petroleum Refinery Sources	
. Vacuum producing systems	No emissions of any noncondensible VOC from condensers, hot wells or accumulators to a firebox, incinerator or boiler.

EXHIBIT 2-1(2)
U.S. Environmental Protection Agency

Category	RACT Guidelines Emission Limitations[a]
. Wastewater separators	Minimize emissions of VOC by providing covers and seals on all separators and forebays and following suggested operating procedures to minimize emissions
. Process unit turnaround	Minimize emissions of VOC by depressurizatic venting to vapor recovery, flare or firebox. No emissions of VOC from a process unit or vessel until it's internal pressure is 136 kilo pascals (17.7 psia) or less
Bulk Gasoline Terminals	Equipment such as vapor control system to prevent mass emissions of VOC from control equipment to exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Bulk Gasoline Plants	Provide submerged filling and vapor balancing so that VOC emissions from control equipment do not exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Storage of Petroleum Liquids in Fixed Roof Tanks	Provide single seal and internal floating roof to all fixed roof storage vessels with capacities greater than 150,000 liters (39,000 gal.) containing volatile petroleum liquids for which true vapor pressure is greater than 10.5 kilo Pascals (1.52 psia)
Service Stations (Stage I)	Provide submerged fill and vapor balance for any stationary storage tank located at a gasoline dispensing facility
Use of Cutback Asphalt	The manufacture, mixing, storage, use or application may be approved where: long-life stockpile storage is necessary; the use or application is an ambient temperature less than 10°C (50°F) is necessary; or it is to be used solely as a penetrating prime coat

Note: An alternative scenario to the recommended RACT guidelines for surface coating of automobiles is also studied. It assumes that requirements are modified to meet specific technologies.

a. Annotated description of RACT guidelines

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, U.S. Environmental Protection Agency, EPA-90512-78-001, April 1978.

- The timing requirement for implementation of controls to meet RACT emission limitations was January 1, 1982.

- All costs and emission data were presented for 1977.

- Emissions sources included were existing stationary point sources in the applicable industrial categories with VOC emissions greater than 3 pounds in any hour or 15 pounds in any day.

- The impact of each of the RACT guidelines was studied statewide (i.e., attainment areas, nonclassified areas and other areas that might not be regulated to the guidelines stated above are included in this analysis).

- The following volatile organic compounds were exempted:

  - Methane
  - Ethane
  - Trichlorotriflorethane (Freon 113)
  - 1,1,1-trichloroethane (methyl chloroform).[1]

- The cost of compliance was determined from the current level of control, (i.e. if an affected facility currently had an incinerator in place, the cost of compliance and resulting VOC emission reduction are not included in this analysis.)

[1] The exemption status of methyl chloroform under these guidelines may be subject to change.

2.4 APPROACH

This section describes the overall approach and methodology applied in this assignment. In general, the approach varied for each state and also for each industrial category studied. This section specifically describes the overall approach that was applied for the state of Ohio. The methodology applied to determine the economic impact for each of the fifteen RACT industrial categories in Ohio is described in further detail in the first section of each chapter dealing with the specific RACT category.

There are five parts to this section to describe the approach for determining estimates of:

- Industry statistics
- VOC emissions
- Process descriptions
- Cost of controlling VOC emissions
- Comparison of direct cost with Selected Direct Economic Indicators.

2.4.1 Industry Statistics

The assembly of economic and statistical data for each industrial category was an important element in establishing the data base that was used for projection and evaluation of the emissions impact. Some of the major variables for each industrial category were:

- Number of manufacturers
- Number of employees
- Value of shipments
- Number of units manufactured
- Capital expenditures
- Energy consumption
- Productivity indices
- Current economics (financial) status
- Industry concentration
- Business patterns (small vs. large; downstream integration)
- Age distribution of facilities
- Future trends and developments.

Some of the industrial categories studied cover a large number of potentially affected facilities. For these categories, industry statistical data were collected by applying a categorical approach rather than by attempting to identify all the individual firms likely to be affected. The industrial categories studied by this approach included:

- Solvent metal cleaning
- Bulk gasoline plants
- Storage of petroleum liquids in fixed roof tanks.

For these industrial categories, secondary data sources and nonconfidential Booz, Allen files served as the primary resources for the data base. Industry and association interviews were then conducted to complete, refine and validate the industry statistical data base.

For the eight surface coating RACT industry categories studied (cans, coils, paper, fabrics, automobiles and light duty trucks, metal furniture, magnet wire and large appliances) the number of facilities potentially affected was in a manageable range (generally less than 30 facilities per RACT industrial category); therefore, a more deliberate approach was applied:

- As a first step, the facilities potentially affected by the RACT guidelines were identified from secondary data sources.
    - This compiled list was then corrolated to identify the facilities potentially affected but not listed as VOC emitters in the Ohio emission data.
    - The Booz, Allen study team then performed telephone interviews with a sampling of the facilities identified where there was doubt concerning inclusion. (For industrial categories where only a few facilities were identified, such as coil coating, all the potentially affected facilities were contacted.)
- Industry category statistical data were compiled using secondary sources such as:
    - Department of Commerce
    - Census of Manufactures
    - Trade associations
    - Bureau of Labor Statistics
    - National Technical Information Services.
- The industry statistical data were refined by two mechanisms:
    - Assessing the statistical data for reasonableness in comparison to the list of potentially affected facilities
    - Using industry and association interviews for completion and validation.

2.4.2 VOC Emissions

An approach to make maximum utilization of the existing Ohio emission inventory was explored.

- State EPA representatives were interviewed to determine the completeness and validity of emission data available for each RACT industrial category. It was determined that:
  - VOC emission data for major industrial sources appeared to be missing a significant number of potentially affected facilities.
  - The emission inventory did not provide relevant data that could be utilized for economic evaluation, i.e., air flow rate, type of process, the input and emission factors. That data had to be estimated from industry interviews.
  - The data base would not provide a baseline for economic impact analysis.
- Therefore, a project task was established by the Ohio EPA to collect emission data for the surface coating industrial categories. These RACT industrial categories were:
  - Cans
  - Coils
  - Fabrics
  - Paper
  - Automobiles
  - Metal furniture
  - Large appliances
  - Magnet wire
  - Fixed roof tanks.
- For some of these RACT categories, Ohio could not complete the updating of the emission inventory in a timely fashion and Booz, Allen had to estimate the emissions from these categories by utilizing other techniques. For instance, some emission estimates were based solely on industry interviews, such as the automobile RACT category.

- For the other RACT categories to be studied, the emissions were estimated by applying relevant factors (VOC emissions per facility, throughput, etc.) that had been developed by EPA studies. Although this categorical approach cannot be validated to the degree of a point source by point source approach, the emissions can be reasonably estimated on a statewide basis because of the large number of sources in each RACT industrial category. Emissions were estimated by this approach for the following RACT industrial categories:

  - Bulk gasoline plants
  - Bulk gasoline terminals
  - Solvent metal cleaning
  - Service stations
  - Cutback asphalt
  - Miscellaneous refinery sources.

- The emission estimates for each of the fifteen RACT industrial categories studied were refined during industry interviews.

2.4.3 Process Descriptions

For each of the industrial categories, the basic technology and emission data were reviewed and summarized concisely for subsequent evaluation of engineering alternatives. In this task, the RACT documents that had been prepared for each industrial category and other air pollution control engineering studies served as the basis for defining technological practice. Additional alternatives to control that met the requirements of the RACT guidelines were identified from literature search. The most likely control alternatives were assessed and evaluated by:

- Technical staff at Booz, Allen
- Interviews with industry representatives
- Interviews with EPA representatives
- Interviews with equipment manufacturers.

2.4.4 Cost of Controlling VOC Emissions

The cost of control to meet the requirements of the RACT guidelines had been presented in the RACT documents, other technical EPA studies and trade journal technical documents and by industry representatives. The approach applied in developing capital and annualized cost estimates was to:

- Utilize available secondary source information as the primary data source.

- Validate the control alternatives industry is likely to apply.

- Calibrate these cost estimates provided in technical documents.

It was not within the purpose or the scope of this project to provide detailed engineering analyses to estimate the cost of compliance.

Cost data presented within the body of the report were standardized in the following manner:

- All cost figures are presented for a base year, 1977.

- Capital cost figures represent installed equipment cost including:

  - Engineering
  - Design
  - Materials
  - Equipment
  - Construction.

  The capital cost estimates do not account for costs such as:

  - Clean-up of equipment
  - Lost sales during equipment downtime
  - Equipment startup and testing
  - Initial provisions (spare parts).

- Capital related annual costs are estimated at 25 percent of the total capital cost per year (unless explicitly stated otherwise). The estimation procedure applied was built up from the following factors:

  - Capital recovery factor for interest and depreciation of 16.3 percent, based on a 10 percent interest rate and 10 year life of equipment.

  - Maintenance--4 to 5 percent

  - Taxes and insurance--4 percent.

  The capital-related annual costs do not account for investment costs in terms of return on investment parameters (i.e., the "opportunity cost" of money is not included).

- Annual operating costs of compliance with the RACT guidelines were estimated for each of the control alternatives studied. The annual operating costs included were:

  - Direct labor
  - Raw material costs (or savings)

- Energy
- Product recovery cost (or savings)

Other types of costs, not included in this analysis, involve compliance costs, such as:

- Demonstration of control equipment efficiency

- Supervisory or management time

- Cost of labor or downtime during installation and startup.

- The annualized cost is the summation of the annual operating costs and the capital related annual costs.

2.4.5 <u>Comparison of Direct Cost with Selected Direct Economic Indicators</u>

In each of the industrial categories studied, after the costs (or savings) of compliance had been determined, these costs were compared with selected economic indicators. This comparison was performed to gain a perspective on the compliance costs rather than to estimate price changes or other secondary effects of the regulation. Presented below are typical comparisons of direct costs with indicators that are presented in this study.

- Annualized cost in relation to current price-To gain a perspective on the compliance cost in relation to current prices of the manufactured items at the potentially affected facilities the annualized cost is presented in terms of a price increase assuming a direct pass-through of costs to the marketplace.

  - This analysis was based on the average cost change (including those facilities that may have little or no economic impact associated with meeting the proposed standards) divided by the average unit price of goods manufactured.

  - For this reason as well as many others (that might be addressed in a rigorous input-output study to estimate eventual price increase), this analysis should not be interpreted as forecast of price changes due to the proposed standards.

- Annualized costs as a percent of current value of shipment-The annualized costs applied are for all those facilities potentially affected divided by the estimated value of shipments for the statewide industrial category (i.e., including those facilities which currently may meet the proposed standard). This approach tends to understate the effect to those specific firms requiring additional expenses to meet the proposed standard. Therefore, when available, the compliance cost is also presented as a percent of the value of shipments for only those firms not currently meeting the proposed regulation.

- Capital investment as a percent of current annual capital appropriations--Estimated statewide capital investment for the potentially affected facilities divided by the estimated capital appropriations for the industry affected as a whole in the state (including those facilities that may not require any capital investment to meet the proposed standard.)

2.5 QUALITY OF ESTIMATES

The quality of the estimates that are presented in this report can be judged by evaluating the basis for estimates of the individual study components. In each of the chapters that deal with the development of estimated compliance cost, the sources of information are fully documented. In addition, the study team has categorically ranked the overall data quality of the major sources and, therefore, of the outcomes. These data quality estimates were ranked into three categories:

- High quality ("hard data")--study inputs with variation of not more than ± 25 percent

- Medium quality ("extrapolated data")--study inputs with variation of ± 25 to ± 75 percent

- Low quality ("rough data")--study inputs with variation of ± 50 to ± 150 percent.

Each of these data quality estimates are presented in the individual chapters. The overall quality ranking of the study inputs for each RACT industrial category was generally in the medium quality range.

2.6 DEFINITIONS OF TERMS

Listed below are definitions of terms that are used in the body of the report:

- Capture system--the equipment (including hoods, ducts, fans, etc.) used to contain, capture, or transport a pollutant to a control device.
- Coating applicator--an apparatus used to apply a surface coating.
- Coating line--one or more apparatuses or operations which include a coating applicator, flash-off area and oven, wherein a surface coating is applied, dried and/or cured.
- Control device--equipment (incinerator, adsorber or the like) used to destroy or remove air pollutant(s) prior to discharge to the ambient air.
- Continuous vapor control system--a vapor control system that treats vapors displaced from tanks during filling on a demand basis without intermediate accumulation.
- Direct cost pass-through--the relationship of the direct annualized compliance cost (increase or decrease) to meet the RACT limitations in terms of units produced (costs per unit value of manufactured goods.)
- Emission--the release or discharge, whether directly or indirectly, of any air pollutant into the ambient air from any source.
- Facility--any building, structure, installation, activity or combination thereof which contains a stationary source of air contaminants.
- Flashoff area--the space between the application area and the oven.
- Hydrocarbon--any organic compound of carbon and hydrogen only.

- Incinerator--a combustion apparatus designed for high temperature operation in which solid, semisolid, liquid or gaseous combustible wastes are ignited and burned efficiently and from which the solid and gaseous residues contain little or no combustible material.

- Intermittent vapor control system--a vapor control system that employs an intermediate vapor holder to accumulate vapors displaced from tanks during filling. The control device treats the accumulated vapors only during automatically controlled cycles.

- Loading rack--an aggregation or combination of gasoline loading equipment arranged so that all loading outlets in the combination can be connected to a tank truck or trailer parked in a specified loading space.

- Organic material--a chemical compound of carbon excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

- Oven--a chamber within which heat is used to bake, cure, polymerize and/or dry a surface coating.

- Prime coat--the first film of coating applied in a two-coat operation.

- Reasonably available control technology (RACT)--the lowest emission limit as defined by EPA that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. It may require technology that has been applied to similar, but not necessarily identical, source categories.

- Reid vapor pressure--the absolute vapor pressure of volatile crude oil and volatile nonviscous petroleum liquids, except liquified petroleum gases, as determined by American Society for Testing and Materials, Part 17, 1973, D-323-72 (Reapproved 1977).

- Shutdown--the cessation of operation of a facility or emission control equipment.

- Solvent--organic material which is liquid at standard conditions and which is used as a dissolver, viscosity reducer or cleaning agent.

- Standard conditions--a temperature of 20°C (68°F) and pressure of 760 millimeters of mercury (29.92 inches of mercury).

- Startup--the setting in operation of a source or emission control equipment.

- Stationary source--any article, machine, process equipment or other contrivance from which air pollutants emanate or are emitted, either directly or indirectly, from a fixed location.

- Topcoat--the final film of coating applied in a multiple coat operation.

- True vapor pressure--the equilibrium partial pressure exerted by a petroleum liquid as determined in accordance with methods described in American Petroleum Institute Bulletin 2517, "Evaporation Loss from Floating Roof Tanks," 1962.

- Equivalent barrel of oil--energy demand is converted into barrels of oil at the conversion rate of 6,000,000 BTU per barrel of oil.

- Vapor collection system--a vapor transport system which uses direct displacement by the liquid loaded to force vapors from the tank into a vapor control system.

- Vapor control system--a system that prevents release to the atmosphere of at least 90 percent by weight of organic compounds in the vapors displaced from a tank during the transfer of gasoline.

- Volatile organic compound (VOC)--any compound of carbon that has a vapor pressure greater than 0.1 millimeters of mercury at standard conditions excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate.

3.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF OHIO

3.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF OHIO

This chapter presents a detailed economic analysis of implementing RACT controls for can manufacturing plants in the State of Ohio. The chapter is divided into five sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of can manufacturing plants, interviews and analysis.

3.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for can manufacturing plants in Ohio.

The quality of the estimates is described in detail in the latter part of this section.

3.1.1 Industry Statistics

Industry statistics on can manufacturing plants were obtained from several sources. All data were converted to a base year 1977 based on specific scaling factors. The number of establishments for 1977 was based on a review of the 1976 County Business Patterns and supplemented by interviews with selected can manufacturing corporations. The number of employees was obtained from the 1976 County Business Patterns and refined based on information supplied by the Can Manufacturers Institute.

The number of cans manufactured was based upon scaling up 1972 published data to 1977.

- The 1972 Census of Manufactures reported a total U.S. volume of shipments of 78 billion units with a value of $4.5 billion.

- The value of shipments in the East North Central Region was reported as:

State	Value of Shipments, 1972 ($ Million)	Percent of U.S. Total
Ohio	236.5	5.24
Illinois	465.9	10.33
Michigan	74.0	1.64
Wisconsin	Withheld	7.76
Indiana	Withheld	
TOTAL	1,126.5	24.97

- The value of shipments for 1976 in the U.S. was reported to be $6,357 million. Based upon the same ratio of state production to total U.S. production as in 1972, the 1976 production in the states was estimated to have been:

State	1976 Value of Shipments ($ Million)	Units Produced 1976 (Billion)
Ohio	333.3	4.4
Illinois	656.7	8.6
Michigan	104.3	1.4
Wisconsin	304.8	4.0

- For 1977, the U.S. Industrial Outlook, 1977 indicates that the increase in production is 3 percent, with a 10 percent increase in value of shipments. This factor was used to estimate 1977 can production and the value of shipments.

- The product mix of the types of cans currently produced in the state was estimated using the national average and refined using data obtained from the Ohio emissions inventory and from interviews.

3.1.2 VOC Emissions

The data for determining the current level of emissions was estimated by the study team because the Ohio emissions inventory was incomplete at the time this study was undertaken. The estimate was based upon the Wisconsin Point Source Emission inventory and the relative can production by each can type (two-piece beer and beverage, three-piece beer and beverage, three-piece food) in the states of Ohio and Wisconsin. Most can manufacturing plants employ similar technology to produce the same product, so that there is a good correlation between can production and coating consumption once the type of can manufactured is known.

3.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for can manufacturing plants are described in Control of Volatile Organic Emissions from Stationary Sources, EPA-450/2-77-008. The data provide the alternatives available for controlling VOC emissions from can manufacturing plants. Several studies of VOC emission control were also analyzed in detail, and the industry trade association and can manufacturers were interviewed to ascertain the most likely types of control techniques to be used in can manufacturing plants in Ohio. The specific studies analyzed were Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories, and informational literature supplied by the Can Manufacturers Institute to the state EPA programs.

The alternative approaches to VOC control as presented in the RACT document were supplemented by several other approaches. The approaches were arrayed and the emissions to be reduced from using each type of control were determined. This scheme forms the basis of the cost analysis, for which the methodology is described in the following paragraphs.

3.1.4 Cost of Control Approaches and the Resulting Reduction in VOCs

The costs of VOC control approaches were developed by:

- Separating the manufacturing process into discrete coating operations:
  - By can manufacturing technology
  - By type of can manufactured; i.e., beer vs. food
- Determining the alternative approaches to control likely to be used for each type of coating operation
- Estimating installed capital costs for each approach
- Estimating the probable use of each approach to control considering:
  - Installed capital cost
  - Annualized operating cost
  - Incremental costs for materials and energy
  - Technical feasibility by 1981

  (This estimate was based on discussions with knowledgable individuals in the can manufacturing industry.)
- Aggregating costs to the total industry in Ohio.

Costs were determined from analysis of the previously mentioned studies:

- Control of Volatile Organic Emissions from Stationary Sources, EPA-450/2-77-008
- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories

and from informational data supplied by the Can Manufacturers Institute and from interviews with major can manufacturing companies.

The cost of compliance and the expected emission reduction in Ohio were developed based on can industry operational data and refined using interviews with can manufacturers. Based upon the assessment of the degree and types of controls currently in place, the cost of VOC emission control and the net reduction in emissions were estimated.

3.1.5 Economic Impact

The economic impact was analyzed by considering the lead time requirements needed to implement RACT, assessing the feasibility of instituting RACT controls in terms of available technology, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary impacts on market structure, employment and productivity from implementing RACT controls in Ohio.

3.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on can manufacturing plants in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data, "B" indicates data were extrapolated from hard data and "C" indicates data were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 3-1, on the following page, rates each study output and overall quality of the data. However, emission data are only as good as the assessment of the 1977 technical approach to emission controls, particularly the degree of usage of "exempt" solvents and the percentage of solvent that is actually incinerated.

EXHIBIT 3-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions			X
Cost of emissions control			X
Statewide costs of emissions			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

3.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for can manufacturing plants in Ohio are presented in this section. The source of industry statistics was the Ohio emissions inventory, The Can Manufacturer's Insitute and the individual can manufacturing companies. Data in this section form the basis for assessing the impact of implementing RACT to VOC emissions from can manufacturing plants in the state.

3.2.1 Size of the Industry

There are approximately 23 major can manufacturing facilities in Ohio. The Columbus area is becoming the most important can manufacturing center in the state.

- Exhibit 3-2, on the following page, presents a summary of can manufacturing facilities in the state.
- Approximately 4.6 billion cans were shipped in 1977. The value of industry shipments in 1977 is estimated at about $360 million.

The estimated number of employees in 1977 was 4,100. Can industry capital investments in Ohio are estimated to have been $15 million to $30 million in 1977. (Based upon an extrapolation of 1972 data--which reported that 7.1 percent of total, industry capital expenditures, were in Ohio--the total 1977 expenditures would be about $15 million. Since Ohio's share of total industry expenditures has not been determined, the $10 million to $20 million range was used.)

3.2.2 Comparison of the Industry to the State Economy

The Ohio can manufacturing industry employs 0.2 percent of the state labor force, excluding government employees. The state is one of the largest producers of cans in the nation.

3.2.3 Characterization of the Industry

The can industry is composed of independent and captive manufacturers. Nationwide, about 70 percent of all cans are produced by independent manufacturers and about 30 percent by captive producers. The majority of captive can producers use the cans to package canned food/soup and beer.

The independent can producers generally operate on a "job shop" basis, producing cans for several customers on the same production facilities. In addition to differences in can size and shape, there are differences in coatings resulting from:

EXHIBIT 3-2 (1)
U.S. Environmental Protection Agency
LIST OF METAL CAN MANUFACTURING FACILITIES
POTENTIALLY AFFECTED BY RACT IN OHIO

Name of Firm	Location	Product	Notes
American Can Company[a]	Whitehouse	2-piece beer cans	Steel cans
Continental Can Company	Columbus	3-piece beer and soft drink assembly	Assembly only
Continental Can Company	Cincinatti (Bedford Hts.)	3-piece beer and soft drink cans	Sheet coating and sealing, assembly
National Can Company	Marion	3-piece food cans	
National Can Company	Warren	General purpose cans assembly	The plant is a major coating facility supplying coated stock to other plants
National Can Company	Archbold	Food can assembly	
National Can Company[a]	Columbus (Obetz)	2-piece beer cans 3-piece beer and soft drink cans 3-piece food cans	2 production lines
Heekin Can Company[a]	Cincinatti (Anderson)	3-piece beer and soft drink cans 3-piece food cans	The plant is a major coating facility supplying coated stock to other plants
Metal Container Corp.[a] (Anhausser Busch)	Columbus	2-piece beer cans	2 production lines; steel cans
Crown Cork and Seal	Cleveland		
Crown Cork and Seal	Perrysburg		
Ball Metal Container[a]	Findlay	3-piece beverage cans	
Buckeye Stamping Co.	Columbus		
Cambell Soup Company	Napoleoun		
Central States Can Company[a]	Massillon		

Name of Firm	Location	Product	Notes
Davis Can	Solon		
Libby McNeil and Libby	Lime		
Owens Illinois	Perrysburg		
Pet Inc.	Byran		
Robertson Can	Springfield		
Ross Labs	Columbus		
Sherwin Williams	Hubbard		Paint cans
Stolle Corporation	Sidney		

a. Emission data supplied by Ohio EPA.

Source: Booz, Allen & Hamilton Inc. assessment of data provided by the Ohio Environmental Protection Agency and the Can Manufacturers Institute. Organizations on the Ohio EPA VOC--RACT listing that are totally or primarily involved with the production of metal barrels, drums and pails (SIC 3412) have been excluded from this inventory.

- The need to protect different products with varying characteristics from deterioration through contact with the metal can

- The decoration requirements of customers and requirements for protection of the decoration.

Nationally, the can industry produces more than 600 different shapes, types and sizes to package more than 2,500 products. A relatively few can sizes and coating combinations employed for packaging beverages and food represent about 80 percent of the market. The approximate percentage of total can production represented by the major groups follows.

Type of Can		Percent of Total Production
Beer and soft drink		54
Fruit and vegetable		18
Food cans in the category that includes soup cans		8
Other		20
	TOTAL	100

In Ohio, the can industry is focused on meeting the needs of the brewing, soft drink and canning industries in the state.

- 2.0 billion beer and soft drink cans were produced using two-piece construction.

- 0.8 billion three-piece beer and soft drink cans were produced.

- 1.8 billion food, general cans and aerosol cans were produced almost entirely of three-piece construction.

Of the 4.6 billion cans produced in Ohio in 1977, 2.8 billion (61 percent) were beer and soft drink cans with the balance beer, food and general purpose cans.

The can industry in Ohio, as well as nationally, has experienced rapid technological changes since 1970 caused by the introduction of new can making technology--the two-piece can. These changes in can manufacturing technology have resulted in the closing of many can plants producing the traditional three-piece product and replacing the capacity with two-piece cans. An above-average amount of two-piece capacity has been installed in Ohio as compared to the other states. There is evidence that the technological trend will continue, so that by 1981 about 80 percent of the beer and beverage cans and a relatively small but growing percentage of other cans will be of two-piece construction.

3.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on can manufacturing operation, estimated VOC emissions, the extent of current emission control and the likely alternatives which may be used for controlling VOC emissions in Ohio.

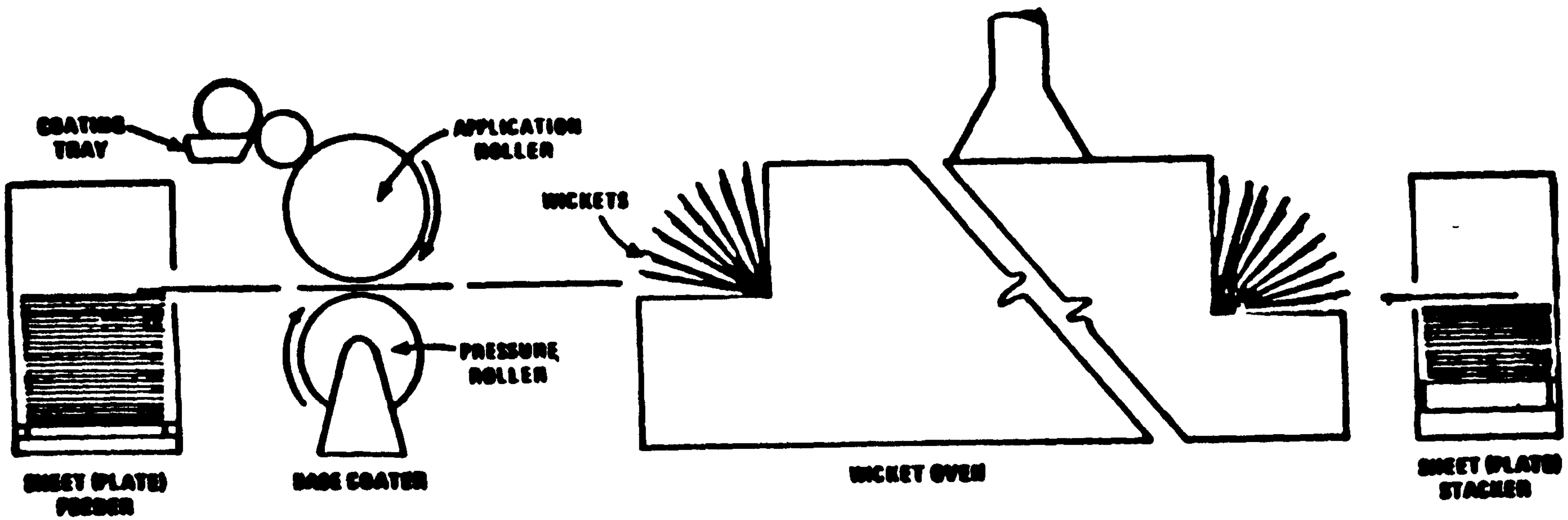
3.3.1 Can Manufacturing Operations

The can industry produces cans using two fundamental technologies, the traditional three-piece method and the newer two-piece technology.

The three-piece can technology consists of two separate operations: sheet coating and can fabrication (assembly). Sheet coating and can assembly operations are frequently performed in separate facilities. The major can manufacturers operate centralized facilties for the coating and decorating of flat sheets. These centralized plants are often called "feeder plants." Sheets are coated at a rate of about 2.5 base boxes per minute, which is equivalent to approximately 1,250 twelve-ounce cans per minute. The specific operations in three-piece can manufacture are summarized below.

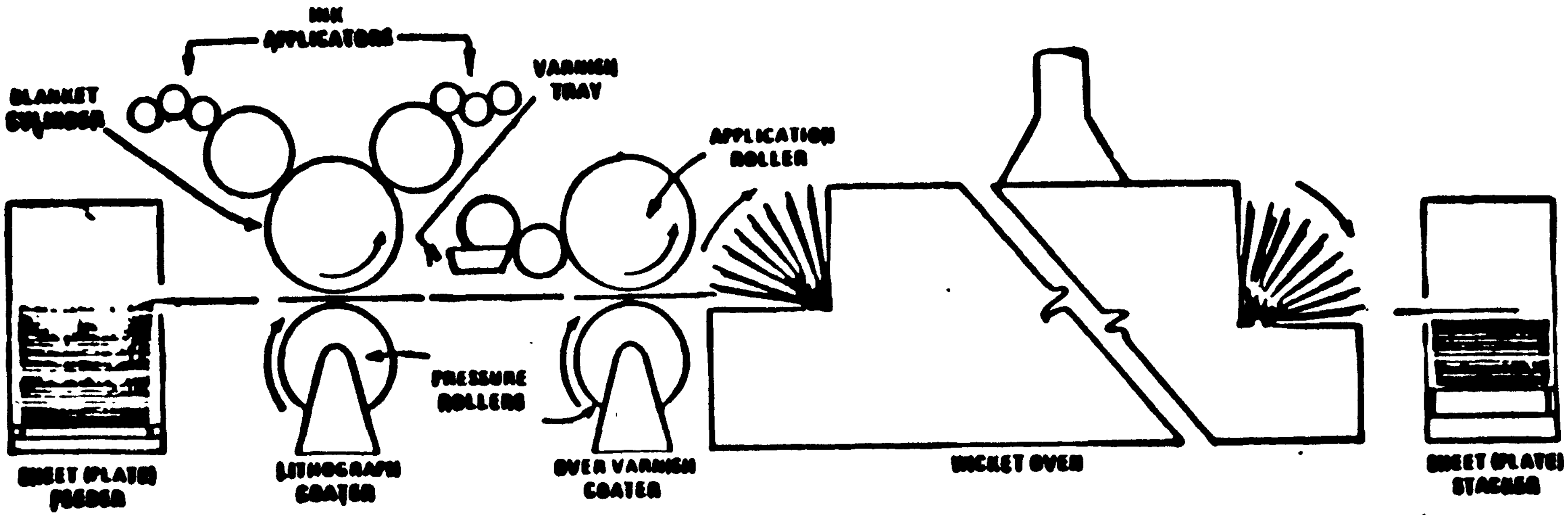
- Sheets of metal are coated and decorated with 28 or 35 can bodies (outs). This is accomplished in two steps.
  - The sheets are base coated on the interior side and then passed through a wicket oven.
  - Food cans, as well as some beer and soft drink cans, are given an exterior base coat.
  - In the case of beer and soft drink cans, the base coated sheets are decorated (printed), over coated with varnish and then cured in a smaller wicket oven.
  - Exhibits 3-3 and 3-4, on the following page, present flow diagrams of the base coating and decorating operations.

EXHIBIT 3-3
U.S. Environmental Protection Agency
SHEET BASE COATING OPERATION



Source: U.S. Environmental Protection Agency

EXHIBIT 3-4
U.S. Environmental Protection Agency
SHEET PRINTING OPERATION



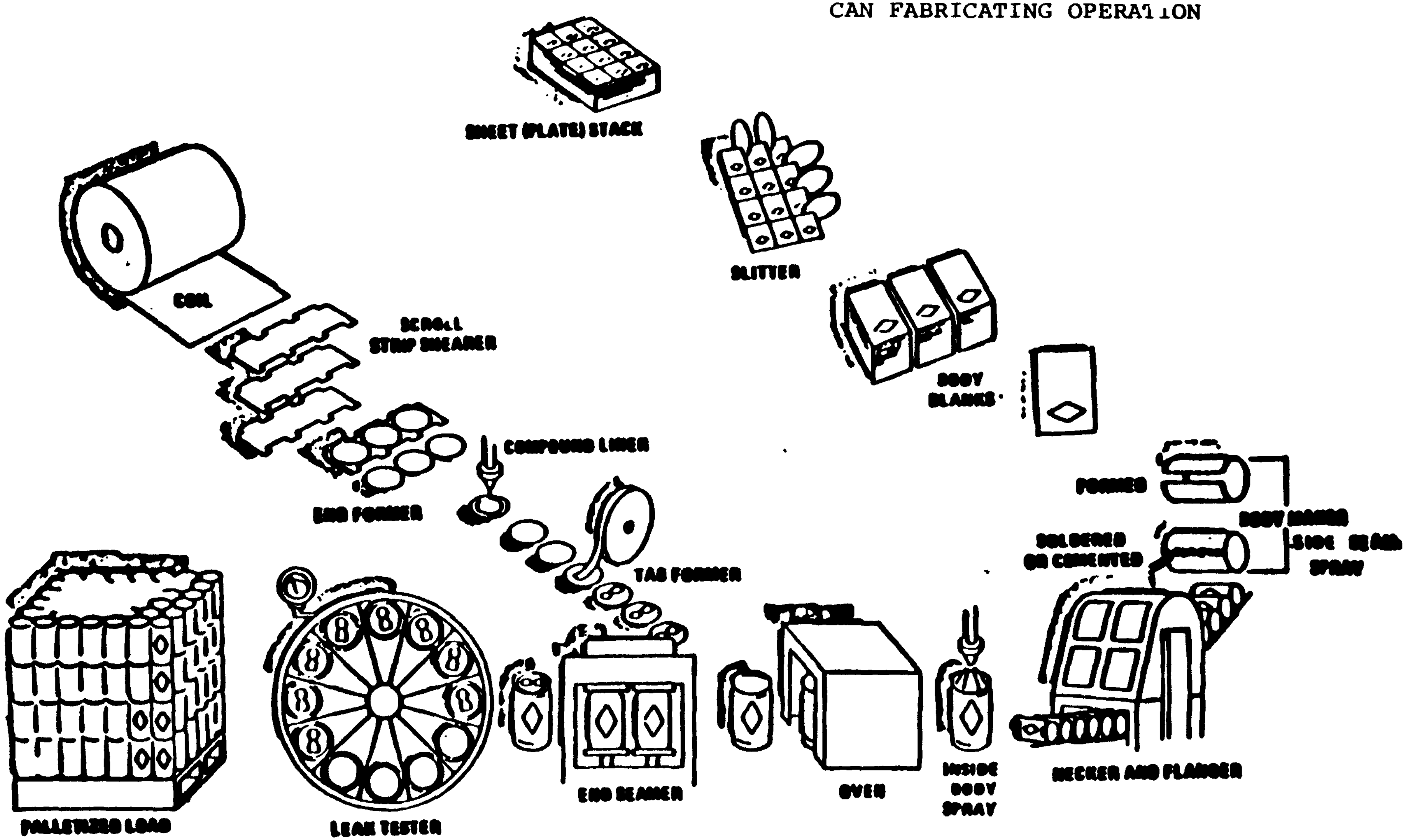
Source: U.S. Environmental Protection Agency

- Can bodies are formed from the coated sheets.
  - The printed sheets are slit into individual body blanks and fed into the "body maker."
  - The blank is rolled into a cylinder and soldered, welded or cemented.
  - The seam is sprayed (striped) on the inside and outside with an air dry lacquer to protect the exposed metal. Sometimes this is done only on the inside surfaces.
- Can ends are formed from coated sheet stock and fed to the end seamer where final fabrication is completed.
  - Can ends are stamped from coated stock and perimeter coated with synthetic rubber compound gasketing.
  - Solvent-based compounds are air-dried and water-based compounds are oven-dried.
- The can is fabricated from the body and the end in an "end sealer," leak tested and palletized for shipment. Exhibit 3-5, on the following page, presents a schematic of can end and three-piece can fabricating operations.

Two-piece cans are generally manufactured in an integrated high-speed process capable of producing 600 or 800 cans per minute.

- Coil stock is formed into a shallow cup.
- The cups are drawn and ironed into the form of a can.
- The cans are washed to remove the lubricant.
- An exterior base coat is applied (if required) by reverse roller coating and cured in a continuous oven.
- The cans are printed and then coated with a protective varnish. The coating is then baked in an oven. Steel cans are sometimes given two separate interior coatings.

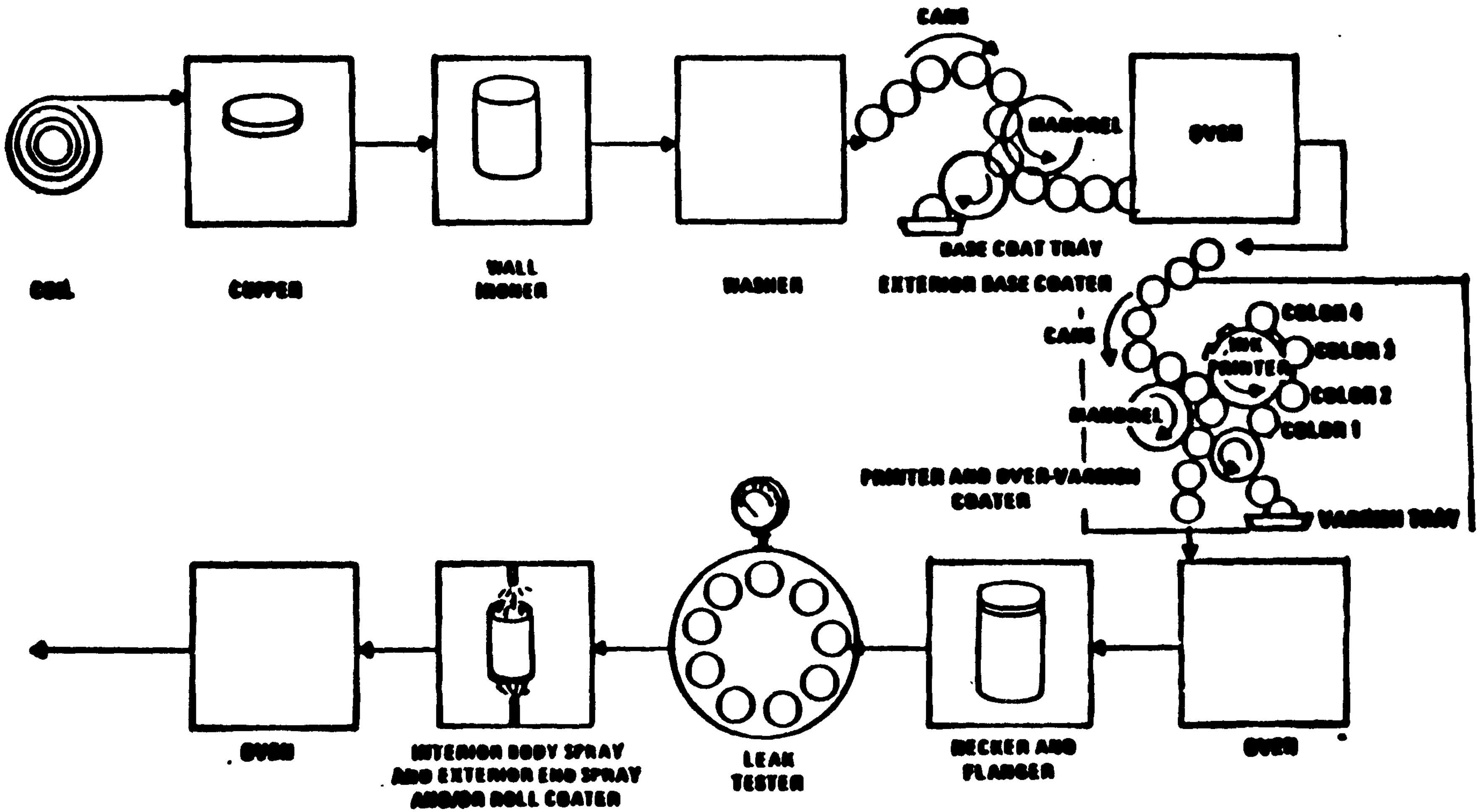
EXHIBIT 3-5
U.S. Environmental Protection Agency
CAN END, AND THREE-PIECE BEER AND BEVERAGE
CAN FABRICATING OPERATION



Source: U.S. Environmental Protection Agency

- The cans are necked, flanged and tested.
- The interior of the cans are spray coated and baked in the oven.
- An exterior end spray coating is applied:
  - For aluminum cans to prevent blocking
  - For steel cans to prevent rusting.
- Exhibit 3-6, on the following page, is a process diagram of a two-piece can fabricating and coating operation.
- Two-piece cans are largely made from aluminum.
  - Virtually all aluminum cans are of two-piece construction.
  - Aluminum lends itself to two-piece construction, yet offers no advantage to warrant converting three-piece can lines to aluminum.
- Although there are a limited number of two-piece steel can production facilities, two major plants are located in Ohio:
  - American Can, Whitehouse
  - Metal Container Corp., Columbus.

EXHIBIT 3-6
U.S. Environmental Protection Agency
TWO-PIECE ALUMINUM CAN FABRICATING AND COATING OPERATION



Source: U.S. Environmental Protection Agency

3.3.2 Emissions and Current Controls

The can industry is moving toward products with inherently lower VOC emissions during manufacture. Differences in the manufacturing process between two-piece and three-piece cans allow for a 50 percent to 60 percent reduction in emissions in converting from a three-piece beer can to a two-piece beer can decorated in a similar manner. This is caused by a greater number of interior coating operations for three-piece cans, as well as a tendency to eliminate certain exterior coatings on two-piece beer and soft drink cans. The exhibits, on the following pages, present the emissions from typical can coating operations based upon average coating properties, can production rates and annual hours of operation. They present data for conventional systems, as well as for low solvent systems. It is important to note that, in most instances, can manufacturing does not require all the coatings.

- Exhibit 3-7 presents VOCs resulting from coating operations used in the manufacture of two-piece cans.
- Exhibit 3-8 presents VOCs resulting from sheet coating operations used in the manufacture of three-piece cans.
- Exhibit 3-9 presents VOCs resulting from typical three-piece can assembly operations.

The emissions from the industry, developed through the analysis of typical coating operations and the assumed product mix, total an uncontrolled level of 4,600 tons. Emissions from producing typical products are included in Exhibits 3-12 and 3-13 under the 1978 base case alternatives.

Can Type	Quantity (million)	VOC (tons/million)	Total VOC (tons)
2-piece beer and soft drink	2,000	0.67	1,340
3-piece beer and drink	800	1.79	1,432
3-piece food and other	1,800	0.99	1,782
TOTAL			4,554

EXHIBIT 3-7 (1)
U.S. Environmental Protection Agency
EMISSIONS FOR TYPICAL COATING
OPERATION USED IN THE MANUFACTURE
OF TWO-PIECE CANS

Operation	Density (lb./gal.)	Solids (wt. %)	Organic Solvent (wt. %)	Organic Solvent (lb./gal.)	Water (gal./gal. coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. incl. water)	Yield (1000 can/ gal.)
	Coating Properties							
Organic Systems								
Print and varnish	8.0	45	100	4.40	0	4.40	4.40	12
Size and print	8.0	40	100	4.80	0	4.80	4.80	20
White base coat and print	11.0	62.5	100	4.13	0	4.13	4.13	9
Interior body spray	7.9	26	100	5.85	0	5.85	5.85	6[a]
End coating Al	8.0	45	100	4.40	0	4.40	4.40	200
End coating steel	8.0	45	100	4.40	0	4.40	4.40	40
Low Solvent Systems								
Waterborne								
Print and varnish	8.5	35	20	1.11	0.53	2.36	1.11	11
Size and print	8.5	30	20	1.19	0.57	2.76	1.19	17
White base coat and print	11.7	62	20	0.89	0.43	1.55	0.88	8
Interior body spray	8.55	20	20	1.37	0.66	3.99	1.36	5[a]
End coating Al	8.5	35	20	1.11	0.53	2.36	1.11	200
End coating steel	8.5	35	20	1.11	0.53	2.36	1.11	40
UV Cure High Solids								
Print and varnish[b]	8.0	95	100	0.40	0	0.40	0.40	25

Operation	Production (cans/min.)	Production (Million cans/yr.)	Coating Consumed (gal./hr.)	Coating Consumed (1000 gal./yr.)	VOC (lb./hr.)	VOC (tons/yr.)	VOC (lb./million cans)
Organic Systems							
Print and varnish	650	253.5	3.25	21.1	14.3	46.5	364
Size and print	650	253.5	1.95	12.7	9.4	30.6	241
White base coat and print	650	253.5	4.33	28.1	17.8	57.9	457
Interior body spray	650	253.5	6.50	42.3	38.0	123.5	974
End coating Al	650	253.5	0.20	1.3	0.9	2.9	23
End coating steel	650	253.5	0.98	6.4	4.3	14.0	110
Low Solvent Systems							
Waterborne							
Print and varnish	650	253.5	3.55	23.1	3.9	12.7	100
Size and print	650	253.5	2.29	14.9	2.7	8.8	69
White base coat and print	650	253.5	4.88	31.7	4.3	14.0	110
Interior body spray	650	253.5	7.80	50.7	10.6	34.5	272
End coating Al	650	253.5	0.20	1.3	0.2	0.7	6
End coating steel	650	253.5	0.98	6.4	1.1	3.6	28
UV Cured High solids							
Print and varnish[b]	650	253.5	1.56	10.1	0.6	2.0	15

a. Assuming 75 percent beer cans, all given a single coat, and 25 percent soft drink cans, given a double coating

b. Booz, Allen & Hamilton Inc. estimate based on data supplied by CMI, individual can manufacturers and the EPA document 450/2-77-008

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by Can Manufacturers Institute and interviews with can companies.

EXHIBIT 3-8 (1)
U.S. Environmental Protection Agency
COATING AND PRINTING OPERATIONS USED IN
THE MANUFACTURE OF THREE-PIECE CANS
(Sheet Coating Operation)

Operation	Coating Properties							Dry Coating Thickness	
	Density (lb./gal.)	Solids (wt %)	Organic Solvent (wt %)	Organic Solvent (lb./gal.)	Water (gal/gal coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. including water)	(Mg / 4in^2)	(lb. / basebox)
Conventional Organics Systems									
Sizing and print	8.0	40	100	4.80	0	4.80	4.80	5	0.086
Inside basecoat	8.05	40	100	4.83	0	4.83	4.83	20	0.346
Outside white and print	11.0	62.5	100	4.13	0	4.13	4.13	40	0.692
Outside sheet printing and varnish	8.0	45	100	4.40	0	4.40	4.40	10	0.172
Low Solvent Systems									
Sizing (waterborne)	8.5	30	20	1.19	0.57	2.76	1.19	5	0.086
Inside basecoat									
High solids	8.0	80	100	1.60	0	1.60	1.60	20	0.346
Waterborne	8.8	40	20	1.06	0.51	2.15	1.05	20	0.346
Outside white									
High solids	12.0	80	100	2.40	0	2.40	2.40	40	0.692
Waterborne	11.7	62	20	0.89	0.43	1.55	0.88	40	0.692
Outside sheet print and varnish (waterborne)	8.5	35	20	1.11	0.53	2.36	1.11	10	0.172

Operation	Production (base box / hr.)	Production (1000 base boxes[a] / year)	Coating Consumption (gallon / basebox)	Coating Consumption (gallon / hour)	Coating Consumption (1000 gal. / year)	VOC (lb. / hour)	VOC (tons / year)	VOC (lbs / 1000 base boxes)
Conventional Organics Systems								
Sizing and print	150	240	.027	4.1	6.6	19.7	15.8	130
Inside basecoat	150	240	.107	16.1	25.7	77.8	62.2	517
Outside white and print	150	240	.100	15.0	24.0	62.0	49.6	413
Outside sheet printing and varnish	150	240	.048	7.2	11.5	31.7		211
Low Solvent Systems								
Sizing (waterborne)	150	240	.034	5.1	8.1	6.1	4.9	41
Inside basecoat								
High solids	150	240	.054	8.1	13.0	13.0	10.4	87
Waterborne	150	240	.098	14.7	23.5	15.4	12.3	103
Outside white								
High solids	150	240	.072	10.8	17.3	25.9	20.7	172
Waterborne	150	240	.095	14.3	22.9	12.6	10.1	841
Outside sheet print and varnish (waterborne)	150	240	.057	8.6	13.8	9.5	7.6	63

a. Assuming 1,600 hours per year of operation.

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by CMI and individual can companies.

EXHIBIT 3-9 (1)
U.S. Environmental Protection Agency
EMISSIONS OF TYPICAL COATING
OPERATIONS USED IN THREE-PIECE
CAN ASSEMBLY

Operation	Density (lb./gal.)	Solids (wt. %)	Organic Solvent (wt. %)	Organic Solvent (lb./gal.)	Water (gal./gal. coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. incl. water)	Yield (1000 can/ gal.)
Organic Systems								
Interior body spray (beer)	7.9	26	100	5.85	0	5.85	5.85	4
Inside stripe (beer & bev.)	8.0	13.5	100	6.9	0	6.92	6.92	70
(food)	8.0	13.5	100	6.9	0	6.92	6.92	70
Outside stripe (beer)	8.0	13.5	100	6.9	0	6.92	6.92	50
End sealing compound (beer & bev.)	7.1	39	100	4.3	0	4.33	4.33	10
(food)	7.1	39	100	4.3	0	4.33	4.33	10
Low Solvent Systems (water borne)								
Interior body spray (beer)	8.55	20	20	1.37	0.66	3.99	1.36	5
Inside stripe (beer & bev.)	8.55	36	20	1.09	0.53	2.30	1.08	70
(food)	8.55	36	20	1.09	0.53	2.30	1.08	70
Outside stirpe (beer)	8.55	36	20	1.09	0.53	2.30	1.08	45
End sealing compound (beer & bev.)[a]	9.00	40	3	0.16	0.63	0.43	0.16	10
(food)[a]	9.00	40	3	0.16	0.63	0.43	0.16	10

Operation	Production[b] (cans/min.)	(Million cans/yr.)	Coating Consumed (gal./hr.)	(1000 gal./yr.)	VOC (lb./hr.)	(tons/yr.)	(lb./million cans)
Organic Systems							
Interior body spray (beer)	400	120	6.00	30.0	35.1	87.8	1,463
Inside stripe							
(beer & bev.)	400	120	0.30	1.5	2.1	5.3	88
(food)	400	72	0.30	0.9	2.1	3.2	88
Outside stripe (beer)	400	120	0.48	2.4	3.3	8.3	138
End sealing compound							
(beer & bev.)	400	120	2.40	12.0	10.4	26.0	433
(food)	400	72	2.40	7.2	10.4	15.6	433
Low Solvent Systems (Waterborne)							
Interior body spray (beer)	400	120	4.8	24.0	6.5	16.3	272
Inside stripe							
(beer & bev.)	400	120	0.30	1.5	0.3	0.8	13
(food)	400	72	0.30	0.9	0.3	0.5	13
Outside stripe (beer)	400	120	0.53	2.6	0.6	1.5	25
End sealing compound							
(beer & bev.)[a]	400	120	2.40	12.0	0.4	1.0	17
(food)[a]	400	72	2.40	7.2	0.4	0.6	17

a. Waterborne systems are currently only used on aerosol and oil cans.

b. Assumes 4,000 hours per year, as an average of 3,000 hours for food cans and 5,000 hours for beer and beverage cans.

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by CMI and individual can companies

An analysis of the interview notes and the partially completed Ohio emissions inventory indicates that emissions in 1977 were about 25 percent below the theoretical level or about 3,400 tons. This reduction was achieved by the wide-spread usage of waterborne coatings in two-piece can plants.

3.3.3 RACT Guidelines

The RACT Guidelines for VOC emission control are specified as the amount of allowable VOC, in pounds per gallon of coating, minus any water in the solvent system. To achieve this guideline, RACT suggests the following options:

- Low solvent coatings
  - Waterborne
  - High solids
  - Powder coating
  - Ultraviolet curing of high solids coatings
- Incineration
- Carbon adsorption.

The RACT guidelines have established different limitations for each of four groups of can coating operations. Exhibit 3-10, on the following page, presents the recommended VOC limitations, compared with typical, currently available, conventional coatings.

3.3.4 Selection of the Most Likely RACT Alternatives

Projecting the most likely industry response for control of VOC emissions in can manufacturing facilities is complicated by the thousands of different products offered by the can industry. Based on industry interviews, several general assumptions can be made regarding the industry in Ohio as well as nationally.

- The industry preferred response will be to use low solvent coatings (primarily waterborne) wherever technically feasible because of their low cost--see incremental cost comparisons on Exhibits 3-12 and 3-13.
  - The choice between thermal incinerators and catalytic incinerators will be based on the availability of fuel and the preference of the individual companies.

EXHIBIT 3-10
U.S. Environmental Protection Agency
RACT GUIDELINES FOR CAN COATING OPERATIONS

Coating Operation	Recommended Limitation		Typical Currently Available Conventional Coatings
	kg. per liter of coating (minus water)	lbs. per gallon of coating (minus water)	lbs. per gallon of coating (minus water)
Sheet basecoat (exterior and interior) and overvarnish; two-piece can exterior (basecoat and overvarnish)	0.34	2.8	4.1-5.5
Two- and three-piece can interior body spray, two-piece can exterior end (spray or roll coat)	0.51	4.2	6.0
Three-piece can side-seam spray	0.66	5.5	7.0
End sealing compound	0.44	3.7	4.3

Source: U.S. Environmental Protection Agency

- Incinerators with primary heat recovery will be used in preference to those with secondary recovery or no heat recovery.

. The industry will not install carbon adsorption systems because of the very poor performance record established to date in several can plants that have evaluated this control approach.

. Ten likely control alternatives, as well as the three base cases, are discussed in the paragraphs below. The percentage of cans likely to be manufactured by each of the control option alternatives, by 1982, is summarized in Exhibit 3-11, on the following page. The resulting emissions are summarized in Exhibits 3-12 and 3-13, at the end of this section. For cases involving incineration, the following assumptions were made.

  - Energy cost is $2.25 per million BTUs.

  - Capital cost is $20,000 per CFM.

  - Incinerators operate at 10 percent of the lower explosive limit.

  - 90 percent of the roller coating emissions are collected and incinerated.

  - 30 percent of the interior spray coating emissions are collected and incinerated.

The assumptions on cost operating parameters and likely industry response to each control alternative were based upon discussions with knowledgeable industry sources and on Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

3.3.4.1 Two-Piece Beer and Soft Drink Cans--1978 Base Case

At the present time, the majority of beer and soft drink cans produced in Ohio are produced with one exterior coating, a procedure defined as print and varnish.

. The can is printed directly over the base metal and then varnished using a low solids organic-borne varnish--eliminating the base coat.

. The interior of the can is sprayed, using a non-comforming interior body spray.

EXHIBIT 3-11
U.S. Environmental Protection Agency
PERCENTAGE OF CANS MANUFACTURED
USING EACH ALTERNATIVE

Can Type	Water-borne or Other Low Solvent Coatings	Thermal Incineration with Primary Heat Recovery	Print Only, All Low Solvent Coatings	Low Solvent Coatings Except End Sealant Which Is Incinerated	UV Cured Outside Varnish Waterborne Inside Spray
2-piece beer and soft drink	40	0	60	--	0
3-piece beer and soft drink	25	20	--	55	--
3-piece food and other cans	25	20	--	55	--
Sheet coating and end compounding in feeder plants of material to be shipped for assembly elsewhere	60	40	--	--	--

Note: The percentage of cans produced using each control alternative is based upon interviews with individuals in the can industry.

Source: Booz, Allen & Hamilton Inc.

- The end of the can is spray coated, using a non-comforming body spray.

In this base case alternative, no incineration is assumed although, in fact, most of the operations in Ohio currently incinerate some of the emissions. The coating consumption is approximately 250 gallons per million cans, resulting in emissions of 0.67 tons per million cans.

3.3.4.2 Two-Piece Beer and Soft Drink Cans--Waterborne Coatings as Proposed in RACT

In this alternative, all the coating operations currently employed in the base case have been converted to waterborne coatings. The cost of converting to waterborne systems was assumed to be minimal.

- The capital cost for converting each of three coating operations was estimated to be $10,000. This results in an annualized cost of $30 per million cans--assuming that the annualized cost of capital is 25 percent of the total installed capital cost and that 250 million cans are produced annually on the coating line.[1]
- The cost of the coatings is the same as for conventional coatings--industry sources believe that by 1980 this will be the case.
- The energy consumption is the same--this would appear reasonable since most energy consumed is used to heat the belt and the metal cans.
- The yield (spoilage) is the same--it appears that the industry will continue to encounter significant spoilage in changing over to new coatings. However, as the technology is established, it is assumed that spoilage will decline to currently acceptable levels.

The total incremental annualized compliance cost of using waterborne solvents is estimated to be about $30 per million cans. This represents a direct cost increase of less than 0.05 percent. The emissions would be reduced to 0.19 tons per million cans--a 75 percent reduction at a cost of about $62 per ton of VOC removed.

[1]Annualized capital cost includes depreciation, interest, taxes, insurance and maintenance.

It is estimated that 40 percent of the two-piece beer and soft drink cans would be produced using this alternative by 1981--primarily for steel cans.

3.3.4.3 Two-Piece Beer and Soft Drink Cans--Base Case with Thermal Incinerators and Primary Heat Recovery

This alternative assumes that all coating operations currently employed in the base case are retrofitted with thermal incinerators. This alternative is presently employed on several two-piece can lines in Ohio.

- The capital required for three incinerators would be about $66,000--at $20,000 installed cost per CFM.
- The annualized capital cost would be about $66 per million cans.
- The energy costs to operate the incinerators would be about $62 per million cans, at $2.25 per million BTUs.
- Material cost would be comparable to the base case.

The total incremental cost to incinerate emissions from conventional coatings would be about $128 per million cans. This represents a cost increase of approximately 0.2 percent, to reduce emissions by about 42 percent to 0.39 tons per million cans. The reason for the low overall efficiency is that a considerable portion of the VOC escapes as fugitive emissions prior to incineration.

- 90 percent of the exterior coating emissions reach the incinerator.
- 30 percent of the interior spray coating emissions reach the incinerator.

The cost of incineration is about $441 per ton of emission removed. It is estimated that no two-piece can production will utilize this alternative by the end of 1981--incinerators currently in use will be shut down.

3.3.4.4 Two-Piece Beer and Soft Drink Cans--Supplemental Scenario I

This alternative is based upon combining low solvent coatings with industry product trends that lower the product cost. It includes:

- Print only, eliminating all coating operations--this is used for some aluminum cans at the present time

- Waterborne interior body spray as proposed by RACT

- End coatings using a low solvent varnish--either waterborne or high solids.

The elimination of one coating operation would result in a net saving of about $750 per million cans, comprised of a material savings of about $540 and an energy saving of about $230 per million cans. The incremental capital cost would be $20 per million cans. Emissions are reduced by 79 percent to 0.14 tons per million cans, at a saving of about $1,450 per ton of emissions reduced or about $1,300 per ton of emission controlled. It is estimated that 60 percent of the cans produced in 1982 will utilize this method.

However, it is questionable whether, in determining the economic impact of VOC regulations, the implementation of RACT can be given credit for market driven changes in product configuration. Without the credit, the annualized cost would be $20 per million cans.

3.3.4.5 Two-Piece Beer and Soft Drink Cans--Supplemental Scenario II

This scenario is based upon the use of an experimental UV cured varnish, a waterborne interior body spray and an end coating using a low solvent varnish.

Because of the current high cost of UV cured varnishes, this approach is only experimental. Based on today's prices of about $6.50 per gallon for conventional varnishes and $16.25 for UV cured varnishes, this is the most expensive approach to emission reduction, about $734 per million cans.

- The incremental varnish cost is about $810 per million cans.

- The energy saving is about $105 per million cans.

- The annualized capital cost for converting the coating systems to UV cured and waterborne coatings is about $30 per million cans.

This scenario provides a 78 percent reduction in emissions from the base case, to 0.15 tons per million cans at a cost of about $1,400 per ton of emission reduced. Because of the high cost, it is not expected that this approach will be implemented by 1982.

3.3.4.6 Three-Piece Beer and Soft Drink Cans--Base Case

At the present time, the majority of three-piece beer and soft drink cans are produced by the following coating operations:

- Interior base coat
- Decoration and over varnish
- Interior and exterior stripe
- Interior spray coating
- End sealant.

The production of beer cans differs from the production of soft drink cans in some respects, the impact of which has not been considered in this study.

- Beer cans almost always have an exterior stripe, but soft drink cans frequently do not.

- Beer cans always have an inside spray coating but soft drink cans usually do not. However, soft drink cans frequently have a heavier inside base coat to offset the elimination of the spray coating.

Consideration of these differences has been elminated to reduce the complexity of the study. Because of the declining importance of three-piece beer and beverage cans, the impact will be smaller in 1982 than it would be currently.

The total emissions from this alternative are 1.79 tons per million cans (2.5 times the emissions from a similar two-piece can).

3.3.4.7 Three-Piece Beer and Soft Drink Cans--Waterborne Coatings as Proposed in RACT

In this alternative, all the coating operations currently employed in the base case have been converted to waterborne coatings. The cost of converting to waterborne systems was assumed to be minimal.

- The capital cost for converting each of five coating operations was assumed to be $10,000. This results in an annualized capital cost of $104 per million cans--assuming that the cost of capital and maintenance is 25 percent of the total installed capital cost and that 120 million cans are produced annually on the coating line.

- The raw material cost of coatings is the same as for conventional coatings.

- The energy consumption is the same--this would appear reasonable since most of the energy is consumed to heat the wickets and belts and also the can metal.

- The yield (spoilage) is the same--it appears that the industry will continue to encounter significant spoilage in changing over to new coatings. However, as the technology is established, it is assumed that spoilage will decline to currently acceptable levels.

The total incremental cost to convert to waterborne coatings is estimated to be about $100 per million cans. This represents a cost increase of about 0.15 percent. The emissions would be reduced to 0.34 tons per million cans, an 80 percent reduction at a cost of about $72 per ton.

It is estimated that 25 percent of all beer and soft drink facilities will employ this option. The acceptance of this technology will be retarded by the lack of a complete line of available coatings.

3.3.4.8 Three-Piece Beer and Soft Drink Cans--Base Case with Thermal Incinerators and Primary Heat Recovery

This alternative assumes that all coating operations currently employed in the base case are retrofitted with thermal incinerators. Several thermal incinerators are currently being employed on coating lines in Ohio.

The capital required for five incinerators would be about $320,000--assuming an installed cost of $20,000 per CFM.

- The annualized capital cost would be about $668 per million cans.

- The energy cost to operate the incinerators would be $166 per million cans.

- The material costs would be the same as the base case.

The total incremental cost of adopting thermal incineration is estimated to be about $834 per million cans. This represents a cost increase of about 0.2 percent. The emissions would be reduced by 59 percent to 0.74 tons per million cans at a cost of $794 per ton of emissions removed. Because of the prohibitively high costs of this alternative, it is estimated that it will be employed only on 20 percent of all three-piece beer and soft drink cans manufactured in Ohio in 1982.

3.3.4.9 Three-Piece Beer and Soft Drink Cans--All Waterborne Except End Sealant, Which Is Thermally Incinerated

It is likely that the can industry will adopt a hybrid system which will focus on waterborne or possibly other low solvent coatings and thermal incineration of the end sealant and which probably will not be universally available by 1982. Because end sealing compounds represent approximately 12 percent of the VOC from three-piece beer and soft drink can manufacture, this case was developed under the assumption that technology-based exceptions will not be granted.

- The capital cost of converting four coating operations and adding one incinerator would be about $340 per million cans.

- The additional energy costs of one incinerator would be about $93 per million cans.

- Material cost would be the same.

The total incremental cost of this scenario would be about $171 per million cans. This represents a cost increase of about 0.2 percent, to reduce emissions by 80 percent. It is estimated that about 55 percent of the beer and soft drink cans will be produced using this technology.

3.3.4.10 Three-Piece Food Cans--Base Case

Three-piece food cans are currently produced utilizing the following coating operations:

- Interior base coat
- Exterior base coat
- Interior stripe
- End sealant.

The emissions from this case are estimated to be 0.99 tons per million cans.

3.3.4.11 Three-Piece Food Cans--Waterborne as Proposed in RACT

In this alternative, all the coating operations currently employed in the base case have been converted to waterborne coatings.

The total incremental cost to convert to waterborne coatings is estimated to be $113 per million cans. A 76 percent reduction in emissions is achieved, to 0.24 tons per million cans. It is unlikely that a complete spectrum of waterborne coatings will be available to meet industry requirements by 1982 because:

- The focus of research is on two-piece beer and soft drink cans, which is the most rapidly growing market segment.
- The need to achieve FDA approval for the broad spectrum of products required has caused coating manufacturers to focus on the large-volume coatings required for beer and soft drinks.

As a result, it is estimated that only 25 percent of the cans will be produced using this control approach.

3.3.4.12 Three-Piece Food Cans--Base Case with Thermal Incinerators and Primary Heat Recovery

This alternative assumes that all coating operations currently employed in the base case are retrofitted with thermal incinerators.

The total incremental cost of adopting this approach is estimated to be about $690 per million cans; about $595 in capital cost and $95 in energy costs. Emissions would be reduced by 81 percent, to 0.19 tons per million cans. An estimated 20 percent of the cans would be produced using this approach.

3.3.4.13 Three-Piece Food Cans--All Waterborne Except End Sealant, Which Is Thermally Incinerated

Because waterborne and other low solvent coatings are not available, it is likely that the industry will develop a hybrid approach utilizing waterborne coatings where available and incinerating the balance of the emissions. The end sealing compound appears to be the coating most likely to be unavailable in low solvent form by 1982--end sealing compounds release about 18 percent of the VOC emissions from food can manufacturing operations.

The total incremental cost of this scenario is about $200 per million cans; $500 in capital cost and $100 in energy costs. The emissions are reduced by about 79 percent to 0.25 tons per million cans. It is estimated that 55 percent of the cans would be produced using this approach.

3.3.4.14 Sheet Coating Feeder Plant--Low Solvent As Proposed in RACT

In this alternative all the sheet coating and end compounding operations will be converted to waterborne. The total incremental cost to convert to waterborne is estimated to be about $15 per million cans. It is unlikely that a complete spectrum of waterborne coatings will be available to meet industry requirements by 1982; as a result, 60 percent of the stock will be coated with waterborne coatings.

3.3.4.15 Sheet Coating Feeder Plant--Thermal Incinerators And Primary Heat Recovery

This alternative assumes that all sheet coating and end compounding lines are retrofitted with incinerators. At the present time a significant number of sheet coating lines in Ohio already are operating incinerators. Because of the already installed incinerators and the lack of a complete spectrum of coatings, it is estimated that 40 percent of the stock will be coated using thermal incinerators for VOC control.

EXHIBIT 3-12
U.S. Environmental Protection Agency
EMISSIONS FROM COATING TWO-PIECE ALUMINUM
BEER AND SOFT DRINK CANS

Alternative	Capital ($/million cans)	Annualized Incremental Costs ($/million cans)				Coating Input (gals./million cans)	Emissions			
		Annualized Capital Cost	Materials	Energy	Total		VOC Emissions (tons/million cans)	VOC Decrease (tons/million cans)		Incremental Cost ($/ton)
1978 BASE CASE Print and varnish Nonconfirming interior body spray (exempt solvents) End coating	0	0	0	0	0	250	0.67	a	a	a
WATERBORNE AS PROPOSED IN RACT	120	30	0	0	30	340	0.19	0.48	75	63
BASE CASE WITH THERMAL INCINERATORS & PRIMARY HEAT RECOVERY	266	66	0	62	128	250	0.39	0.29	42	441
SUPPLEMENTAL SCENARIO 1 Print only Waterborne interior body spray End coating using a low varnish solvent	80	20	(540)	(230)	(750)	200	0.14	0.53	79	(1415)
SUPPLEMENTAL SCENARIO 2 Print UV cured varnish Waterborne interior body spray End coating using a low solvent varnish	120	30	810	105	734	240	0.15	0.52	78	1411

a. Not Applicable

Source: Booz, Allen & Hamilton Inc. estimates

EXHIBIT 3-13
U.S. Environmental Protection Agency
EMISSIONS FROM COATING THREE-PIECE CANS

Case	Annualized Incremental Costs ($/million cans)					Coating And Emissions				
	Capital ($/million cans)	Annualized Capital Cost/Millions	Materials	Energy	Total	Coating Input (gals./million cans)	VOC Emissions (tons/million cans)	VOC Decrease (tons/million cans)		Incremental Cost ($/ton)
					BEVERAGE CANS					
1978 BASE CASE Interior base coat Decoration and/or varnish Interioring and exterioring stripe Interior spray End sealant	0	0	0	0	0	894	1.79	a	a	a
WATERBORNE AS PROPOSED IN RACT	416	104	0	0	104	720	0.34	1.45	81	72
BASE CASE WITH THERMAL INCINERATORS AND HEAT RECOVERY PRIMARY	2670	668	0	166	834	694	0.74	1.05	59	794
SUPPLEMENTAL SCENARIO [illegible] Waterborne except end sealant which is incinerated	686	171	0	20	191	715	0.35	1.44	80	133
					FOOD CANS					
1978 BASE CASE Interior base coat Exterior base coat Interior stripe End sealant	0	0	0	0	0	424	0.99	a	a	a
WATERBORNE AS PROPOSED IN RACT	453	113	0	0	113	439	0.24	0.75	76	151
BASE CASE WITH THERMAL INCINERATORS AND PRIMARY HEAT RECOVERY	2380	595	0	95	687	424	0.19	0.80	81	859
SUPPLEMENTAL SCENARIO 4 All waterborne except end sealant which is incinerated	768	192	0	17	209	435	0.23	0.76	77	275

a. Not Applicable

Source: Booz, Allen & Hamilton Inc. estimates

3.4 COST AND VOC BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for alternative VOC emission controls are presented in this section based upon the costs per million cans developed for each alternative in the previous section. The extrapolation is based upon can production and emission for actual can manufacturing processes and not upon the representative plants.

3.4.1 Costs for Alternative Control Systems

Although there is no typical can manufacturing facility, the following four representative plants describe the situation in most can manufacturing facilities.

- Representative Plant A produces two-piece beer and soft drink cans on two lines. Each line operates at 650 cans per minute for 6,500 hours annually, to produce approximately 250 million cans--total plant production is 500 million cans.

- Representative Plant B produces 80 percent three-piece beer and soft drink cans and 20 percent three-piece food cans using three assembly lines. The sheet coating lines operate at 2.5 base boxes per minute for about 4,000 hours per year, to support the three assembly lines. Each can assembly line operates at 400 cans per minute, the beer lines for 5,000 hours annually and the food can lines for 3,000 hours annually.

- Representative Plant C coats and decorates flat stock for use in satellite assembly plants. The plant coats at 2.5 base boxes per minute. Its operating rate is approximately 1,000 hours per satellite plant production line. Assuming the plant supports four lines, its operating rate would be 4,000 hours annually.

- Representative Plant D produces food cans from precoated stock. It contains two can assembly lines, each of which operates at 400 cans per minute for 3,000 hours annually. The total plant production is 144 million cans.

Capital and annual operating costs for each of the representative plants are presented for each applicable alternative on Exhibit 3-14, on the following page. In summary, the capital cost to adopt the alternative controls to the four representative plants ranges from $20,000 to convert the can assembly plant to waterborne coatings) to more than $400,000 (to retrofit the three-piece coating and assembly plant with incinerators). The incremental operating costs (energy plus 25 percent of capital) range from a savings of $375,000 (for the two-piece beer and soft drink plant that was converted to "print only") to a cost of $387,000 (for operating incinerators at the three-piece coating and assembly plant).

3.4.2 Extrapolation of the Costs to the Statewide Industry

The costs developed are incremental costs based on the production volume and mix estimate for 1977. Industry changes related to plant closings, conversion to two-piece lines, consumption patterns or other areas not directly related to RACT implementation were not included. One exception is that the trend to print-only on existing lines was addressed and the portion allocated to RACT was estimated and included in the final figures.

The can manufacturing industry in Ohio is part of an integrated nationwide network (the greatest volume of cans are produced by firms with nationwide operations for customers who source their products nationwide), of facilities using established and nonproprietary technology. Therefore, Ohio costs can be readily estimated from data developed on a nationwide bases.

Extrapolation of the costs to the statewide industry requires, first, segmenting the industry in Ohio according to the types and number of major cans produced, quantifying emissions from each type of can production and identifying the 1977 level of controls, if any, to develop a 1977 baseline case. Second, the likely industry response to the regulations must be developed; and finally, the cost of implementing this response must be calculated. The data and estimates necessary to perform this extrapolation have been presented in previous sections.

- Can production (in units) by type was presented in section 3.2.3.
- Emissions (per million cans) from the production of cans using the various coating operations was presented in Exhibits 3-7, 3-8 and 3-9 and combined on Exhibits 3-12 and 3-13, for several control alternatives for the major types of cans (including print only).

EXHIBIT 3-14

U.S. ENVIRONMENTAL PROTECTION AGENCY
COST OF IMPLEMENTING RACT ALTERNATIVES FOR
REPRESENTATIVE CAN MANUFACTURING PLANTS ($1,000)

Representative Plant	Waterborne		Thermal Incinerators		Print Only/Waterborne		UV Cured/Waterborne		Waterborne Incinerate End Sealant	
	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense
A. 2-piece beer & soft drink can 2 lines 500 million cans	60	15	132	64	40	(375)	60	367	a	a
B. 3-piece beer & soft drink and food can coating and assembly plant 1 coating line 1 sheet varnish line 3 assembly lines 310 million cans	100	25	415	387	a	a	b	b	138	106
C. Sheet coating facility for 50% beer cans & 50% food cans 1 sheet coating line 1 sheet varnishing line 1 end compounding line Supplies stock for 290 million cans	30	8	255	143	a	a	b	b	82	34
D. Food can assembly plant 2 assembly lines with inside striping 144 million cans	20	5	60	20	a	a	b	b	a	a

a. Not applicable
b. Not considered to be a likely response by 1982

Source: Booz, Allen & Hamilton Inc. estimates

- Theoretical uncontrolled emissions were calculated by multiplying the number of cans of each type by the 1977 least case alternative on Exhibits 3-12 and 3-13. This estimate of 4,554 tons was presented in section 3.2.2.

- Because the data in the Ohio emissions inventory were incomplete and had several inaccuracies (e.g., total coating consumption at Metal Container Corporation and fraction of emissions to the control equipment), the assessment of the current situation was based primarily on the data collected from the interviews and the work completed for other states in EPA Region V. Net emissions were reduced 1,200 tons in 1977 to the 1977 base line of 3,400 tons:

  - 600 tons through incineration

  - 600 tons through waterborne and other low solvent coatings.

The industry response in 1982 to the RACT alternatives was presented in section 3.3.4 and summarized on Exhibit 3-11. It included a discussion of the cost and emission reductions from the theoretical level of uncontrolled emission. Exhibit 3-15, on the following page, shows that likely industry capital expenditures of $2.7 million will be required to comply with RACT. The annual compliance cost is estimated at $785,000, excluding a credit of $900,000 for reduced material and energy costs that arise from reducing the number of coatings on two-piece cans to enhance their cost effectiveness against other packages. It is estimated that emissions will be reduced by 3,200 tons from the theoretically uncontrolled level of 4,600 tons, excluding an additional 300 ton reduction that is expected to result through the increased usage of print only

Based on the above assumptions, the compliance costs are estimated at $2.68 million in capital expenses. Because of the annual cost savings involved, the industry will probably take the steps indicated for two-piece cans whether or not the regulation is in place. The capital cost applicable to the regulation is estimated at $2.68 million. It would be $2.73 million without the conversion to print only.

Annual average unit cost of emission reduction is estimated to be $247 per ton. Three-piece food and other cans have the highest unit cost, $360 per ton.

EXHIBIT 3-15(1)
U.S. Environmental Protection Agency
COST OF COMPLIANCE TO RACT FOR THE
CAN MANUFACTURING INDUSTRY IN OHIO

CAN TYPE	Can Production (millions of units)					Capital Investment (thousands of $)				
	Water-borne or Other Low Solvent Coatings	Thermal Incineration with Primary Heat Recovery	Print Only, All Low Solvent Coatings	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Water-borne or Other Low Solvent Coatings	Thermal Incineration with Primary Heat Recovery	Print Only, All Low Solvent Coatings	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total
2-piece beer and soft drink	800		1200	a	2,000	96	0	96	a	192
3-piece beer and soft drink	200	160	a	440	800	83	426	0	246	755
3-piece food and other cans	450	360	a	990	1,800	113	856	a	759	1,728
Subtotal					4,600	292	1,282	96	1,005	2,675
Amount Not Resulting From RACT						a	a	—	a	(100)
Total Applicable To RACT						292	1,282	96	1,005	2,675

CAN TYPE	Annual Compliance Cost (thousands of $)					Emission Reduction (tons)					
	Water-borne or Other Low Solvent Coatings	Thermal Incineration with Primary Heat Recovery	Print Only, All Low Solvent Coatings	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Water-borne or Other Low Solvent Coatings	Thermal Incineration with Primary Heat Recovery	Print Only, All Low Solvent Coatings	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Unit Cost of Emission Reduction ($ per ton)
2-piece beer and soft drink	24	0	(900)	a	(876)	384	0	636	a	1,020	(858)
3-piece beer and soft drink	21	133	a	75	229	290	166	a	634	1,090	209
3-piece food and other cans	51	247	a	198	496	337	288	a	752	1,377	360
Subtotal	96	380	(900)	273	(151)	1,011	454	636	1,386	3,487	(43)
Amount Not RACT	a	a	936	a	936	a	a	(313)	a	(313)	
TOTAL RACT	96	380	36	273	785	1,011	454	323	1,386	3,174	247

a. Not applicable.

Source: Booz, Allen & Hamilton Inc.

The substantial cost of developing, testing and obtaining FDA approval of low solvent coatings has not been included in this evaluation, because it is outside the scope of this study and the bulk of it will probably be incurred at the national level. An evaluation of these costs and the degree to which they should properly be allocated to each state must be undertaken on a national basis.

A factor that should be taken into account is that the analysis assumes that production lines will be converted in proportion to the number of cans made by each production mode. Where a single line makes several types of cans, a portion of which can be converted to low solvent systems, the production line might still require installation of afterburner control under RACT requirements, though its use would only be intermittent. The potential effect of this on the cost estimates is difficult to quantify. It is discussed below.

If we assume that all sheet coating and three-piece assembly lines were required to install incinerators, to maintain capability to utilize both conventional and low solvent coatings, the projections would be changed as follows:

- Capital expenditure would be increased by $3.1 million or 115 percent.
- Annual cost would increase by $775,000. This represents the capital related costs only.
- Emissions reduction estimates would be unchanged.

The figures presented above represent outside limits with actual experience likely to fall somewhere between the two figures. Since most of the can fabrication facilities in Ohio are dedicated to beverage cans, for which low solvent coatings systems are likely to be developed by 1982, the effect of this capability maintenance factor will be felt on relatively few production lines.

Assuming that 1977 baseline emissions were 3,400 tons, implementation of RACT will reduce emissions by approximately 2,000 tons to the same 1,380 tons (excluding the additional 300 ton reduction for conversion to print only. The 1982 reduction is expected to emphasize waterborne coatings rather than incineration. Assuming that no new incinerators will be constructed, the capital cost for converting from the existing level of control in 1977 to meet the RACT guidelines would be about $400,000.

3.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including: availability of equipment and capital; feasibility of the control technology; and impact on economic indicators such as value of shipments, unit price, state economic variables and capital investment.

3.5.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This implies that can manufacturers must have either low solvent coatings or VOC control equipment installed and operating within the next three years. The timing of RACT imposes several requirements on can manufacturers including:

- Obtaining development quantities of low solvent coatings from their suppliers and having them approved by their customers
- Having coating makers obtain FDA approval where necessary
- Obtaining low solvent coatings in sufficient quantity to meet their volume requirements
- Acquiring the necessary VOC control equipment
- Installing and testing incinerators or other VOC control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

3.5.2 Feasibility Issues

Technical and economic feasibility issues implementing RACT controls are discussed in this section.

The can manufacturing industry, in conjunction with coating suppliers and incinerator vendors, has extensively evaluated most of the approaches to meeting RACT. The feeling in the industry is that, but for one notable exception, RACT can be achieved by January 1, 1982, using low solvent coatings--primarily waterborne. The coating most likely to be unavailable in 1982 is the end sealing compound. The physical characteristics of this material, as well as its method of application, do not lend themselves to incineration. Currently, the coating is air dried over a period of 24 hours.

The can manufacturers have shut down a significant number of three-piece can manufacturing facilities. It appears likely that the implementation of RACT will accelerate this trend because of the lower cost of compliance with two-piece cans and the probable reluctance on the part of can manufacturers to invest capital in facilities producing products with declining demand.

3.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annualized cost of implementing RACT with the total value of cans sold in the state.

The net incremental annualized cost from the uncontrolled level to can manufacturers is estimated to be a savings of $0.115 million (less than 0.1 percent) of current manufacturing costs. However, this savings includes a credit of $900,000 for reduced material and energy costs that arise from reducing the number of coatings on two piece cans. Excluding this credit meeting the RACT limitations would represent an annualized cost of $785,000 (approximately 0.2 percent of the value of shipments).

3.5.4 Ancillary Issues Relating to the Impact of RACT

This section present two related issues that were developed during the study.

The can manufacturers are seeking to have the guidelines altered to encompass a plantwide emissions basis. This would allow a credit from one operation, where emissions were reduced to below the RACT recommended level, to be applied to another operation that is not in compliance. The plant would be in compliance if the total emissions were reduced to the level proposed in RACT. It appears that the impact of this proposed regulation, if accepted, would be to further concentrate the difficult-to-control emissions, such as end sealing compounds, into the largest facilities and to reduce further the number of can assembly plants.

High solvent coatings represent a considerable fire hazard. The conversion to low solvent coatings has reduced fire insurance costs for at least one can manufacturing facility.

* * * *

Exhibit 3-16, on the following page, presents a summary of the current economic implications of implementing RACT for can manufacturing plants in the State of Ohio.

EXHIBIT 3-16
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are about 23 can manufacturing facilities
Indication of relative importance of industrial section to state economy	The 1977 value of shipments was about $360 million
Current industry technology trends	Beer and beverage containers rapidly changing to two-piece construction
VOC emissions	3,400 tons per year (Booz, Allen estimate); theoretical uncontrolled level is 4,600 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Low solvent coatings (waterborne)
Assumed method of control to meet RACT guidelines	Low solvent coatings (waterborne)
Affected Areas in Meeting RACT	
Capital investment (statewide)	$2.7 million from uncontrolled state (0.4 million above 1977 in-place level). Current investments are $15 million to $30 million
Annualized credit (statewide)	$0.15 million credit--less than 0.1 percent of current direct annual operating costs[1]
Price	No price increase
Energy	Increase of 5,200 equivalent barrels of oil annually to operate incinerators (virtually no increase from 1977 level)
Productivity	No major impact
Employment	No major impact
Market structure	Accelerated technology conversion to two-piece cans Further concentration of sheet coating operations into larger facilities
Problem area	Low solvent coating technology for end sealing compound
VOC emission after RACT control	1,100 tons per year (29 percent of current emission level)
Cost effectiveness of RACT control	$247 annualized cost/annual ton of VOC reduction from theoretical level attributed to implementation of RACT

[1] This savings includes a credit of $900,000 for reduced material and energy costs that arise from reducing the number of coatings on two-piece cans. Excluding this credit, meeting the RACT limitations would represent an annualized cost of $785,000 (approximately 0.2 percent of the value of shipments).

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Control of Volatile Organic Emissions from Stationary Sources, EPA-450/2-77-008, May 1977.

Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories, Enfield, CT, August 23, 1977

Private conversations at the following companies:

American Can Company, Greenwich, Connecticut
Continental Can Company, Chicago, Illinois
Heekin Can Company, Augusta, Wisconsin
National Can Company, Chicago, Illinois
Libby McNeil & Libby, Baraboo, Wisconsin
Joseph Schlitz Brewing Company, Oak Creek, Wisconsin
Carnation Company, Waupam, Wisconsin
Campbell Soup Company, Napoleun, Ohio
Green Giant Company, Ripon, Wisconsin
Fall River Canning Company, Fall River, Wisconsin
Miller Brewing Comapny, Miller, Wisconsin
Ocononowoc Canning Company, DeForest, Wisconsin
Diversified Packagers, Howell, Michigan
Can Manufacturers Institute, Washington, D.C.

4.0 THE ECONOMIC IMPACT OF IMPLEMENTATION OF RACT GUIDELINES TO THE SURFACE COATING OF COILS IN THE STATE OF OHIO

4.0 THE ECONOMIC IMPACT OF IMPLEMENTATION OF RACT GUIDELINES TO THE SURFACE COATING OF COILS IN THE STATE OF OHIO

As will be shown in this chapter, the coil coating business in the state of Ohio will be affected by the implementation of RACT standards. The economic impact, although significant to some of the individual firms affected, is minor relative to the overall industry capital investment and operating cost.

This chapter is divided into four sections:

- Specific methodology and quality of estimates
- Applicable RACT guidelines and control technology
- Coil coating operations in the state of Ohio
- Direct economic implications

4.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Economic impacts

for the surface coating of coils in Ohio.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

4.1.1 Industry Statistics

The coil coating is listed under Standard Industrial Classification (SIC) 3479. Our methodology to gather statewide statistical data on coil coating in Ohio was as follows:

- A list of potentially affected facilities was compiled in conjunction with state EPA authorities and trade association sources.

- Interviews were performed with those companies appearing on the list of emitters to validate their participation in this industry sector (this list was not 100 percent validated).

4.1.2 VOC Emissions

In the state of Ohio, 16 coil coating facilities with at least 29 coating lines were identified. The following sources were utilized to identify VOC emitters in this industry category:

- Ohio EPA emission inventory
- National Coil Coaters Association
- Thomas Register
- Direct industry contact

4.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emission for the surface coating of coils are described in Control of Volatile Organic Emissions From Existing Sources, Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks, EPA-405/2-77-008, May 1977.

4.1.4 Cost of Control of VOC Emissions for Surface Coating of Coils

The costs of control of volatile organic emissions for surface coating of coils were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining system components
- Defining a model plant
- Applying the costs developed by Springborn Laboratories (under EPA contract number 68-02-2075, August 23, 1977) to the most likely alternative types of control:
  - Installed capital cost
  - Direct operating cost
  - Annual capital charges
  - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

4.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Ohio.

4.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of coils in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that is published for the base year), "B" indicates data that was extrapolated from hard data and "C" indicates data that was not available in secondary literature and was estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 4-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 4-1
U.S. Environmental Protection Agency
SURFACE COATING OF COILS
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics			X
Emissions			X
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

4.2 APPLICABLE RACT STANDARDS AND CONTROL TECHNOLOGY

This section includes a review of:

- Applicable RACT standards
- The technology of coil coating
- Commercial aspects of the business
- Approved control technologies
- Estimated capital and operating costs to control VOC emissions.

4.2.1 Approved RACT Standards

As indicated in the EPA guidelines Article XX.9204, subpart (d) (1):

> ...no owner or operator of a coil coating line... may cause, allow or permit discharge into the atmosphere of any volatile organic compounds in excess of 0.31 kilograms per liter of coating (2.6 pounds per gallon), excluding water, delivered to the coating applicator from prime and topcoat or single coat operations.

Thus, of the approximately 4 to 6 pounds of VOC contained in a gallon of paint to be applied with coil coating techniques, the operator must not allow emission of more than 2.6 pounds. The reduction in emissions may be achieved by utilization of low solvent content coating technology, thermal incineration or other approved methods.

4.2.2 The Technology of Coil Coating

Coil coating is the coating of any flat metal (aluminum or steel typically) sheet or strip that comes in rolls or coils. This process consists of taking the coil through a series of steps in one continuous process. Generally, these steps include:*

- Cleaning--removal of mill-applied protective oils, dirt, rust and scale
- Rinsing--removal of the products of the cleaning process
- Pretreating--with chemicals such as iron and zinc phosphates, chromates and complex oxides to prepare the metal for coatings
- Rinsing--after the pretreatment

*Source: National Coil Coaters Association brochure

- Painting--commonly by application of primer and finish coats with a "reverse" roller technique in which the roll applying the coating turns in the opposite direction of the metal being coated

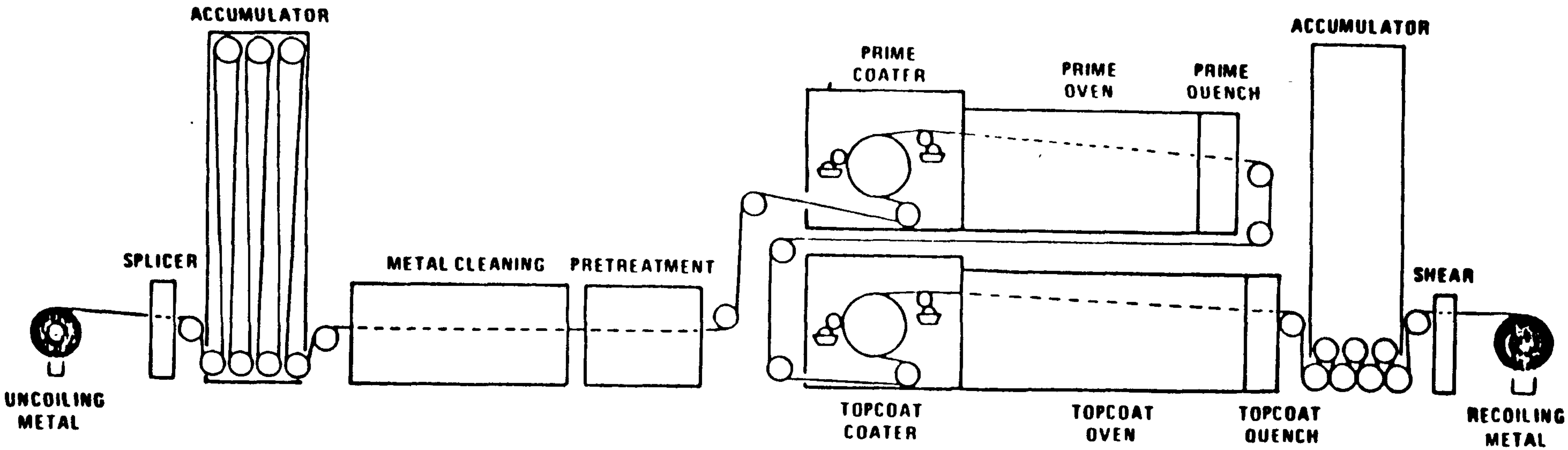
- Curing--all coatings are cured in seconds as they pass through ovens, mostly of the convention or heat air type. At the end of the curing operation, the coated metal is recoiled for shipment.

Configurations of coil coating lines differ. On some lines, the metal is uncoiled at one end of the line and recoiled at the opposite end. On other lines, called "wrap around" lines, the metal is uncoiled and recoiled at about the same point on the line. Some coil coating lines have a single coater and one curing or baking oven; others, called "tandem" lines, have several successive coaters each followed by an oven, so that several different coatings may be applied in a single pass. Exhibit 4-2, on the following page, is a schematic of a "tandem" coil coating line.

The metal on the coil coating line is moved through the line by power-driven rollers. It is uncoiled as the process begins and goes through a splicer, which joins one coil of metal to the end of another coil for continuous, nonstop production. The metal is then accumulated so that, during a splicing operation, the accumulator rollers can descend to provide a continuous flow of metal throughout the line. The metal is cleaned at temperatures of 120°F to 160°F, brushed, and rinsed to remove dirt, mill scale, grease and rust before coating begins. The metal is then treated for corrosion protection and for proper coating adhesion with various pretreatments, depending on the type of metal being coated and the type of coatings applied.

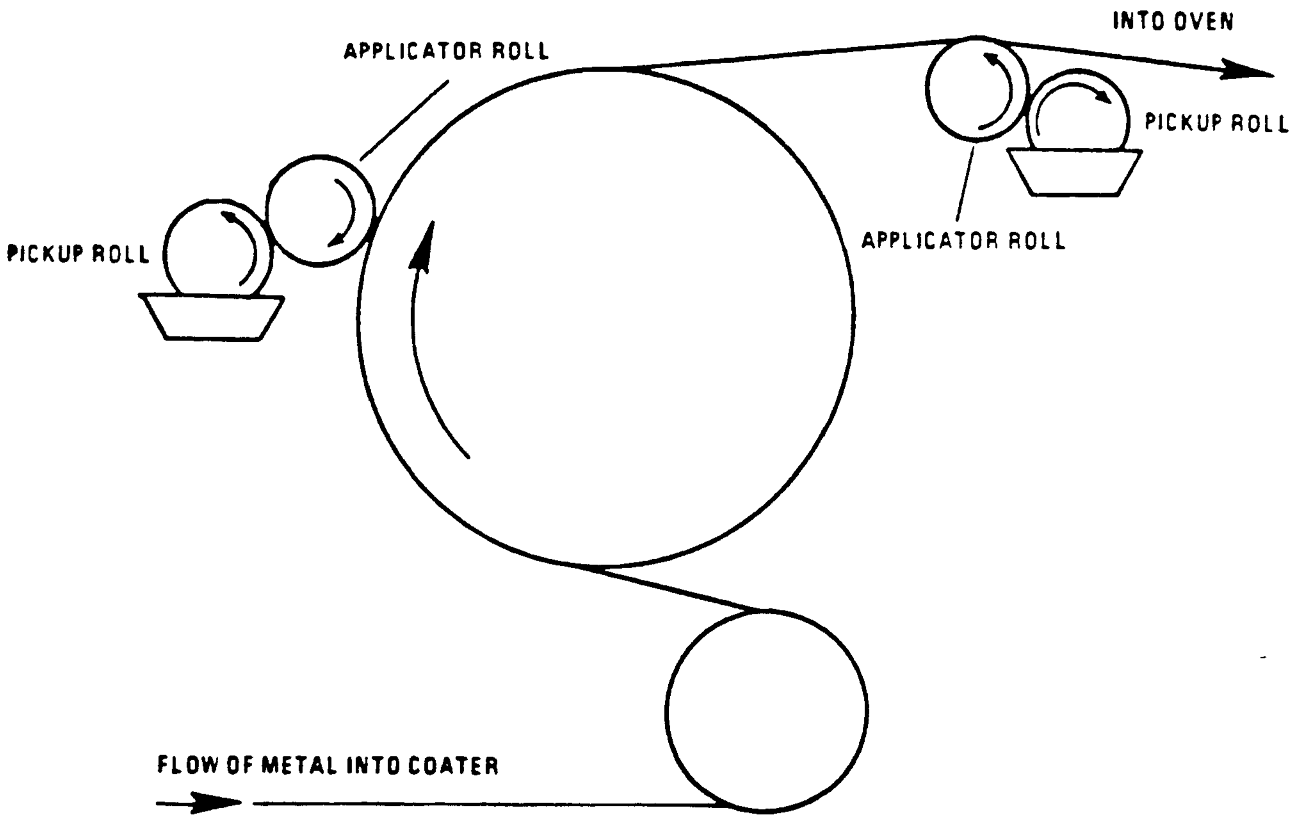
The first coat or primecoat may be applied on one or both sides of the metal by a set of three or more power-driven rollers. The pick-up roll, partially immersed in the coating, transfers the coating to the applicator roll. The metal is coated as it passes between the applicator roll and the large back-up roll. The metal is typically reverse roll coated. Exhibit 4-3, following Exhibit 4-2, is a schematic of a typical roll coater. A third roll, called a "doctor" roll, may be used to control film thickness when applying a high viscosity coating, by making contact with the pick-up roll.

EXHIBIT 4-2
U.S. Environmental Protection Agency
DIAGRAM OF A COIL COATING LINE



Source: Control of Volatile Organic Emissions from Existing Stationary Sources-Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks (EPA, 405/2-77-008, May 1977).

EXHIBIT 4-3
U.S. Environmental Protection Age
TYPICAL REVERSE ROLL COATER



Source: Control of Volatile Organic Emissions from Existing Stationary Sources-Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks (EPA, 405/2-77-008, May 1977).

The applied coating is usually dried or baked in a continuous, catenary or flotation or a double-pass oven that is multizone and high production. The temperatures of the preheat, drying or baking zones may range from 100°F to 1000°F depending on the type and film thickness of coating used and the type of metal being coated. The flow rates of the ovens' exhausts may vary from approximately 4,000 scfm to 26,000 scfm. Many of these ovens are designed for operation at 25 percent of the room-temperature lower explosive level when coating at rated solvent input. As the metal exits the oven, it is cooled in a quench chamber by either a spray of water or a blast of air followed by water cooling.

A second coat or topcoat may be applied and cured in a manner similar to the primecoat. The topcoat oven, however, is usually longer than the primecoat oven and contains more zones.

Another method of applying a primecoat on aluminum coils or a single coat on steel coils is to electrodeposit a waterborne coating to either one or both sides of the coil. The coil enters a V-shaped electrocoating bath that contains a roll on the bottom. As the metal goes around the roll, electrodes on each side can be activated and permit the coagulation of the paint particles on either one or both surfaces of the coil. The coated coil is then rinsed and wiped by squeeges to remove the water and excess paint particles. For steel coils, the electrodeposited coating must be baked in an oven. For aluminum coils, however, the primecoat is stable enough to go over rolls immediately to the topcoat coater without destroying the finish, and then be baked as a two-coat system.

After cooling, the coated metal passes through another accumulator, is sheared at the spliced section, usually waxed and finally recoiled. The accumulator rolls rise during the shearing process, collecting the coated metal to ensure continuous production.

Organic vapors are emitted in three areas of a coil coating line: the areas where the coating is applied, the oven and the quench area. The oven emits approximately 90 percent of the organic vapors and a majority of the other pollutants. Of the remaining 10 percent of hydrocarbons emitted, approximately 8 percent are emitted from the coater area and approximately 2 percent are emitted from the quench area.

4.2.3 Commercial Aspects of the Business

Coil coating was first practiced in the 1930s as a technique to coat metal for venetian blinds. As the technical, operating and economic advantages became apparent, the industry experienced remarkable growth. Since 1962, for example, estimated shipments have shown an average annual growth rate of some 16.5 percent. By 1977, as shown in Exhibit 4-4, on the following page, more than four million tons of aluminum and steel were coated using this method.

In terms of dollars, the four million tons of coated coil produced in the U.S. in 1977 represented a total product value of some $3.5 billion. Other pertinent indicators of the scale of this business include the following:

- Approximately 13 billion square feet of coated coil were produced.
- Organic coatings of several types currently utilized by the coil coaters in North America represent 19 million gallons. These, coupled with various types of film laminates, represent a total estimated value of $140 million in coatings.
- Chemical pretreatment for coil coaters is estimated at a value of $10 million.
- It requires approximately 12.8 billion cubic feet of natural gas and 4.1 million gallons of propane to cure these coatings. To coat the equivalent metal by "post painting" would require approximately five times this amount of energy.
- Today, there are 182 coil coating lines in North America, ranging in maximum coil width capacity from 2 to 60 inches and capable of running at maximum speed from 100 to 700 feet per minute.
- If all these lines were running at full capacity, it is estimated that they could coat more than 20 billion square feet of metal per year.

4.2.4 Approved Control Technologies

Per the Environmental Protection Agency Guidelines in Article XX.9204, subpart (d)(2), the emission limit shall be achieved by:

- The application of low solvent content coating technology; or

EXHIBIT 4-4
Environmental Protection Agency
ESTIMATED TONNAGE OF METAL COATED IN THE U.S. IN 1977 WITH COIL COATING TECHNIQUES

Market	Steel Shipments (tons)	Aluminum Shipments (tons)
Building products	1,100,000	610,000
Transportation	1,400,000	100,000
Appliances	140,000	25,000
Containers, packaging	80,000	200,000
Furniture, fixtures and equipment	110,000	15,000
Other uses	220,000	50,000
	3,050,000	1,000,000

Source: National Coil Coaters Association statistics.

- Incineration, provided that 90 percent of the nonmethane volatile organic compounds (VOC measured as total combustible carbon) which enter the incinerator are oxidized to carbon dioxide and water; or

- A system demonstrated to have control efficiency equivalent to or greater than provided under the preceding paragraphs. . .and approved by the Director.

4.2.5 Estimated Capital and Operating Costs to Control VOC Emissions

Estimates of capital and operating costs to control VOC emissions from coil coating operations were prepared by Springborn Laboratories, Inc., for the Environmental Protection Agency (Contract No. 68-02-2075, August 23, 1977). These estimates are discussed in this section.

The model chosen handles material 40 inches wide and coats at a speed of 300 feet per minute. This yields a yearly production of 204 million square feet when operated for 4,000 hours per year. The material usage is 344,630 gallons of paint and 34,460 gallons of solvent per year.

Case I — The base case with no controls for emissions; shows the cost of a new line using conventional enamel coating which does not meet RACT

Case II — The use of waterborne coating materials with no additional treatment of emissions

Case III — The base case with a thermal incinerator on each of the primecoat and topcoat ovens. Due to the relation of the coating applicator to the curing oven, the oven exhausts are assumed to be 90 percent of total emissions. The incinerator is figured with primary heat exchange to minimize the fuel costs and operates at an average 90 percent efficiency.

Emission control costs for each of the cases studied are summarized in Exhibit 4-5, on the following page. As indicated, additional capital costs to install emission control systems range from $50,000 to $254,000 over the base case capital cost depending on the alternative selected. Operating costs range from $8,000 to $75,000 more than the base case, or 0.3 percent to 2.5 percent increased cost per unit. Costs per ton of solvent range from $11 to $112.

EXHIBIT 4-5
U.S. Environmental Protection Agency
SUMMARY OF EMISSION CONTROL COSTS

Output 204,000,000 SF/yr.
(18,950,000 sq. meters)
4,000 hours/year

	Case	Total Investment $	Increase over Base Case $	Total Annual Cost $	Increased Annual Cost over Base Case $	Cost/Unit 1000 SF (1000 SM) $	Increased Cost Per 1000 SF over Base $	Increased Cost Per 1000 SF over Base %	Tons (Metric Tons) Solvent Emitted/Yr.	Decreased Emission over Base (Metric Tons)	Emission Reduction %	Cost/Ton (Metric Ton) To Remove Solvent $
I	Base Case - solvent-borne primecoat & topcoat	3,300,000	-	2,977,400	-	14.59 (157.05)	-	-	832.3 (755)	-	-	
II	Waterborne primecoat & topcoat	3,350,000	50,000	2,985,800	8,400	14.64 (157.58)	0.05	0.3	98.9 (89.9)	733.4 (665.1)	88	11.45 (12.63)
III	Base Case with thermal incinerators on ovens; primary heat recovery	3,554,260	254,260	3,052,860	75,460	14.96 (161.03)	0.37	2.5	158.1 (143.5)	674.2 (611.5)	81	111.93 (123.40)

4.3 COIL COATING OPERATIONS IN THE STATE OF OHIO

From information provided by Ohio EPA and from Booz, Allen study team interviews, it was determined that there are 16 coil coating facilities in the state of Ohio. It was assumed that each of the facilities for which no detailed information from the emission inventory was available has a single line. Therefore, there are 29 coating lines in Ohio as some facilities had more than one line. Details pertinent to these operations are shown in Exhibit 46, on the following page. Many of these facilities currently have incinerators and for purposes of this study they were assumed to meet the RACT requirements.

EXHIBIT 4-6
U.S. Environmental Protection Agency
COIL COATING OPERATIONS IN OHIO

Company	Plant Location	No. of Lines	Emission Control Equipment	1975, VOC Emissions, Tons	1975, VOC Emissions, lb/gal	Comment
Alcan Aluminum	Warren OH	1	None	769	4.10	
Alside Aluminum	N. Hampton Township OH	3	None	878	5.60	
American Metal (Don Products)	West Lake OH	2	Thermal Incinerators	472	4.18	As of 1978, assumed to meet RACT
Anaconda (Alsco)	Gnadeanhutten OH	8	Incinerator plus high solids	24	0.21	Assumed to meet RACT
Armco Steel	Middletown OH	1	Incinerator	190	1.05	Assumed to meet RACT
Brainard Div. (Sharon Steel)	Howland OH	N/A	N/A	N/A	N/A	
Epic Metals	Oregon OH	1	None	59	4.67	
Kaiser Aluminum	Toledo OH	3	Incinerator plus waterborne	154	0.54	Assumed to meet RACT
Lifeguard Ind.	Cincinnati OH	N/A	N/A	N/A	N/A	
Norandex	Walton Hills OH	1	Incinerator	15	1.76	Assumed to meet RACT
Repulbic Steel	Youngstown OH	1	None	404	4.44	
Reynolds Metals	Ashville OH	1	None	N/A	N/A	
Elwin G. Smith (Cyclops Corp.)	Cambridge OH	1	None	N/A	N/A	
Stolle	Sidney OH	2	Incinerator (operates poorly)	1,324	5.00	
Thomas Steel	Warren OH	1	None	24	5.77	
Wheeling-Pittsburg (Pittsburg-Cornfield)	Cornfield OH	1	None	86	5.56	
				4,389		

N/A = Information not available

Source: Booz, Allen & Hamilton Inc.

4.4 DIRECT ECONOMIC IMPLICATIONS

As was shown in Exhibit 4-6, five coil coating firms in Ohio (with 15 coating lines) are already in compliance with RACT standards. In addition, three firms (with 4 coating lines) are in the process of installing controls and it was assumed that no additional economic impact will be felt. Therefore, if we assume that in each case where no information was available, one line uncontrolled must be brought within standards, ten lines must be brought into control. For each line, the capital cost of control is estimated at $250,00 and the operating cost is estimated at $75,000 per year. Therefore, approximately $2.5 million investment will be required to bring the industry within RACT standards. Annual operating costs will be about $0.75 million.

* * * *

Exhibit 4-7, on the following page, summarizes the findings presented in this chapter.

EXHIBIT 4-7
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR COIL COATING FACILITIES IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are 16 coil coating facilities potentially affected by the coil coating RACT guideline in Ohio. Five firms currently meet RACT emission limitations
Current industry technology trends	Due to the pressures of energy availability as well as environmental protection, most firms have or are installing regenerative type incinerators
1975 VOC emissions (actual)	4,400 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Regenerative thermal incineration
Assumed method of control to most RACT guidelines	Regenerative thermal incineration

Affected Areas in Meeting RACT	Discussion
Capital Investment (statewide)	$2.5 million incremental capital required by eight firms if they were to install controls on 10 processing lines
Annualized Cost (statewide)	$.75 million
Energy	Small increased fuel consumption for regenerative incineration
Productivity	No major impact
Employment	No major impact
Market structure	The captive coil coating operations not meeting the RACT limitation may opt to purchase coated material in lieu of investing significant capital requirements
RACT timing requirements (1982)	Since most coil coating facilities in Ohio meet the RACT limitations, timing requirements should be met
Problem area	Low solvent coating technology is currently inadequate to meet product requirements
VOC emission after control	785 tons per year (18 percent of 1975 VOC emission level)
Cost effectiveness of control	$207 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Springborn Laboratories, Inc., Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report. EPA Contract No. 68-02-2075, August 23, 1977.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II. Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks. EPA-450/2-77-008, May 1977.

Private conversations at the following:

Alside Aluminum, N. Hampton Township, Ohio
Anaconda (Alsco), Gnadeanhutten, Ohio
Kaiser Aluminum, Toledo, Ohio
Lifeguard Industries, Cincinatti, Ohio
Elwin G. Smith (Cyclops Corp.), Cambridge, Ohio
National Coil Coaters Association

5.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF OHIO

5.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Ohio which are engaged in the surface coating of paper. This is meant to include protective or decorative coatings put on paper, pressure-sensitive tapes regardless of substrate, related web coating processes on plastic film and decorative coatings on metal foil, but does not include conventional printing processes which apply inks. The chapter is divided into five sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of paper coating; interviews with paper coaters, coating equipment and materials manufacturers; and a review of pertinent published literature.

5.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for plants engaged in the surface coating of paper. The quality of these estimates is discussed in the last part of this section.

5.1.1 Industry Statistics

Paper coating is practiced in a number of industries. Among products that are coated using organic solvents are: adhesive tapes; adhesive labels; decorated, coated and glazed paper; book covers; office copier paper; carbon paper; typewriter ribbons; photographic film; paper cartons; and paper drums. The firms coating paper are classified in a number of groupings in the U.S. Department of Commerce's Standard Industrial Classification system. The major coaters may be found in the following 16 SIC groups:

SIC	Description
2611	Pulp mills
2621	Paper mills, except building paper mills
2631	Paperboard mills
2641	Paper coating and glazing
2643	Bags, except textile bags
2645	Diecut paper and paperboard and cardboard
2649	Paper converting, n.e.c.
2651	Folding paperboard boxes
3291	Abrasive products
3292	Asbestos products
3293	Gaskets, packing and sealing devices
3497	Metal foil and leaf
3679	Electronic components, n.e.c.
3842	Orthopedic, prothetic and surgical appliances and supplies
3861	Photographic equipment and supplies
3955	Carbon paper and inked ribbons

This list does not include plants listed in the SIC category 2700 (Printing, Publishing and Allied Industries), where paper coating other than printing may also be a part of the overall processing of the printed product.

Statistics concerning these industries were obtained from a number of sources. All data where possible were converted to the base year 1977 for the state using scaling factors developed from U.S. Department of Commerce data as presented in County Business Patterns. The primary sources of economic data were the 1972 Census of Manufactures and 1976 Annual Survey of Manufactures. Industry oriented annuals such as Lockwoods' Directory and Davidson's Blue Book and the Thomas Register of American Manufacturers were used to identify some of the individual companies engaged in paper conversion (i.e., coating of paper in roll form for sale to other manufacturers) and to identify other paper coating firms in the state.

The actual number of firms expected to be affected by the proposed regulations was obtained by a comparison of a tentative list of firms with the Ohio Environmental Protection Agency emission inventory. This comparison was made with the assistance of the Agency's personnel. The inventory did not appear to be complete and it was necessary to extrapolate the available Ohio data using information developed by Booz, Allen on similar paper coating RACT implementation economic impact studies completed for the states of Illinois, Michigan and Wisconsin.

5.1.2 VOC Emissions

The Ohio emission inventory was used as a basis for estimation of the total paper coating VOC emissions in the state. As mentioned above, the inventory appeared to be incomplete and it was necessary to extrapolate the emissions estimated on the basis of the inventory alone. This extrapolation was made using an estimated emission rate per employee in the affected plants.

5.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from sources included in the paper coating category are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-76-028). The feasibility of applying the various control methods to paper coating discussed in this document was reviewed with coating firms, coating suppliers, coating equipment manufacturers and industry associations. These methods include both coating reformulation and the use of control devices, such as incinerators and carbon adsorbers.

Because of the wide variety of coating processes and coating materials in use, most methods of control will find some applicability. The percentage of emissions to be controlled by reformulation and by control devices was estimated based on a review of the literature and on information obtained from the interviews described above.

5.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions in accord with the proposed regulations were determined from:

- Estimated current emissions
- Estimated type of control to be used
- A development of capital, operating and energy requirements for an average-sized model installation
- Extrapolation of the model plant costs to an industry total based on current emissions.

Model plant costs were primarily based on information provided from:

- Control of Volatile Organic Emissions from Stationary Sources, Volume I (EPA-450/2-76-028)
- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

Additional cost data was supplied by equipment and material suppliers and published literature sources. Major coaters were consulted to determine industry views on acceptable control methods and, in some cases, to provide direct estimates of their projected control costs and experience in control equipment installations.

5.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in the state.

5.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of paper in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 5-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 5-1
U.S. Environmental Protection Agency
DATA QUALITY--SURFACE COATING OF PAPER

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions		X	
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

5.2 INDUSTRY STATISTICS

Industry characteristics, statistics and trends for paper coating in Ohio are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in the state and for the affect upon individual firms. Though there are a number of firms which coat paper as a part of the manufacturing process, this discussion concentrates primarily on those firms whose major activity is paper coating only.

5.2.1 Size of the Industry

The Bureau of Census reports a total of about 409 firms in 16 SIC categories in Ohio where paper coating, as defined in proposed RACT guidelines, is the main business of the firm or may be a part of its manufacturing activity. The number of firms and other relevant statistics in each SIC grouping are summarized in Exhibit 5-2, on the following page.

Total value of shipments for these firms is estimated to be about $2.2 billion, with a total of about 35,000 employees. New capital expenditures are estimated to be about $96 million annually, based on the most recent (1976) Annual Survey of Manufactures. The 39 firms in SIC category 2641, those expected to be most affected by the proposed regulations, have estimated shipments of $254 million, with a total of 4,985 employees.

However, in Ohio a total of only 25 to 30 plants are expected to be affected by the proposed paper coating regulations. This estimate is based upon a review of paper converters in Lockwood's Directory and the Ohio Industrial Directory, a review of the current Ohio emission inventory and telephone interviews with major paper coating firms. The total annual value of shipments of these firms is estimated at about $600 million, based on paper coating statistics for similar RACT impact studies.

5.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of plants in the SIC categories listed above with the state economy indicates that these plants represent about 2.6 percent of the total value of manufacturing shipments in Ohio. The industry employs 2.7 percent of all manufacturing employees in the state.

EXHIBIT 5-2
U.S. Environmental Protection Agency
1976 INDUSTRY STATISTICS--SURFACE
COATING OF PAPER SIC GROUPS IN OHIO

SIC Code	Description	Number of Plants	Total Number of Employees	Total Payroll ($1,000)	Estimated Value of Shipments[a] ($1,000)	Estimated New Expenditures[a] ($1,000)
2611	Pulp mills	3	60	c	7,800	1,400
2621	Paper mills, except building paper mills	18	7,622	114,671	536,600	20,300
2631	Paperboard mills	20	2,680	40,674	219,700	18,800
2641	Paper coating and glazing	39	4,985	67,897	254,200	16,400
2643	Bags, except textile bags	20	1,440	15,664	96,000	2,700
2645	Diecut paper and paperborad and cardboard	27	1,004	10,209	67,400	1,900
2649	Paper converting, n.e.c.	17	660	5,891	37,300	700
2651	Folding paperboard boxes	39	3,700	c	242,000	5,900
3291	Abrasive products	35	2,825	35,488	194,300	11,300
3292	Asbestos products	9	764	7,623	45,500	900
3293	Gaskets, packing and sealing devices	36	1,831	18,434	67,600	2,400
3497	Metal foil and leaf	6	1,478	19,482	117,000	2,800
3679	Electronic components, n.e.c.	59	2,421	21,150	101,500	4,200
3842	Orthopedic, prothetic and surgical appliances and supplies	63	2,557	23,918	108,300	3,700
3861	Photographic equipment and supplies	14	590	7,057	48,600	1,900
3955	Carbon paper and inked ribbons	4	370	c	27,900	500
Total		409	34,987	388,158	2,171,700	95,500

a. Estimated by using ratios of (value of shipment/total salary and wages) and (capital expenditures/total salary and wages) for each SIC group as published in 1976 Annual Survey of Manufacturers where value of shipments or expenditures are not tabulated for the state.

b. None listed.

c. Not listed to protect proprietary information.

Source: Booz, Allen & Hamilton Inc.: 1976 County Business Patterns, and 1976 Annual Survey of Manufactures, U.S. Department of Commerce

5.2.3 Historical and Future Patterns of the Industry

The nationwide value of shipments in the industries expected to be affected by the proposed paper coating regulations, in general, exceed the growth rate of the economy. As summarized in Exhibit 5-3, on the following page, the value of shipments increased in every category between 1972 and 1976, with an average annual growth rate of about 12.1 percent over the period. Compared to an average inflationary rate of 6 to 8 percent, this is equivalent to a real growth rate of 4 to 6 percent. In some individual categories, growth rates were even greater. Paper production increased by an uncorrected average annual growth rate of 16.5 percent; metal and foil by 16 percent; paper coating and glazing by about 12 percent, only slightly less than the average.

It is expected that the growth rate will continue at these rates for the near future.

EXHIBIT 5-3
U.S. Environmental Protection Agency
HISTORICAL TRENDS IN VALUE OF SHIPMENTS OF
U.S. PLANTS ENGAGED IN PAPER COATING ($ millions)

SIC Code	1972	1973	1974	1975	1976
2611	710	849	1,525	1,630	2,055
2621	6,385	7,514	9,942	9,650	11,768
2631	4,153	4,862	6,516	6,055	6,724
2641	1,954	2,284	2,645	2,626	3,074
2643	1,886	2,183	2,867	2,980	3,379
2645	676	747	923	943	1,027
2649	631	833	1,079	1,090	1,288
2651	1,487	1,644	1,890	1,952	2,223
3291	888	1,067	1,235	1,222	1,433
3292	763	823	963	900	988
3293	665	723	835	843	1,020
3499	702	753	973	1,065	1,267
3679	3,060	3,430	3,210	3,450	4,120
3842	1,450	1,620	1,800	2,090	2,240
3861	5,624	6,435	7,490	7,627	8,844
3955	237	268	309	285	294
Total	31,271	36,035	42,400	44,408	51,744

Source: 1976 Annual Survey of Manufactures, U.S. Department of Commerce.

5.3 TECHNICAL SITUATION IN THE INDUSTRY

This section presents a description of the principal processes used in the surface coating of paper and similar products proposed to be included under the RACT Surface Coating of Paper regulations. These products include a myriad of consumer and industry oriented items, such as pressure-sensitive tapes, adhesive labels, book covers, milk cartons, flexible packaging materials and photographic film. Although many of these products are also printed in one manner or another, the emissions from printing inks are not included in the RACT regulations pertaining to paper coating; only the emissions specifically issuing from the coating operation are included. An estimate of these emissions for the state is also presented in this section.

5.3.1 General Coating Process Description

In organic solvent paper coating, resins are dissolved in an organic solvent mixture and this solution is applied to a web (continuous roll) of paper. As the coated web is dried, the solvent evaporates and the coating cures. An organic solvent has several advantages: it will dissolve organic resins that are not soluble in water, its components can be changed to control drying rate, and the coatings show superior water resistance and better mechanical properties than most types of waterborne coatings. In addition, a large variety of surface textures can be obtained using solvent coatings.

Most organic solvent-borne coating is done by paper converting companies that buy paper from the mills and apply coatings to produce a final product. The paper mills themselves sometimes apply coatings, but these are usually waterborne coatings consisting of a pigment (such as clay) and a binder (such as starch or casein). However, much additional coating is done by firms only as part of the manufacturing process. For instance, many printed items (e.g., periodical covers, playing cards and cartons) are printed first and then coated in the printing plant with a protective coating which can provide abrasion resistance, water resistance or decorative effects.

Nationwide emissions of organic solvents from paper coating have been estimated to be 0.56 million tons per year.[1] This estimate includes resin emissions from solventless polyethylene extrusion coatings applied to milk cartons and resin emissions from water emulsion coatings and from rubber adhesives used to glue paper bags and boxes. A lower estimate, based on solvent emissions from the type of coating operations found in SIC 2641, is 0.35 million tons per year. The true total emission rate, however, is probably closer to the 0.56 million tons per year value. This is slightly less than 3.0 percent of the estimate of 19 million tons per year of hydrocarbon emissions from all stationary sources previously reported by EPA.[2] Manufacturing of pressure sensitive tapes and labels, the largest single solvent emission source in SIC 2641, alone accounts for 0.29 million tons per year.

Solvent emissions from an individual coating facility will vary with the size and number of coating lines. A plant may have one or as many as 20 coating lines. Uncontrolled emissions from a single line may vary from 50 pounds per hour to 1,000 pounds per hour, depending on the line size. The amount of solvent emitted also depends on the number of hours the line operates each day.

Exhibit 5-4, on the following page, gives typical emission data from various paper coating applications.

5.3.2 Nature of Coating Materials Used

The formulations usually used in organic solvent-borne paper coatings may be divided into the following classes: film-forming materials, plasticizers, pigments and solvents. Dozens of organic solvents are used. The major ones are: toluene, xylene, methyl ethyl ketone, isopropyl alcohol, methanol, acetone and ethanol.

Although a single solvent is frequently used, often a solvent mixture is necessary to obtain the optimum drying rate. Too rapid drying results in bubbles and an "orange peel" effect in the coating; whereas, slow drying coatings require more time in the ovens or slower production rates. Variations in the solvent mixture also affect the solvent qualities of the mix.

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1. T. W., Hughes, et al., Source Assessment: Prioritization of Air Pollution from Industrial Surface Coating Operations, Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C., under Contract No. 68-02-1320 (Tech. 14) Publication No. 650/2-75-019a.

2. EPA-450/2-76-028, Op. Cit.

EXHIBIT 5-4
U.S. Environmental Protection Agency
EMISSION DATA FROM TYPICAL PAPER COATING PLANTS

Number of coating lines	Solvent Usage (lb./day)	Solvent Emissions (lb.day)	Control Efficiency (%)[a]	Control Device
2	10,000	10,000	-	None
5	15,000	15,000	-	None
8	9,000	9,000	-	None
2	1,200	1,200	-	None
10	24,000	950	96	Carbon adsorption
20	55,000	41,000	90	Carbon adsorption (not all lines controlled)
3	5,000	1,500	90	Carbon adsorption
3	21,000	840	96	Carbon adsorption
1	10,500	500	96	Afterburner

a. Neglecting emissions that are not captured in the hooding system.

Source: Control of Volatile Organics from Stationary Sources, Vol. II, EPA-450/2-77-008.

The main classes of film formers used in conventional paper coating are cellulose derivatives and vinyl resins. The most commonly used cellulose derivative, nitrocellulose has been used for paper coating decorative paper, book covers and similar items since the 1920s. It is relatively easy to formulate and handle, and it dries quickly, allowing lower oven temperatures than vinyl coatings. The most common vinyl resin is the copolymer of vinyl chloride and vinyl acetate. These vinyl copolymers are superior to nitrocellulose in toughness, flexibility and abrasion resistance. They also show good resistance to acids, alkyds, alcohols and greases. Vinyl coatings tend to retain solvent, however, so that comparatively high temperatures are needed. In general, nitrocellulose is most applicable to the decorative paper field, whereas vinyl copolymers are used for functional papers, such as some packaging materials.

In the production of pressure-sensitive tapes and labels, adhesives and silicone release agents are applied using an organic solvent carrier. The adhesive layer is usually natural or synthetic rubber, acrylic or silicone. Because of their low cost, natural and synthetic rubber compounds are the main film formers used for adhesives in pressure-sensitive tapes and labels, although acrylic and silicone adhesives offer performance advantages for certain applications. In most cases tapes and labels also involve the use of release agents applied to a label carrier or the backside of tape to allow release. The agents are usually silicone compounds applied in a dilute solvent solution.

5.3.3 Coating Process Most Commonly Used

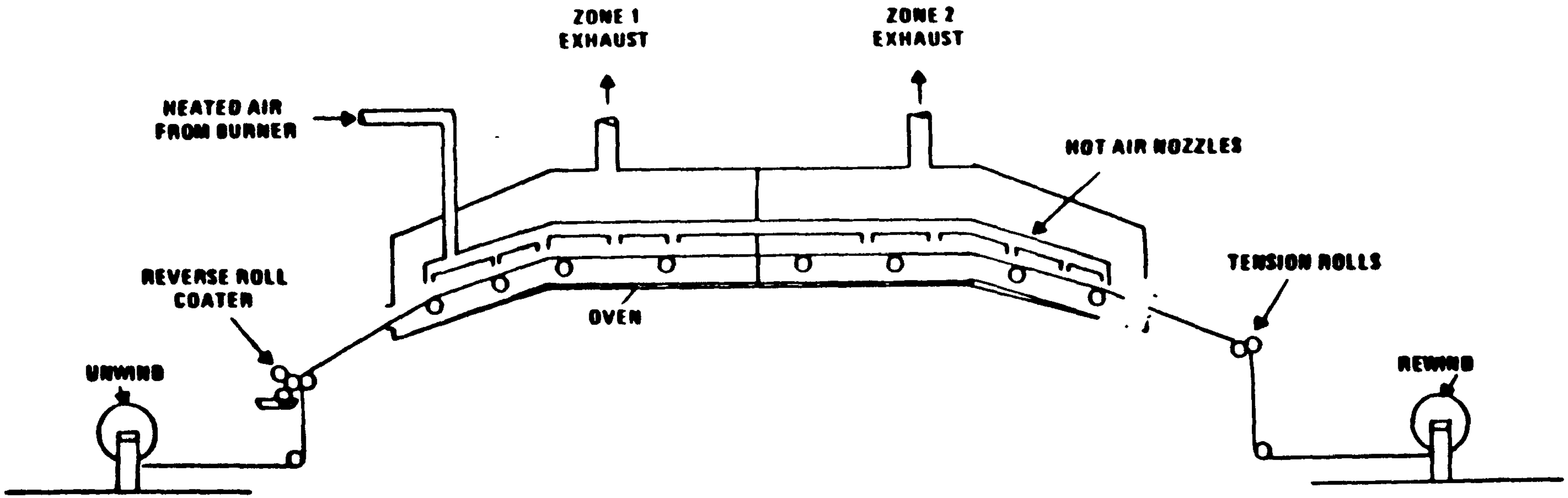
Exhibit 5-5, on the following page, shows a typical paper coating line. Components include an unwind roll, a coating applicator (knife, reverse roll or gravure), an oven, various tension and chill rolls and a rewind roll. The unwind, rewind and tension rolls display various degrees of complexity, depending on the design of the line.

The coating applicator and the oven are the main areas of organic emission in the paper coating facility.

Coatings may be applied to paper in several ways. The main application devices are knives, reverse rollers or rotogravure devices.

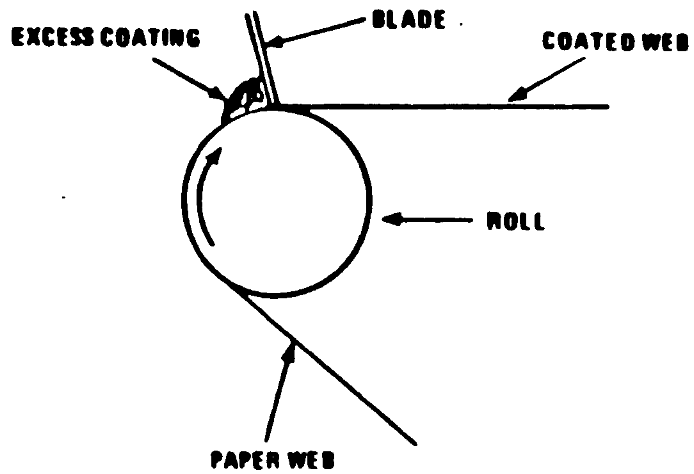
<u>A knife coater</u> (Exhibit 5-6, following Exhibit 5-5, consists of a blade that scrapes off excess coating on the paper. The position of the knife (relative to the paper surface) can be adjusted to control the thickness of the coating. The knife coater is simply constructed and easy to clean.

EXHIBIT 5-5
U.S. Environmental Protection Agency
TYPICAL PAPER COATING LINE



Source: Control of Volatile Organic Emissions from Existing Sources, Volume II; Surface Coating of Cans, Coils, Paper Fabrics, Automobiles and Light-Duty Trucks, EPA 450/2-77-008, May 1977.

EXHIBIT 5-6
U.S. Environmental Protection Agency
KNIFE COATER



Source: Control of Volatile Organic Emissions from Existing Sources, Volume II; Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles and Light-Duty Trucks, EPA 450/2-77-008, May 1977.

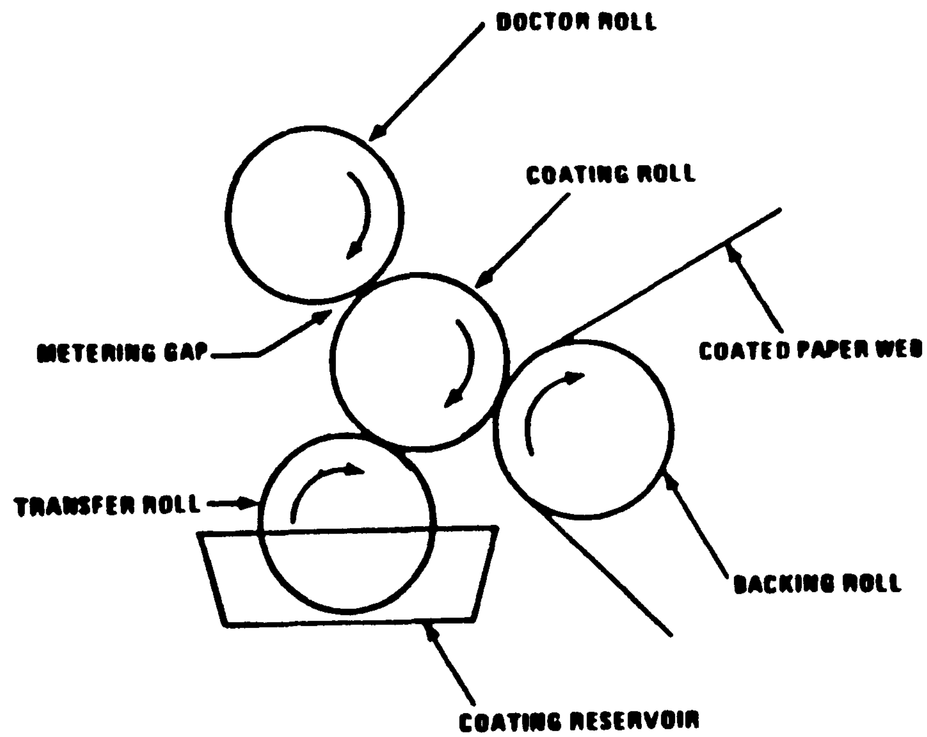
The reverse roll coater (Exhibit 5-7, on the following page) applies a constant thickness of coating to the paper web, usually by means of three rolls, each rotating in the same direction. A transfer roll picks up the coating solution from a trough and transfers it to a coating roll. (Sometimes there is no transfer roll and the coating is pumped directly onto a coating roll.) A "doctor roll" removes excess material from the coating roll. The gap between the doctor roll and the coating roll determines the thickness of the coating. The web is supported by a rubber backing roll where the coating roll contacts the paper. The coating roll turns in a direction opposite to that of the paper, hence the name "reverse roll." This reverse direction of the coating roll reduces striations in the coating that can form if the coating roll is turned in the same direction as the paper web.

Knife coaters can apply solutions of much higher viscosity than roll coaters and thus, less solvent is emitted per pound of coating applied. Knife coaters handle coatings with viscosity up to 10,000 centipoise (cp). Reverse roll coaters operate best in a much more dilute range, where viscosity is 300 to 1,500 cp. Roll coaters, however, can usually operate at higher speeds and show less tendency to break the paper.

Rotogravure, another type of application method used by paper coaters, is usually considered a printing operation. With it, the image area on the coating or rotogravure roll is recessed relative to the nonimage area. The coating is picked up in the recessed area of the roll and transferred directly to the substrate. The gravure printer can print patterns or a solid sheet of color on a paper web. Rotogravure can also be used to apply materials, such as silicone release coatings for pressure-sensitive tapes and labels. Because of the similarities, the regulation is applicable t gravure as well as knife and roll coating.

Most solvent emissions from coating paper come from the dryer or oven. Ovens range from 20 feet to 200 feet in length and may be divided into two to five temperature zones. The first zone, where the coated paper enters the oven, is usually at a low temperature (110°F). Solvent emissions are highest in this zone. Other zones have progressively higher temperatures that cure the coating after most of the solvent has evaporated. The typical curing temperature is 250°F, although in some ovens temperatures of 400°F are reached. This is generally the maximum because higher temperatures can damage the paper. Exhaust streams from oven zones may be discharged independently to the atmosphere or into a common exhaust and sent to some type of air pollution control device. The average exhaust temperature is about 200°F.

EXHIBIT 5-7
U.S. Environmental Protection Agency
REVERSE ROLL COATER



Source: *Control of Volatile Organic Emissions Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks*, EPA 450/2-77-008, May 1977

However, in some coatings, such as in the manufacture of photographic films or thermographic recording paper, the heat sensitivity of the films requires that temperatures considerably lower than this must be used. Exhaust temperatures may be as low as 100°F. Thus, much larger relative volumes of air must be used than is possible with common paper coating.

5.3.3 Current VOC Emissions

Current emissions from paper coating operations in Ohio are believed to range from about 28,000 to 38,000 tons per year. This estimate is based upon extrapolation of emission data for this paper coating category developed by Booz, Allen for the states of Illinois, Michigan and Wisconsin. The emission data for these three states were confirmed by detailed examination of emission inventory records and an exhaustive telephone survey of companies expected to be affected by the regulations.

Extrapolation was done using an average emission rate per employee in SIC plant groups in each state expected to coat paper as a major part of their operations. In Exhibit 5-8, on the following page, are tabulated the total number of plants and their employees in three combinations of SIC groupings for Ohio, Illinois, Michigan and Wisconsin and the total and averaged paper coating emissions for Illinois, Michigan and Wisconsin. The most reliable average emission rates for extrapolation to Ohio emissions in the study team's opinion are considered to be those based upon SIC groups 2641, 2649 and 3955 and the emission rates for the states of Illinois and Michigan. Based on experience with paper coating studies in other states, most firms in which the principal activity is paper coating are included in these three SIC groups. Furthermore, both of these states are highly industrialized and are expected to have an industrial plant profile most like Ohio's.

5.3.4 RACT Guidelines

The RACT guidelines[1] for control of VOC emissions from the surface coating of paper require that emission discharges of VOCs be limited to 2.9 pounds per gallon of coating material delivered to the coating applicator.

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[1] Regulatory Guidance for Control of Volatile Organic Compounds Emissions from 15 Categories of Stationary Sources, EPA 950/2-78-001.

EXHIBIT 5-8
U.S. Environmental Protection Agency
SUMMARY OF DATA USED FOR ESTIMATION
OF PAPER COATING EMISSIONS IN OHIO

	SIC Groups[a]		
	A	B	C
ILLINOIS			
Number of plants	72	171	563
Number of employees	5,272	12,989	34,987
Total paper coating emissions--33,500 for the state (tons/year)			
Average emissions (tons/year/employee)	6.35	2.58	0.95
MICHIGAN			
Number of plants	38	85	397
Number of employees	2,735	7,435	22,990
Total paper coating emissions--13,000 for the state (tons/year)			
Average emissions (tons/year/employee)	4.75	1.7	0.56
WISCONSIN			
Number of plants	22	49	255
Number of employees	3,658	5,348	29,380
Total paper coating emissions--6,300 for the state (tons/year)			
Average emissions (tons/year/employee)	1.72	1.2	0.21
OHIO			
Number of plants	60	127	409
Number of employees	6,015	11,140	37,611

a. As obtained from 1976 County Business Patterns, U.S. Dept. of Commerce
Group A includes SIC Codes 2641, 2649, 3955
Group B includes SIC Codes 2631, 2641, 2643, 2645, 2649, 3955
Group C includes SIC Codes 2611, 2621, 2631, 2641, 2643, 2645, 2649, 2651, 3291, 3292, 3293, 3499, 3679, 3842, 3861, 3955
See Exhibit 5-2, following page 5-6, for description of SIC Codes.

Source: Booz, Allen & Hamilton Inc.

The recommended methods of achieving this requirement are:

- The application of low solvent content coatings; or
- Incineration, provided that 90 percent of the nonmethane VOCs (measured as combustible carbon) which enter the incinerator are oxidized to carbon dioxide and water; or
- A system demonstrated to have control efficiency equivalent to or greater than provided by either of the above methods.

In the following section are discussed several methods of low solvent and solventless systems, which have been demonstrated to be applicable to some paper coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Sources, Volume II, which should be consulted for a more thorough discussion. In some instances, additional comment was obtained from coaters, coating material suppliers and control equipment manufacturers.

5.3.5 Low Solvent and Solventless Coatings

In Exhibit 5-9, on the following page, are listed several types of coating materials, which have found utility in paper coating, and an estimate of expected solvent reduction.

5.3.5.1 Waterborne Coatings

Waterborne coatings have long been used in coating paper to improve printability and gloss. The most widely used types of waterborne coatings consist of an inorganic pigment and nonvolatile adhesive. These waterborne coatings are useful but cannot compete with organic solvent coatings in properties such as weather, scuff and chemical resistance. Newer waterborne coatings have been developed in which a synthetic insoluble polymer is carried in water as a colloidal dispersion or an emulsion. This is a two-phase system in which water is the continuous phase and the polymer resin is the dispersed phase. When the water is evaporated and the coating cured, the polymer forms a film that has properties similar to those obtained from organic-solvent-based coatings.

EXHIBIT 5-9
U.S. Environmental Protection Agency
ACHIEVABLE SOLVENT REDUCTIONS USING LOW SOLVENT COATINGS IN PAPER COATING INDUSTRY

Type of Low Solvent-Coating	Reduction Achievable (%)[a]
Waterborne coatings	80-99
Plastisols	95-99
Hot melts	99+
Extrusion coatings	99+
Pressure-sensitive adhesives	
Waterborne	80-99
Hot melts	99
Prepolymer	99
Silicone release agents	
100 percent nonvolatile coatings	99+
Waterborne emulsions	80-99

a. Based on comparison with a conventional coating containing 35 percent solids by volume and 65 percent organic solvent by volume.

Source: EPA 450/2-77-008, op. cit.

5.3.5.2 Plastisols and Organisols

Plastisols are a colloidal dispersion of synthetic resin in a plasticizer. When the plasticizer is heated, the resin particles are solvated by the plasticizer so that they fuse together to form a continuous film. Plastisols usually contain little or no solvent, but sometimes the addition of a filler or pigment will change the viscosity so that organic solvents must be added to obtain desirable flow characteristics. When the volatile content of a plastisol exceeds 5 percent of the total weight, it is referred to as an organisol.

Paper is coated with plastisols to make such products as artificial leather goods, book covers, carbon paper and components of automobile interiors. Plastisols may be applied by a variety of means, but the most common method is probably reverse roll coating. One advantage of plastisols is that they can be applied in layers up to 1/8 thick. This avoids the necessity of multiple passes through a coating machine.

Although organic solvents are not evaporated from plastisols, some of the plasticizer may volatilize in the oven. This plasticizer will condense when emitted from the exhaust stack to form a visible emission.

5.3.5.3 Hot Melt Coatings

Hot melt coatings contain no solvent; the polymer resins are applied in a molten state to the paper surfaces. All the materials deposited on the paper remain as part of the coating. Because the hot melt cools to a solid coating soon after it is applied, a drying oven is not needed to evaporate solvent or to cure the coating. Energy that would have been used to heat an oven and to heat makeup air to replace oven exhaust is therefore saved. Considerable floor space is also saved when an oven is not used. In addition, the paper line speed can be increased because the hot melt coating cools faster than a solvent coating can dry.

One disadvantage with hot melt coatings is that materials that char or burn when heated cannot be applied by hot melt. Other materials will slowly degrade when they are held at the necessary elevated temperatures.

Hot melts may be applied by heated gravure or roll coaters and are usually applied at temperatures from 150°F to 450°F. The materials with a lower melting point are generally waxy materials with resins added to increase gloss and hardness. The materials with a higher melting point form films that have superior scuff resistance, transparency and gloss. These coatings form excellent decorative finishes. One particular advantage of hot melts is that a smooth finish can be applied over a rough textured paper. This is possible because the hot melt does not penetrate into the pores of the paper.

5.3.5.4 Extrusion Coatings

A type of hot melt coating, plastic extrusion coating is a solventless system in which a molten thermoplastic sheet is discharged from a slotted dye onto a substrate of paper, paperboard or snythetic material. The moving substrate and molten plastic are combined in a nip between a rubber roll and a chill roll. A screw-type extruder extrudes the coating at a temperature sometimes as high as 600°F. Low and medium density polyethylene are used for extrusion coating more than any other types of resins.

5.3.5.5 Pressure-Sensitive Adhesive Coatings

In 1974, sales of pressure-sensitive adhesives in the United States exceeded $1 billion, and the growth rate was about 15 percent per year. Products using pressure-sensitive adhesives include tapes and labels, vinyl wall coverings and floor tiles. Nationwide, organic solvent emissions from pressure-sensitive tape and label manufacture have been estimated to be 580 million pounds per year.

Waterborne adhesives have the advantage that they can be applied with conventional coating equipment. Waterborne emulsions, which can be applied less expensively than can solventborne rubber-based adhesives, are already in use for pressure-sensitive labels. A problem with waterborne adhesives is that they tend to cause the paper substrate to curl and wrinkle.

Pressure-sensitive hot melts currently being marketed consist mostly of styrene-butadiene rubber block copolymers. Some acrylic resins are used, but these are more expensive. The capital expense of hot melt coating equipment is a problem for paper coaters that have already invested heavily in conventional solvent coating equipment.

Prepolymer adhesive coatings are applied as a liquid composed of monomers containing no solvent. The monomers are polymerized by either heat or radiation. These prepolymer systems show promise, but they are presently in a developmental stage only.

5.3.5.6 Silicone Release Coatings

Silicone release coatings, usually solvent-borne, are sometimes used for pressure-sensitive, adhesive-coated products. Two low-solvent alternatives are currently on the market. The first is a 100 percent nonvolatile coating which is usually heatcured, but may be radiation cured. This is a prepolymer coating which is applied as a liquid monomer that is crosslinked by the curing process to form a solid film. The second system is water emulsion coatings which is lower in cost than the prepolymer coating. However, because of wrinkling and other application problems the waterborne coating may be of limited value.

Some silicone coating materials which are under development use single solvent systems that can be readily recovered by carbon adsorption. Current coatings are troublesome since some silicone is carried into the adsorber where it clogs the carbon pores to reduce adsorption efficiency.

5.3.6 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures above 1,200°F for direct incineration and 700°F for catalytic incineration. Natural gas is the most commonly used fuel though fuel oils, propane or other fluid hydrocarbons can be employed. Fuel oil is not generally acceptable because of the sulfur oxides generated in combustion or possible catalyst poisoning in the oil. Another problem is the generation of nitrogen oxides in direct fired incinerators because of the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot incinerator exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or baking ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from the combustion of the volatile organic compounds in the exhausts.

Both catalytic and direct fired systems are capable of high heat recovery efficiency if several conditions occur:

- VOC concentrations are or can be increased to 8-10 percent or more of their LEL (lower explosion limit).
- Oven temperatures are sufficiently high to be able to use most of the sensible heat in the exhaust gases after primary heat exchange. Usually, temperatures above 140°F to 150°F can be sufficient to allow 85 percent or more overall heat recovery.
- Where catalytic incinerators are used, no compounds must be present in the gases treated which could poison or blind the catalyst.

In most paper coating operations, except for heat-sensitive products such as photographic paper and film, these conditions can be met. In other cases, 50-85 percent primary heat recovery can be attained and at least a portion of the incinerator exhaust heat can be used for in-plant energy requirements.

Paper coaters who use coating machinery for a multiplicity of processes have commented that catalytic incineration would probably not be used because of the possibility of catalyst poisoning. Direct fired incineration would be used.

5.3.7 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from paper coating operations. Most operational systems on paper coating lines were installed because they were profitable. Pollution control has usually been a minor concern. Carbon adsorption systems at existing paper coating plants range in size from 19,000 scfm to 60,000 scfm. Exhausts from several paper coating lines are often manifolded together to permit one carbon adsorption unit to serve several coating lines. Paper products that are now made on carbon-adsorption-controlled lines include pressure-sensitive tape, office copier paper and decorative paper.

Carbon adsorption is most adaptable to single solvent processes. Many coaters using carbon adsorption have reformulated their coatings so that only one solvent is required. Toluene, a widely used solvent for paper coating, is readily captured in carbon adsorption systems.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing recovered solvents may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In some cases, such as in the preparation of photographic films or thermographic recording paper, extremely high purity solvents are necessary to maintain product performance and even distillation may be insufficient to produce the quality of recovered solvent needed. For most other coating formulations, distillation is adequate.

Separation of solvent mixtures by distillation is a well-established technology and several plants are already doing this. One paper coating plant has been using such distillation procedures since 1934. Distillation equipment can be expensive, however, and it is hard to build flexibility into a distillation system. Flexibility is needed because many paper coaters, especially those who do custom work for others, are constantly changing solvent formulations.

However, in some plants where mixed solvents are used, azeotropic mixtures can occur which can be separated only by specialized techniques. Even large coaters have commented that they did not have the knowledge at hand necessary for the complex distillation and separation procedures needed.

Another problem with carbon adsorption is the potential of generating explosive conditions in the adsorber because of the localized increases in combustible organic material concentrations. Ignition apparently can be caused by static electricity in systems where dry air at high flow rates is treated. Several explosions of absorbers have been reported in paper coating and other plants.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem where steam is used for re-generation. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

5.4 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for paper coating in the state, based on the emissions as discussed on page 5-12 of this report. Where possible, the validity of the costs were confirmed with coating firms and equipment manufacturers.

Though some coaters will substitute low solvent or solventless coating for current high solvent systems, no reliable information was available to estimate the amount of such coatings which might be used. Several coaters also commented that though they had low solvent coatings under development the coatings would not be sufficiently evaluated to meet proposed compliance schedules. Therefore, it has been assumed (for cost estimating purposes) that either incineration or carbon adsorption will be used to comply with the proposed regulations.

5.4.1 Costs of Alternative Control Systems

Exhibits 5-10 and 5-11, on the following pages, present costs for typical incineration and carbon adsorption systems as developed by EPA sources. Both systems are based on the assumption that exhaust air flow rates can be reduced sufficiently to attain LEL levels of 25 percent. This is possible with well-designed ovens where excess air can be reduced or where product characteristics allow.

Several paper coaters indicate that this may not be possible with older coating lines or with certain types of coating. Coating drying rate is a function of air flow rate, temperature and vapor concentration in the air. If air flow rates are to be reduced, drying temperatures or drying times must be increased. Because of the heat sensitivity of some coating, temperature increases may not be possible. Increase in drying time will necessitate either more time in the ovens or reduced production rates. Several coaters of heat sensitive products indicated that in order to achieve special characteristics they could not increase emission concentrations above 5 to 6 percent of LEL and could not use oven temperatures above 140°F. Plants manufacturing conventional coated products, however, can decrease air flow rates sufficiently to increase VOC concentrations in the exhausts to 40-50 percent with only moderate increases in temperatures or changes in production rates. We have assumed for cost estimation purposes that a 25 percent LEL can be attained on the average.

EXHIBIT 5-10
U.S. Environmental Protection Agency
INCINERATION COSTS FOR A TYPICAL PAPER COATING OPERATION

Incineration Device	Installed Cost ($)	Annualized Cost ($/yr.)	Control Cost ($/ton of solvents recovered)
No heat recovery			
Catalytic	155,000	100,000	51
Noncatalytic (Afterburner)	125,000	105,000	54
Primary heat recovery			
Catalytic	180,000	75,000	39
Noncatalytic (Afterburner)	150,000	66,000	34
Primary and secondary heat recovery			
Catalytic	220,000	54,000[a]	28[a]
Noncatalytic (Afterburner)	183,000	26,000[a]	13[a]

Note: Typical operation parameters are: process rate of 15,000 scfm; temperature of 300°F, operation at 25 percent of LEL. See Volume I, Chapter 4, for costs for other operating parameters. Costs are believed to be valid only for mid-1974.

a. Assumes heat is recovered and used at a total heat recovery of 70 percent.

Source: EPA-450/2-76-028

EXHIBIT 5-11
U.S. Environmental Protection Agency
CARBON ADSORPTION COSTS FOR PAPER COATING INDUSTRY

	Installed Cost ($)	Annualized Cost ($/yr.)	Control Cost ($ ton of solvent recovered)
No credit for recovered solvent	320,000	127,000	125
Recovered solvent credited at fuel value	320,000	60,000	40
Solvent credited at market	320,000	(100,000)[a]	(50)[a]

Note: Operating parameters are: process rate of 15,000 scfm, temperature of 170°F, operation at 25 percent of LEL. See Volume I, Chapter 4, for details on cost estimates. Costs are believed to be valid only for mid-1974.

a. Costs in parenthesis indicate a net gain.

Source: EPA-450/2-76-028

Both incinerator costs and adsorber costs are a function of equipment size and vary generally with air flow rate. It was assumed for projection of overall costs in the state that control equipment, on the average, would be sized for 15,000 scfm per unit[1]. In most plants, it is impractical to manifold exhausts so that all exhausts could be treated in one add-on emission control system. In the case of incinerators, it would be difficult to use secondary heat recovery on ovens where the incinerator is remote from the oven.

This assumption of 15,000 SCFM per unit can lead to errors in both capital costs and annualized costs because of economies of scale. For instance, as shown in Exhibit 5-10, the capital costs of a 15000 SCFM noncatalytic incinerator are equivalent to about $8.30/SCFM as estimated in EPA 450/2-76-028. In the same report, a 7500 SCFM unit would have a cost of $110,000 or $14.60/SCFM and a 30,000 SCFM unit a cost of $15,000 or $5.00/SCFM. The 15,000 SCFM assumption is, therefore, considered to lead only to an approximation of compliance costs and may understate actual costs. Until the actual number of firms affected and their emissions are known, a more accurate estimate is probably not possible.

The major problem in estimating total installed costs of control systems is the added cost of installation. The EPA estimates were made on the assumption of an easily retrofitted system. In practice coaters have found actual installed costs to be three to five times those summarized in Exhibits 5-10 and 5-11. For instance, E.I. DuPont de Nemours, based on their experience on actual installed equipment, estimates[2] $1.2 million for a carbon adsorber to treat 15,000 scfm of exhaust gases. Recent prices from recuperative type incinerator manufacturers for a 15,000 scfm direct-fired, ceramic bed primary recuperative heat exchanger are about $150,000 for the incinerator alone; installed costs, with provision for return of exhausts for secondary heat recovery, are estimated to be more than $300,000. The estimates in Exhibits 5-10 and 5-11 indicate installed costs of $320,000 for an equivalent adsorber, and $140,000 for the incinerator.

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[1] Using assumptions itemized in Exhibit 5-12, an average of 13,500 SCFM per unit is estimated if 25 firms are assumed have one unit each.

[2] T.A. Kittleman and A.B. Akell, "The Cost of Controlling Organic Emissions," Chemical Engineering Progress, April 1978.

5.4.2 Estimated Statewide Costs

The total emissions considered to be applicable under RACT, as discussed on page 5-12 of this report, are about 28,000 to 38,000 tons per year. Based on this emission rate and EPA costs as summarized in Exhibits 5-10 and 5-11, capital costs are estimated as $6.0 million to $8.2 million, with annual costs of $1.0 million to $1.4 million per year. All bases and assumptions used in this estimate are summarized in Exhibit 5-12, on the following page. The costs presented in Exhibits 5-10 and 5-11 were increased by 25 percent to account for inflationary increases from mid-1974 to mid-1977.

However, as discussed on page 5-20, experience has shown that these adjusted costs are probably low by as much as three to four times because of difficult retrofit situations or the need for modification of ovens or collection systems. Actual capital costs are, therefore, estimated to range from $18 million to $33 million rather than $6.0 million to $8.2 million. Adjusting the capital cost component of the annual costs as estimated in EPA 450/2-78-028 for this increased capital costs, equivalent annualized costs are estimated to be $6.0 million to $11.0 million.

5.4.3 Estimated Emission Reduction

Assuming that 90 percent of all solvents used in coating operations can be collected by properly designed hoods and ovens, emissions could be reduced by 23,000 to 31,000 tons per year. This is based on a 90 percent capture of emissions by a carbon adsorber or destruction in an incinerator, an overall reduction in emissions of 81 percent.

In many cases this may result in a much lower emission rate than required by the 2.9 pound per gallon RACT limit proposed. A plant may, by proper selection of exhaust streams, reduce the cost of compliance by treating only those emissions which would result in an average emission rate of 2.9 pounds per gallon of coating. However, the RACT limit of 2.9 pounds per gallon is based on typical coatings now used in the industy in concert with 81 percent overall reduction in emissions. Unless solvent coatings are used, compliance can only be achieved plantwide by using a system which provides an emission reduction level of 81 percent.

EXHIBIT 5-12
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE

Assumptions

75 percent of emissions are controlled by incineration with primary and secondary heat recovery; 25 percent by carbon adsorption with recovered solvent credited at fuel prices. (Based on estimated distribution of methods of control from interviews with coating firms.)

25 percent LEL is equal to 3,000 ppm of toluene by volume.

Air flow can be reduced to reach 25 percent LEL.

The price of a 15,000 SCFM system can be used as an average. No costs are added for distillation or additional waste disposal.

33,500 tons of emissions are treated per year over an operating period of 5,840 hours per year.

Other assumptions regarding incinerator and adsorber prices, as estimated in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations, EPA-450/2-76-028, are valid.

Source: Booz, Allen & Hamilton Inc.

5.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of implementing the RACT guidelines for surface coating of paper on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), state economic variables and capital investment.

5.5.1 RACT Timing

Current proposed guidelines for paper coating suggest several compliance deadlines for alternative methods of compliance.[1] Generally, for add-on systems they call for installation of equipment and demonstration by mid-1980 or late 1980; for low solvent systems, by late 1980 or mid-1981, depending upon the degree of research and development needed. Major coaters, material suppliers and equipment manufacturers believe these deadlines to be unattainable.

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months. A major coater with considerable experience with similar installations estimates that the complete cycle of installation, from initial selection of control method to testing of the system, would require 37 months plus an additional 12 months to establish an economically sound method of control.

- Only a small number of companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements by all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed.

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[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Source Categories, EPA-905/2-78-001

- A major coating firm estimates that the use of low solvent or solventless coatings may take as long as 68 months from initial research, through product evaluation and customer acceptance to final production. Product and process development alone may take as long as 24 months and product evaluation over 14 months.

In general, it appears that if either add-on control systems are used or new low solvent systems need to be developed, deadlines must be extended.

5.5.2 Technical Feasibility Issues

Though low solvent or solventless materials are used in many paper coating operations at present, many types of solvent-based systems have no satisfactory replacement. The alternative materials do not meet the product quality standards demanded by the coaters. Additional development is needed and will require the combined efforts of both the coaters (who must maintain product quality) and the coating material suppliers. Ideally, the new coating materials should be adaptable to existing coating equipment to minimize additional capital investment.

As discussed above, both incineration and carbon adsorption are not completely satisfactory add-on control systems. Incineration requires large volumes of additional fuel if good heat recovery is not accomplished; carbon adsorption is not usable on many coating systems because of the multiplicity of compounds used in solvent mixtures.

5.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

The net increase in annual operating costs to coaters was estimated at $6.0 million to $11.0 million. Based on similar economic impact studies, these additional costs are projected to represent 1.1 percent to 1.6 percent of the total annual value of shipments of the firms affected by the proposed regulations. Assuming a "direct pass-through" of these costs, prices will increase by about the same fraction.

The major economic impact in terms of cost to most individual companies will be the large capital expenditures required for add-on devices, rather than increased annual operating costs. For most companies, these costs would exceed their current level of capital expenditures for plant improvement and expansion. A large pressure-sensitive paper coater in another state, for instance, has estimated that a capital investment of about $2 million would be needed to meet proposed guidelines. His current capital expenditure program is normally in the range of $1.5 million.

A typical case is a Michigan firm which manufacturers various types of recording paper and produces 40 percent of the electrocardiogram paper used in this country. Although with additional development, some of its coating solutions could be replaced with low solvent or waterborne ones, incineration or carbon adsorption would be the only method of complying with the regulation as now proposed. Based on projected costs for either of these add-on control systems, the firm is seriously considering terminating or moving operations. Similar financial difficulties are foreseen for marginally profitable firms which have limited capital access or for which the added annual costs of compliance are prohibitive.

5.5.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Employment is expected to be only moderately affected. Employment would be reduced if marginally profitable facilities closed, but the present indication from the industry is that plant closures may occur only for small firms with limited capital access. However, even some large firms may be forced to close down marginally profitable coating lines with a resultant decrease in employment.

It is likely that market stucture may be affected by the closure of firms with limited capital access, with their sales being absorbed by larger firms. The number of closures, however, is expected to be small if capital resources can be made available to the companies, since operating costs have only a small effect on sales price and would be the same for all firms affected.

No significant effect on overall productivity is foreseen except for a small change resulting from the need for add-on control system operating and maintenance personnel.

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Exhibit 5-13, on the following page, summarizes the conclusions reached in this study and the implications of the estimated costs of compliance for paper coaters.

EXHIBIT 5-13
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR PAPER COATERS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	Approximately 25-30 plants in the state are expected to be affected by these regulations. However, if this category is interpreted to include all types of paper coating, including publishing, far more firms would be affected
Indication of relative importance of	The 1977 value of shipments of these is estimated to be $600 million. These plants are estimated to employ 8,000-10,000 employees
Current industry technology trends	Gravure coating replacing older systems
1977 VOC emissions (actual)	Approximately 28,000-35,000 tons per year were identified from the emission inventory. Actual emissions are expected to be higher
Industry preferred method of VOC control to meet RACT guidelines	Though low solvent coating use is increasing, progress is slow. Add-on control systems will probably be used
Assumed method of control to meet RACT guidelines	Thermal incineration with primary and secondary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $18 million to $33 million depending on retrofit situations. This is likely to be more than 100 percent of normal expenditures for the affected paper coaters
Annualized cost (statewide)	$6.0 million to $11.0 million annually. This may represent 1.1 to 1.6 percent of the 1977 annual sales for the affected paper coaters
Price	Assuming a "direct cost pass-through"--1.1 to 1.6 percent
Energy	Assuming 70 percent heat recovery, annual energy requirements would increase by approximately 175,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	Smaller firms may be unable to secure capital funding for add-on systems
RACT timing requirements (1982)	RACT guideline needs clear definition for rule making Equipment deliverables and installation of incineration systems prior to 1982 may present problems
Problem areas	Retrofit situations and installation costs are highly variable

EXHIBIT 5-13(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
VOC emissions after control	5,000-7,000 tons/year (20 percent of 1977 VOC emission level)
Cost effectiveness of control	$250 - $350 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

T. W., Hughes, et al., Source Assessment: Prioritization of Air Pollution from Industrial Surface Coating Operations, Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C., under Contract No. 68-02-1320 (Tech. 14) Publication No. 650/2-75-019a.

T. A. Kittleman and A. B. Akell, "The Cost of Controlling Organic Emissions," Chemical Engineering Progress, April 1978.

Springborn Laboratories, Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report. EPA Contract No. 68-0202075, August 23, 1977.

Davidson's Textile Blue Book, 1977.

Lockwoods' Directory of the Paper Industry, 1977.

Thomas Register of American Manufacturers, 1978.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I. EPA-450/2-76-028, May 1977.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II. EPA-450/2-77-008, May 1977.

U.S. Environmental Protection Agency, Regulatory Guidance for Control of Volatile Organic Compounds Emissions from 15 Categories of Stationary Sources, EPA-950/2-78-001, April 1978.

U.S. Department of Commerce, Annual Survey of Manufactures, 1976.

U.S. Department of Commerce, County Business Patterns, 1976.

U.S. Department of Commerce, Census of Manufactures, 1972.

Private conversations at the following:

Armak Company, Marysville, Michigan, and Alliance, Ohio
American Can Company, Greenwich, Connecticut
Fasson, Painesville, Ohio
Presto Adhesive Paper Co., Miamisburg, Ohio
3M Company, St. Paul, Minnesota
Morgan Adhesives, Milan, Ohio
National Flexible Packaging Association, Cleveland, Ohio
Pressure Sensitive Tape Council, Chicago, Illinois
Continental Can Company, Newark, Ohio
General Electric Company, Coshocton, Ohio
Mead Corporation, Chillicothe, Ohio
St. Regis Paper Company, Battle Creek, Michigan, and Troy, Ohio
World Wild Games, Radnor, Ohio
TEC Systems, DePere, Wisconsin
Overly Inc., Neenah, Wisconsin
Bobst-Champlain, Roseland, New Jersey
REECO, Inc., Morris Plains, New Jersey

6.0 <u>THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF OHIO</u>

6.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Ohio which are engaged in the surface coating of fabrics and vinyls. This RACT category is meant to include the roll, knife or rotogravure coating and oven drying of textile fabrics (to impart strength, stability, appearance or other properties), or of vinyl coated fabrics or vinyl sheets. It includes printing on vinyl coated fabrics or vinyl sheets to modify appearance but not printing on textile fabrics for decorative or other purposes. It does not, however, include the coating of fabric substrates with vinyl plastic polymers, which are usually applied as melts or plastisols, that result in only minor amounts of emissions. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Alternative control methods
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of fabric coating; interviews with fabric and vinyl coaters, coating equipment and materials manufacturers and add-on control equipment manufacturers; and a review of pertinent published literature.

6.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for plants in the state engaged in the surface coating of fabrics and vinyls. The quality of these estimates is discussed in the last part of this section.

6.1.1 Industry Statistics

The coating of fabrics is used to produce a large variety of common consumer and industrial products. Typical products are raincoats, upholstery, wall covering, tablecloths, window shades, gasketing, diaphragms, lifeboats and bookcovers. In most cases the finished product is manufactured by firms who purchase the coated fabric from a manufacturer whose principal activity is fabric coating. However, there are a number of vertically integrated firms (the major automobile manufacturers are typical) which both coat fabrics and manufacture finished goods from them. Other exceptions are firms which both manufacture fabrics and coat them. Thus firms which coat fabrics or vinyl coated fabrics or sheeting can be found in a number of Standard Industrial Classification categories; these are listed below:

SIC	Description
2211	Broad woven fabric mills, cotton
2221	Broad woven fabric mills, man-made and silk
2241	Narrow fabrics and other, small wares mills
2258	Warp knit fabric mills
2261	Finishers of broad woven fabrics of cotton
2262	Finishers of broad woven fabrics of man-made fiber and silk
2269	Finishers of textiles, n.e.c.*
2295	Coated fabrics, not rubberized
2297	Nonwoven fabrics
3069	Fabricated rubber products, n.e.c.*
3079	Miscellaneous plastics products
3291	Abrasive products
3293	Gaskets, packing, sealing devices

*not elsewhere classified

General statistics concerning the firms included in these SIC groupings were obtained from the most recent Census of Manufactures, County Business Patterns and other economic summaries published by the U.S. Department of Commerce.

Data on industrywide shipments of coated fabrics was obtained from the Textile Economics Bureau (New York City, N.Y.). Identification of individual candidate firms which might be affected by the proposed regulation was made by review of industry directories:

- Davidson's Textile Blue Book
- Rubber Red Book
- Modern Plastic Encyclopedia
- Thomas Register of American Manufacturers
- Ohio Directory of Manufacturers
- Membership list of the Canvas Products Association.

A list of establishments expected to be affected by the proposed fabric coating RACT regulations in the state was sent to the Ohio EPA for comparison with its emission inventory. Six firms were located which have fabric coating operations.

6.1.2 VOC Emissions

The Ohio Environmental Protection Agency emission inventory was used as a basis for the estimation of the total VOC emissions from the fabric coating plants identified. They are believed to represent 90 percent or more of the emissions in this RACT category. Emissions from fabric coating plants not identified in the state, if they exist, are expected to be small and negligible.

6.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from fabric coating processes are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008). The report suggests the use of various low solvent or solventless coatings which have found some use in the industry, as well as add-on devices, such as incinerators or carbon adsorbers. In some cases waterborne of other low solvent coatings can be used.

6.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions were determined by an independent estimate of control costs by the study team based upon emissions obtained from the Ohio Environmental Protection Agency inventory.

This estimate used design and cost information provided by incinerator and carbon adsorber manufacturers or available in the published literature and in the following EPA reports:

- Control of Volatile Organic Emissions from Stationary Sources, Volume I (EPA-450/2-76-028)

- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

Estimates of emission reduction are largely dependent upon the efficiency with which solvents can be collected from the coating operation. In formulation of the proposed regulation EPA has estimated that, by proper collection system design, at least 90 percent of the solvents in the applied coating material can be collected. This 90 percent is not meant to include solvents which might be lost in the compounding of the coating or used for cleaning of the process equipment or fabric.

Practically all fabric coating emissions in the state result from vinyl coating operations. In most cases, single solvent systems are used and are readily amendable to carbon adsorption recovery. Compliance costs were therefore estimated assuming that carbon adsorption would be used to control 75 percent of the emissions and incineration with heat recovery to control the remaining 25 percent. This assumption was generally agreed to in telephone interviews with representatives of all six Ohio coaters contacted.

6.1.5 Economic Impacts

The economic impacts were determined by: analyzing the lead time requirements to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Ohio. Because of the confidential nature of value of shipments and other financial details, none of the six companies interviewed would disclose this information. Comments are thus based on estimated amounts of such quantities as capital expenditures and value of shipments.

6.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impacts of implementing RACT controls on the surface coating of fabrics in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are available for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 6-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 6-1
U.S. Environmental Protection Agency
DATA QUALITY--SURFACE COATING OF FABRICS

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	X		
Emissions	X[a]		
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

a. Emission data supplied by Ohio Environmental Protection Agency, state emission inventory.

Source: Booz, Allen & Hamilton Inc.

6.2 INDUSTRY STATISTICS

Industry characteristics, statistics and trends for fabric coating are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in this category upon the state economy and upon the individual firms concerned. The effects upon the firms involved are somewhat different because of their relative sizes, though proportionately the effects are similar.

6.2.1 Size of the Industry

The Bureau of Census, in 1976 County Business Patterns, reported a total of about 808 plants in SIC categories in which plants coating fabrics in Ohio would be expected to be tabulated.

Pertinent data concerning these plants are summarized in Exhibit 6-2, on the following page. As mentioned earlier based on a review of industrial directories and other published information, six plants were found in which fabric coating, as defined in the proposed "fabric coating" regulation, is being used. Statistics concerning these six plants are summarized in Exhibit 6-3, following Exhibit 6-2.

As shown, these firms are estimated to employ a total of 2,600 people.

6.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of these plants with the state economy indicates that these plants represent about 0.4 percent of the total value shipments by manufacturing plants and employ about 0.2 percent of manufacturing workers in Ohio.

6.2.3 Historical and Future Patterns of the Industry

The fabric coating industry in the U.S., except for the general economic slump in 1975, has shown a gradual but steady growth in sales and shipments over the last several years as demonstrated by Exhibits 6-4 and 6-5, following Exhibit 6-3. The largest growth in terms of dollar value of shipments was for vinyl coated fabrics which increased by $215.5 million in shipments from 1972 to 1976, compared with an increase of $301 million for all coated fabrics. Pyroxylin (cellulose nitrate) coatings, because of their low cost and

EXHIBIT 6-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR PLANTS IN SIC CATEGORIES
WHERE FABRIC COATING MAY BE USED IN OHIO

SIC	Name	Number of Firms	Number of Employees	Annual Payroll ($000s)
2211	Broad woven fabric mills, cotton	b	-	-
2221	Broad woven fabric mills, man-made and silk	b	-	-
2241	Narrow fabrics and other, small wares mills	6	417	3,855
2258	Warp knit fabric mills	b	-	-
2261	Finishers of broad woven fabrics of cotton	4	370	a
2262	Finishers of broad woven fabrics of man-made fiber and silk	b	-	-
2269	Finishers of textiles, n.e.c.	1	750	a
2295	Coated fabrics, not rubberized	16	2,353	30,571
2297	Nonwoven fabrics	b	-	-
3069	Fabricated rubber products, n.e.c.	161	21,612	272,460
3079	Miscellaneous plastics products	549	39,966	464,349
3291	Abrasive products	37	2,825	35,488
3293	Gaskets, packing, sealing devices	36	1,831	18,434
		808	69,707	821,302

a. Not reported to protect proprietary information.

b. None listed

Source: 1976 County Business Patterns, U.S. Department of Commerce.

EXHIBIT 6-3
U.S. Environmental Protection Agency
FIRMS EXPECTED TO BE AFFECTED BY FABRIC
COAT REGULATIONS

Company	Location	Approximate Number of Employees	Estimated[a] Emissions	Activity
Borden Chemical Co. Columbus Coated Fabrics Div.	Columbus	1,000	1,399	Vinyl coating and lamination
Chrysler Corp.	Sandusky	325	1,850	Vinyl coating
Custom Coated Products	Cincinnati	30	96	Fabric coating
General Tire Corp., Textile Leather Div.	Toledo	650	798	Vinyl coating
Inmont Corp.	Toledo	325	1,857	Vinyl coating
Uniroyal	Port Clinton	300	1,472	Vinyl coating
		2,630	7,472	

a. Obtained from Ohio Environmental Protection Agency emission inventory.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 6-4
U.S. Environmental Protection Agency
U.S. ANNUAL VALUE OF SHIPMENTS OF COATED FABRICS
($ millions)

Item	1972	1973	1974	1975	1976
Pyroxylin-Coated Fabrics	26.3	27.3	34.5	28.0	32.5
Vinyl Coated Fabrics	601.9	693.7	728.7	681.5	817.4
Other Coated Fabrics	154.1	188.0	212.6	202.7	213.8
Coated Fabrics, not rubberized	26.3	29.4	(13.6)[a]	(1.4)[a]	(33.8)[a]
Rubber Coated Fabrics	67.9	73.6[b]	83.5[b]	72.0[b]	80.0[b]
TOTAL	876.5	1,011.9	1,156.5	985.6	1,177.5

Notes:

a. Values obtained by difference from gross shipments of all coated fabrics, not rubberized

b. Booz, Allen estimate based on shipments of "Other Rubber Goods, N.E.C.", SIC Code 30698

Source: 1976 *Annual Survey of Manufactures*

EXHIBIT 6-5
U.S. Environmental Protection Agency
U.S. ANNUAL SHIPMENTS OF BACKING MATERIALS FOR COATED FABRICS
(in millions of pounds)

	1972	1973	1974	1975	1976
Transportation Fabric, all fibers[a]	95.4	100.9	64.6	65.3	81.5
Coated and Protective Fabrics[b]	133.7	149.3	167.5	137.8	177.6
TOTAL	229.1	250.2	232.2	203.1	259.1

Notes:

a. Transportation fabric includes auto seat upholstery and slipcovers, sidewall, headlining and sheeting. The cotton poundage include the knit and woven fabric used as the backing for vinyl sheeting. The item includes convertible auto tops & replacements thereof, as well as upholstery used in other kinds of transportation, such as airplanes, railroad & subway cars, buses, etc. It does not include seat padding, transportation rugs window channeling flocking, tassels, trim, etc., or the textile glass fiber used in reinforced plastic seating for subways, buses, etc.

b. Coated and protective fabrics includes parachutes, deceleration chutes and tow targets; awnings; beach, garden & tractor umbrellas; inflatable dunnage and cushions, air-supported structures and automotive air-spring diaphragms; boat and pool covers; tarpaulin covers for athletic fields, etc.; also, the substrates used for vinyl sheeting. The cotton poundage include awnings, boat covers, tarpaulins and tents. Not included here are the cotton poundages used for vinyl substrates; such poundages are tabulated with their appropriate end use, i.e., transportation upholstery, upholstery etc. Does not include man-made fiber surfaces for recreational fields.

Source: Textile Economics Bureau, *Technicon*, November 1977 ease of application, still continue to occupy a steady though proportionately smaller share of the market. Natural and artifical rubber coated fabrics, because of unique properties not obtainable with plastic materials, also maintain a substantial (about 10 percent) share of the coated fabric market. Vinyl and urethane coatings, however, are replacing a larger share of both markets.

6.3 TECHNICAL SITUATION IN THE INDUSTRY

This section describes the principal materials and processes used in fabric and vinyl coating and various methods which are considered to be reasonably available to control technology to meet proposed regulations. The proposed RACT guidelines for fabric coating and an estimate of the total VOC emission reduction possible if the guidelines are implemented in the state are also presented.

6.3.1 General Coating Process Description

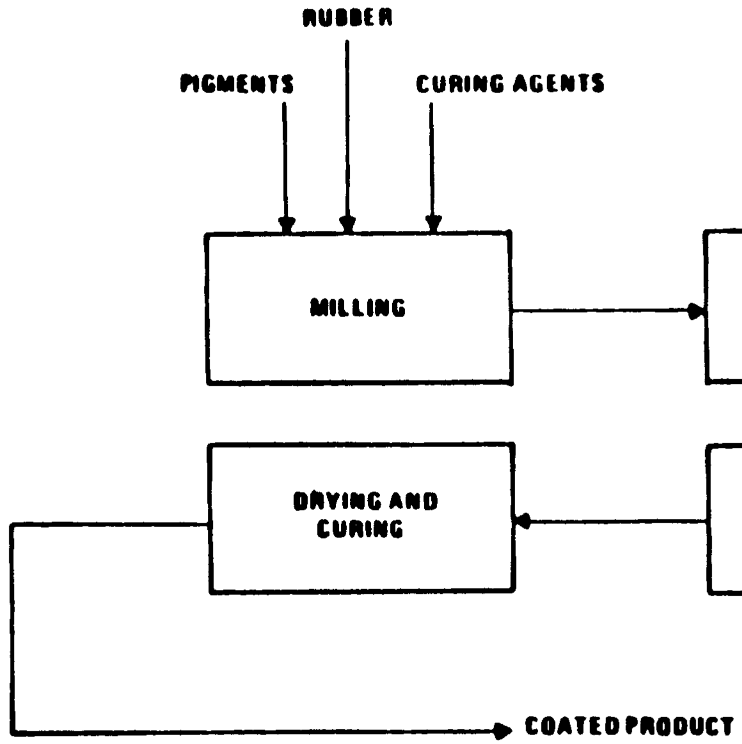
Fabrics are coated primarily to render them resistant to penetration by various fluids or gases, improve abrasion resistance or modify the appearance or texture. Typical examples are materials used in shower curtains; rubber life rafts; ballons; drapery material; synthetic leathers for shoes, upholstery or luggage; table cloths; and outdoor clothing. The base fabrics can be asbestos fiber cloth, burlap and pite, cotton drill, duck canvas, glass fabrics, knit cotton or rayon, nonwoven fabrics or nylon sheeting. In the case of coating of vinyls, the substrate is a flexible vinyl sheet or cloth-supported vinyl on which a coating is applied to enhance the appearance or durability of the vinyl surface.

Typical coating materials are rubber compounds, vinyl resins of various types, polyesters, polyurethanes, nitrocellulose resins, oleo resins, phenolic resins, epoxy resins and polyethylene. Various techniques are used for applying these coatings as melts, plastisols, latexes, solutions or other forms. Since these proposed guidelines are primarily concerned with coatings applied as solutions, where large volumes of volatile organic materials can be emitted, the following discussions will be limited primarily to processes for coating with coating materials dissolved in organic solvents.

Exhibit 6-6, on the following page, shows the general operations involved in most fabric or vinyl coating operations. Four basic operations are involved:

- Milling -- Milling is primarily restricted to coatings containing rubber. Natural and synthetic rubbers are usually milled with pigments, curing agents and fillers to produce a homogeneous mass that can be dissolved in a suitable solvent. Organic solvents are not usually involved in the milling process; thus, there are seldom any organic emissions from this operation.

EXHIBIT 6-6
U.S. Environmental Protection Agency
TYPICAL FABRIC COATING OPERATION



Source: Control of Volatile Organic Emissions from Stationary Sources, Volume I (EPA-450/2-76-028)

- <u>Mixing</u> -- Mixing is the dissolution of solids from the milling process in a solvent. The formulation is usually mixed at ambient temperatures. Sometimes only small fugitive emissions occur. However, some vinyl coaters estimate that as much as 25 percent of plant solvents are lost in mixing operations.

- <u>Coating Application</u> -- Fabric is usually coated by either a knife or a roller coater. Both methods are basically spreading techniques used for high speed application of coatings to flat surfaces. In some unique situations, dip coating may be used.

- <u>Drying and Curing</u> -- Finally, the coating is dried or cured in a final operation using heat or radiation to remove the solvents or set the coating.

In general, the coating line is the largest source of solvent emissions in a fabric coating plant, and the most readily controllable. Some coating plants report that over 70 percent of solvents used within the plant are emitted from the coating line. Other plants, especially those involved in vinyl coating, report that only 40 to 60 percent of solvents purchased by the plant are emitted from the coating line. Remaining solvents are lost as fugitive emissions from other stages of processing and in cleanup. These fugitive losses are generated by:

1. Transfer from rail cars or tank trucks to storage tanks, and subsequent transfer to processing tanks

2. Breathing losses from vents on storage tanks

3. Agitation of mixing tanks which are vented to the atmosphere

4. Solvent evaporation from cleanup of the coating applicator when coating color or type is changed

5. Handling, storage and disposal of solvent soaked cleaning rags

6. Waste ink disposal -- Waste ink is usually distilled to recover much of solvent. After distillation the sludge, which still contains some solvent, is usually dumped in a land-fill

7. Losses from drums used to store coatings which are being pumped onto a coating applicator. These are usually drums which are not hooded and may not even be covered

8. Cleaning empty coating drums with solvent

9. Cleaning coating lines with solvent

10. Evaporation of solvent from the coated fabric after it leaves the coating line. From 2-3 percent of total plant solvent usage remains in the product. Half of this may eventually evaporate into the air.

Control techniques for the above types of sources include tightly fitted covers for open tanks, collection hoods for areas where solvent is used for cleanup and closed containers for solvent wiping cloths.

6.3.2 Nature of Coating Materials Used

Coating formulations used in organic solventborne coatings normally incorporate film-forming materials, plasticizers, pigments and solvents. A multitude of organic solvents are used; solvents such as acetone toluene, heptane, xylene, methyl ethylketone, isobutyl alcohol and tetrahydrofuran are widely used in rubber, vinyl and urethane coating formulations.

In some cases, a single solvent is used, but more generally mixed solvents are employed to obtain optimum drying rates and coating mixture properties. Too rapid drying results in undesirable surface properties such as "orange peel" or other effects; improper viscosity or solvency of the coating mixture may prevent proper coating of the substrate; slow drying can limit production rates.

As discussed earlier, a number of film-forming materials are used. Typical coating materials are epoxy resins, melamine-formaldehyde resins, nitrocellulose resins, oleoresinous compounds, phenolic resins, polyesters, polyurethanes, rubber compounds and vinyl resins. Miscellaneous resins such as polyethylene and ethylene copolymers, starch and casein compounds, and acrylic resins are not discussed here since most use coating techniques which are not solvent related.

Plasticizers are added where the flexibility of the coating is important, such as in clothing or upholstery fabric. Pigments or opacifiers are added to clear film formers to provide the colors or other appearance effects desired or are used in inks as a separate coating operation to modify the surface of the coating. Pigments applied as a printed coating are normally further coated with a clear finish coat to provide the luster desired and provide protection from wear.

6.3.3 Coating Processes Commonly Used

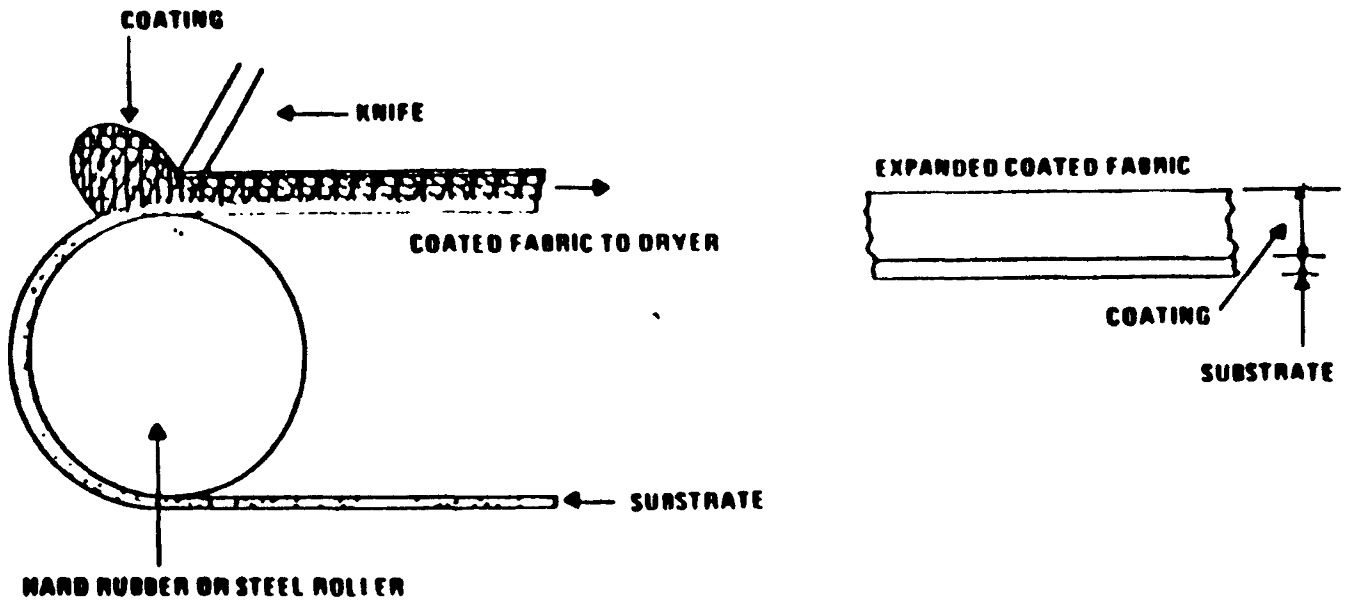
Exhibits 6-7 and 6-8, on the following pages, illustrate the two major methods of applying solvent-based coatings--knife coating and roll coating.

- Knife coating is probably the least expensive method. The substrate is held flat by a roller and drawn beneath a knife that spreads the viscous coating evenly over the full width of the fabric. Knife coating may not be appropriate for coating materials such as certain unstable knitgoods, or where a high degree of accuracy in the coating thickness is required.

- Roller coating is done by applying the coating material to the moving fabric, in a direction opposite to the movement of the substrate, by hard rubber or steel rolls. The depth of the coating is determined by the gap between rolls (A and B as shown in Exhibit 6-7). The coating that is transferred from A to B is then transferred to the substrate from roll B. Unlike knife coaters, roller coaters apply a coating of constant thickness without regard to fabric irregularities.

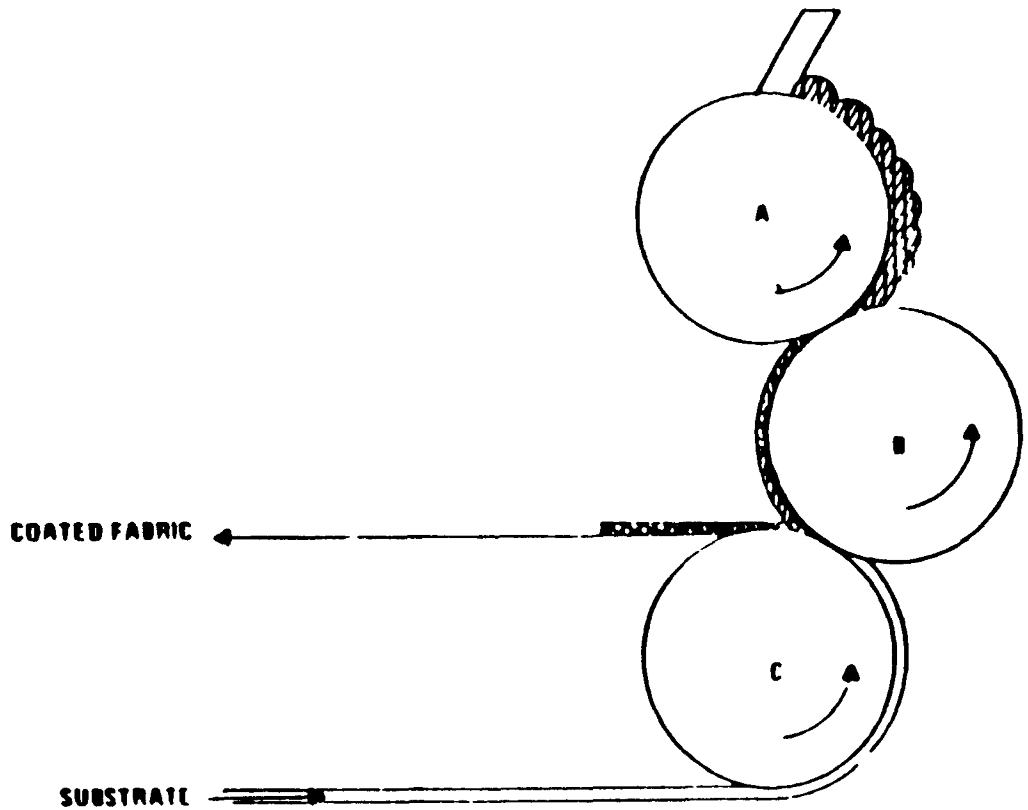
Rotogravure printing is widely used in vinyl coating of fabrics and is a large source of solvent emissions. Rotogravure printing uses a roll coating technique in which the pattern to be printed is etched as a series of thousands of tiny recessed dots on the coating roll. Ink from a reservoir is picked up in these recessed dots and is transferred to the fabric surface. Shadow prints are used to simulate leather grain. A variety of patterns are printed on such items as vinyl wall paper. A transparent protective topcoat over the printed pattern is also applied with rotogravure techniques.

EXHIBIT 6-7
U.S. Environmental Protection Agency
KNIFE COATING OF FABRIC



Source: Control of Volatile Organic Emissions from Stationary Sources, Volume I (EPA-450/2-76-028)

EXHIBIT 6-8
U.S. Environmental Protection Agency
ROLLER COATING OF FABRIC



Source: Control of Volatile Organic Emissions from Stationary Sources, Volume II (EPA-450/2-76-028)

Solvent emissions from the coating applicator account for 25 to 35 percent of all solvent emitted from a coating line. This solvent may be collected by totally enclosing the coating applicator in a small room or booth and sending all booth exhaust to a control device. However, a total enclosure of the coater may be difficult to retrofit on many existing lines. Another alternative is to cover the coater with a hood which can collect most of the solvent emissions.

The final operation in the coating process is the drying and curing of the applied coating material. Sixty-five to 75 percent of solvent emissions from the coating line usually occur in this step. In most ovens, almost all solvent emissions are captured and vented with exhaust gases. On some coating lines the emissions from the coating applicator hood are ducted to the oven and included with the oven exhaust.

Estimated and reported solvent concentration levels from drying operations range between 5 and 40 percent of the LEL (lower explosion limit). Typically, drying ovens are designed to process fabric on a continuous basis, operating with a web or conveyor feed system. Ovens can be enclosed or semienclosed and, depending on size, may exhaust from a few thousand to tens of thousand of cubic feet per minute of air. If an add-on control device is to be installed, it is generally in the owner's best interest to minimize the volume of air since the cost of add-on control devices is largely determined by the amount of air treated.

The oven heat increases the evaporation rate of the solvent and, with some coatings, will produce chemical changes within the coating solids to give desired properties to the product. In many cases, evaporation rates are controlled to give the desired properties to the coated fabric.

Many drying ovens in older plants are only semienclosed. As a consequence, they draw in excessive dilution air. Solvent concentrations range between 5 and 12 percent of the LEL according to both calculations and reports by industry. However, levels of up to 50 percent of the LEL are possible if proper safety devices are used. At least three plants in the United States are operated at 40 to 50 percent of LEL.

6.3.4 Emissions and Current Controls

As discussed earlier, six fabric or vinyl coaters have been identified in Ohio. As shown in Exhibit 6-3, the total VOC emissions from coating lines is estimated (from data supplied by the Ohio Environmental Protection Agency) to be 7,500 tons. Only the Textile Leather Division of the General Tire Company is known to have an emission control system (carbon adsorption) in operation at this time on a portion of the emissions from the plant.

6.3.5 RACT Guidelines

The RACT guidelines for control of VOC emissions from fabric coating require that emissions from coating lines be limited to a level of 2.9 pounds per gallon of coating for coating of fabric substrates and 3.8 pounds per gallon for coating of vinyl substrates.[1] These limits are achievable for the use of add-on control devices, 60 percent solids organicborne coatings, or 24 percent solids waterborne coating, which is 80 percent water/20 percent organic solvent. Typically, for add-on control devices, it is anticipated that reduction would be 81 percent, requiring that 90 percent of the VOC be captured and delivered to the control device which also must have an efficiency of 90 percent.[2]

1. Regulatory Guidance For Control of Volatile Organic Compounds Emissions From 15 Categories of Stationary Sources, EPA-905/2-78-001

2. Control of Volatile Organic Emissions From Existing Stationary Sources (page vi), Vol. II, EPA-450/2-77-008

6.4 ALTERNATIVE CONTROL METHODS

In this section are briefly discussed methods of low solvent and solventless systems, which have been demonstrated to be applicable to some fabric coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Sources, Volumes I and II, which should be consulted for a more thorough discussion. In some instances, additional comment was obtained from coaters, coating material suppliers and control equipment manufacturers.

6.4.1 Low Solvent and Solventless Coatings

Organic emissions can be reduced 80 to 100 percent through use of coatings which inherently have low levels of organic solvents. Both high-solids and waterborne coatings are used. The actual reduction achievable depends on the organic solvent contents of the original coating and the new one. Using a coating which has a low organic solvent content may preclude the need for an emission control device. Often the coating equipment and procedures need not be changed when a plant converts to coatings low in organic solvent.

Although a number of fabric coaters through the country have converted to low solvent coating, either in part or in total, one may not presume them to be universally applicable. Each coating line is somewhat unique and many coated fabrics have different specifications.

None of the plants identified were aware of suitable alternative coatings currently available which would meet the quality and performance standards required in all of their products. Most firms believe that if sufficient time were allowed for research and development, a majority of their coatings could be replaced by low solvent ones. There may be some coatings which could not be replaced.

6.4.2 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures over 1,200°F for direct incineration and 700°F for catalytic incineration. Natural gas is the most commonly used fuel though propane, fuel oils, or other fluid hydrocarbons can be employed. Fuel oil is not generally acceptable because of the sulfur oxides generated in combustion or the presence of catalyst poisons in the oil. Another problem is the generation of nitrogen oxides in direct fired incinerators resulting from the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or curing ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from combustion of volatile organic compounds in the exhausts.

Both catalytic and direct fired systems are capable of high heat recovery efficiency if several conditions occur:

- VOC concentrations are or can be increased to 8-10 percent or more of their LEL (lower explosion limit).
- Oven temperatures are sufficiently high to enable use of the sensible heat in the exhaust gases after primary heat exchange. Usually, oven temperatures above 140°F are sufficient to allow 85 percent or more overall heat recovery.
- Where catalytic incinerators are used, no compounds must be present in the gases treated which could poison or blind the catalyst.

In most coating operations, drying and curing temperatures are 250°F or higher. By reduction of air flow to reach exhaust levels of 8-10 percent or higher and proper design of the heat recovery system, it may be possible to achieve overall heat recoveries of 85 percent or greater. For purposes of cost estimation, however, it was assumed that only 70 percent heat recovery efficiency could be reached.

6.4.3 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from paper coating operations. Most operational systems on coating lines were installed because they were profitable. Pollution control has usually been a minor concern. Carbon adsorption systems on coating lines range in size from a few thousand to tens of thousands of cubic feet per minute. Exhausts from several coating lines are often manifolded together to permit one carbon adsorption unit to serve several coating lines.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing solvent may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. If this solvent mixture is recovered, it sometimes cannot be reused in formulating new batches of coatings. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In this case, solvents must be separated by distillation.

However, in some cases azeotropic, constant boiling, mixtures can occur which can be separated only by specialized techniques. Most coating firms would not have the skills necessary for the complex distillation and separation procedures needed. For small adsorption systems, the additional separation expenses would probably exceed the cost of fresh solvent.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem where steam is used for bed regeneration. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

The Textile Leather Division of the General Tire Company has had a carbon adsorption system in operation for several years on a coating line using methyl ethyl ketone. The system uses steam regeneration of the bed and requires distillation of the recovered solvent to remove its water content. No major difficulty has been encountered with the operation of the combined system; they would probably use carbon adsorption again to comply with the proposed regulations particularly if solvent prices continue to increase. Most other vinyl coaters also thought the carbon adsorption would probably be the most cost effective system in the long run.

6.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for fabric coating in the state. Where possible, the validity of the costs were confirmed with coating firms and equipment manufacturers.

6.5.1 Estimated Compliance Costs

Exhibits 6-9 and 6-10, following the next page, summarize costs for typical incineration and carbon adsorption systems as developed by EPA sources[1]. These are based on the assumption that exhaust flow rates can be reduced sufficiently to obtain LEL levels of 25 percent. This is possible with well-designed capture systems where intake air flows can be reduced.

The major problem in estimating individual installed costs of control systems is the added cost of installation. The EPA estimates were made on the assumption of an easily retrofitted system. In practice, coaters have found actual installed costs to be three to five times those summarized in Exhibit 6-9 and 6-10. For instance, E.I. DuPont de Nemours, based on their experience on actual installed equipment, estimates[2] $1.2 million for a carbon adsorber to treat 15,000 scfm of exhaust gases. Recent prices from recuperative type incinerator manufacturers for a 15,000 scfm direct fired, ceramic bed primary recuperative heat exchanger are about $150,000 for the incinerator alone. Installed costs, with provision for return of exhausts for secondary heat recovery, are estimated at more than $300,000. The estimates in Exhibits 6-9 and 6-10 indicated costs of $320,000 for an equivalent adsorber, and $140,000 for the incinerator.

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[1]EPA 450/2-76-028 Op. Cit.

[2]T.A. Kittleman and A.B. Akell, "The Cost of Controlling Organic Emissions," Chemical Engineering Progress, April 1978.

The study team has, for the purposes of this report, multiplied the capital costs provided in the EPA report by three to provide what is believed to be a more realistic add-on device equipment cost. In addition, costs have been added to adsorber systems for the installation of a distillation and solvent purification system for recovery and reuse of solvent. From discussions with the coaters affected, methyl ethyl ketone is the primary solvent used. For recovery, a distillation system will be required for separation of the solvent from the condensed steam used for carbon bed regeneration.

Overall compliance costs were based on the assumption that air flow rates could be reduced to allow operation at 25 percent of LEL and that volatile organic compounds were emitted only during actual coating periods. Total actual coating time per year was assumed to be 3,120 hours. This is equivalent to 260 days per year at 12 hours per day and was selected as a reasonable average yearly operating period on the basis of discussions with personnel from the plants affected.

Total estimated capital and annual operating costs for all affected plants in Ohio are summarized in Exhibit 6-11, following Exhibit 6-11. The annual direct operating costs are based primarily on cost data presented in the previously referenced EPA report (EPA 450/2-76-028)[1] adjusted for reduced operating time, capital cost charges increased by a factor of three, the addition of distillation solvent purification costs and, in the case of adsorption, savings due to recovery of methyl ethyl ketone. Other general assumptions are summarized in Exhibit 6-11, following Exhibit 6-10.

Total compliance costs are estimated as summarized in Exhibit 6-12 at about $10 million in capital and $1 million in annualized costs. The low annual cost is due largely to the savings from recovered solvent when carbon adsorption is used. Slight savings in fuel costs are also effected by the use of secondary heat recovery in the incinerator systems. Both capital and annualized costs are subject to a number of errors because of the assumptions used. The basic one is the installation costs of the control system used because of uncertainties concerning retrofit situations, the need for drying oven or coating-machine. Individual site costs may be considerably higher (or lower) than those estimated on an average basis as done here because of characteristics and needs of the actual coating operations. A more accurate estimate can only be made by a detailed examination of each plant site and coating line.

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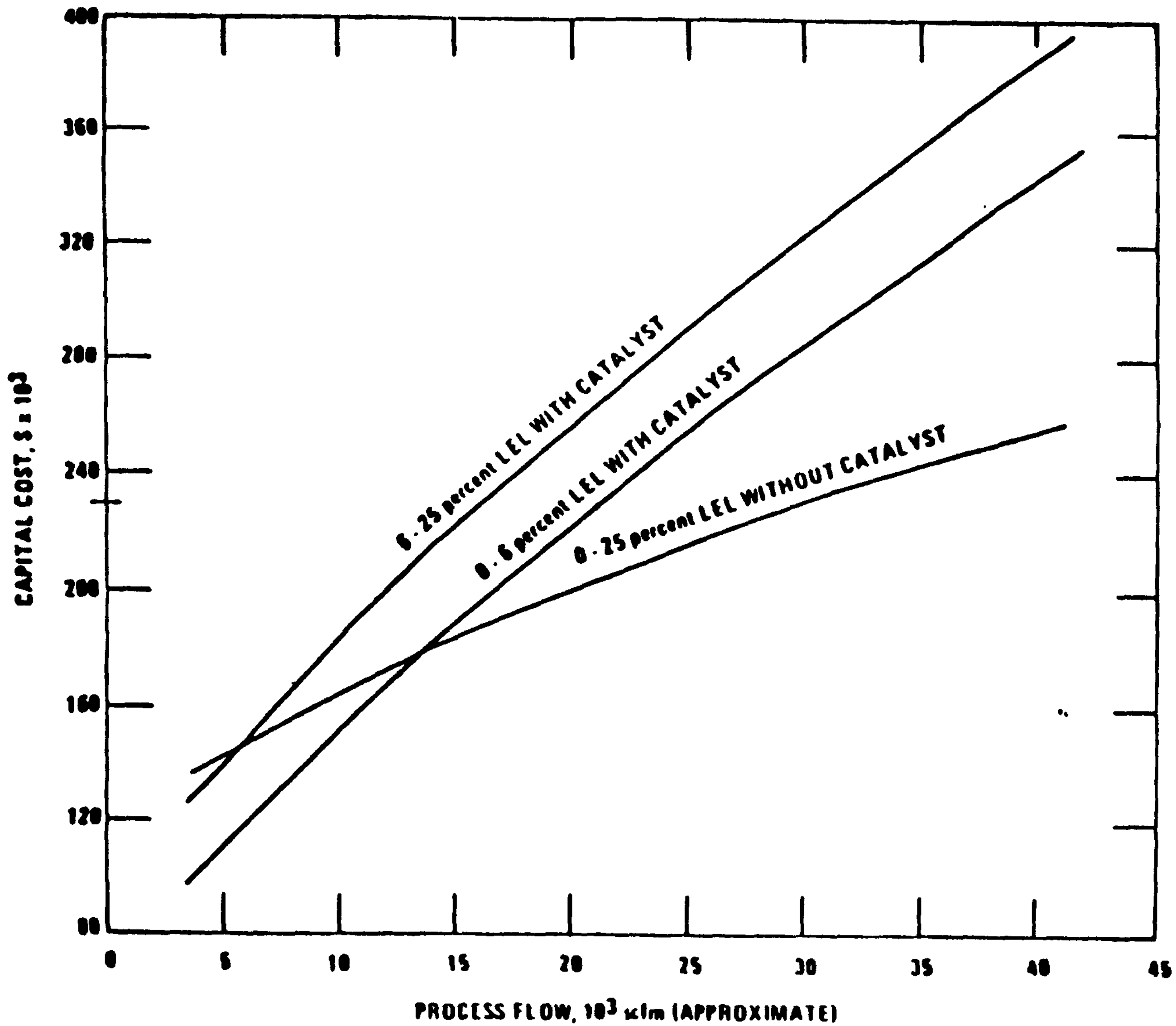
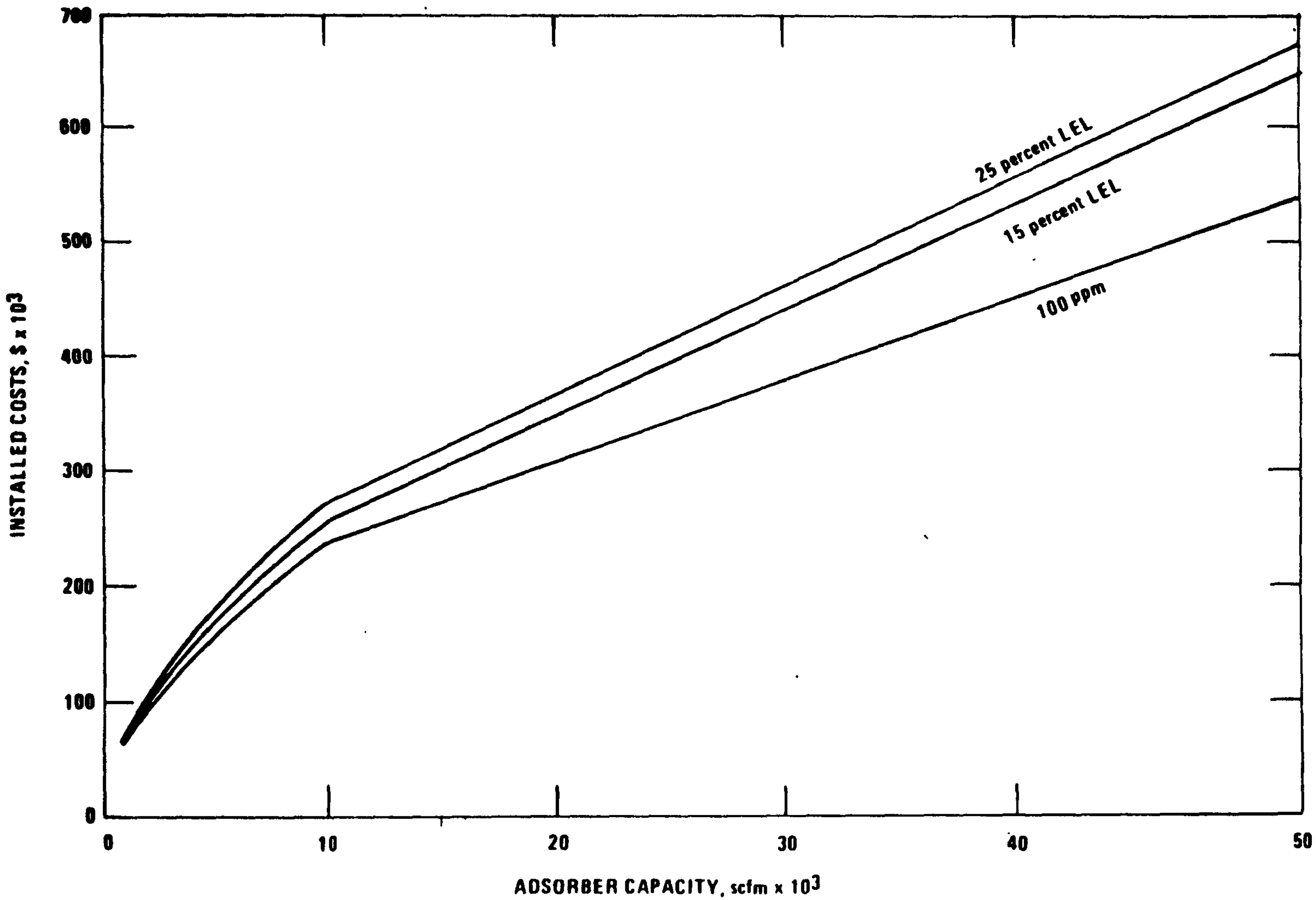
[1]This report should be reviewed for details on capital and annualized cost estimation methods.

EXHIBIT 6-9
U.S. Environmental Protection Agency
CAPITAL COST FOR DIRECT FLAME AND CATALYTIC INCINERATORS WITH PRIMARY AND SECONDARY HEAT EXCHANGE



Source: Control of Volatile Organic Emissions from Stationary Sources, Volume I (EPA-450/2-76-028)

EXHIBIT 6-10
US. Environmental Protection Agency
ESTIMATED INSTALLED ADSORBER SYSTEM COST



Source: Control of Volatile Organic Emissions from Stationary Sources Volume I (EPA-450/2-76-028)

EXHIBIT 6-11
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE

Assumptions

25 percent of emissions are controlled by incineration with primary and secondary heat recovery and 75 percent by carbon adsorption followed by distillation. 90 percent of solvent emissions from the coating lines are collected and the add-on control removes 90 percent of this. Total reduction is 81 percent. This degree of reduction may not be required in some cases where lower solvent concentration coatings are used.

25 percent LEL is equal to 4,250 ppm of methylethyl ketone by volume at 200°F.

Air flow can be reduced to reach 25 percent LEL

Emission rate is constant over a period of 3,120 hours per year.

Other assumptions regarding incinerator prices and operating parameters, as estimated in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations, EPA-450/2-76-028, are valid except that capital costs are increased by 300 percent and direct costs are increased by 25 percent to account for cost escalations from 1974-1977.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 6-12
U.S. Environmental Protection Agency
SUMMARY OF ESTIMATED COMPLIANCE COSTS
FOR FABRIC COATING IN OHIO

System	Capital	Solvent Recovery Savings	Net Annual Costs
Incineration	$ 1,600,000	-	$ 360,000
Carbon Adsorption	8,400,000	$2,050,000	650,000
Total	$10,000,000	$2,050,000	$1,010,000

Source: Booz, Allen & Hamilton Inc.

6.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of implementing the RACT guidelines for surface coating of fabrics on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), state economic variables and capital investment.

6.6.1 RACT Timing

Current proposed guidelines for fabric coating suggest three sets of compliance deadlines for alternative methods of compliance.[1] Generally, for add-on systems they call for installation of equipment and demonstration by mid-1980 or late 1980; for low solvent systems, by late 1980 or mid-1981, depending upon the degree of research and development needed. Major coaters, material suppliers and equipment manufacturers believe these deadlines to be unattainable.[2]

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months. A major paper coater with considerable experience with similar installations estimates that the complete cycle of installation, from initial selection of control method to testing of the system, would required 37 months plus an initial 12 months to establish an economically sound method of control.

- Only a small number of companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements by all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed.

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[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Source Categories, EPA-905/2-78-001.

[2] Refer to list of firms interviewed.

- A major coating firm estimates that the use of low solvent or solventless coatings may take as long as 68 months from initial research, through product evaluation and customer acceptance to final production. Product and process development alone may take as long as 24 months and product evaluation over 14 months.

In general, it appears that if either add-on control systems are used or new low solvent systems need to be developed, deadlines may need to be extended.

6.6.2 Technical Feasibility Issues

As discussed above, low solvent or solventless materials are used in many coating operations. At present, however, many types of solvent-based systems have no satisfactory replacement. The alternative materials do not meet the product quality standards demanded by the coaters. Additional development is needed and will require the combined efforts of both the coaters (who must maintain product quality) and the coating material suppliers. Ideally, the new coating materials should be adaptable to existing coating equipment to minimize additional capital investment.

As discussed above, both incineration and carbon adsorption are not completely satisfactory add-on control systems. Incineration requires large volumes of additional fuel if good heat recovery is not achieved; carbon adsorption is not useable on many coating systems because of the multiplicity of compounds used in solvent mixtures.

6.6.3 Comparison of Costs with Selected Economic Indicators

The net increase in the annual operating costs to coaters cannot be estimated with a high degree of confidence since operating costs are highly sensitive to various retrofit situations, the efficiency of heat recovery and other factors, as discussed above. Based on the estimated annual costs of about $1.0 million as presented in Exhibit 6-11, and the estimated value of shipments (about $3.0 million) of the firms affected compliance costs would be about 0.3 percent of the value of shipments. In a recent report,[1] increased annual costs for control of emissions from a rubber coating line using carbon adsorption with recovered solvent priced at fuel value only were estimated to be about 0.9 percent of the price of the finished rubberized fabric.

[1] Springborn Laboratories, Inc., op. cit.

The major economic impact in terms of cost to individual companies will probably be a result of capital related rather than increased annualized costs. The capital required for RACT compliance will represent a significant amount of capital appropriations for most firms and may force some plants to shut down noncompetitive operations (a comment made by several firms interviewed).

6.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Total employment in the state is expected to be marginally affected since about 2,600 workers are employed by the plants identified. Some plants may terminate some coating operations if compliance costs are prohibitive.

Within the state, the market structure will probably not be appreciably affected by the proposed regulation. Five of the firms have essentially the same product line (coated vinyl fabric) and would be affected about equally. A special situation may occur, however, for marginally profitable plants, which may find the added cost of compliance prohibitive and may be forced to close operations. This was not investigated. The sixth firm, has a different product line and would be affected differently from the other firms; exactly how was not evaluated. All firms, however, may be affected by an uneven imposition of compliance to competitors in other states. This would affect their competitiveness in the marketplace, since costs of compliance could increase the price of coated goods by about 0.3 percent or more.

Productivity is not expected to be affected except for a short period when lines must be shut down for modifications or installation of equipment.

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Exhibit 6-13, on the following page, summarizes the conclusions and projected implications of the results from this study.

EXHIBIT 6-13
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR FABRIC COATERS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	Six firms were identified as being affected by the proposed regulation
Indication of relative importance of industrial section to state economy	Total value of shipments by the plants identified could not be determined. These plants employ about 2,600 persons
Current industry technology trends	Newer plants are built with integrated coating and emission control systems; older plants are only marginally competitive now
1977 VOC emissions (actual)	Current emissions are estimated at about 7,500 tons/year
Industry preferred method of VOC control to meet RACT guidelines	Direct fired incineration or carbon adsorption for short range; low solvent coatings are a long range goal
Assumed method of VOC control to meet RACT guidelines	Direct fired incineration with primary and secondary heat recovery and carbon adsorption with distillation

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Study team estimate is about $10 million
Annualized operating cost (statewide)	Approximately $1.0 million
Price	Assuming a "direct pass-through of costs" prices of coated fabrics will increase by about 0.3 percent
Energy	Assuming 70 percent heat recovery about 34,000 equivalent barrels of additional fuel oil would be required per year
Productivity	No major impact
Employment	No major impact
Market Structure	No change in market structure within the state is anticipated; firms affected have different product lines or are about the same size
RACT timing requirements (1982)	Plants may have problem in control equipment deliveries
Problem areas	Additional capital and operating costs may make the plants uncompetitive with more modern and efficient ones Capital and operating costs can only be approximated because of unknown retrofit situations
VOC emissions after RACT control	1,500 tons/year (20 percent of 1977 VOC emission
Cost effectiveness of RACT control	$170 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

T. A. Kittleman and A. B. Akell, "The Cost of Controlling Organic Emissions," Chemical Engineering Progress, April 1978.

Springborn Laboratories, Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report. EPA Contract No. 68-02-2075, August 23, 1977.

Textile Economics Bureau, Technicon. November 1977.

Davidson's Textile Blue Book, 1977.

Rubber Red Book, New York, Palmerton Publishing Company, 1978.

Modern Plastics Encyclopedia, New York, McGraw-Hill, 1978.

Thomas Register of American Manufacturers, 1978.

Ohio Directory of Manufacturers, 1977.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I. EPA-450/2-76-028, May 1977.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II. EPA-450/2-77-008, May 1977.

U.S. Environmental Protection Agency, Regulatory Guidance for Control of Volatile Organic Compounds Emissions from 15 Categories of Stationary Sources. EPA-905/2-78-001, April 1978.

U.S. Department of Commerce, County Business Patterns, 1976.

Private conversations at the following:

- Canvas Products Manufacturers Association
- Bobst-Champlain
- REECO, Inc.
- Overly, Inc.
- Textile Economics Institute
- Technical Systems
- Borden Chemical Company, Columbus Coated Fabrics Division, Columbus, Ohio
- Chrysler Corporation, Sandusky, Ohio
- Custom Coated Products, Cincinnati, Ohio
- General Tire Corporation, Textile Leather Division, Toledo, Ohio
- Inmont Corporation, Toledo, Ohio
- Uniroyal, Port Clinton, Ohio

7.0 ECONOMIC IMPACT OF IMPLEMENTING RACT FOR THE SURFACE COATING OF AUTOMOBILES IN THE STATE OF OHIO

7.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF AUTOMOBILES IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT for surface coating of automobiles in the State of Ohio.

The capital cost and energy requirements to achieve the recommended RACT limitations were anticipated to be higher than for any other industrial category studied. In addition, the EPA is currently considering modifying the limitations in certain areas. Therefore, the economic impact and analysis for surface coating of automobiles is presented in two scenarios of RACT implementation:

- RACT compliance by 1982
- Modified RACT timing requirements (and possible limitations) to meet developing technologies.

To the extent that light duty trucks are also manufactured in the same automobile assembly plant, their impact is included. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Emissions and current controls
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of the application of surface coatings on automobiles, interviews, industry public hearing submissions and analysis.

7.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact

for the surface coating of automobiles in Ohio.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

7.1.1 Industry Statistics

The potentially affected facilities were identified from the emission inventory and from Ward's Automotive Yearbook. Detailed industry statistical data for value of shipments, capital expenditures, employment, etc., were not available for the state in secondary sources. Therefore, these estimates were factored from national data based on the number of units output in the state and study team analysis.

The number of units manufactured in 1976 was obtained from Ward's Automotive Yearbook.

7.1.2 VOC Emissions

Booz, Allen estimated the 1977 VOC emissions based on information provided by industry interviews, submissions to public hearings and typical emission rates for automobile assembly plants that were reported in other states studied in EPA Region V.

7.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emmission for the surface coating of automobiles are described in Control of Volatile Organic Emissions from Existing Stationary Sources--Volume II (EPA-450/2-77-008, May 1977). Manufacturers were interviewed to ascertain the most feasible types of control for organic emissions in the coating of automobiles.

7.1.4 Cost of Control of VOC Emissions

The costs of control of volatile organic emissions were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining system components
- Developing installed capital costs for modifications of likely coating processes based on industry estimates, EPA estimates and Booz, Allen study team judgment
- Developing costs of control for the likely coating processes on a model plant basis:
  - Installed capital costs
  - Direct operating costs
  - Annual capital charges
  - Energy requirements
- Applying model plant costs to the specific facilities affected in the state and aggregating costs to the total industry for the state.

These costs were presented for two scenarios of RACT implementation:

- RACT compliance by 1982
- Modified RACT timing requirements and possible limitations to meet developing technologies.

Under the first scenario (RACT compliance by 1982), a waterborne system similiar to the systems used in developing RACT guidelines was studied.

Under the second scenario, a high solids enamel topcoat system (or other equivalent technology) that is not fully developed (commercially for automobile coatings) was studied.

7.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Ohio.

7.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of automobiles in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data, (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 7-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 7-1
U.S. Environmental Protection Agency
SURFACE COATING OF AUTOMOBILES
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions		X	
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

7.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for automobile assembly plants in Ohio are presented in this section. Data in this section form the basis for assessing the impact of implementing RACT for control of VOC emissions for automobile manufacturing plants in the state.

7.2.1 Size of the Industry

There are five major automobile and light duty truck manufacturing facilities that would be affected by the RACT guidelines in Ohio. General Motors has two assembly plants in Lordstown and Norwood. Ford has two assembly plants in Lorain and Avon Lake, and American Motors has an assembly plant in Toledo. Exhibit 7-2, on the following page, presents the potentially affected facilities and the approximate number of automobiles manufactured.

In 1977, there were approximately 700,000 automobiles manufactured in Ohio, approximately 8.7 percent of the automobiles manufactured in the U.S. There are two states that currently manufacture more automobiles than Ohio, but only one (Michigan) has appreciably more automobile production. The table below presents the percent of U.S. car production by state for the 1976 model year.

State	Percent of U.S. Total Automobile Production
Michigan	33.9
Missouri	9.2
Ohio	8.7
New Jersey	6.8
California	6.7
Georgia	6.6
Wisconsin	6.4
Other states	21.7

Additionally, there were approximately 430,000 light duty trucks manufactured at the facilities in Ohio. The 1977 value of shipments of automobile and light duty trucks in Ohio is estimated to be $5.5 billion. These manufacturing facilities employ approximately 31,000 employees. The capital expenditures for these five plants is not available; however historically the auto industry nationwide expenditures for new plant and new equipment is 1-2 percent of the value of shipments.

EXHIBIT 7-2
U.S. Environmental Protection Agency
LIST OF POTENTIALLY AFFECTED
FACILITIES BY THE RACT
GUIDELINE FOR SURFACE COATING
OF AUTOMOBILES--OHIO

Company or Division	Location	Make and Type of Vehicle Manufactured	Automobile Production for 1976 Model Year	Truck Production for the 1976 Model Year
Ford-Automotive Assembly Division	Lorain	LTD II Cougar Econoline Vans	175,000	---
Ford	Avon Lake	Club Wagons	44,000	174,000
General Motors: GM Assembly	Lordstown	Chevrolet Buick Oldsmobile Pontiac Chevrolet GMC vans	234,000	129,000
General Motors: GM Assembly	Norwood	Chevrolet Pontiac	252,000	---
Jeep Corporation (American Motors Corp.)	Toledo	Jeep-trucks, wagoneers, CJ-5, CJ-7, Cherokee	---	127,000
Total, Ohio (Approximately 8.7 percent of U.S. total automobile production)			706,000	430,000

Source: Plants of U.S. Motor Vehicle Manufacturers, 1978, Motor Vehicle Manufacturers Association of the United States, Inc.

7.2.2 Comparison of the Industry to the State Economy

The Ohio automobile and light duty truck assembly industry employs 2.4 percent of the state labor force, excluding government employees. The value of shipments from automobile assembly plants represents approximately 6.2 percent of the statewide value of products manufactured.

7.2.3 Characterization of the Industry

The RACT guidelines apply only to automobile assembly plants and not to custom shops, body shops or other repainting operations. The automobile assembly industry receives parts from a variety of sources and produces finished vehicles. Various models, usually of the same general body style, may be built on an assembly line. Assembly lines typically operate at 30 to 75 vehicles per hour and produce approximately 4,000 vehicles per year.

The automobile manufacturing industry is unique in that these companies are large and have extensive expertise in the coatings technology developed. The surface coating of the automobile must offer adequate protection against corrosion as well as provide an attractive appearance and durability for the customer. In developing technologies to meet the market needs, the manufacturers have invested extensive capital in specific technologies. The major difference in current technology within the industry is the raw material and the associated equipment used for top coating applications. General Motors has traditionally utilized lacquer systems while other manufacturers traditionally utilize enamel coatings. In 1977, there were only two plants using waterborne enamels, Van Nuys and South Gate California, both General Motors facilities. For prime coating of automobiles there has been a recent trend towards water-based cathodic electrodeposition because of the increased coverage, uniformity and paint recovery. Some of the anodic electrodeposition facilities installed in the late 1960s and 1970s have converted to cathodic to eliminate odor problems and further improve corrosion protection. However, the majority of the plants in the U.S still utilize spray, dip or flow coating with solvent-based coatings.

7.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents an overview of the types of coating process alternatives that might be used to reduce emissions from the surface coating of automobiles.

7.3.1 Process Description of Surface Coating of Automobiles

There are two major process areas for the surface coating of automobiles:

- Prime coat
- Topcoat.

Processes for assembly of automobiles are described in Control of Volatile Organic Emissions from Existing Stationary Sources--Volume II (EPA-450/2-77-008, May 1977).

This section provides a summary of central technologies that may be used for reducing solvent emissions.

7.3.1.1 Primers

The prime coat serves the dual function of protecting the surface from corrosion and providing for good adhesion of the topcoat. Currently, most primers used are organic solvent-borne and are applied by a combination of manual and automatic spray, dip or flow coating methods. However, there are a number of new low-organic solvent-based primers, now used in limited quantities, that could replace these:

- Electrodeposition primers--These are electrophoretically deposited waterborne primers. The process can be either cathodic or anodic. The cathodic, which was developed more recently, offers an improved corrosion protection but does have slightly more VOC emissions than the anodic process. Many automobile assembly facilities have recently invested substantial capital to convert facilities to the cathodic electrodeposition process.

- Waterborne primers--These are waterborne primers that are applied by spray, dip or flow coating processes. The processes require less capital than an electrodeposition process but do not offer the product quality advantages.

- Powder primers--This technology is still in early development stages but it could offer significant emission reductions. Major technical problems to date have been the significant processing changes required and product smoothness.

7.3.1.2 Topcoats

Two types of topcoats are currently used in industry--lacquers and enamels. Most General Motors facilities are based on lacquer technology while the other automobile manufacturers all employ enamel topcoats. There are a number of technology developments which may apply in future periods.

- Waterborne topcoats--Reductions in organic solvent emissions of up to 92 percent from topcoat spray booths and ovens are achievable using waterborne topcoats. The exact reduction depends on both the original coating and the replacement. If, for example, the lacquer (6.5 pounds of organic solvent per gallon of coating) and the waterborne had 2.8 pounds of organic solvent per gallon of coating (as do GM coatings in California), reduction would be 92 percent. If the original coating were 33 volume percent solids, reduction would be 70 percent.

  Waterborne topcoats are currently being used at two General Motors automobile assembly plants in California on a full-scale basis. Although there can be no argument as to the technical feasibility of waterborne topcoats, the number of major process modifications necessary to retrofit this technology to an existing plant are significant (often requiring a completely new processing line). Also, the utilization of energy is much greater than for solvent systems.

- Powder coatings--Acrylic powder coatings have been evaluated as topcoats for General Motors and Ford cars on a development basis at Framingham, Massachusetts, and Metuchen, New Jersey. Along with process color change and other difficulties that are potentially correctable, the greatest remaining obstacle to powder utilization as an automotive topcoat is the lack of an acceptable metallic color. This commercial unacceptability of powder metallic colors would be a particular problem, since over 50 percent of cars manufactured over the past several years have been metallic.

  Although very low in hydrocarbon emissions, powder coating do not represent a viable approach for automobile manufacturers in the near-term future.

- High solids (60-80 percent by volume solids) two-component urethanes--Considerable research effort is being devoted to high solids (60-80 percent by volume solids) low-temperature curing urethane systems. Experience with urethanes in general in the aircraft industry indicates excellent weathering and environmental resistance at the low coating weights required on aircraft, although the urethanes used are not at 60-80 percent solids as applied.

  At this point in time, there does not appear to have been any major evaluation by automotive manufacturers of the high solids materials.

  High solids urethane systems do offer significant potential in reducing emissions and energy costs, but would not be expected to be available for automotive use in the near future.

  An additional problem with urethanes is the exposure to isocyanates from the coatings. Exposure woul have to be minimized to assure worker safety.

- High solids (35-55 percent by volume solids) dispersion lacquers--Many suppliers have taken an intermediate approach to high solids systems. For example, a 55 percent solids dispersion system is currently in use on trucks in Canada on an advanced development basis. High solids dispersion systems (35 percent) have also recently been evaluated at an Oldsmobile plant.

  None of these, however, have been production proven on automotive lines and additional development would be required to evaluate their performance.

- High solids (30-62 percent by volume solids) enamels--All major automobile manufacturers other than General Motors use enamel topcoats. The average solids content of enamels currently being applied is approximately 30 percent; metallic colors usually have a lower solids content. Paint suppliers and the automotive industry are actively attempting to achieve higher solid enamels.

In the short term (one to two years) some high solids colors may be available for use; however, it is unlikely that the full color offering (especially metallics) could be converted to high solids technology.

7.3.2 Emissions And Current Controls

This section presents the estimated VOC emissions from automobile assembly facilities in Ohio in 1977 considering the current level of emission controls implemented in the state. Exhibit 7-4, on the following page, shows the estimated emissions in 1977 from the three major companies. The VOC emissions are estimated based on the following level of current control and coating processes:

- General Motors has two facilities, located at Lordstown and Norwood. The total VOC emissions from these facilities are approximately 10,000 tons per year.
  - The Lordstown automobile assembly facility currently utilizes the following types of coating systems:
    - Cathodic electrodesposition primers
    - A solvent-based primer surfacer (15 to 20 percent solids)
    - A dispersion acrylic lacquer topcoat (approximately 18 percent solids).
  - For light duty trucks manufactured at Lordstown the assembly facility utilizes the following type of coating systems:
    - Cathodic electrodesposition primer
    - A solvent-based primer surfacer (15 to 20 percent solids)
    - An enamel topcoat(approximately 28-32 percent solids
  - The Norwood automobile assembly facility currently utilizes the following types of coating systems:
    - Cathodic electrodesposition primer
    - A solvent-based primer surfacer (15 to 20 percent solids)
    - An acrylic lacquer topcoat (approximately 13 percent solids).

EXHIBIT 7-4
U.S. Environmental Protection Agency
OHIO VOC EMISSIONS--SURFACE
COATING OF AUTOMOBILES AND
LIGHT DUTY TRUCKS

Company Name	Locations	Estimated 1977 VOC Emissions (tons per year)
General Motors	Lordstown, Norwood	10,000
Ford Motor Company	Lorain, Avon Lake	2,500
American Motors	Toledo	1,150
Total, 1977		13,650

Source: Booz, Allen & Hamilton Inc., analysis of emission estimates supplied by industry, reported current controls and processes at the affected facilities, and VOC emissions for similiar coating technologies reported in other states of EPA Region V.

- Ford Motor Company has two facilities located at Lorain and Avon Lake. The total VOC emissions from these facilities are approximately 2,500 tons per year. The coating systems utilized are similiar at both plants.

  - Cathodic electrodesposition is used for the prime coat.

  - The primer surfacer used is a 55 percent volume solids (guide coat).

  - A 28 to 32 percent solids enamel is used for the top coat.

- American Motors has an assembly facility in Toledo, Ohio. The VOC emission from this facility is approximately 1,150 tons per year.

  - There are two different primer coats applied to the auto bodies:

    - An epoxy dip primer at 38 percent solids

    - A reinforcement spray primer at 30 percent solids.

  - The topcoat is an enamel system at 30 percent solids (±5 percent).

7.3.3 RACT Guidelines

The RACT guidelines (as recommended in EPA-450/2-77-008) for VOC emission control specify the amount of allowable VOC in pounds per gallon of coating, minus any water in the solvent system. The RACT guidelines have established different limitations for each process operation. These recommended limits are shown in the table below.

Affected Process Operations	Average Lbs. VOC/ Gallons of Coating Minus Water
Prime application and flash-off area and oven	1.9
Topcoat application, flash-off area and oven	2.8
Final repair application, flash-off area and oven	4.8

These limits apply to all objects surface coated in the plant, including the body, fenders, chassis, small parts, wheels and sound deadeners. They do not apply to adhesives.

These guidelines, as stated, are very specific to certain types of control options, either in emission limit or timing, that may be subject to change by the EPA, in the near future.

- The prime coat application limitations were based on an anodic electrodeposition system followed by a 25 percent solids waterborne surface coat for thickness and improved adhesion of the topcoat. Since the guideline development, it has been recognized that a cathodic electrodeposition system offers additional benefits especially in the areas of increased corrosion protection and odor control. With current coating technology, the 1.9 pounds per gallon limitations of the RACT guidelines cannot be achieved with a cathodic system (emissions would be approximately 2.1 pounds per gallon). In light of continued technology development and potential change in limits, it was assumed for purposes of this anaylsis, that a cathodic electrodeposition process with emissions of approximately 2.1 pounds per gallon would meet the RACT requirements.

- The topcoat limits were based on water borne systems that were introduced at the General Motors South Gate and Van Nuys, California, facilities to meet Los Angeles emission regulations. For purposes of this analysis, two scenarios were assumed in which RACT topcoat limitations could be met(1) waterborne coatings and (2) other technology with equivalent emission character. It is anticipated that new technology will be developed which will effect reductions equivalent to water borne coatings at lower costs and energy use.

7.3.4 Selection of the Most Likely RACT Alternatives

Projecting the most likely industry response for control of VOC emissions in automobile assembly facilities is complicated by the different processing techniques manufacturers have in place and the potential change of recommended RACT limitations. Several general assumptions can be made.

- The RACT limitations as recommended (EPA-450/2-77-008) for prime coat application, flash-off area and oven are specifically based on use of an anodic electrodeposition system followed by a 25 percent solids waterborne coating. Recent technology developments in cathodic electrodeposition provide an improved system (versus anodic electrodeposition) and, therefore, this is likely to be the preferred industry response wherever feasible. A cathodic system has somewhat higher solvent content than anodic electrodeposition systems, the capital and operating costs for both electrodeposition systems are similar.

- The RACT limitations, as recommended for topcoat application, flash-off area and oven, are specifically based on use of waterborne coatings at two General Motors facilities. Although this alternative is extremely capital and energy intensive, it is the only currently available proven alternative that would meet the recommended RACT limitations, if compliance is required by the 1982 timeframe.

- Other topcoat coating technologies (such as high solids enamels, urethane enamels or powder coatings) could potentially offer significant emission reduction and be cost effective for manufacturers. However, these technologies are at various stages of development and none have been technically proven for an automotive assembly plant.

- The industry will install incinerators only as a last resort if there is no economically feasible low solvent coating technology available. The annual cost of energy requirements for the incineration of large volume and low concentration air flows (such as would be required to control the total facility) is generally cost prohibitive. Incineration may, however, be used in combination with coatings of reduced solvent content to produce emission levels in accord with the RACT guidelines. For instance, an assembly plant using a topcoat enamel system may use a higher solids enamel and incinerate a portion of the emission from the spray booths or ovens.

- Carbon adsorption systems are not a likely control alternative because of the large air flow rate of the spray system.

Due to the uncertainty of the industry response to the RACT recommended limitations, two scenarios of selection of alternatives were developed for purposes of this study.

- Scenario I (High Side)--the industry response to meet the recommended RACT limitations by 1982 would be:

    - Prime coat--anodic or cathodic electrodeposition

    - Topcoat--waterborne coating

    - Final repair--solvent-borne enamel with 35 percent solids

- Scenario II (Technology Dependent)--RACT timing requirements and possibly emission limitations are modified to meet developing technologies.

Exhibit 7-5 and 7-6, on the following pages, present the selection of the most likely RACT alternatives under the two scenarios.

EXHIBIT 7-5
U.S. Environmental Protection Agency
SELECTION OF THE MOST LIKELY RACT ALTERNATIVES UNDER SCENARIO I (RACT COMPLIANCE BY 1982)

Processing Area	Control Alternatives	Discussion
Primer	Anodic electrodeposition primer followed by waterborne "surfacer"	Very low VOC emission levels are achievable yet system has some technology disadvantages to other alternatives
	Cathodic electrodeposition primer followed by a waterborne or high solids "surfacer"	Offers improved corrosion protection and eliminates odor problem of anodic "E-coat" VOC emission levels are moderately higher than the recommended RACT limitations
	Spray, dip or flow coat solvent-based primers with incineration	High operating cost for energy demands
Topcoat	Waterborne enamels	Only technologically proven alternative that would meet the RACT requirements Extremely high capital cost and energy requirements
Repair	35 percent solids enamel	Technology is not fully developed, i.e., some colors cannot be matched with currently available coatings
	Current or modified coatings with incineration	High operating cost for energy demands

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 7-6(1)
U.S. Environmental Protection Agency
SELECTION OF THE LIKELY RACT
ALTERNATIVES UNDER SCENARIO II
(MODIFIED RACT TIMING AND POSSIBLY
LIMITATIONS)

Processing Area	Control Alternatives	Discussion
Primer	Anodic electrodeposition primer followed by waterborne "surfacer"	Very low VOC emission levels are achievable yet system has some technology disadvantages to other alternatives
	Cathodic electrodeposition primer followed by a waterborne or high solids "surfacer"	Offers improved corrosion protection and eliminates odor problem of anodic "E-coat" VOC emission levels are moderately higher than the recommended RACT limitations
	Other spray, dip or flow coat primers with incineration	High operating cost for energy demands
	Powder coatings	Undeveloped technology however, has potential applications for use on steel or as "surfacer" Low VOC emission levels might be achievable and cost effective
Topcoat	Waterborne enamels	Only technologically proven alternative that would meet the RACT requirements Extremely high capital cost and energy requirements

Processing Area	Control Alternatives	Discussion
	High solids enamels	Technology to achieve the 62 percent solids required by RACT limitations is not developed. However, paint suppliers are optimistic for potential application of up to a 55 percent solids enamel
		If technology develops, only minor modifications would be required -t facilities curren. using enamels
		Major modifications would still be required for facilities using lacquer coatings
	Urethane enamels	Technology is not developed
		Potentially large energy savings and improved properties
		Toxicity protection is required for workers
	Powder	Technology is not developed
		Potential energy and recovery savings
		Color limitations
Repair	35 percent solids enamel	Technology is not fully developed, i.e., some colors cannot be matched with currently available coatings

Processing Area	Control Alternatives	Discussion
	Current or modified coatings with incineration	High operating cost for energy demands

Source: Booz, Allen & Hamilton Inc.

7.4 COST AND VOC BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for the two assumed scenarios of alternative VOC emission controls are presented in this section. Under Scenario I, it is assumed that the RACT requirements would be met by a waterborne system. Under Scenario II, it is assumed that the RACT timing requirements (and possibly limitations) are modified to meet developing technologies. The costs presented in this section are based on studies performed by the EPA and automobile manufacturers to determine the estimated costs for actual plants. The study team utilized published data to develop the cost estimate presented in the section. The final section presents an extrapolation of the typical costs for automobile assembly plants to meet the RACT requirements for the two scenarios.

7.4.1 Costs for Alternative Control Systems under Scenario I

Under Scenario I, it is assumed that the RACT requirements must be met with existing proven technology. Therefore, the following control alternatives are assumed:

- Cathodic or anodic electrodeposition of primers. Although the RACT requirements of 1.9 pounds of VOC emissions per gallon of coating are specific for the anodic process, this analysis assumes that cathodic electrodeposition of waterborne coatings would meet the RACT requirements
- Waterborne topcoat system
- 35 percent volume solids enamel repair system.

A electrodeposition waterborne system can be used only directly over metal or other conductive surfaces. Although the system offers an improved product advantage over other types of primer application methods, the conversion represents a significant capital cost. The cost of conversion for a typical electrodeposition system at an automobile assembly plant is presented below.[1] Costs will vary significantly depending on the retrofit situation.

- The installed capital cost would be approximately $10 million to $12 million, not including additional energy requirements (if necessary).
- Direct operating costs (utilities, direct labor and raw materials) would be approximately $20,000 less annually than conventional application techniques.

1 These cost estimates were developed by the Booz, Allen study team after a review of operating costs reported in "Control of Volatile Organic Emissions From Existing Stationary Sources" - Volume II (EPA-450/2-77-008) and estimates provided by General Motors, Ford MOtor Company, and American Motors in Technical Support Documentation for the States of Ohio, Illinois and Wisconsin.

- Interest, depreciation, taxes and insurance are estimated to be approximately $1.5 million annually (assuming 15 percent of capital investment based on a 20-year equipment life).

- Therefore, the total annualized cost of the conversion to an electrodeposition waterborne system would be approximately $1.5 million.

- The additional energy demands are estimated to be approximately 5 million to 6 million kilowatt hours per year.

If the electrodeposition system were anodic, the resulting VOC emissions for the priming operation including primer surfacer would be approximately 1.9 pounds of VOC per gallon of coating. If the electrodeposition system were cathodic, the resulting VOC emissions would be approximately 2.5 pounds of VOC per gallon of coating. For purpose of economic analysis it is assumed that both anodic and cathodic EDP require essentially equivalent capital and operating costs.

The conversion of the topcoat application to a waterborne system would require extensive modification of the existing facilities, essentially equivalent to the cost of new line. The conversion would require changes, such as humidification equipment, a longer spray booth, new ovens, replacement of existing piping with stainless steel piping, sludge handling equipment, floor conveyors (for some facilities) and additional power generating equipment. The conversion cost for a waterborne system has been estimated by the EPA and all the major automobile manufacturers. These estimates may differ by 100 percent, depending on the particular facility being studied. After an evaluation of these cost estimates, the study team found that a typical facility is likely to incur the following costs to convert to a waterborne system.

- The installed capital cost would be approximately $40 million to $50 million, including additional power requirements.

- Incremental direct operating costs (utilities, direct labor and raw materials) would be approximately $750,000 annually, mostly for energy.

- Interest, depreciation, taxes, and insurance are estimated to be approximately $7 million annually (assuming 15 percent of capital based on a 25-year equipment life and 10 percent interest rate).

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1 These cost estimates were developed by the Booz, Allen Study team after a review of operating costs reported in "Control of Volatile Organic Emissions From Existing Stationary Sources" - Volume II (EPA-450/2-77-008) and estimates provided by General Motors, Ford Motor Company and American Motors in Technical Support Documentation for the states of Ohio, Illinois and Wisconsin.

- The annualized cost of the conversion to a waterborne system would be approximately $8 million.

- The additional energy demands are estimated to be equivalent to approximately 38,000 equivalent barrels of oil annually.

The resulting VOC emission from a waterborne topcoat system would be approximately 2.8 pounds of VOC per gallon of coating.

The cost of conversion to a 35 percent enamel for topcoat repair is assumed to be minimal in relation to the conversion costs for the other coating applications. A 35 percent topcoat repair enamel cannot be obtained today for all types of paints applied. However, this limitation might be met by incinerating a portion of the total emissions to achieve the equivalent of a 4.8 pounds per gallon limitation.

7.4.2 Cost for Alternative Control Systems under Scenario II

Under Scenario II, it is assumed that the RACT requirements are modified based on the following control alternatives.

- Cathodic or anodic electrodeposition of primers is used.

- High solids enamels, urethane enamels or powder coatings technologies are developed for topcoat application.

- 35 percent solids enamel is used for topcoat repair.

The conversion cost for a electrodeposition waterborne system would be the same as developed for Scenario I.

The conversion of the topcoat application to a high solids enamel, urethane enamel or powder coating would depend on the particular system applied and the current coating technology used by the manufacturer.

- Since three facilities in Ohio currently use enamel topcoating, this analysis assumes that they would meet the RACT requirements with high solids enamel technology developments.

- Under this scenario, minimal capital and operating costs changes would be required as the existing equipment is likely to be adjustable to higher solids coatings.

- The average VOC emissions per gallon of coating would depend on the high solids enamels that are developed. Depending on the timing constraints high solid enamels ranging from 40 percent to 63 percent could be achieveable based on projected technology developments that are currently being applied by other industrial sectors.

• For manufacturers that are currently using lacquer topcoat systems, there is likely to be significant capital requirement to meet further technology development:

  - A conversion to high solids enamel is likely to require changes in equipment, such as:

    .. conveyor systems
    .. ovens
    .. in-house repair
    .. spray systems
    .. sludge disposal system

  - The conversion requirements for urethane enamels or powder coatings is at too early a stage to estimate costs.

  - The equipment modifications would depend on the particular technology adapted at these facilities and the available equipment. Based on Booz, Allen study team estimates, the anticipated capital costs are likely to be less than $10 million per facility. Therefore, for purposes of this study, a judgmental analysis leads to the following cost determination to convert current lacquer processing:

    .. Capital cost of $10 million

    .. Annualized cost of $1.5 million (assuming 15 percent of capital cost)

Exhibit 7-7, on the following page, presents the conversion costs for the two scenarios developed.

7.4.3 Extrapolation to the Statewide Industry

Exhibit 7-8, following Exhibit 7-7, presents the extrapolated costs of meeting the RACT guidelines under two scenarios that were developed. These costs are based upon:

- The estimates of cost of compliance under the two scenarios that were presented in sections 7.4.1 and 7.4.2.

- The current processing techniques at the five potentially affected facilities in the state.

- Applying the model plant costs developed under each scenario to each specific facility affected in the state and aggregating the results (i.e., if cathodic electrodeposition is already in operation at a specific facility the cost compliance and the resulting potential emission reductions would not be included in this analysis).

EXHIBIT 7-7
U.S. Environmental Protection Agency
ESTIMATED COST FOR MODEL PLANT TO
MEET AUTOMOBILE RACT REQUIREMENTS

	Capital Cost ($ millions)	Direct Operating Cost ($ millions)	Annualized Capital Cost ($ millions)	Annualized Cost--Rounded ($ millions)	Energy Demand (equivalent barrels of oil)
SCENARIO I					
Primer	10-12	(0.02)	1.5-1.8	1.6	13,000
Topcoat	40-50	0.8	6.0-7.5	8	37,000
Final Repair	-	-	-	-	-
Total, Scenario I	50-62	0.78	7.5-9.3	9.6	50,000
SCENARIO II					
Primer	10-12	(0.02)	1.5-1.8	1.6	13,000
Topcoat					
(Enamel Facilities/ Lacquer Facilities)	<1/<10	-	<1.5	<1.5	-
Final Repair	-	-	-	-	-
Total, Scenario II	10-22	-	1.5-3.3	1.6-3.1	13,000

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 7-8
U.S. Environmental Protection Agency
STATEWIDE COSTS TO MEET THE RACT GUIDELINES
FOR AUTOMOBILE ASEMBLY PLANTS

Characteristic	Scenario I	Scenario II
Number of plants	5	5
1977 VOC emissions (tons per year)	13,650	13,650
Potential emission reduction (tons per year)	10,900	8,650-10,900[a]
VOC emissions after RACT (tons per year)	2,750	2,750-5,000
Capital cost ($ millions, 1977)	280	34
Annualized cost ($ millions, 1977)	44	5
Annualized cost per ton of emission reduction	4,040	460-580

a. Emission reduction based on average solids concentration of topcoat of 40 percent to 62 percent.

Source: Booz, Allen & Hamilton Inc.

7.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including: availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price, state economic variables and capital investment. In this section, both scenarios that were developed for surface coating of automobiles are discussed.

7.5.1 RACT Timing

Under Scenario I, it is assumed that the recommended RACT guidelines must be implemented statewide by 1982. This implies that the automobile manufacturers must have either low solvent coatings or VOC control equipment installed and operating within the next four years. The timing of RACT is discussed for each of the major processes within automobile facilities.

- To meet the RACT requirement for primer coating operations, cathodic or anodic electrodeposition will have to be installed. In general, the industry has been installing the cathodic electrodeposition process over the past few years and four of the five affected facilities in Ohio already have a cathodic electrodeposition process.
    - Nationwide, these timing requirements for primers represent a moderate forcing of the current technology trend for most manufacturers.
    - For American Motors the conversion to an electrodeposition process represents significant changes in their current process. Construction plans would have to start immediately to meet the 1982 timeframe.
- To meet the RACT requirements for topcoating operations, the only proven technology existing today is waterborne coating.
    - Conversion to waterborne coatings represents a complete changeover of existing facilities. Essentially, new production lines would have to be installed at all facilities in Ohio.

- Construction alone would probably take between three to four years. Although this deadline of construction might be met if Ohio were the only state implementing RACT, it could not be met on a nationwide basis by automobile manufacturers.

- To meet the RACT requirements for final repair, the equivalent of a 35 percent solids enamel must be achieved.

  - At American Motors, Ford, and the General Motors light duty trucks, which utilize enamel systems, it has not been proven that high solids enamels can be achieved for metallic colors. The timing requirements might have to be met with add-on equipment in the short run (until technology developments are proven for high solids enamel repairs).

Under Scenario II, it is assumed that the RACT requirements are modified, to meet specific technologies. The only major processing area where significant timing modifications need to be adapted would be for topcoating.

- It is likely that high solids enamels technologies will be developed over the next two or three years, although it is highly unlikely a 62 percent solids enamel could be developed before 1982.

- Topcoat changes at all facilities are likely to be substantial unless an adaptable technology can be developed.

The sections which follow further discuss the feasibility of implementing RACT within the required timeframe and the economic implications.

7.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

The automobile manufacturing industry has extensively evaluated most of the approaches to meeting RACT. The feeling in the industry is that RACT cannot be achieved by January 1, 1982, using low solvent coatings--primarily waterborne.

- The capital construction requirements to achieve waterborne topcoat RACT limitations cannot be achieved on a nationwide basis by 1982.

- The RACT controls for primer operations could be achieved by a 1982 timeframe if they are modified to incorporate the cathodic electro-deposition processing technology. However, in some older facilities where changes are extensive, additional time may be required.

- It is probable that the final repair limitations could be achieved (with moderate technology advances) at all automobile facilities currently using enamel systems.

7.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annual operating cost of implementing RACT with automobiles manufactured in the state, the value of wholesale trade in the state and the unit value of automobiles.

Under Scenario I, which assumes that the recommended RACT limitations are met with electrodeposition for primers, waterborne topcoat processes and a 35 percent solids enamel topcoat:

- The capital requirement is estimated to be $280 million, which represents approximately 340 percent of normal capital expenditures (assuming current capital expenditures represent 1.5 percent of value of shipments).

- The net annualized cost increase is estimated to be $44 million, which represents approximately 0.8 percent of the statewide auto industry's value of shipments.

- Assuming a "direct cost pass-through" the net price increase would be approximately $38 per car manufactured.

- The automobile manufacturing industry represents approximately 6 percent of the statewide economy and the direct cost increase of compliance represents approximately 0.05 percent of the value of shipments statewide (all manufacturing industry).

Under Scenario II, which assumes that the RACT requirements are modified to meet specific technologies;

- The capital requirement is estimated to be approximately $34 million, which represents approximately 40 percent of normal capital expenditures (assuming capital expenditures represent 1.5 percent of value of shipments).

- The net annualized cost increase is approximately $5 million, which represents approximately 0.1 percent of the value of shipments.

- Assuming a "direct cost pass-through" the price increase would be approximately $4 to $5 per car manufactured.

- The direct cost increase of compliance represents less than 0.01 percent of the value of shipments statewide (all manufacturing industry).

7.5.4 Ancillary Issues Relating to the Impact of RACT

The automobile manufacturers are seeking to have the guidelines altered to encompass a plant-wide emissions basis. This would allow a credit from one operation, where emissions were reduced to below the RACT recommended levels, to be applied to another operation that is not in compliance under this proposal. The plant would be in compliance if the total emissions were reduced to the level proposed in RACT. It appears that the impact of this proposed regulation, if accepted, would be a reduction in compliance cost of the RACT requirements. For instance, a manufacturer might lower the emissions from prime coats below the RACT standard to avoid installing emission control equipment for final repair coating operations.

7.5.5 Selected Secondary Economic Impact

This section discusses the secondary impact of implementing RACT in employment, market structure and productivity.

The automobile assembly industry represents approximately 6 percent of Ohio's manufacturing industry and Ohio ranks as the third largest automobile manufacturing state in the nation.

- If the recommended RACT limitations (Scenario I) require waterborne coating technology, the effect would probably be a total remodeling of existing lines and facilities. This might represent a slight decrease in employment at these facilities and a moderate increase in productivity.

- If the RACT limitations are modified to meet developing technologies, no significant effects on employment and productivity are forecast.

Regardless of the RACT scenario implemented, no significant change in market structure is likely to occur.

- Under Scenario I, all manufacturers would incur cost increases and none of the manufacturers stated that this would result in market structure changes.

- Under Scenario II, General Motors is likely to incur higher costs than other manufacturers but less cost per facility than under Scenario I. General Motors feels that all of the currently proven technology alternatives and final repair would result in quality tradeoffs (with the exception of retrofit control equipment).

* * * *

Exhibits 7-9 and 7-10, on the following pages, present a summary of the current economic implications of implementing RACT under the two scenarios studied for automobile assembly plants in the state of Ohio.

EXHIBIT 7-9(1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT SCENARIO I FOR
AUTOMOBILE ASSEMBLY PLANTS IN THE
STATE OF OHIO

SCENARIO I
(RACT Limitations
Implemented By 1982)

Current Situation	Discussion
Number of potentially affected facilities	Three companies operating five assembly plants
Indication of relative importance of industrial section to state enconomy	1977 value of shipments was approximately \$5.6 billion which represents approximately 6.2 percent of the state's manufacturing industry. Of all states, Ohio ranks third in automobile production
Current industry technology trends	Prime coat--cathodic electrodeposition Topcoats--high solids enamels for manufacturers using enamel systems
1977 VOC emissions (actual)	Approximately 13,700 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Cathodic electrodeposition for prime coat. High solids enamel for topcoat.
Assumed method of control to meet RACT guidelines	Cathodic electrodeposition for prime coat Waterborne enamels for topcoat High solids enamels for final repair

Affected Areas in Meeting RACT Scenario I	Discussion
Capital investment (statewide)	\$280 million (approximately 340 percent of current annual capital expenditures for the industry in the state)
Annualized cost (statewide)	\$44 million (approximately 0.8 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass-through" approximately \$38 per automobile manufactured
Energy	Increase of 250,000 equivalent barrels of oil annually primarily for operation of waterborne topcoating systems
Productivity and employment	Conversion to waterborne systems would require total rework of existing processing lines. Major modifications would probably increase efficiency and line speed in some facilities.

EXHIBIT 7-9(2)
U.S. Environmental Protection Agency

SCENARIO I
(RACT Limitations
Implemented By 1982)

Current Situation	Discussion
Market structure	No major effect
RACT timing requirements (1982)	Conversion of all automobile assembly plants to topcoating waterborne systems cannot be achieved by 1982
Problem areas	Prime coat RACT limitations are based on anodic electrodeposition systems and need to be modified to reflect cathodic processing. Topcoat RACT limitations are based on waterborne coatings, which is not a cost or energy effective alternative. Final repair RACT limitations are based on high solids enamel technology which would require major modifications for manufacturer's using lacquer systems
VOC emission after RACT control	2,750 tons per year (20 percent of 1977 emission level)
Cost effectiveness of RACT control	$4,040 annualized cost/annual ton of VOC reduction

EXHIBIT 7-10
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT SCENARIO II FOR
AUTOMOBILE ASSEMBLY PLANTS IN THE
STATE OF OHIO

SCENARIO II
RACT Requirements Are
Modified To Meet Specific
Technologies

Current Situation	Discussion
Number of potentially affected facilities	Three companies operating five assembly plants.
Indication of relative importance of industrial section to state economy	1977 value of shipments was approximately $5.6 billion which represents approximately 6.2 percent of the state's manufacturing industry. Of all states, Ohio ranks third in automobile production
Current industry technology trends	Prime coat--cathodic electrodeposition Topcoats--high solids enamels for manufacturers using enamel systems
1977 VOC emissions (actual)	Approximately 13,700 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Cathodic electrodeposition for prime coat. High solids enamel for topcoat.
Assumed method of control to meet RACT guidelines	Cathodic electrodeposition for prime coat High solids enamels for topcoat. High solids enamel for final repair.

Affected Areas in Meeting RACT Scenario II	Discussion
Capital investment (statewide)	$34 million (approximately 40 percent of current annual capital appropriations for the industry in the state)
Annualized cost (statewide)	$5 million (approximately 0.1 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass-through" approximately $4 to $5 per automobile manufactured
Energy	Dependent on technology applied
Productivity and employment	No major effect

EXHIBIT 7-10 (2)
U.S. Environmental Protection Agency

SCENARIO II

Current Situation	Discussion
Market structure	No major effect
RACT timing requirements	Primer and final repair limitations could be implemented at most facilities by 1982 Topcoat limitations could be set at a 40 percent to 62 percent solids by 1985 dependent on technology developments
Problem area	Limitations for topcoat are dependent on technology development
VOC emission after RACT control	2,750-5,000 tons per year (20 percent to 37 percent of 1977 emission levels dependent on limitations)
Cost effectiveness for RACT control	$460-$580 annualized cost/annual ton for VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

"Ford's War On Rust," Industrial Finishing. August 1978.

Carl A. Gottesman, "The Finishing Touch," Coat and Painting. April 28, 1977, pp. 19-24.

"G.M.'s Mel Halstead Looks At...," Industrial Finishing. April 1977, pp. 16-20.

Bruce N. McBane, "Automotive Coatings," Treastise on Coatings, Vol. 4: Formulations, Part I, R.R. Myers and J.S. Long, eds. New York, Marcel Dekker, 1975.

Herbert W. Reiner, "It Pays to Electrocoat," Plating and Surface Finishing. May 1976, pp. 15-20.

R.E. Roberts and J.B. Roberts, "Reducing Solvent Emissions in Automotive Spray Paint," J. Air. Poll. Control Assoc. Vol. 26, No. 4 (April 1976), pp. 353-358.

Joe Schrantz, "The Lincoln Clear Coat Program," Industrial Finishing. July 1978, pp. 20-23.

General Motors Corporation, Recommended VOC Emission Limitations and Technical Support Document for the State of Ohio, July 1978.

Motor Vehicle Manufacturers Association of the U.S., Inc., Plants of U.S. Motor Vehicle Manufacturers. December 1977.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. II. EPA-450/2-77-008, May 1977.

Letter to Mr. Ned E. Williams, Director, Ohio Environmental Protection Agency, from Environmental Activities Staff of General Motors Corporation, August 16, 1978.

Private conversations at General Motors Warren, Michigan

Private conversations at American Motors, Detroit, Michigan.

Private conversations at Ford Motor Company, Dearborn, Michigan.

8.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN THE STATE OF OHIO

8.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN THE STATE OF OHIO

This chapter presents a detailed economic analysis of implementing RACT controls for surface coating of metal furniture in the State of Ohio. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of metal furniture plants, interviews and analysis.

8.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for estimating:

- **Industry statistics**
- **VOC emissions**
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for surface coating of metal furniture in Ohio.

The quality of the estimates is described in detail in the last part of this section.

8.1.1 Industry Statistics

Industry statistics on metal furniture manufacturing plants were obtained from several sources. All data were converted to a base year 1977, based on specific scaling factors. The number of establishments for 1977 was based on the data provided by the Ohio EPA and supplemented by a review of the 1976 County Business Patterns, Moody's Industrial Manual and interviews with selected metal furniture manufacturing corporations. The total number of employees was obtained from the 1976 County Business Patterns. The number of employees for individual companies was based on information obtained during interviews with selected metal furniture manufacturers and from the Ohio Manufacturers Directory.

The industry value of shipments was estimated by scaling up 1972 and 1976 published data to 1977. Because of the lack of uniform data, different approaches were used for the household and business/institutional furniture subcategories of this industry, as discussed below.

8.1.1.1 Value of Shipments for Household Metal Furniture

The 1976 Current Industrial Reports presented the 1976 U.S. value of shipments of household metal furniture (SIC 2514) as $1,161 million and indicated an 8.7 percent increase in the value of shipments for 1977. The 1972 Census of Manufacturers reported that the value of shipments in

the East North Central region was 25 percent of the U.S. value of shipments. The breakdown of the value of shipments in this region was reported as follows:

State	Percent of Regional Total	Percent of U.S. Total
Ohio	7	1.8
Illinois	52	13.0
Michigan	4	1.0
Wisconsin	16	4.0
Indiana	21	5.3

The 1977 value of shipments of metal household furniture in Ohio was estimated by scaling up the 1976 U.S. value of shipments to 1977 and applying the above regional breakdown.

8.1.1.2 Value of Shipments for Business/Institutional Metal Furniture

Business/institutional metal furniture includes office furniture (SIC 2522), metal partitions (SIC 2542) and public building furniture (SIC 2531). The value of shipments for each of these groups was obtained as follows:

- For office furniture, the 1976 Current Industrial Reports presented the U.S. value of shipments as $1,002 million and indicated an 8 percent increase in the value of shipments for 1977. It also reported a 47.4 percent share of the U.S. value of shipments for the East North Central region. Since the regional breakdown of value of shipments was not available, the regional breakdown by the Number of establishments with 20 or more employees (as given in the Current Industrial Reports) was used to estimate the value of shipments for individual states:

State	Percent of Regional Number of Establishments
Ohio	22
Illinois	15
Wisconsin	7
Michigan	50
Indiana	6

The 1977 value of shipments was estimated by scaling up the 1976 U.S. value of shipments to 1977 and using the above breakdown.

- For metal partitions, which also include shelving, lockers, storage racks and accessories and miscellaneous fixtures, the 1972 Census of Manufactures reported the value of shipments for Ohio as $85.6 million. The 1977 value of shipments was estimated by assuming a 6 percent linear rate of growth between 1972 and 1977.

- For public building furniture which includes metal, wood and plastic furniture for stadiums, schools and other public buildings, the 1972 Census of Manufactures reported the U.S. value of shipments as $546.9 million and the value of shipments for Ohio as $20 million. Since the breakdown among metal, wood and plastic furniture was also not reported, half of the total value of shipments was assumed to be for metal furniture. The 1977 value of shipments was estimated by assuming a 6 percent linear rate of growth between 1972 and 1977.

8.1.2 VOC Emissions

The VOC emission data were obtained in two ways. For the plants that are listed in the Ohio EPA's emissions inventory, the emissions data were obtained for the inventory through personal communication with Mr. Bill Juris of Ohio EPA and were verified for selected manufacturers through interviews with the manufacturers. For those plants not listed in the inventory, the emissions data were estimated by multiplying the number of employees by a factor of 0.3 tons per year per empoyee. This factor was derived from the data for surface coating of metal furniture in Illinois and it compared favorably for the several facilities in Ohio, for which similar data were available.

8.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for metal furniture plants are described in Control of Volatile Organic Emissions from Stationary Sources, EPA-450/2-77-032. The data provide the alternatives available for controlling VOC emissions from metal furniture manufacturing plants. Several studies of VOC emission control were also analyzed in detail, and metal furniture manufacturers were interviewed to ascertain the most likely types of control techniques to be used in metal furniture manufacturing plants in Ohio. The specific studies analyzed were Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories, and informational literature supplied by the metal furniture manufacturers.

8.1.4 Cost of Controlling VOC Emissions for Surface Coating of Metal Furniture

The costs of control of volatile organic emissions for surface coating of metal furniture were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining equipment components
- Developing installed capital costs for modifications of existing systems
- Aggregating installed capital costs for each alternative control system
- Defining two model plants
- Developing costs of a control system for the model plants:
  - Installed capital cost
  - Direct operating cost
  - Annual capital charges
  - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

The model plants used as the bases for estimating the costs of meeting RACT were solvent-based dipping and electrostatic spraying operations. The cost of modifications to handle waterborne or high solids was not considered to be a function of the type of metal furniture to be coated, since no modifications to the production lines are necessary. Modifications are required only to the coatings handling and pumping and spraying equipment, and these would not differ for different types of furniture pieces.

8.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Ohio.

8.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of metal furniture in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that is published for the base year), "B" indicates data that was extrapolated from hard data and "C" indicates data that was not available in secondary literature and was estimated based on interviews, analysis or previous studies and best engineering judgment. Exhibit 8-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 8-1
U.S. Environmental Protection Agency
SURFACE COATING OF METAL FURNITURE DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions		X	
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

8.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for metal furniture manufacturing plants in Ohio are presented in this section. Data in this section form the basis for assessing the impact of implementing RACT for control of VOC emissions from metal furniture manufacturing plants in the state.

8.2.1 Industry Characteristics

Metal furniture is manufactured for both indoor and outdoor use and may be divided into two general categories: office or business and institutional, and household. Business and institutional furniture is manufactured for use in hospitals, schools, athletic stadiums, restaurants, laboratories and other types of institutions, and government and private offices. Household metal furniture is manufactured mostly for home and general office use.

8.2.2 Size of the Industry

The Ohio EPA reports and Booz, Allen interviews have identified 15 companies with 16 plants participating in the manufacture and coating of metal furniture, as shown in Exhibit 8-2, on the following page. These companies accounted for an estimated $50 million in household metal furniture shipments and $234 million in business/institutional metal furniture shipments in 1977. This is equivalent to about 10 percent and 4 percent of the U.S. value of shipments of household and business/institutional metal furniture, respectively. The estimated number of employees in the entire metal furniture industry in Ohio for 1977 was 7,300.

8.2.3 Comparison of the Industry to the State Economy

A comparison of the value of shipments of metal furniture with the state economy indicates that the metal furniture industry represents about 0.3 percent of the total Ohio value of shipments of all manufactured goods. The industry employs 0.6 percent of all people employed in manufacturing in Ohio.

Exhibit 8-2
U.S. Environmental Protection Agency
LIST OF METAL FURNITURE MANUFACTURERS
POTENTIALLY AFFECTED BY RACT IN OHIO

Facility	Location
Albion Industries, Inc.	Cleveland
Columbus Showcase Co.	Bellevue
Dayton Display	Dayton
Diebold, Inc.	Wooster
Frick-Gallagher Manufacturing Co.	Wellston
G.F. Business Equipment Co.	Youngstown
Harvard Division, Rusco Industries, Inc.	Bedford
Miami Carey Co.	Monroe
Nutone Division, Scovill Manufacturing Co.	Cincinnati
Republic Steel Manufacturing Division	Canton
Shott Manufacturing Division	Cincinnati
Sperry Univac (sold to RQA Office Supply Products, Inc.)	Marietta
Toledo Guild Products, Inc.	Toledo
Toledo Metal Furniture Co.	Toledo
Zerbee Textile Co.	Bellefontaine

Source: Booz, Allen & Hamilton Inc. and Ohio EPA

8.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on metal furniture manufacturing operation, estimated VOC emissions, the extent of current control and the likely alternatives which may be used for controlling VOC emissions in Ohio.

8.3.1 Metal Furniture Manufacturing and Coating Operation

Manufacturing of metal furniture consists of the following steps: fabrication of furniture parts, coating and final assembly. Coating operations usually include surface preparation, coating and curing.

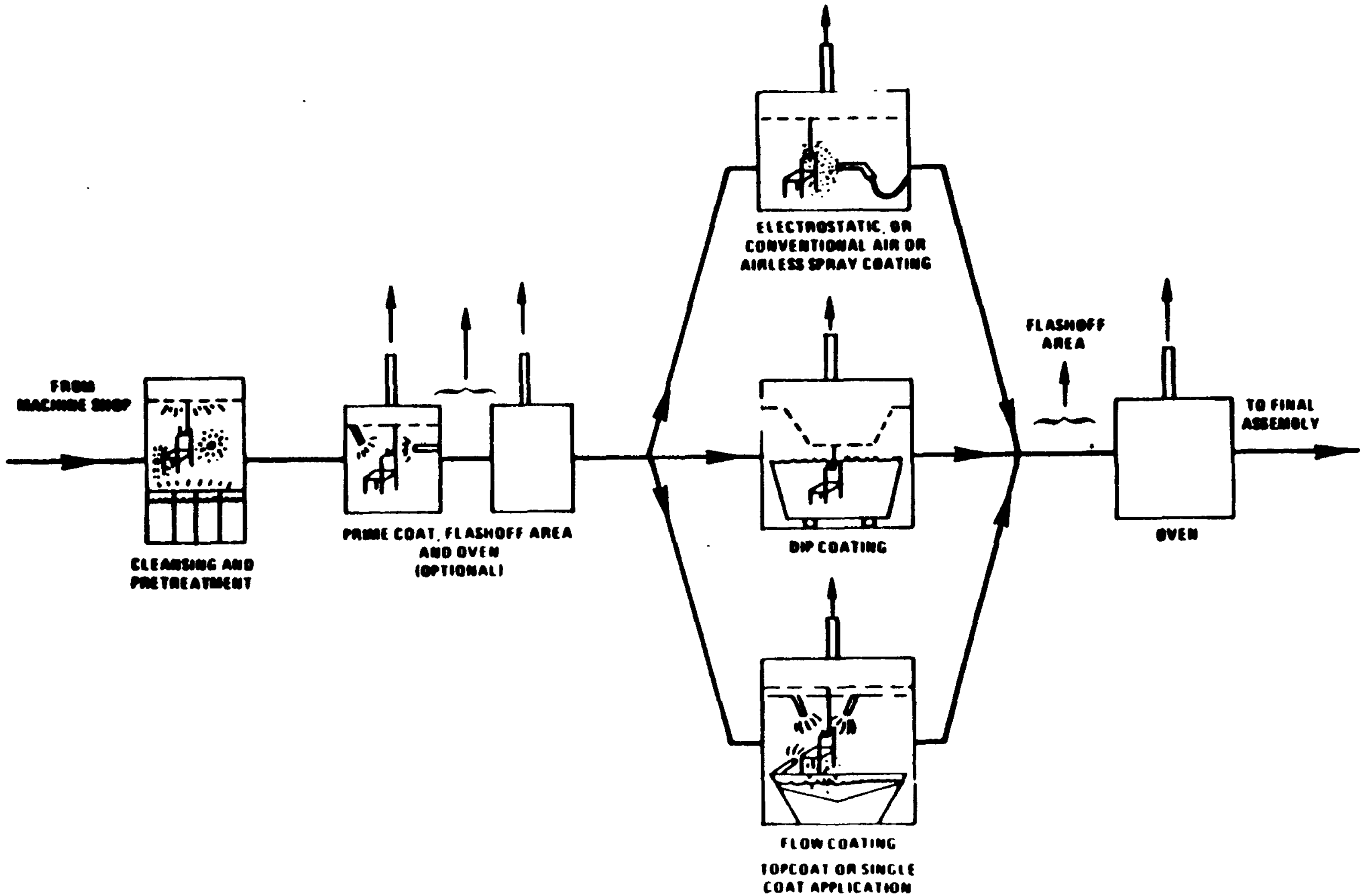
The surface preparation typically consists of cleansing, pretreating, hot and/or cold rinse and drying. Depending on individual facilities, these steps may be eliminated by substituting an organic solvent cleaning operation or cleaning pieces in a shot-blast chamber.

Most metal furniture is finished with a single coat applied by spraying, dipping and flow coating. The latter two techniques are generally used when manufacturers only use one or two colors. Spraying is used when a variety of colors are offered and is accomplished by electrostatic spraying or by the conventional airless or air spray methods. If the product requires two coats, a primecoat is applied by one of the same methods used for the topcoat or single coat.

Most painted furniture or furniture pieces are baked in an oven; however, in some cases they are air dried. After the coating application and before baking, the solvent in the coating film is allowed to rise slowly in a flash-off area to avoid popping of the film during baking. The common steps in the coating operations are illustrated in Exhibit 8-3, on the following page.

Most of the coatings applied to metal furniture are enamel, although some lacquers and metallic coatings are also used. Coating thickness generally varies from 0.7 to 1.5 mils.

Exhibit 8-3
U.S. Environmental Protection Agency
COMMON TECHNIQUES USED IN COATING OF METAL FURNITURE PIECES



Source: U.S. Environmental Protection Agency

8.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from metal furniture manufacturing facilities in Ohio in 1977 and the current level of emission controls implemented in the state. Exhibit 8-4, on the following page, shows the total emissions from the 16 metal furniture manufacturing facilities to be about 1,532 tons per year. None of the manufacturers interviewed have implemented complete hydrocarbon emissions controls systems, although Republic Steel has converted some of their operations to waterborne coating and the Nictone Co. has implemented a waterborne flow coating line.

8.3.3 RACT Guidelines and Control Options

The emission limitations that can be achieved through the application of Reasonably Available Control Technology (RACT) for the metal furniture coating industry are present in Exhibit 8-5, on the following pages. This emission limit is based on the use of low organic solvent coatings. It can also be achieved with waterborne coatings and is approximately equivalent (on the basis of solids applied) to the use of an add-on control device that collects or destroys about 80 percent of the solvent from a conventional high organic solvent coating. In some cases, greater reductions (up to 90 percent) can be achieved by installing new equipment which uses powder or electrodeposited waterborne coatings. A comparison of the various control options is presented in Exhibit 8-6, following Exhibit 8-5.

8.3.4 Selection of the Most Likely RACT Alternatives

The choice of application of control alternatives, for the reduction of hydrocarbon emissions in existing facilities for the surface coating of metal furniture, requires a line-by-line evaluation. A number of factors must be considered, based on the individual characteristics of the coating line to be controlled. The degree of economic dislocation is a function of these factors.

The first factor to be considered is whether the existing equipment can be used by the substitution of a coating material which will meet the RACT guideline. This alternative would require the least capital expenditure and may minimize production downtime.

If the existing equipment has to be modified, replaced or expanded, factors to consider are the kind

Exhibit 8-4
U.S. Environmental Protection Agency
1977 VOC EMISSIONS FROM SURFACE COATING
OF METAL FURNITURE IN OHIO

Facility Name	Number of Employees	Coating Process	Number of Coating Lines	Current Emissions (Actual) (tons/yr)
Albion Industries	10	N/A	N/A	3[a]
Columbus Showcase Co.	50	N/A	N/A	15[a]
Dayton Display Co.	11	spray	1	3[a]
Diebold Inc.	N/A	spray	3	50
Frick-Gallagher Manufacturing Co.	91	N/A	N/A	27[a]
G.F. Business Equipment Co.	1,500	spray	6	515
Harvard Division, Rusco Industries	150	dip	3	45[a]
Miami Carey Co.	590	spray, dip	2	78
Nutone Division, Scovill Manufacturing Co.	N/A	spray, flow coat	3	35
Republic Steel	N/A	spray, dip	2	350
Shott Manufacturing Co.	19	dip	1	1
Sperry Univac				
Reno Plant	N/A	spray	4	339
Green Street Plant	N/A	spray	2	29
Toledo Guild Products		N/A	N/A	18[a]
Toledo Metal Furniture	75	N/A	N/A	22[a]
Zerbee Textile Co.	7	N/A	N/A	2[a]
TOTAL				1,532

a. Estimated by assuming 0.3 tons/yr/employee of VOC emissions based on the data from surface coating of metal furniture in Illinois and the data available for the Ohio facilities.

Source: Personal communication with Mr. William Juris of Ohio EPA and Booz, Allen & Hamilton, Inc. estimates

EXHIBIT B-5
U.S. Environmental Protection Agency
EMISSION LIMITATIONS FOR RACT IN SURFACE
COATING OF METAL FURNITURE

Affected Facility	Recommended Limitation: kg of organic solvent emitted per liter of coating (minus water)	Recommended Limitation: lbs. of organic solvent emitted per gallon of coating (minus water)
Metal furniture coating line	0.36	3.0

Source: Environmental Protection Agency.

EXHIBIT 8-6(1)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Waterborne (electrodeposition, EDP)	Primecoat or single coat	90-95[a]	Provides excellent coverage corrosion protection and resistance Fire hazards and potential toxicity are reduced Dry off oven may be omitted after cleansing if an iron-phosphate pretreatment is used Good quality control due to fully automated process may be offset by increased electrical requirements for the coating, refrigeration and circulation systems if EDP replaces waterborne flow or dip coating operations. This would not be true if EDP replaces a spraying operation EDP can be expensive on small-scale production lines
Waterborne (spray dip or flow coat)	All applications	60-90[a]	This will likely be the first option considered because of the possibility that these coatings can be applied essentially with existing equipment

EXHIBIT 8-6(2)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Waterborne (spray dip or flow coat) (continued)			Requires a longer flash-off area than organic solvent-borne coatings
			Curing waterborne coatings may allow a decrease in oven temperature and some reduction in airflow, but limited reduction if high humidity conditions occur
			Spraying electrostatically requires electrical isolation of the entire system. Large lines may be difficult to convert because coating storage areas may be hundreds or thousands of feet away from the application area
			Dip or flow coating application requires closer monitoring due to its sensitive chemistry
			Weather conditions affect the application, so flash-off time, temperature, air circulation and humidity must be frequently monitored

EXHIBIT 8-6(3)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Waterborne (spray dip or flow coat) (continued)			Changes in the number of nozzles may be required Sludge handling may be more difficult
Powder (spray or dip)	Top or single coat	95-99[a]	No solid or liquid wastes to dispose of Powder may reduce energy requirements in a spray booth and the ovens because less air is required than for solvent-borne coatings and flash-off tunnel is eliminated Powder can be reclaimed, resulting in up to 98% coating efficiency All equipment (spray booths, associated equipment and often ovens) used for liquid systems must be replaced Powder films cannot be applied in thicknesses of less than 2 mils and have appearance limitations Powder coatings may be subject to explosions

EXHIBIT 8-6(4)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Powder (spray or dip)(continued)			Excessive downtime (half-hour) is required during color changes. If powders are not reclaimed in their respective colors, coating usage efficiency drops to 50% to 60%
High solids (spray)	Top or single coat	50-80[a]	May be applied with existing equipment Reduces energy consumption because it requires less airflow in the spray booth, oven and flash-off tunnel Potential health hazard associated with isocyanates used in some high-solid two-component systems
Carbon adsorption	Prime, single or top coat (application and flash-off areas)	90[b]	Although it is technically feasible, no metal furniture facilities are known to use carbon adsorption Additional energy requirements is a possible disadvantage Additional filtration and scrubbing of emissions from spray booths may be required

EXHIBIT 8-6(5)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Carbon adsorption (continued)			There is little possibility of reusing recovered solvents because of the variety of solvent mixtures
			Many facilities may require dual-bed units which require valuable plant space
			Particulate and condensible matter from volatilization and/or degradation of resin, occurring in baking ovens with high temperature, could coat a carbon bed
Incineration	Prime, single or topcoat (ovens)	90[b]	These are less costly and more efficient than carbon adsorbers for the baking ovens because the oven exhaust temperatures are too high for adsorption and the high concentration of organics in the vapor could provide additional fuel for the incinerator

EXHIBIT 8-6(6)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Incineration (continued)			Heat recovery system to reduce fuel consumption would be desirable and would make application and flash-off area usage a viable option

a. The base case against which these percent reductions were calculated is a high organic solvent coating which contains 25 volume percent solids and 75 percent organic solvent. The transfer efficiencies for liquid coatings were assumed to be 80 percent for spray, 90 percent for dip or flow coat, 93 percent for powders and 99 percent for electrodeposition.

b. This percent reduction in VOC emissions is only across the control device and does not take into account the capture efficiency.

Source: Control of Volatile Organic Emissions from Stationary Sources--Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

of changes that have to be made, the capital costs, the change in operating costs, the length of time needed to make the changes, the effect on the production rate, the operational problems that will have to be handled and the effect on the quality of the product.

Interviews with industry representatives indicate that most manufacturers will use their existing spraying equipment and modify it to handle high solids or water-borne coatings. The existing dipping or flow coating equipment will be modified to handle waterborne coating. One manufacturer will have to modify the existing dip coating equipment to electrodeposition to meet the RACT guidelines.

8.4 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section presents the cost for the most likely control systems and associated VOC reduction benefit. First the costs for the two types of model plants are presented, which are then extrapolated to the statewide industry. For one plant in the state, the costs were obtained directly from the manufacturer.

8.4.1 Model Plant Costs and VOC Reduction Benefits

Two types of model plants, each with different sizes, were selected for the surface coating of metal furniture. The first type included an electrostatic spraying line with outputs of 3 million square feet and 48 million square feet of surface area coated per year. The second type included a dip coating line with outputs of 7 million square feet and 22.5 million square feet of surface area coated per year. Assuming a one-color single-coating line, the capital, operation and maintenance costs for the model plant were estimated. The cost of pretreatment facilities, ovens and plant building was excluded from total capital costs. The annualized cost includes coating materials, utilities, operation and maintenance labor, maintenance material and capital charges (depreciation, interest, taxes, insurance and administrative charges). General plant overhead cost was excluded from the annualized cost. The estimated costs for the model base plant and the incremental costs for the most likely control options are presented in Exhibit 8-7 for the electrostatic spraying and in Exhibit 8-8 for dip coating lines, on the following pages.

The assumptions for the cost estimates are discussed in the RACT guidelines document (EPA-450/2-77-032). It should be noted that the incremental costs, or savings can change significantly if the underlying assumptions are changed. For example, if the base plant assumption of 25 percent solids coating was 30 percent solids coating, no savings for conversion to higher solids (70 percent) would result. Similarly, capital costs for conversion to waterborne coating would increase dramatically, if significant changes to the facility were needed, compared to the assumption of cleaning and corrosion protection only of existing dip tanks.

Exhibit 8-7
U.S. Environmental Protection Agency
ESTIMATED COST OF CONTROL FOR MODEL
EXISTING ELECTROSTATIC SPRAY COATING LINES

	Model Plant A-1 (3 Million Square Feet/Yr)				Model Plant A-2 (48 Million Square Feet/Yr)			
	Base Plant Cost	Incremental Costs for Conversion			Base Plant Cost	Incremental Costs for Conversion		
	25% Solids	Higher Solids	Waterborne	Powder	25% Solids	Higher Solids	Waterborne	Powder
Installed capital cost ($000)	255	15	15	60	1,200	62	62	317
Direct operating costs (savings) ($000)	175	(6)	5	17	1,113	(81)	50	343
Capital charges ($000/yr)	48	3	3	11	224	12	12	59
Net annualized cost (credit) ($000/yr)	223	(3)	8	28	1,337	(69)	62	402
Solvent emissions controlled (tons/yr)	N/A	21	20	24	N/A	336	314	380
Percent emissions reduction	N/A	86	80	97	N/A	86	80	97
Annualized cost (credit) per ton of VOC controlled ($/ton)	N/A	(143)	400	1,167	N/A	(205)	197	1,076

Note: 1977 dollars and short tons

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

Exhibit B-8
U.S. Environmental Protection Agency
ESTIMATED COST OF CONTROL OPTIONS FOR
MODEL EXISTING DIP COATING LINES

	Model Plant B-1 (7 Million Square Feet/Yr)		Model Plant B-2 (22.5 Million Square Feet/Yr)	
	Base Plant Cost 25% Solids	Incremental Costs for Conversion to Waterborne	Base Plant Cost 25% Solids	Incremental Costs for Conversion to Waterborne
Installed capital cost ($000)	105	3	215	5
Direct operating costs ($000)	135	10	450	17
Capital charges ($000/yr)	20	1	40	1
Net annualized cost ($000/yr)	155	11	490	18
Solvent emissions controlled (tons/yr)	N/A	27	N/A	122
Percent emissions reduction	N/A	80	N/A	80
Annualized cost per ton of VOC controlled ($/ton)	N/A	407	N/A	148

Note: 1977 dollars and short tons

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977

8.4.2 Extrapolation of Control Costs to the Statewide Industry

Exhibit 8-9, on the following page, presents the extrapolated costs for meeting RACT guidelines for VOC emission control for surface coating of metal furniture to the statewide industry in Ohio. The estimates were derived as follows.

- Based on emissions estimates given in Exhibit 8-4, 16 plants would require controls to comply with the RACT guidelines.

- The distribution of control options was based on industry interviews, as well as Booz, Allen estimates. In general, existing spray coating lines are likely to convert to high solids where high quality finish is required and to waterborne where less emphasis is placed on appearance.

- The capital cost of control was estimated by scaling up the model plants A-1 and B-1 costs by a capacity factor calculated as follows, except for those manufacturers who provided the data to Booz, Allen during interviews. The capacity factor was estimated to be one for the coating lines with emissions per line equal to or less than those of the model plants. For the coating lines with greater emissions per line than those of the model plant, the capacity factor per line was determined to be equal to:

  $$(\text{actual emissions/model plant emissions})^{0.6}$$

  The annual capital charges were estimated to be 18.7 percent of the capital cost.[1]

- Based on the data from the U.S. EPA, the incremental annual operating costs was determined to be proportional to the amount of emissions reduction and was scaled up from the model plant costs.

The data in Exhibit 8-9 show that the control of VOC for surface coating of metal furniture to meet the RACT guidelines in Ohio would require a statewide capital investment of about \$929,000 and a statewide direct annualized cost of about \$41,000. The estimated capital cost for individual establishments varies from \$3,000 to \$200,000. It should be noted that these findings

[1] Includes 12 year life, 10 percent interest, and 4 percent for taxes and insurance.

Exhibit 8-9
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF
EXISTING METAL FURNITURE COATING LINES
TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL

Characteristic	Projected Control Option: High Solids Spray	Waterborne Spray	Waterborne Dip	Total
Number of plants[a]	8	7	2	16
Number of process lines	19	15	3	37
Uncontrolled emissions (ton/yr)	956	475	101	1,532
Potential emission reduction (ton/yr)[b]	822	380	81	1,283
Installed capital cost ($000)[c]	441	477	11	929
Direct annual operating cost (credit) ($000) (1-3 shifts/day)[c]	(239)	94	31	(114)
Annual capital charges (credit) ($000)[d]	82	71	2	155
Net annualized cost (credit) ($000)[d]	(157)	165	33	41
Annualized cost (credit) per ton of emission reduced ($)	(191)	434	407	32

a. Total number of plants is less than the sum of individual columns because some plants have both spraying and dipping lines.
b. Based on control efficiency of 86 percent for high solids and 80 percent for waterborne coating.
c. Based on cost for model plant A-1 and B-1 from Exhibits 8-7 and 8-8, and from data provided by selected manufacturers.
d. 18.7 percent of capital cost.
Source: Booz, Allen & Hamilton Inc.

are based on the assumption that all metal furniture manufacturing plants will experience average costs or savings similar to those experienced by the model plants. However, based on the data for other states, some plants in Ohio may require substantial capital investment to modify the existing facilities to meet the RACT, while others would experience less.

8.5 DIRECT EONOMIC IMPACTS

This section presents the direct economic impacts of implementing the RACT guidelines for surface coating of metal furniture, on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

8.5.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This implies that surface coaters of metal furniture must have made their process modifications and be operating within the next four years. The timing requirements of RACT impose several requirements on metal furniture coaters:

- Determine the appropriate emission control system.
- Raise or allocate capital to purchase new equipment or modify existing facilities.
- Acquire the necessary equipment or coating material for emission control.
- Install new equipment or modify existing facilities and test equipment and/or new materials to ensure that the system complies with RACT and provides acceptable coating quality.
- Generate sufficient income from current operations to pay the additional annual operating costs incurred with emission control.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the requirement timeframe.

8.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing the RACT guidelines are discussed in this section.

Several metal furniture manufacturers in Ohio, Illinois and Wisconsin interviewed during this study have attempted to implement the control systems discussed in this report. One has already converted the entire facility to waterborne electrostatic spray and dip coating during plant modernization, whereas another has converted to powder coating. Because these manufacturers use a limited number of colors, they have been able to successfully convert their existing operations to waterborne or powder coating. Others interviewed use a variety of colors, some as many as 1,500, and have experimented with high solids and waterborne coatings, but have not succeeded in obtaining the desired quality paint formulations in the variety of colors needed from the suppliers. The development of suitable coating materials in a variety of colors is the key to successful implementation of RACT in the required time.

Unless major modifications are required, such as complete isolation of large coating facilities to convert to electrostatically sprayed waterborne coating, the cost of conversion to high solids or waterborne coatings is not likely to have a significant effect on the implementation of the RACT guidelines for surface coating of metal furniture.

8.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

The net increase in the annualized cost to the coaters of metal furniture represents approximately 0.014 percent of the industry's 1977 value of shipments manufactured in the state. This increase may translate to a few cents per unit of furniture manufactured to more than $1 per unit manufactured if the costs are passed through to the customers depending on the furniture surface area coated.

Based on the data presented in Exhibit 8-9, the major economic impact in terms of cost to the other companies will be capital related than from increased annual operating costs. Several companies are estimated to require from $45,000 to $200,000 capital investment, which may present a capital appropriation problem for these companies. For the remaining companies, capital appropriation would be a problem only if significant facilities modifications were required.

In general, marginally profitable companies could be severely affected, although none of the companies interviewed had considered going out of business because of the projected increased capital requirements and inability to pass on these costs trhough higher prices.

8.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Employment is expected to remain unchanged. Employment would be reduced if marginally profitable facilities closed, but the present indication from the industry is that no such closures are anticipated.

The market structure for metal furniture industry is not expected to be affected by the implementation of RACT in Ohio.

Productivity for those coaters who would be coating only with high solids could be increased, because they will be able to get more paint on per unit volume basis and reduce paint application time.

* * *

Exhibit 8-10, on the following page, presents a summary of direct economic implication of implementing RACT for metal furniture coating in Ohio.

EXHIBIT 8-10
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are 16 metal furniture manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was $284 million
Current industry technology trends	Trend is towards the use of a variety of colors
1977 VOC emissions (actual)	1,532 tons per year
Industry preferred method of VOC control	Low solvent coatings
Assumed method of control to meet RACT guidelines	Low solvent coatings

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$929,000
Annualized cost (statewide)	$41,000 (approximately 0.014 percent of current value of shipments)
Price	Varies from a few cents to more than $1 per unit of furniture depending upon surface area coated
Energy	No major impact
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirement (1982)	Companies using a variety of colors may face a problem
Problem area	Low solvent coating in a variety of colors providing acceptable quality needs to be developed
VOC emissions after RACT	249 tons per year (16 percent of current emissions level)
Cost effectiveness of RACT	$32 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Stationary Sources, Volume III: Surface Coating of Metal Furniture. EPA-450/2-77-032, December 1977.

U.S. Department of Commerce, County Business Patterns, 1976.

U.S. Department of Commerce, Census of Manufactures, 1977.

Springhorn Laboratories, Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Enfield, CT, August 23, 1977.

Private conversations at the following:

Syd Leach, Sales Office, Toledo, Ohio
Custom Counter Top, Courtland, Ohio
Dayton Display, Inc., Dayton, Ohio
G. F. Business Equipment, Youngstown, Ohio
Sperry Univac, Marrietta, Ohio
Miami Cary, Monroe, Ohio
Nutone, Cincinatti, Ohio
Republic Steel, Canton, Ohio
Diebold, Wouster, Ohio
Harvard Mfg., Bedford, Ohio

9.0 THE ECONOMIC IMPACT OF IMPLEMENTATION RACT GUIDELINES FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF OHIO

9.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF OHIO

The State of Ohio EPA has identified two facilities that surface coat magnet wire for insulation. The information from the emission inventory indicates that both these facilities have implemented controls that conform to the RACT guidelines as acceptable control alternatives.

Exhibit 9-1, on the following page, lists the data provided by the State of Ohio EPA on the magnet wire coaters. Exhibits 9-2, 9-3 and 9-4, following Exhibit 9-1, summarize the emission limitations and control options for surface coating for insulation of magnet wire.

Based on the following assumptions, there will be no economic impact in Ohio for implementing RACT in the industry category of surface coating for insulation of magnet wire:

- All magnet wire coaters have been identified by the Ohio EPA.
- The controls reported to the Ohio EPA have been implemented by these facilities.
- The controls are sufficient to meet the RACT guidelines.
- One of the facilities utilizing catalytic incineration has achieved only 75 percent efficiency. Some additional costs might be required to meet RACT requirements at this facility.

EXHIBIT 9-1
U.S. Environmental Protection Agency
MAGNET WIRE COATERS IN THE STATE OF OHIO

Facility	Type of Control	Current Hydrocarbon Emission (tons/yr.)	Average Control Efficiency (percent)	Potential Emission Reduction through RACT (tons/yr.)
Packard Electric	Catalytic Incineration EXT. Thermal Incinerator	163	75	100
Phelps Dodge Magnet Wire Co.	Catalytic Incineration EXT. Thermal Incinerator	50	90	0
TOTAL		218		100

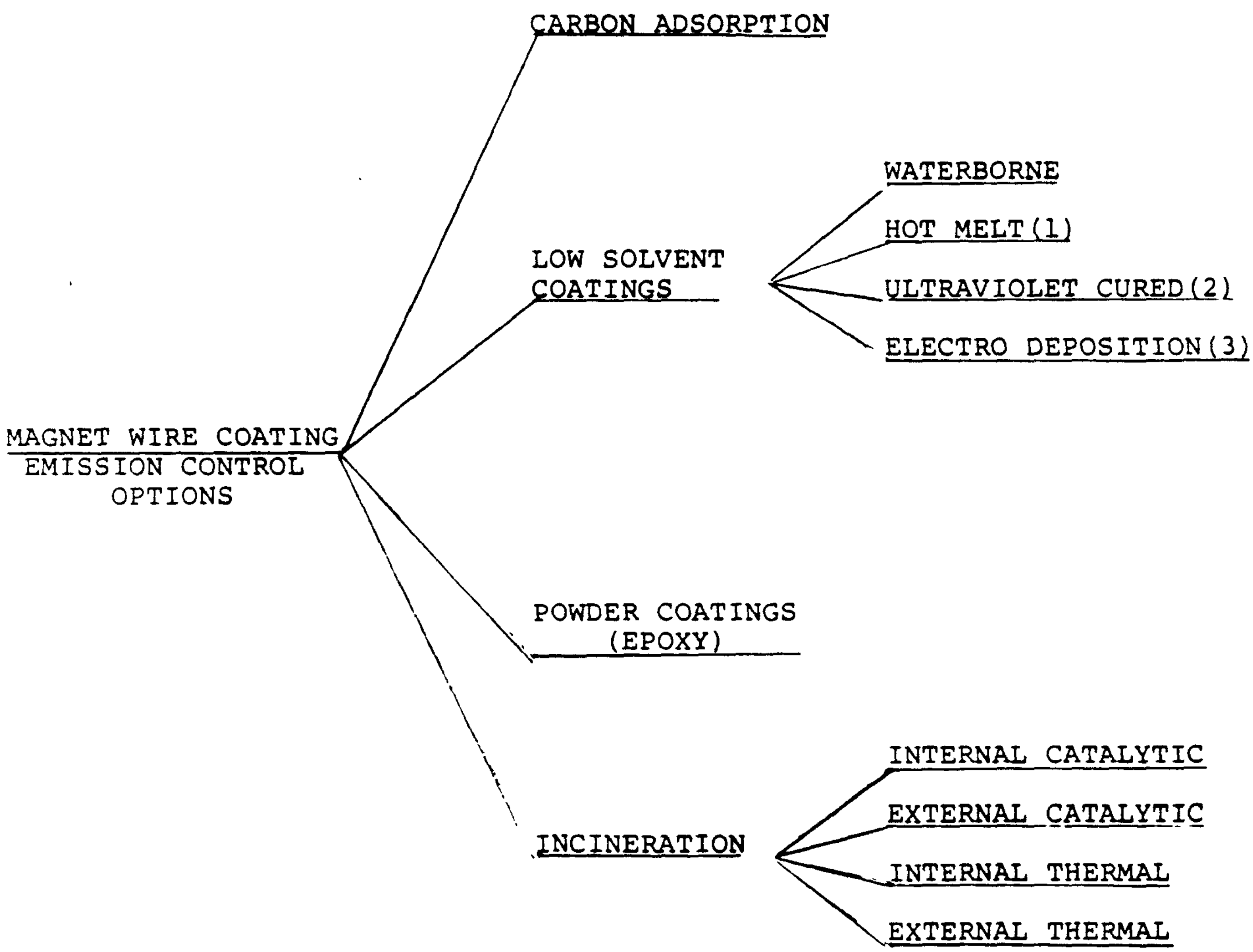
Source: Ohio EPA

EXHIBIT 9-2
U.S. Environmental Protection Agency
EMISSION LIMITATIONS FOR RACT IN THE
SURFACE COATING FOR INSULATION OF MAGNET WIRE

Affected Facility	Recommended Limitations For Low Solvent Coatings: kg solvent per liter of coating (minus water)	lbs. solvent per gallon of coating (minus water)
Wire coating oven	0.20	1.7

Source: Control of Volatile Organic Emissions from Stationary Source--Volume IV: Surface Coating for Insulation of Magnetic Wire, EPA-450/2-77-033, December 1977.

EXHIBIT 9-3
U.S. Environmental Protection Agency
SUMMARY OF APPLICABLE CONTROL TECHNOLOGY
FOR CONTROL OF ORGANIC EMISSION FROM THE
SURFACE COATING FOR INSULATION
OF MAGNET WIRE



Notes: (1) Has been used successfully in Europe.
(2) Available for specialized applications.
(3) Theoretically possible, but not commercially developed.

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnet Wire, EPA-450/2-77-033, December 1977.

EXHIBIT 9-4(1)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE SURFACE
COATING FOR INSULATION OF MAGNET WIRE

Affected Facility	Control Options	Typical Percent Reduction	Comparison of Control Options
Magnet wire coating ovens	Incineration		
	Catalytic, internal	75-95	All major wire oven designers now incorporate internal catalysts into their design. This design recirculates clean, heated air into the wire drying zone. However, this option will not be considered part of this study since it is not a retrofit option.
	Catalytic, external	75-95	An add-on option, this is energy intensive and is not easily adapted to primary heat recovery. Catalytic devices cannot be implemented where polyester amide-imide coatings are used, since they act as catalyst poison. Experimental catalysts are being developed to overcome this problem.
	Thermal, internal	98	Hot, clean gases can be recirculated back to the drying zone but this type of incinerator has not been popular with wire coaters because it is a high energy user.
	Thermal, external	98	This option is readily adaptable to both primary and secondary heat recovery.
	Low solvent coating	a	This option has not been developed with the properties that meet all wire coating needs.
	Waterborne coating	80	Presently being used in small quantities, these are not available with properties suitable for all wire coating applications and don't have good high-temperature resistance.
	Powder coating	a	Applied to wire on an experimental basis. The upper temperature range of 130°C for epoxy powder coating is well below the 220°C operating temperature at which many types of electrical equipment must operate. Powder can be used only on large diameter wires. For finer wire, the powder particle approaches the wire diameter and will not adhere well to the wire.

Affected Facility	Control Options	Typical Percent Reduction	Comparison of Control Options
	Hot melt coating	a	This has been reported successful in Europe.
	Ultraviolet cured coatings	a	This is available for specialized systems.
	Electrodeposition coatings	a	This is theoretically possible; but once a layer of coating is applied by the wire, the surface is insulated against further electrodeposition.

a. Not available

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnet Wire EPA-450/2-77-003, December 1977

10.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF OHIO

10.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT for surface coating of large appliances in the State of Ohio. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Emissions and current controls
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of the application of surface coatings on large appliances, interviews and analysis.

10.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for the surface coating of large appliances in Ohio.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

10.1.1 Industry Statistics

The major appliance industry contains six major industrial areas as defined by the Standard Industrial Code (SIC).

SIC Code	Description
3582	Commercial laundry
3585	Commercial refrigeration and air conditioning
3589	Commercial cooking and dishwashing
3631	Household cooking
3632	Household refrigerator and freezer
3633	Household laundry
3639	Household appliances, N.E.C. (includes water heaters, dishwashers, trash compactors)

Current Industrial Report provides detailed industry statistical data for the major appliance industry on a national basis. However, because of confidentiality and disclosure problems, there is no individual data source which provides a comprehensive analysis of the statistical data for each individual state. Therefore, our methodology to provide statewide major appliance statistical data was as follows:

- A list of potentially affected facilities was compiled from the state emission inventory, associations and trade journals.

- Interviews were performed with some of the manufacturers to validate the list of potentially affected facilities (this list was not 100 percent validated).

- Secondary source data were collected for each of the industry categories from sources such as:

  - Sales and Marketing Management (April 25, 1978)

  - 1972 Census of Manufactures

- The Booz, Allen study team, utilizing all available inputs, including interviews with selected manufacturers, determined an estimated, percent of the total U.S. value of shipments applicable to the state in each SIC category.

For those categories which included products not included in this study, the value of shipments of these items were factored out of the totals.

Data on number of units shipped were not available for commercial appliances, so economic impact based on unit costs for the total large appliance industry could not be calculated.

10.1.2 VOC Emissions

The Ohio EPA performed a preliminary study on hydrocarbon emissions from the coating of large appliances and is in the process of verifying the data. Only the total number of facilities and total emissions were available from this report.

10.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emission for the surface coating of large appliances are described in Control of Volatile Organic Emissions from Existing Stationary Sources--Volume V: Surface Coating of Large Appliances, (EPA-450/2-77-034, December 1977). Several manufacturers of large appliances and coating application equipment were interviewed to ascertain the most feasible types of control for organic emissions in the coating of large appliances.

All manufacturers interviewed agreed that, currently, consideration was being given to meeting the present RACT deadlines through one modification to the existing topcoating equipment (i.e., high solids) and through two possible alternatives to primecoating operations (i.e., waterborne dip or flow coat or high solids), depending on the type of existing equipment. Therefore, the analysis for this report was based on these alternatives. The methodology for the cost analysis is described in the following paragraphs.

10.1.4 Cost of Control of VOC Emissions for Surface Coating of Large Appliances

The costs of control of volatile organic emissions for surface coating of large appliances were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining system components
- Developing installed capital costs for modifications of existing systems
- Aggregating installed capital costs for each alternative control system
- Defining a model plant
- Developing costs of a control system for the model plant:
  - Installed capital cost
  - Direct operating cost
  - Annual capital charges
  - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

The model plant that was used as a basis for establishing the cost of process modification to meet RACT was a solvent-based dip (or flow coat) primecoat and a solvent-based electrostatic bell or disc topcoat. The cost of modification to water-borne dip or flow coat primecoat and to high solids electrostatic disc or bell topcoat was not considered to be a function of the type of major appliance to be coated, since no modifications to the production lines are necessary. Modifications are required only to the coatings handling and pumping and spraying equipment, and these would be approximately the same whether washers, dryers or refrigerators were being coated.

Since industry interviewees indicated that about half the household appliance industry primecoats before topcoating and half does not, the costs of control for the industry will reflect the additional cost that half the industry must incur in having to convert both phases of its coating operation to meet RACT guidelines.

10.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Ohio.

10.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of large appliances in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data, (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 10-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 10-1
U.S. Environmental Protection Agency
SURFACE COATING OF LARGE APPLIANCES
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions		X	
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

10.2 INDUSTRY STATISTICS

Industry statistics and business trends for the manufacture and surface coating of large appliances in Ohio are presented in this section. The discussion includes a description of the number of facilities, a comparision of the size of the major appliance industry to the state economic indicators, a historical characterization of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions in Ohio.

10.2.1 Size of the Industry

The Ohio EPA has indicated ten companies participating in the manufacture and coating of large appliances. These companies accounted for between $2.0 billion to $3.0 billion in shipments. The estimated number of employees was not available. The data and the sources of information are summarized in Exhibit 10-2, on the following page, and indicate that Ohio shipped an estimated 13 percent to 19 percent of the U.S. value of shipments in the large appliance industry.

10.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of large appliances (in the SIC categories stated previously) with the state economy indicates that the large appliance industry represents between 2.0 percent and 3.2 percent of the total Ohio value of shipments of all manufactured goods. These figures are shown in Exhibit 10-3, following Exhibit 10-2, along with the sources of the data.

10.2.3 Historical and Future Patterns of the Industry

The shipments of major appliances have generally followed the economic condition of the country. In the last ten years, sales have generally increased annually, except during the recession in 1974 and 1975. Shipments peaked in 1973 for all major appliances.

Shipments picked up in 1976 and continued to grow in 1977. The outlook through 1982 is a continued annual growth of about 3 percent to 5 percent.

EXHIBIT 10-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS--SURFACE COATING OF LARGE APPLIANCES
OHIO

SIC Code	RACT Category	U.S. Totals[a] 1977: Estimated No. of Units Shipped (thousand)	U.S. Totals[a] 1977: Estimated Value of Shipments ($ million)	Ohio Totals[a]: Estimated Percent of U.S. Shipments	Ohio Totals[a]: Estimated Value of Shipments ($ million)	Ohio Totals[a]: Estimated No. of Units Shipped (thousand)
3582	Commercial laundry	b	200	4-8	8-16	b
3585	Commercial refrigeration and air conditioning	b	9,500	12-18	1,200-1,700	b
3589	Commercial cooking and dishwashing	b	150	6-9	9-14	b
3631	Household cooking	5,000	1,500	20-25	300-400	1,000-1,250
3632	Household refrigerator and freezer	7,300	2,000	15-20	300-400	1,100-1,500
3633	Household laundry	8,500	1,500	15-18	220-270	1,200-1,600
3639	Household appliances: Water heaters, Dishwashers, Trash compactors	9,300	800	5-7	40-60	400-650
	TOTAL		15,650	13-19	2,077-2,860	3,700-5,000

a. Current Industrial Reports, Major Household Appliances, 1977 (issued June 1978) for categories 3631, 3632, 3633 and 3639. 1972 Census of Manufactures Service Industry Machine Shops (issued March 1975 and updated to 1977) for categories 3582, 3585 and 3589. Sales and Marketing Management (April 25, 1977) for categories 3631, 3632, 3633 and 3585.

b. Not available

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 10-3
U.S. Environmental Protection Agency
COMPARISON OF LARGE APPLIANCE STATISTICS WITH
STATE OF OHIO ECONOMIC DATA

	Estimated Ohio Economic Indicators	Estimated Percent of Ohio Manufacturing Economy Engaged in Large Appliance Manufacturing
Total 1977 value of shipments of all manufactured goods	$89.8 Billion	2.0 to 3.2
Number of employees in manufacturing	1.3 Million	a

a. Not available

Source: Current Industrial Reports, Major Household Appliances, 1977 (issued June 1978) for categories 3631, 3632, 3633 and 3639. 1972 Census of Manufactures Industry Machines and Machine Shops, (issued March 1975 and updated to 1977) for categories 3582, 3585 and 3589. Sales and Marketing Management, (April 24, 1978) for categories 3631, 3632, 3633 and 3585; Sales and Marketing Management, April 25, 1977; Annual Survey of Manufactures, Statistics for States Standard Metropolitan Statistical Areas, Large Industrial Counties and Selected Cities, 1976; Booz, Allen & Hamilton Inc.

The growth of the major appliance market will be reflected in the growth of the housing industry and the socio-economic effects of the trends toward smaller families, single-person households, higher energy costs and the like.

Historical and future growth patterns are shown in Exhibits 10-4 and 10-5, on the following pages.

EXHIBIT 10-4
U.S. Environmental Protection Agency
HISTORICAL U.S. SALES FIGURES--SELECTED MAJOR HOUSEHOLD APPLIANCES FOR 1968-1977

	Appliance Sales (Millions of Units)									
Appliance	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Washer	2.9	4.4	4.1	4.6	5.1	5.5	4.9	4.2	4.5	4.9
Dryer	2.9	3.0	2.9	3.3	3.9	4.3	3.6	2.9	3.1	3.6
Range	4.4	4.5	4.5	4.3	4.8	5.0	4.1	3.6	4.2	4.7
Dishwasher	1.9	2.1	2.1	2.5	3.2	3.7	3.3	2.7	3.1	3.4
Refrigerator	5.2	5.3	5.3	5.7	6.3	6.8	5.9	4.6	4.8	5.7

Source: Appliance, April 1978, pp. 37-40.

EXHIBIT 10-5
U.S. Environmental Protection Agency
FIVE-YEAR U.S. SALES FORECAST FOR SELECTED MAJOR HOUSEHOLD APPLIANCES (1978-1982)

Appliance	Appliance Estimates (Millions of Units)				
	1978	1979	1980	1981	1982
Washer	5.4	5.6	5.7	5.8	5.8
Dryer	4.0	4.2	4.4	4.5	4.6
Range	5.2	5.4	5.6	5.7	5.8
Dishwasher	3.7	3.9	4.1	4.4	4.6
Refrigerator	6.0	6.2	6.4	6.5	6.6

Source: *Appliance*, January 1978, pp. 54-55.

10.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents the process description for the preparation, application and curing of surface coatings for large appliances, estimated VOC emissions from facilities coating large appliances in Ohio and the extent of current control in use.

10.3.1 Large Appliance Process Description

A large appliance plant typically manufactures one or two types of appliances and contains only one or two lines. The lines may range from 1,200 to 4,000 meters (3/4 mile to 2-1/2 miles) in length and operate at speeds of 3 to 15 meters (10 to 50 feet) per minute.

Cases, doors, lids, panels and interior parts for large appliances are stamped from sheet metal and hung on overhead conveyors. The parts are transported to the cleaning and pretreatment sections which are typically located on the ground floor of the plant.

Exhibit 10-6 and Exhibit 10-7, on the following pages, describe and illustrate the pretreatment, coating and curing processes for a typical large appliance facility.

EXHIBIT 10-6

U.S. Environmental Protection Agency

PRESENT MANUFACTURING TECHNOLOGY DESCRIPTION

MANUFACTURING AND PRETREATMENT PROCESS DESCRIPTION

Large appliance plant typically manufacturers one or two different types of appliances and contains only one or two lines

- **Lines may range from 1,200 to 4,000 meters (3/4 to 2-1/2 miles) in length**
- **Lines may operate at speeds of 3 to 15 meters (10 to 50 feet) per minute**

Parts are transported on overhead conveyors

- **Cleaned in an alkaline solution**
- **Rinsed**
- **Treated with zinc or iron phosphate**
- **Rinsed again**
- **Treated with chromate (if iron phosphate is used)**
- **Dried at 300°F to 400°F in a gas fired oven and cooled before coating**

Exterior parts may enter a prime preparation booth to check the pretreatment

- **Parts can be sanded and tack-ragged (wiped) to provide an even finish**

COATING PROCESS DESCRIPTION

Primecoat or interior single coat (0.5 to 1.0 mils) is applied

- Dip coating occurs in a continuously agitated tank
- Flow coating occurs in an enclosed booth as the parts move through on a conveyor and are sprayed by stationary or oscillating nozzles
  - Parts may enter a flash-off tunnel to allow coating to flow out properly
- Spray coating occurs in booths either by automatic electrostatic spraying or manually
  - Flashoff of 7 minutes to allow solvents to rise slowly in the film to avoid popping in the oven

Prior to topcoating, the parts are checked for smoothness and manually sanded, "tack-ragged" or retouched with a spray gun

Topcoat or exterior single coat (direct-to-metal topcoat (1.0 to 1.5 mils) is applied

- Usually applied by automated electrostatic discs, bell or other type of spray equipment
- Usually applied in many colors
- Applied in side-draft or down-draft spray booths equipped with water wash and undergoes a 10-minute flashoff period

Inside of many exterior large appliance parts are sprayed with gelsonite for additional moisture resistance and for sound deadening

CURING PROCESS DESCRIPTION

Coated parts are baked for about 20 minutes at 180°C to 230°C (350°F to 450°F) in a multipass oven

Baked for 20 to 30 minutes at 140°C to 180°C (270°F to 350°F) in a multipass oven

TYPICAL COATINGS AND SOLVENTS

Coatings include:

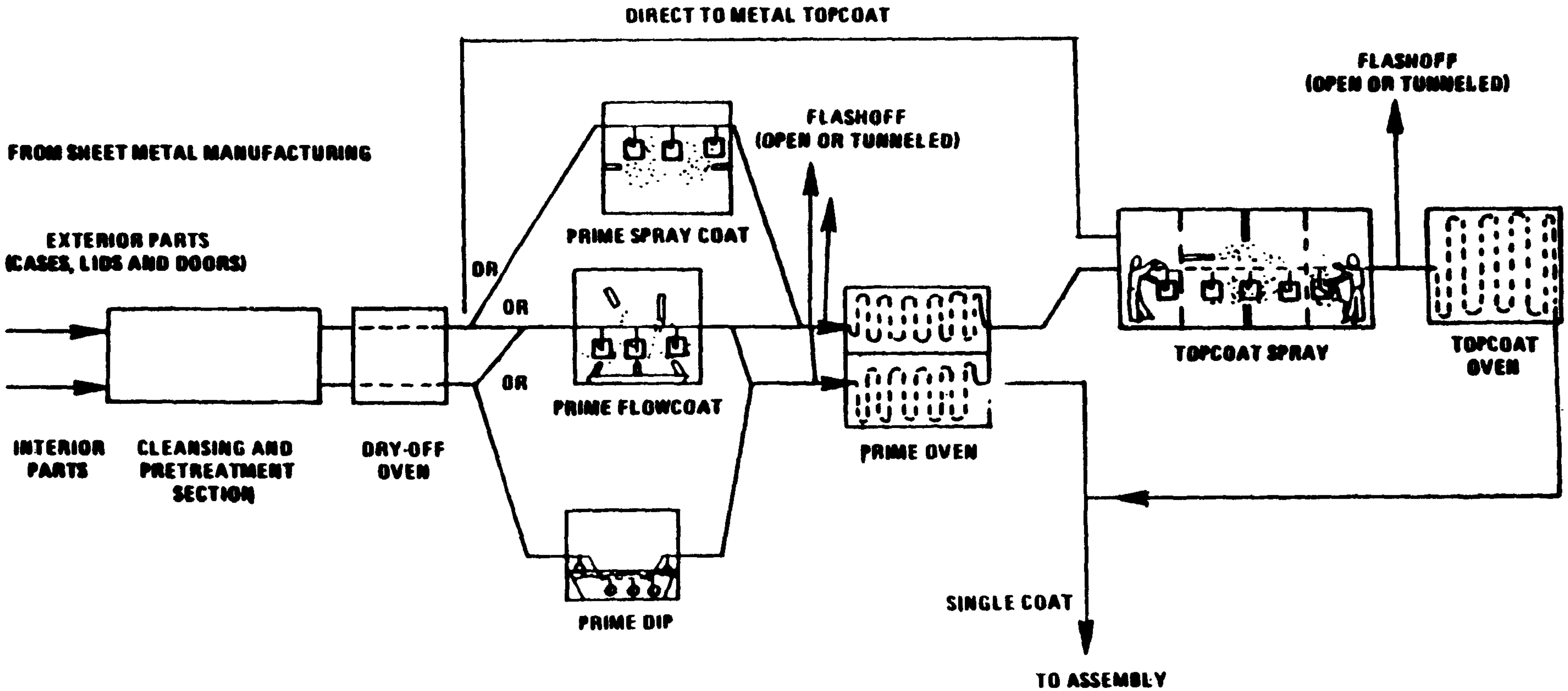
- **Epoxy**
- **Epoxy-acrylic**
- **Acrylic or polyester enamels**
- **Alkyd resins**

Solvents include:

- **Esters**
- **Keytones**
- **Aliphatics**
- **Alcohols**
- **Aromatics**
- **Ethers**
- **Terpenes**

Source: Control Of Volatile Organic Emissions From Existing Stationary Sources -- Volume V: Surface Coatings Of Large Appliances,

EXHIBIT 10-7
U.S. Environmental Protection Agency
DIAGRAM OF A LARGE APPLIANCE COATING LINE



Source: Control Of Volatile Organic Emissions From Existing Stationary Sources--Volume V: Surface Coating Of Large Appliances, EPA-450/2-77-034, December 1977.

10.4 EMISSIONS AND CURRENT CONTROLS

This section presents information on the distribution of VOC emissions during the coating operation, the estimated VOC emissions in Ohio in 1977 and the current level of emission control implemented in the state.

VOC emissions occur in three areas during the process of coating large appliances. They are the application, flashoff and oven areas. The percent distribution of VOC emissions by area is as follows:

	Percent of VOC Emission	
Application Method	Application and Flashoff	Oven
Dip	50	50
Flow coat	60	40
Spray	80	20

The percent reduction of emissions for prime coating with waterborne dip of flow coat operations was assumed to be 80 percent and for high solids (62 percent volume) top coat 60 percent. An overall average of 70 percent reduction in VOC emissions is assumed in implementation of RACT guidelines for surface coating of large appliances.

The total estimated emissions, as provided by the Ohio EPA, in tons per year in Ohio from 10 coating facilities of major appliances are 3,500 per year. The identification of individual companies and their respective emissions were not available from the Ohio EPA.

10.4.1 RACT Guidelines

The RACT guidelines for control of VOC emissions from the surface coating of major appliances require the following:

- Use of waterborne, high solids (at least 62 percent by volume) or powder coating to reduce VOC emissions
- Use of add-on control devices, such as incinerators or carbon adsorbers.

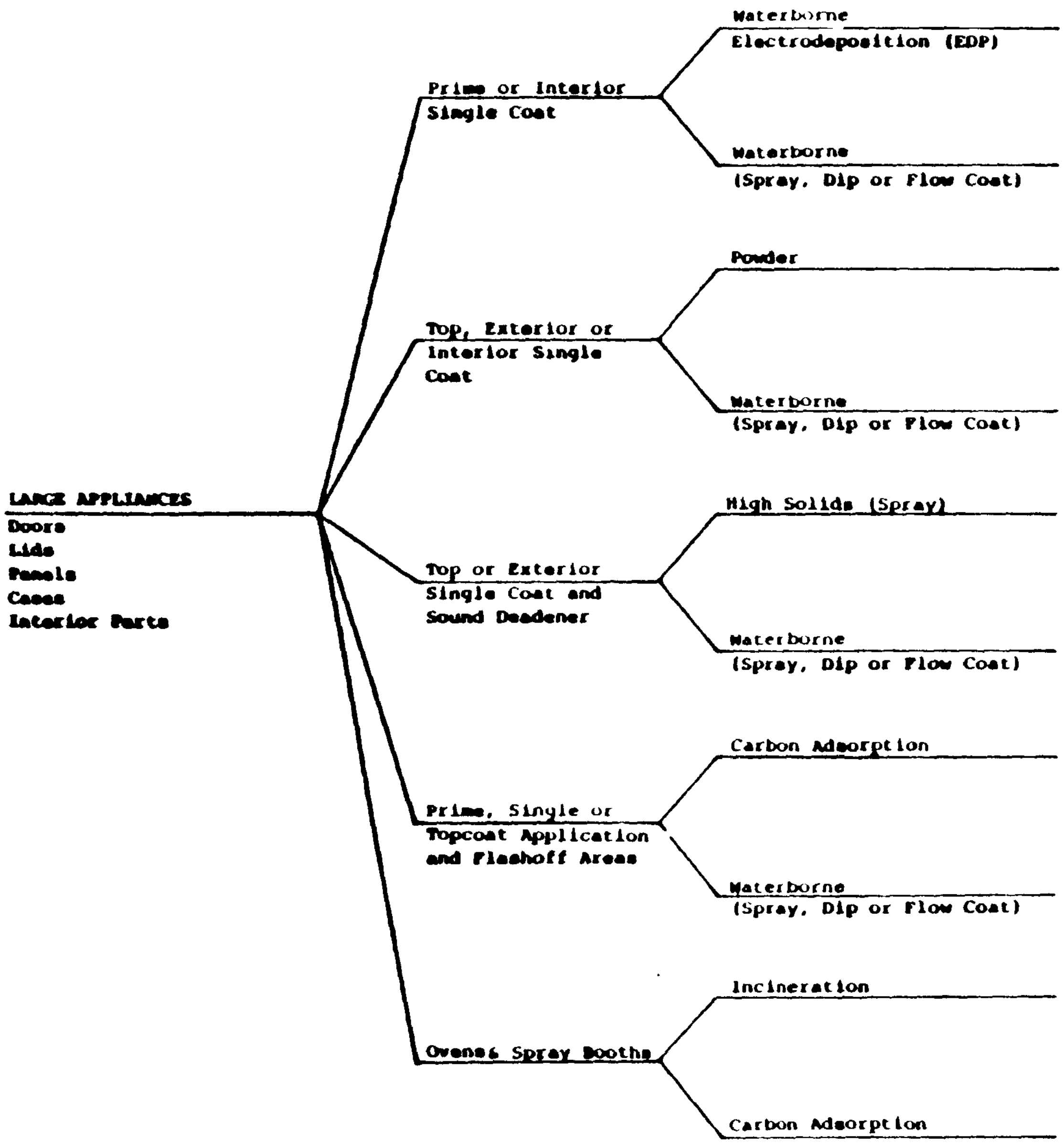
Exhibits 10-8, 10-9 and 10-10, on the following pages, summarize the RACT emission limitations and control options for VOC emissions control for surface coating of large appliances.

EXHIBIT 10-8
U.S. Environmental Protection Agency
EMISSION LIMITATIONS FOR RACT IN THE SURFACE COATING OF LARGE APPLIANCES

Affected Facility	Recommended Limitations For Low Solvent Coatings: kg solvent per liter of coating (minus water)	Recommended Limitations For Low Solvent Coatings: lbs. solvent per gallon of coating (minus water)
Prime, single or topcoat application area, flash-off area and oven	0.34	2.8

Source: Control of Volatile Organic Emissions from Stationary Sources--Volume V: Surface Coating of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-9
U.S. Environmental Protection Agency
SUMMARY OF APPLICABLE CONTROL TECHNOLOGY FOR
COATING OF LARGE APPLIANCE DOORS, LIDS,
PANELS, CASES AND INTERIOR PARTS



urce: Control f Volatile Organic Emissions rom Existing Stationary Sources--Volume V: Surface Coating of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-10 (1)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE
LARGE APPLIANCE INDUSTRY

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
Prime or interior single coat	Waterborne (electrodeposition, EDP)	90-95[a]	Provides excellent coverage corrosion protection and detergent resistance Fire hazards and potential toxicity are reduced Dry off oven may be omitted after cleansing if an iron-phosphate pretreatment is used Lower energy consumption via lower ventilation requirements Good quality control due to fully automated process may be offset by increased electrical requirements for the coating, refrigeration and circulation systems if EDP replaces waterborne flow or dip coating operations This would not be true if EDP replaces a spraying operation EDP can be expensive on small-scale production lines
All applications	Waterborne (spray dip or flow coat)	70-90[a]	This will likely be the first option considered because of the possibility that these coatings can be applied essentially with existing equipment Requires a longer flash-off area than organic solvent-borne coatings Curing waterborne coatings may allow a decrease in oven temperature and some reduction in airflow but limited reduction if high humidity conditions occur

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
			Spraying electrostatically requires electrical isolation of the entire system. Large lines may be difficult to convert because coating storage areas may be hundreds or thousands of feet away from the application area
			Dip or flow coating application requires closer monitoring due to their sensitive chemistry
			Weather conditions affect the application, so both flash-off time, temperature, air circulation and humidity must be frequently monitored
			Changes in the number of nozzles may be required
			Sludge handling may be more difficult
Top, exterior or interior single coat	Powder	95-99[a]	No solid or liquid wastes to dispose of
			Powder may reduce energy requirements in a spray booth and the ovens because less air is required than for solvent-borne coatings and flash-off tunnel is eliminated
			Powder can be reclaimed resulting in up to 98% coating efficiency
			All equipment (spray booths, associated equipment and often ovens) used for liquid systems must be replaced
			Powder films cannot be applied in thicknesses in less than 2 mils and have appearance limitations
			Powder coatings may be subject to explosions
			Excessive downtime (half-hour) is required during color changes. If powders are not reclaimed in their respective colors, coating usage efficiency drops to 50% to 60%

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
Top or exterior single coat and sound deadener	High solids (spray)	60-80[a]	May be applied with existing equipment Reduces energy consumption because it requires less airflow in the spray booth, oven and flash-off tunnel Potential health hazard associated with isocyanates used in some high-solid two-component systems
Prime, single of top coat application and flash-off and spray booths	Carbon adsorption	90[b]	Although it is technically feasible, no larger appliance facilities are known to use carbon adsorption Additional energy requirements is a possible disadvantage Additional filtration and scrubbing of emissions from spray booths may be required There is little possibility of reusing recovered solvents because of the variety of solvent mixtures Many facilities may require dual-bed units which will require valuable plant space Particulate and condensible matter from volatilization and/or degradation of resin occuring in baking ovens with high temperature could coat a carbon bed
Ovens	Incineration	90[b]	These are less costly and more efficient than carbon adsorbers for the baking ovens because the oven exhaust temperatures are too high for adsorption and the high concentration of organics in the vapor could provide additional fuel for the incinerator Heat recovery system to reduce fuel consumption would be desirable and would make application and flash-off area usage a viable option

a. The base case against which these percent reductions were calculated is a high organic solvent coating which contains 25 volume percent solids and 75 percent organic solvent. The transfer efficiencies for liquid coatings were calculated to be 80 percent, for powders about 93 percent and for electrodeposition about 99 percent.

b. This percent reduction in VOC emissions is only across the control device and does not take into account the capture efficiency.

Source: Control of Volatile Organic Emissions from Stationary Sources--Volume V: Surface Coatings of Large Appliances EPA-450/2-77-034, December 1977.

10.4.2 <u>Selection of the Most Likely RACT Alternatives</u>

The choice of application of control alternatives, for the reduction of hydrocarbon emissions in existing facilities for the surface coating of large appliances, requires a line-by-line evaluation. A number of factors must be considered, based on the individual characteristics of the coating line to be controlled. The degree of economic dislocation is a function of these factors.

The first factor to be considered is whether the existing equipment can be used by the substitution of a coating material which will meet the RACT guideline. This alternative would require the least capital expenditure and minimize production downtime.

If the existing equipment has to be modified, replaced or added to, other factors to consider are the kind of changes that have to be made, the capital costs, the change in operating costs, the length of time needed to make the changes, the effect on the production rate, the operational problems that will have to be handled and the effect on the quality of the product.

Interviews with industry representatives indicate a unanimous opinion in the area of choosing the alternative(s) for VOC emission control in coating large appliances. The industry intends to use their existing topcoat application equipment and modify it to handle high solids. Those companies that use a primecoat will convert their conventional solvent systems to either waterborne dip or flow coat or high solids discs or bells. The alternatives are shown in Exhibit 10-13, on the following page.

Other alternatives such as electrodeposition for primecoating or powder coating for single coat application may be implemented in special cases, i.e., where extensive corrosion protection is required. These alternatives are not incorporated into this study because their applicability was not specifically identified in this state.

10.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for the VOC emission control systems are presented in this section. The costs for the alternative primecoat and topcoat applications are described individually. The final section presents an extrapolation of typical costs for surface coating of large appliances to the statewide industry.

10.5.1 Costs for Alternative Control Systems

Estimates of capital and annualized costs are presented for controlling solvent emissions from application areas and curing ovens in primecoats and topcoats of large appliances. The estimates were provided by appliance coaters who have either made conversions to the appropriate process modifications or who are in the preliminary estimating stage prior to implementation of these modifications.

The process modifications involve the converting of a solventborne primecoat or topcoat line to a coating system which emits lesser amounts of VOC. The coating lines and the costs for their modification are shown in Exhibit 10-12, on the following page.

If an existing prime coat conventional-solvent-based dip operation is converted to waterborne dip, the capital costs cover the requirements for additional equipment for close humidity and temperature control during flashoffs and for changeover to materials handling system (pumps and piping) that can handle waterborne coatings without corrosion related problems. Based on these assumptions, the capital installed cost of these modifications is estimated at between $50,000 and $75,000. No additional floor space is required so the capital allocated building costs remain unchanged. The fixed costs associated with the increased capital requirements are estimated at between $13,000 and $19,000. This includes depreciation, interest, taxes, insurance, administration expenses and maintenance materials.

For the conversion of primecoat or topcoat solvent-based electrostatic disc or bell spray to high solids, the cost of such conversion is based on a number of assumptions: that the paint will have to be preheated to reduce the viscosity prior to application, that the existing pumping system will have to be replaced (including the installation of larger capacity/head pumps and large diameter piping) and that high speed (25,000 to 50,000 RPM) turbine or air drive discs or bells will be required. Also, it is assumed that the type of booth remains unchanged and that the existing painting configuration (including the proper indexing layout) requires no change.

EXHIBIT 10-11
U.S. Environmental Protection Agency
MOST LIKELY RACT CONTROL ALTERNATIVES FOR
SURFACE COATING OF LARGE APPLIANCES
IN STATE OF OHIO

Coat	Existing System	Most Likely Alternative Control Techniques
Prime	Dip or flow coating Conventional solvent	Dip or flow coating with waterborne solvent Electrostatic application with discs or bells of high solids coatings . Preheat paint, or . Use high speed discs or bells
Top	Electrostatic application with discs or bells of conventional solvents	Electrostatic application with discs or bells of high solids coating . Preheat paint, or . Use high speed discs or bells

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 10-12
U.S. Environmental Protection Agency
ESTIMATED COST FOR PROCESS MODIFICATION
OF EXISTING LARGE APPLIANCE COATING LINES
TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL

Existing System	Most Likely Control Alternative	Major Process Modification	Capital Cost
Primecoat			
Conventional solvent-based dip or flow	Waterborne dip of flow coat	Instrumentation for close control of temperature and humidity Total repiping and replacement of pumps	Installed capital $50,000 - $75,000 Annualized cost $13,000 - $19,000
Conventional solvent-based electrostatic spray, disc or bell	High solids electrostatic	Pre-heating system Installation of high disc or bells Repiping for larger line sizes and possible coatings pump replacements	Installed capital $50,000 - $75,000 Annualized cost $13,000 - $19,000
		Major revamp of booth line configuration and air handling system in addition to changes stated above	Installed capital $150,000 - $250,000 Annualized cost $37,000 - $63,000
Topcoat			
Conventional solvent-based electrostatic spray, disc or bell	High solids electrostatic	Preheating system Installation of high speed disc or bells Repiping for larger line sizes and possible coatings pump replacement	Installed capital $50,000 - $75,000 Annualized cost $13,000 - $19,000
		Major revamp of booth configuration and air handling system in addition to changes stated above	Installed capital $150,000 - $250,000 Annualized cost $37,000 - $63,000

Source: Booz, Allen & Hamilton Inc.

Based on these assumptions, the capital installed cost of these modifications is estimated at between $50,000 and $75,000. No additional floor space is required so the capital allocated building costs remain unchanged. The fixed costs associated with the increased capital requirements are estimated at between $13,000 and $19,000. This includes depreciation, interest, taxes, insurance, administration expenses and maintenance materials.

Each paint application conversion to meet RACT has its own unique characteristics. Where such conversions require major changes in booth structure, paint application techniques and air handling system, the costs will be considerably higher than the figures stated above. A first pass estimate, provided from industry interviews with appliance coaters, at these major changes indicates a capital requirement of $150,000 to $250,000 per booth. The annualized costs would be $37,000 to $63,000. Based on industry interviews and Booz, Allen judgment, it is assumed that 50 percent of the topcoating application units will require major modifications.

The annual operating expenses will not change appreciably because the manpower requirements remain the same for the two systems. There will be a minor savings in the utilities, associated with the oven curing of the high solids coating. This could amount to about $1 per hour of operation time ($2,000 to $6,000 per year per line (equivalent to 700 cubic feet of natural gas/hour/line).

The overall cost of coating materials may increase slightly even though conversion to water-based or high solids coating will eliminate the need for solvent thinning. This overall increase is expected because of the anticipated price increases in the coatings that will be required to meet the RACT guidelines. At this time, difinitive numbers in change of paint prices cannot be developed but an overall paint cost increase of between 10 percent and 20 percent may be anticipated.

10.5.2 Extrapolation to the Statewide Industry

Exhibit 10-13, on the following page, extrapolates the costs for meeting RACT guidelines for VOC emission control for surface coating of large appliances to the statewide industry in Ohio. The estimates are based on the following assumptions:

- All large appliance coaters will implement the control alternatives stated in this report to comply with RACT.

EXHIBIT 10-13
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF
EXISTING LARGE APPLIANCE COATING LINES
TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL
OHIO

Characteristic	Plants with Top-coat Process Only	Plants with Primecoat and Topcoat Process	Total
Number of plants	5	5	10
Mumber of process lines	10	10	20
Estimated value of shipments ($ billion)	a	a	2.0-3.0
Uncontrolled emissions (Ton/yr)	a	a	3,500
Potential emission reduction (Ton/yr)	a	a	2,450
Installed Capital Cost[b] ($ Thousand)	1,625	2,375	4,000
Direct annual operating cost (credit) ($ Thousand) (1-3 shifts/day)	(20-60)	(20-60)	(40-120)
Annual capital charges[b] ($ Thousand)	406	593	999
Net Annual operating cost[c] ($ Thousand)	346[d]-386[e]	533[d]-573[e]	879[d]-959[e]
Annual cost per ton or emission reduced ($)	a	a	358[d]-391[e]

a. Not available
b. Figures represent the upper limit of the installed capital cost, and annual charges
c. Net annual operating cost is the summation of the direct annual operating cost and the annual capital charges
d. Represents a three-shift/day operation
e. Represents a one-shift/day operation

Source: Booz, Allen & Hamilton Inc.

- **The distribution of primecoat or topcoat or both as applications, as per industry interview, is: 50 percent of the coaters topcoat only; the other half both primecoat and topcoat the appliances, unless specific information was available for individual facilities.**

- **Each plant is assumed to have two process lines.**

- Also 50 percent of the topcoat applications require major modifications to meet RACT.

- The ten plants identified by the Ohio EPA represent the majority of all the state industry production of large appliances.

- For the specific alternatives listed in Exhibit 10-12, the cost of process modifications for the prime or top coat operations are the same.

Actual costs to large appliance coaters may vary depending on the type of control alternative, manufacturer's equipment and coating material selected by each manufacturing facility.

Based on the above assumptions, the total capital cost to the industry in Ohio for process modifications to meet RACT guidelines is estimated at $4.0 million. The annual cost is estimated at $358 to $391 per ton of emission controlled.

10.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing the RACT guidelines for surface coating of large appliances on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

10.6.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This implies that surface coaters of large appliances must have made their process modifications and be operating within the next three years. The timing requirements of RACT impose several requirements on major appliance coaters:

- Determine the appropriate emission control system.
- Raise or allocate capital to purchase equipment.
- Acquire the necessary equipment for emission control.
- Install and test the emission control equipment to insure that the system complies with RACT.
- Generate sufficient income from current operations to pay the additional annual operating costs incurred with emission control.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

10.6.2 Technical Feasibility Issues

Technical and economic feasibility issues of implementing the RACT guidelines are discussed in this section.

Only one major appliance manufacturer interviewed has attempted to implement the control alternatives discussed in this report. The company has converted its conventional solvent flow primecoat to water reducible flow coat.

Although a longer flash-off period for water reducible coatings is usually required, there was not enough floor space available to add the process line. However, additional heating was added and the flash-off area temperature was elevated to 130°F-180°F. Also, extensive humidity controls had to be added because of the sensitivity of water reducible finish to moisture in the flash-off area.

The facility also has attempted the application of medium solids polyester (55 percent to 60 percent by volume) as a top-coat, using the existing electrostatic discs. There have been no attempts at pre-heating the paint, and the discs have been run at 2,400 RPM to 3,300 RPM. The unit, as it is presently constituted, will not apply 62 percent volume solids or higher. Pre-heat and/or higher speed disc modifications will have to be made to handle the more viscous coatings. Under the present operating conditions, the facility is not meeting the RACT guidelines for solvent emission control.

The equipment manufacturers interviewed have indicated that present technology is available to handle and apply high solids (greater than 62 volume percent solids) using electrostatic speed application. In addition, high solids coating material suppliers indicated that sufficient quantities of paint would be available to meet the expected market demand. Application equipment manufacturers have indicated that, even with the projected demand for their equipment, they can maintain a 10-week to 12-week delivery schedule.

10.6.3 Comparison Of Direct Cost With Selected Direct Economic Indicators

The net increase in the annual operating cost to the coaters of large appliances represents approximately 0.038 percent of the industry's 1977 value of shipments manufactured in the state. This may translate to an approximate cost increase of $0.21 per unit of household appliances coated; the average cost of a unit is $230.

The major economic impact in terms of cost to individual companies will be capital related rather than from increased annual operating costs. The capital required for RACT compliance may represent a significant amount of capital appropriations for the companies affected.

Any marginally profitable companies may be severely affected, although none of the companies interviewed had considered going out of business because of the projected increased capital requirements and inability to pass on these costs through higher prices.

10.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Employment is expected to remain unchanged. Employment may be reduced if marginally profitable facilities closed, but the present indication from the industry is that no such closures are anticipated.

It appears that implementation of the RACT guidelines will have no significant impact on the present market structure. The major appliance industry can be characterized as being highly competitive and manufacturers interviewed state that the regulation may present some cost inequities to smaller and/or less profitable production lines, i.e., if certain manufacturers incur disproportionate compliance costs they probably will not be passed along in the marketplace in the form of a price increase and could further deteriorate the profit position of marginally profitable operations.

Productivity for those coaters who are topcoating only with high solids may be increased if they are able to get more paint on per unit volume and reduce paint application time.

* * *

Exhibit 10-14, on the following page, presents a summary of the current economic implications of implementing RACT for surface coating of large appliances in the state of Ohio.

EXHIBIT 10-14
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	There are ten major large appliance manufacturers and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $2.4 billion and represents 10 percent of the estimated $15 billion U.S. value of shipments of the major appliance industry
1977 VOC emissions (actual)	3,500 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat
Assumed method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$4.0 million
Annualized cost (statewide)	$920,000 which represents 0.038 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.21/unit for household appliances (based on a price of $230 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 8,000 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	Possible problems meeting equipment deliveries and installation are anticipated
Problem area	Commercial application of high solids (greater than 62% by volume) has not been proven
VOC emission after RACT control	1,050 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$374 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton, Inc.

BIBLIOGRAPHY

Appliance, April 1978

Annual Survey of Manufactures, 1976

Census of Manufactures, Industry Machines and Machine Shops, 1972

Current Industrial Reports, Major Household Appliances, 1977

Sales and Marketing Management, April 24, 1978

U.S. Environmental Protection Agency, *Control of Volatile Organic Emissions from Stationary Sources--Volume V: Surface Coating of Large Appliances*. EPA-450/2-77-034, December 1977.

Private conversations at the following:

Ferro Corporation, Cleveland, Ohio
Frigidaire, Division of General Motors, Dayton, Ohio
Interrad, Stamford, Connecticut
Nordsen Corporation, Amherst, Ohio
Ransburg Corporation, Indianapolis, Indiana
Whirlpool Corporation, Findlay, Ohio
Association of Home Appliances Manufacturers, Chicago, Illinois

11.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF OHIO

11.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF OHIO

This chapter summarizes the estimated economic impact of the implementation of reasonably available control technology for volatile organic compound emissions from solvent metal degreasers. Solvent metal degreasing is the process of cleaning the surfaces of articles to remove oil, dirt, grease and other foreign material by immersing the article in vaporized or liquid organic solvent. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Estimated costs of RACT implementation
- Direct economic impacts
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of solvent metal cleaning; interviews with degreaser users, equipment and materials suppliers; and a review of pertinent published literature.

11.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATE

11.1.1 Background

Solvent metal cleaning is normally done in one of three devices:

- A cold cleaner, in which the article is immersed, sprayed or otherwise washed in a solvent at or about room temperature.
- An open top vapor degreaser, in which the article is suspended in a solvent vapor over a pool of boiling solvent. The solvent vapors condense on the article and dissolve or wash soils and greases from it.
- A conveyorized degreaser, in which articles are conveyed on a chain, belt or other conveying system either through a spray or pool of cold solvent or through the vapor of a boiling solvent.

The cold cleaner and open top vapor degreaser are designed for batch cleaning and are used in both manufacturing operations and maintenance operations. The conveyorized cleaners are designed for continuous use and are normally found only in manufacturing operations. A more detailed discussion of these cleaners is presented in a later section of this chapter.

The EPA has estimated[1] that about 1.3 million cold cleaners operate in the U.S.; about 70 percent are used in maintenance or service cleaning and 30 percent in manufacturing. There are also an estimated 22,200 open top vapor degreasers and 4,000 vapor conveyorized degreasers. In 1975, estimated emissions in the United States from these cleaners exceeded 700,000 metric tons, making solvent cleaning the fifth largest stationary source of organic emissions.

1. Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

As recently as 1974, most degreasing operations were exempt from state regulations that covered solvent degreasing, since they rarely emitted more than the 3,000 pounds per day of volatile organic compounds (VOC). They could also qualify for exemption by the substitution of a solvent not considered to be photochemically active. However, the EPA's current direction is toward positive reduction of all VOC emissions, and the EPA has proposed control technology for solvent metal cleaning operations which can achieve sizeable total emission reduction. This technology involves the use of proper operating practices and the use of retrofit control equipment.

Proper operating practices are those which minimize solvent loss to the atmosphere. These include covering degreasing equipment whenever possible, properly using solvent sprays, employing various means to reduce the amount of solvent carried out of the degreaser on cleaned work, promptly repairing leaking equipment and most important, properly disposing of wastes containing volatile organic solvents.

In addition to proper operating practices, many control devices can be retrofit to existing degreasers; however, because of the diversity in their designs, not all degreasers require the same type of control devices. Small degreasers using a room temperature solvent may require only a cover, whereas large degreasers using boiling solvent may require a refrigerated freeboard chiller or a carbon adsorption system. Two types of control equipment which will be applicable to many degreaser designs are drainage facilities for cleaned parts and safety switches and thermostats, which prevent large emissions from equipment malfunction. These controls, the types of degreasers to which they can be applied and the expected emission reductions are described later in this chapter.

11.1.2 Method of Estimation of the Number of Degreasers

Subsequent estimation of the economic impact of implementing the proposed RACT for solvent metal cleaning is based upon a determination of the number of solvent metal cleaners in the state. This determination was made on the basis of a detailed industrywide study of metal degreasing in the U.S., conducted by the Dow Chemical Company under contract to the EPA. The results of the study are reported in: Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations, Contract No. 68-02-1329, June 30, 1976.

The report was based on a telephone survey of more than 2,500 plants in the metal working industry (SIC groups 25, 33, 34, 35, 36, 37, 38 and 39) with more than 19 employees. The report presents estimates of the:

- Percentage of U.S. plants using solvent degreasing
- Percentage of plants using cold cleaners, open top vapor degreasers or conveyorized cleaners
- Average number and type of vapor degreasers used in these plants
- Distribution of these quantities by region.

All of these quantities are further identified by the eight metal working industries. In the report (based on the 1972 Census of Manufactures), 15,294 open top and 2,796 conveyorized vapor degreasers were estimated to be in use in the eight SIC groups; an additional 5,000 to 7,000 open top degreasers were estimated[1] to be in use in 1972 by other manufacturing or service firms not included in one of the eight SIC groups.

To determine the number of open top and conveyorized vapor metal degreasers in the state, first the number of plants in each of the eight SIC groups was determined for the state. The average number of plants using solvent metal degreasing and the average number and type of cleaners used per plant were then obtained by using the factors presented in the Dow report. The results of these calculations and the factors used are tabulated in Exhibit 11-2, in section 11.2. The total number of open top degreasers in the state was then estimated by multiplying the number expected to be used in metal working SIC groups by the ratio of 22,200/15,200 (the ratio of total number of open top units in the U.S. to that in the eight SIC groups).

Because of their expense and function, conveyorized vapor degreasing units are most likely to be used in manufacturing only. Therefore, the total number of these units in the state was assumed to be same as that calculated for the eight SIC metal working industries. The total number of conveyorized cleaners, vapor and cold, was then determined by multiplying the number of vapor conveyorized cleaners by 100/85, the EPA[2] estimated ratio of total conveyorized cleaners to vapor conveyorized cleaners in the U.S.

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1. Interviews with Parker Johnson, Vice President, Sales, Baron Blakeslee Corp., Cicero, Illinois, and with Richard Clement, Sales Manager, Detrex Chemical, Detroit, Michigan, July 1978.

2. Control of Volatile Organic Emissions from Solvent Metal Cleaning EPA-450/2-77-022, November 1977.

The number of cold cleaners in the state was determined by using the Dow estimates of cold cleaning done in plants in the eight SIC metal working industries and an EPA estimate of 1,300,000 cold metal cleaners in the U.S., including 390,000 in manufacturing and 910,000 in maintenance or service use.[1]

- The EPA estimates of all cold cleaners in manufacturing in the U.S. was multiplied by the ratio of the number of plants in the metal working industries (SICs 25 and 33-39) in the state to the number in the U.S.

- Then, the EPA estimates of all cold cleaners in maintenance and service use in the U.S. were multiplied by the ratio of the number of plants in the metal working industries plus selected service industries (SIC codes 551, 554, 557, 7538, 7539, 7964) for the state to the number in the U.S. These service industries are expected to have at least one or more cold cleaners.

  - SIC 551 applies to industries categorized as new or used car dealers.

  - SIC 554 applies to industries categorized as gasoline service stations.

  - SIC 557 applies to industries categorized as motorcycle dealers.

  - SIC 7538 applies to industries categorized as general automotive repair shops.

  - SIC 7539 applies to industries categorized as automotive repair shops, n.e.c.

  - SIC 7964 applies to industries categorized as armature rewinding shops.

The estimates of the total number of cold cleaners in the state obtained by these calculations are tabulated in Exhibit 11-3.

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1. Cold cleaners in manufacturing use are meant to include only those cleaners employed in the manufacturing process; cold cleaners in maintenance and service use are those employed for this purpose by either manufacturing or service establishments.

11.1.3 Method of Estimation of Nonexempt Degreasers

The RACT guidelines propose several exemptions for degreasers based primarily on size, type of solvent used or emission rate.

- The RACT guidelines apply to cleaners with emissions over 15 pounds in any one day or 3 pounds in any one hour whichever is greater. It has been estimated[1] that about 70 percent of cold cleaners would have VOC emissions less than this and would be exempt.

- Cleaners used exclusively for chemical or physical analysis or determination of product quality and acceptance are to be exempt. Since few such cleaners exist, no correction was made to the estimated number of cleaners used in determining the estimated compliance costs.

- Those cleaners using 1,1,1-trichloroethane and trichlorotrifluoroethane are to be exempt. Estimates of the number of open top degreasers which use either of these solvents range from 35 percent to 60 percent.[2] For the purpose of calculating cost impacts in this study, 35 percent was used. About 10 percent of conveyorized cleaners are expected to be exempt[2] and about 20 percent of cold cleaners.[1]

- Open top vapor degreasers with less than one square meter (10.8 square feet) air/vapor interface and conveyorized degreasers with less than two square meters (21.6 square feet) are to be exempt. This exemption applies to about 30 percent of open top cleaners and 5 percent of conveyorized degreasers.[2]

The guidelines leave open to the degreaser user the option of changing from a nonexempt solvent to an exempt one. In most cases, this will require some modification of the degreaser and an additional expense for the modification. In this study it was assumed that no substitution is made. In most cases, 1,1,1-trichloroethane would be used as a substitute for existing solvents; this would require equipment conversions because of potential corrosiveness and other properties of this compound. No estimation of costs of conversion was made since data are unavailable on the number of systems which would be converted. If Freon 113 were used as a substitute new cleaners would probably have to be purchased.

1. Interview with Safety-Kleen Co., Gray-Mills Co. and Kleer-Flo Co. personnel; these firms are manufacturers of cold solvent metal degreasing equipment.

2. Based on information in EPA 450/2-77-022, op. cit., and interviews with Baron-Blakeslee and Detrex Chemical personnel.

No reliable information has been found which relates size of cleaner with solvent composition. Therefore, we have assumed a uniform distribution of solvent composition with cleaner size, i.e., the number of small cleaners using exempt solvents is the same as the number of large cleaners using exempt solvents. For instance, the total of nonexempt open top vapor degreasers in the state was determined by multiplying the total number of open top vapor degreasers in the state by the fractions that are nonexempt by solvent use and by size, i.e.:

Number exempt by size = (Total number of open top degreasers) x (Fraction exempt by size, 0.3)

Number exempt by solvent = (Total number of open top degreasers - number exempt by size) x (Fraction exempt by solvent, 0.35)

Total number of affected (nonexempt) degreasers = (Total number of open top degreasers) - (Number exempt by size) - (Number exempt by solvent)

The resulting estimate of the total number of degreasers in the state and those exempt from the proposed regulations by size and solvent composition are summarized in Exhibit 11-4, in section 11.2.

11.1.4 Method of Estimation of Number and Type of Retrofitted Controls Needed

The proposed regulations specify certain controls which can be retrofitted to existing solvent metal cleaners. These are discussed in detail in a later section of this chapter. Briefly they are:

- For nonexempt cold cleaners--
  - A cover must be installed when the solvent used has a volatility greater than 15 millimeters of mercury at 38°C, or is agitated, or the solvent is heated; and
  - An internal drainage facility (or, where that is not possible, an external closed drainage facility) must be installed, such that the cleaned parts drain while covered, when the solvent used has a volatility greater than 32 millimeters of mercury at 38°C; and
  - Where the solvent has a volatility greater than 32 millimeters of mercury at 38°C, a freeboard must be installed that gives a freeboard ratio (i.e., distance from cleaner top to solvent surface divided by cleaner width) greater than or equal to 0.7; or a water cover where the solvent is heavier and immiscible or unreactive with water; or some other system of equivalent control.

- For nonexempt open top vapor degreasers--
  - The vapor degreaser must be equipped with a cover; and
  - A spray safety switch must be installed which shuts off the spray pump when the vapor level drops more than 4 inches; and
  - If the freeboard ratio is greater than 0.75, a powered cover must be installed or a refrigerated chiller; or an enclosure in which a cover or door opens only when the dry part is entering or exiting the degreaser; or a carbon adsorption system; or an equivalent control system.
- For nonexempt conveyorized degreasers--
  - A refrigerated chiller; or carbon adsorption system; or another equivalent control system must be installed; and
  - The cleaner must be equipped with a drying tunnel or rotating basket to prevent cleaned parts from carrying out solvent; and
  - A condenser flow switch and thermostat, a spray safety switch and a vapor high level control thermostat must be installed; and
  - Openings must be minimized during operation so that entrances and exits silhouette workloads; and
  - Downtime covers must be provided for closing off the entrance and exit during shutdown hours.

Exhibits 11-16, 11-17 and 11-18 in section 11.4, summarize estimates of the percentage of nonexempt cleaners needing these controls. Equipment manufacturers were the primary source of the percentages used. In applying this information, it was assumed that the number and types of controls needed were independent of size.

11.1.5 Method of Estimation of Current Emissions and Expected Reductions

Current VOC emissions from solvent metal degreasing and the reductions anticipated by the enforcement of the proposed regulations are based on information presented in Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977. This report estimates average emissions for each type of degreaser. The total current emissions were obtained by multiplying these estimated average emissions by the number of each type of degreaser in the state.

The report also estimates the reduction in emissions possible by implementation of various types of controls. The methods proposed in recent EPA guidance can result in reduction of 50 percent to 69 percent for various types of degreasers. Emission levels which would result from implementation of the RACT proposals for solvent metal cleaners was obtained by use of these estimated reductions for the number of nonexempt cleaners in the state. For purposes of estimation, a 50 percent reduction was used for cold cleaners. For open top vapor and conveyorized cleaners, a 60 percent reduction was used.

11.1.6 Method of Estimation of Compliance Costs

Compliance costs also were based primarily on the cost data presented in the EPA report, Control of Volatile Organics Emissions from Solvent Metal Cleaning, for average-sized, cold, open top vapor and conveyorized cleaners. The cost data, however, were verified by discussions with equipment manufacturers. Where some costs, such as for safety switches or downtime covers, were not estimated in the report, estimates were based on further discussions with equipment manufacturers. In the EPA report, costs were presented for various retrofit control options; in each case, the control which would provide minimum net annualized costs was used in the estimates made here. Other costs not presented in the EPA report were determined as follows:

- Capital costs for safety switches, minimizing conveyorized cleaner openings and downtime covers were estimated on the basis of discussions with equipment manufacturers. Costs used were:
  - $275 per manual cover and $100 per safety switch installation for open top vapor degreasers
  - $250 per safety switch installation, $300 per downtime cover installation, $2,500 per drying tunnel and $1,000 for reducing openings for conveyorized cleaners.

- An average of $300 was estimated as the cost to increase free board of cold cleaners using high volatility solvents.

- Additional annual capital charges were estimated as 25 percent of capital costs, to include depreciation, interest, maintenance, insurance and administrative costs.

- Labor costs for mounting downtime covers on conveyorized cleaners at shift end were estimated at $1,500 per year per cleaner.

- Additional costs which might result from decreased productivity, labeling and other requirements of the proposed regulations were assumed to be small and negligible.

11.1.7 Quality of Estimates

Several sources of information were utilized in assessing the emissions, direct compliance cost and economic impact of implementing RACT controls on plants using solvent metal degreasers in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data, "B' indicates data that were not available in secondary literature and were extrapolated from hard data (i.e., data that are published for the base year) and "C" indicates data were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 11-1, on the following page, rates each study output and overall quality of the data.

EXHIBIT 11-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	X	X	
Emissions		X	
Cost of emissions control		X	X
Statewide costs of emissions			X
Overall quality of data		X	

Source: Booz, Allen & Hamilton Inc.

11.2 INDUSTRY STATISTICS

This section summarizes an estimation of the total number of solvent metal cleaners in the state determined by the methods discussed in section 11.1.2 of this report. As shown in Exhibits 11-2 and 11-3, on the following pages, a total of 1,294 open top vapor degreasers, 298 conveyorized degreasers and 75,610 cold cleaners are estimated to be in use in Ohio in manufacturing, maintenance and service. As discussed earlier, not all of these will be subject to RACT regulations because of size or solvent exemptions. About 30 percent of open top vapor degreasers, 5 percent of conveyorized degreasers and 70 percent of cold cleaners are expected to be exempt on the basis of size. About 35 percent of open top vapor degreasers, 10 percent of conveyorized degreasers and 20 percent of cold cleaners are expected to be exempt because they use exempt solvents 1,1,1-trichloroethane or Freon 113. Applying these factors results in the total of affected cleaners shown in Exhibit 11-4, following Exhibit 11-3.

It is difficult to estimate the number of establishments affected by the regulations, since a plant may have one or many cleaners of each type. In fact, large-scale users may have more than 100 degreasing operations in one plant location. Metal working industries would be major users; eight SIC codes, 25 and 33-39, cover these industries.

These classifications include such industries as automotive, electronics, appliances, furniture, jewelry, plumbing, aircraft, refrigeration, business machinery and fasteners. However, use of solvent cleaning is not limited to those industries, since many cleaners are used, for both manufacturing and maintenance, in nonmetal working industries such as printing, chemicals, plastics, rubber, textiles, paper and electric power. Also, most automotive, railroad, bus, aircraft, truck and electric motor repair stations use metal solvent cleaners at least part time.

As shown in Exhibit 11-2, 1,566 establishments in the SIC codes 25 and 33-39, with more than 19 employees are estimated to use solvent metal degreasing. However, as shown in Exhibit 11-3, following Exhibit 11-2, there are a total of 8,135 plants in SIC groups 25 and 33-39 and an additional 11,360 plants in service industries; all of these are expected to have some type of solvent degreaser and could be potentially affected.

Exhibit 11-2(1)
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF VAPOR DEGREASERS
IN OHIO

Item	SIC GROUP								
	25 Metal Furniture	33 Primary Metals	34 Fabricated Products	35 Nonelectrical Machinery	36 Electrical Equipment	37 Transptn. Equipment	38 Instruments and clocks	39 Misc. Industry	Total
Number of Ohio plants with more than 19 employees[a]	121	406	1,004	1,013	328	234	124	148	3,378
Percent of U.S. plants using solvent degreasing[b]	46	40	42	52	55	50	65	39	
Percent of Ohio plants using solvent degreasing	45	39	41	51	54	49	64	38	
Number of Ohio plants using solvent degreasing	54	158	411	516	177	115	79	56	1,566
Percent of U.S. plants using vapor degreasing	48	42	41	33	67	43	62	56	
Percent of Ohio plants using vapor degreasing	46	40	39	31	64	41	59	53	
Number of Ohio plants using vapor degreasing	25	63	160	160	113	47	47	30	645
Average number of vapor degreasers per U.S. plant	1.98	2.21	1.62	1.61	2.03	3.25	2.27	1.02	
Average number of vapor degreasers per Ohio plant	1.85	2.06	1.51	1.50	1.89	3.03	2.12	0.95	
Number of vapor degreasers in Ohio	46	130	241	240	213	142	100	28	1,140

Exhibit 11-2(2)
U.S. Environmental Protection Agency
(Ohio)

Item	SIC GROUP 25 Metal Furniture	33 Primary Metals	34 Fabricated Products	35 Nonelectrical Machinery	36 Electrical Equipment	37 Transptn. Equipment	38 Instruments and clocks	39 Misc. Industry	Total
Percent in U.S. as open top degreasers	74	79	79	81	87	87	94	89	
Percent in Ohio as open top degreasers	69	74	74	76	81	81	88	83	
Number of open top vapor degreasers in Ohio	32	96	178	182	172	115	88	23	886[c]
Number of conveyorized vapor degreasers in Ohio	14	34	63	58	41	27	12	5	254[d]

Note: All data based on plants with more than 19 employees. Number of degreasers rounded to the nearest whole integer.

a. Source: County Business Patterns, U.S. Dept. of Commerce, 1976.

b. Source of data on percentage of plants solvent degreasing, those with open top or conveyorized vapor degreasers and average numbers of degreasers per plant: Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations, Dow Chemical Company under EPA Contract 68-02-1329, June 30, 1976.

c. To adjust quantities to account for vapor degreasers in other SIC groups multiply by the factor (22,200/15,200) the ratio of all vapor degreasers in U.S. to open top vapor degreasers in metal working SIC groups.

d. To adjust quantities to include cold conveyorized cleaners, multiply by 100/85, since conveyorized vapor cleaners are estimated to represent 85 percent of all conveyorized cleaners.

Source: Booz, Allen & Hamilton Inc. analysis of Department of Commerce and EPA Reports

EXHIBIT 11-3
U.S. Environmental Protection Agency
ESTIMATED NUMBERS OF COLD
CLEANERS IN OHIO

	U.S.	Ohio
Total number of plants in SIC Groups 25,33,34,35,36.37,38,39[a]	125,271	8,135
Estimated number of cold cleaners in manufacturing[b]	390,000	25,300
Total number of plants in service industries 551,554,557,7538,7539,7964[a]	227,350	11,360
Estimated number of cold cleaners[b,c] in maintenance and service use	910,000	50,310
Estimated total number of cold cleaners[b]	1,300,000	75,610

Notes:

a. Source: 1976 County Business Patterns, U.S. Department of Commerce, 1976.

b. Source: Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

c. This includes cold cleaners in maintenance and service applications by both manufacturing and repair firms.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-4
U.S. Environmental Protection Agency
ESTIMATE OF AFFECTED SOLVENT METAL
CLEANERS IN OHIO

Exemption	Number of Cleaners by Type		
	Cold	Open Top Vapor	Conveyorized
Total number of cleaners	75,610	1,294	298
Number exempt by size	52,930	388	14
Number nonexempt by size	22,680	906	283
Number further exempted by type of solvent used	4,540	317	28
Total number of affected cleaners	18,140	589	255

Source: Booz, Allen & Hamilton Inc.

11.3 THE TECHNICAL SITUATION IN THE INDUSTRY

11.3.1 Solvent Metal Cleaning Processes[1]

Solvent metal cleaning describes those processes using nonaqueous solvents to clean and remove soils from metal surfaces. These solvents, which are principally derived from petroleum, include petroleum distillates, chlorinated hydrocarbons, ketones and alcohols. Organic solvents, such as these, can be used alone or in blends to remove water-insoluble soils for cleaning purposes and to prepare parts for painting, plating, repair, inspection, assembly, heat treatment or machining.

A broad spectrum of organic solvents is available. Choices among the solvents are based on the solubility of the soil, toxicity, flammability, evaporation rate, effect on nonmetallic portions of the part cleaned and numerous other properties. Exhibit 11-5, on the following page, lists solvents normally used in solvent degreasing.

The cleaning techniques can be broken down into two categories: cold cleaning and vapor degreasing. In cold cleaning, parts are dipped, sprayed, brushed or wiped with solvents at or near room temperature. In vapor degreasing, cold parts are suspended in a solvent vapor which condenses on the parts and dissolves greases and other soils.

Typically, the cleaning process is done in one of three types of cleaners or degreasers:

- A cold cleaner
- An open top vapor degreaser
- A conveyorized degreaser.

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1 The descriptive and other information in this section has been obtained from Control of Volatile Organic Emissions from Solvent Metal Cleaning (EPA-450/2-77, November 1977). This document should be consulted for a more detailed description of the techniques and devices used for solvent degreasing.

EXHIBIT 11-5
U.S. Environmental Protection Agency
SOLVENTS CONVENTIONALLY USED IN
SOLVENT METAL DEGREASING

General Type	Solvent
Alcohols	Ethanol (95%) Isopropanol Methanol
Alipatic hydrocarbons	Heptane Kerosene Stoddard Mineral spirits 66
Aromatic hydrocarbons	Benzene SC 150 Toluene Turpentine Xylene
Chlorinated solvents	Carbon tetrachloride Methylene chloride Perchloroethylene 1,1,1-trichloroethane Trichloroethylene
Fluorinated solvents	Trichlorotrifluoroethane (FC-113)
Ketones	Acetone Methyl ethyl ketone

Source: Booz, Allen & Hamilton Inc.

11.3.1.1 Cold Cleaners

Cold cleaner operations include spraying, brushing, flushing and immersion. The solvent occasionally is heated in cold cleaners but always remains well below its boiling point.

Cold cleaners are estimated to result in the largest total emission of the three categories of degreasers. This is primarily because there are so many of these units (more than 1 million nationally) and because much of the waste solvent that is disposed of is allowed to evaporate. It is estimated that cold cleaners emit 420,000 short tons of organics per year, about 55 percent of the national degreasing emissions. Cold cleaning solvents nationally account for almost all of the aliphatic, aromatic and oxygenated degreasing solvents and about one-third of halogenated degreasing solvents.

Despite the large aggregate emission, the average cold cleaning unit generally emits only about one-third ton per year of organics, with about one-half to three-fourths of that emission resulting from evaporation of the waste solvent at a disposal site.

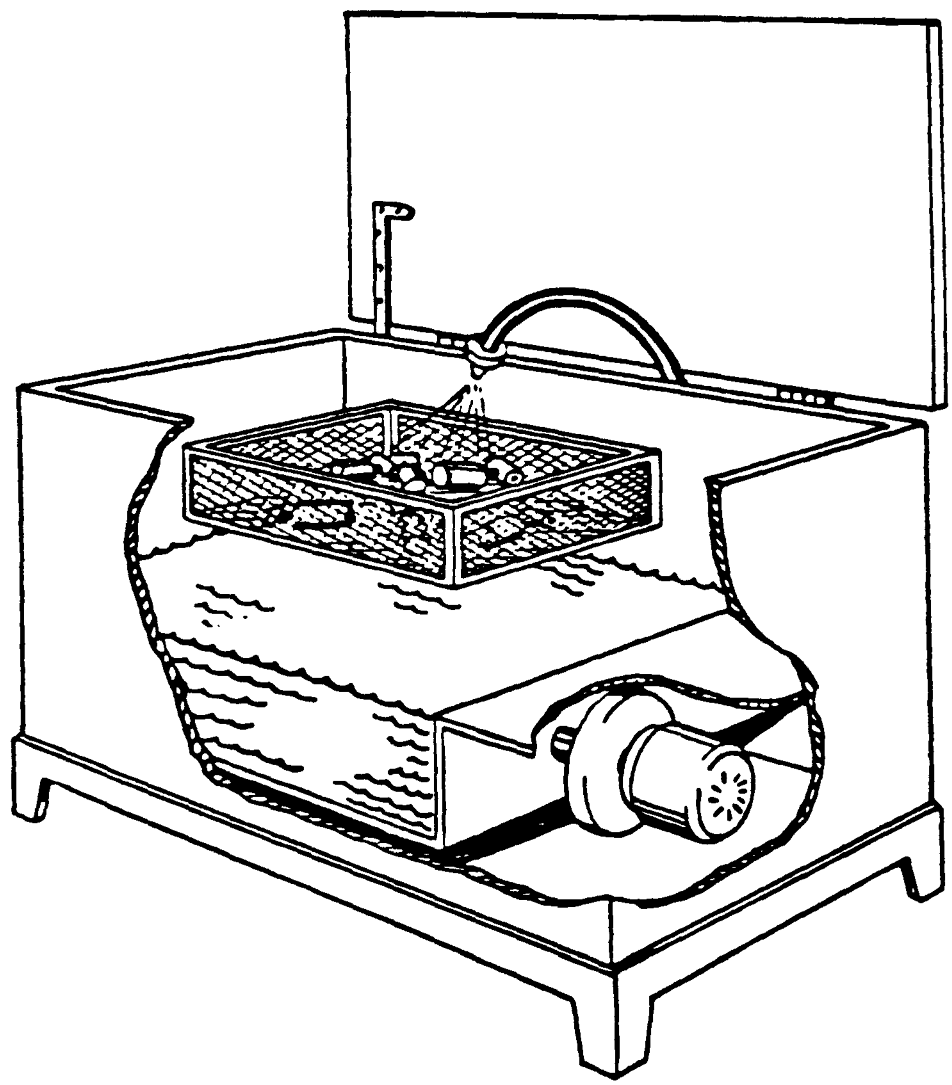
In a typical cold cleaner (Figure 11-1, on the following page), dirty parts are placed in a basket and are cleaned manually by spraying or soaking in a dip tank. The solvent in this dip tank is often agitated to enhance the cleaning action. After cleaning, the basket of cleaned parts may be suspended over the solvent to allow the parts to drain, or the cleaned parts may be drained on an external drainage rack which routes the drained solvent back into the cleaner. The cover should be closed whenever parts are not being handled in the cleaner. Typically, a maintenance cold cleaner has about 0.4 m^2 (4 $ft.^2$) of opening and about 0.1 m^3 (30 gallon) capacity.

The two basic types of cold cleaners are maintenance cleaners and manufacturing cleaners. The maintenance cold cleaners are usually simpler, less expensive and smaller. They are designed principally for automotive and general plant maintenance cleaning.

Manufacturing cold cleaners usually give a higher quality of cleaning than maintenance cleaners do, and are thus more specialized. Manufacturing cold cleaning is generally an integral stage in metal working production. There are fewer manufacturing cold cleaners than maintenance cleaners but the former tend to emit more solvent per unit because of the larger

FIGURE 11-1
U.S. Environmental Protection Agency
TYPICAL COLD CLEANER

SPRAY CLEANING EQUIPMENT



Source: EPA 450/2-77-022, op. cit.

size and workload. Manufacturing cleaners use a wide variety of solvents, whereas maintenance cleaners use mainly petroleum solvents such as mineral spirits (petroleum distillates and Stoddard solvents). Some cold cleaners can serve both maintenance and manufacturing purposes and thus are difficult to classify.

11.3.1.2 Open Top Vapor Degreasers

Vapor degreasers clean through the condensation of hot solvent vapor on colder metal parts. Open top vapor degreasers are batch loaded, i.e., they clean only one workload at a time.

Open top vapor degreasers are estimated to result in the second largest emission of the three categories of degreasers. It is estimated that open top vapor degreasers emit 220,000 short tons of organic per year, this being about 30 percent of the national degreasing emissions.

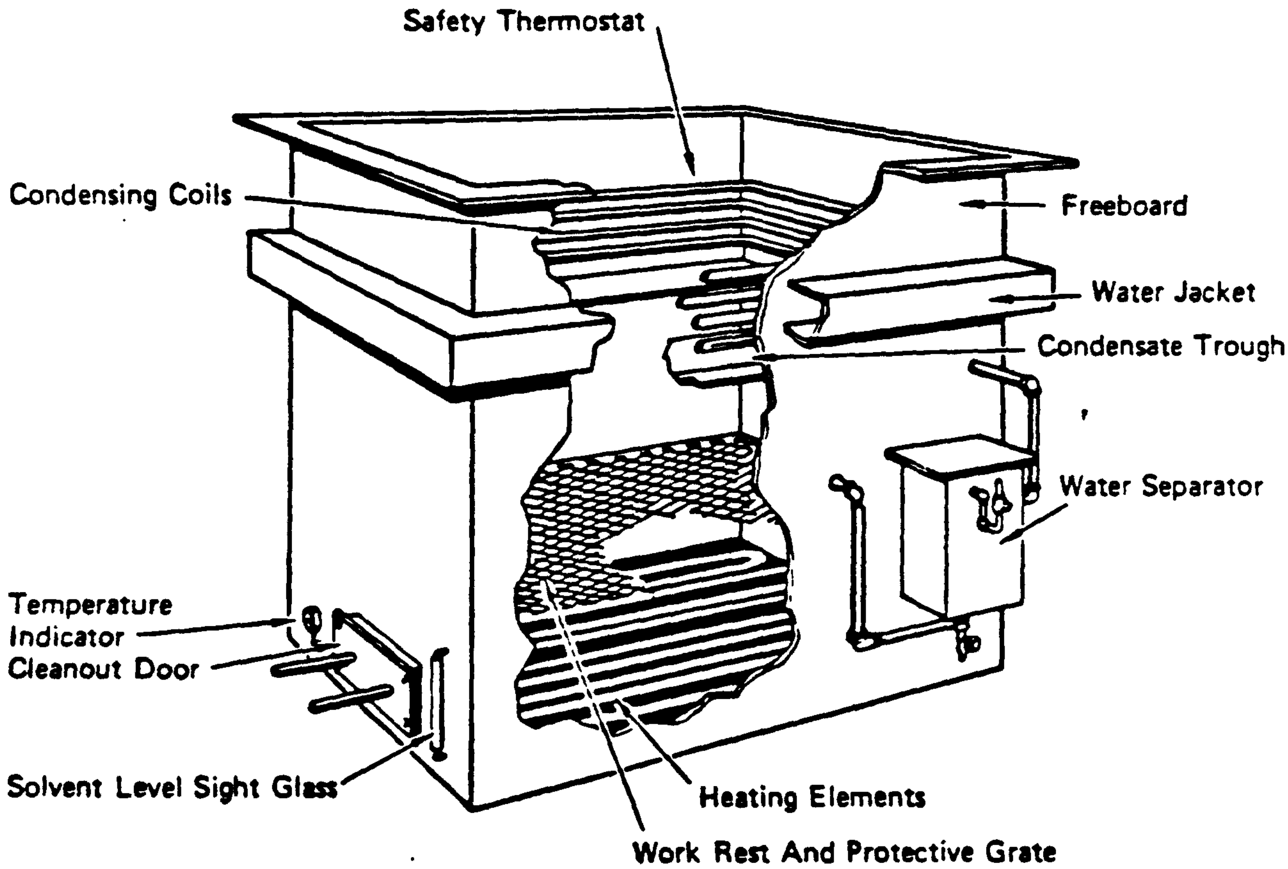
In the vapor degreaser, solvent vapors condense on the parts to be cleaned until the temperature of the parts approaches the boiling point of the solvent. The condensing solvent both dissolves oils and provides a washing action to clean the parts. The selected solvents boil at much lower temperatures than do the contaminants; thus, the solvent/soil mixture in the degreaser boils to produce an essentially pure solvent vapor.

The simplest cleaning cycle involves lowering the parts into the vapor zone so that the condensation action can begin. When condensation ceases, the parts are slowly withdrawn from the degreaser. Residual liquid solvent on the parts rapidly evaporates as the parts are removed from the vapor zone. The cleaning action is often increased by spraying the parts with solvent (below the vapor level) or by immersing them into the liquid solvent bath.

A typical vapor degreaser, shown in Figure 11-2, on the following page, is a tank designed to produce and contain solvent vapor. At least one section of the tank is equipped with a heating system that uses steam, electricity or fuel combustion to boil the solvent. As the solvent boils, the dense solvent vapors displace the air within the equipment. The upper level of these pure vapors is controlled by condenser coils located on the sidewalls of the degreaser. These coils, which are supplied with a coolant such as water, are generally located around the entire inner surface of the degreaser, although for some smaller equipment they are limited to a spiral coil at one end of the degreaser. Most vapor degreasers are also equipped with a water jacket which provides additional cooling and prevents convection of solvent vapors up hot degreaser walls.

FIGURE 11-2
U.S. Environmental Protection Agency
TYPICAL OPEN TOP VAPOR DEGREASER

OPEN TOP DEGREASER



Source: EPA 450/2-77-022, op. cit.

The cooling coils must be placed at some distance below the top edge of the degreaser to protect the solvent vapor zone from disturbance caused by air movement around the equipment. This distance from the top of the vapor zone to the top of the degreaser tank is called the freeboard and is generally established by the location of the condenser coils.

Nearly all vapor degreasers are equipped with a water separator, such as that depicted in Figure 11-2. The condensed solvent and moisture are collected in a trough below the condenser coils and directed to the water separator. The water separator is a simple container which allows the water (being immiscible and less dense than solvents) to separate from the solvent and decant from the system while the solvent flows from the bottom of the chamber back into the vapor degreaser.

11.3.1.3 Conveyorized Degreaser

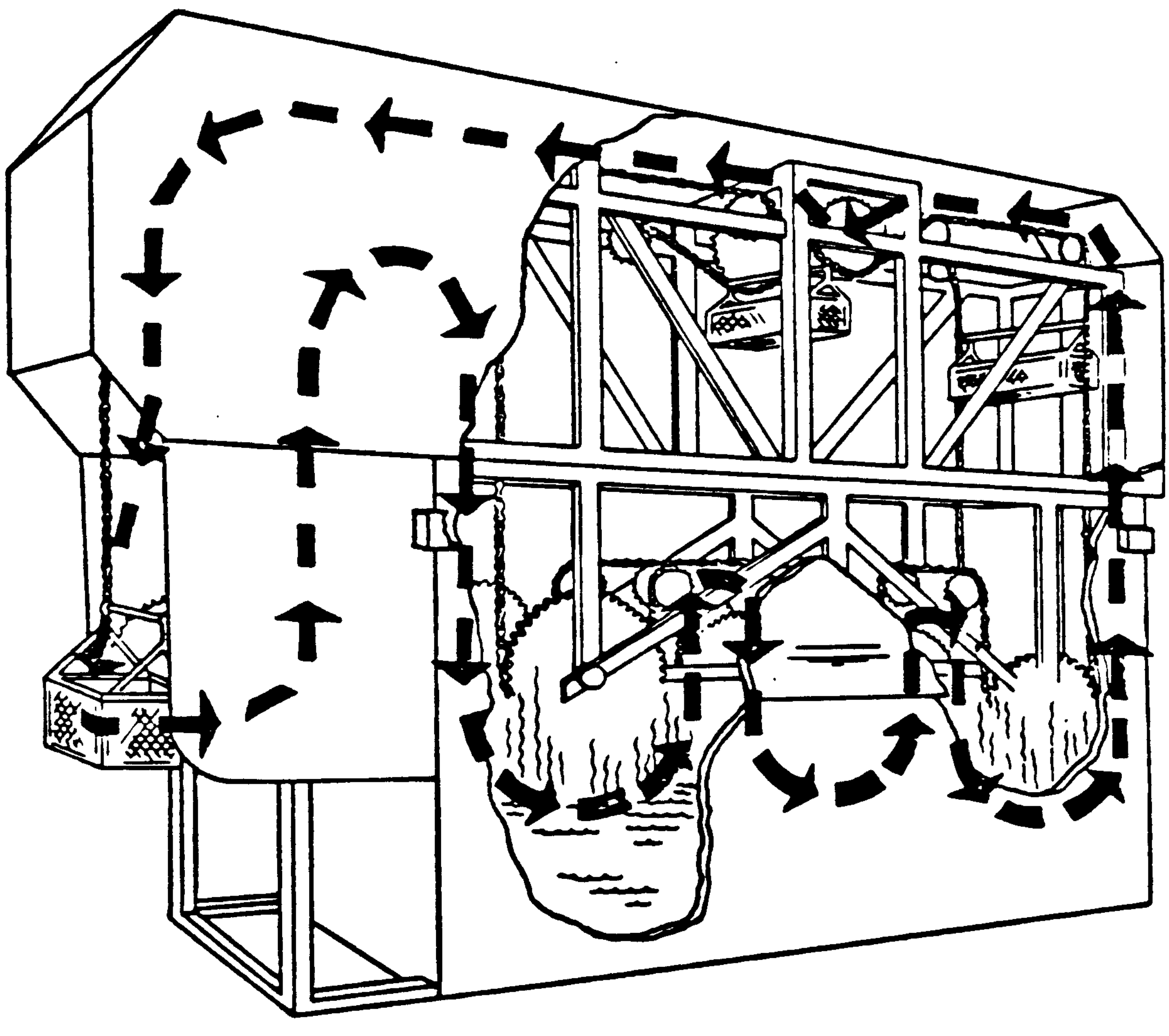
There are several types of conveyorized degreasers, operating both with cold and with vaporized solvents. An average conveyorized degreaser emits about 25 metric tons per year of solvent; however, because of their limited numbers, these degreasers contribute only about 15 percent of the total solvent degreasing emissions. Because of their large work capacity, conveyorized degreasers actually emit less solvent per part cleaned than either open top vapor degreasers or cold cleaners.

In conveyorized equipment, most, and sometimes all, of the manual parts handling associated with open top vapor degreasing has been eliminated. Conveyorized degreasers are nearly always hooded or covered. The enclosure of a degreaser diminishes solvent losses from the system as the result of air movement within the plant. Conveyorized degreasers are used by a broad spectrum of metal working industries but are most often found in plants where there is enough production to provide a constant stream of products to be degreased.

There are a number of types of conveyorized degreasers employing various techniques of conveying the parts, either through a pool or spray of cold cleaning solvents or through a space containing vaporized solvent. A cross-rod degreaser (Figure 11-3, on the following page) illustrates the general concepts of operation of the various types of conveyorized degreasers.

FIGURE 11-3
U.S. Environmental Protection Agency
TYPICAL CONVEYORIZED DEGREASER

CROSS-ROD CONVEYORIZED DEGREASER



Source: EPA 450/2-77-022, op. cit.

The cross-rod degreaser obtains its name from the rods between the two power driven chains from which parts are supported as they are conveyed through the equipment. The parts are contained in pendant baskets or, where tumbling of the parts is desired, perforated cylinders. These cylinders are rotated by a rack and pinion design within the solvent and/or the vapor zone. This type of equipment lends itself particularly well to handling small parts which need to be immersed in solvent to obtain satisfactory cleaning or require tumbling to provide drainage from cavities in the parts.

Other types of conveyorized degreasers similarly use rotating wheels, conveyor belts, monorail or other systems to convey the parts through the degreasing medium.

11.3.2 Proposed Emission Control Systems for Solvent Metal Cleaners[1]

The EPA has proposed two different emission control methods, A and B, for each of the three types of cleaners: cold, open top vapor and conveyorized. The control methods can be combined in various ways to form a number of alternative control systems. Generally, control system A consists of proper operating practices and simple, inexpensive control equipment. Control system B consists of system A plus other devices that increase the effectiveness of control. Elements of control systems A or B can be modified to arrive at the level of control needed. The control systems are presented in the three exhibits, Exhibit 11-6, 11-7 and 11-8, on the following pages, and are briefly discussed below In most recent RACT guidelines, use of control system B has been proposed to maximize emission reductions;[2] costs, therefore, were assumed only for this case.

11.3.2.1 Cold Cleaning Control Systems

The most important emission control for cold cleaners is the control of waste solvent. The waste solvent needs to be reclaimed or disposed of so that a minimum evaporates into the atmosphere. Next in importance are the operating practices of closing the cover and draining cleaned parts. Several other control techniques become significant only in a small fraction of applications.

The difference in effect between systems A and B (Exhibit 11-6) is not large because most of the cold cleaning emissions are controlled in system A. If the requirements of system A

1 Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022

2 Regulatory Guidance for Control of Volatile Organic Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001

EXHIBIT 11-6

U.S. Environmental Protection Agency
CONTROL SYSTEMS FOR COLD CLEANING

Control System A

Control Equipment:

1. Cover

2. Facility for draining cleaned parts

3. Permanent, conspicuous label, summarizing the operating requirements

Operating Requirements:

1. Do not dispose of waste solvent or transfer it to another party, such that greater than 20 percent of the waste (by weight) can evaporate into the atmosphers.* Store waste solvent only in covered containers.

2. Close degreaser cover whenever not handling parts in the cleaner.

3. Drain cleaned parts for at least 15 seconds or until dripping ceases.

Control System B

Control Equipment:

1. Cover: Same as in System A, except if (a) solvent volatility is greater than 2 Kpa (15 mm Hg or 0.3 psi) measured at 38°C (100°F),** (b) solvent is agitated, or (c) solvent is heated, then the cover must be designed so that it can be easily operated with one hand. (Covers for larger degreasers may require mechanical assistance, by spring loading, counterweighting or powered systems.)

2. Drainage facility: Same as in System A, except that if solvent volatility is greater than about 4.3 Kpa (32 mm Hg or 0.6 psi) measured at 38° C (100°F), then the drainage facility must be internal, so that parts are enclosed under the cover while draining. The drainage facility may be external for applications where an internal type cannot fit into the cleaning system.

3. Label: Same as in System A

4. If used, the solvent spray must be solid, fluid stream (not a fine, atomized or shower type spray) and at a pressure which does not cause excessive splashing.

5. Major control device for highly volatile solvents: If the solvent volatility is 4.3 Kpa (33 mm Hg or 0.6 psi) measured at 38°C (100°F), or if solvent is heated about 50°C (120°F), then one of the following control devices must be used:

a. Freeboard that gives a freeboard ratio*** 0.7

b. Water cover (solvent must be insoluble in and heavier than water)

c. Other systems of equivalent control, such as refrigerated chiller or carbon absorption.

Operating Requirements:

Same as in System A

---

* Water and solid waste regulations must also be complied with
** Generally solvents consisting primarily of mineral spirits (Stoddard) have volatilities 2 Kpa.
*** Freeboard ratio is defined as the freeboard height divided by the width of the degreaser.

Source: EPA 450/2-77-022, op. cit.

EXHIBIT 11-7(1)

U.S. Environmental Protection Agency

EPA PROPOSED CONTROL SYSTEMS FOR OPEN TOP VAPOR DEGREASERS

Control System A

Control Equipment:

1. Cover that can be opened and closed easily without disturbing the vapor zone.

Operating Requirements:

1. Keep cover closed at all times except when processing work loads through the degreaser.

2. Minimize solvent carry-out by the following measures:

a. Rack Parts to allow full drainage.
b. Move parts in and out of the degreaser at less than 3.3 m/sec (11 ft/min).
c. Degrease the work load in the vapor zone at least 30 sec. or until condensation ceases.
d. Tip out any pools of solvent on the cleaned parts before removal.
e. Allow parts to dry within the degreaser for at least 15 sec. or until visually dry.

3. Do not degrease porous or absorbent materials, such as cloth, leather, wood or rope.

4. Work loads should not occupy more than half of the degreaser's open top area.

5. The vapor level should not drop more than 10 cm (4 in) when the work load enters the vapor zone.

6. Never spray above the vapor level.

7. Repair solvent leaks immediately, or shutdown the degreaser.

8. Do not dispose of waste solvent or transfer it to another party such that greater than 20 percent of the waste (by weight) will evaporate into the atmosphere. Store waste solvent only in closed containers.

9. Exhaust ventilation should not exceed 20 m^3/min per m^2 (65 cfm per ft^2) of degreaser open area, unless necessary to meet OSHA requirements. Ventilation fans should not be near the degreaser opening.

10. Water should not be visually detectable in solvent exiting the water separator.

Control System B

Control Equipment:

1. Cover (same as in system A).

2. Safety switches

a. Condenser flow switch and thermostat - (shuts off sump heat if condenser coolant is either not circulating or too warm).
b. Spray safety switch - shuts off spray pump if the vapor level drops excessively, about 10 cm (4 in).

Source: EPA 450/2-77-022, op. cit.

3. Major Control Device:

Either: a. Freeboard ratio greater than or equal to 0.75, and if the degreaser opening is 1 m^2 (10 ft^2), the cover must be powered,
b. Refrigerated chiller,
c. Enclosed design (cover or door opens only when the dry part is actually entering or exiting the degreaser.),
d. Carbon adsorption system, with ventilation 15 m^3/min per m^2 (50 cfm/ft^2) or air/vapor area (when cover is open), and exhausting 25 ppm solvent averaged over one complete adsorption cycle, or
e. Control system, demonstrated to have control efficiency, equivalent to or better than any of the above.

4. Permanent, conspicuous label, summarizing operating procedures #1 to #6.

Operating Requirements:

Same as in System A.

Source: EPA 450/2-77-022, op. cit.

EXHIBIT 11-8

U.S. Environmental Protection Agency
EPA PROPOSED CONTROL SYSTEMS FOR CONVEYORIZED DEGREASERS

Control System A

Control Equipment: None

Operating Requirements:

1. Exhaust ventilation should not exceed 20 m^3/min per m^2 (65 cfm per ft^2) of degreaser opening, unless necessary to meet OSHA requirements. Work place fans should not be used near the degreaser opening.

2. Minimize carry-out emissions by:

a. Racking parts for best drainage.
b. Maintaining verticle conveyor speed at 3.3 m/min (11 ft/min).

3. Do not dispose of waste solvent or transfer it to another party such that greater than 20 percent of the waste (by weight) can evaporate into the atmosphere. Store waste solvent only in covered containers.

4. Repair solvent leaks immediately, or shutdown the degreaser.

5. Water should not be visibly detectable in the solvent exiting the water separator.

Control System B

1. Major control devices; the degreaser must be controlled by either:

a. Refrigerated chiller,
b. Carbon adsorrtion system, with ventilation 15 m^2/min per m^2 (50 cfm/ft^2) of air/vapor area (when down-time covers are open), and exhausting 25 ppm of solvent by volume averaged over a complete adsorption cycle, or
c. System demonstrated to have control efficiency equivalent to or better than either of the above.

2. Either a drying tunnel, or another means such as rotating (tumbling) basket, sufficient to prevent cleaned parts from carrying out solvent liquid or vapor.

3. Safety switches

a. Condenser flow switch and thermostat - (shuts off sump heat if coolant is eiter not circulating or too warm).
b. Spray safety switch - (shuts off spray pump or conveyor if the vapor level drops excessively, e.g. 10 cm (4 in.)).
c. Vapor level control thermostat - (shuts off sump heat when vapor level rises too high).

4. Minimized openings: Entrances and exits should silhouette work loads so that the average clearance (between parts and the edge of the degreaser opening) is either 10 cm (4 in.) or 10 percent of the width of the opening.

5. Down-time covers: Covers should be provided for closing off the entrance and exit during shutdown hours.

Operating Requirements:

1. to 5. Same as the System A

6. Down-time cover must be placed over entrances and exits of conveyorized degreasers immediately after the conveyor and exhaust are shutdown and removed just before they are started up.

Source: EPA 450/2-77-022, op. cit.

were followed conscientiously by nearly all of the cold cleaning operators, there would be little need for the additional system B requirements. However, because cold cleaning operators tend to be lax in keeping the cover closed, equipment requirements #1 and #4 in system B are added. Similarly, the modifications for #2 and the equipment requirements in #3 would effect significant emission reductions in a few applications.

The effectiveness of the control systems depends greatly on the quality of operation. On the average, system A is estimated to be able to reduce cold cleaning emissions by 50 (± 20) percent and system B may reduce it by 53 (± 20) percent. The low end of the range represents the emission reduction projected for poor compliance, and the high end represents excellent compliance. The expected benefit from system B is only slightly better than that for system A for an average cold cleaner because the additonal devices required in system B generally control only bath evaporation, about 20 to 30 percent of the total emission from an average cold cleaner. For cold cleaners with high volatility solvents, bath evaporation may contribute about 50 percent of the total emission; EPA estimates that system B could achieve 69 (± 20) percent control efficiency, whereas system A might achieve only 55 (±20) percent.[1]

11.3.2.2 Open Top Vapor Degreasing Control Systems

The basic elements of a control system for open top vapor degreasers are proper operating practices and use of control equipment. There are about ten main operating practices. The control equipment includes a cover, safety switches and a major control device, either high freeboard, refrigerated chiller, enclosed design or carbon adsorption as outlined in Exhibit 11-7.

A vapor level thermostat is not included because it is already required by OSHA on "open surface vapor degreasing tanks." Sump thermostats and solvent level controls are used primarily to prevent solvent degradation and protect the equipment and thus are also not included here. The emission reduction by these controls is a secondary effect in any event. The two safety switches serve primarily to reduce vapor solvent emissions.

[1] EPA 450/2-77-022

EXHIBIT 11-9
U.S. Environmental Protection Agency
AVERAGE UNIT EMISSION RATES AND EXPECTED
EMISSION REDUCTIONS

EMISSION RATES WITHOUT CONTROLS

Type of Degreaser	Averaged Emission Rate Per Unit (short tons/yr.)
Cold cleaners, batch [a]	0.33
Open top vapor degreaser	11.00
Conveyorized degreaser	29.70

PERCENT EMISSION REDUCTION EXPECTED WITH TYPE B CONTROLS

Type of Degreaser	Percent Emission Reduction Expected
Cold cleaner, batch	
Low volatility solvents	53 (± 20)
High volatility solvents	69 (± 20)
Open top vapor degreaser	60 (± 15)
Conveyorized degreaser	60 (± 15)

a. Does not include emissions from conveyorized-type cold cleaners which represent about 15 percent of all conveyorized cleaners.

Source: EPA-450/2-77-022, op. cit.

11.3.3 Emissions and Expected Emission Reduction

In Exhibit 11-9, on the following page, are summarized the average emissions from solvent metal degreasers by type and also the percent emission reduction expected by implementation of Type B method of controls on affected degreasers. The levels are based on estimated emissions as presented in the previously referenced EPA report (EPA 450/2-77-022) and represent current average emission levels and expected reductions achievable if emission controls are rigorously enforced. For estimation, 50 percent reduction was used for cold cleaners and 60 percent for open top vapor and conveyorized degreasers.

Exhibit 11-10, following Exhibit 11-9, presents the estimated current emissions from solvent metal degreasing and the expected emissions if the B methods of control are implemented for metal cleaners and proposed exemptions for size and type of solvent are implemented. As shown, emissions are expected to be reduced from about 48,100 short tons per year to a total of 36,700 short tons per year. The major portion of these reduced emissions, 28,100 tons, are from solvent metal cleaners exempt from the proposed RACT regulations either by size or by the nature of solvent used. Implementation of the regulations will reduce emissions only by 11,400 short tons per year (48,100-36,700).

11.4 ESTIMATED COSTS OF RACT IMPLEMENTATION

As discussed in section 11.1.6, compliance costs are based upon EPA estimates of the costs and benefits of various retrofitted methods of control. These estimates are summarized in Exhibits 11-11 and 11-12, on the following pages.

Costs of implementation of the RACT regulations are summarized in Exhibits 11-13, 11-14 and 11-15, following Exhibit 11-12, on the assumption that control method B is used to maximize emission reduction on nonexempt cleaners. Exhibits 11-16, 11-17 and 11-18, following Exhibit 11-15, summarize the number and type of controls needed by cleaner type as determined from interviews with cleaner manufacturers. Total expenditures for all cleaners, vapor and cold types, are estimated to be about $9.2 million in capital and about $1.1 million in net annualized costs. The low net annualized costs result primarily from the savings in solvent use which the regulations are expected to provide.

In most cases, the regulations are not expected to present a financial burden to individual firms. The largest single expenditure would be for retrofitting a monorail conveyorized degreaser with chiller, switches, drying tunnel, reduced openings and downtime covers. Total cost for an average-sized degreaser of about 3.8 square meters area (40.9 ft^2) would be less than $12,500. A large unit, 14 square meters, would cost about $27,000 to $30,000. Since these conveyorized systems would only be used in large plants with large sales volumes, this implementation cost is not expected to present a hardship to most firms. There may be a few marginally profitable firms, however, which may find access to sufficient capital difficulty. The number of such firms is anticipated to be small.

EXHIBIT 11-10
U.S. Environmental Protection Agency
ESTIMATED CURRENT AND REDUCED EMISSIONS FROM
SOLVENT METAL CLEANING IN OHIO
(TONS/YEAR)

Type of Cleaner	Estimated Current Emissions	Current Emissions From Affected Cleaners	Estimated Emissions from Affected Cleaners After RACT	Estimated Emissions from Exempt Cleaners After RACT[a]	Estimated Total Emissions After RACT[a]
Open top vapor	14,200	6,400	2,600	7.800	10,400
Conveyorized	8,900	7,700	3,000	1,200	4,200
Cold	25,000	5,900	3,000	19,100	22,100
Total	48,100	20,000	8,600	28,100	36,700

Note: Emissions rounded to nearest 100 tons/year

a. Includes emissions from cleaners exempt by size or using 1,1,1-trichloroethane or Freon 113

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-12
U.S. Environmental Protection Agency
CONTROL COSTS FOR AVERAGE-SIZED
OPEN TOP VAPOR AND CONVEYORIZED CLEANERS

1. CONTROL COSTS FOR TYPICAL SIZE OPEN TOP VAPOR DEGREASER
(Vapor to Air Area of 1.67 m^2)

Control Technique	Manual Cover	Carbon Adsorption[a]	Refrigerated Chiller	Extended Freeboard & Powered Cover
Installed capital ($)	300	10,300	6,500	8,000
Direct operating cost ($/yr.)	10	451	259	100
Capital charges ($/yr.)[b]	75	2,575	1,625	2,000
Solvent cost (credit) ($/yr.)	(860)	(1,419)	(1,290)	(1,161)
Net annualized cost (credit) ($/yr.)	(775)	1,607	594	939

2. CONTROL COSTS FOR TYPICAL CONVEYORIZED DEGREASERS
(Vapor to Air Vapor Area of 3.8 m^2)

Control Technique	Monorail Degreaser		Crossrod Degreaser	
	Carbon[a] Adsorber	Refrigerated Chiller	Carbon[a] Adsorber	Refrigerated Chiller
Installed capital ($)	17,600	8,550	17,600	7,460
Direct operating costs ($/yr.)	970	430	754	334
Capital charges ($/yr.)	4,400	2,138	4,400	1,865
Solvent cost (credit) ($/yr.)	(5,633)	(5,633)	(2,258)	(2,258)
Annualized cost (credit) ($/yr.)	(263)	(3,065)	2,896	(59)

a. Not used in cost estimates since net annualized costs for carbon absorption are the highest for any control method.

b. Capital charges used in study estimate were 25 percent of capital instead of 17 percent used by EPA source.

Source: EPA 450/2-77-022, op. cit.

EXHIBIT 11-11
U.S. Environmental Protection Agency
CONTROL COSTS FOR COLD CLEANER
WITH 5.25 Ft.^{2} AREA

Item	Low Volatility Solvent[a]	High Volatility Solvent[b]
Installed capital ($)	25.00	365
Direct operating costs ($/yr.)	1.00	2.60
Capital charges ($/yr.)[c]	6.25	91.25
Solvent cost (credit) ($/yr.)	(4.80)	(39.36)
Annualized cost (credit) ($/yr.)	2.45	54.49

[a]Costs include only a drainage facility for low volatility solvents.

[b]Includes $65 for drainage facility, a mechanically assisted cover and extension of freeboard.

[c]Capital charges used in study estimates were 25 percent of capital instead of 17 percent used in EPA report.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-14
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR OPEN TOP
VAPOR DEGREASERS FOR THE STATE OF OHIO

1. CAPITAL COSTS

Item	Costs
Safety switches	$ 9,100
Powered covers	2,824,000
Manual covers	53,100
Total	$2,888,900

2. ANNUAL OPERATING COSTS

Item	Costs
Direct operating costs	$ 37,100
Capital charges	722,200
Solvent cost (credit)	(562,000)
Net annualized costs	$ 197,300

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-13
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR COLD CLEANERS
FOR THE STATE OF OHIO

1. CAPITAL COSTS

Item	Number of Degreasers Needing Conversion	Costs
Capital	12,340	$4,194,800

2. ANNUAL OPERATING COSTS

Item	Costs
Direct operating costs	$ 30,600
Capital charges	1,048,700
Solvent cost (credit)	(454,300)
Net annualized costs	$ 625,000

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-16
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF COLD CLEANERS
NEEDING CONTROLS IN THE STATE
OF OHIO

Type of Control	Percent of Cleaners Needing Control	Number of Cleaners[c] Needing Control
Drainage facility only[a]	5	910
Freeboard and drainage[b]	63	11,430

Notes:

a. Based on 10 percent of cleaners using low availability solvents and half of these needing drainage facilities.
b. Based on 90 percent of cleaners using high volatility solvents and 70 percent needing additional freeboard and drainage
c. Numbers of these rounded to nearest 10 units.

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-15
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR CONVEYORIZED
DEGREASERS FOR THE STATE OF OHIO

1. CAPITAL COSTS

Item	Costs
Refrigerator chillers	
Monorail degreasers	$ 784,600
Crossrod degreasers	1,026,800
Safety switches	11,200
Drying tunnel	55,900
Reduce openings	201,200
Downtime covers	60,400
Total	$2,140,100

2. ANNUAL OPERATING COSTS

Item	Costs
Direct operating costs	$ 430,700
Capital charges	535,000
Solvent cost (credit)	(829,840)
Net allualized cost	$ 135,900

Source: Booz, Allen & Hamilton, Inc.

Implementation of the regulations will reduce demand for metal cleaning solvents. At an average price of 15 cents per pound (mineral spirits are about 10 cents per pound; chlorinated solvents are about 20 cents per pound), this would result in a reduction in solvent sales of about $3.4 million annually based on a reduction in emissions of 11,400 tons yearly. This may result in a loss of employment for firms supplying metal cleaning solvents.

11.5.3 Effect of Compliance upon Energy Consumption

Carbon adsorbers, refrigerated chillers and distillation units are the principal energy consuming control devices used for controlling degreasing emissions. The refrigerated chiller, which would probably be the preferred method of control because of its low capital and operating costs, will increase a degreaser's energy consumption by about 5 percent. The EPA has estimated consumption of 0.2 kw to 2.2 kw by a chiller, used on a typical open top vapor degreaser of 1.7m^2 size.[1] For a typical conveyorized degreaser of about 3.8m^2 size, consumption is estimated, on this basis, to be 0.5 kw to 5.0 kw. Only conveyorized degreasers are expected to use chillers to comply; and about 90 percent or 255 of these currently do not have chillers. Assuming 2,250 hours per year operation, total additional energy consumption annually would be about 285,000 kw-hours to 2,850,000 kw-hours. This is equal to $11,400 to $111,400 per year in additional power costs, at a cost of $0.04 per kw-hour. Most of this cost is recovered by savings in solvent use.

[1]EPA-450/2-7-002, op.cit.

EXHIBIT 11-17
U.S. Environmental Protection Agenc
ESTIMATED NUMBER OF OPEN TOP VAPOR
DEGREASERS NEEDING CONTROL IN THE
STATE OF OHIO

Type of Control	Percent of Cleaners Needing Control	Number of Cleaners Needing Control
Manual covers	30	177
Safety switches	20	118
Powered cover	60	353

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-19
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	About 20,000 plants
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is in the range of $55 billion, about one-half of the state's 1977 value of shipments.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents
1977 VOC emissions (actual)	48,100 tons/year (of which 20,000 tons are subject to RACT)
Industry preferred method of VOC control to meet RACT guidelines	Substitution. Otherwise lowest cost option as specified by EPA will be used.
Assumed method of VOC control meet RACT guidelines	Equipment modifications as specified by the RACT guidelines

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$9.2 million
Annualized operating cost (statewide)	$1.1 million, (less than 0.002 percent of the 1977 statewide value of shipments)
Price	Metal cleaning is only a fraction of manufacturing costs; price affect expected to be less than 0.01 percent
Energy	Less than a 1500 equivalent barrels of oil per year in reduction
Productivity	5-10 percent decrease for manually operated degreasers. Will probably not affect conveyoriz cleaners.
Employment	No effect except a possible slight decrease in firms supplying metal degreasing solvents
Market Structure	No change
RACT timing requirements (1982)	Equipment availability--only a few companies now supply the recommended control modification
Problem Areas	No significant problem areas seen. Most firms will be able to absorb cost.
VOC emission after RACT control	36,700 tons/year (76 percent of 1977 VOC emissi level--however, this does not include emission controls for exempt solvents)
Cost effectiveness of RACT control	$105 annualized cost per ton of emissions reduc

Source: Booz, Allen & Hamilton Inc.

11.5 DIRECT ECONOMIC IMPLICATIONS

11.5.1 Time Required to Implement Proposed RACT Regulations

Because so many degreasers are affected under the proposed regulation (589 open top vapor degreasers, 255 conveyorized degreasers and 18,140 cold cleaners in Ohio alone) and because each requires retrofitting of a control device, some users may not be able to comply within proposed compliance schedules because of equipment availability.[1] Discussions with personnel from the major manufacturers of vapor and cold degreasers reveal that none are prepared to provide the necessary controls in quantities to meet a cumulative U.S. wide demand. Some cleaners could be converted to 1,1,1-trichloroethane and thus become exempt. In fact, many metal solvent cleaners have been converted to trichloroethane in the last few years in anticipation of RACT regulations. However, not all existing machines can be converted because of inadequate condensing sections or improper materials of construction. Trichloroethane can be extremely corrosive if stabilizers are insufficiently replenished. In fact, stainless steel vapor degreasers using 1,1,1-trichloroethane have been reported to fail because of corrosion following the loss of stabilizer.

11.5.2 Effect of Compliance upon Selected Economic Indicators

Implementation of the proposed regulations is expected to have a negligible effect on factors such as value of shipments, prices, capital investment or the state economy as a whole, because of the low total capital and annual operating costs required by solvent metal cleaner owners. For example, total shipments in SIC groups 25 and 33-39 alone exceeded $52 billion in 1975 and are expected to exceed $55 billion in 1977. Total capital expenditures for retrofitting are estimated to amount to less than 0.02 percent of this; annualized costs are estimated to be less than 0.002 percent, including a slight drop in productivity because of work practice modifications.

Similarly, implementation is expected to have a negligible impact on total capital expenditures, which amounted to about $1.1 billion in 1976. Since it appears that compliance may require several years in practice, average capital expenditures will be about $2.5 million per year and would be about 0.2 percent or less of normal capital expenditures for plants in these SIC groups.[2] Considering that these expenditures are spread over service industries, and other industries also not included in SICs 25 and 33-39, the overall economic impact is even less significant.

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1 Based on comments by several degreasing equipment manufacturers who have not geared up production for potential demands created by implementation of RACT guidelines.

2 1976 Census of Manufactures data for average capital expenditures per employee in these SIC groups was used in conjunction with County Business Pattern data to estimate these values.

11.6 SELECTED SECONDARY ECONOMIC IMPACTS

Implementation is also expected to have minor, if not negligible impact upon other factors, such as employment, market structure and productivity. The proposed regulations include some change in work practices which will decrease productivity in the metal cleaning operation by 5 percent to 10 percent. Since metal cleaning is normally a minor step in the manufacturing or service process, any change in productivity and employment in user plants will be insignificant.

There will, however, be some temporary increase in employment by those firms manufacturing such components as refrigeration chillers and drying tunnels, that may be required for retrofit controls. No estimates have been made because manufacturers of such components are located throughout the country. This temporary increase, however may be balanced by a slight decrease in employment occurring because of lower solvent consumption. The decrease would occur primarily in shipping and repackaging operations.

The implementation of the RACT guidelines should not have any major affect on the current market structure of the industries using solvent metal cleaning. Cleaners requiring highest retrofitting costs (i.e., for conveyorized cleaners) are generally owned by large firms. Smaller firms would be expected to have only cold cleaners or open top vapor degreasers. The highest capital costs would be for an open top unit which would require an expenditure of $8,000 or less to comply. This is not expected to be a significant financial burden even to small firms.

* * * *

Exhibit 11-19, on the following page, summarizes the conclusions presented in this report.

BIBLIOGRAPHY

U.S. Department of Commerce, County Business Patterns,1976.

U.S. Department of Commerce, Census of Manufactures, 1972

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Solvent Metal Cleaning EPA-450/2-77-002, November 1977.

U.S. Environmental Protection Agency, Regulatory Guidance for Control of Volatile Organic Emissions from 15 Categories of Stationary Sources. EPA-905/2-78-001, April 1978.

Dow Chemical Company, Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations. EPA Contract 68-02-1329, June 30, 1976.

Private conversations with the following:

Dextrex Chemical Company, Detroit, Michigan
Ethyl Corporation
DuPont
Dow Chemical Company
PPG
Allied Chemical Company
R.R. Street
Baron Blakeslee Corporation, Cicero, Illinois

12.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CONTROL OF REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS IN THE STATE OF OHIO

12.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CONTROL OF REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT controls of refinery vacuum producing systems, wastewater separators and process unit turnarounds in the State of Ohio. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of refineries, interviews and analyses.

12.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for control of refinery vacuum producing systems, wastewater separators and process unit turnarounds in the State of Ohio.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

12.1.1 Industry Statistics

Industry statistics on refineries were obtained from several sources. All data were converted to a base year, 1977, based on the following methodologies:

- The number of refineries for 1977 was obtained from the Oil and Gas Journal, March 20, 1978, and the American Petroleum Institute.

- The number of employees in 1977 was estimated based on data from the County Business Patterns, Department of Commerce, 1976.

- The output in barrels per day of refined petroleum liquids was estimated based on data supplied by the American Petroleum Institute for 1977.

- Value of shipments was estimated based on a value of refined product of $13.95 per barrel. This price was obtained from the National Petroleum News Fact Book, 1977.

- Capital expenditures were estimated based on data from the Chase Manhattan Bank.

12.1.2 VOC Emissions

Uncontrolled emissions from wastewater separators and process unit turnarounds were estimated using factors from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025. Uncontrolled emissions from vacuum producing systems were estimated using Revision of Evaporative Hydrocarbon Emission Factors, EPA-450/3-76-039. Emissions at existing levels of control were estimated using the data supplied by the Ohio Environmental Protection Agency. Emissions at complete control were based on percent recoveries estimated in Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025.

12.1.2 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from refinery vacuum producing systems, wastewater separators and process unit turnarounds are described in Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025. These data provide the alternatives available for controlling VOC emissions from these refinery operations. Several studies of VOC emission control were also analyzed in detail; and petroleum trade associations, refinery operators and vapor control equipment manufacturers were interviewed to ascertain the most likely types of control processes which would be used in refineries in Ohio. The specific studies analyzed were: Technical Support Document Petroleum Refinery Sources Illinois Environmental Protection Agency; Human Exposures to Atmospheric Emissions from Refineries, American Petroleum Institute, July 1973; and Economic Impact of EPA's Regulations on the Petroleum Refining Industry.

The alternative types of vapor control equipment likely to be applied to refinery vacuum producing systems, wastewater separators and process unit turnarounds were described, and percentage reductions from using each type of control were determined. The methodology for the cost analysis based on this scheme is described in the following paragraphs.

12.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the alternative types of control systems likely to be used
- Developing installed capital costs for each control system
- Aggregating applicable installed capital costs to the refineries in the state
- Developing additional costs including:
  - Direct operating costs
  - Annual capital charges
  - Petroleum credit
  - Net annual cost.

Costs were determined from analyses of the following previous studies:

- Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA 450/2-77-025
- Hydrocarbon Emissions from Refineries, American Petroleum Institute, October 1977

and from interviews with petroleum marketers' associations, refinery operators, major oil companies and vapor control equipment manufacturers.

The assignment of the estimated cost of control for refineries in Ohio required knowledge of the level of current controls, the number of refineries and characteristics of uncontrolled refinery processes. These data were provided by the Ohio Environmental Protection Agency. It is estimated based on industry interviews with three refiners in Ohio that all of the seven refiners in Ohio would currently comply with RACT requirements, except for approximately five uncovered wastewater separators and ten process units at various refineries.

12.1.5 Economic Impacts

The economic impacts were determined by analyzing the leadtime requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment, and productivity as a result of implementing RACT controls in Ohio.

12.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost, and economic impact of implementing RACT controls on selected refinery operations in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies, and best engineering judgment. Exhibit 12-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 12-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions		●	
Cost of emissions control		●	
Statewide costs of emissions			●
Economic impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton, Inc.

12.2 INDUSTRY STATISTICS

Industry facilities, statistics and business trends for refineries in Ohio are presented in this section. The discussion includes a description of the facilities and their characteristics, a comparison of the size of the refining industry to state economic indicators, a historical characterization and description of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions from selected refinery operations.

12.2.1 Size of the Industry

There are seven refineries in Ohio, each listed in Exhibit 12-2, on the following page, along with location, crude capacity and vacuum distillation capacity. The statewide employment, output, value of shipments and capital expenditures for Ohio refineries are displayed in Exhibit 12-3, following Exhibit 12-2.

12.2.2 Comparison of the Industry to the State Economy

In this section, the refining industry is compared to the economy of the State of Ohio by comparing industry statistics to state economic indicators. Employees in the refining industry represent 0.05 percent of the total state civilian labor force of Ohio. The value of refined products from Ohio refineries represents approximately 12 percent of the total value of wholesale trade in Ohio in 1977.

12.2.3 Industry Trends

Petroleum refining is the third largest industry in the United States. Until the 1970s the output of the refining industry had grown at a steady rate. Currently, approximately 280 refineries are owned by approximately 140 firms, located in 40 of the 50 states, Guam, Puerto Rico, and the Virgin Islands. The refining industry manufactures hundreds of distinguishably different products, which may be grouped into four broad product classes: gasoline, middle distillates, residual and other.

The bulk of refining is done by firms which also market refined products or produce crude oil, or both.

PETROLEUM REFINERIES IN OHIO

Name of Firm	Location	Crude Capacity MBPSD [a]	Vacuum Distillation Capacity MBPSD
Ashland Petroleum Co.	Canton	66	33
	Findlay	21	8
Gulf Oil Co.	Cleves	44	13
	Toledo	51	13
Standard Oil Co. of Ohio	Lima	177	51
	Toledo	126	68
Sun Co., Inc.	Toledo	130	22
TOTALS		615	208

a. MBPSD: Millions of barrels per standard day.

Source: Oil & Gas Journal, March 20, 1978, pp. 108-130, and American Petroleum Institute

Exhibit 12-3
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR
REFINERIES IN OHIO

Establishments	Employees	Output (000, Barrels per day)	Yearly Value of Shipments ($ Million, 1977)	Yearly Capital Expenditures ($ Million, 1977)
7	2,500[a]	590[b]	3,000[c]	50[d]

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a. Estimated by Booz, Allen & Hamilton Inc., based on County Business Patterns (Department of Commerce), in 1976.

b. Based on data supplied by the American Petroleum Institute for 1977.

c. Assumes a value of $13.95 per barrel as average for 1977 (source: National Petroleum News Factbook, 1977).

d. Assumes capital expenditures in 1976 in the state were the same percent of the total U.S. expenditure on refineries as in 1977. Data for 1976 supplied by the Chase Manhattan Bank.

Foreign, Federal, state and local governments all influence the oil product market in terms of taxes, price controls, tariffs on imports of crude oil and products. Foreign crude oil price had, until 1973, been lower than prices for domestic crude oil. With the advent of the OPEC cartel in 1975, imported crude oil prices have risen sharply.

12.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on refinery operation, estimated VOC emissions from selected refinery operations in Ohio, the extent of current controls in use, the requirements of vapor control under RACT and the likely RACT alternatives which may be used for controlling VOC emissions from selected refinery operations in Ohio.

12.3.1 Refinery Operations

The refinery operations considered in this report are:

- Vacuum producing systems
- Wastewater separators
- Process unit turnarounds.

The emissions from these sources vary from one petroleum refinery to another depending on such factors as refinery size and age, crude type, processing complexity, application of control measures and degree of maintenance.

12.3.2 Vacuum Producing Systems

Crude oil is a mixture of many different hydrocarbon compounds. These compounds are distinguished by their hydrocarbon type and by their normal boiling temperatures. In crude oil refining the first processing step is the physical separation of the crude oil into different fractions of specific boiling temperature ranges. This separation is performed in the atmospheric distillation unit and in the vacuum distillation unit.

Vacuum distillation receives its name from the sub-atmospheric operating pressure of the fractionation tower(s) employed. The vacuum distillation separates heavy petroleum distillates from reduced crude (atmospheric distillation tower bottoms). Vacuum fractionation with steam stripping is employed to avoid excessive temperatures that would be encountered in producing these heavy distillates by atmospheric fractionation.

In the vacuum distillation process, reduced crude is first heated in a direct-fired furnace to a predetermined temperature of approximately 730°F to 770°F. The hot oil is then charged to the vacuum producing unit for separation of distillates from the charge stock. Vacuum residuum is recovered as the fractionator's bottoms product. Vacuum fractionators are maintained at approximately 100 mmHg absolute pressure by one of the following:

- Steam ejectors with contact condensers
- Steam ejectors with surface condensers
- Mechanical pumps.

12.3.2.1 Steam Ejectors with Contact Condensers

Direct contact or barometric condensers are used for maintaining a vacuum by condensing the steam used in the ejector jet plus steam removed from the distillation column. In the contact condenser, condensable VOC and steam from the vacuum still and the jet ejectors are condensed by intimately mixing with cold water. The noncondensable VOC is frequently discharge to the atmosphere. A two-stage steam jet ejector is shown in Exhibit 12-4, on the following page, and a three-stage ejector with a booster is shown in Exhibit 12-5, following Exhibit 12-4. These are typical of vacuum producing systems used in existing refineries.

12.3.2.2 Steam Ejectors with Surface Condensers

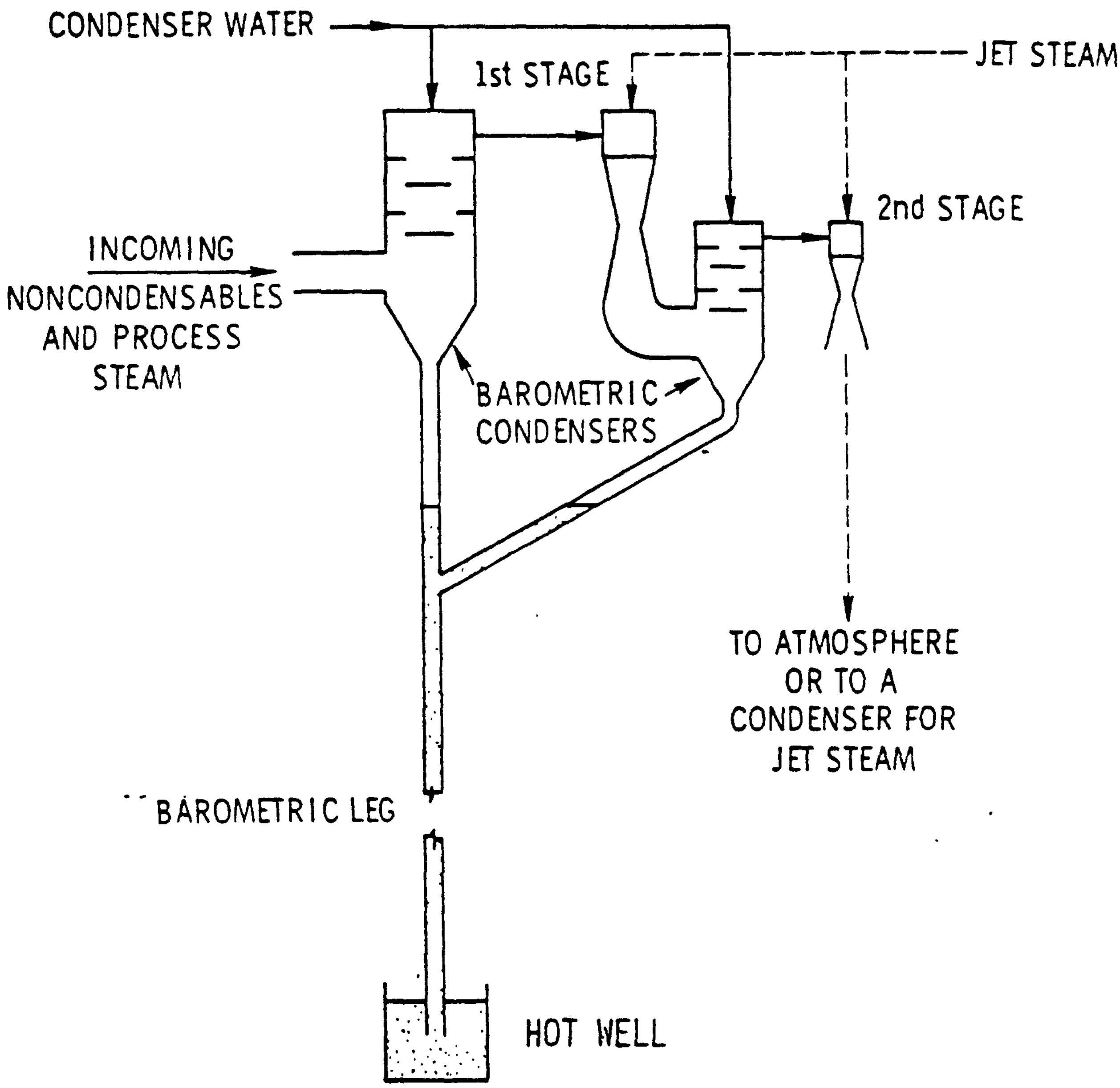
Modern refiners prefer surface condensers to contact condensers. In a surface condenser, noncondensables and process steam from the vacuum still, mixed with steam from the jets, are condensed by cooling water in tube heat exchangers and thus do not come in contact with cooling water. This is a major advantage since it reduces by 25 fold the quantity of emulsified wastewater that must be treated. A disadvantage of surface condensers is their greater initial investment and maintenance expense for the heat exchangers and additional cooling tower capacity necessary for the cooling water.

12.3.2.3 Mechanical Vacuum Pumps

Steam jets have been traditionally favored over vacuum pumps. Recently, however, because of high energy costs for generating steam and the cost for disposing of wastewater from contact condensers, vacuum pumps are being used. In addition to energy savings, vacuum pumps have fewer cooling tower and/or wastewater treatment requirements compared to steam ejector systems. Aside from the stripping steam, the ejected stream is essentially all hydrocarbon so it can be vented thorugh a small condenser before being combusted in a flare or sent to the refinery fuel gas system.

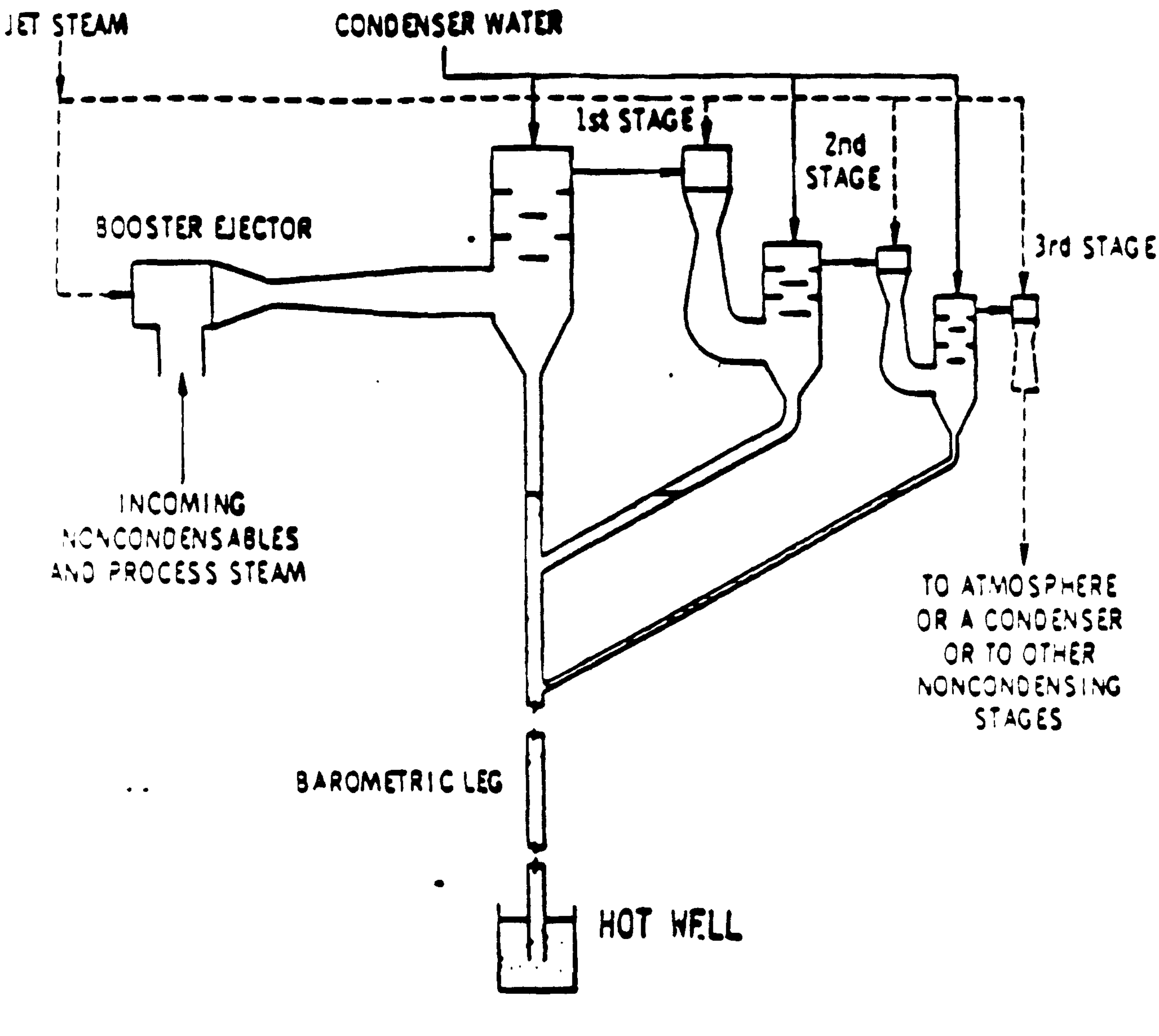
Exibit 12-4
U.S. Environmental Protection Agency

VACUUM PRODUCING SYSTEM UTILIZING
A TWO STAGE CONTACT CONDENSER



Source: Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025.

Exhibit 12-5
U.S. Environmental Protection Agency
VACUUM PRODUCING SYSTEM UTILIZING
BOOSTER EJECTOR FOR LOW VACUUM SYSTEMS



Source: Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025.

12.3.3 Wastewater Separators

Contaminated wastewater originates from several sources in petroleum refineries including, but not limited to, leaks, spills, pump and compressor seal cooling and flushing, sampling, equipment cleaning, and rain runoff. Contaminated wastewater is collected in the process drain system and directed to the refinery treatment system where oil is skimmed in a separator and the wastewater undergoes additional treatment as required.

Refinery drains and treatment facilities are a source of emissions because of evaporation of VOC contained in wastewater. VOC will be emitted wherever wastewater is exposed to the atmosphere. As such, emission points include open drains and drainage ditches, manholes, sewer outfalls and surfaces of forebays, separators and treatment ponds. Due to the safety hazards associated with hydrocarbon-air mixtures in refinery atmospheres, current refinery practice is to seal sewer openings and use liquid traps downstream of process drains, thus minimizing VOC emissions from drains and sewers within the refinery.

12.3.4 Process Unit Turnarounds

Refinery units such as reactors, and fractionators, are periodically shut down and emptied for internal inspection, and startup is termed a unit turnaround. Purging the contents of a vessel to provide a safe interior atmosphere for workmen is termed a vessel blowdown. In a typical process unit turnaround, liquid contents are pumped from the vessel to some available storage facility. The vessel is then depressurized, flushed with water, steam or nitrogen and ventilated. Depending on the refinery configuration, vapor content of the vessel may be vented to a fuel gas system, flared or released directly to atmosphere. When vapors are released directly to atmosphere, it is through a blowdown stack which is usually remotely located to ensure that combustible mixtures will not be released within the refinery.

12.3.5 Emissions and Current Controls

This section presents the estimated VOC emissions from selected refinery operations in Ohio in 1977 and the current level of emission control already implemented in the state. Exhibit 12-6, on the following page, shows total

U.S. Environmental Protection Agency
ESTIMATED HYDROCARBON EMISSIONS FROM
SELECTED REFINERY OPERATIONS IN OHIO

Number of Refineries		Estimated Hydrocarbon Emissions (TPY) Without Control[a]	At Estimated Existing Level of Control[bc]	At Complete Control[c]
7	Vacuum Producing Systems	2,020	negligible	negligible
	Wastewater Separators	8,979	6,285	314
	Process Unit Turnarounds	65,097	9,000	450
	TOTAL	76,096	15,285	764

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a. Emissions are estimated using factors from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025. Emissions from vacuum producing systems were estimated using Revision of Evaporative Hydrocarbon Emission Factors, EPA-450/3-76-039.

b. Current level of emissions was estimated using data supplied by the State of Ohio. Emissions from wastewater separators for the estimated five refineries with uncovered wastewater separators are estimated to be 70 percent of the uncontrolled emissions. Emissions from the estimated ten uncontrolled process units are estimated to be 14 percent of the uncontrolled emissions.

c. Assumes 95 percent recoveries.

estimated emissions from the 7 refineries in Ohio, if there were no emission controls for vacuum producing units, wastewater separators or process unit turnarounds. The estimated emissions at the existing level of control are also shown along with estimated emissions at the complete level of control.

In Ohio, refineries have most likely implemented control measures for vacuum producing units, most process unit turnarounds and at least two wastewater separators. An estimated five wastewater separators at refineries in Ohio are presently not covered.

Emissions were estimated based on EPA emission factors reported by U.S. EPA. The EPA is currently updating emission factors based on a new analysis of previous test data. EPA reports the emission factors may change as a result of their ongoing program; therefore, caution must be exercised in using these emission factors.

12.3.6 RACT Guidelines

The RACT guidelines for VOC emission control from vacuum producing systems, wastewater separators and process unit turnarounds require the following control systems:

- Vacuum producing units—The control measure for vacuum producing units is to vent the non-condensable hydrocarbon stream to a flare or to the refinery fuel gas system.
- Wastewater separators—The control measure for emissions from wastewater separators is to cover the separators. Emissions are collected and sent to the flare or refinery fuel gas system.
- Process unit turnarounds—Process unit turnaround emissions are controlled by piping emissions to a flare or to the refinery fuel gas system.

Proper operation and maintenance of equipment will also reduce emissions from cracks and leaks in the system.

12.3.7 Selection of the Most Likely RACT Alternative

The techniques for the control of VOC emissions from refinery vacuum producing systems, wastewater separators and process unit turnarounds are discussed in detail in this section.

12.3.7.1 Controlling Emissions from Vacuum Producing Units

Steam ejectors with contact condensers, steam ejectors with surface condensers and mechanical vacuum pumps all discharge a stream of noncondensable VOC while generating the vacuum. Steam ejectors with contact condensers also have potential VOC emissions from their hot wells. VOC emissions from vacuum producing systems can be prevented by piping the noncondensable vapors to an appropriate firebox or incinerator or (if spare compressor capability is available) compressing the vapors and adding them to refinery fuel gas. The hot wells associated with contact condensers can be covered and the vapors incinerated. Controlling vacuum producing systems in this manner will result in negligible emissions of hydrocarbons from this source. Such systems are now in commercial operation and have been retrofitted in existing refineries. For purposes of this report it is assumed that recovered VOC are used in the refinery fuel gas system.

12.3.7.2 Controlling Emissions from Wastewater Separators

Reasonable control of VOC emissions from wastewater separators consists of covering the forebays and separator sections, thus minimizing the amount of oily water exposed to atmosphere. Commercially operating systems include a solid cover with all openings sealed, totally enclosing the compartment liquid contents, or a floating pontoon or double-deck type cover, equipped with closure seals to enclose any space between the cover's edge and compartment wall. Also, any gauging and sampling device in the compartment cover can be designed to provide a projection into the liquid surface to prevent VOC from escaping. The sampling device can also be equipped with a cover or lid that is closed at all times except when the device is in actual use. It is assumed that 95 percent of these emissions are recovered and used in the refinery fuel gas system based on data reported in Control of Refinery Vacuum Producing Systems Wastewater Separators and Process Unit Turnarounds, p.43.

12.3.7.3 Controlling Emissions from Process Unit Turnaround

A typical process unit turnaround would include pumping the liquid contents to storage, purging the vapors by depressurizing, flushing the remaining vapors with water, steam or nitrogen, and ventilating the vessel so workmen can enter. The major potential source of VOC emissions is in depressurizing the vapors to the atmosphere. After the vapors pass through a knockout pot to remove the condensable hydrocarbons, the vapors can be added to the fuel gas system, flared or directly vented to atmosphere. Atmospheric emissions will be greatly reduced if the vapors are combusted as fuel gas or flared until the pressure in the vessel is as close to atmospheric pressure as practicably possible. The exact pressure at which the vent to the atmosphere is opened will depend on the pressure drop of the disposal system. Most refineries should easily be able to depressurize processing units to five psig or below, before venting to the atmosphere. Many refineries depressurize a vessel to almost atmospheric pressure and then steam the vessel to the flare header before opening it to atmosphere. In some refineries, the hydrocarbon concentration is as low as 1 percent to 30 percent before the vessel is vented to atmosphere. Based on current industry practise at two refineries in Ohio, it is assumed that no VOC emissions are recovered and used in the refinery fuel gas system.

* * * *

The sections which follow discuss the costs of implementing these control techniques at refineries in Ohio.

12.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for VOC emission control equipment are presented in this section. The costs for the three emission control systems described in Section 12.3 are described for vacuum producing systems, wastewater separators and process unit turnarounds individually, followed by an extrapolation of costs for an estimated five uncovered wastewater separators and ten process units for the statewide industry.

12.4.1 Costs for Emission Control Systems

The installed capital costs for the three emission control systems (summarized in Exhibit 12-7, on the following page) were derived from analysis of the RACT guidelines, from interviews with refinery operators and major oil companies and from previous cost and economic studies of refineries.

Control measures for vacuum producing systems at a typical 100,000 barrel per day capacity refinery, range in costs from approximately $24,000 for vacuum producing systems using either surface condensers or mechnical pumps to $52,000 for vacuum producing systems using contact (barometric) condensers. These cost estimates are based on the refinery requiring the following equipment.

- For vacuum producing systems using other surface condensers or mechanical pumps, typical equipment includes:
  - 200 feet of piping
  - 6 valves
  - 1 flame arrestor.
- For vacuum producing systems using contact (barometric) condensers, typical equipment includes:
  - 400 feet of piping
  - 12 valves
  - 2 flame arrestors
  - Hotwell cover area of 100 ft^2.

In an interview with Exxon it was reported that control of wastewater separators using covers can range from $30 per square foot to $2,000 per square foot, depending upon the types of covers used. The RACT guideline document reports a cost of $12.50 per square foot which has been used in this analysis. Refineries with old wastewater separators may be required to rebuild the separators. Such costs have not been reflected in this report because of lack of data

Exhibit 12-7
U.S. Environmental Protection Agency
INSTALLED CAPITAL COSTS OF VAPOR CONTROL SY
FOR VACUUM PRODUCING SYSTEMS, WASTEWATE
SEPARATORS AND PROCESS
UNIT TURNAROUNDS

Vacuum Producing Systems		Wastewater Separators ($, 1977)	Process Unit Turnarounds ($, 1977)
Surface Condensors or Mechanical ($, 1977)	Contact Condensers ($, 1977)		
24,000[a]	52,000[b]	63,000[c]	100,000[e]

Note: Capital costs are for a typical 100,000 barrel per day refinery

a. Equipment includes 200 feet of piping, 6 valves and 1 flame arrestor.

b. Equipment includes 400 feet of piping, 12 valves, 2 flame arrestors, 100 $ft.^2$ area hotwell cover.

c. Cover for 5,000 $ft.^2$ wastewater separator.

d. Equipment includes 1,000 ft. of piping and 20 valves.

Source: Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77 25, pp. 4-10.

Equipment required for controlling emissions from process unit turnarounds basically include piping and valves. The installed capital costs for a typical 100,000 barrel per day refinery would be in the range of $10,000 per process unit; there are, on the average ten process units for a 100,000 barrel per day refinery.

Costs for actual refinereis will differ from this typical refinery depending on the number of vacuum producing systems and the amount of piping required, the area of the wastewater separator and the type of separator and the number of process units that need control.

Cost estimates obtained from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025 and verified thorugh interviews will vary from one refinery to another, reflecting the variability in refinery size, configuration, age, product mix and degree of control.

In Ohio, it is estimated that seven refineries have already incurred costs for control of vacuum producing systems, most process unit turnarounds and all but approximately five wastewater separators.

The remainder of this section therefore presents the costs for covering the five uncovered wastewater separators and an estimated ten process units.

12.4.2 Extrapolation to the Statewide Industry

Exhibit 12-8, on the following page, shows the extrapolation of vapor recovery costs for covering five wastewater separators and ten process units to the statewide industry in Ohio. The estimates are based on the following:

- Each wastewater separator is, on the average, 7,500 square feet. The actual size of the wastewater separators will vary from one refinery to another, some larger and some smaller than the average size determined through interviews.
- Each of the ten process units can be controlled at a cost of $10,000.
- Installed capital cost includes parts and labor.

Exhibit 12-8

U.S. Environmental Protection Agency

STATEWIDE COSTS FOR VAPOR CONTROL SYSTEMS FOR REFINERY WASTEWATER SEPARATOI AND PROCESS UNIT TURNAROUND

Characteristics/Cost Item	Data
Number of process units	10
Number of wastewater separators	5
Emission reduction (tons/year)	14,521
Installed capital ($, 1977)	571,000
Direct annual operating cost ($, 1977)	17,130
Annual capital charges ($, 1977)	142,750
Annual gasoline credit[a] ($, 1977)	543,361
Net annual credit ($, 1977)	383,481
Annual credit per ton of emissions reduced ($ per ton)	26

a. Based on 95 percent of reduced emissions of 5,970 tons recovered from five previously uncovered wastewater separators and valued at $13.00 per barrel. The gasoline credit does not include emissions which were reduced by sending to a flare system (process unit turnaround emissions).

Source: Booz, Allen & Hamilton, Inc.

- Annualized direct operating costs, expected to be 3 percent of installed capital costs,[1] include costs for labor, utilities, recordkeeping and training.

- Annualized capital charges, estimated to be 25 percent of installed capital costs, include costs for depreciation, interest, maintenance, taxes and insurance.

- The petroleum credit is based on recovering 95 percent of emissions from wastewater separators and is valued at $13.00 per barrel.

- Net annualized costs are the sum of the capital charges and direct operating costs, less the petroleum credit.

Actual costs to refinery operators may vary, depending on the type of manufacturer's equipment selected by each refinery operator. However, because three of the refineries in the state are above 100 MBPSD and four are below, this estimated costs for the 100 MBPSD are reasonable.

Based on the above, the total cost to the industry for installing vapor recovery equipment on the five remaining wastewater separators and ten process units is estimated to exceed $570,000. The amount of petroleum recovered is valued at $543,361. The annual credit per ton of emissions controlled is estimated to be $26.

12.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing RACT for refineries in Ohio. The impacts include capital availability, technical feasibility and value of shipments. It is estimated that emissions are currently controlled from vacuum producing systems and all but ten process unit turnarounds. It was further estimated that there are five uncovered wastewater separators in Ohio.

- Capital availability—The Ohio refineries will need to raise an estimated $570,000 to implement RACT controls. It is expected that the refiner will be able to raise sufficient capital since the petroleum credit will more than offset the cost of implementing RACT controls.

- Technical feasibility—Emission controls for vacuum producing units, wastewater separators, and process unit turnarounds have been successfully demonstrated in several refineries in the United States. It is expected that Ohio will be able to successfully implement emission controls to comply with RACT.

- Value of shipments—Based on U.S. EPA emission factors, it is estimated that $543,000 worth of petroleum liquids may be recovered annually by implementing RACT.

12.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

- Employment—No change in employment is anticipated from implementing RACT in Ohio.
- Market structure—The market structure will remain unchanged when RACT is implemented in Ohio.
- Productivity—Worker productivity will probably be unaffected by implementing RACT in Ohio.

* * * *

Exhibit 12-9, on the following page, summarizes the findings of this chapter.

Exhibit 12-9

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	7
Indication of relative importance of industrial section to state economy	1977 industry sales were $3 billion. The estimated annual crude oil throughput was 215million barrels
Current industry technology trends	Most refineries have installed controls equivalent to RACT with the exception of 5 uncover wastewater separators and 10 uncontrolled process units
1977 VOC actual emissions	15,000 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Vapor recovery of emissions by piping emissions to refinery fuel gas system or flare and by covering wastewater separators
Estimated method of VOC control to meet RACT guidelines	Vapor recovery of emissions from process unit to refinery fuel gas system, cover wastewaster separators and piping emissions from process units to flare

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$571,000
Annualized credit (statewide)	$383,000
Price	No major impact
Energy	Assuming full recovery of emissions —net savings of 101,600 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	764 tons per year
Cost effectiveness of control	$26 annualized credit/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025, October 1977.

Revision of Evaporative Hydrocarbon Emission Factors, PB-267 659, Radian Corp., August 1976.

Control of Hydrocarbon Emissions from Petroleum Liquids, PB-246 650, Radian Corp., September 1975.

Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA 905/2-78-001, April 1978.

Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921, Environmental Protection Agency, September 1974.

Economic Impact of EPA's Regulations on the Petroleum Refining Industry, PB-253 759, Sobotka and Co., Inc., April 1976.

Hydrocarbon Emissions from Refineries, American Petroleum Institute, Publication No. 928, July 1973.

Technical Support Document, Petroleum Refinery Sources, Illinois Environmental Protection Agency.

Petroleum Refining Engineering, W.L. Nelson, McGraw-Hill Book Company, Inc. New York, 1958.

Petroleum Refinery Manual, Henry Martin Noel, Reinhold Publishing Corporation, New York, 1959.

Oil and Gas Journal, April 23, 1973.

Petroleum Products Handbook, Virgil B. Guthrie, Editor, Mcgraw-Hill Book Company, New York, 1960.

Private conversations with the following:

Mr. Robert Watt, Plant Manager, Ashland Petroleum Oil Co., Canton Ohio refinery.

Gulf Oil Company, Cleves, Ohio refinery

Standard Oil Company of Ohio, Lima, Ohio refinery

Ohio Petroleum Marketers Association, Mr. Roger Dreyer

Mr. Ed Sullivan, Amoco Oil Refinery, Wood River, Illinois

Texaco Refinery, Lockport, Illinois, Mr. Oliver Goodlander.

Exxon Research, Mr. Fritz, New Jersey

Exxon Corporation, Mr. Gorden Potter, Houston, Texas

U.S. EPA, Mr. Chuck Masser, Research Triangle Park, North Carolina

American Petroleum Institute, Mr. Karlowitz, Washington, D.C.

Mr. William Juris, Ohio Environmental Protection Agency

13.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS THE STATE OF OHIO

13.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT controls for tank truck gasoline loading terminals in the State of Ohio. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of tank truck gasoline loading terminals, interviews and analysis.

13.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for tank truck gasoline loading terminals in the State of Ohio.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

13.1.1 Industry Statistics

Industry statistics on tank truck gasoline loading terminals were obtained from several sources. All data were converted to a base year, 1977, based on the following specific methodologies:

- The number of establishments for 1977 was extrapolated from the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals, based on the decline in the number of terminals from 1967 to 1972.

- The number of employees in 1977 was derived by determining the number of employees per establishment in 1972 from the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals, and multiplying this factor by the number of establishments estimated for 1977.

- The number of gallons of gasoline sold from bulk plants and terminals in 1977 in the State of Ohio was obtained from data in the Ohio emissions inventory. The percentage of sales from terminals was estimated to be 70 percent of this total based on data in the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals.

- Sales, in dollars, of motor gasoline for 1977 were estimated by multiplying the number of gallons of gasoline sold in 1977 by the national dealer tankwagon price in 1977 (42.5¢/gallon), which was reported in the National Petroleum News Fact Book, 1978.

13.1.2 VOC Emissions

VOC emissions for tank truck gasoline loading terminals were estimated based on gasoline throughput, emission factors and characteristics of tank truck gasoline loading terminals presented in Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017.

13.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for tank truck gasoline loading terminals are described in Control of Hydrocarbons from Tank Truck Gasoline Loading Terminals, EPA-450/2-77-026. These data provide the alternatives available for controlling VOC emissions from tank truck gasoline loading terminals. Several studies of VOC emission control were also analyzed in detail, and interviews with petroleum trade associations, terminal operators and vapor control equipment manufacturers were conducted to ascertain the most likely types of control processes which would be used in terminals in Ohio. The specific studies analyzed were: Demonstration of Reduced Hydrocarbon Emissions from Gasoline Loading Terminals, PB-243 363; Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921; and The Economic Impact of Vapor Control in the Bulk Storage Industry, draft report to U.S. EPA by Arthur D. Little.

The alternative types of vapor control equipment likely to be applied to tank truck gasoline loading terminals were analyzed. Model plants reflecting each control alternative were defined and each type of control alternative used was applied to the number of tank truck gasoline loading terminals in the state. The methodology for the cost analysis of VOC emissions control is described in the following paragraphs.

13.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining systems components

- Developing installed capital costs for systems components

- Aggregating installed capital costs for each alternative control system

- Defining two model terminals based on throughput levels

- Developing costs of the alternative control systems for the two model terminals including:

  - Installed capital cost
  - Direct operating costs
  - Annual capital charges
  - Gasoline credit
  - Net annual cost

- Assigning model terminal costs to terminals in Ohio

- Aggregating costs to the total industry in Ohio.

Costs were determined mainly from analyses of the RACT guidelines and from interviews with petroleum marketers' associations, terminal operators and vapor control equipment manufacturers.

The assignment of the estimated cost of control to Ohio required a profile of a tank truck gasoline loading terminals in the state by sizes of gasoline throughput. national profile is presented which is assumed to approximate the terminals in Ohio.

13.1.5 Economic Impact

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Ohio.

13.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on tank truck gasoline loading terminals in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 13-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 13-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		●	
Emissions			●
Cost of emissions control		●	
Statewide costs of emissions			●
Economic impact			●
Overall quality of data			●

Source: Booz, Allen & Hamilton, Inc.

13.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for tank truck gasoline loading terminals in Ohio are presented in this section. The discussion includes a description of the number of facilities and their charcteristics, a comparison of the size of the gasoline terminal industry to state economic indicators, a historical characterization and description of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT on tank truck gasoline loading terminals in Ohio.

13.2.1 Size of the Industry

There were an estimated 50 tank truck gasoline loading terminals, as of 1977, in Ohio. Industry sales from terminals in Ohio were in the range of $1.480 billion, with an estimated yearly throughput of 3.484 billion gallons of gasoline. The estimated number of employees in 1977 was 1,120. These data and the sources of information are summarized in Exhibit 13-2, on the following page. Annual capital investments have not been estimated. In general, tank truck gasoline loading terminal investments are for plant and equipment to replace worn-out facilities, modernize the establishments or improve operating efficiencies.

13.2.2 Comparison of the Industry to the State Economy

A comparison of the tank truck gasoline loading terminal industry to the economy of the State of Ohio is shown in this section by comparing industry statistics to State economic indicators. Employees in the tank truck gasoline loading terminal industry represent 0.02 percent of the total State civilian labor force of Ohio. The value of gasoline sold from terminals represented less than 6 percent of the total value of wholesale trade in Ohio in 1977.

13.2.3 Characterization of the Industry

Tank truck gasoline loading terminals are the primary distribution point in the petroleum product marketing network as shown in Exhibit 13-3, following Exhibit 13-2. Terminals receive gasoline from refineries by pipeline, tanker or barge.

Exhibit 13-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR TANK TRUCK
GASOLINE LOADING TERMINALS IN OHIO

Number of Establishments	Number of Employees	Sales ($ Billion, 1977)	Gasoline Sold (Billions of Gallons)
50[a]	1,120[b]	1.480[c]	3.484[d]

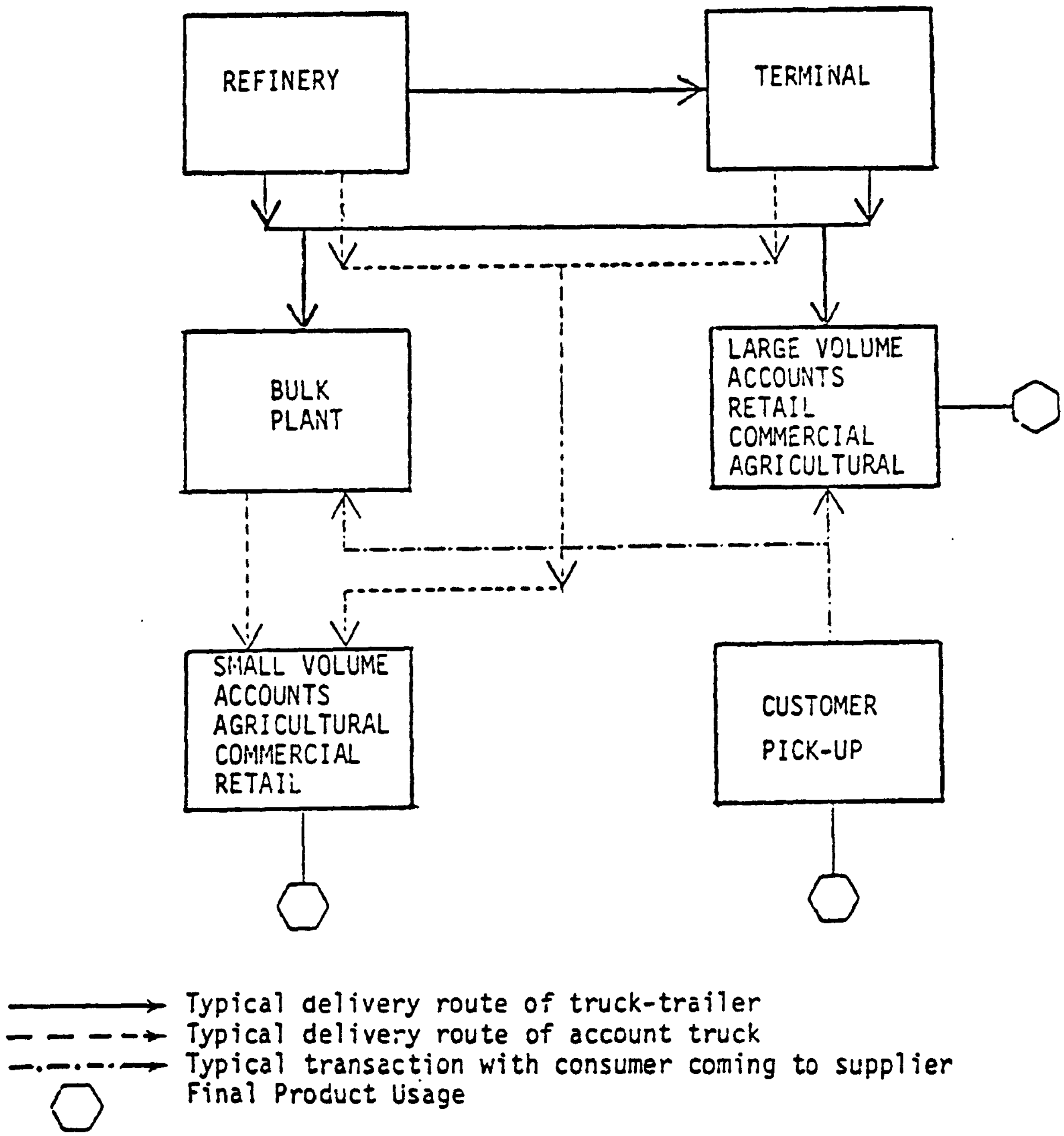
a. Booz, Allen & Hamilton Inc. estimate based on the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals.

b. Booz, Allen & Hamilton Inc. estimate based on the ratio of the number of employees to the number of establishments in 1972.

c. Number of gallons of motor gasoline sold in 1977 multiplied by the national dealer tankwagon price in 1977 (42.51¢/gallon).

d. Booz, Allen & Hamilton Inc. estimate based on data from the Ohio emissions inventory.

Exhibit 13-3
U.S. Environmental Protection Agency
GASOLINE DISTRIBUTION NETWORK



Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976, p. 3-2.

Most gasoline terminals load all of the petroleum product they receive into truck transports at the terminals' loading racks. These truck transports usually have storage capacities between 8,000 and 9,000 gallons and deliver gasoline to service stations and bulk gasoline plants for further distribution.

Over two-thirds of the gasoline terminals in the United States are owned by major oil companies and refiner/marketers. The remaining gasoline terminals are owned by independents. The major oil companies and regional refiners own a proportionately greater number of the large gasoline terminals and proportionately fewer of the small gasoline terminals.

Approximately ten years ago, petroleum companies began to consider gasoline terminals as separate profit centers. Terminals are now expected to recover all operating expenses as well as to provide an acceptable return on capital. Since terminals are now treated as profit centers, petroleum marketers have closed many uneconomic and marginal facilities throughout the country. Some marketers have withdrawn from selected regions of the country as part of their overall corporate strategy. Gasoline terminals in these markets are being consolidated, sold or closed.

Gasoline terminals are generally located near refineries pipelines and large metropolitan areas. The daily throughput ranges from 30,000 gallons per day to over 600,000 gallons per day. In a report entitled Hydrocarbon Control Strategies for Gasoline Marketing Operations, terminals nationally are characterized as having sixty percent fixed-roof tanks, forty percent floating roof tanks and twenty-five percent of terminals bottom fill. These characteristics are assumed to characterize terminals in Ohio.

Exhibit 13-14, on the following page, shows an estimated national distribution of gasoline terminals by throughput. This distribution is assumed to be representative of terminals in Ohio, for the purpose of this analysis.

13.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on tank truck gasoline loading terminal operations, estimated VOC emissions from terminal operations in Ohio, the extent of current controls in use, the requirements of vapor control required by RACT and the likely RACT alternatives which may be used for controlling VOC emissions from gasoline terminals in Ohio.

13.3.1 Tank Truck Gasoline Loading Terminal Operations

Tank truck gasoline loading terminals are the primary distribution facilities which receive gasoline from pipelines, tankers and barges; store it in above-ground storage tanks; and subsequently dispense it via tank trucks to bulk gasoline plants and service stations. Tank truck gasoline loading terminals with an average daily gasoline throughput of 20,000 gallons per day or more (as defined by EPA) require vapor control equipment to reduce VOC emissions from gasoline terminal operations.

13.3.1.1 Facilities

The following description of tank truck gasoline loading terminals was based on a synthesis of information from:

- Control of Hydrocarbons from Tank Truck Gasoline Loading Terminals, EPA-450/2-77-026
- Illinois "Technical Support Document, Bulk Gasoline Terminals, Bulk Gasoline Plants and Fixed Roof Petroleum Storage Tanks"
- Industry interviews
- Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921.

Gasoline terminal facilities generally include tanks for gasoline storage, loading racks and incoming and outgoing tank trucks.

The most prevalent type of gasoline storage tank found at gasoline terminals is the above-ground storage tank. These tanks are usually cylindrical with domed ends (vertical or horizontal). Typical storage capacities range from

500,000 to 5,000,000 gallons and each terminal averages 4.5 tanks.

A typical loading rack used for dispensing gasoline to account trucks includes shut-off valves, meters, relief valves, electrical grounding, lighting, by-pass plumbing and loading arms. Loading may be by bottom fill, top splash or top submerged fill. It is assumed bottom filling is used at 25 percent of the terminals in Ohio and that the remaining terminals use top submerge filling. A typical tank truck gasoline loading terminal has one or two loading racks equipped with 4 to 20 loading arms, with an average gasoline pumping rate of 495 gallons per minute.

Trailer-transport trucks are used to supply bulk plants and gasoline service stations with gasoline. Trailer-transport trucks have four to six compartments and deliver approximately 8,000 to 9,000 gallons of gasoline to the bulk plant or service station. Most commonly, trailer-transport trucks are owned by oil companies or commercial carriers. There are several trucks per facility. One terminal operator, who pumps 1.26 million gallons of gasoline per day, reported that he owns 30 trucks.

13.3.1.2 Operations

VOC emissions occur at various stages in tank truck gasoline loading terminal operations. Gasoline is loaded into trailer-transport trucks from gasoline storage tanks via loading racks. The two methods of loading gasoline into tank trucks are bottom filling and top submerged filling. Emissions occur from this operation through the displacement of vapor laden air in the tank truck with gasoline, leakage in seals and overfilling the truck. Vapor collection and proper operation and maintenance are the recommended methods for controlling these emissions.

Another major source of emissions is from vaporization of gasoline in the storage tank because of changes in pressure in the tank caused by variation in temperature. These emissions, referred to as breathing losses, are controlled by adjusting the pressure relief valve on the storage tank and equipping storage tanks of greater than 40,000 capacity with internal floating roofs.

Vapors collected during tank truck filling are condensed or oxidized by vapor controlled equipment discussed in detail in Section 13.3.4.

13.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from tank truck gasoline loading terminals in Ohio in 1977 and the current level of emission control already implemented in the state. Exhibit 13-5, on the following page, shows the total estimated emissions in tons per year from gasoline terminals in Ohio. The estimated VOC emissions from the 50 tank truck gasoline loading terminals are 17,378 tons per year.

It is estimated that bottom filling is used at 25 percent of the gasoline terminals in Ohio and that the remaining terminals employ top submerge filling. This estimate is based on national data presented in Hydrocarbon Control Strategies from Gasoline Marketing Operations, EPA-450/3-78-017. An assumption was made, for purposes of this report that no terminals in Ohio are currently equipped with vapor recovery systems, since no data was obtained through interviews to indicate otherwise.

13.3.3 RACT Guidelines

The RACT guidelines for VOC emission control from tank truck gasoline loading terminals require the following control systems:

- Top submerged or bottom fill of gasoline storage tanks and outgoing tank trucks
- Vapor collection from trailer-transport truck loading
- Vapor recovery or thermal oxidation of collected vapors
- Proper operation and maintenance of equipment.

Exhibit 13-6, following Exhibit 13-5, summarizes the RACT guidelines for VOC emissions control from tank truck gasoline loading terminals.

13.3.4 Selection of the Most Likely RACT Alternatives

Control of VOC emissions from tank truck gasoline loading terminals is achieved using submerged or bottom filling of storage tanks and of tank trucks and vapor control of the loading of outgoing trailer-transport trucks.

Exhibit 13-5
U.S. Environmental Protection Agency
VOC EMISSIONS FROM TANK TRUCK GASOLINE LOADING TERMINALS IN OHIO

Number of Facilities	Estimated Number of Tanks	Total Emissions (tons/year)
50	225[a]	17,378[b]

a. Based on Illinois EPA survey indicating 4.5 tanks per facility.

b. Booz, Allen & Hamilton Inc. estimate based on data from the Ohio emissions inventory and Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017.

Source: Booz, Allen & Hamilton Inc.

Exhibit 13-6
U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR
TANK TRUCK GASOLINE LOADING TERMINALS

Facilities Affected	Sources of Emissions	RACT Control Guideline
Tank truck terminals with daily throughput of greater than 76,000 liters (20,000 gallons) of gasoline	Filling tank trucks and breathing and working losses from storage tanks	Top submerge or bottom fill tank truck and one of the following vapor control systems: - Adsorption/ Absorption - Refrigeration - Compression Refrigeration Absorption - Thermal Oxidation
	Leakage	Maintenance of areas that may leak

Source: U.S. Environmental Protection Agency

There are several alternative means of achieving vapor control at tank truck gasoline loading terminals, based on the type of vapor control equipment installed.

Four likely alternatives for vapor control are:

- Adsorption/absorption
- Compression refrigeration absorption
- Refrigeration
- Thermal oxidation.

Each type of vapor control system is briefly described below.

13.3.4.1 Adsorption/Absorption (AA)

Vapor control by adsorption/absorption is achieved by the following method. Vapors from tank truck loading operations are collected and directed to one of two activated carbon beds. Vapors are condensed into pores in the carbon. These vapors are then regenerated by pulling a vacuum over the bed. Cold gasoline is then circulated in a separator and the hot vapors are absorbed into the cold gasoline. This process has recently been marketed and is becoming competitive with the refrigeration system described below. It has been reported that less maintenance is required for this type of vapor recovery system than for the other three types.

13.3.4.2 Compression Refrigeration Absorption (CRA)

Vapor control by compression refrigeration absorption is achieved by the following method. Vapors from tank truck loading operations are collected in a vapor holder. The pressure is increased in the holder, thus causing vapors to condense. Further condensation is then achieved by mixing chilled gasoline and vapors under pressure and the vapors are absorbed into the gasoline. From interviews with manufacturers of vapor recovery equipment it is reported that this system is becoming less popular than the more recently developed refrigeration system described below. Therefore, it was assumed that this type of system will not be used in Ohio.

13.3.4.3 Refrigeration (RF)

Vapor recovery using refrigeration is based on the condensation of gasoline vapors by refrigeration at atmospheric pressure. Vapors displaced from tank truck loading operations enter a horizontal fin-tube condenser where they are cooled to a temperature of about -40°F and condensed. Because vapors are treated as they are vented from tank trucks, no vapor holder is required. Condensate is withdrawn from the condenser and the remaining air, containing only a small amount of hydrocarbons, is vented to the atmosphere. This system is priced competitively with AA systems because of market pressure, although it is estimated to be more costly to build.

13.3.4.4 Thermal Oxidation (OX)

Vapor control by thermal oxidation is achieved by incineration devices. Gasoline vapors are displaced to a vapor holder. When the vapor holder reaches its capacity, vapors are released to the oxidizer, after mixing with a properly metered air stream, and combusted. Later models of this type of thermal oxidizer do not require vapor holders; vapors from the tank trucks during loading operations are vented directly to the thermal oxidizer. It is not expected that this type of vapor control system will be used in Ohio since there are fire hazards with a flame and one terminal operator reported during interviews that terminal operators are reluctant to burn valuable hydrocarbons.

13.3.5 Leak Prevention from Tank Trucks

For vapor control systems to operate optimally, it is essential to maintain leakless tank trucks. This is achieved by using proper operating procedures and periodic maintenance of hatches, P-V valves and liquid and gaseous connections.

13.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for VOC emission control equipment are presented in this section. The costs for the four types of vapor control systems described in Section 13.3 are presented for two model tank truck gasoline loading terminals. The final section presents an extrapolation of model terminal control costs to the statewide industry.

13.4.1 Factory Costs for Four Types of Vapor Control Systems

The factory costs for the four types of vapor control systems (summarized in Exhibit 13-7, on the following page) were derived from analysis of the RACT guidelines; from interviews with terminal operators, major oil companies and equipment manufacturers; and from previous cost and economic studies of tank truck gasoline loading terminals.

Adsorption/absorption and refrigeration systems are expected to be the only two types of vapor control systems used at tank truck gasoline loading terminals in Ohio. It is estimated that 50 percent of the systems will be adsorption/absorption and the other 50 percent will be refrigeration systems. Factory costs for both systems are assumed to be equal because of competitive pressures. Maintenance costs for refrigeration systems are approximately 2 percent higher than those for adsorption/absorption systems.

13.4.2 Costs for Two Model Tank Truck Gasoline Loading Terminals

Two model tank truck gasoline loading terminals and their associated vapor control costs are characterized in this section. The costs are based on the control estimates for adsorption/absorption and refrigeration systems reported by equipment manufacturers and through interviews.

Exhibit 13-8, following Exhibit 13-7, defines two model tank truck gasoline loading terminals characteristics and associated control costs. It is assumed that approximately 50 percent of the terminals in Ohio can be characterized by Model Terminal A; the remaining 50 percent are assumed to be characterized by Model Terminal B. It is estimated that trucks requiring vapor control modifications are largely accounted for by the model plant estimates.

Exhibit 13-7
U.S. Environmental Protection Agency
FACTORY COSTS OF ALTERNATIVE
VAPOR CONTROL SYSTEMS

Type of Control System	Factory Cost[a] for 250,000 gallon per day system ($000, 1977)	Factory Cost for 500,000 gallon per day system ($000, 1977)
Adsorption/Absorption	120[b]	155
Compression-Refrigeration-Absorption	128	164
Refrigeration	120[c]	155
Thermal Oxidation	72	95

a. Costs are based on average of range of costs quoted by vendors to the U.S. Environmental Protection Agency and reported in The Economic Impact of Vapor Control on the Bulk Storage Industry, draft report, July 1978.

b. Hydrotech Engineering reported a factory price of $92,000 for a 250,000 gallon per day unit.

c. Expect system priced competitively to adsorption/absorption system due to market pressure.

Source: Hydrotech, U.S. Environmental Protection Agency, Exxon and Booz, Allen & Hamilton Inc. estimates

Exhibit 13-8
U.S. Environmental Protection Agency
DESCRIPTION AND COST OF MODEL TANK TRUCK GASOLINE LOADING TERMINALS EQUIPPED WITH VAPOR CONTROL SYSTEMS

Tank Truck Gasoline Loading Terminal Characteristics	Model Terminal A	Model Terminal B
Throughput	250,000 gallons/day	500,000 gallons/day
Loading racks	1	1
Storage tanks	3	3
Tank trucks	6	15
Compartments per account truck	4	4
Vapor control systems	Adsorption/Absorption Refrigeration	Adsorption/Absorption Refrigeration

Tank Truck Gasoline Loading Terminal Costs	AA	RF	AA	RF
Installed capital cost[a]	$258,000	$258,000	$355,000	$355,000
Annualized direct operating costs				
. Electricity	3,900	9,900	7,800	13,300
. Maintenance	10,800	13,200	13,950	17,050
. Operating labor	1,500	1,500	1,500	1,500
. Carbon replacement	2,400	-	4,700	-
Subtotal (direct operating costs)	18,600	24,600	27,950	38,350
Annualized capital charges	54,180	54,180	74,550	74,550
Net annualized cost (not including gasoline credit)	72,780	78,780	102,500	112,900

a. Includes factory cost of equipment, installation and modifications (100 percent of factory cost) and cost of $3000 per truck for modifications.

Source: Booz, Allen & Hamilton Inc.

The costs for the model terminals are used in Section 13.4.3 to extrapolate costs of vapor control equipment to the industry statewide. The costs for each model terminal are:

- Installed capital cost, which includes equipment and modification costs, labor and costs to modify trucks ($3,000 per truck)

- Annualized direct operating costs which include electricity, maintenance, operating labor and carbon replacement costs. Maintenance costs for the adsorption/absorption system are slightly lower than those for refrigeration

- Annualized capital charges include costs for depreciation, interest, taxes and insurance and are estimated to be 21 percent of the installed capital cost

- Net annualized operating costs, which are the sum of the capital charges and direct operating costs. It should be noted that gasoline credit has not yet been accounted for. Gasoline credit will be taken into account when the costs are extrapolated to the industry.

Another cost characterization that can be made is hydrocarbon reduction versus cost. This finding will also be shown in the statewide analysis.

13.4.3 Extrapolation to the Statewide Industry

Exhibit 13-9, on the following page, shows the extrapolation of vapor recovery costs to the statewide industry in Ohio. The estimates are based on the following assumptions:

- In Ohio, 50 percent of the tank truck gasoline loading terminals can be characterized by Model Terminal A and the remaining can be characterized by Model Terminal B.

- Fifty percent of the terminals will implement the adsorption/absorption vapor control system to comply with RACT and the other 50 percent will implement the refrigeration system to comply with RACT.

Exhibit 13-9
U.S. Environmental Protection Agency
STATEWIDE COSTS OF VAPOR CONTROL SYSTEMS
FOR TANK TRUCK GASOLINE LOADING TERMINALS

Characteristic/Cost Item	Data
Number of terminals	50
Total annual throughput (billions of gallons)	3.484
Uncontrolled emissions (tons/year)	17,378
Emission reduction from terminals (tons/year)	15,640
Installed capital cost ($ million, 1977)	15.33
Direct annual operating costs ($ million, 1977)	1.369
Annual capital charges ($ millions, 1977)	3.21
Annual gasoline credit[a] ($ millions, 1977)	6.073
Net annualized cost (credit) ($ millions, 1977)	(1.494)
Annual cost per ton of emissions, terminal emissions only ($ per ton)	161
Annual cost (credit) per ton of emissions reduced[a] ($ per ton)	(32)
Annual cost (credit) per ton of emissions reduced from gasoline marketing[b] ($ per ton)	106

a. Based on 46,308 tons of emissions recovered which includes 17,909 tons collected from gasoline service stations, 12,759 tons collected from bulk plants and 15,640 tons collected at the terminal.

b. Annual cost of emissions reduced from gasoline marketing based on sum of net annualized costs from terminals, bulk plants, gasoline dispensing facilities and fixed-roof tanks divided by the sum of emissions reductions from these same categories.

Source: Booz, Allen & Hamilton, Inc.

- Ninety percent of terminal emissions are recovered based on information obtained from interviews with manufacturers of adsorption/absorption vapor control equipment and refrigeration vapor control equipment

- RACT is implemented at bulk gasoline plants and gasoline service stations in the state and the gasoline vapors collected from bulk gasoline plants and gasoline service stations are recovered and credited to the tank truck gasoline loading terminal.

Based on the above, the total cost to the industry for installing vapor recovery equipment is estimated to exceed $15 million.

The value of gasoline recovered from terminal emission reductions only is $2.051 million. The value of gasoline recovered from terminal emission reduction plus emission returned to the terminal from bulk gasoline plants and gasoline service stations is $6.073 million. The annual cost per ton of emissions from terminal emission reduction only is $161 per ton. The annual credit per ton of emissions recovered at the terminal from combined emissions from terminals, bulk plants and gasoline service stations is $32 per ton. The overall cost per ton of emissions reduced from gasoline marketing is $106 per ton.

13.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including availability of equipment and capital; feasibility of the control technology; and impact on state economic indicators.

13.5.1 RACT Timing

RACT is assumed implemented statewide by January 1, 1982. This implies that tank truck gasoline loading terminal operators must have vapor control equipment installed and operating within the next three years. The timing requirements of RACT impose several requirements on terminal operators including:

- Determining appropriate vapor control system
- Raising capital to purchase equipment
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

13.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Several tank truck gasoline loading terminal operators in the United States have successfully implemented vapor control systems. State adoption of RACT regulations will generate a new demand for vapor control systems. It is expected based on information from industry interviews that sufficient leadtime is available to meet the increased demand, thus making the implementation of RACT technically feasible.

In the area of economic feasibility it has been reported from interviews that terminal operators should have access to capital to purchase vapor control equipment, and it is expected from information through interviews that terminals will not cease operations because of the cost of implementing RACT. If RACT is implemented statewide at tank truck gasoline loading terminals, bulk gasoline plants and gasoline service stations, there should be a possible savings for bulk terminals if the total system operates at maximum efficiency.

13.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net annualized credit of implementing RACT with the total value of gasoline sold in the state and the value of wholesale trade in the state.

The net annualized credit to the tank truck gasoline loading terminals resulting from RACT represents 0.1 percent of the total gasoline sold from affected terminals in the state. When compared to the statewide value of wholesale trade, the annualized credit is small.

13.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary economic impact of implementing RACT on employment, market structure and productivity that was derived from industry interviews and analysis of data.

- Employment—No decline in employment is predicted since terminals should not close solely because of RACT requirements. A slight increase in operating and maintenance labor will be required through implementation of RACT but this is predicted to have minimal impact on any employment increase.

- Market structure—No change in market structure is expected from implementation of RACT.

- Productivity—No change in worker productivity is expected to result from implementation of RACT.

* * * *

Exhibit 13-10, on the following page, presents a summary of the findings of this report.

Exhibit 13-10
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN OHIO

Current Situation	Discussion
Number of potentially affected facilities	50
Indication of relative importance of industrial section to state economy	1977 industry sales were $1,480 million, with annual throughput of 3.484 billion gallons. The primary market is rural accounts.
Current industry technology trends	New terminals will be designed with vapor recovery equipment
1977 VOC actual emissions	17,378 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Bottom or submerge fill and vapor recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$15.3 million
Annualized credit (statewide)	$1.494 million (approximately 0.1 percent of value of shipments)
Price	No change in price
Energy	Assuming full recovery of gasoline from terminal emissions only—net savings of 106,830 barrels annually from terminal emissions
Productivity	No major impact
Employment	No direct impact
Market structure	No direct impact
Problem area	Gasoline credit from vapors from bulk gasoline plants and gasoline service stations require uniform RACT requirements throughout the state
VOC emissions after control from terminal operations only	1,738 tons per year
Cost effectiveness of control	$32 annualized credit/annual ton of VOC controlled from terminals, and emissions returned from bulk gasoline plants and gasoline service stations (i.e., 46,308 tons per year).

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Hydrocarbon Control Strategies from Gasoline Marketing Operations, EPA-450/3-78-017, April 1978.

National Petroleum News Fact Book, 1976, McGraw Hill, Mid-May 1976.

National Petroleum News Fact Book, 1977, McGraw Hill, Mid-May 1977.

National Petroleum News Fact Book, 1978, McGraw Hill, Mid-June 1978.

Control of Hydrocarbons from Tank Truck Gasoline Loading Terminals, EPA-450/2-77-026, U.S. Environmental Protection Agency, October 1977.

The Economic Impact of Vapor Control on the Bulk Storage Industry, prepared for U.S. Environmental Protection Agency by Arthur D. Little, draft report, July 1978.

Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, April 1978.

Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921, Environmental Protection Agency, September 1974.

1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals, U.S. Bureau of Census.

Demonstration of Reduced Hydrocarbon Emissions from Gasoline Loading Terminals, PB-234 363.

Private conversation with Mr. Clark Houghton, Mid-Missouri Oil Company.

Private conversation with Mr. Gordon Potter, Exxon, Houston, Texas.

Private conversation with Mr. James McGill, Hydrotech, Tulsa, Oklahoma.

Private conversation with Mr. Frederick Rainey, Shell Oil Company, Houston, Texas.

"1978 Marketing Directory and Yearbook," Michigan Petroleum Association, 1978.

Private conversation with Mr. William Deutsch, Illinois Petroleum Marketers Association, Springfield, Illinois.

Private conversation with Mr. Richard Pressler, Illinois Environmental Protection Agency, Springfield, Illinois.

14.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF OHIO

14.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT controls for bulk gasoline plants in the State of Ohio. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of bulk gasoline plants, interviews, and analysis.

14.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for bulk gasoline plants in the State of Ohio.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

14.1.1 Industry Statistics

Industry statistics on bulk gasoline plants were obtained from several sources. All data were converted to a base year, 1977, based on specific scaling factors:

- The number of establishments for 1977 was extrapolated from the 1967 and 1972 Census of Wholesale Trade for Petroleum Bulk Stations and Terminals.

- The number of employees in 1977 was derived from the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals, by determining the number of employees per establishment in 1972 and multiplying this factor by the number of establishments reported for 1977.

- The number of gallons of gasoline sold in 1977 in the State of Ohio was estimated based on data from the Ohio emissions inventory for terminals and bulk plants. It was determined that 30 percent of the combined throughput was from bulk plants based on the ratio of bulk plant gasoline sales to total gasoline sold from bulk plants and terminals in 1972 (reported in the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals).

- Sales, in dollars, of motor gasoline for 1977 were estimated by multiplying the number of gallons of gasoline sold in 1977 by the national dealer tank-wagon price in 1977 (42.51¢/gallon—reported in the National Petroleum News Fact Book, 1978).

14.1.2 VOC Emissions

VOC emissions were estimated for bulk gasoline plants in Ohio based on the following methodology: Emissions per 1,000 gallons of throughput presented in Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035 were multiplied by the estimated number of gallons of gasoline sold from bulk gasoline plants in Ohio in 1977.

14.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for bulk gasoline plants are described in Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035. These data provide the alternatives available for controlling VOC emissions from bulk gasoline plants. Several studies of VOC emission control were also analyzed in detail, and interviews with petroleum trade associations, bulk plant operators, and vapor control equipment manufacturers were conducted to ascertain the most likely types of control processes which would be used in bulk gasoline plants in Ohio. The specific studies analyzed were: Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants, EPA 340/1-77-014; Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013; Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, EPA PB-236 921; and Study of Gasoline Vapor Emission Controls at Small Bulk Plants, EPA,PB-267-096.

The alternative types of vapor control equipment likely to be applied to bulk gasoline plants were arrayed, and percentage reductions from using each type of control were determined. The methodology for the cost analysis based on this scheme is described in the following paragraphs.

14.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the alternative types of control systems likely to be used

- Estimating the probable use of each type of control system

- Defining systems components

- Developing installed capital costs for systems components

- Aggregating installed capital costs for each alternative control system

- Defining two model plants

- Developing costs of control systems for model plants including

  - Installed capital cost
  - Direct operating costs
  - Annual capital charges
  - Gasoline credit
  - Net annualized cost

- Assigning model plant costs to plants in Ohio

- Aggregating costs to the total industry in Ohio.

Costs were determined from analyses of the following previous studies:

- Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA 450/2-77-035

- Study of Gasoline Vapor Emission Controls at Small Bulk Plants, EPA PB-267 096

- Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013

- Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants, EPA 340/1-77-014

and from interviews with petroleum marketers' associations, bulk plant operators, and vapor control equipment manufacturers.

The assignment of the estimated cost of control to Ohio required a profile of bulk plants for the state, showing the percentage of plants for:

- Various ranges of throughput
- Using top loading for account trucks
- Using bottom loading
- Plants with vapor control equipment already installed.

Since detailed data on bulk gasoline plant characteristics were not available for Ohio, it was assumed that data developed in a previous study of small bulk plants in Colorado and California could be used to broadly characterize the bulk plant population throughput in Ohio.

Bulk plants in Ohio may have a different distribution of number of plants by throughput range, although these data were not available for Ohio.

14.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment, and producitivity as a result of implementing RACT controls in Ohio.

14.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost, and economic impact of implementing RACT controls on bulk gasoline plants in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies, and best engineering judgment. Exhibit 14-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 14-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		●	
Emissions		●	
Cost of emissions control		●	
Statewide costs of emissions			●
Economic Impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton, Inc.

14.2 INDUSTRY STATISTICS

Industry characterisitcs, statistics, and business trends for bulk gasoline plants in Ohio are presented in this section. The discussion includes a description of the number of facilities and their characteristics, a comparison of the size of the bulk gasoline plant industry to state economic indicators, a historical characterization and description of the industry, and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions from bulk gasoline plants in Ohio.

14.2.1 Size of the Industry

There were an estimated 670 bulk gasoline plants, as of 1977, in Ohio. Industry sales were in the range of $693 million, with an estimated yearly throughput of 1.631 billion gallons of gasoline. The estimated number of employees in 1977 was 2,805. These data and the sources of information are summarized in Exhibit 14-2, on the following page. Annual capital investments have not been estimated. In general, bulk plant capital investments are for plant and equipment to replace worn-out facilities, modernize the establishments, or improve operating efficiencies.

14.2.2 Comparison of the Industry to the State Economy

A comparison of the bulk gasoline plant industry to the economy of the State of Ohio is shown in this section by comparing industry statistics to state economic indicators. Employees in the bulk gasoline plant industry represent less than 0.1 percent of the total state civilian labor force of Ohio. The value of gasoline sold from bulk plants represented less than two percent of the total value of wholesale trade in Ohio in 1977.

14.2.3 Characterization of the Industry

Bulk plants are an intermediate distribution point in the petroleum product marketing network as shown in Exhibit 14-3, following Exhibit 14-2. Bulk gasoline plants compete with bulk gasoline tank terminals and large retail gasoline outlets. Ownership and operation of bulk plants are predominantly by independent jobbers and commissioned

Exhibit 14-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR BULK GASOLINE PLANTS IN OHIO

Number of Establishments	Number of Employees	Sales ($ Million, 1977)	Gasoline Sold (Billions of Gallons)
670[a]	2,805[b]	693[c]	1.631[d]

a. Booz, Allen & Hamilton estimate based on 11.28% decline nationally for bulk plants from 1967 to 1972.

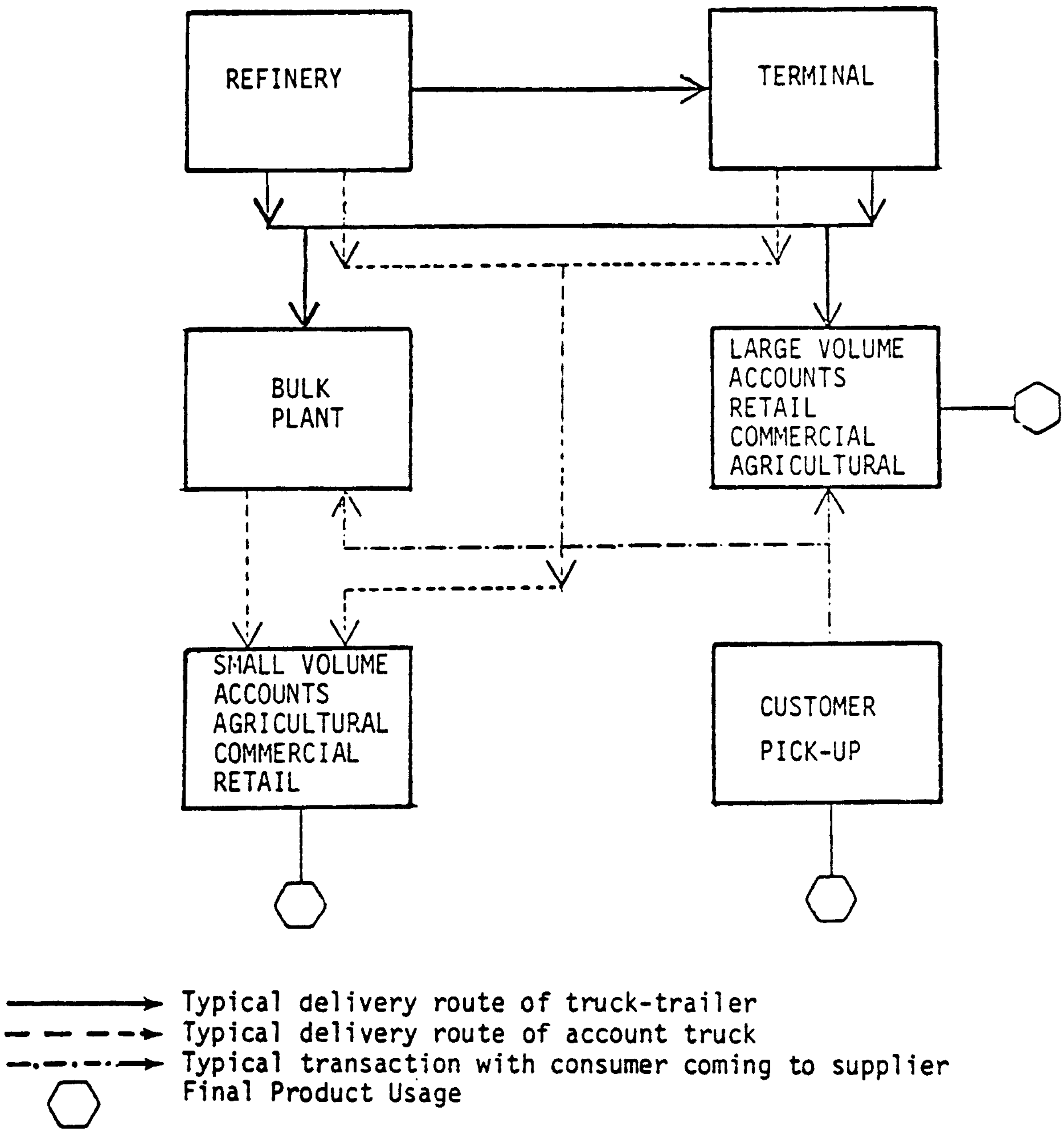
b. Booz, Allen & Hamilton estimate based on the ratio of the number of employees to the number of establishments in 1972.

c. Number of gallons of motor gasoline sold in 1977 multiplied by the national dealer tankwagon price in 1977 (42.51¢/gallon). National Petroleum News Fact Book, 1978.

d. Booz, Allen & Hamilton estimate based on data from the Ohio emissions inventory.

Exhibit 14-3

U.S. Environmental Protection Agency
GASOLINE DISTRIBUTION NETWORK



Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976, p. 3-2.

agents but also includes cooperatives and salaried employees. The independent jobber owns the equipment and structures at his bulk plant, the inventory, and rolling stock, and he contracts directly with the oil company for gasoline. A commissioned agent usually does not own the equipment and facilities but operates the bulk plant for a major integrated oil company.

Bulk gasoline plants are typically located near towns and small cities, since their predominant market is agricultural and small retail accounts. The maximum daily throughput of a bulk gasoline plant ranges from less than 2,000 gallons per day up to 20,000 gallons per day. Exhibit 14-4, on the following page, shows a typical distribution of bulk gasoline plants by plant throughput nationwide. It is assumed this distribution characterizes bulk gasoline plants in Ohio.

It is estimated that the majority of the bulk gasoline plants are up to 25 years old, with a few new modernized, higher volume plants. Forty years ago, bulk gasoline plants were a major link in the gasoline distribution network. From that time, their importance has been declining in the marketing sector of the petroleum industry, basically for economic reasons. There is evidence that profitability in bulk gasoline plants has been decreasing. The number of bulk gasoline plants decreased by 11 percent nationally from 1967 to 1972 and is predicted to continue declining in the near term.[1] This decline is largely attributable to major oil companies disposing of commission-agent-operated bulk plants.

1 National Petroleum News Fact Book, 1976.

Exhibit 14-4
U.S. Environmental Protection Agency
NATIONAL DISTRIBUTION OF BULK GASOLINE
PLANTS BY AMOUNT OF THROUGHPUT

Gasoline Throughput (gallons per day)	Percentage of Plants
Less than 2,000	24
2,000 to 3,999	27
4,000 to 5,999	16
6,000 to 7,999	8
8,000 to 9,999	12
10,000 to 11,999	4
12,000 to 13,999	1
14,000 to 15,999	2
16,000 to 17,999	1
18,000 to 20,000	5

Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA, September 1976.

14.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on bulk gasoline plant operation, estimated VOC emissions from bulk gasoline plant operations in Ohio, the extent of current control in use, the requirements of vapor control required by RACT and the likely RACT alternatives which may be used for controlling VOC emissions from bulk gasoline plants in Ohio.

14.3.1 Bulk Gasoline Plant Operations

Bulk gasoline plants are typically secondary distribution facilities which receive gasoline from bulk gasoline tank terminals by trailer-transport trucks; store it in above-ground storage tanks, and subsequently dispense it via account trucks to local farms, businesses and service stations. Bulk gasoline plants with an average daily gasoline throughput of 20,000 gallons per day or less have been defined by EPA as requiring vapor control equipment to reduce VOC emissions from bulk gasoline plant operations.

14.3.1.1 Facilities

Bulk plant facilities generally include tanks for gasoline storage, loading racks, and incoming and outgoing tank trucks.

The most prevalent type of gasoline storage tank found at bulk plants is the above ground storage tank. These tanks are usually cylindrical with domed ends (vertical or horizontal). Typical storage capacities range from 13,000 to 20,000 gallons and the number of tanks at each plant ranges from one to eight, with an average of three tanks per plant. The number of tanks is likely to be greater for plants with throughput greater than the average throughput.

A typical loading rack used for dispensing gasoline to account trucks includes shut-off valves, meters, relief valves, electrical grounding, lighting, by-pass plumbing and loading arms. Loading may be by bottom fill, top splash, or submerge fill pipe through hatches, or dry connections on the tops of trucks. It is estimated that top splash filling is used in about 50 percent of bulk plants and submerged filling in the remaining 50 percent of the bulk gasoline plants. A typical bulk gasoline plant has one loading rack with an average pumping rate of 125 gallons per minute.

Trailer-transport trucks supply bulk plants with gasoline, while account trucks deliver gasoline to bulk plant customers. Trailer-transport trucks have four to six compartments and deliver approximately 8,000 gallons of gasoline to the bulk plant. Most commonly, trailer-transport trucks are owned by oil companies or commercial carriers. Account trucks usually have four compartments with a total capacity of 2,000 gallons. Bulk plants have an average of two account trucks, and these trucks are most commonly owned by the bulk plant operator.

The facility description was synthesized from information obtained from:

- Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.
- Stage I Vapor Recovery and Small Bulk Plants in Washington, D.C., Baltimore, Maryland, and Houston/Galveston, Texas, EPA-340/1-77-010
- Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013
- Industry interviews.

14.3.1.2 Operations

VOC emissions occur at various stages in bulk plant operations. Gasoline is unloaded from trailer-transport trucks into gasoline storage tanks. The two methods of unloading gasoline into storage tanks are bottom filling and top submerged filling. Emissions occur from this operation through the displacement of vapor laden air in the storage tank with gasoline. Vapor balancing between the tank truck and the storage tank is the recommended method for controlling these emissions.

Another major source of emissions is from vaporization of gasoline in the storage tank because of changes in pressure in the tank caused by variation in temperature. These emissions, referred to as breathing losses, are controlled by adjusting the pressure relief valve on the storage tank.

The final major occurrence of emissions is during loading of account trucks which dispense gasoline to bulk plant customers. The cause of emissions during account truck filling is from turbulence of the liquids being loaded and the resulting vaporization. The vapor laden air in the account truck is displaced to the atmosphere during filling. Top loading account trucks cause greater emissions than trucks loading from the bottom since greater liquid turbulence occurs. Vapor balancing the account truck and the storage tank is the primary method for controlling emissions.

14.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from bulk gasoline plants in Ohio in 1977 and the current level of emission control already implemented in the state. Exhibit 14-5 on the following page, shows the total estimated emissions in tons per year from bulk plants in Ohio. The estimated VOC emissions from the 670 bulk plants are 19,439 tons per year.

It was estimated that 50 percent of the loading facilities are currently equipped with submerged loading equipment and that approximately 50 percent of bulk gasoline plants in Ohio use top splash filling based on data from Michigan and Wisconsin.

14.3.3 RACT Guidelines

The RACT guidelines for VOC emission control from bulk gasoline plants require the following control systems:

- Top submerged or bottom fill of gasoline storage tanks and outgoing account trucks
- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank
- Vapor balancing between the gasoline storage tank and the outgoing account truck
- Proper operation and maintenance of equipment.

Exhibit 14-6, following Exhibit 14-5, summarizes the RACT guidelines for VOC emissions control from bulk gasoline plants.

Exhibit 14-5
U.S. Environmental Protection Agency
VOC EMISSIONS FROM BULK GASOLINE
PLANTS IN OHIO

Number of Facilities	Estimated Number of Tanks	Yearly Throughput (billions of gallons)	Total Emissions
670	2,010[a]	1.631	19,439

a. Booz, Allen & Hamilton estimate based on 3 tanks per facility.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 14-6
U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR
BULK GASOLINE PLANTS

Facilities Affected	Sources of Emissions	RACT Control Guideline
Bulk plants with daily throughputs of 76,000 liters (20,000 gallons) of gasoline or less	Vapor displacement from filling account trucks, and breathing losses and working losses from storage tanks	Submerge filling and vapor balancing: . Vapor balancing of transport truck and storage tank . Vapor balancing of storage and account truck
	Cracks in seals and connections	Proper operation maintenance
	Improper hook up of liquid lines and top loading nozzles	Proper operation maintenance
	Truck cleaning	Proper operation maintenance
	Pressure vacuum relief valves	Proper operation maintenance

Source: Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

14.3.4 Selection of the Most Likely RACT Alternatives

Control of VOC emission from bulk gasoline plants is achieved using submerged or bottom filling of storage tanks and account trucks and vapor balancing between the loading and unloading of incoming and outgoing trailer-transport trucks and the gasoline storage tanks. There are several alternative means of achieving vapor control at bulk gasoline plants, based on the manner in which the bulk plant is operated.

Three likely control alternatives, summarized in Exhibit 14-7, on the following page, are discussed separately in the paragraphs which follow.

14.3.4.1 Alternative I

Control Alternative I involves top submerged loading and equipping the bulk plant with a vapor balancing system. In detail, this control alternative implies:

- Submerged filling of gasoline storage tanks
- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank
- Submerged top loading of outgoing account trucks
- Vapor balancing of gasoline storage tank and outgoing account truck
- Equipping account trucks with vapor balancing connections.

It is estimated that bulk plants in Ohio would select Control Alternative I to achieve vapor recovery to meet the state RACT requirements. During interviews, the industry has questioned whether vapor recovery by this control method will achieve 90 percent emissions recovery as stated in the RACT guidelines.

14.3.4.2 Alternative II

Control Alternative II involves implementing a complete vapor balancing system on bulk plants which currently

Exhibit 14-7
U.S. Environmental Protection Agency
ALTERNATIVE CONTROL METHOD
FOR VAPOR CONTROL AT BULK GASOLINE PLANTS

Alternative Number	Description of Control Method
I	Top submerged filling and vapor balance entire system
II	Vapor balance existing bottom filled bulk plant
III	Convert top filled bulk plant to bottom filled, and vapor balance total system

Source: Booz, Allen & Hamilton analysis of Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

operate with bottom filling. In detail this control alternative encompasses:

- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank
- Vapor balancing between the gasoline storage tank and the outgoing account truck
- Modification of account trucks to accommodate a vapor recovery connection.

The cost for this alternative would be similar to costs for Control Alternative I.

14.3.4.3 Alternative III

Control Alternative III involves converting top loading bulk gasoline plants to bottom filling and implementing a complete vapor balancing system. In detail, this control alternative entails:

- Converting the loading rack to bottom filling
- Converting storage tank loading to bottom filling
- Vapor balancing the incoming trailer-transport truck and the gasoline storage tank
- Converting the account truck to bottom loading and installing vapor balancing connections on the account truck.

The additional cost of converting a bulk plant from top filling to bottom filling makes Control Alternative III more costly than Control Alternative I or II. This additional cost may be attributable to improved bulk plant operations rather than compliance with proposed limitations.

14.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for VOC emission control equipment are presented in this section. The costs for the three alternative control systems described in Section 14.3 are described individually, followed by costs for typical bulk plants. The final section then presents a projection of typical bulk gasoline plant control costs to the statewide industry.

14.4.1 Costs for Alternative Control Systems

The costs for the three alternative control systems (summarized in Exhibit 14-8, on the following page) were derived from analysis of the RACT guidelines, from interviews with bulk plant operators and petroleum marketing trade associations, and from previous cost and economic studies of small bulk plants.

Control Alernative I is expected to be the most widely applied system for bulk plants in Ohio. The U.S. EPA currently endorses the cost estimates developed by Pacific Environmental Services, Inc. for the Houston/Galveston area bulk plants. However, several large volume bulk plant operators who were interviewed have reported vapor control costs in excess of $50,000 which included conversion of the loading rack to bottom filling.

Control Alternative II is similar in cost to Control Alternative I.

Control Alternative III is the most costly control system. Several bulk gasoline plant operators interviewed in California and Maryland have adopted this system, although it cannot be shown from the data in Ohio that any bulk gasoline plant in Ohio would be willing to implement a system this costly. This alternative, therefore, is not included in the projection of vapor control costs to the statewide industry in the next section.

14.4.2 Costs for Two Model Bulk Plants

Two model bulk plants and their associated vapor control costs are characterized in this section. The costs are based on the control estimates for Control Alternative I, reported by Pacific Environmental Services, Inc. for bulk plants in the Houston/Galveston area. Several other

Exhibit 14-8

U.S. Environmental Protection Agency

COSTS OF ALTERNATIVE VAPOR CONTROL SYSTEMS

Cost Estimate	Alternative I	Alternative II	Alternative III (Includes conversion to botton filling)
National Oil Jobbers Council estimate	1 truck (4-compartments) 1 loading rack (3 arms) 3-inch system Pre-set meters Direct Cost (no labor) $20,524 (without air) $22,754 (with air)	Similar to costs for alternative I	1 truck (4-compartments) 1 loading rack (3 arms) 3-inch system Pre-set meters Direct cost (No labor) $27,729
Pacific Environmental Services estimate of Houston/Galveston area system	1 loading rack Meters Average installed cost $3,200 (without metering) $7,700 (with metering)		
Wiggins system			1 truck 4-compartments) 1 loading rack (4 arms) Pre-set meters Installed cost $17,352-$18,416

Source: National Oil Jobbers Council, Pacific Environmental Services Inc., Wiggins Division, Delaware Turbines, Inc.

bulk plant operators have reported costs in excess of $50,000 for vapor control systems although these cost estimates exceed the level of control required to meet the RACT requirements.

Exhibit 14-9, on the following page, defines two model bulk plant characteristics and associated control costs. It is assumed that approximately 75 percent of the bulk plants in Ohio can be characterized by Model Plant A; the remaining 25 percent are assumed to be characterized by Model Plant B.

The costs for the model plants are used in Section 14.4.3 to project costs of vapor control equipment to the industry statewide. The costs for each model plant are:

- Installed capital cost, which includes parts and labor
- Annualized direct operating costs, expected to be 3 percent of installed capital costs, including costs for labor, utilities, recordkeeping, and training costs.[1]
- Annualized capital charges, estimated to be 25 percent of installed capital costs, including costs for depreciation, interest, maintenance, taxes, and insurance
- Net annualized operating costs, which are the sum of the capital charges and direct operating costs. It should be noted that gasoline credit has not yet been accounted for. Gasoline credit will be taken into account when the costs are projected to the industry.

Another cost characterization that can be made is hydrocarbon reduction versus cost. This finding will also be shown in the statewide analysis.

14.4.3 Projection to the Statewide Industry

Exhibit 14-10, following Exhibit 14-9, shows the projection of vapor recovery costs to the statewide industry in Ohio. The estimates are based on the following:

- In Ohio, 75 percent of the bulk gasoline plants can be characterized by Model Plant A and the

1. Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035, p. 4-6.

Exhibit 14-9
U.S. Environmental Protection Agency
DESCRIPTION AND COST OF MODEL BULK PLANTS
EQUIPPED WITH VAPOR CONTROL SYSTEMS

Bulk Plant Characteristics	Model Bulk Plant A	Model Bulk Plant B
Throughput	2,500 gallons/day	13,000 gallons/day
Loading racks	1	1
Storage tanks	3	3
Account trucks	2	4
Compartment per account truck	4	4
Vapor control system	Alternative I	Alternative I

Bulk Plant Costs	Model Bulk Plant A	Model Bulk Plant B
Installed capital cost[a]	$13,700	$19,700
Annualized direct operating costs @ 3 percent of installed cost	411	591
Annualized capital charges @ 25 percent of installed capital cost	3,425	4,925
Net annualized cost (not including gasoline credit)	3,836	5,516

a. Cost to modify one 4-compartment account truck estimated to be $3,000.

Source: Booz, Allen & Hamilton, Inc.

Exhibit 14-10
U.S. Environmental Protection Agency
STATEWIDE COSTS OF VAPOR CONTROL
SYSTEMS FOR BULK GASOLINE PLANTS

Characteristic/Cost Item	Data
Number of facilities	670
Total annual throughput (billions of gallons)	1.631
Uncontrolled emissions (tons/year)	19,439
Emission reduction (tons/year)	14,176
Net emissions (tons/year)	5,263
Installed capital[b] ($ million, 1977)	10.237
Direct annual operating cost ($ million, 1977)	.307
Annualized capital charges ($ millions, 1977)	2.55
Annualized gasoline credit[a] ($ million, 1977)	.186
Net annualized cost ($ millions, 1977)	2.67
Annual cost per ton of emissions reduced ($ per ton)	188

a. Based on 10 percent of emission reduction (resulting from less turbulence in gasoline loading) accrued to bulk plants at 40¢ per gallon.

b. Includes cost of $50,000 to equip 335 bulk plants with a submerged fill pipe at a cost of $150 per plant.

Source: Booz, Allen & Hamilton Inc.

remaining can be characterized by Model Plant B.

- All bulk plants will implement the Control Alternative I vapor control system to comply with RACT.

Actual costs to bulk plant operators may vary depending on the type of control alternative and manufacturer's equipment selected by each bulk plant operator.

Based on the above, the total cost to the industry for installing vapor recovery equipment is estimated to exceed $10 million. The amount of gasoline prevented from vaporizing using vapor control is valued at approximately $186,000. Approximately 10 percent of total emissions can be credited to the bulk plant since installation of vapor control equipment will reduce the amount of vaporization by approximately 10 percent. The annual cost per ton of emissions controlled is estimated to be $188 per ton.

The statewide costs of vapor control systems by size of bulk gasoline plant are analyzed and arrayed in Exhibit 14-11. It is noted that bulk plants with throughput less than 4,000 gallons per day achieve only 20 percent reduction in overall emissions yet bear over 45 percent of the annual cost of hydrocarbon emission control costs. Emissions were allocated based on the estimated percentage of statewide throughput in each throughput class. Annualized costs were distributed for each throughput class based on the national percentage of plants in each throughput class.

Exhibit 14-11
U.S. Environmental Protection Agency
STATEWIDE COSTS OF VAPOR CONTROL
SYSTEM BY SIZE OF BULK GASOLINE PLANT

Bulk Plant Gasoline Throughput (gallons per day)	Percentage of Plants	Current Estimated Annual VOC Emissions (tons per year)	Estimated Annual VOC Emissions After RACT Control (tons per year)	Net VOC Emission Reduction (tons per year)	Percentage of Total VOC Emissions Reduced	Estimated Annual Cost ($ millions, 1977)	Percent of Total Annual Cost	Net Hydrocarbon Cost Effectiveness ($, 1977 / tons per year)
Less than 2,000	24	1,244	337	907	6.4	.573	21.50	632
2,000 - 3,999	27	2,819	763	2,056	14.5	.644	24.16	314
4,000 - 5,999	16	2,779	753	2,026	14.3	.380	14.25	188
6,000 - 7,999	8	1,944	526	1,418	10.0	.194	7.20	137
8,000 - 9,999	12	3,752	1,016	2,736	19.3	.419	15.72	153
10,000 - 11,999	4	1,536	416	1,120	7.9	.141	5.29	125
12,000 - 13,999	1	428	116	312	2.2	.036	1.35	115
14,000 - 15,999	2	1,050	284	766	5.4	.073	2.74	95
16,000 - 17,999	1	583	158	425	3.0	.036	1.35	84
18,000 - 20,000	5	3,304	894	2,410	17.0	.167	6.26	69

Source: Booz, Allen & Hamilton Inc.

14.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables, and capital investment.

14.5.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This requires that bulk gasoline plant operators must have vapor control equipment installed and operating within the next three years. The timing requirements of RACT impose several requirements on bulk plant operators including:

- Determining appropriate vapor control system
- Raising capital to purchase equipment
- Generating sufficient income from current operations to pay the additional annual operating costs incurred with vapor control
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

14.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Several bulk plants in the U.S. have attempted to implement vapor control systems with varying degrees of success. One bulk plant operator interviewed in Maryland implemented vapor recovery at a cost of $65,000 in 1974. The operator indicated that recent tests have shown the system operates well within the 90 percent recovery requirement of RACT. This particular bulk plant was converted to bottom filling and completely vapor balanced. The plant's throughput was 20,000 gallons per day and included one loading rack and three account trucks. This plant would be characterized as installing a sophisticated Alternative III control system. The plant is also operated by a major oil company, so capital availability problems were not similar to a small, independently owned bulk plant.

Bulk plants in the Houston/Galveston area, on the contrary, have implemented "bare bone" type control systems that were individually designed and installed at a bulk plant which was owned by a major oil company. No emission data are available to verify whether these systems are in compliance, but U.S. EPA estimates that these control systems are sufficient to meet the requirements of RACT. These systems are not marketed by any equipment manufacturer; therefore, their availability for widespread application is doubtful at the present time.

State adoption of RACT regulations will generate a demand for economical vapor control systems for bulk plants. It is, therefore, anticipated that off-the-shelf systems could be developed within the next four years that are similar to the control system implemented in the Houston/Galveston area; thus making the implementation of RACT technically feasible.

A number of economic factors are involved in determining whether a specific bulk plant operator will be able to implement vapor control systems and still remain profitable. These include:

- Degree of competition
- Ability to pass on a price increase
- The current profitability of the plant
- Age of the plant
- State of repair of the plant
- Ownership—major oil company or private individual.

By dividing the annual cost per plant by annual plant throughput it is estimated that small bulk plants, with throughput less than 4,000 gallons per day, could possibly experience a direct cost increase of nearly 0.28 cents per gallon if they implement RACT. This may affect up to 50 percent of the bulk plants in the state and these plants are likely to be located in rural areas.

The key to the direct economic impact will be the ability of a bulk plant operator to pass on up to a 0.28 cent increase in the price of gasoline to customers (assuming a full cost passthough). One small bulk plant operator in Missouri reported during an interview that his gross profit margin per gallon of gasoline is 4 to 5 cents per gallon. His net profit margin is 0.5 cent per gallon. This operator stated that he plans to discontinue operations rather than comply with RACT. Again, sufficient data are not available to determine if this would be typical of small bulk plants in the state. In a previous study of the economics of vapor recovery for small bulk plants, a trend of declining profitability in bulk plant operations was identified.[1] If this trend continues, vapor control systems may not be affordable at marginal plants. Many bulk plants now operate at a profit only because their plants are fully depreciated. In the same study it was also determined that a large percentage of small bulk plants may not be able to raise sufficient capital to purchase vapor control equipment. Furthermore, it is estimated that the price of vapor control systems is likely to increase in the future at a rate greater than the GNP. One bulk plant operator stated that prices for vapor control have risen 30 percent over the past three years. It is possible that the industry decline could continue and that some bulk plant operators may cease operations because of their present financial condition and the additional financial burden of the RACT requirements.

The paragraphs which follow compare statewide compliance costs of RACT control, in 1977 dollars, to various economic indicators.

14.5.3 Comparison of Direct Cost With Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annual operating cost of implementing RACT with the total value of gasoline sold in the state, the value of wholesale trade in the state, and the unit price of gasoline.

The net increase in the annualized cost to the bulk gasoline plants due to RACT represents 0.35 percent of the total gasoline sold in the state. When compared to the statewide value of wholesale trade, these annual cost increases represent less than 0.01 percent. The impact on the unit price of gasoline varies with the bulk plant throughput. As discussed in the preceding section, the small bulk plants

1 Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA, 340/1-77-013, September 1976.

may experience a direct cost increase of up to 0.3 cent per gallon of gasoline sold, whereas the large bulk plants may experience a much smaller direct cost increase. Assuming a full cost passthrough, the price of gasoline is likely to rise more in rural areas than urban areas (i.e., the small volume bulk plants tend to be located in rural areas).

14.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impacts of implementing RACT on employment, market structure, and productivity.

For bulk gasoline plants that comply with RACT requirements, no additional manpower requirements are expected. Overall bulk gasoline plant industrial sector employment may continue to decline if the number of bulk gasoline plants operating in the state decline. Based on the statewide estimates of number of employees and number of bulk plants, an average of approximately 4.6 jobs could be lost with the closing of a bulk plant. No estimate was made of the number of bulk plants that might close due to RACT.

The impact on the market structure for bulk plants differs significiantly in urban and rural areas. The importance of bulk plants in the urban areas may be declining because of competition from retailers and tank truck terminals and could continue to decline regardless of RACT requirements.

In rural areas, the bulk plants serve as a vital link in the gasoline distribution network, since large trailer transport trucks cannot be accommodated by many rural roads serving the farm accounts. It is estimated that approximately 60 percent of the customers served by the small bulk plants in the rural areas are farm accounts, which could be severely impacted if the small bulk plants are forced out of business. The increased operating cost of complying with RACT may create market imbalances if the compliance cost cannot be passed on to the marketplace in terms of a price increase (i.e., the market structure would tend to concentrate further). As small bulk plant operators cease operation, the supply of fuel to some farmers could be threatened. Bulk plants not equipped with vapor control equipment may not be able to serve gasoline service stations equipped with vapor control equipment due to incompatible hardware configurations. A uniform policy, therefore, is necessary so that market disruptions due to equipment incompatibility are minimized.

The productivity of a specific bulk plant is a function of the type of vapor control system installed. If a bulk plant converts to bottom filling along with vapor recovery, the productivity of the bulk plant should increase.

However, some vapor control systems may decrease plant productivity if flow rates substantially decline, requiring longer times to load and unload trucks.

*   *   *   *   *

Exhibit 14-12 presents a summary of the findings of this report.

Exhibit 14-12
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN OHIO

Current Situation	Discussion
Number of potentially affected facilities	670
Indication of relative importance of industrial section to state economy	1977 industry sales were $693 million, with annual throughput of 1.631 billion gallons. The primary market is rural accounts
Current industry technology trends	Only small percent of industry has new/ modernized plants
1977 VOC actual emissions	19,440 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Top submerge or bottom fill and vapor balancing (cost analysis reflects top submerge fill, not bottom fill)

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$10.1 million
Annualized cost (statewide)	$2.66 million (approximately 0.36 percent of value of shipment)
Price	Assuming a "direct cost passthrough" . Industrywide—$.0014 per gallon increas . Small operations—$.003 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 96,800 barrels annually
Productivity	No major impact
Employment	No direct impact; however for plants closing potential average of 4.6 jobs lost per plant closed
Market structure	Regulation could further concentrate a declining industry. Many small bulk gas plant today are marginal operations; further cost increases could result in some plant closing
Problem area	Severe economic impact for small bulk plant operations. Regulation could cause further market imbalances. Emission control efficiency of cost effective alternatives has not been fully demonstrated
VOC emission after control	5,263 tons per year (27 percent of current V level)
Cost effectiveness	$188 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton, Inc.

BIBLIOGRAPHY

National Petroleum News Fact Book, 1967, McGraw Hill, Mid-May 1976.

National Petroleum News Fact Book, 1977, McGraw Hill, Mid-May 1977.

National Petroleum News Fact Book, 1978, McGraw Hill, Mid-June 1978.

"Economic Analysis of Vapor Recovery Systems on Small Bulk Plants," EPA 340/1-77-013, September 1976.

"Stage I Vapor Recovery and Small Bulk Plants in Washington, D.C., Baltimore, MD, and Houston/ Galveston, TX," EPA 340/1-77-010, April 1977.

"Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants," EPA 340/1-77-014, April 1977.

"Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources," EPA 905/2-78-001, April 1978.

"Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources," PB-236 921, Environmental Protection Agency, September 1974.

"Control of Volatile Organic Emissions from Bulk Gasoline Plants," EPA 450/2-77-035, December 1977.

Memorandum, "Meeting with EPA and Others on Bulk Plant Vapor Recovery," National Oil Jobbers Council, Mr. Bob Bassman, Council, March 21, 1978.

Letter to Mr. William F. Hamilton, Economic Analysis Branch, United States Environmental Protection Agency, from California Independent Oil Marketers Association, February 28, 1978.

Private conversation with Mr. Clark Houghton, Missouri Bulk Plant Operator.

Private conversation with Mr. D. L. Adams, Phillips Petroleum, Towson, Maryland.

Private conversation with Mr. Robert Schuster, bulk plant operator in Escondido, California.

Private conversation with Mr. Burton McCormick, bulk plant operator in Santa Barbara, California.

"The Lundburg, Letter," Pele-Drop, North Hollywood California.

Private conversation with Mr. William Deutsch, Illinois Petroleum Marketers Association, Springfield, Illinois.

15.0 STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN OHIO

15.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT controls for the storage of petroleum liquids in fixed-roof tanks. The major sections of the chapter include:

- Specific methodology and quality of estimates
- Technical characteristics of fixed-roof tanks and VOC emission control technology
- Profile of statewide fixed-roof tank industry and estimated annual VOC emissions
- Cost of controlling VOC emissions
- Economic impact.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of fixed-roof storage tanks, interviews and analysis.

15.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining:

- Technical characteristics of fixed-roof tanks
- Profile of fixed-roof tanks
- VOC emissions
- Cost of vapor control systems
- Economic impact of emission control for the storage of petroleum liquids in fixed-roof tanks.

The quality of these estimates is discussed in the last part of this section.

15.1.1 Technical Characteristics of Fixed-Roof Tanks

The technical characteristics of fixed-roof tanks and processes for controlling their emissions were obtained mainly from the RACT guideline entitled, Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-450/2-77-036, and from several other studies of fixed-roof tanks listed in the reference section of this report.

15.1.2 Profile of Fixed-Roof Tanks

The Ohio Environmental Protection Agency provided a listing of all affected fixed-roof tanks greater than 40,000-gallon capacity used for storing petroleum liquids in Ohio.[1] Capacity of each tank as well as the type of petroleum liquid stored were also provided. Annual statewide throughput was calculated based on a turnover rate of 30 times per year based on data in a report, Benzene Emission Control Costs in Selected Segments of the Chemical Industry. These data form the basis for calculating statewide VOC emissions in Ohio.

1 Ohio currently has a regulation requiring internal floating covers on fixed roof tanks greater than 65,000 gallons and holding organic meterials with a vapor pressure of 1.5 psia or greater. This regulation is applicable to existing tanks in Priority I areas for oxidants and new tanks regardless of location. Priority I area includes the following counties and metropolitan areas: Butler, Clark, Claermont, Cuyahoga, Darke, Delaware, Fairfield, Franklin, Geauga, Green, Hamilton Lake, Licking, Lorain, Lucas, Madison, Medina, Miami, Montgomery, Perry, Pickaway, Portage, Preble, Stark, Summit, Union, Warren, and Wood Counties and Cleveland, Columbus, Dayton, and Cincinnati metropolitan areas.

15.1.3 VOC Emissions

VOC emissions for affected tanks were calculated based on the emission factors for working and breathing losses of various types of petroleum liquids. The emission factors were obtained from Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency. Tank capacity, fuel type and number of tanks were provided by the Ohio Environmental Protection Agency.

15.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the type of control system
- Developing installed capital costs for each tank
- Developing total annual costs of control systems for the number of tanks in the state including:
  - Installed capital cost
  - Direct operating costs
  - Annual capital charges
  - Petroleum liquid credit
  - Net annualized cost
- Aggregating costs to the total affected industry in Ohio.

Costs were determined from analyses of the following studies:

- Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA 450/2-77-036
- Benzene Emission Control Costs in Selected Segments of the Chemical Industry, prepared for Manufacturing Chemists Association by Booz, Allen & Hamilton Inc., June 12, 1978

and from interviews with petroleum marketers' associations, petrochemical manufacturers and vapor control equipment manufacturers.

The projection of the estimated cost of control to Ohio required a profile of fixed-roof tanks for storing petroleum liquids for the state, showing the capacity of each tank and the type of petroleum liquid being stored. These data were provided by the Ohio Environmental Protection Agency for affected fixed-roof tanks greater than 40,000-gallon capacity.

15.1.5 Economic Impact of Emission Control

The economic impact of emission control for equipping fixed-roof tanks used for storing petroleum liquids can be determined only in terms of the statewide cost of controls. Since several industries use fixed-roof tanks, economic impacts on individual industries depend on the extent to which the industries must bear the increased cost. The economic impact analysis in this report is, therefore, limited to estimating statewide costs of controls and qualitatively assessing the potential impacts on these costs on various industries.

15.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls for affected fixed-roof tanks in Ohio. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 15-1, on the following page, rates each study ouput listed and the overall quality of the data.

Exhibit 15-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions			●
Cost of emissions control		●	
Statewide costs of emissions		●	
Economic impact			●
Overall quality of data		●	

Source: Booz, Allen & Hamilton Inc.

15.2 TECHNICAL CHARACTERISTICS OF FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS

This section describes the technical characteristics of fixed-roof tanks for storing petroleum liquids, the sources and types of VOC emitted by these tanks, the control measures for reducing VOC emissions from fixed-roof tanks and RACT guidelines.

15.2.1 Characteristics of Fixed-Roof Tanks for Storing Petroleum Liquids

Fixed-roof tanks consist of a cylindrical steel shell with a permanently affixed roof as characterized in Exhibit 15-2, on the following page. The roof design may vary from cone shape to flat. The fixed-roof tank is the least expensive type of storage tank to construct and is generally considered to be the minimum acceptable standard for storage of petroleum liquids. The tank is designed to operate at only slight internal pressure or vacuum.

Fixed-roof tanks having greater than 40,000-gallon capacity and containing petroleum liquids greater than 1.52 psia are the specific fixed-roof tanks under analysis in this report, excluding those tanks which already comply under a previous regulation. These tanks are used for storing petroleum liquids at refineries, bulk terminals and tank farms and along pipelines. Tanks are generally loaded by submerged fill and are unloaded into tank cars, tank trucks, ships, barges or pipelines.

The processes of petroleum liquid storage, tank loading and unloading are sources of VOC emissions in Ohio. Specific sources and types of emissions from such tanks are discussed in the paragraphs which follow.

15.2.2 Sources and Types of VOC Emissions from Fixed-Roof Storage Tanks

VOC emissions result from the process of storing petroleum liquids in fixed-roof storage tanks and loading and unloading tanks with petroleum liquids. Fixed-roof tanks are designed to operate at only slight internal pressure or vacuum, and as a result the emissions from storage, filling and emptying can be appreciable.

15.2.2.1 Emissions from Petroleum Liquid Storage

Emissions from petroleum liquid storage, referred to as breathing losses, occur from changes in temperature and pressure in the storage tank. Vapors are expelled from the tank when diurnal temperature and barometric pressure changes cause expansion and contraction of the volatile petroleum liquid. These VOC emissions, or losses, occur in the absence of any liquid level change in the tank. Breather valves (pressure vacuum) are installed on many fixed-roof tanks to prevent vapors from escaping to the atmosphere because of small changes in temperature and barometric pressure or very small fluctuations in liquid level. These vents, however, will vent vapors to the atmosphere during normal filling and draw air into the tank during emptying.

15.2.2.2 VOC Emissions from Filling and Emptying Storage Tanks

VOC emissions resulting from filling and emptying storage tanks are referred to as "working losses." As a tank is filled the vapor laden air in the airspace between the liquid and the tank top is displaced to the atmosphere through breather vents.

Emptying losses occur when air drawn into the tank through the breather vent becomes saturated with hydrocarbon vapor and expands such that the volume of the vapor laden air exceeds the capacity of the vapor space.

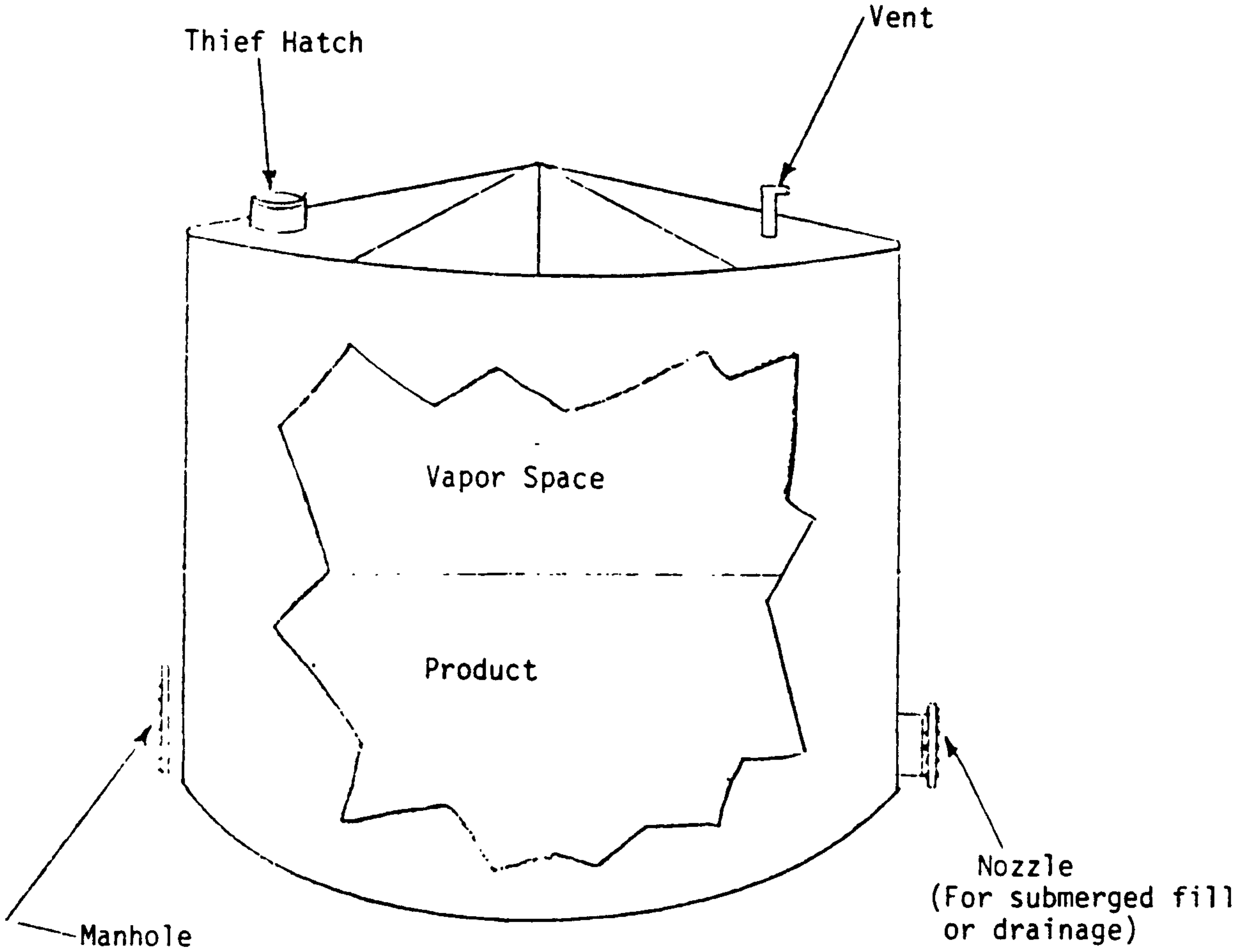
Additional VOC emissions occur during tank cleaning and from any corrosion spots or deterioration in the tank.

15.2.3 Techniques for VOC Emission Control

Fixed-roof tank emissions are most readily controlled by the installation of internal floating roofs. An internal floating roof for fixed-roof tanks is a cover floating on the liquid surface inside the tank, rising and falling with the liquid level. Exhibit 15-3, on the following page, is a schematic of a typical fixed-roof tank equipped with an internal floating roof or cover. There are two types of internal floating roofs:

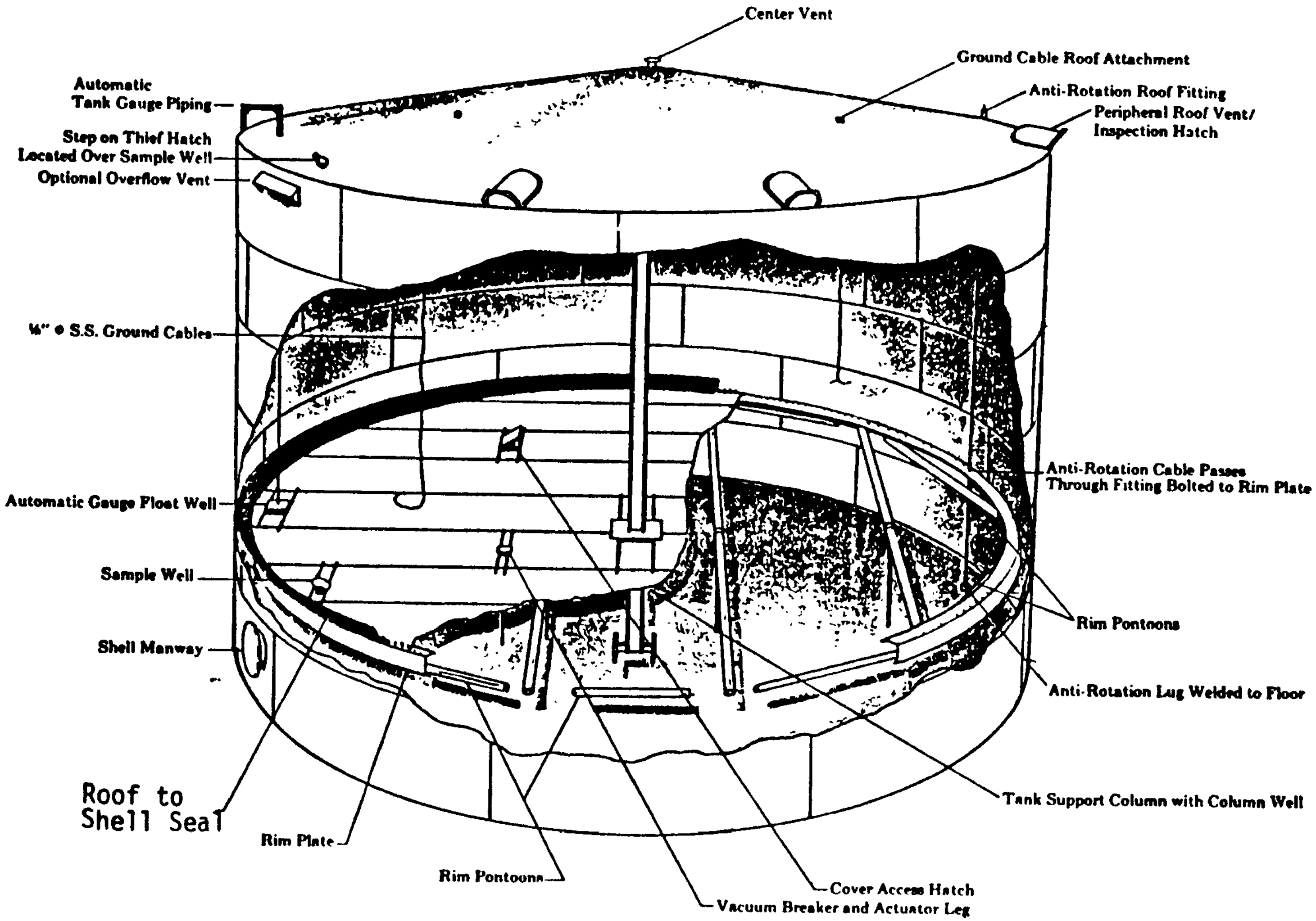
- A pan-type steel floating roof
- A nonferrous floating roof made of aluminum or polyurethane.

Exhibit 15-2
U.S. Environmental Protection Agency
TYPICAL FIXED ROOF TANK



Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-00, U.S. Environmental Protection Agency, April 1978

Exhibit 15-3
U.S. Environmental Protection Agency
SCHEMATIC OF TYPICAL FIXED ROOF TANK
WITH INTERNAL FLOATING COVER



Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, U.S. Environmental Protection Agency, April 1978

The fixed-roof protects the internal floating roof and seal from deterioration from climatological effects and eliminates the possibility of the floating roof sinking from the weight of rain or snow loads.

A closure device must be used to seal the gap between the tank shell and the internal floating roof around the roof perimeter. Special materials are available for the closure device in a wide range of designs to accommodate the entire spectrum of petroleum liquids. Exhibit 15-4, on the following page, illustrates several typical internal floating roofs and perimeter closure seals.

Other modifications may need to be made to the fixed-roof tank before it is equipped with an internal floating roof. Tank shell deformations and obstructions may require correction; special structural modifications such as bracing, reinforcing and plumbing vertical columns may be necessary. Anti-rotational guides should be installed to keep the internal floating roof openings in alignment with the fixed-roof openings. Special vents are installed on the fixed roof or on the walls at the top of the shell to minimize the possibility of VOCs approaching the flammable range in the vapor space.

15.2.4 RACT Guideline for VOC Emission Control

The RACT guidelines call for installation of an internal floating roof for fixed-roof tanks storing greater than 40,000 gallons of petroleum liquids with a true vapor pressure that exceeds 1.52 psia. The guidelines do not apply to storage tanks equipped with external floating roofs or to storage tanks having capacities less than 416,000 gallons used to store crude oil and condensate prior to lease custody transfer.[1]

It is expected that the State of Ohio will prepare legislation for the storage of petroleum liquids which is modeled after the RACT guidelines.

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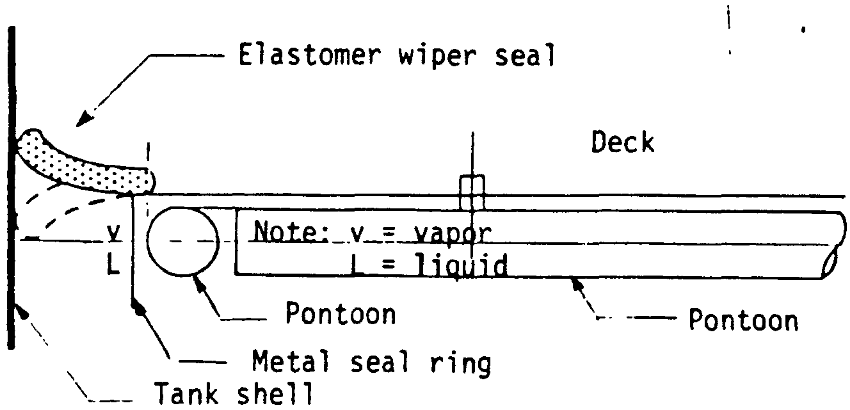
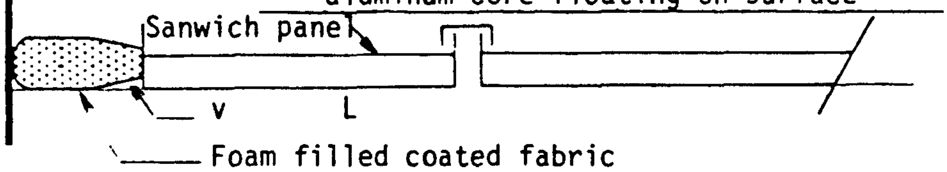
1 "Custody transfer" means the transfer of produced crude oil and/or condensate, after processing and/or treating in the production operations, from storage tanks or automatic transfer facilities to pipelines or any other forms of transportation.

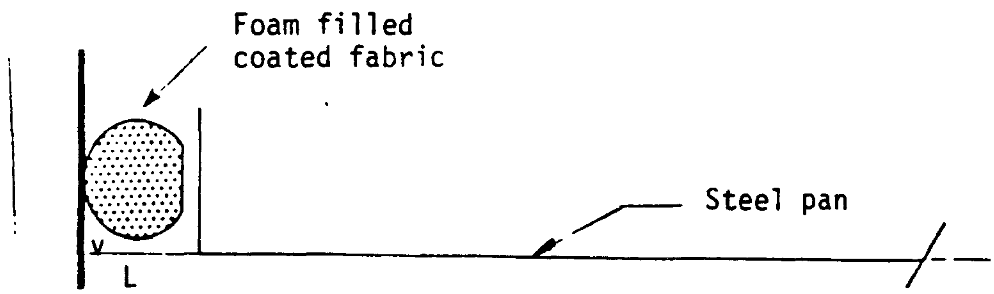
Exhibit 15-4
U.S. Environmental Protection Agency
TYPICAL FLOTATION DEVICES AND PERIMETER SEAL
FOR INTERNAL FLOATING COVERS AND
COVERED FLOATING ROOF

Aluminum deck supported above liquid by tubular aluminum pontoons



Aluminum sandwich panels with honeycombed aluminum core floating on surface





Source: Based on Annex A, API Publication 2519, Second Edition

15.3 AFFECTED FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS AND ESTIMATED VOC EMISSIONS

This section contains data on the affected fixed-roof tanks used for storing petroleum liquids in the State of Ohio and the estimated annual VOC emissions from these tanks.

The Ohio Environmental Protection Agency compiled a list of affected fixed-roof tanks from their emissions inventory. The capacity of each tank and the type of petroleum liquid stored were provided in the listing (see Exhibit 15-5). There are 6 unregulated fixed-roof tanks greater than 40,000-gallon capacity containing gasoline and not equipped with an internal floating roof in Ohio.[1] The total storage capacity of these tanks is 7.144 million gallons, and the annual throughput of petroleum liquid is estimated to be 214 million gallons.

It is estimated that annual VOC emissions from the storage of petroleum liquids in fixed-roof tanks in Ohio are 1,217 tons per year.

It is further estimated that these emissions could be reduced by 90 percent or to 122 tons per year by implementing RACT in Ohio, assuming no existing control of these tanks.

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[1]Fixed roof tanks over 60,000 gallons in Priority I areas of Ohio are currently required to be equipped with floating roofs. Although the Ohio EPA could not verify if all the affected tanks in the Priority I area were in control, the regulation has been in effect and has been enforced. Therefore, representatives of the Ohio EPA stated that, although there is a possibility that some tanks are not equipped properly in the Priority I area, most, if not all, of the tanks are currently controlled.

Exhibit 15-5
U.S. Environmental Protection Agency
DISTRIBUTION OF FIXED-ROOF
TANKS IN OHIO BY
CAPACITY AND COST

Tank	Capacity (000, gallons)	Installed Capital Cost ($, 000)
A	147	30.12
B	147	30.12
C	210	36.16
D	3,292	332.04
E	3,292	332.04
F	56	20.00

Source: Ohio EPA and Booz, Allen & Hamilton Inc.

15.4 COST OF CONTROLLING VOC EMISSIONS

This section presents a cost analysis of equipping fixed-roof tanks used for storing petroleum liquids with internal floating roofs as a means of controlling VOC emissions.

The costs for emission control equipment include:

- Installed capital cost, including parts and labor
- Annual capital charges, estimated to be 25 percent of installed capital cost and including costs for depreciation, interest, maintenance, taxes and insurance. Capital charges assuming a 30 year equipment life would be lower on an annual basis
- Annualized direct operating costs, estimated to be 2 percent of installed capital cost and including costs for inspection and recordkeeping[1]
- Annual petroleum liquid credit
- Net annualized operating costs, the sum of the capital charges and direct operating costs less the petroleum liquid credit.

Costs reported in EPA-450/2-77-036 were not used since more recent data by tank capacity were available in Benzene Emission Control Costs in Selected Segments of the Chemical Industry.

Capital costs were determined for each tank from the graph in Exhibit 15-6, on the following page. This graph was prepared by Booz, Allen based on interviews with petroleum refineries, petrochemical manufacturers, tank manufacturers and emission control equipment manufacturers. Total installed capital cost, including labor, is two times the value given on the graph since the graph represents equipment costs and installation costs are 100 percent of equipment costs based on interviews. All costs are for 1977.

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1 Estimated from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, assuming maintenance is 4 percent of the capital cost.

Exhibit 15-7
U.S. Environmental Protection Agency
VOC EMISSIONS CONTROL COSTS FOR
STORAGE OF PETROLEUM LIQUIDS IN
FIXED-ROOF TANKS IN OHIO

SUMMARY OF COSTS

Number of tanks	6
Total capacity (millions of gallons)	7.144
Estimated annual throughput (millions of gallons)	214
Uncontrolled emissions (tons per year)	1,217
Emissions reduction (tons per year)	1,095
Controlled emissions (tons per year)	122
Installed capital cost ($ millions, 1977)	.780
Annualized capital charges ($ million, 1977)	.195
Annualized direct operating costs ($ millions, 1977)	.015
Annual petroleum credit ($ millions, 1977)	.140
Net annualized cost ($ millions, 1977)	.07
Cost per ton of emissions reduced ($, 1977)	$63.92

a. Assume value of petroleum liquid saved is $.39 per gallon and density of petroleum liquid is 6.1 pounds per gallon.

Source: Booz, Allen & Hamilton Inc.

A summary of the cost aggregated statewide from the emission control of petroleum liquids stored in fixed-roof tanks is shown in Exhibit 15-7, on the following page. The total installed capital cost for equipping the six uncontrolled fixed-roof tanks in Ohio with internal floating roofs is $780,480. The net annualized cost is $70,000 at a cost of $63.92 per ton of emissions reduced.

Exhibit 15-8
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS
IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected storage tanks	Six
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 214 million gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
VOC emissions	1,217 tons per year
Preferred method of VOC control to meet RACT guidelines	Single seal and internal floating roof
Affected Areas in Meeting RACT	
Capital investment (statewide)	$780,000
Annualized cost (statewide)	$70,000
Price	No change in price anticipated
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 7,479 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	No problems anticipated
VOC emission after control	122 tons per year
Cost effectiveness of control	$64 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

15.5 ECONOMIC IMPACT

This section discusses the economic impact of equipping fixed-roof tanks used for storing petroleum liquids with internal floating roofs to control VOC emissions. The impacts analyzed include: total cost statewide; impact of industries that may be affected and their ability to raise the capital needed for the controls; and effects on employment, productivity and market structure.

- Total cost in Ohio—An estimated $780,000 will be required statewide in Ohio to equip affected fixed-roof tanks for storing petroleum liquids with internal floating roofs. This represents approximately 0.9 percent of the estimated value of petroleum liquids sold from these affected tanks in Ohio and an insignificant percent of the value of wholesale trade in Ohio.

- Industries affected—Fixed-roof tanks, greater than 40,000 gallons, used for storing petroleum liquids are usually owned by major oil companies, large petrochemical firms and bulk gasoline tank terminal companies. It is expected that these companies will be able to meet the capital requirements. The source of capital is likely to be the company's traditional source of funds.

- Employment—No change in employment is predicted from the implementation of RACT.

- Productivity—No change in worker productivity will result from the implementation of RACT.

- Market structure—No change in market structure will result from implementation in RACT.

*   *   *   *

Exhibit 15-8, on the following page, presents a summary of the findings of this report.

BIBLIOGRAPHY

Benzene Emission Control Costs in Selected Segments of the Chemical Industry, prepared for Manufacturing Chemists Association by Booz, Allen & Hamilton Inc., June 12, 1978.

Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-450/2-77-036, U.S. Environmental Protection Agency, December 1977.

Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, U.S. Environmental Protection Agency, April 1978.

Revision of Evaporative Hydrocarbon Emission, PB-267 659, Radian Corp., August 1976.

16.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT STAGE I FOR GASOLINE DISPENSING FACILITIES IN THE STATE OF OHIO

16.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT STAGE I FOR GASOLINE DISPENSING FACILITIES IN THE STATE OF OHIO

This chapter presents a detailed analysis of implementing RACT Stage I controls for gasoline dispensing facilities in the State of Ohio. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of gasoline service station vapor recovery, interviews and analysis.

16.1 SPECIFIC METHODOLOGY AND QUALITY

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Economic impact of emission control

for gasoline dispensing facilities in the State of Ohio.

The quality of the estimates based on a three point scale is described in detail in the latter part of this section.

16.1.1 Industry Statistics

Industry statistics on gasoline dispensing facilities were obtained from several sources. All data were converted to a base year, 1977, based on specific scaling factors. The number of service stations for 1977 was reported in the National Petroleum News Fact Book, 1978. The number of "non-service stations" was estimated to be an additional 137 percent of the number of service stations in the state based on a study entitled, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry.[1] The number of employees at service stations in 1977 was determined by multiplying the national average number of employees per service station (3.5) by the number of establishments in the state which were reported in 1977. The number of employees at non-service stations is estimated to be two employees per facility. The number of gallons of gasoline sold in 1977 in the state was estimated by using data from the 1975 Federal Highway Statistics and escalating the 1975 number by 2 percent (determined from Illinois Environmental Protection agency data) for 1977. Sales, in dollars, of motor gasoline for 1977 were estimated by multiplying the number of gallons of gasoline sold in 1977 by the average national service station price (excluding tax) in 1977 (50.7¢/gallon) which was reported in the National Petroleum News Fact Book, 1978.

16.1.2 VOC Emissions

Emissions from gasoline dispensing facilities (including emissions from underground tank breathing,

1 Prepared for the Department of Labor, OSHA, C 79911, March, 1978, pp. 4-7

underground tank filling, vehicle refueling and spillage) in Ohio were calculated by multiplying emission factors by gasoline throughput statewide. The emission factors were reported in Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017, April 1978. It was estimated, based on data from interviews, that 90 percent of the gasoline dispensing facilities in Ohio employ submerge filling of underground storage tanks and the remaining 10 percent employ splash fill.

16.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for gasoline dispensing facilities are described in Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations. This document provides data on alternative methods available for controlling VOC emissions from gasoline dispensing facilities. Several studies of VOC emission control were also analyzed in detail and interviews with petroleum trade associations, gasoline service station operators, and vapor control equipment manufacturers were conducted to ascertain the most likely types of equipment which would be used in gasoline dispensing facilities in Ohio. The specific studies analyzed were: Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/2-76-042; A Study of Vapor Control Methods for Gasoline Marketing Operations, PB-246-088, Radian Corporation; Reliability Study of Vapor Recovery Systems at Service Stations, EPA-450/3-76-001; Technical Support Document Stage I Vapor Recovery at Service Stations, draft, Illinois Environmental Protection Agency.

16.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Developing costs of two different control systems for a model gasoline dispensing facility including:
  - Installed capital cost
  - Direct operating costs
  - Annual capital charges
  - Gasoline credit
  - Net annualized cost
- Aggregating costs to the statewide gasoline dispensing facility industry.

Costs were determined from analyses of the studies listed previously and from interviews with petroleum marketers' associations, gasoline service station operators, and vapor control equipment manufacturers.

It was assumed from interviews with industry trade associations that 75 percent of the gasoline dispensing facilities would install coaxial or concentric vapor balance systems and the remaining 25 percent would install the two point vapor balance system. Costs for the two systems are assumed to be represented by the costs developed for the model gasoline dispensing facility. Statewide costs were projected from the model costs. It was assumed that gasoline dispensing facilities in the state will be required to meet the RACT guidelines.

16.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary impacts on market structure, employment and productivity resulting from implementation of RACT controls.

16.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on gasoline dispensing facilities. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 16-1, on the following page, rates each study output and the overall quality of the data.

Exhibit 16-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions		●	
Cost of emissions control		●	
Statewide costs of Emissions			●
Economic impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton, Inc.

16.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for gasoline dispensing facilities are presented in this section. The discussion includes a description of the number of facilities and their characteristics, a comparison of the size of the industry to state economic indicators, a historical characterization and description of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT, Stage I, to VOC emissions from gasoline dispensing facilities in Ohio.

16.2.1 Size of Industry

There were an estimated 9,531 gasoline service stations in Ohio in 1977, and an additional estimated 13,057 "non-service stations" which include gasoline dispensing facilities such as marinas, general aviation facilities, commercial and industrial gasoline consumers and rural operations with gas pumps. Industry sales were in the range of $2.59 billion, with a yearly throughput of 5.116 billion gallons of gasoline. The estimated number of employees in 1977 was 33,400 employees in service stations and 26,114 employees in "non-service stations" for a total of 59,500 employees. These data and the sources of information are summarized in Exhibit 16-2, on the following page. Total capital investments by the gasoline dispensing facilities were not identified, although in general facility operators make investments in plant and equipment to replace worn-out facilities and equipment, modernize the establishments or improve operating efficiencies.

16.2.2 Comparison of Industry to State Economy

The gasoline dispensing facility industry is compared to the economy of the State of Ohio in this section by comparing industry statistics to state economic indicators. Employees in the industry represent approximately 0.1 percent of the total state civilian labor force of Ohio. The value of gasoline sold from gasoline dispensing facilities represented 7 percent of the total value of retail trade in Ohio in 1977.

Exhibit 16-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR GASOLINE
DISPENSING FACILITIES IN OHIO

Number of Facilities		Number of Employees			
Service Stations	Non-Service Stations	Service Stations	Non-Service Stations	Sales ($Billion, 1977)	Gasoline Sold (Billions of Gallons)
9,531[a]	13,057[b]	33,400[c]	26,114[d]	2.59[e]	5.117[f]

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a. National Petroleum News Fact Book, 1978.

b. Includes gasoline dispensing facilities such as marinas, general aviation facilities, commercial and industrial gasoline consumers and rural

c. Estimate based on the ratio of the number of employees to the number of establishments nationally in 1977.

d. Estimate based on two employees per facility.

e. Number of gallons of motor gasoline sold in 1977 multiplied by the national service station price in 1977 (50.70¢/gallon), National Petroleum News Fact Book, 1978.

f. Estimated based on Federal highway statistics for 1975 and escalated by 2 percent for 1977.

Source: Booz, Allen & Hamilton Inc.

16.2.3 Characterization of the Industry

Gasoline service stations and retail outlets are the final distribution point in the petroleum marketing network, as shown in Exhibit 16-3, on the following page. Several types of gasoline service stations and retail gasoline outlets offer services ranging from self-service to full service. A general classification of service stations in the United States is listed in Exhibit 16-4, following Exhibit 16-3, along with the percentage of each type of station existing nationally in 1977. Facility ownership may be characterized by one of the following four arrangements:

- Supplier owned/supplier operated
- Supplier owned/dealer leased
- Dealer owned/dealer operated
- Convenience store.

An estimated 26 percent of facilities are owned and operated by the station's supplier of gasoline, 44 percent are owned by the supplier and leased to a dealer and 30 percent are owned and operated by an independent dealer.[1]

Gasoline marketing is characterized by high fixed costs, with operations varying by degree of labor intensity. Conventional service stations (service bay with mechanics on duty and nongasoline automotive items available) are the most labor intensive, while self-service "gas and go" stations exemplify low labor intensity.

The number of gasoline dispensing facilities nationally has been declining since 1972, while the throughput per facility has been rising. This trend is also evident in Ohio and is predicted to continue. It is estimated that, by 1980, one-half the gasoline dispensing facilities in the country will be totally self-service.[2]

16.2.4 Gasoline Prices

Gasoline prices vary among types of gasoline dispensing facilities within a geographical area. Convenience stores are apt to have higher pump prices than large self-service "gas

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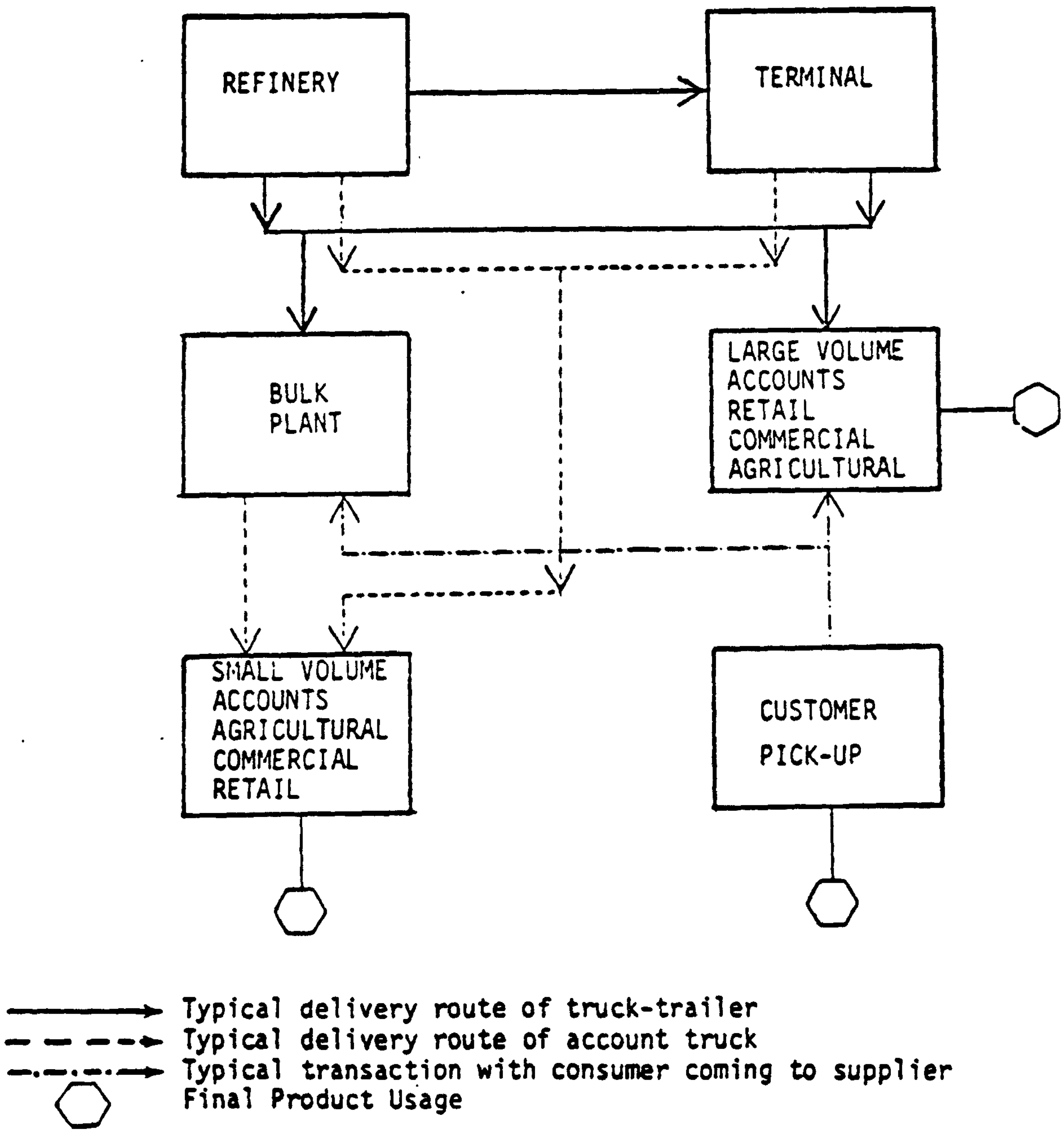
1 Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042, November 1976, p. 6.

2. Ibid., p. 2.

Exhibit 16-3

U.S. Environmental Protection Agency

GASOLINE DISTRIBUTION NETWORK



Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, p. 3-2.

Exhibit 16-4
U.S. Environmental Protection Agency
CLASSIFICATION OF GASOLINE DISPENSING FACILITIES

Type of Service Station	Percentage of Population
Full-service	41.8
Self-service	9.4
Split island	37.3
Convenience store	4.4
Car wash	4.5
Truck stop	1.9
Mini service	0.7
TOTAL	100.0

Source: National Petroleum News Fact Book, 1978, p. 106

and go" stations. The pump price less the dealer tank wagon price represents the gross margin on a gallon of gasoline. Gasoline dispensing facility operating costs then must come out of the gross margin for gasoline as well as the gross margin for other products which may be sold at the facility. Operating costs vary substantially among the various types of facilities. It is reported that some facilities operate with nearly zero net margin or profit, while others may enjoy up to four to five cents per gallon profit. Sufficient data are not available on gasoline dispensing facilities in Ohio to present a thorough analysis of existing price structures and degree of competition in the industry within the State.

16.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on gasoline dispensing facility operation, estimated VOC emissions from facility operations in the state, the extent of current control in use, the vapor control requirements of RACT and the likely alternatives which may be used for controlling VOC emissions from gasoline dispensing facilities in Ohio.

16.3.1 Gasoline Dispensing Facility Operations

Gasoline dispensing facilities are the final distribu-ion point in the gasoline marketing network. Gasoline is delivered from bulk gasoline plants via account truck or from the bulk gasoline tank terminal via trailer-transport truck, stored in underground storage tanks, and subsequently dispensed via pump to motor vehicles. Gasoline dispensing facilities are characterized by their services and business operations: full service stations, split island stations, self-service stations, and convenience store operations. In full service stations, attendants offer all services including gasoline pumping and mechanical check-ups. If fuel is used at any of the last three classes of stations, the customers may fill up the tanks themselves. In split island stations, both self-service and full service are offered. At the two remaining types of stations, only self-service is available.

Gasoline service stations and other gasoline dispensing facilities will be required to comply with Stage I vapor control by January 1, 1982.

16.3.1.1 Facilities

Equipment at gasoline dispensing facilities used in handling gasoline are: gasoline storage tanks, piping and gasoline pumps. The most prevalent type of gasoline storage tank is the underground tank. It is assumed that there are typically three storage tanks per facility based on information in Hydrocarbon Control Strategies for Gasoline Marketing Operations, p. 2-17. Gasoline is dispensed to motor vehicles through pumps and there may be anywhere from one to twenty pumps per facility. Stage I vapor control regulations apply to the delivery of gasoline to the facility and the subsequent storage in underground tanks.

16.3.1.2 Operations

Uncontrolled VOC emissions at gasoline dispensing facilities come from loading and unloading losses from tank trucks and underground tanks, refueling losses from vehicle tanks, breathing losses from the underground tank vent and from spillage. Stage I vapor control applies to tank truck unloading and working and breathing losses from underground storage tanks.

Tank trucks are unloaded into underground storage tanks either by splash loading or submerged loading. Splash loading results in more emissions than submerged loading.

More specifically, losses occur when:

- Organic liquids vaporize into the air that is drawn into the tank truck compartment during unloading of the tank truck.
- Vapors are displaced from the underground storage tank during tank loading.
- Changes in temperature and pressure in the underground storage tank result in vapors being vented to the atmosphere.

The control measures involve vapor balancing between tank truck and storage tank and submerged filling of the gasoline storage tank. Vapor recovery systems are also available for emission control when combined with a vapor balancing system.

Since most storage tanks at gasoline dispensing facilities are relatively small and underground, it is unlikely that they are equipped with sophisticated control equipment. The breathing losses, therefore, can be controlled by adjusting the pressure relief valve.

16.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from gasoline dispensing facilities in Ohio in 1977 and the current level of emission control already implemented in the State. Exhibit 16-5, on the following page, shows the total estimated emissions in tons per year from gasoline dispensing facilities in Ohio. Emissions, based on gasoline throughput,

Exhibit 16-5
U.S. Environmental Protection Agency
VOC EMISSIONS FROM GASOLINE DISPENSING
FACILITIES IN OHIO

Estimated Number of Facilities	Average Yearly Throughput (Millions of Gallons)	Total Emissions (Tons/Year)
22,588	5,117	45,506

Source: Booz, Allen & Hamilton Inc.

are estimated to be 45,506 tons per year. Emissions include emissions from underground tank breathing, underground tank filling, vehicle refueling and spillage.

It was assumed that 90 percent of the storage tank loading was by the submerge fill method based on industry interviews.

16.3.3 RACT Guidelines

The RACT guidelines for Stage I VOC emission control from gasoline dispensing facilities require the following controls:

- Submerged fill of gasoline storage tanks
- Vapor balancing between the truck and the gasoline storage tank
- Proper operation and maintenance of equipment.

Exhibit 16-6, on the following page, summarizes the RACT guidelines for VOC emissions control from gasoline dispensing facilities.

16.3.4 Selection of the Most Likely RACT Alternatives

Stage I control of VOC emissions from gasoline dispensing facilities is achieved using submerged filling of storage tanks and vapor balancing between the unloading of incoming tank trucks and the gasoline storage tanks. There are alternative means of achieving vapor balance based primarily on the method of connecting the vapor return line to the gasoline storage tank. The two primary methods for connecting vapor return lines, two point connection and coaxial or concentric connection (often referred to as tube-in-tube connection), are described in Sections 16.3.4.2 and 16.3.4.3.

16.3.4.1 Vapor Balance System

The purpose of the vapor balance system is to return displaced vapors from the underground gasoline storage tank to the tank truck during storage tank loading. There

Exhibit 16-6
U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR
TYPICAL GASOLINE DISPENSING
FACILITY

Facilities Affected	Sources of Emissions	RACT Control Guidelines
Gasoline service stations and gasoline dispensing facilities	Storage tank filling and unloading tank truck	Stage I vapor control system, i.e., vapor balance system which returns vapors displaced from the storage tank to the truck during storage tank filling; and submerge filling

Source: Design Criteria for Stage I Vapor Control Systems - Gasoline Service Stations, U.S. EPA, November 1975.

are two basic versions of vapor balancing for Stage I.

The "two point" method depected in Exhibit 16-7. on the following page, shows a storage tank with two risers. One riser is for fuel delivery and the other is for returning vapors to the tank truck. The other method, "concentric or coaxial system," shown in Exhibit 16-8, following Exhibit 16-7, employs a concentric liquid vapor return line, thus requiring only one tank riser.

The vapor balance systems use flexible hoses carrying liquid gasoline from the tank truck down a drop tube to the underground storage tank. Entering liquid forces the air-hydrocarbon mixture in the storage tank out through a flexible vapor return hose to the tank truck. At the truck, the vapor return hose is connected to a piping manifold which is interconnected with the truck compartments by vents. The vents are opened selectively during truck unloading, allowing returning vapors from the underground tank to enter respective product compartments on the truck.

16.3.4.2 Two Point Vapor Balance System

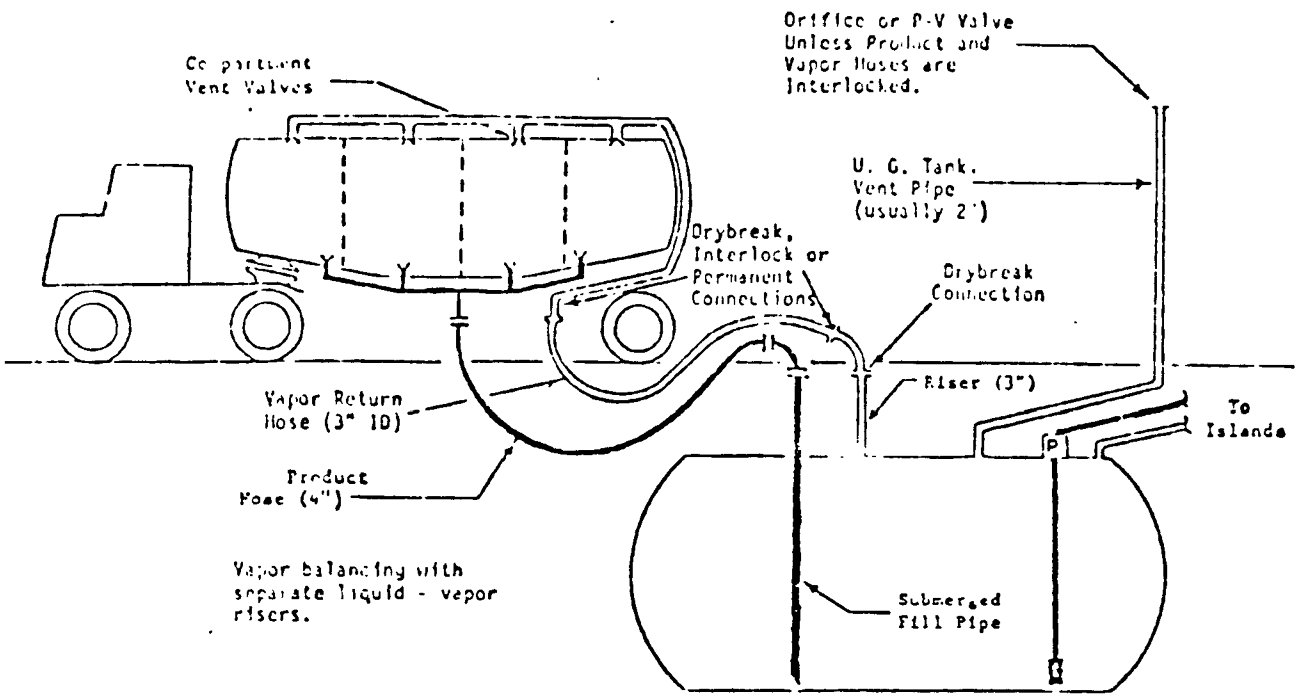
The most effective method of transferring displaced vapors from the underground tank to the truck is by using a separate connection to the underground storage tank for the vapor return hose as shown in Exhibit 16-8. Equipment costs for this type of system are less expensive than for the coaxial or concentric system, although installation costs are considerably higher. U.S. EPA has tested this type of system to show that it complies to RACT requirements. It is estimated that 25 percent of the gasoline dispensing facilities would install the two point system, bearing a higher cost but achieving greater efficiency.

16.3.4.3 Concentric or Coaxial Vapor Balance Systems

At some gasoline dispensing facilities, a separate riser is not available on storage tanks or the gasoline dispensing facility operator does not wish to incur the additional installation expense to excavate to an unused entry to install a separate riser. For these cases, coaxial devices have been developed to remove vapors from the same opening through which the fuel is delivered.

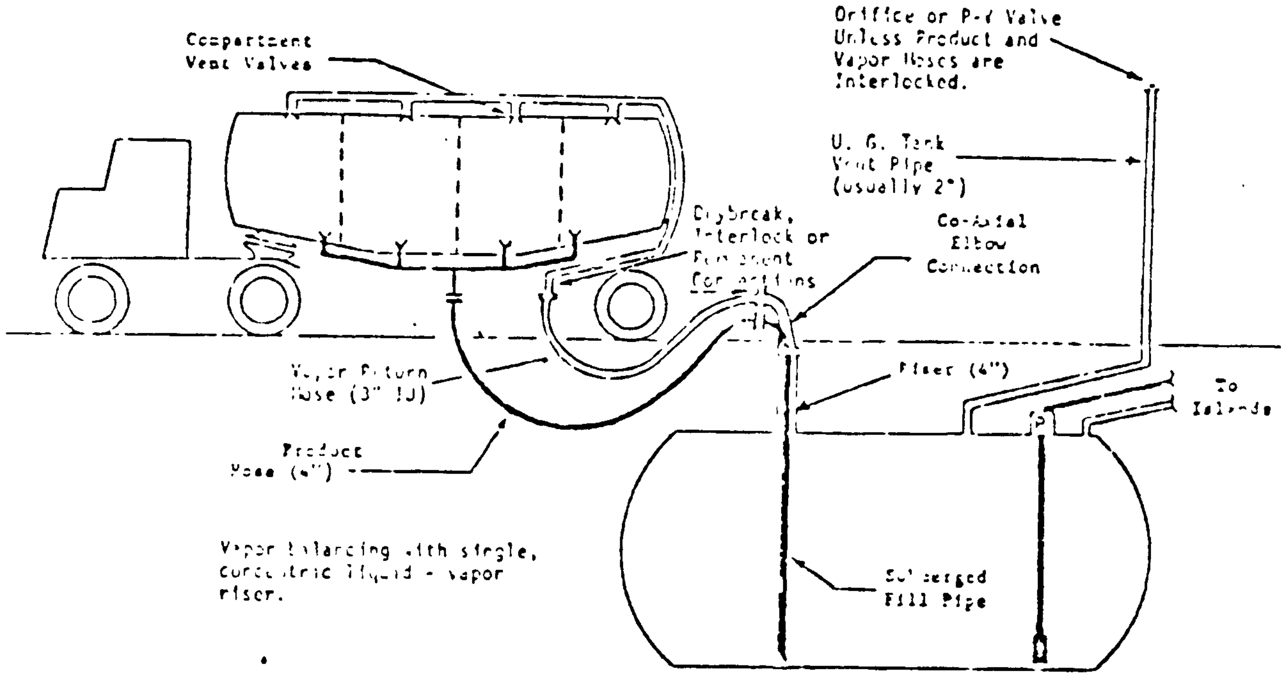
As shown in Exhibit 16-8, a drop tube of smaller diameter is inserted in the existing fuel riser. The vapors exit

Exhibit 16-7
U.S. Environmental Protection Agency
STAGE I VAPOR CONTROL SYSTEM -
VAPOR BALANCING WITH SEPARATE LIQUID-VAPOR RISE



Source: <u>Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations</u>, U.S. EPA, November 1975.

Exhibit 16-8
U.S. Environmental Protection Agency
STAGE I VAPOR CONTROL SYSTEM -
VAPOR BALANCING WITH CONCENTRIC LIQUID-VAPOR RISERS



Source: Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations, U.S. EPA, November 1975.

through the annular space. A coaxial adaptor fits on the riser and provides connections for the fuel delivery hose to the vapor return hose. In the other system, the fuel and vapor passages are separated in a "Y" fitting which is permanently attached to the underground tank. The fittings for the hose connections are located in a conventional manhole. Most of these coaxial devices provide less cross-sectional area in the vapor return passage than do separate connectors and tend to reduce vapor recovery efficiency and gasoline storage tank fill rates to some extent. It is estimated that 75 percent of the gasoline dispensing facilities would install this type of system due to the lower installed cost of the system.

16.3.4.4 Manifolded Vent Lines

Several schemes have been used to manifold vents from two or more tanks to a common vapor hose connection. Manifolding may be above or below grade. A number of configurations have been developed for use with suitable vent restrictions. A three-way connector provides the most effective arrangement since connection of the vapor hose to the common connector blocks flow to the atmosphere and routes all displaced vapor to the tank truck. In any manifold piping system, care must be exercised to prevent contamination of "no-lead" gasoline products.

16.3.4.5 Drop Tubes for Submerged Filling

Submerged fill is required by Stage I vapor control. The submerged fill requirement means use of a drop tube extending to within six inches of the storage tank bottom. Under normal industry practices, a tube meeting this specification will always be submerged since the storage tanks are not pumped dry.

16.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR RACT STAGE I REQUIREMENTS

Costs for VOC emission control equipment are presented in this section. The costs for a typical gasoline dispensing facility are described, followed by a projection to the statewide industry.

16.4.1 Costs for Vapor Control Systems

The costs for vapor control systems were derived from analysis of the petroleum marketing trade associations data and from previous cost and economic studies of gasoline dispensing facilities, and are summarized for a typical gasoline dispensing facility in Exhibit 16-9, on the following page. Costs are based on the type and amount of equipment at a gasoline dispensing facility. The cost of Stage I vapor control for a typical facility of 45,000 gallons per month throughput has been estimated as follows. Capital costs of installing the two point vapor-balance equipment at existing facilities are about $2,000 per station. This cost includes equipment costs ($300-$500) and installation ($1,300-$1,600).[1] The installed capital cost for a coaxial or concentric system is reported by U.S.EPA to be $150 to $200 per tank, including parts and labor. Annualized capital costs are estimated at 25 percent of installed capital cost and include interest, depreciation, taxes and maintenance. This cost analysis does not consider the cost of tank truck modification. The cost of modification of trucks to receive the displaced vapors is about $2,000-$3,000 per truck. It is assumed that the service station operator does not own the tank truck and, therefore, will not bear this cost.

Stage I vapor control at gasoline dispensing facilities will not increase direct annual operating costs. Gasoline credit is not included in Exhibit 16-9, but it will be included in the statewide costs in the next section. The net annualized cost for a typical gasoline service station with 45,000 gallons per month throughput is estimated to be $500 for the two point system and $150 for the concentric or coaxial system.

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1 Air Pollution Control Technology Applicable to 26 Sources of Organic Compounds, U.S. Environmental Protection Agency, May 27, 1977. (This cost includes excavation and construction of manifolded stroage tanks.)

Exhibit 16-9
U.S. Environmental Protection Agency
STAGE I VAPOR CONTROL COSTS FOR A TYPICAL GASOLINE DISPENSING FACILITY

Description of Model Gasoline Dispensing Facility

Monthly throughput (gallons)	45,000
Number of storage tanks	3

Costs
($, 1977)

	Two Point System	Coaxial or Concentric System
Installed capital cost	2,000	600
Annualized capital charges[a]	500	150
Direct operating cost	0	0
Net annualized cost	500	150

a. Twenty-five percent of installed capital cost. Includes depreciation, interest, taxes, insurance and maintenance.

Source: Booz, Allen & Hamilton Inc.

16.4.2 Extrapolation to the Statewide Industry

Exhibit 16-10, on the following page, shows the extrapolation of vapor control costs to the statewide industry based on the costs for a typical gasoline dispensing facility. It should be noted that actual costs to gasoline dispensing facility operators may vary depending on the type of control method and manufacturer's equipment selected by each facility operator.

The total cost to the industry for installing vapor control equipment is estimated to exceed $21.4 million. The amount of gasoline prevented from vaporizing using submerged filling of the gasoline storage tank is valued at $176,000 per year. The annualized cost per ton of emissions controlled is estimated to be $195 per ton. The distribution of the statewide costs and emissions reduction by the size of gasoline dispensing facilities based on throughput is shown in Exhibit 16-11, following Exhibit 16-10. Based on these data, gasoline dispensing facilities with throughput less than 24,000 gallons per month account for 45 percent of the estimated statewide cost of control but only 23 percent of the estimated emissions reduction from gasoline dispensing facilities.

Exhibit 16-10
U.S. Environmental Protection Agency
STATEWIDE COSTS IN OHIO FOR STAGE I
VAPOR CONTROL OF
GASOLINE DISPENSING FACILITIES

SUMMARY OF COSTS

Number of facilities	22,588
Total annual throughput (millions of gallons)	5,117
Uncontrolled emissions (tons/year)	45,506
Emissions reduction (tons/year)	26,523
Emissions after RACT control (tons/year)	18,983
Installed capital ($ millions)	21.46
Annualized capital cost ($ millions)	5.365
Annual gasoline credit ($ millions)	0.176
Net annualized cost ($ millions)	5.189
Net annualized cost per ton of emissions reduced ($ per ton/year)	195

a. Emission reduction based on reducing emissions from tank filling by employing submerged filling and vapor balancing.

b. Gasoline credit of $1.076 million calculated based on converting frc splash fill to submerged fill and gasoline valued at $0.507 per gall

Source: Booz, Allen & Hamilton Inc.

Exhibit 16-11
U.S. Environmental Protection Agency
STATEWIDE COSTS OF VAPOR CONTROL
SYSTEMS BY SIZE OF GASOLINE
DISPENSING FACILITY IN OHIO

Gasoline Dispensing Facility Throughput (000 gallons per month)	Percentage[a] of Facilities	Percentage[a] of Volume	Current Estimated Annual VOC Emissions (tons per year)	Estimated Annual VOC Emission After RACT Control (tons per year)	Net VOC Emission Reduction (tons per year)	Percentage of Total VOC Emissions Reduced	Estimated Annual Cost ($, millions, 1977)	Percentage of Total Annual Cost	**Net Hydrocarbon Control Cost Effectiveness** ([illegible] 1977 tons per year)
< 10	4.5	1	455.06	189.83	265.23	1	0.233	4.5	878
11-24	40.7	22	10,011.32	918.77	5,835.06	22	2.112	40.7	362
25-49	31.2	30	13,651.8	5,694.9	7,95[illegible]	30	1.619	31.2	203
50-99	18.7	33	15,016.98	6,264.39	8,752.59	33	0.070	18.7	111
> 100	4.9	14	6,370.84	2,657.62	3,713.[illegible]	14	0.254	4.9	68

a. The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, p. 32.

Source: Booz, Allen & Hamilton Inc.

16.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing Stage I RACT controls to the statewide industry including availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price, state economic variables and capital investment.

16.5.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This means that gasoline dispensing facility operators must have vapor control equipment installed and operating within the next three years. The timing requirements of RACT impose several requirements on facility operators including:

- Determining the appropriate method of vapor balancing
- Raising capital to purchase equipment
- Generating sufficent income from current operations to pay the additional annual operating costs incurred with vapor control
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and economic impacts of meeting the above requirements within the required timeframe.

16.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Gasoline service stations in several air quality control regions of the United States have successfully implemented Stage I vapor control systems.

State adoption of Stage I RACT regulations will generate additional demand for the vapor control systems for gasoline dispensing facilities. However, it is estimated that off-the-shelf systems will be readily available within the next three years, thus making the implementation of Stage I RACT technically feasible.

A number of economic factors are involved in determining whether a specific facility operator will be able to implement vapor control systems and still remain profitable. These include:

- Ability to obtain financing
- Ownership—major oil company or private individual
- Ability to pass on a price increase
- The current profitability of the gasoline dispensing facility
- Age of the facility.

A major finding in a study on gasoline dispensing facility vapor control was that small facilities could have problems raising the necessary capital to purchase and install vapor control equipment. The inability to raise the necessary capital to install vapor control equipment is predicted to cause the closing of some facilities.

Gasoline dispensing facilities that are owned by major oil companies may have better access to capital than privately owned facilities. A private gasoline dispensing facility owner may have to borrow capital from local banks, friends or relatives, whereas a facility owned by a major oil company may receive funding out of the oil company's capital budget.

It is estimated that small gasoline dispensing facilities with throughput less than 10,000 gallons per month (which represent approximately 4.5 percent of the facilities in the State) will experience a cost increase of nearly $.0045 per gallon to implement RACT, whereas larger facilities will experience a smaller cost increase. This will put the smaller stations at a competitive disadvantage in terms of passing on the costs to the customers by raising prices.

Recent experience indicates that temporary disruption resulting from Stage I RACT control installation can have serious impacts on the service station profitability. In an interview, the Greater Washington/Maryland Service Station Association reported that several stations experienced loss of business for up to three weeks while Stage I vapor control was being installed. Service station driveways were torn up, greatly restricting access to pumps.

In some instances, oil company owned service stations were sold or closed down because the oil companies did not want to expend funds for vapor control at these marginally profitable operations.

The older gasoline dispensing facilities reportedly may experience greater cost and temporary loss of business than new facilities when implementing Stage I vapor control because of the more extensive retrofit requirements.

The number of gasoline dispensing facilities has been declining nationally over the past few years for a number of reasons, including a trend towards reducing overhead costs by building high throughput facilities. This trend is likely to continue whether or not vapor control is required. Implementation of Stage I RACT control may simply accelerate as marginal operations may opt not to invest in the required capital costs. Sufficient data for this state are not available to quantify the magnitude of this impact.

The paragraphs which follow compare statewide costs of RACT control, in 1977 dollars, to various economic indicators.

16.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annual operating cost of implementing RACT with the total value of gasoline sold in the state, the value of retail trade in the state and the unit price of gasoline.

The net increase in the net annualized cost to the gasoline dispensing industry from RACT represents 0.2 percent of the value of the total gasoline sold in the state. Compared to the statewide value of retail trade, this annual cost increase is insignificant. The impact of the unit price of gasoline on individual facilities varies with the facility throughput. As discussed in the preceding section, the small facilities, less than 10,000 gallons per month throughput, may experience an annualized cost of up to $.0045 per gallon of gasoline sold, whereas the large facilities may experience a smaller annualized cost increase.

16.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and gasoline dispensing facility operations.

Employment is expected to decline, if a number of small, marginally profitable gasoline facilities cease operation in lieu of investing capital for compliance with RACT. Based on the statewide estimates of number of employees and number of service stations, approximately three jobs will be lost with the closing of a gasoline dispensing facility. No estimate was made of the total number of facilities that may close due to RACT.

The market structure is not expected to change significantly because of Stage I vapor control requirements. The industry trend is such that there would be 50 percent self-service stations by 1980s. The total number of stations is predicted to decline, while throughput per station is predicted to increase.

The impact on a specific facility operation is expected to be slight. Fill rates for loading gasoline storage tanks may slightly decline if coaxial or concentric vapor hose connections are used.

*   *   *   *

Exhibit 16-12, on the following page, presents a summary of the findings on this report.

Exhibit 16-12
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR GASOLINE DISPENSING FACILITIES IN THE STATE OF OHIO

Current Situation	Discussion
Number of potentially affected facilities	22,600
Indication of relative importance of industrial sector to state economy	Industry sales are $2.6 billion with a yearly throughput of 5.116 billion gallons
Current industry technology trends	Number of stations has been declining and throughput per station has been increasing. By 1980, one-half of facilities in U.S. will be totally self-service
1977 VOC actual emissions	45,506 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACT guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$21.46 million
Annualized cost (statewide)	$5.189 million (approximately 0.2 percent of the value of gasoline sold)
Price	Assuming a "direct cost pass-through"—less than $0.002 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 181,000 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	Compliance requirements may accelerate the industry trend towards high throughput stations (i.e., marginal operations may opt to stop operations)
Problem area	Older facilities face higher retrofit costs—potential concerns are dislocations during installation
VOC emissions after control	18,983 tons per year from tank loading operation tank breathing, vehicle refueling and spillage
Cost effectiveness of control	$195 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017, April 1978.

"Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda," EPA-450/3-76-042, November 1976.

National Petroleum News Fact Book, 1978, McGraw Hill, Mid-June 1978.

"Cost Data-Vapor Recovery Systems at Service Stations," PB-248 353, September 1975.

"Human Exposure to Atmospheric Benzine," EPA Contract No. 68-01-4314, October 1977.

"Reliability Study of Vapor Recovery Systems at Service Stations," EPA-450/3-76-001, March 1976.

"Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources," EPA-905/2-78-001, April 1978.

"Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources," PB-236 921, Environmental Protection Agency, September 1974.

Private conversation with Mr. Vic Rasheed, Greater Washington/Maryland Service Station Association.

"The Lundburg Letter," Pele-Drop, North Hollywood, California.

"Revision of Evaporative Hydrocarbon Emission Factors," Radian Corporation, PB-267 659, August 1976.

"A Study of Vapor Control Methods for Gasoline Marketing Operations," Radian Corporation, PB-246 088, April 1975.

"Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations," U.S. EPA, November 1975.

17.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF OHIO

17.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF OHIO

This chapter presents a detailed analysis of the impact of implementing RACT for use of cutback asphalt in the State of Ohio. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of the use of cutback asphalt, interviews and analysis.

17.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Controlling of VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for the use of cutback asphalt in Ohio.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

17.1.1 Industry Statistics

Industry statistics on the use of cutback asphalt were obtained from the U.S. Bureau of Mines. Sales in tons were available for 1976. Sales in 1977 were assumed to be equal to 1976. The value of shipmentswas calculated by applying an average unit price of 36 cents per gallon.

17.1.2 VOC Emissions

VOC emissions from the use of cutback asphalt in Ohio were calculated by multiplying the emission factors for cutback asphalt by the number of tons of asphalt used. The emission factor for slow cure asphalt is 0.078 tons per ton, for medium cure asphalt 0.209 tons per ton, and for rapid cure asphalt 0.20 tons per ton.[1]

17.1.3 Process for Controlling VOC Emissions

The process for controlling VOC emissions from the use of cutback asphalt is decribed in "Control of Volatile Organic Compounds from Use of Cutback Asphalt," EPA-450/2-77-037, and "Air Quality and Energy Conservation Benefits from Using Emulsions to Replace Cutbacks in Certain Paving Operations," EPA-450/12-78-004. Interviews were conducted with asphalt trade associations, asphalt producers, and government agencies to gather the most up-to-date information on costs for cutback asphalt and asphalt emulsions, the feasibility of using emulsions in place of cutback

1 "Control of Volatile Organic Compounds from Use of Cutback Asphalt," EPA-450/2-77-037, p. 1-3.

asphalt and the associated cost implications. Other sources of information were "Mineral Industry Surveys," U.S. Bureau of Mines; "Magic Carpet, the Story of Asphalt," The Asphalt Institute; "Technical Support for RACT Cutback Asphalt," State of Illinois; and "World Use of Asphalt Emulsion," paper by Cyril C. Landis, Armak Company.

17.1.4 Cost of Vapor Control

The costs for control of VOC emissions from the use of cutback asphalt are incurred by using emulsions in place of cutback asphalt. These costs include:

- Differential cost per gallon of emulsion versus cutback asphalt
- Changes in equipment for applying emulsions in place of cutback asphalt
- Training of personnel to work with asphalt emulsions in place of cutback asphalt.

Additionally, if every state incorporates the RACT guidelines, additional plant capacity to produce asphalt emulsions would have to be created.

Costs were determined from analyses of the studies listed above and from interviews with asphalt trade associations, government agencies and producers and users of cutback asphalt and emulsions. Differential costs were for replacing cutback asphalt with asphalt emulsions, and these costs were extrapolated to the state.

17.1.5 Economic Impacts

The economic impacts were determined by assessing the feasibility of instituting RACT controls; analyzing the lead time requirements for implementing RACT; and determining any changes in employment, productivity and market structure.

17.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT for the use of cutback asphalt. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 17-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 17-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions		●	
Cost of emissions control		●	
Statewide costs of emissions			●
Economic impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton, Inc.

17.2 INDUSTRY STATISTICS

This section presents information on the cutback asphalt industry, statewide statistics of cutback asphalt use, and comparison of cutback asphalt consumption to the statewide value of wholesale trade. A history of the use of cutback asphalt and its future pattern of use are also discussed. Data in this section form the basis for assessing the technical and economic impacts of implementing RACT in Ohio.

17.2.1 Industry Description

The cutback asphalt industry encompasses the production and use of cutback asphalt. Cutback asphalt is one product resulting from the refining and processing of asphalt from crude oil. Exhibit 17-2, on the following page, depicts how asphalt is produced at the refinery and then further processed. Cutback asphalt is produced from refined asphalt and petroleum liquids at an asphalt mixing plant. It is then stored in tanks or loaded into tank trucks and sold to end users, primarily state highway organizations and construction contractors.

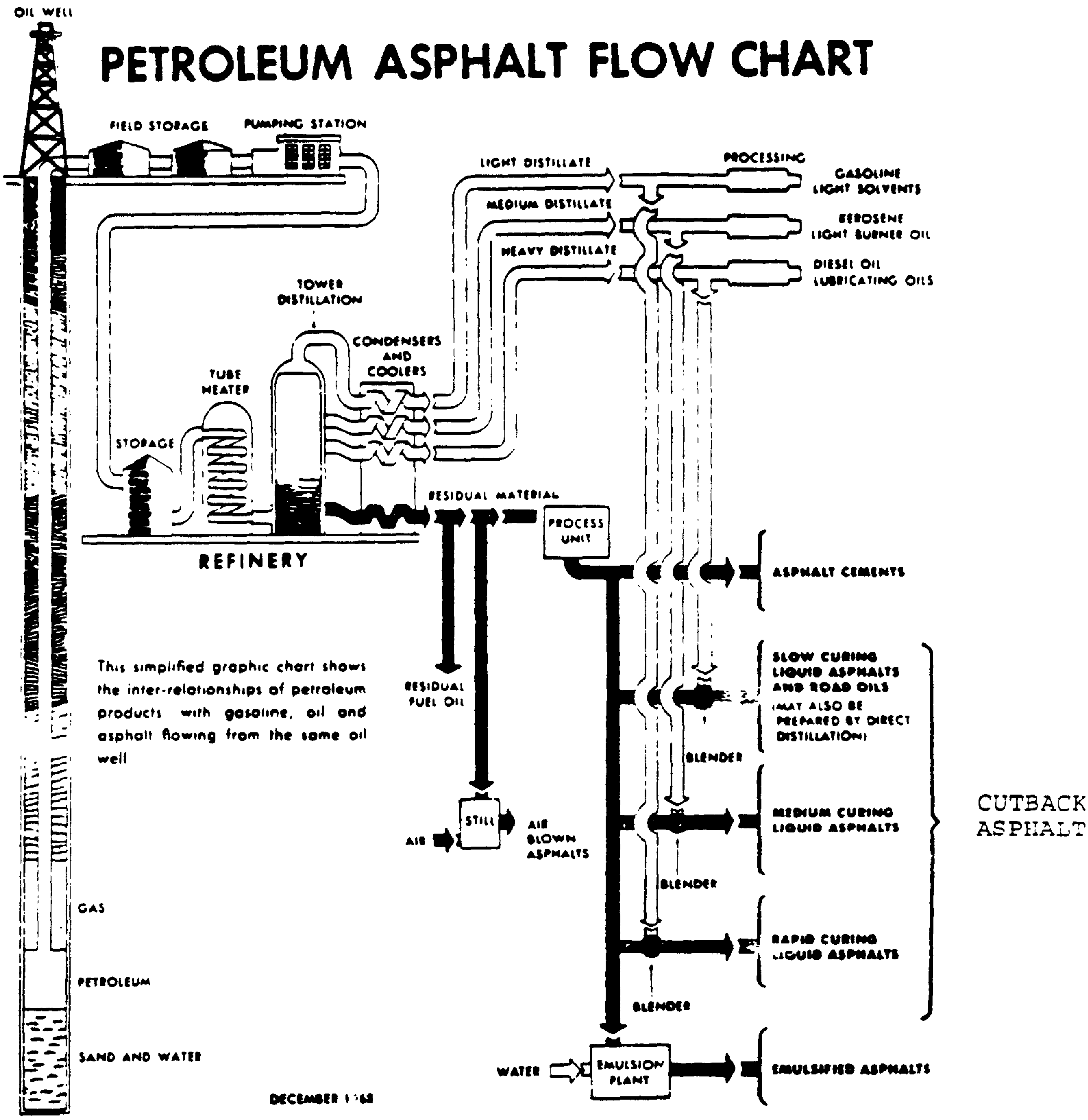
Since RACT control requires the use of asphalt emulsions to replace cutback asphalt, it is necessary to understand how each of the asphalt types is produced. A discussion of asphalt production and use appears in a later section of this report.

17.2.2 Size of the Cutback Asphalt User Industry

This report addresses the size of the cutback asphalt user industry in Ohio. Although some cutback asphalt may be produced in Ohio, the production industry is not the focus of this study since RACT requires control of the use of cutback asphalt. An estimated 265,000 tons of cutback asphalt were purchased in Ohio in 1977 at a value of $24.3 million. The value is based on an estimated average price per gallon of $0.36.

Cutback asphalt is primarily used in paving in Ohio. The number of employees involved in cutback asphalt paving operations in Ohio is unknown although it was estimated from interviews that there are approximately six employees per county currently employed in the use of cutback asphalt.

Exhibit 17-2
U.S. Environmental Protection Ager
PETROLEUM ASPHALT FLOW CHART



Source: The Asphalt Institute

17.2.3 Comparison to Statewide Economy

The value of shipments of cutback asphalt to the statewide value of wholesale trade in Ohio is small.

17.2.4 Demand for Cutback Asphalt

In the 1920s and 1930s, cutback asphalt emerged as a low-cost adequate binder for paving materials that provided weather resistance and a dust-free surface to respond to the rapidly growing demand for increased highway mileage brought on by the increasing numbers of automobiles. After the Second World War, the sale of cutback asphalts remained at an almost constant level while the sales and use of asphalt cement more than quadrupled from 1954 to 1974. Since 1973, the use of cutback asphalt has decreased. Exhibit 17-3, on the following page, shows the historical sales nationally from 1970 to 1976 of asphalt cement, cutback asphalt and asphalt emulsions.

17.2.5 Prices

Historically, asphalt emulsions were up to 10 percent less expensive per gallon than cutback asphalt; currently, the price difference is not appreciable.

Exhibit 17-3
U.S. Environmental Protection Agency
HISTORICAL NATIONAL SALES OF ASPHALT CEMENT, CUTBACK ASPHALT AND ASPHALT EMULSIONS

YEAR	ASPHALT CEMENT Use of (000 of tons)	ASPHALT CEMENT Percent of Total	CUTBACK ASPHALT Use of (000 of tons)	CUTBACK ASPHALT Percent of Total	ASPHALT EMULSIONS Use of (000 of tons	ASPHALT EMULSIONS Percent of Total	TOTAL Use of
1970	17,158	72.7	4,096	17.4	2,341	9.9	23,594
1971	17,612	73.8	3,994	16.7	2,275	9.5	23,821
1972	18,046	74.2	3,860	15.9	2,399	9.9	24,305
1973	20,235	74.8	4,220	15.6	2,585	9.6	27,040
1974	19,075	77.4	3,359	13.6	2,208	9.0	24,642
1975	16,324	75.7	3,072	14.2	2,197	10.1	21,593
1976	16,183	75.3	3,038	14.2	2,254	10.5	21,474

Source: U.S. Bureau of Mines

17.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on the use and production of asphalt. The sources and VOC emission characteristics of cutback asphalt are then described followed by: estimated statewide VOC emissions from the use of cutback asphalt; the VOC control measures required by RACT; and the VOC emission control procedure for use of cutback asphalt in Ohio.

17.3.1 Asphalt and Its Uses

Asphalt is a by-product of petroleum distillation (natural or man-made) which has been put to use in many different ways. In ancient times, asphalt was used in its natural form to caulk boats and ships, for mortar in masonry construction and as cement for mending stone tools. In the present day, asphalt is used primarily for paving and in a wide range of construction applications including: roofing, weatherproofing, floor tile, insulating materials, molded electrical equipment, papers, shingles and coatings.

Asphalt is highly suitable for paving because it is durable and weather resistent. The types of paving applications in which asphalt is used range from a thin layer sprayed on a dirt road to keep down dust, to a heavy duty pavement of thick layers of asphalt mixed with aggregate designed to carry heavy traffic. Asphalt pavement may vary greatly in thicknesses and strengths, depending on the traffic it will be required to carry.

Three major types of asphalt pavements are currently in use in the United States:

- Asphalt cement
- Cutback asphalt
- Asphalt emulsions.

Asphalt cement pavements are often referred to as "hot mix." This type of pavement is not under consideration for RACT. Cutback and asphalt emulsions fall into the class of "liquid asphalt" and are discussed in detail since RACT guidelines specify replacing the use of highly volatile cutback asphalt with asphalt emulsions.

Cutback asphalts are produced by liquifying asphalt cement by blending it with a petroleum solvent. Three basic types of cutback asphalt are:

- Slow cure asphalt, sometimes referred to as road oil, is composed of asphalt cement and oils of low volatility.

- Medium curing cutback asphalt is a liquid asphalt composed of asphalt cement and a kerosene-type diluent of medium volatility.

- Rapid curing cutback asphalt is liquid asphalt composed of asphalt cement and a naphtha of gasoline-type diluent of high volatility.

Asphalt emulsions are emulsions of asphalt cement and water which contain a small amount of emulsifying agent. Asphalt and water are normally immiscible products, but the emulsifying agent causes the two products to mix.

Cutback and emulsified asphalt are used in nearly all paving applications. In most applications, cutback asphalt and asphalt emulsions are sprayed directly on the road surface; the principal other mode is in cold mix applications normally used for wintertime patching. As cutback asphalt cures, VOC evaporates to the atmosphere. Asphalt emulsions, however, consist of asphalt suspended in water, which evaporates during curing.

17.3.2 Production of Asphalt

Asphalt is a product of the distillation of crude oil. It is found naturally and can also be produced from petroleum refining. Almost all asphalt used in the United States is refined from petroleum. Such asphalt is produced in a variety of types and grades ranging from hard brittle solids to almost water-thin liquids. The types of products produced from refining crude oil are shown in Exhibit 17-2. About 70 percent of the asphalt produced in the United States is used for paving.

Asphalt is distilled from crude oil at refineries. The "crude" is distilled at atmospheric pressure to remove the lower boiling materials, such as gasoline, kerosene, diesel oil and gas oil. Nondistillable asphalt is then recovered from selected topped crude by vacuum distillation; oil and wax are removed as distillates; and the asphalt is left as residue. At this stage of production, asphalt cement has been produced. Some of this product is then blended with various petroleum solvents to produce cutback asphalt. Asphalt cement is further processed at an emulsion plant to produce asphalt emulsion. Asphalt cement used directly for paving must be heated and mixed with aggregate at a "hot mix" plant.

17.3.2.1 Cutback Asphalt Manufacture

Cutback asphalt is manufactured by blending asphalt cement and solvents at an asphalt mixing plant. Processes for manufacturing cutback asphalt can be batch or continuous. In batch processing, a suitable solvent is pumped into a vessel, then hot (fluid) asphalt is added and both components are mixed by mechanical agitation. When the appropriate formula has been obtained the mixture is poured into tanks and sealed. Increased demand for cutback asphalt brought about the advent of continuous processing for manufacture. In a continuous process the asphalt and solvent are pumped through positive displacement meters to a mixing or blending station and then through a heat exchanger to storage tank, ship, tank car or tank truck.

17.3.2.2 Asphalt Emulsion Manufacture

Continuous manufacture is the most common process for manufacturing asphalt emulsions. In this process, the asphalt and water are mixed or emulsified in a colloidal mill. In most types of colloidal mills, the hot asphalt is drawn out into thin films between a stator and a high speed rotor. The metal surfaces may be smooth or rough and the space between them is adjustable. In the presence of the aqueous emulsifying solution the film breaks into the small drops found in the finished emulsion. Asphalt emulsions must be perfectly homogeneous and able to withstand storage and shipping. Most emulsions must not be subjected to temperatures below 0°C because freezing of the aqueous solution will coagulate the asphalt particles.

17.3.3 Sources and VOC Emission Characteristics of Cutback Asphalt

Hydrocarbons evaporate from cutback asphalts at the job site and at the mixing plant. At the job site, hydrocarbons are emitted from equipment used for applying the asphaltic product and from road surfaces. At the mixing plant, hydrocarbons are released during mixing and stockpiling. The largest source of emissions, however, is the road surface itself. In Ohio, cutback asphalt is used in construction and maintenance of secondary roads throughout the state.

It is the petroleum distillate (diluent) in the cutback asphalt that evaporates. The percentage of diluent that evaporates depends on the cure type.

The diluent in the three types of cutback asphalt that evaporates represents the following average weight percent of the asphalt mix:

- Slow cure—25 percent
- Medium cure—70 percent
- Rapid cure—80 percent.

Total emissions from the use of cutback asphalt are discussed below.

17.3.4 RACT Guidelines

The RACT guidelines specify that the manufacture, storage and use of cutback asphalt may not be permitted unless it can be shown that lifelong stockpile storage is necessary, or the use of application at ambient temperatures less than 50°F is necessary, or the cutback asphalt is to be used solely as a penetrating prime coat. The RACT guidelines advise the use of asphalt emulsion in place of cutback asphalt. Emissions from asphalt emulsion are negligible, and it has been demonstrated in several parts of the country that asphalt emulsion is an adequate substitute for cutback asphalt.

To use asphalt emulsion in place of cutback asphalt, it will be necessary to:

- Retrain employees on the use of asphalt emulsions
- Make minor modifications to equipment used in applying cutback asphalt to accommodate asphalt emulsions, including:
  - The possible need for new nozzles on the truck which applies the asphalt, called a distributor truck
  - Adjustments to the pumps to apply the emulsion
  - Cleaning equipment prior to using emulsion
- Create emulsion plant capacity to meet the increased demand

- Provide asphalt manufacturing facilities with venting for steam.

It is reported that asphalt emulsions cannot be applied in the rain. This is currently true of rapid cure and medium cure cutback asphalt. The same equipment that is used to apply cutback asphalt can be used with asphalt emulsions, with the exception of minor equipment modifications listed previously.

17.3.5 VOC Emission Control Procedure for Ohio

The State of Ohio is preparing draft legislation on the use of cutback asphalt which will be similar to the RACT guideline.

17.3.6 Statewide Emissions

Total emissions from the use of cutback asphalt in Ohio for 1977 are estimated at 53,100 tons. Exhibit 17-4, on the following page, shows a breakdown of emissions for rapid, medium and slow cure cutback asphalt.

Exhibit 17-4
U.S. Environmental Protection Agency
ESTIMATED HYDROCARBON EMISSIONS FROM TH
USE OF CUTBACK ASPHALT IN OHIO

Sales[a] of Cutback Asphalt (000 Tons)			Estimated Hydrocarbon Emissions In 1977 (000 Tons)			
Rapid Cure	Medium Cure	Slow Cure	Rapid Cure	Medium Cure	Slow Cure	Total
88	164	13	18.0	34.1	1.0	53.1

[a] 1977 sales were assumed to equal 1976.

Source: Mineral Industries Surveys, U.S. Dept. of the Interior, Bureau of Mines; "Control of Volatile Organic Compounds from the Use of Cutback Asphalt," EPA 450/2-77-037

17.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR RACT REQUIRMENTS

Costs for using asphalt emulsions in place of cutback asphalts are presented in this section. Each cost item is discussed and quantified and the total cost is then calculated on a statewide basis.

17.4.1 Costs Associated with Using Asphalt Emulsions in Place of Cutback Asphalt

Costs for using asphalt emulsions in place of cutback asphalt were determined through interviews with asphalt trade associations and asphalt manufacturers and previous studies of asphalt. Costs will be incurred by both producers and users of cutback asphalt and asphalt emulsions.

Asphalt producers may incur costs in building additional emulsion plants for producing asphalt emulsions if current plant capacity in inadequate to meet increased demand. These costs would be incurred nationwide. These costs are not included in this study.

Costs to users of cutback asphalt who must convert to emulsions are primarily those expenditures associated with retraining personnel and making minor equipment modifications. The existing price/gallon advantage accruing to emulsions is approximately offset by the quantity advantage accruing to cutbacks (in terms of required asphalt content and comparitive durability). Put differently, expenditures on materials should remain approximately constant, but those on capital and labor should increase as users convert to asphalt emulsions. The most significant cost to the user will be for retraining personnel in the methods of asphalt emulsion application. It is estimated that these training costs are $300 per person including the cost of supervision for the training session.

Modification of trucks used in applying asphalt consists of replacing nozzles at a cost of $5 per nozzle. An average truck is equipped with 30 nozzles; therefore, the cost per truck would be $150. Other equipment costs include adjusting pumps and cleaning equipment before asphalt emulsions can be applied, and these are considered to be minimal.

Total user costs are assumed to be incurred on a one time basis. Minor equipment costs are generally not capitalized but are expensed in the accounting period in which they are incurred. The paragraph which follows shows total costs to the state for converting from the use of cutback asphalt to asphalt emulsion.

17.4.2 Extrapolation to the Statewide Industry

The total costs to Ohio for converting from using cutback asphalt to using asphalt emulsions are estimated at $198,000, and the cost per ton of hydrocarbon emissions reduced is estimated at $3.73. Annualized operating costs are negligible, since minor equipment costs and retraining costs are not capitalized. Summary of these costs is given in Exhibit 17-5, on the following page. By way of comparison, highway and street construction costs for all government systems in Ohio, for 1976 were[a]:

- Capital outlay - $452 million
- Maintenance - $377 million
- Administration - $35 million.

[a]Federal Highway Administration, Office of Highway Statistics, Table HF-2

Exhibit 17-5
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR RACT
FOR USE OF CUTBACK ASPHALT

Direct Cost Summary

Cutback asphalt used (thousands of tons)	265
Potential emissions reduction from converting to use of asphalt emulsions [a] (tons per year)	53,100
Retraining costs [b]	$158,400
Equipment modification costs [c]	$ 39,600
Total one-time costs [d]	$198,000
One-time costs per ton of emissions reduced	$ 3.73
Annualized operating cost per ton of emission reduced	$ 0

a. This represents the maximum emissions reduction if all cutback asphalt were replaced with emulsion. However, some cutback asphalt is likely to be used because of exemptions.
b. Cost based on retraining six employees per county.
c. Cost based on modifying three distributor trucks per county.
d. Assuming no county currently uses asphalt emulsions.

Source: Booz, Allen & Hamilton, Inc.

17.5 ECONOMIC IMPACTS

This section presents a discussion of the economic impacts and the technical feasibility of implementing RACT for the use of cutback asphalt in Ohio. The technical feasibility is primarily associated with whether asphalt emulsions can be substituted for cutback asphalt in paving applications. The use of asphalt emulsions in place of cutback asphalt has been demonstrated to be technically feasible in several states in the United States. New York State, where the climate is similar to that of Ohio, has converted from cutback to asphalt emulsions with little or no difficulty. Economic impacts include the effects of implementing RACT on cost, price, supply and demand; on employment; on productivity; and on market structure.

The overall economic impact of implementing RACT for use of cutback asphalt in Ohio is estimated to be minimal. Specific economic impacts include impacts on:

- Cost—The estimated one-time cost of $198,000 distributed over 88 counties in Ohio is small compared to the total statewide cost of highway construction.

- Price—The prices of cutback asphalt and asphalt emulsions are predicted to be unaffected by RACT.

- Supply and Demand—The demand for asphalt emulsion is predicted to more than double by 1980 when RACT is scheduled for implementation, since the use of asphalt emulsion will replace the current use of cutback asphalt. Producers of asphalt emulsions may have to build new emulsion plants to meet the expanded demand when RACT is implemented nationally. It is anticipated that sufficient lead time is available to assure an adequate supply of asphalt emulsion to meet the increased demand in Ohio.

- Employment—No change in employment is predicted from implementing RACT, although it will be necessary to train approximately 528 employees in Ohio on the use of asphalt emulsions.

- Productivity—Worker productivity is not expected to be substantially affected by implementation of RACT.

- <u>Market Structure</u>—No change in market structure for the use of asphalt emulsions in place of cutback asphalt is anticipated since the products are procured in a similar manner.

*   *   *   *   *

Exhibit 17-6 presents a summary of the findings of this report.

EXHIBIT 17-6
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTATING RACT FOR USE OF CUTBACK ASPHALT
IN THE STATE OF OHIO

Current Situation	Discussion
Use potentially affected	In 1977, estimated use of cutback asphalt was 265,000 tons[a]
Indication of relative importance of industrial section to state economy	1977 sales of cutback asphalt were estimated to be $24.3 million
Current industry technology trends	Nationally, use of cutback asphalt has been declining
1977 VOC actual emissions	53,100 tons annually
Industry preferred method of VOC control to meet RACT guidelines	Replace with asphalt emulsions

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$0.2 million
Annualized cost (statewide)	No change in paving costs are expected
Price	No change in pavings costs are expected
Energy	No major impact to the user[b]
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	Winter paving Short range supply of asphalt emulsions
VOC emission after control	Net VOC emission reduction is estimated to be up to a maximum of 53,100 tons annually[c]
Cost effectiveness of control	$0 annualized cost/annual ton of VOC reduction

a. All of this use may not be affected by the regulations because of likely exemptions.

b. If all cutback asphalt were replaced with emulsions, up to 530,000 equivalent barrels of oil savings might accrue to the manufacturer, not user. This is based on the difference in total energy associated with manufacturing, processing and laying of cutback asphalt (50,200 BTU per gallon) and emulsions (2,830 BTU per gallon). One ton of cutback asphalt or emulsion contains 256 gallons and one barrel of oil contains 6.05 million BTUs.

c. Based on replacing all cutback asphalt with emulsions.

Source: Booz Allen & Hamilton Inc.

BIBLIOGRAPHY

"Control of Volatile Organic Compounds from Use of Cutback Asphalt," EPA-450/2-77-037, December 1977.

"Air Quality and Energy Conservation Benefits from Using Emulsions to Replace Asphalt Cutbacks in Certain Paving Operations," EPA-450/2-78-004, January 1978.

"Mineral Industry Surveys," U.S. Department of the Interior, Bureau of Mines, June 27, 1977.

"Magic Carpet, The Story of Asphalt," The Asphalt Institute, 1977.

"Proposed Amendments to Pollution Control Regulations," Illinois Environmental Protection Agency.

"Technical Support for RACT Cutback Asphalt," Illinois Environmental Protection Agency.

"World Use of Asphalt Emulsion," Cyril C. Landise, Armak Company, Chicago, Illinois, March 5, 1975.

"Atmospheric Emissions from the Asphalt Industry," PB-227 372, National Environmental Research Center, December 1973.

Asphalt, Its Composition, Properties and Uses, Ralph N. Traxler, Reinhold Publishing Company, New York, 1961.

The Asphalt Handbook, The Asphalt Institute, April 1965.

Introduction to Asphalt, The Asphalt Institute, November 1967.

Telephone interview with Mr. Charles Maday, U.S. EPA,

Telephone interview with Mr. Charles Owen, The Asphalt Institute,

Telephone interview with Mr. Terry Drane, Emulsified Asphalt, Inc.

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16. ABSTRACT

The major objective of the contract effort was to determine the direct economic impact of implementing RACT standards in Ohio. The study is to be used primarily to assist EPA and Ohio decisions on achieving the emission limitations of the RACT standards.

The economic impact was assessed for the following 15 RACT industrial categories: surface coatings (cans, coils, paper, fabrics, automobiles and light duty trucks, metal furniture, insulation of magnet wire, large appliances); solvent metal cleaning; bulk gasoline terminals; refinery systems; bulk gasoline plants; storage of petroleum liquids in fixed roof tanks; gasoline dispensing stations--Stage I; and use of cutback asphalt.

The scope of this project was to determine the costs and direct impact of control to achieve RACT guideline limitations for these 15 industry categories in Ohio. Direct economic costs and benefits from the implementation of RACT limitations were identified and quantified while secondary impacts (social, energy, employment, etc.) are addressed, they were not a major emphasis in the study.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Gasoline marketing Air pollution Metal coatings Solvent substitution Emission limits	Air pollution control Stationary sources Ohio Economic impact Hydrocarbon emissions Coatings	

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