United States Environmental Protection Agency
Region IV Air Programs Branch Atlanta, Georgia 30308
EPA 904/9-79-037
April 1979

Air

EPA

Economic Impact of Implementing RACT Guidelines in the State of Kentucky

FINAL REPORT

ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES IN THE STATE OF KENTUCKY

TASK ORDER NUMBER 6 UNDER:

Basic Ordering Number 68-02-2544

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

to:

AIR PROGRAMS BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY

from:

BOOZ, ALLEN & HAMILTON Inc.

October 1979

This is a draft report and the data presented represents preliminary findings and should not be quoted or cited.

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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 for volatile organic compounds for twelve industrial categories and of proposed Sulfur Dioxide (SO_2) regulations in the state of Kentucky. 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 12 RACT Guidelines and the SO_2 Limitation
- Economic Implications of Each RACT Guideline and the SO_2 Limitation.

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 oxident 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 assist the states in the determination of the direct economic impact of selected segments of their SIPs for six states (Alabama, Georgia, Kentucky, North Carolina, South Carolina and Tennessee) of Region IV of the U.S. Environmental Protection Agency. These studies will be used primarily to assist EPA and state decisions on achieving emission limitations.

1.1.2 Scope

The scope of this project for Kentucky was to determine the costs and direct impacts of control to achieve RACT guideline limitations as implemented in statewide regulations in 12 industrial categories and the SO_2 limitation in two industries. 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 and the SO_2 industrial categories studied.

In Kentucky, the economic impact was analyzed for the implementation of RACT guidelines for the following 12 industry categories:

- Surface coating of paper
- Surface coating of fabrics
- Surface coating of automobiles and light duty trucks
- Surface coating of metal furniture
- Surface coating of large appliances
- Solvent metal cleaning
- Bulk gasoline terminals
- Bulk gasoline plants
- Storage of petroleum liquids in fixed roof tanks
- Service stations--Stage I
- Use of cutback asphalt
- Miscellaneous refinery sources.

Also in Kentucky, the proposed SO_2 limitations were studied for two coal-fired power plants in Muhlenburg County and one refinery in Boyd County.

The major study guidelines in the determination of the economic impact of the RACT guidelines are discussed below.

- 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, on the following page.

- All costs and emission data were presented for 1977.

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

- Potentially affected facilities were assessed in accordance with proposed air pollution control regulations in Kentucky.

1. For two industrial categories (Service Stations and Solvent Metal Cleaning) size characteristics were used as the basis for inclusion, rather than emissions.

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 SPECIFIC INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvents (lbs. solvent per gallon of coating, minus water)
Surface coating of:	
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
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 carryouts.
. 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; power cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout.

EXHIBIT 1-1(2)

Category	RACT Guideline Emission Limitations[a]
Petroleum refinery sources	
. Vacuum producing systems	No emissions of any noncondensible VOC from condensers, hot wells or accumulators to a firebox, incinerator or boiler.
. Wastwater 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 by VOC by depressurization venting to vapor recovery, flare or firebox. No emissions of VOC from a process unit or vessel until its 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.
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 with an annual throughput greater than 200,000 gallons.
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 at 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 the timing requirements and possible limitations are modified to meet developing 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 proposed SO_2 regulations affect two counties in Kentucky, Muhlenburg and Boyd. These counties have been reclassified to a more stringent limitation of SO_2 emissions. Exhibit 1-2, on the following page, summarizes the existing and proposed SO_2 emission limitations. The proposed changes apply only to sources having a total heat input greater than 1500 mmbtu/hour.

To determine the economic impact of the proposed SO_2 regulations, the following major guidelines are used:

- The emission limitation for each facility was studied at the control level established by the proposed Kentucky regulations.
- All costs and emissions data were presented for 1977.
- The control techniques used would be those identified in the proposed regulations.

Exhibit 1-2

U.S. Environmental Protection Agency

EXISTING AND PROPOSED SO_2 LIMITATIONS FOR SOURCES WITH A TOTAL HEAT INPUT GREATER THAN 1500 MMBTU/HR IN TWO COUNTIES IN KENTUCKY

County	Present Classification	Proposed Classification	Allowable Emissions: Present Regulation	Allowable Emissions: Proposed Regulation
Muhlenburg	IV	IVA	Liquid 3.5 lbs/mmbtu Solid 5.2 lbs/mmbtu	Liquid 2.1 lbs/mmbtu Solid 3.1 lbs/mmbtu
Boyd	V	VA	Liquid 4.0 lbs/mmbtu Solid 6.0 lbs/mmbtu	Liquid 0.4 lbs/mmbtu Solid 0.6 lbs/mmbtu

Source: Kentucky Division of Air Pollution Control

1.1.3 Approach for VOC Analysis

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 interviews with industry representatives in the state.

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 (fabrics, paper, automobiles and light duty trucks, metal furniture and large appliances) --The potentially affected facilities and emissions were obtained primarily from the Kentucky Division of Air Pollution Control and interviews. Therefore, the following general methodology was applied:

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

  - Data from the Kentucky emission inventory were categorized and compiled for each RACT industrial category.

  - Firms not listed in the emission inventory were identified. All of these facilities were then contacted concerning their inclusion.

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

  - Interviews were conducted by Booz, Allen to determine emissions (when not available), 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, refineries, service stations, fixed roof tanks, cutback asphalt 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.

  - The Kentucky Division of Air Pollution Control identified facilities which would be affected by the proposed regulation for bulk gasoline plants, terminals and fixed roof tanks.

  - Emissions were estimated by applying relevant factors (e.g., emissions per facility or throughput) which have been determined by the EPA.

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

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

1.1.4 Approach for SO_2 Analysis

The approach and methodology used to assess proposed SO_2 regulations in Kentucky was based on the examination of three specific facilities affected:

- Facility statistics were developed from secondary sources and interviews.

- Emission data were provided by the Kentucky Division of Air Pollution Control.

- Engineering cost estimates were available from previous EPA studies.

1.1.5 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 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.

1.2 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE TWELVE RACT GUIDELINES AND THE SO_2 LIMITATIONS

1.2 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE TWELVE RACT GUIDELINES AND THE SO_2 LIMITATIONS

The implementation of the RACT emission limitations for 12 industrial categories and SO_2 limitations in Kentucky involves an estimated $275 million capital cost and $84 million annualized cost. This section is presented in two parts, consistent with emissions to be controlled (VOC and SO_2).

1.2.1 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE TWELVE RACT GUIDELINES

The implementation of RACT emission limitations for 12 industrial categories in Kentucky involves an estimated $36.5 million capital cost and $6.7 million annualized cost per year. The net VOC emission reduction is estimated to be 26,000 tons annually from a 1977 baseline of 33,000 tons at the affected facilities. Exhibit 1-3, 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 12 industrial categories.

- Approximately 2,400 facilities are potentially affected by the 12 RACT guidelines in Kentucky.
  - Ninety-four percent of the potentially affected facilities are represented by the solvent metal cleaning (1,600 facilities) and service station (633 facilities) industrial categories.
  - Less than 1 percent (20 facilities) of the potentially affected facilities are represented by the five surface coating industrial categories (paper, fabrics, automobiles, metal furniture and large appliances).
- In 1977, the estimated annual VOC emissions (including those already controlled) from affected facilities in the 12 RACT industrial categories totalled approximately 33,158 tons.
  - Five gas marketing categories (tank truck loading terminals, bulk gas plants, fixed roof tanks, miscellaneous refinery sources and service stations) represented 50 percent of the total VOC emissions.

EXHIBIT 1-3
U.S. Environmental Protection Agency
SUMMARY OF IMPACT OF IMPLEMENTING RACT
GUIDELINES IN 12 INDUSTRIAL CATEGORIES -- KENTUCKY

	Emissions				Cost of RACT Control		Cost Indicators		Cost Effectiveness
Industry Category	Number of Facilities Potentially Affected	1977 VOC Emissions (tons/yr.)	Estimated VOC Emissions After Implementing RACT (tons/yr.)	Net VOC Emission Reductions (tons/yr.)	Capital Cost[a] ($ millions)	Annualized Cost (credit) ($ millions)	Annualized Cost as Percent of Value of Shipments[b] (percent)	Annualized Cost Per Unit Shipment (cost per unit)	Annualized Cost (credit) Per Ton of VOC Reduction ($ per tons/yr.)
Surface coating of paper	6	2,400	460	1,940	4.9	1.2	0.4	-	$ 600
Surface coating of fabric	1	-	-	-	-	-	-	-	-
Surface coating of automobiles	1	1,770	550	1,220	13	1.9	0.2	$11/auto	1,560
Surface coating of metal furniture	5	460	75	385	0.16	0.01	0.01	-	16
Surface coating of large appliances	7	7,149	2,144	5,005	6.55	1.50	0.10	$0.25/ household unit	300
Solvent metal cleaning	1,600	3,350	2,477	873	1.0	0.12	<0.01	NA	145
Refinery vacuum wastewater separators and turnarounds	3	6,950	100	6,850	0.12	0.03	negligible	negligible	5
Tank truck gasoline loading terminals	32	5,490	550	4,940	6.82	1.17	0.14	$0.001/gal.	237
Bulk gasoline plants	3	64	18	46	0.05	0.01	0.6	0.002/gal.	274
Storage of petroleum liquids in fixed roof tanks	82	2,655	265	2,390	3.3	0.6	-	<$0.001	256
Service Stations (Stage I)	633	1,500	75	1,425	0.6	0.14	<0.1	$0.001/gal.	95
Cutback Asphalt	-	1,370	480	890	0.02				17
TOTAL	2,373	33,158	7,194	25,964	36.5	6.7			

[illegible] are rounded and approximated for comparison purposes.

  - Solvent metal cleaning represented 10 percent of the total VOC emissions (from the 12 RACT categories studied).

  - Use of cutback asphalt represented 4 percent of the total VOC emissions.

  - Five surface coating categories represented 36 percent of the total VOC emissions.

- The net emission reduction achievable by implementing the Kentucky regulations of the 12 RACT guidelines is estimated to be approximately 26,000 tons annually. The approximate percent of the total VOC emissions reduced by implementing RACT by industrial category group is:

  - Gas marketing categories--60 percent of VOC emission reduction

  - Surface coating categories--33 percent of VOC emission reduction

  - Solvent metal cleaning category--3 percent of VOC emission reduction

  - Use of cutback asphalt--3 percent of VOC emission reduction.

- The capital cost for the 12 industrial categories to achieve the RACT guidelines is estimated to be $36.5 million.

  - Approximately 36 percent of the total estimated capital cost is for control of automobile assembly plants. The capital required to meet Kentucky guidelines for automobile surface coating is estimated to be $13 million. (This was based on an alternative scenario to the recommended RACT limitations for automobiles that was studied. This RACT control scenario would represent an estimated capital cost of $100 million.)

  - The five industrial categories dealing with petroleum marketing (bulk gasoline plants, refineries, bulk gasoline terminals, fixed roof tanks and service stations) account for approximately $10.9 million (or 30 percent of the total) of the estimated capital cost.

- The annualized cost of the 12 RACT industrial categories to achieve Kentucky regulations of the RACT guidelines is estimated to be $6.7 million. The control of automobile assembly plants is estimated to be $1.9 million annualized cost. In terms of cost indicators, the annualized compliance cost per value of shipments will have the largest effect on the following industrial categories:

  - Bulk gasoline plants--The annualized compliance costs represent approximately 0.6 percent value of shipments. But only three plants are expected to be affected.

  - Paper coating--The annualized costs represent approximately 0.4 percent of the 1977 affected industry's value of shipments.

  - Surface coating of automobiles--The annualized compliance costs represent approximately 0.2 percent of 1977 statewide value of shipments.

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

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

    - Surface coating of automobiles (but Kentucky compliance timetable has been lengthened for topcoat operations)

    - Surface coating of large appliances

    - Surface coating of metal furniture (full color line).

- Equipment delivery and installation of control equipment were identified as potential problems on a nationwide basis in the following industrial categories:

  - .. Surface coating of paper
  - .. Solvent metal degreasing
  - .. Gasoline service stations
  - .. Bulk gasoline plants.

- 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 the effect of being another contributing factor to the industry trends of high throughput facilities in service stations.

- The annualized cost of compliance for the five gasoline marketing categories is estimated to be $1.8 million. Assuming a "direct-cost pass-through" for the statewide industry, the annualized cost would represent a price increase of less than 0.1 cent per gallon. However, within the four county urban nonattainment areas, the impact would be greater.

- The implementation of the RACT guidelines for the 12 industrial categories is estimated to represent a net energy savings of 105,000 equivalent barrels of oil annually, as shown in Exhibit 1-4, following the next page. Assuming a value of oil at $13 per barrel, this is an equivalent energy savings of $1.37 million annually.

  - RACT compliance requirements for the five industrial categories dealing with petroleum marketing (service stations, bulk gasoline terminals, bulk gasoline plants, refineries and tank truck gas loading terminals) represent a net energy saving of approximately 109,000 barrels of oil annually. However, the feasibility of control efficiency has not been totally demonstrated, and these estimates are likely to overstate the achievable energy savings for bulk gasoline plants and service stations.

EXHIBIT 1-4

U.S. Environmental Protection Agency
ESTIMATED CHANGE IN ENERGY DEMAND RESULTING
FROM IMPLEMENTATION OF 12 RACT GUIDELINES IN KENTUCKY

Industry Category	Energy Demand Change Increased (Decrease) (Equivalent barrels of oil)	Energy Demand Change Cost/(Savings)[a] ($ million)
Surface coating of paper	12,900	0.17
Surface coating of fabrics	-	-
Surface coating of automobiles	Not estimated	-
Surface coating of metal furniture	(2,100)	(0.03)
Surface coating of large appliances	(5,650)	(0.07)
Refinery systems	(49,000)	(0.064)
Solvent metal cleaning	Negligible	Negligible
Tank truck gasoline loading terminals	(34,000)	(0.44)
Bulk gasoline plants	(350)	(0.01)
Storage of petroleum liquids in fixed roof tanks	(16,000)	(0.21)
Service stations (STAGE I)	(9,500)	(0.12)
Use of cutback asphalt	(1,800)	(0.02)
TOTAL	(105,500)	(1.37)

Note: Surface coating of automobiles was not estimated because of the uncertainty of topcoat technology.
a. Based on the assumption that the cost of oil is $13 per barrel.
Source: Booz, Allen & Hamilton Inc.

- Energy demands for compliance requirements for automobile assembly plants was not estimated because of the uncertainty of topcoat processing alternatives.

In 1977, the statewide value of shipments of the 12 industrial categories potentially affected by RACT was $4.5 billion, which represents approximately 18 percent of Kentucky's total value of shipment of manufacturing goods. (The value of shipments for solvent metal cleaning and petroleum storage in fixed roof tanks is not included, since these operations are only a very small part of larger operations.) The estimated annualized cost of implementing the RACT guidelines ($6.5 million) represents 0.1 percent of the value of shipments for the 12 RACT industrial categories affected.

1.2.2 Statewide Agrregate Economic Impact of the SO_2 Limitations

The implementation of the proposed SO_2 limitations at three facilities in Boyd and Muhlenburg counties involves an estimated $152 million capital cost and $62 million annualized cost. The net SO_2 reduction is estimated to be over 386,000 tons per year. Exhibit 1-5, on the following page, presents a quantitive summary of the emissions, estimated cost of controls and cost effectiveness of the proposed SO_2 limitation.

- Each of the three affected facilities has proposed a different technique for compliance with the proposed limitation.
  - The Paradise steam plant plans to install a flue gas disulfurizer and coal washing operation. The estimated capital cost is $151 million and annualized cost is $46.5 million.
  - The Green River plant plans to convert to low sulfur coal. There are no capital costs involved, but the higher cost of coal represents an annualized cost increase.
  - The Cattlesburg refinery plans to blend low sulfur fuel oil. The estimated capital cost is $0.6 million and the annualized cost is $14 million.

EXHIBIT 1-5
U.S. Environmental Protection Agency
SUMMARY OF CAPITAL, AND ANNUAL
COSTS AND EMISSION REDUCTION FOR
THE STATE OF KENTUCKY OF
THE PROPOSED SO_2 REGULATION

	Capital Cost $ millions	Annualized Cost $ millions	Emission Reduction tons/year	Annualized Cost Per Ton SO_2 Emission Reduced
Paradise Steam Plant	151.2	46.5	348,000	$133
Green River Plant	-	1.1	9,500	$111
Cattlesburg Refinery	.6	14.0	27,759	$503
Total	151.8	61.6	386,259	$160

Source: Booz, Allen & Hamilton Inc.

- Assuming a full cost pass-through, the cost of compliance of the proposed SO_2 limitations would represent:

  - For TVA customers--an average increase in the price of electricity of 2.4 percent.

  - For Kentucky utilities customers an average price increase in electricity of 0.4 percent over the estimated price for meeting the current regulation. Since most of the projected increase is reflected in the current price of electricity because of better emissions control than that required under the existing regulations, the customers may experience a much lower price increase because of compliance with the proposed regulation.

  - For Ashland Petroleum customers an average price increase of refined products of less than one percent.

1.3 ECONOMIC IMPLICATIONS OF EACH RACT GUIDELINE AND THE SO_2 LIMITATION

1.3 ECONOMIC IMPLICATIONS OF EACH RACT GUIDELINE AND THE SO_2 LIMITATION

This section presents a summary of the economic impact for each of the 12 RACT industrial categories and the industies affected by the SO_2 limitations 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 Paper

This study covered six plants identified under the RACT requirements for paper coaters. 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.

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 $4.2 million and $5.6 million, with an annualized cost of $1.0 million to $1.3 million (approximately 0.5 percent of the statewide value of shipments).

Assuming 70 percent heat recovery, the annual energy requirements are expected to increase by approximately 12,900 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.

1.3.2. Surface Coating of Fabrics

Only one of the fabric coating facilities in Kentucky are anticipated to incur major economic costs to meet the RACT requirements. A preliminary list of 18 facilities were identified as potentially being affected by the RACT requirements. Interviews with all of these firms revealed that either the facilities would not be subject to the RACT requirements (i.e., they were not coaters of fabric or they utilized spray or extrusion methods of coating) or the facilities utilized latex coating materials. Therefore, although there may be some associated costs for RACT compliance (monitoring, recordkeeping, etc.) no major costs or emission reductions are anticipated for this RACT industrial category except possibly at the one facility.

1.3.3 Surface Coating of Automobiles

The Ford Motor Company has a facility with two production lines located in Louisville. The EPA recommended RACT guidelines would require conversion to waterborne paints. However, the Kentucky regulations represent modified timing requirements for topcoat systems.

It is assumed that automobile assembly plants will develop and apply the following paint technologies:

- Cathodic electrodeposition for primecoat
- High solids enamels, urethane enamels, powder coating or equivalent technologies for topcoat
- High solids enamels for final repair.

The capital requirements are estimated to be $13 million. The estimated annualized compliance cost is $1.9 million. If this increased cost were passed on directly, it would represent an increase in price of $11 per automobile manufactured.

1.3.4 Surface Coating of Metal Furniture

There are five facilities in Kentucky identified as manufacturers and coaters of metal furniture, which would be affected by the proposed limitations for the RACT industrial category.

To meet the RACT requirements, these facilities will need to invest approximately $162,000 in capital, and the annualized cost of control is approximately $6,000.

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

To meet the RACT requirements, the low solvent coating materials may not totally be available in the quality, color variety or specifications of each of the manufacturers. The development of totally suitable coating materials (or changes in current manufacturing requirements) is the key to successful implementation of the RACT requirements within the given time limitations.

1.3.5 Surface Coating of Large Appliances

There are seven large appliance manufacturing facilities in Kentucky, including General Electric, the largest individual manufacturing plant in the state. To meet the RACT requirements, these seven facilities would be required to invest approximately $6.55 million in capital and incur additional annualized costs of $1.5 million (approximately 0.10 percent of the industry's statewide value of shipments).

Assuming a "direct cost pass-through," the cost increase for household appliances relates to a price increase of approximately $0.25 per unit. Long term, no major productivity, employment or market structure dislocations appear to be associated with implementation of the RACT guidelines. However, in the short term, during construction of process modifications to meet the emission limitations, employment dislocations and lost production could occur. Because of the major construction required for the Louisville area to meet the RACT requirements, there probably is a shortage of skilled construction labor force to meet the timing requirements.

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

1.3.6 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 Kentucky will affect an estimated 1,600 metal cleaning operations. The regulation is expected to have a negligible economic effect on industry because of the relatively minor changes required. For Kentucky, the 1,600 facilities potentially affected represent a capital cost of $1.0 million and an annualized cost of $0.12 million (less than 0.002 percent of industry value of shipments).

Because of the large number of degeasers nationwide 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 a 1982 time frame.

No major productivity, employment and market structure dislocations are predicted to result from RACT implementation.

1.3.7 Refinery Vacuum Systems, Wastewater Separators and Process Unit Turnarounds

There are three refinery facilities in the state of Kentucky potentially afffected by the proposed RACT guidelines. The RACT requirements represent a capital investment of approximately $120,000 and an annualized cost of approximately $30,000.

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

1.3.8 Tank Truck Gasoline Loading Terminals

There are 32 facilities identified in the state of Kentucky as tank truck gasoline loading terminals and affected by the limitation requirements. Emission control of these facilities is expected to require a capital investment of $6.8 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. Based on this savings, the net annualized cost for implementation of RACT for bulk gasoline loading terminals is estimated to be $1.2 million.

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

1.3.9 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.

To meet the Kentucky requirements for urban nonattainment areas, only three bulk gas plants were identified which must be equipped with vapor balance and submerged fill systems. This recommended control system is not cost-effective for the individual 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 3 facilities represent $47,000 and $1,400 respectively.

1.3.10 Storage of Petroleum Liquids in Fixed Roof Tanks

There are an estimated 82 fixed roof tanks in the state of Kentucky which would have to be equipped with a internal floating roof to comply with the proposed RACT requirements. The VOC emissions (1977) for these tanks are estimated to be more than 2,600 tons.

These tanks are primarily owned by major oil companies and bulk gasoline tank terminal companies. The capital cost to equip these tanks with a single seal floating roof is estimated to be $3.3 million. The estimated annualized cost is $0.6 million, which would represent a price increase (assuming "direct cost pass-through") of less than $0.001 per gallon of throughput.

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

Implementation of the RACT guideline is estimated to represent a net energy savings of 16,000 equivalent barrels of oil annually (assuming 90 percent control efficiency).

1.3.11 Service Stations

There are approximately 630 service stations which are located in the four county nonattainment areas of Kentucky, and which will be potentially affected by the regulation. The implementation of submerged fill and vapor balancing at these stations is estimated to be $10.6 million in capital and the annualized cost is estimated to be $0.14 million. This annualized cost represents an average cost increase of approximately $0.001 per gallon; however, larger stations will experience a much smaller unit cost increase. The service stations could experience 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 Kentucky will result in a net energy savings equivalent to 9,500 barrels of oil per year, assuming 95 percent recovery of gasoline. This assumed control efficiency has not been fully demonstrated. Only a small percent of the economic benefit from the recovered gasoline vapors will directly accrue to the service stations.

1.3.12 Use of Cutback Asphalt

In 1977, it is estimated that 6,600 tons of cutback asphalt was utilized in the nonattainment areas of Kentucky. Replacement of the solvent-based asphalt with asphalt emulsion will cause no dislocation in employment or worker productivity. Capital and training cost investment is estimated at $20,000. No change in paving costs are expected from the implementation of the RACT guideline.

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.

1.3.13 Proposed SO_2 Limitations

The implementation of the proposed SO_2 limitations in Boyd and Muhlenburg counties will affect two utility companies and a refinery. The two steam plants involved account for approximately 9 percent of the state's total utility generated electricity. The refinery accounts for 80 percent of the states total refinery throughput capacity.

The cost of compliance at the three facilities is estimated to be approximately $152 million in capital and $62 annualized cost. Assuming a "full cost pass through" the complaince costs represent an increased cost of electricity for TVA customers of 2.4 percent. For Kentucky Utilities and Ashland Refinery customers the costs represent less than 1 percent increase in price.

* * * *

A summary of the direct economic implications of implementing RACT in each of the 12 industrial categories studied is presented in Exhibits 1-6 through 1-17, on the following pages.

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

Current Situation	Discussion
Number of potentially affected facilities	Six 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 six plants is estimated to be $250 million. They are estimated to employ approximately 2,000 people.
Current industry technology trends	Gravure coating replacing older systems.
1977 VOC emissions (actual) applicable under RACT	Approximately 2,400 tons per year were identified from the emission inventory.
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 $4.2 million to $5.6 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)	$1.0 million to $1.3 million annually. This may represent 0.4 to 0.5 percent of the 1977 annual sales for the affected paper coaters.
Price	Assuming a "direct cost pass-through"--0.4 to 0.5 percent.
Energy	12,900 barrels
Productivity	No major impact.
Employment	No major impact.
Market structure	Smaller firms may be unable to secure capital funding for add-on systems, which are typically $250,000 or more for a moderate sized incinerator to over $1 million for a carbon adsorber.

EXHIBIT 1-6 (2)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF KENTUCKY

Affected Areas in Meeting RACT	Discussion
RACT timing requirements (1982)	RACT guideline needs clear definition for enforcement Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems.
Problem areas	Retrofit situations and installation costs are highly variable. Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 456 tons/year (19 percent of 1977 VOC emission level).
Cost effectiveness of control	\$520 - \$680 annualized cost/annual ton of VOC reduction.

Note: Cost data is based on emission information supplied by the Kentucky Air Pollution Control Board.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-7 (1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT SCENARIO II FOR
AUTOMOBILE ASSEMBLY PLANTS IN THE
STATE OF KENTUCKY

SCENARIO II
RACT Timing Requirements (And Possible Limitations) Are Modified To Meet Developing Technologies

Current Situation	Discussion
Number of potentially affected facilities	One company operating two production lines
Indication of relative importance of industrial section to state enconomy	1977 value of shipments was approximately $0.9 billion which represents approximate 4.5 percent of the state's manufacturing industry
Current industry technology trends	Prime coat--cathodic electrodeposition topcoats--higher solids enamels for manufacturers using enamel systems
1977 VOC emissions (actual)	1,770 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)	$13 million (approximately 100 percent of current annual capital appropriations for the industry in the state)
Annualized cost (statewide)	$1.9 million (approximately 0.2 percent c the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass-through" approximately $11 per automobile manufactured
Energy	Dependent on technology applied
Productivity and employment	No major effect

EXHIBIT 1-7 (2)
U.S. Environmental Protection Agency

SCENARIO II
RACT Timing Requirements (And
Possibly Limitations) Are Modified
To Meet Developing Technologies

Current Situation	Discussion
Market structure	No major effect
RACT timing requirements	Primer and final repair limitations could probably be implemented by 1982 Topcoat limitations could be set at a 40 percent to 62 percent solids by 198 dependent on technology developments
Problem area	Limitations for topcoat are dependent on technology development
VOC emission after RACT control	550-1,050 tons per year (31 percent to 59 percent of 1977 emission levels, depending on limitations)
Cost effectiveness for RACT control	$1,550-2,600 annualized cost/annual to for VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-8
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	There are five metal furniture manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was approximately $77 million industry-wide and approximately $40 million for five affected facilities
1977 VOC emissions (actual)	460 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)	$162,000
Annualized cost (statewide)	$6,000, which represents 0.007 percent of the industry's 1977 value of shipments
Price	Increase a few cents to over $1/unit depending on the surface area coated
Energy savings	2,100 equivalent barrels of oil per yr.
Productivity	No major impact
Employment	Small adverse impact if some operations close
Market structure	No major impact
RACT timing requirements (1982)	Companies using a variety of colors may face a problem finding suitable low solvent coatings
Problem area	Low solvent coating in a variety of colors providing acceptable quality needs to be developed
VOC emissions after RACT	75 tons per year (approximately 16 percent of current emissions level)
Cost effectiveness of RACT	$16/annual ton of VOC emissions reduction

Source: Booz, Allen and Hamilton Inc.

EXHIBIT 1-9

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR SURFACE COATING OF LARGE
APPLIANCES IN THE STATE OF KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	There are seven major large appliance manufacturers and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $1.5 billion and represents 10 percent of the estimated $15 billion U.S. value of shipments of the major appliance industry
1977 VOC emissions (actual)	7,149 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)	$6.55 million
Annualized cost (statewide)	$1.50 million which represents 0.10 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.25/unit for household appliances (based on a price of $250 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 5,650 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	2,144 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$300 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-10
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING
IN THE STATE OF KENTUCKY[1]

Current Situation	Discussion
Number of potentially affected cleaners	About 1,600.
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is in the range of 9.7 billion.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents.
1977 VOC emissions (actual)	3,350 ton/year.
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 to meet RACT guidelines	Equipment modifications as specified by the RACT guidelines.

Affected Areas in Meeting Ract	Discussion
Capital investment (statewide)	$1.0 million.
Annualized cost (statewide)	$0.12 million (less than 0.002 percent of the 1977 affected facilities' value of shipments).
Price	Metal cleaning is only a fraction of manufacturing costs; price effect expected to less than 0.002 percent.
Energy	Less than 100 equivalent barrels of oil per year increase.
Productivity	5-10 percent decrease for manually operated degreasers. Will not affect conveyorized cleaners.

EXHIBIT 1-10 (2)

Affected Areas in Meeting RACT	Discussion
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	2,477 tons/year (74 percent of 1977 VOC emission level).
Cost-effectiveness of RACT control	$145 annualized cost per ton of emissions reduced.

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1 These estimates are statewide and assume no exempt solvents.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-11
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 KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	Three
Indication of relative importance of industrial section to state economy	1977 industry sales were $840 million. The estimated annual crude oil throughput was 60 million barrels
Current industry technology trends	All three refineries comply with RACT for process unit turnarounds
1977 VOC actual emissions	6,950 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 covering wastewater separators
Assumed method of VOC control to meet RACT guidelines	Vapor recovery of emissions from process unit to flare, cover wastewater separators and piping emissions from process units to flare.

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$120,000
Annualized cost (statewide)	$33,000
Price	No major impact
Energy	Assuming full recovery of emissions —net savings of 48,600 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	Negligible
Cost effectiveness of control	$5 annualized cost/annual ton of of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-12

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	32
Indication of relative importance of industrial section to state economy	1977 industry sales were $805 million, with annual throughput of 1,894 billion gallons.
Current industry technology trends	New terminals will be designed with vapor recovery equipment
1977 VOC actual emissions	5,491 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Submerge fill or bottom fill vapor recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$6.819 million
Annualized cost (statewide)	$1.172 million (approximately 0.14 percent of value of shipment)
Price	No change in price is anticipated
Energy	Assuming full recovery of gasoline—net savings of 33,750 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 emission after control	550 tons per year
Cost effectiveness of control	$237 annualized cost/annual ton of VOC reduction from terminals

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-13

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN URBAN NONATTAINMENT COUNTIES OF KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	Three
Indication of relative importance of industrial section	1977 industry sales were $113 million, with annual throughput of 0.27 billion gallons. The three facilities potentially affected represented less than 2 percent of 1977 industry sales.
Current industry technology trends	Only small percent of industry has new/ modernized plants
1977 VOC actual emissions	64 tons per year (three potentially affected facilities)
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 (four counties)	$47,000
Annualized cost (four counties)	$12,600 (approximately 0.6 percent of value of shipment from three facilities)
Price	Assuming a "direct cost passthrough" Three facilities--$0.0024 per gallon increase
Energy	Assuming full recovery of gasoline--net savings of 350 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	18 tons per year (28 percent of current emissions)
Cost effectiveness	$274 annualized cost/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 STORAGE OF PETROLEUM LIQUID IN THE STATE OF KENTUCKY

Current Situation	Discussion
Number of potentially affected storage tanks over 40,000	82
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 891 million gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
VOC emissions	2,655 tons per year
Preferred method of VOC control meet RACT guidelines	Single seal and internal floating roof
Affected Areas in Meeting RACT	
Capital investment (statewide)	$3.3 million
Annualized cost (statewide)	$0.6 million
Price	Assuming a "direct cost passthrough"--less than 0.1 cents per gallon of throughput
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 16,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market Structure	No major impact
Problem area	Potentially availability of equipment to implement RACT standard
VOC emission after control	266 tons per year
Cost effectiveness of control	$256 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-15 (1)
U.S. Environmental Protection Agecny
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT FOR
GASOLINE DISPENSING FACILITIES
IN THE STATE OF KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	633
Indication of relative importance of industrial sector to county economy	4 county industry sales from the affected facilities are $0.197 billion with a yearly throughput of 0.388 billion gallons
Current industry technology trends	Number of stations has been declining and throughput per station has been increasing. By 1980, one-half of stations in U.S. are predicted to become totally self-service
1977 VOC emissions (actual)	1,500 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACT guidelines	Submerged fill and vapor balance
Assumed method of control to meet RACT guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (4 counties)	$0.6 million
Annualized cost (4 counties)	$0.14 million (less than 0.1 percent of the value of gasoline sold at those affected facilities)
Price	Assuming a "direct cost pasthrough" --less than $0.001 per gallon of gasoline sold at the affected facilities
Energy	Assuming full recovery: 460,000 gallons/year (9,500 barrels of oil equivalent) saved[a]
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 shut down)

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[a] One gallon of gasoline has 125,000 BTU's. One barrel of oil equivalent has 6,050,000 BTU's.

RACT timing requirements (1982)	Retrofitting all service stations within time constraints may be difficult in a few instances
Problem area	Older stations face higher retrofit costs—potential concerns are dislocations during installations
VOC emission after RACT control	75 tons per year from tank loading operation
Cost effectiveness of RACT control	$95 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-16 (1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT FOR USE OF
CUTBACK ASPHALT IN THE STATE OF KENTUCKY

Current Situation	Discussion
Use potentially affected	In 1977, use of cutback asphalt was 24,561 tons statewide and an estimated 6,631 tons in non-attainment counties.
Indication of relative importance of industrial section to non-attainment county economies	1977 sales of cutback asphalt were estimated to be $2.3 million statewide and $0.5 million in non-attainment counties.
Current industry technology trends	Nationally, use of cutback asphalt has been declining.
1977 VOC emissions (actual)	5,087 tons annually statewide; 1,370 in non-attainment counties, 890 of which would be controlled under the proposed regulation.
Industry preferred method of VOC control to meet RACT guidelines	Replace with asphalt emulsions
Assumed method of control to meet RACT guidelines	Replace with asphalt emulsions

Affected Areas in Meeting RACT	Discussion
Capital investment in non-attainment areas	$0.02 million
Annualized cost in non-attainment areas	No change in paving costs are expected.
Price	No change in paving costs are expected.
Energy	1,800 barrels of oil equivalent saved[a]
Productivity	No major impact
Employment	No major impact

[a] The saving accrues to manufacturer, not user. The total energy associated with manufacturing, processing and laying one gallon of cutback is approximately 50,200 BTUs/gallon. For emulsified asphalts, it is 2,830 BTUs/gallon. One barrel of oil equivalent is assumed to have 6.05 million BTUs, and one ton of cutback asphalt is assumed to have 256 gallons.

EXHIBIT 1-16 (2)

RACT timing requirements (1981)	Long range supply of asphalt emulsions are expected to be available.
Problem area	Winter paving Short range supply of asphalt emulsions
VOC emission after RACT control	Net VOC emission reduction is estimated to be 890 tons annually
Cost effectiveness of RACT control	The cost is $17 per ton in the first year. In subsequent years the cost/ton is zero.

Source: Booz, Allen & Hamilton Inc.

2.0 INTRODUCTION AND OVERALL STUDY APPROACH

2.0 INTRODUCTION AND OVERALL STUDY APPROACH

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

- Background
- Summary of State Implementation Plan revisions and state's need for assistance
- Scope for Volatile Organic Compounds (VOC) analysis
- Scope for SO_2 analysis
- Approach for VOC analysis
- Approach for SO_2 analysis
- Quality of estimates
- Definition of terms used.

Each of these sections is discussed below.

The approach and quality of estimates is discussed in detail in each of the respective chapters dealing with the specific industrial categories affected by the volatile organic compounds and sulfur dioxide control regulations.

2.1 BACKGROUND

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.

Under the direction of Region IV, the EPA contracted with Booz, Allen & Hamilton Inc. (Booz, Allen) to assist the states of Alabama, Georgia, Kentucky, North Carolina, South Carolina and Tennessee in analyzing the economic, energy and social impacts of the SIP revisions proposed by these states. The assignment was initiated on September 28, 1978, and, as a first step, the proposed SIP revisions and the type of assistance desired by each state were reviewed.

After a review with each of the states and EPA Region IV representatives, a work scope was defined that would include in the study an analysis of the direct economic and energy impacts for those industrial segments most likely to have a significant impact at the statewide level. For the most part this included industrial categories that had more than a few facilities potentially affected. The next section discusses those specific industrial categories included in this work scope.

2.2 SUMMARY OF PROPOSED SIP REVISIONS IN KENTUCKY AND THE STATE'S NEED FOR CONTRACTOR SUPPORT

Kentucky has proposed statewide regulations to reduce volatile organic compound (VOC) emissions by implementing the Reasonably Available Control Technology (RACT) guidelines developed by the EPA for existing stationary sources. The state has also committed to implement motor vehicle inspection/maintenance programs and transportation control measures in two non-attainment areas. In addition, the state will revise the sulfur dioxide (SO_2) emissions standards for existing sources in two counties. Finally, the total suspended particulates (TSP) regulations may be revised in one county.

The state officials were interviewed to determine their need for support in analyzing the economic impact of the SIP revisions. The analysis of implementing the RACT guidelines for reducing VOC emissions was expressed as the fundamental concern. Specifically, the state needed assistance in the analysis of 12 of the 15 industrial categories for which the EPA has published RACT guidelines. These 12 RACT industrial categories are described in the next section. The other three industrial categories (surface coating of cans, coil and magnet wire insulation) were excluded from this study because a very limited number of sources were affected by the proposed regulation in those categories. Although the cost impact in those categories excluded might be significant for an individual firm studied, it is unlikely that the economic or energy impact at the macrolevel (statewide) would be significant. The state also needed support in the analysis of proposed revisions to the SO_2 regulations in two counties.

2.3 SCOPE FOR VOC ANALYSIS

The primary objective of this study is to determine the costs and impact of compliance with the proposed SIP revisions for six states in EPA, Region IV. The study will emphasize the analysis of direct economic costs and benefits of the proposed SIP revisions. Secondary (social and energy) impacts will also be addressed but are not the major study emphasis.

In Kentucky, the economic impact will be analyzed for the implementation of RACT guidelines to reduce VOC from the following 12 industry categories:

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

General study guidelines in the determination of the economic impact of the RACT guidelines include:

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

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 SPECIFIC INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvents (lbs. solvent per gallon of coating, minus water)
Surface coating of:	
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
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 carryouts.
. Open top degreaser	Provide cleaner with: safety switches; powered cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout.

Category	RACT Guideline Emission Limitations[a]
Petroleum refinery sources	
. Vacuum producing systems	No emissions of a noncondensible VOC from condensers, hot wells or accumulators by piping to a firebox, incinerator or adding them to the refinery fuel gas
. 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 depressurization venting to vapor recovery, flare or firebox. No emissions of VOC from a process unit or vessel until its internal pressure is 136 kilo pascals (1717 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.
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 with a capacity of 7,500 liters (2,000 gal.) or greater.

Category	RACT Guidelines Emission Limitations[a]
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 at 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 the timing requirements and possible limitations are modified to meet developing 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.

- 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 three pounds in any hour or 15 pounds in any day.

- The following volatile organic compounds were exempted:

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

Specific guidelines for the analysis of VOC control from certain industry categories were as follows:

- The service station industry category regulations apply only to service stations located in Boone, Kenton, Jefferson and Campbell Counties that have an annual throughput greater than or equal to 250,000 gallons.

- Although the fixed-roof storage tanks regulations apply statewide for tanks over 40,000 gallons, the existing storage tanks in Jefferson, Boone, Campbell and Kenton Counties are already in control as a result of the regulations promulgated in 1972.

- The Kentucky regulations for bulk plants apply only to facilities with throughputs greater than 200 gallons/day but less than 20,000 gallons/day in the 4 counties designated non-attainment for ozone.

- The regulations on the use of cutback asphalt require that the emulsified asphalt to be used in place of the cutback asphalt must not contain more than 15 percent by volume of oil distillate.

- The compliance schedule for the various industry categories will be as follows:

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

- January 1981 for bulk plants located in Boone, Boyd, Campbell, Dariess, Fayette, Henderson, Jefferson, Kenton or McCracken County, and January 1, 1983 for bulk plants located in other counties

- April 1, 1981 for surface coating of paper, fabrics, metal furniture and large appliances

- March 1, 1981 for solvent metal cleaning

- February 1, 1981 for service stations

- January 1, 1981 for refinery sources and bulk terminals

- January 1, 1982 for surface coating of automobiles and light duty trucks

- April 1, 1980 for cutback asphalt.

2.4 SCOPE FOR SO_2 ANALYSIS

The primary objective of this task is to determine the costs and direct economic impacts of controls needed to meet proposed SO_2 regulations in Kentucky. The impact must be addressed for the two industries involved as well as the State of Kentucky. Direct economic costs and benefits that can be realized from the proposed SO_2 regulations shall be identified and quantified. While secondary (social, energy and employment) impacts are to be addressed, they are not the major emphasis of the study.

The proposed SO_2 regulations affect two counties in Kentucky, Muhlenburg and Boyd. These counties have been reclassified to a more stringent limitation of SO_2 emissions. Exhibit 2-2, on the following page, summarizes the existing and proposed SO_2 emission limitations. The proposed changes apply only to sources having a total heat input greater than 1500 mmbtu/hr.

Two coal fired power plants in Muhlenburg County and one refinery in Boyd County have been identified as being affected by these proposed regulations.

To determine the economic impact of the proposed SO_2 regulations, the following major guidelines are used:

- The emission limitation for each facility was studied at the control level established by the proposed Kentucky regulations.

- All costs and emission data were presented for 1977.

- The control techniques used would be those identified in the proposed regulations.

Exhibit 2-2

U.S. Environmental Protection Agency

EXISTING AND PROPOSED SO_2 LIMITATIONS FOR SOURCES WITH A TOTAL HEAT INPUT GREATER THAN 1500 MMBTU/HR IN TWO COUNTIES IN KENTUCKY

County	Present Classification	Proposed Classification	Allowable Emissions: Present Regulation	Allowable Emissions: Proposed Regulation
Muhlenburg	IV	IVA	Liquid 3.5 lbs/mmbtu Solid 5.2 lbs/mmbtu	Liquid 2.1 lbs/mmbtu Solid 3.1 lbs/mmbtu
Boyd	V	VA	Liquid 4.0 lbs/mmbtu Solid 6.0 lbs/mmbtu	Liquid 0.4 lbs/mmbtu Solid 0.6 lbs/mmbtu

Source: Kentucky Division of Air Pollution Control

2.5 APPROACH FOR VOC ANALYSIS

This section describes the overall approach and methodology applied in this assignment for VOC analysis. 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 Kentucky. The methodology applied to determine the economic impact for each industrial category in Kentucky is described in further detail in the first section of each chapter dealing with the specific industry 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 costs with selected direct economic indicators.

2.5.1 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

- 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
- Gasoline service stations
- Use of cutback asphalt.

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 remaining industry categories studied, a more deliberate approach was applied:

- For the surface coating industry categories, the facilities potentially affected by the RACT guidelines were identified from both the Kentucky emission data and secondary data sources.

  - These two independently compiled lists were then correlated to identify the facilities potentially affected but not listed as VOC emitters in the Kentucky 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 all the potentially affected facilities were contacted.)

- For bulk gasoline plants and terminals and fixed-roof tanks, the list of potentially affected facilities and facility characteristics were obtained from the state emissions inventory.

- For miscellaneous refinery sources, the list of potentially affected facilities was obtained from secondary sources.

- 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.

2.5.2 VOC Emissions

An approach that made maximum use of the existing Kentucky emission data was defined.

- State Division of Air Pollution Control 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 reasonable.

  - The emission data provided relevant data that could be utilized for economic evaluation, i.e., current emission levels (controlled and uncontrolled emissions) and number of sources (total and those controlled), type of control implemented (if any) and average efficiency of control.

- The State Division of Air Pollution Control provided data for relevant industrial categories. These RACT industrial categories included:

  - Fabrics
  - Paper
  - Automobiles and light duty trucks
  - Metal furniture
  - Large appliances.

- For bulk plants and terminals and fixed-roof tanks, the list of potentially affected facilities and facility characteristics were obtained from the state emissions inventory and emission factors developed by U.S. EPA were used to estimate the emissions.

- 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:

  - Refinery systems
  - Solvent metal cleaning
  - Service stations
  - Cutback asphalt.

- The emission estimates for each of the 12 RACT industrial categories studied were refined during industry interviews.

2.5.3 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 of 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.

2.5.4 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 costs 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 start-up and testing
  - Initial provisions (spare parts).

- Capital related annual costs are estimated at 24 percent of the total capital cost per year (unless explicitly stated otherwise). The estimation procedure applied was built up from the following factors:

  - Depreciation—10 percent (assuming straight-line over a ten-year life)
  - Interest—10 percent
  - Taxes and insurance—4 percent.
  - Maintenance --5 percent.

  The capital-related annual costs do not account for investment costs in terms of return or 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 total of direct operating costs (including product or raw material recovery) and the capital related annual costs.

2.5.5 Comparison of Direct Cost with Selected Direct Economic Indicators

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).

2.6 APPROACH FOR SO_2 ANALYSIS

This section describes the overall approach and methodology used to assess the proposed SO_2 regulations in Kentucky. The first step was to assess the impact on the identified facilities. The approach followed here differs from that used in assessing the RACT implementation due to the nature of the problem. Each facility had to be examined individually.

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

- Facility statistics
- SO_2 emissions
- Process description
- Cost of controlling SO_2 emissions.

2.6.1 Facility Statistics

To assess the impact on a facility, the following types of data were developed for each facility:

- Output of facility
- Capital expenditure
- Energy consumption
- Future trends and development
- Industry size
- Current economic (financial) status.

Facility specific data were identified from:

- Federal Energy Regulatory Commission forms
- Security and Exchange Commission reports (Form 10-K)
- Company annual reports
- Previous studies done by other groups or facilities
- Conversations with representatives of affected facilities.

2.6.2 SO_2 Emissions

SO_2 emissions were provided by the Kentucky Division of Air Pollution Control and were also obtained from the Federal Regulatory Commission data Form 67.

2.6.3 Process Descriptions

The control techniques were identified in the proposed regulations and were used as the basis for the economic impact analysis.

2.6.4 Cost of Controlling SO_2 Emissions

It was not within the purpose or the scope of this project to provide detailed engineering costs to estimate the cost of compliance. Engineering cost estimates were available for two of the three facilities. These estimates were reviewed and refined to make them consistent with the scope of the study. The third facility did not require an engineering estimate for the cost of controlling SO_2 emissions. A more detailed approach for each facility is discussed in the respective sections.

The cost data presented were standardized in the following manner:

- All cost figures were presented for a base year, 1977.
- The capital cost estimates did not account for costs such as:
  - Clean up of equipment
  - Lost sales during equipment downtime
  - Equipment start-up and testing
  - Initial provisions (spare parts).
- The capital-related annual costs did not account for investment costs in terms of return on investment parameters (i.e., "opportunity cost" of money is not included).

2.7 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 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.

2.8 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.

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

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

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Kentucky 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, prosthetic 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. The Kentucky Directory of Manufacturers and 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 were obtained from the Kentucky Department for Natural Resources and Environmental Protection emissions inventory.

5.1.2 VOC Emissions

The Kentucky emission inventory was used as a basis for estimation of the total VOC emissions to be expected in the state. Though the inventory may be incomplete, it is expected to account for the majority of the emissions in the state and for large single sources. The inventory, however, may omit a number of small firms that have low total emissions but could be affected by the RACT guideline.

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:

- 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 (EPA450/276028)
- 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 Kentucky. 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, 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 Kentucky 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.

5.2.1 Size of the Industry

The 1978 Kentucky Directory of Manufacturers and Lockwoods Directory report a total of about 92 firms in 16 SIC categories in Kentucky 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.

Total value of shipments for these firms is estimated to be about $863 million, with a total of about 13,500 employees. New capital expenditures are estimated to be about $45 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.

Of the total 92 firms only six 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 Kentucky Directory of Manufacturers, a review of the current Kentucky emission inventory and telephone interviews with major paper coating firms. The total annual value of shipments of these firms is estimated at about $250 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 1.7 percent of the total value of manufacturing shipments in Kentucky. The industry employs 1.9 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 KENTUCKY

SIC Code	Description	Number of Plants	Total Number of Employees	Total Payroll ($1,000)	Estimated Value of Shipments[a] ($1,000,000)	Estimated New Expenditures[a] ($1,000)
2611	Pulp mills	3	800	7,899	104.7	19,100
2621	Paper mills, except building paper mills	3	700	6,912	64.6	5,730
2631	Paperboard mills[b]	-	-	-	-	-
2641	Paper coating and glazing	6	920	11,321	71.9	2,150
2643	Bags, except textile bags	10	1,397	14,329	93.2	2,580
2645	Diecut paper and paperborad and cardboard	4	167	1,649	11.2	312
2649	Paper converting, n.e.c.	5	1,602	12,595	90.5	1,780
2651	Folding paperboard boxes	7	636	21,247	35.0	1,020
3291	Abrasive products[b]	-	-	-	-	-
3292	Asbestos products	7	550	5,431	32.7	666
3293	Gaskets, packing and sealing devices	3	131	1,293	4.83	170
3497	Metal foil and leaf	3	1,206	11,908	96.0	2,260
3679	Electronic components, n.e.c.	14	2,516	24,314	105.5	4,320
3842	Orthopedic, prosthetic and surgical appliances and supplies	18	2,026	18,809	85.9	2,920
3861	Photographic equipment and supplies	7	623	6,152	51.3	2,010
3955	Carbon paper and inked ribbons	2	207	2,044	15.6	282
Total		92	13,481	145,903	862.93	45,300

a. Estimated by using ratios of (value of shipment/total employment) and (capital expenditures/total employment) 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

Source: Booz, Allen & Hamilton Inc.: 1976 County Business Patterns, and 1976 Annual Survey of Manufactures, U.S. Department of Commerce and the 1978 Kentucky Directory of Manufacturers.

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, 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 increase 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 briefly describes the general process and materials used in the surface coating of paper and similar products proposed to be included under the RACT Surface Coating of Paper regulations. The technology is fully described in the RACT documents. The 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.

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.

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 gives typical emission data from various paper coating applications.

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, EPA-450/2-76-028.

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.

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 Current VOC Emissions

This section presents the estimated VOC emissions from paper coating operations in Kentucky for the year 1977, based on the Kentucky inventory of air pollution sources. A summary of this inventory and applicable emissions for the paper coating RACT category is presented in Exhibit 5-5. Plants listed are believed to represent the major single sources of emissions in the state and in total represent the major portion of paper coating emissions.

Current emissions from paper coating in Kentucky are approximately 2,400 tons per year. This figure is based upon the Kentucky emissions inventory and an exhaustive telephone survey of companies expected to be affected by the regulations.

5.3.4 RACT Guidelines

The RACT guidelines 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.

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

Exhibit 5-5
U.S. Environmental Protection Agency
COMPANY ESTIMATES OF PAPER COATING EMISSIONS
AS REPORTED TO KENTUCKY AIR POLLUTION CONTROL BOARD

Company Name, Location	SIC Code	Employees	Total Reported Emissions	Emissions Applicable Under Paper Coating Category
Anaconda Aluminum Co. Louisville, Jefferson Co.	3497	80	372.0	372.0
Continential Forest Ind. Louisville, Jefferson Co.	2651	100	2,060.0	1,150.0
Crown Zellerbach Corp. Florence, Boone Co.	2641	a	625.3	28.7[b]
Duro Paper Bag Mfg. Ludlow, Kenton Co.	2643	80	17.6	17.6
Duro Paper Bag Mgf. Ludlow, Kenton Co.	2643	400	2.0	2.0
Kendall Company Franklin, Simpson Co.	2641	1,200	1,081.0	683.0
Mead Corporation Florence, Boone Co.	2641	114	327.4	28.7[b]
Mid-Continent Canton Corp. Louisville, Jefferson Co.	2651	50	0.1	0.1[b]
Reynolds Metals Louisville, Jefferson Co.	3497	774	1,004.0	1.8[b]
Southern Specialities Madisonville, Hopkins Co.	2641	75	3,000.0	90.0[b]
St. Regis Paper Co.	2643	1,000	340.0	170.0
			8,829.4	2,543.9[c]

a. Not reported
b. In compliance due to efficiency of emissions controls
c. Six plants with emissions totaling approximately 2,400 tons/year will have to apply controls.

Source: Booz, Allen & Hamilton Inc.

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 5-6, 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. However, newer 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.

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.

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

EXHIBIT 5-6
U.S. Environmental Protection Agency
ACHIEVABLE SOLVENT REDUCTIONS USING LOW
SOLVENT COATINGS IN PAPER COATING INDUSTRY

Type of Low Solvent-Coating	Reduction Achievable (%)*
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

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

Source: Booz, Allen & Hamilton Inc.

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.

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.

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

Waterborne adhesives have the advantage that they can be applied with conventional coating equipment. Waterborne emulsions, which can be applied less expensively than can solvent-borne 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.

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 heat cured, but may be radiation cured. 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. 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.

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 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 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.

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 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.

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 in Section 3.3.3 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

Exhibit 5-7 and 5-8, 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 5-7
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*	28*
Noncatalytic (Afterburner)	183,000	26,000*	13*

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

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

Source: EPA-450/2-76-028

EXHIBIT 5-8
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 LEC. 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. 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.

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 some coaters have found actual installed costs to be three to five times those summarized in Exhibits 5-7 and 5-8.

5.4.2 Estimated Statewide Costs

The total emissions considered to be applicable under RACT, as discussed in Section 5.3.4 of this report, are about 2,400 tons per year. Based on this emission rate and EPA costs as summarized in Exhibits 5-7 and 5-8, capital costs are estimated as $1.4 million, with annualized costs of $336,000 per year. All bases and assumptions used in this estimate are summarized in Exhibit 5-9. The costs presented in Exhibits 5-7 and 5-8 were increased by 25 percent to account for inflationary increases from mid-1974 to mid-1977.

Because most plants will have difficulty in retrofitting add-on control systems, based on the information in EPA 450/276028, capital costs are considered to be low by a factor of three to four. Actual capital costs are estimated to range from $4.2 million to $5.6 million for the plants identified. Equivalent annualized costs would be $1.0 million to $1.3 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 1,944 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.

EXHIBIT 5-9
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.

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.

2,400 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.

- 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.

In general, it appears that if add-on control systems are used deadlines may have to be extended, based on national demand.

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[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Source Categories, EPA-905/278001.

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 annualized costs to coaters was estimated at $1.0 million to $1.3 million. Based on similar economic impact studies, these additional costs are projected to represent 0.4 percent to 0.5 percent of the total annual value of shipments of the firms affected by the proposed regulations. Assuming a "direct passthrough" 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 manufactures various types of recording 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 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.

*   *   *   *

Exhibit 5-10, summarizes the conclusions reached in this study and the implications of the estimated costs of compliance for paper coaters.

EXHIBIT 5-10
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	Six 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 six plants is estimated to be $250 million. They are estimated to employ approximately 2,000 people.
Current industry technology trends	Gravure coating replacing older systems.
1977 VOC emissions (actual) applicable under RACT	Approximately 2,400 tons per year were identified from the emission inventory.
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 $4.2 million to $5.6 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)	$1.0 million to $1.3 million annually. This may represent 0.4 to 0.5 percent of the 1977 annual sales for the affected paper coaters.
Price	Assuming a "direct cost pass-through"--0.4 to 0.5 percent.
Energy	12,900 barrels
Productivity	No major impact.
Employment	No major impact.
Market structure	Smaller firms may be unable to secure capital funding for add-on systems, which are typically $250,000 or more for a moderate sized incinerator to over $1 million for a carbon adsorber.

EXHIBIT 5-10(2)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF KENTUCKY

Affected Areas in Meeting RACT	Discussion
RACT timing requirements (1982)	RACT guideline needs clear definition for enforcement
	Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems.
Problem areas	Retrofit situations and installation costs are highly variable.
	Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 456 tons/year (19 percent of 1977 VOC emission level).
Cost effectiveness of control	\$520 - \$680 annualized cost/annual ton of VOC reduction.

Note: Cost data is based on emission information supplied by the Kentucky Air Pollution Control Board.

Source: Booz, Allen & Hamilton Inc.

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

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

The purpose of this chapter is to present an analysis of the impact of implementing RACT for plants in the State of Kentucky which are engaged in the surface coating of fabrics and vinyls. However, a survey of the fabric and vinyl coating industry in Kentucky by Booz, Allen did not identify any facilities that are likely to be affected by the proposed RACT guildelines in Kentucky. Thus, the proposed RACT guidelines for fabric and vinyl coating would not have an economic impact on the industry in Kentucky. This chapter, therefore, presents the methodology used in identifying potentially affected firms by the RACT guidelines in Kentucky and the results of its application. The chapter is organized into two sections.

- Scope of Proposed Regulations
- Facilities Potentially Affected by the Proposed Regulations.

6.1 SCOPE OF THE PROPOSED REGULATIONS

The proposed Kentucky regulations for controlling VOC emissions from existing fabric coating plants apply to 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 applies to printing on vinyl coated fabrics or vinyl sheets to modify appearance but not to printing on textile fabrics for decorative or other purposes. It also does not apply to the coating of fabric substrates with vinyl plastic polymers which are usually applied to melts or plastisols that result in only minor amounts of emissions.

The proposed regulations apply statewide to plants emitting over three pounds per hour or 15 pounds per day of VOC.

6.2 FACILITIES POTENTIALLY AFFECTED BY THE PROPOSED REGULATIONS

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 for 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; there 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 ware 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	Caskets, packing, sealing devices

A list of 18 establishments expected to be affected by the proposed fabric coating RACT regulations in the state was compiled from the review of the following industry directories:

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

* Not elsewhere classified

6.2 FACILITIES POTENTIALLY AFFECTED BY THE PROPOSED REGULATIONS

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 for 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; there 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 ware 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	Caskets, packing, sealing devices

A list of 18 establishments expected to be affected by the proposed fabric coating RACT regulations in the state was compiled from the review of the following industry directories:

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

* Not elsewhere classified

The Booz, Allen study team interviewed the firms by telephone to determine whether those firms were involved in surface coating of fabric or not and what their emissions or solvent usage were.

As a result of this telephone survey, 14 firms were eliminated from the original list of potentially affected firms because they either do not coat fabrics or are no longer in business.

The remaining four firms included:

. Louisville Textile Weavers	Louisville
. Industrial Plastics of Louisville	Louisville
. Laminating Services, Inc.	Louisville
. American Greetings Corporation	Corbin

Of the above firms, Louisville Textile Weavers applies water soluble protective coating by immersing the fabric in the coating solution. Industrial Plastics uses spraying and dipping methods to coat its products; these fabric coating methods are not subject to the proposed regulations for fabric coating. Laminating Services and American Greetings print fabric or paper which is not covered by the proposed regulations.

In summary, none of the fabric coating facilities in Kentucky would be affected by the proposed Kentucky regulations for VOC control. Thus, there would be no economic impact of implementing the proposed regulation for fabric coating in Kentucky.

7.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF AUTOMOBILES IN THE STATE OF KENTUCKY

7.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF AUTOMOBILES IN THE STATE OF KENTUCKY

This chapter presents a detailed analysis of the impact of implementing RACT for surface coating of automobiles in the State of Kentucky.

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 Federal 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.

The proposed air control regulations for Kentucky for surface coating of automobiles and light duty trucks represent a modified timing requirement for topcoat systems (to the 1982 timing scenario presented in this chapter). Therefore, the economic impact in Kentucky is likely to be represented by Scenario II, which is presented in detail in this chapter.

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 five sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC 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 Kentucky.

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 (only one company manufacturing). 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 the Kentucky EPA and industry interviews.

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.

7.1.5 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 Kentucky.

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 Kentucky. 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	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 Kentucky 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 is one major automobile manufacturing facility that would be affected by the RACT guidelines in Kentucky. Ford has a major assembly plant in Louisville, with two production lines. Exhibit 7-2, on the following page, presents the potentially affected facilities and the approximate number of automobiles and light duty trucks manufactured.

In 1977, there were approximately 93,000 automobiles manufactured in Kentucky, approximately 1.1 percent of the automobiles manufactured in the U.S. In addition, there were approximately 85,000 light duty trucks manufactured at the same facility. The 1977 value of shipments in Kentucky was approximately $0.9 billion. The capital expenditures for this plant are not available; however, historically the expenditures in the auto industry nationwide for new plant and new equipment are 1 percent to 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 - KENTUCKY

Company or Division	Location	Automobile Production for 1976 Model Year	Light Duty Truck Production for 1976 Model Year
Ford-Automotive Assembly Division	Louisville	93,000	85,000

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

This Ford Motor facility employs approximately 3,700 persons, who constitute one percent of the state labor force, excluding government employees; and represents approximately 4.5 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 minutes 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 and 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 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 facilites 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 surface coating of automobiles:

- Prime coat
- Topcoat.

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 solventborne 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 original coating were 12 volume percent solids 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 cards on a development basis at Framingham, Massachusetts, and Metuchen, New Jersey. Along with process color changes 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 matallic.

- Although very low in hydrocarbon emissions, powder coatings 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 would 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 higher 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 the automobile assembly facility in Kentucky in 1977 and the current level of emission controls implemented at the facility. Exhibit 7-3, on the following page, shows the total emissions from the two affected lines at the facility.

- The Ford commercial line in Louisville recently converted the prime coat application to a cathodic electrophoretic system "E-Coat." Although the proposed EPA limitation for prime coat is based on anodic E-coat systems, for purposes of this study it is assumed the current prime coat operation would meet the control requirement of RACT.
  - The cathodic E-coat solvent content is approximately 2.0 pounds per gallon versus the anodic solvent content (recommended by the RACT guidelines) of 0.8 pounds per gallon.
  - The current topcoat application utilizes an enamel coating with approximately 29 percent solids.
  - The current final repair utilizes an enamel with approximately 30 percent solids.
- The Ford passenger line in Louisville does not utilize an "E-Coat" system. Therefore, to meet the control requirements of RACT, modifications would have to be made at most of the regular coating processes.

EXHIBIT 7-3
U.S. Environmental Protection Agency
KENTUCKY EMISSIONS--SURFACE COATING OF AUTOMOBILES

Facility/ Location	Coating Process	Estimated 1977 VOC Emissions (tons/day)	Estimated[a] 1977 VOC Emissions (tons/year)
Ford Motor Company	Body prime	0.85	255
Louisville, KY	Small parts prime	0.26	78
Passenger Line	Small parts enamel	0.66	198
	Body enamel	1.38	414
	Two tone and repair	0.23	69
	Final repair	0.02	6
	Subtotal	3.40	1,020
Ford Motor Company	Prime	0.16	48
Louisville, KY	Enamel	1.33	399
Commercial Line	Two tone and repair	1.0	300
	Subtotal	2.49	747
Total Ford Motor Company Louisville Plant		5.89	1,767

a. Based on 300 day per year operation

Source: Ford Motor Company, Kentucky Environmental Protection Agency.

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 top-coat. 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 waterborne 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 waterborne 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. However, a cathodic system has somewhat higher solvent content than anodic electrodeposition systems.

- 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. 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--organicborne enamel with 35 percent solids.

- Scenario II (Technology Dependent)--RACT timing requirements and possibly emission limitations are modified to meet developing technologies.

Exhibits 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 Agenc
SELECTION OF THE MOST LIKELY RACT
ALTERNATIVES UNDER SCENARIO I (RAC
COMPLIANCE BY 1982)

Processing Area	Control Alternatives	Discussion
Primer	Anodic electrodeposition primer followed by water-borne "surfacer"	Very low VOC emission levels are achievable yet system has some technology disadvantag to other alternatives
	Cathodic electrodeposition primer followed by a waterborne or high solids "surfacer"	Offers improved corros protection and elimina 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 fo energy demands
Topcoat	Waterborne enamels	Only technologically proven alternative that would meet the RACT requirements
		Extremely high capital cost and energy requir ments
Repair	35 percent solids enamel	Technology is not fully developed, i.e., some colors cannot be matche 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 at facilities currently 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. These cost estimates do not reflect specific engineering estimates for the affected lines in Kentucky.

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.

An 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. 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.

- 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 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 analysis of VOC emission reduction, 2.5 pounds per gallon of coating is assumed.

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 $7 million annually (assuming 15 percent of capital based on a 20-year equipment life).

- The annualized cost of the conversion to a waterborne system would be approximately $8 million.

- The additional energy demands are estimated to be 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 timing requirements (and possibly limitations) are modified to reflect developing technologies. Therefore, the following control alternatives are assumed:

- 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 both lines at the affected facility in Kentucky 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.

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 the 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 two potentially affected production lines in the state of Kentucky.

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 to <10	-	<1.5	<1.5	-
Final Repair	-	-	-	-	-
Total, Scenario II	10-22	-	1.5-3.3	1.6-3.1	13,000

Note: Costs are estimated per production line.

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 production lines	2	2
1977 VOC emissions (tons per year)	1,770	1,770
Potential emission reduction (tons per year)	1,220	720-1,220[a]
VOC emissions after RACT (tons per year)	550	550-1,050
Capital cost ($ millions, 1977)	101	13
Annualized cost ($ millions, 1977)	17.6	1.9
Annualized cost per ton of emission reduction($)	14,400	1,550-2,600

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 the commercial line at the Louisville plant already has a cathodic "E-coat" system.

    - On a nationwide basis, these timing requirements for primers represent a moderate forcing of the current technology trend for most manufacturers.

    - For Ford Motor Company in Louisville, the conversion to an electrodeposition process represents changing only the automobile assembly line. 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.

- Construction alone would probably take between three to four years. Although this deadline of construction might be met if Kentucky 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. It has not been proven that high solids enamels can be achieved for metallic colors. The timing requirement might have to be met with add-on control equipment in the short-run (until technology developments are proven for high solids enamel repairs).

Under Scenario II, it is assumed that the RACT timing requirements are modified, so that implementation would meet developing technologies. The only major processing area where significant timing modifications need to be adapted would be for topcoating. The proposed Kentucky air pollution control regulations for surface coating of automobiles and light duty trucks represent a modified timing requirement for the topcoat systems. Therefore, the impact presented for this scenario is likely to be presented by Scenario II rather than Scenario I.

- It is likely that higher 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 fully developed before 1982.

- Topcoat changes at Ford can be minimized if they can meet the proposed limitations with high solids enamel technology.

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 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 electrodeposition 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 $100 million, which represents approximately 700 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 $17 million, which represents approximately 1.9 percent of the statewide auto industry's value of shipments.

- Assuming a "direct cost pass-through" the net price increase would be approximately $95 per car manufactured.

- The automobile manufacturing industry represents approximately 4 to 5 percent of the statewide economy and the direct cost increase of compliance represents approximately 0.08 percent of the value of shipments statewide (all manufacturing industry).

Under Scenario II, which assumes that the RACT timing and possibly limitations are modified to meet technology developments:

- The capital requirement would be approximately $13 million, which represents approximately 100 percent of normal capital expenditures (assuming capital expenditures represent 1.5 percent of value of shipments).

- The net annualized cost increase is approximately $1.9 million, which represents approximately 0.2 percent of the value of shipments.

- Assuming a "direct cost pass-through" the price increase would be approximately $11 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 plantwide 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 4 to 5 percent of Kentucky manufacturing industry.

- If the recommended RACT limitations (Scenario I) require waterborne coating technology, the effect would probably be a total remodeling of existing lines and the remodeling of the existing facility with higher speed lines. This might represent a decrease in employment at this facility and a moderate increase in productivity.

- If the RACT limitations are modified to developing technologies, no significant effects on employment and productivity are forecast. The effect is likely to be a slight decrease in employment (20 to 30 employees) as technological improvements are incorporated.

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 Kentucky.

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 KENTUCKY

SCENARIO I
(RACT Limitations
Implemented By 1982)

Current Situation	Discussion
Number of potentially affected facilities	One company operating two production lines
Indication of relative importance of industrial section to state enconomy	1977 value of shipments was approximately $0.9 billion which represents approximately 4.5 percent of the state's manufacturing industry
Current industry technology trends	Prime coat--cathodic electrodeposition topcoats--higher solids enamels for manufacturers using enamel systems
1977 VOC emissions (actual)	1,770 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)	$100 million (approximately 700 percent of current annual capital expenditures for the industry in the state)
Annualized cost (statewide)	$17.6 million (approximately 2 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass-through" approximately $95 per automobile manufactured
Energy	Increase of 87,000 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.

SCENARIO I
(RACT Limitations
Implemented By 1982)

Current Situation	Discussion
Market structure	Accelerated technology conversion to electrodeposition primer coat
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 energ effective alternative
VOC emission after RACT control	550 tons per year (31 percent of 1977 emission level)
Cost effectiveness of RACT control	$14,400 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

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 KENTUCKY

SCENARIO II
RACT Timing Requirements (And
Possible Limitations) Are Modified
To Meet Developing Technologies

Current Situation	Discussion
Number of potentially affected facilities	One company operating two production lines
Indication of relative importance of industrial section to state enconomy	1977 value of shipments was approximately $0.9 billion which represents approximately 4.5 percent of the state's manufacturing industry
Current industry technology trends	Prime coat--cathodic electrodeposition topcoats--higher solids enamels for manufacturers using enamel systems
1977 VOC emissions (actual)	1,770 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)	$13 million (approximately 100 percent of current annual capital appropriations for the industry in the state)
Annualized cost (statewide)	$1.9 million (approximately 0.2 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass-through" approximately $11 per automobile manufactured
Energy	Dependent on technology applied
Productivity and employment	No major effect

SCENARIO II
RACT Timing Requirements (And Possibly Limitations) Are Modified To Meet Developing Technologies

Current Situation	Discussion
Market structure	No major effect
RACT timing requirements	Primer and final repair limitations could probably be implemented by 1982 Topcoat limitations could be set at a 40 percent to 62 percent solids by 198 dependent on technology developments
Problem area	Limitations for topcoat are dependent on technology development
VOC emission after RACT control	550-1,050 tons per year (31 percent tc 59 percent of 1977 emission levels, depending on limitations)
Cost effectiveness for RACT control	$1,550-2,600 annualized cost/annual tc for VOC reduction

Source: Booz, Allen & Hamilton Inc.

8.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN THE STATE OF KENTUCKY

8.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN THE STATE OF KENTUCKY

This chapter presents a detailed economic analysis of implementing RACT controls for surface coating of metal furniture in the State of Kentucky. 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 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 metal furniture plants, interviews with industry representatives and analysis of findings.

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 Kentucky.

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 Kentucky Directory of Manufacturers supplemented by a review of the 1976 County Business Patterns, and verified and refined by interviews with potentially affected metal furniture manufacturing corporations. The number of employees was obtained from the Kentucky Directory of Manufacturers and refined during interviews with potentially affected metal furniture manufacturers.

The industry value of shipments was estimated by using the national ratio of value of shipments to number of employees for metal furniture, SIC Codes 2514, 2522, 2531 and 2542 from the 1976 Annual Survey of Manufactures. This ratio of approximately $40,000 per employee is in agreement with the actual value of shipments to employees ratio for one metal furniture firm in Kentucky based on information supplied by the firm, and with the value of shipments from the 1972 Census of Manufactures scaled to 1977 assuming a 6 percent linear rate of growth. All of the employees are assumed to be involved in the metal furniture manufacturing operations.

8.1.2 VOC Emissions

The VOC emissions were obtained from the State emissions inventory, except for one facility for which the annual emissions were estimated based on the size of the facility, using the number of employees as a basis.

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 Kentucky. 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 solvent based electrostatic spraying operations. The cost of modifications to handle waterborne or high solids coatings 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 Kentucky.

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 Kentucky. 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	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 Kentucky are presented in this section. Data in this section form the basis for assessing the economic 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

Booz, Allen, through interviews, and the State emissions inventory, has identified five companies participating in the manufacture and coating of metal furniture that are potentially affected by RACT guidelines, as shown in Exhibit 8-2, on the following page. These companies accounted for an estimated $40 million in metal furniture shipments in 1977. This is equivalent to about 1.2 percent of the U.S. value of shipments of metal furniture. The number of employees in these six metal furniture manufacturing firms in Kentucky is approximately 1,000.

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 0.36 percent of the total Kentucky value of shipments of all manufactured goods and the five affected facilities represent approximately 0.2 percent. The industry employs approximately 0.23 percent of all people employed in manufacturing in Kentucky, and the five affected facilities employ approximately 0.12 percent.

EXHIBIT 8-2
U.S. Environmental Protection Agency
LIST OF MANUFACTURERS POTENTIALLY AFFECTED BY RACT GUIDELINES FOR SURFACE COATING OF METAL FURNITURE IN KENTUCKY

Facility Name	Location
Industrial Finishing	Jeffersontown
Kent Division of Walter Kidde	Bellevue
Leggett and Platt	Winchester
Lingo[1]	Florence
Thomas Industries	Louisville

1. Currently using 38 percent solids coating material.

Source: Kentucky Emissions Inventory and Booz, Allen and Hamilton Inc. Interviews.

8.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on metal furniture manufacturing operations, estimated VOC emissions, the extent of current control and the likely alternatives which may be used for controlling VOC emissions in Kentucky.

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. These operations are discussed in detail in the EPA guideline series Control of Volatile Organic Emmissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

8.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from metal furniture manufacturing facilities in Kentucky in 1977 and the current level of emission controls implemented in the state. Exhibit 8-3, on the following page, shows the total emissions from the six metal furniture manufacturing facilities to be about 360 tons per year. These emissions were obtained from the Kentucky Emissions Inventory, except for one firm, Industrial Finishings, Inc., for which emissions were estimated based on the size of the facility.

Experiments with water based coatings by several manufacturers who currently use solvent based electrostatic spray coating lines have not provided the quality of finish or the production line speed desired. One large manufacturer, who will not be affected by RACT, has installed an electrodeposition coating system at a cost of $500,000 replacing the previous electrostatic spray coating system.

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 presented in Exhibit 8-4, following Exhibit 8-3. 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

EXHIBIT 8-3
U.S. Environmental Protection Agency
SUMMARY OF HYDROCARBON EMISSIONS FROM METAL FURNITURE MANUFACTURING FACILITIES IN KENTUCKY

Facility Name	No. of Sources	Current Hydrocarbon Emissions (Tons/Year)
Industrial Finishing	2	6.0
Kent Division of Walter Kidde	2	109.6
Leggett and Platt	2	119.7
Lingo[1]	1	61.9
Thomas Industries	1	163.0
Total Statewide		460.2

1. Currently using 38 percent solids coating material.

Source: Kentucky Emissions Inventory and Booz, Allen and Hamilton Inc. Interviews.

EXHIBIT 8-4
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: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

add-on control device that collects or destroys about 80 percent of the solvent from a conventional high organic solvent coating. 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 8-5, on the following pages.

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 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 several of the affected manufacturers will use their existing spraying equipment and modify it to handle high solids coatings. The reasons given for this preference are that a high quality finish is required, and that extremely high capital costs are required for conversion to waterborne coatings or electrodeposition in relation to the high solids alternative. Manufacturers using dip and flow coating are expected to convert to waterborne coatings.

EXHIBIT 8-5(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

EXHIBIT 8-5(2)
U.S. Environmental Protection Agency

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
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 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

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Waterborne (spray dip or flow coat) (continued)			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
			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

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Powder (spray or dip) (continued)			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
			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	50-80a	May be applied with existing equipment

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
High solids (spray) (continued)			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
			There is little possibility of reusing recovered solvents because of the variety of solvent mixtures

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Carbon adsorption (continued)			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 8-5(7)
U.S. Environmental Protection Agency

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Incinceration (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.

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.

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,[1] maintenance material[1] and capital charges (depreciation, interest, taxes, insurance and administrative charges).[2] 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 8-6 for the electrostatic spraying and in Exhibit 8-7 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, for one of the facilities that uses 35-40 percent solids coating instead of the model plant assumption of 25 percent, less savings for conversion to higher solids (70 percent) would result. The savings of $6,000 in direct operating costs for converting from 25 percent to 70 percent solids for Model Plant A-1 becomes a $2,000 savings when converting from 38 percent to 70 percent solids. Similarly,

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1. Maintenance material and labor charges were assumed to be approximately equal to 4 percent of the capital cost.

2. The capital charges were assumed to be 20.66 percent, which includes 10 percent interest, 4 percent taxes and insurance, and 6.66 percent depreciation based on 15-year life.

EXHIBIT 8-6
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[1] ($000/yr)	53	3	3	12	248	13	13	65
Net annualized cost (credit) ($000/yr)	228	(3)	8	29	1,361	(68)	63	408
Solvent emissions controlled (tons/yr)	N/A	21	20	24	N/A	336	314	380
Percent emissions reduction	N/A	86	80	97	N/A	86	80	97
Annualized cost (credit) per ton of VOC controlled ($/ton)	N/A	(143)	400	1,208	N/A	(202)	201	1,074

Note: 1977 dollars and short tons

1. The capital charges were assumed to be 20.66 percent, which includes 10 percent interest, 4 percent taxes and insurance, and 6.66 percent depreciation based on 15-year life. This differs from the RACT guideline assumption of 18.6 percent.

Source: Booz, Allen and Hamilton, based on Control of Volatile Organic Emissions from Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

EXHIBIT 8-7
U.S. Environmental Protection Agency
ESTIMATED COST OF CONTROL OPTIONS
FOR MODEL EXISTING DIP COATING LINES

	Model Plant B-1 (7 Million Square Feet/Year)		Model Plant B-2 (22.5 Million Square Feet/Year)	
	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[1] ($000/yr)	22	1	44	1
Net annualized cost ($000/yr)	157	11	494	18
Solvent emissions controlled (tons/yr)	N/A	27	N/A	122
Percent emissions reduction	N/A	80	N/A	80
Annualized cost per ton of VOC controlled ($/ton)	N/A	407	N/A	148

Note: 1977 dollars and short tons.

1. The capital charges were assumed to be 20.66 percent, which includes 10 percent interest, 4 percent taxes and insurance and 6.66 percent depreciation based on 15-year life. This differs from the RACT guidelines assumption of 18.6 percent.

Source: Booz, Allen and Hamilton, Based on Control of Volatile Organic Emissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-50/2-77-032, December 1977.

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.

8.4.2 Extrapolation of Control Costs to the Statewide Industry

Exhibit 8-8, 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 Kentucky. The estimates are based on the following assumptions and methods:

- The five plants listed in Exhibit 8-3 that emit measurable quantity of hydrocarbons were assumed to require controls to comply with the RACT guidelines.

- The distribution of control options was based on industry interviews, as well as Booz, Allen estimates. Existing spray coating lines were assumed to convert to high solids or waterborne coatings and existing dip coating lines to waterborne dip.

- The capital cost of control for high solids and waterborne spray and for waterborne dip coating was estimated by scaling up the model plants A-1 and B-1 costs by a capacity factor calculated as follows. The capacity factor was assumed to be one for the coating lines with emissions per line equal to or less than those of the model plants. For the coating lies 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 operating cost for high solids and waterborne spray and waterborne dip coating was assumed to be proportional to the amount of emissions reduction and was scaled up from the model plant costs.

The data in Exhibit 8-8 show that the control of VOC for surface coating of metal furniture to meet the RACT guidelines in Kentucky would require a statewide capital investment of about $162,000 and result in a statewide net annualized cost of approximately $6,000

EXHIBIT 8-8
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF EXISTING METAL FURNITURE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL IN KENTUCKY

Characteristic	High Solids Spray	Projected Control Option		Total
		Waterborne Spray	Waterborne Dip	
Number of plants[a]	4	1	2	5
Number of process lines	6	1	3	10
Uncontrolled emissions (ton/yr)	283	55	122	460
Potential emission reduction (ton/yr)[b]	243	44	98	385
Installed capital cost ($000)[c]	127	24	11	162
Direct annual operating cost (credit) ($000) (1-3 shifts/day)[c]	(63)	11	25	(27)
Annualized capital charges (credit) ($000)[d]	26	5	2	33
Net annualized cost (credit) ($000)	(37)	16	27	6
Annualized cost (credit) per ton of emissions reduced ($)	(152)	364	286	16

a. Total number of plants is less than the sum of individual colums 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, except for one plant converting from 38 percent solids to 70 percent solids where the control efficiency is 75 percent.
c. Based on cost for model plant A-1 and B-1 from Exhibits 8-6 and 8-7.
d. 20.66 percent of capital cost.

Source: Booz, Allen & Hamilton Inc.

Based on data obtained from U.S. EPA (backup data for RACT guidelines), the conversion to high solids or waterborne coatings could result in an energy savings due to reduced heat requirements. Using model plant A-1, for high solids conversion the estimated savings is 129 equivalent barrels of oil per year, and for waterborne spray conversion it is estimated at 171 equivalent barrels per year. Using model plant B-2, for waterborne dip conversion the estimated savings is 192 equivalent barrels per year. Assuming that energy savings is proportional to emissions reduction, the savings for the state would be equivalent to approximately 2,100 barrels of oil annually.

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 pass-through), state economic variables and capital investment.

8.5.1 RACT Timing

RACT must be implemented statewide by April 1, 1981. This implies that surface coaters of metal furniture must have made their process modifications and be operating within less than three 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.

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.

Some metal furniture manufactures have exerpimented with waterborne spray coatings, but have not succeeded in obtaining the desired quality finish. None of the metal furniture manufacturers potentially affected by RACT has implemented high solids coatings to date. However, based on interviews with industry representatives, it is predicted that several manufacturers will convert to high solids spray coatings in order to comply with RACT guidelines. These coating materials may not be available in the desired quality and the variety of colors required by the manufacturers. The development of suitable coating materials in a variety of colors is the key to successful implementation of RACT in the required time.

Another problem likely to be encountered by the metal furniture manufacturers is that of excessive use of the high solids coatings. Experiments by one manufacturer indicate that personnel accustomed to high solvent coatings are likely to apply more than the desired thickness of coating, thus using more paint. This problem could be alleviated through training of personnel. It is also possible that the increased demand for high solids coatings may raise the price of these coating materials.

Unless major modifications to equipment are required, for example, automated coating lines or complete isolation of large 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.

However, for facilities that currently use dip and flow coating processes, conversion from solvent based to water based coating materials could have a significant economic impact on operating costs due to the special preparation and handling of metals to be coated. One manufacturer who uses solvent based flow coating exclusively for the coating of metal household furniture parts indicated that he would consider closing the coating portion of his operation rather than convert to a water based flow coating system.

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 0.007 percent of the industry's 1977 value of shipments manufactured in the State, and 0.015 percent of the value of shipments for the five affected facilities. This increase may translate to a few cents per unit of furniture manufactured to more than $1 per unit manufactured, depending on the furniture surface area coated.

The major economic impact in terms of cost to most individual companies will be capital related rather than from increased annual operating costs, the exceptions being dip and flow coating operations. The capital required for RACT compliance presents a significant capital appropriation problem for the smaller companies, the severity of which will depend upon the ability of these companies to pass on these costs through higher prices. The capital drain could also be reflected in any opportunities lost because of capital usage for RACT compliance.

8.6 SELECTED SECONDARY ECONOMIC IMPACTS

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

Employment could be adversely affected if facilities using dip and flow coating decided to close their operations rather than convert to waterborne coating systems. The number of employees directly involved in these coating operations in the two facilities that use these processes totals less than 100, or approximately 5 percent of the total number of persons employed in the metal furniture industry in Kentucky.

By converting to high solids coatings, productivity could be increased because manufacturers will be able to get more paint on per unit volume basis and reduce paint application time. However, the necessity of converting to airless guns, with slower application of coatings, could reduce coating line speed and thereby reduce productivity for some manufacturers. Line speed is also reduced with the use of waterborne coatings due to increased drying time.

The conversion to high solids or waterborne coatings by the affected manufacturers could result in a net savings of energy equivalent to approximately 1,300 barrels of oil annually.

* * * * *

Exhibit 8-9, on the following page, presents a summary of the current economic implications of implementing the RACT guidelines for surface coating of metal furniture in the State of Kentucky.

EXHIBIT 8-9

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	There are five metal furniture manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was approximately $77 million industry-wide and approximately $40 million for five affected facilities
1977 VOC emissions (actual)	460 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)	$162,000
Annualized cost (statewide)	$6,000, which represents 0.007 percent of the industry's 1977 value of shipments
Price	Increase a few cents to over $1/unit depending on the surface area coated
Energy savings	2,100 equivalent barrels of oil per yr.
Productivity	No major impact
Employment	Small adverse impact if some operations close
Market structure	No major impact
RACT timing requirements (1982)	Companies using a variety of colors may face a problem finding suitable low solvent coatings
Problem area	Low solvent coating in a variety of colors providing acceptable quality needs to be developed
VOC emissions after RACT	75 tons per year (approximately 16 percent of current emissions level)
Cost effectiveness of RACT	$16/annual ton of VOC emissions reduction

Source: Booz, Allen and Hamilton Inc.

10.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF KENTUCKY

10.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF KENTUCKY

This chapter presents a detailed analysis of the impact of implementing RACT for surface coating of large appliances in the State of Kentucky. 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 Kentucky.

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 Kentucky EPA provided a copy of their state's emissions inventory. Emissions were listed for seven companies identified as major emitters in this category. The emission data provided by the Kentucky EPA survey are used as the basis for current VOC emissions in 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.

This study also covers exceptions to the model plant used in the economic analysis and requiring major reconstruction and/or modification of existing lines to meet RACT. These exceptions include major alterations to spray booth configurations or installation of electrodeposition for prime coating operations or both. These exceptions were applied only when specific information was made available from large appliance coaters as to their applicability.

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 Kentucky.

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 Kentucky. 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 Agenc–
SURFACE COATING OF LARGE APPLIANCE:
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimate 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 Kentucky are presented in this section. The discussion includes a description of the number of facilities, a comparison 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 Kentucky.

10.2.1 Size of the Industry

The Kentucky EPA reports and Booz, Allen interviews have identified seven companies participating in the manufacture and coating of large appliances as shown in Exhibit 10-2, on the following page. These companies accounted for between $1.3 billion and $1.7 billion in shipments. The estimated number of employees in 1977 was between 15,000 and 20,000. This data and the sources of information are summarized in Exhibit 10-3, following Exhibit 10-2, and indicate that Kentucky shipped an estimated 8 percent to 11 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 4.5 percent to 8.0 percent of the total Kentucky value of shipments of all manufactured goods. The industry employs between 5.0 percent and 7.0 percent of all people employed in manufacturing in Kentucky. These figures are shown in Exhibit 10-4, following Exhibit 10-3, 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
LIST OF MANUFACTURERS, POTENTIALLY AFFECTED BY RACT GUIDELINES, WHO SURFACE COAT LARGE APPLIANCES IN KENTUCKY

Facility Name	Location
Cissell Manufacturing	Louisville
Clow Corporation	Florence
General Electric	Louisville
Tappan	Murray
Trane Company	Lexington
Queen Products Company	Louisville
Whirlpool	Danville

Source: Kentucky EPA Emissions Inventory

EXHIBIT 10-3
U.S. Environmental Protection Agency
INDUSTRY STATISTICS--SURFACE COATING OF LARGE APPLIANCES
KENTUCKY

		U.S. Totals[a] 1977		Kentucky Totals[a]		
SIC Code	RACT Category	Estimated No. of Units Shipped (thousand)	Estimated Value of Shipments ($ million)	Estimated Percent of U.S. Shipments	Estimated Value of Shipments ($ million)	Estimated No. of Units Shipped (thousand)
3582	Commercial laundry	b	200	3-4 (3582 and 3585 combined)	300-400 (3582 and 3585 combined)	-
3585	Commercial refrigeration and air conditioning	b	9,500			-
3589	Commercial cooking and dishwashing	b	150	-	-	-
3631	Household cooking	5,000	1,500	15-20	250-300	800-1,000
3632	Household refrigerator and freezer	7,300	2,000	20-25	450-500	1,600-1,850
3633	Household laundry	8,500	1,500	15-20	225-275	1,275-1,600
3639	Household appliances: Water heaters Dishwashers Trash compactors	9,300	800	18-25	150-175	1,744-2,100
	TOTAL		15,650	8-11	1,375-1,650	5,400-6,600

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 10-4
U.S. Environmental Protection Agency
COMPARISON OF LARGE APPLIANCE STATISTICS WITH STATE OF KENTUCKY ECONOMIC DATA

	Estimated Kentucky Economic Indicators	Estimated Percent of Kentucky Manufacturing Economy Engaged in Large Appliance Manufacturing
Total 1977 value of shipments of all manufactured goods	$22-28 billion	4.5 to 8.0
Number of employees in manufacturing	280,000-300,000	5.0 to 7.0

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 25, 1977) for categories 3631, 3632, 3633 and 3585; Sales and Marketing Management, April 24, 1978; 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 10-5 and 10-6, on the following pages.

EXHIBIT 10-5
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 10-6
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 Kentucky 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 10-7 and Exhibit 10-8, on the following pages, describe and illustrate the pretreatment, coating and curing processes for a typical large appliance facility.

EXHIBIT 10-7

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:

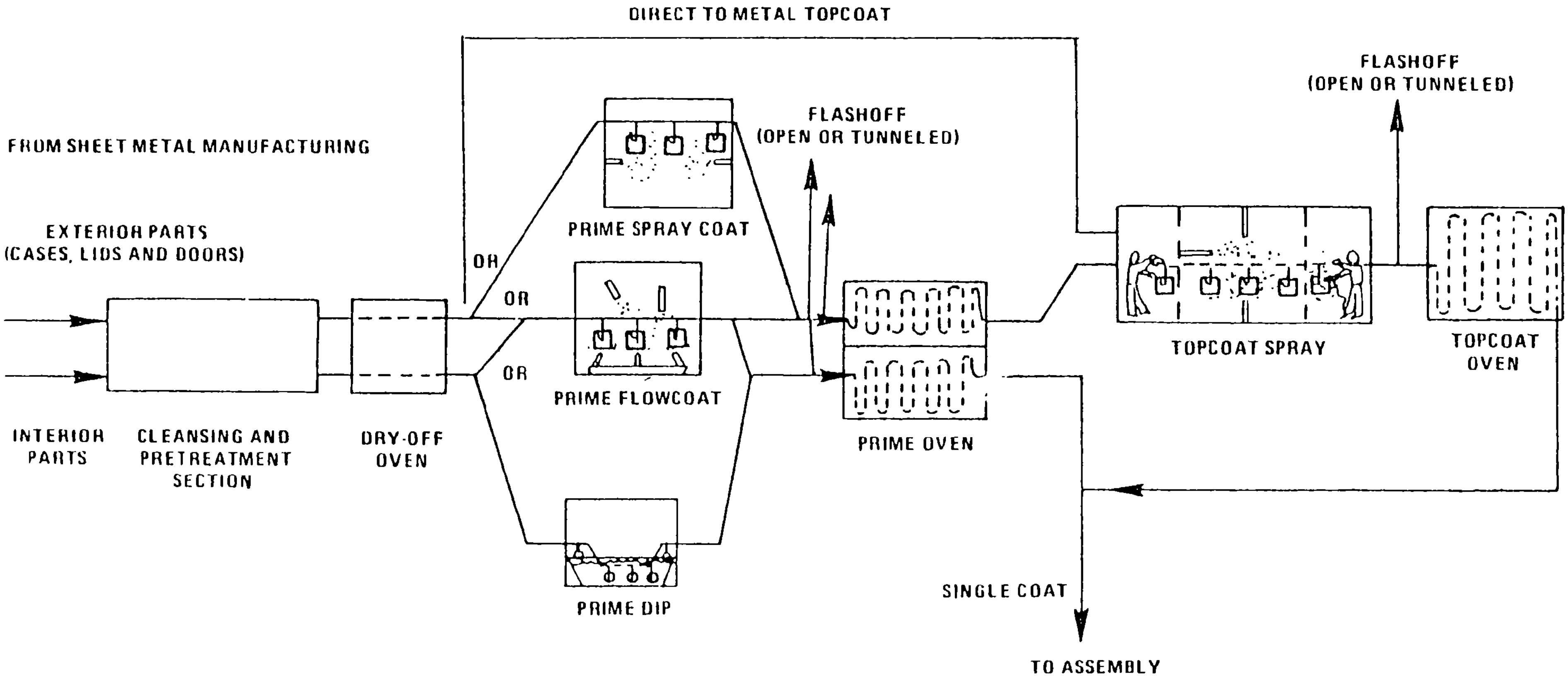
- Epoxy
- Epoxy-acrylic
- Acrylic or polyester enamels
- Alkyd resins

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, EPA-450/2-77-034, December 1977.

EXHIBIT 10-8
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 Kentucky 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

Applicability of RACT to meet the 2.8 pounds of solvent per gallon of coating (minus water) for current operations would provide emission reduction of 80 percent for primecoating and 60 percent for topcoating. Assuming equal emissions for both coating operations, this leads to an average emissions control efficiency with RACT of 70 percent.

Exhibit 10-9, on the following page, shows the total estimated emissions in tons per year from coaters of major appliances in Kentucky. The Kentucky EPA estimated emissions in Kentucky from seven appliance coating facilities are 7,149 tons per year. However, interviews with General Electric and calculations of paint usage indicate an emission level much lower than the EPA estimates.

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 10-10, 10-11 and 10-12, following Exhibit 10-9, summarize the RACT emission limitations and control options for VOC emissions control for surface coating of large appliances.

EXHIBIT 10-9
U.S. Environmental Protection Agency
RACT DATA SUMMARY FOR ESTIMATED VOC EMISSIONS FOR
SURFACE COATING OF LARGE APPLIANCES IN STATE OF KENTUCKY

Facility Name	Current Average Hydrocarbon Emissions (Ton/Year)	Average Control Efficiency with RACT (Percent)	Potential Emission Reduction with RACT (Ton/Year)
Cissell Manufacturing	11	70	8
Clow Corporation	70	70	49
General Electric	6,340[a]	70	4,438
Tappan	116		81
Trane Company	48	70	34
Queen Products Company	9	70	6
Whirlpool	555[b]		389
Total	7,149		5,005

a. This number is based on data from EPA permits and the actual figure may be considerably lower, as indicated by conversation with the appliance coater.

b. Represents only those hydrocarbons subject to RACT guidelines.

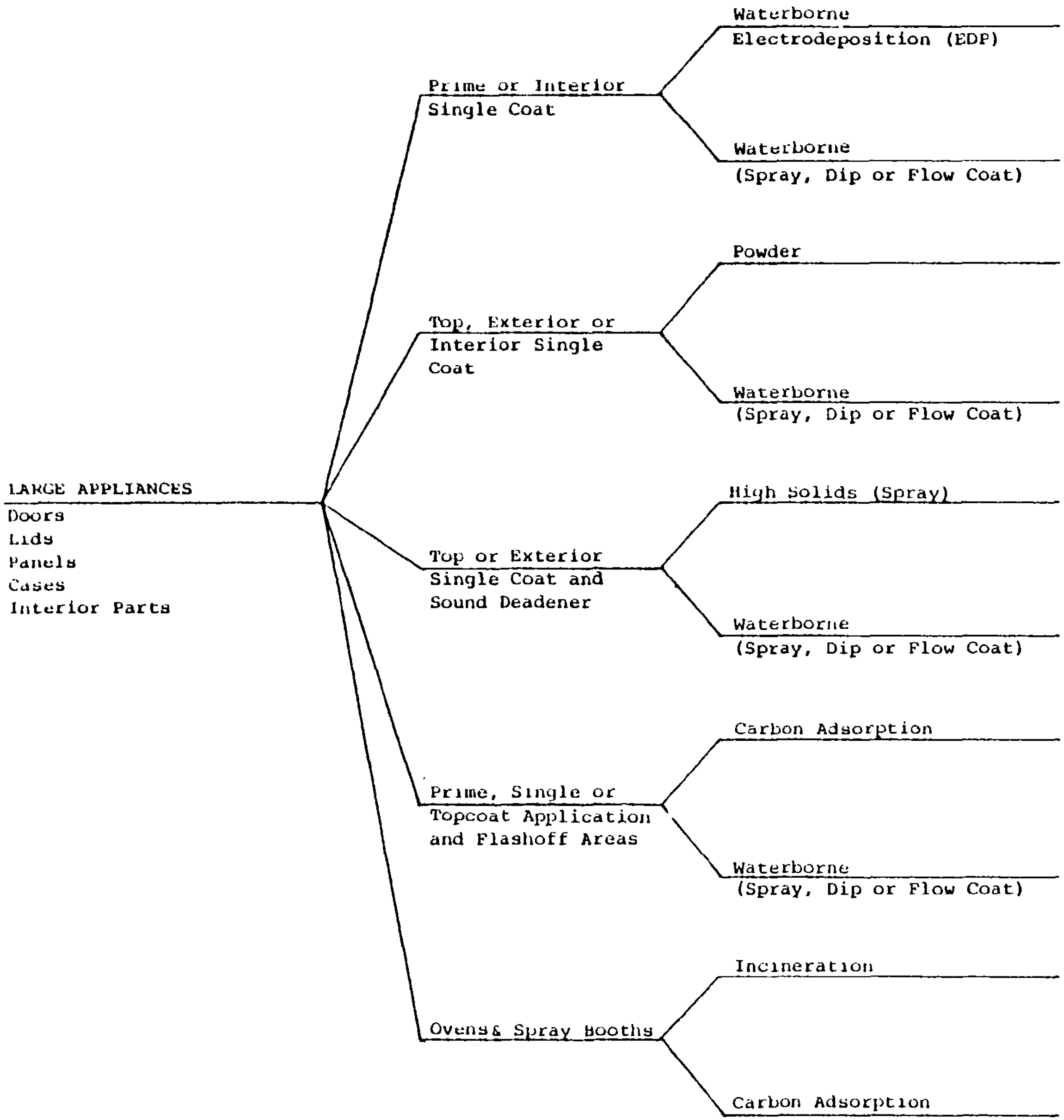
Source: Kentucky EPA Emissions Inventory List

EXHIBIT 10-10
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 10-11
U.S. Environmental Protection Agency
SUMMARY OF APPLICABLE CONTROL TECHNOLOGY FOR
COATING OF LARGE APPLIANCE DOORS, LIDS,
PANELS, CASES AND INTERIOR PARTS



Source: Control f Volatile Organic Emissions rom Existing Stationary Sources--Volume V: Surface Coating of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-12(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 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 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, 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.

Those unique applications, where conversion from conventional enamel to waterborne coatings requires the implementation of technology alternatives other than the ones stated above (i.e., electrodeposition), were addressed in this study on an individual basis, as the information was made available from industry interviews.

EXHIBIT 10-13
U.S. Environmental Protection Agency
MOST LIKELY RACT CONTROL ALTERNATIVES FOR
SURFACE COATING OF LARGE APPLIANCES
IN STATE OF KENTUCKY

Coat	Existing System	Most Likely Alternative Control Techniques
Prime	Dip or flow coating with 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
		Electrodeposition[a]
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

a. Only for applications where conversion to waterborne flow coating will not meet the minimum coverage specifications originally provided by conventional enamel flow coating.

Source: Booz, Allen & Hamilton Inc.

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

Cost 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 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 10-14, on the following page.

If an existing primecoat 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 $15,000 and $20,000. 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 10-14
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 $15,000 - $20,000
	Electrodeposition	Replace existing system with EDP equipment (including washing; ultrafiltration; deionization)	Installed capital $300,000 - $500,000 Annualized cost $75,000 - $125,000
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 $15,000 - $20,000
		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 $15,000 - $20,000
		Major revamp of booth configuration and air handling system in addition to changes stated above	Installed capital $750,000 - $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 $15,000 and $20,000. 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 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.

In special applications areas, such as the primecoating of air conditioner cases, the conversion to waterborne dipcoating will not meet the minimum coverage requirements previously provided by conventional enamel dipcoating. In this case, the conversion to electrodeposition primecoating and high solids topcoating is necessary both to meet RACT and to provide adequate exposure protection for the product.

The cost of electrodeposition, as developed by Springborn Laboratories (under EPA contract number 68-02-2075), is estimated at $500,000 capital installed. The annualized costs would be approximately $125,000.

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, definitive 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 10-15, 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 Kentucky. 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.

- 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.

- The seven plants identified by the Kentucky EPA and from Booz, Allen interviews represent the majority of all the state industry production of large appliances.

- For the specific alternatives listed in Exhibit 10-14, 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 Kentucky for process modifications to meet RACT guidelines is estimated at $6.6 million. The annual cost is estimated at $288 to $314 per ton of emission controlled.

EXHIBIT 10-15
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF
EXISTING LARGE APPLIANCE COATING LINES
TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL
KENTUCKY

Characteristic	Flow Or Dip Coat Operations Converting To Waterborne	Flow Or Dip Coat Operations To Electrodeposition	Spray Operations Requiring Average Modifications	Spray Operations Requiring Major Modifications	Total
Number of applications	7	3	16	13	39
Estimated value of shipment ($ billion)	a	a	a	a	1.3-1.7
Uncontrolled emissions (tons/year)	a	a	a	a	7,149
Potential emission reduction (tons/year)	a	a	a	a	5,005
Installed capital cost[b] ($ thousand)	525	1,500	1,275	3,250	6,550
Direct annual operating cost (credit) ($ thousand) (1-3 shifts per day)	a	a	(32[d]-96[e])	(32[d]-96[e])	(64[d]-192[e])
Annual capital charges ($ thousand)	130	375	319	813	1,637
Net annual operating costs[c] ($ thousand)	130	375	223[d]-287[e]	717[d]-781[e]	1,445[d]-1,573[e]
Annual cost per ton of emission reduced ($)	a	a	a	a	288[d]-314[e]

a. Not available
b. Figures represent the upper limit of the installed capital costs.
c. Net annual operating cost is the summation of the direct annual operating cost and the annual capital charges.
d. Represents a three shift per day operation.
e. Represents a one shift per day operation.

Source: Booz, Allen & Hamilton Inc.

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 has been no attempt at preheating 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. Preheat 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 discs or bells. This requires the use of preheaters and high 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. However, we believe that significant delivery delay may occur if all appliance coaters require delivery of such equipment within the same timeframe.

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 0.1 percent of the industry's 1977 value of shipments manufactured in the state. This increase may translate to an approximate cost increase of $0.25 per unit of household appliance coated; the average cost of a unit is $250.

The major economic impact in terms of cost to individual companies will be capital related rather from increased annual operating costs. The capital required for RACT compliance could represent a significant amount of capital appropriations for the companies affected.

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 would 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., direct cost increases will probably not be passed along in the marketplace in the form of a price increase and will 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 10-16, on the following page, presents a summary of the current economic implications of implementation RACT for surface coating of large appliances in the state of Kentucky.

EXHIBIT 10-16
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR SURFACE COATING OF LARGE
APPLIANCES IN THE STATE OF KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	There are seven major large appliance manufacturer and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $1.5 billion and represents 10 percent of the estimated $15 billion U.S. value of shipments of the major appliance industry
1977 VOC emissions (actual)	7,149 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)	$6.55 million
Annualized cost (statewide)	$1.50 million which represents 0.10 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.25/unit for household appliances (based on a price of $250 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 5,650 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	2,144 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$300 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton Inc.

11.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF KENTUCKY

11.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF KENTUCKY

This chapter presents the estimated economic impact of the implementation of reasonably available control technology for volatile organic compound emissions from solvent metal degreasers. The analysis presented in this chapter is based on the methodologies developed to assess the impact of the RACT guidelines developed by the U.S. EPA, with some modifications to address the revised Kentucky regulations. The modifications are as follows:

- Since the revised Kentucky regulations do not exempt the use of 1,1,1 trichloroethane and trichlorotrifluoroethane, the analytical methodology was modified to address this change.

- The RACT guidelines apply to sources with VOC emissions over 15 pounds in any 1 day or 3 pounds in any 1 hour, whichever is greater. The Kentucky regulations for four urban nonattainment counties, Boone, Campbell, Jefferson, and Kenton, are similar, but for the other counties, they only apply to sources with potential emissions over 100 tons per year. Therefore, the analysis of the Kentucky regulations was divided into two parts. First, the impact of controlling affected sources in the four urban counties was assessed as described in the body of this chapter. The estimated cost per ton of VOC emissions reduction for these counties was then used to evaluate the cost of controlling affected sources in the other counties. Based on the data provided by the Kentucky Division of Air Pollution, the following four facilities in the non-urban counties would be affected by the revised regulations: Emerson Electric, Logan County; A.O. Smith Corp., Montgomery County; Tecumseh Products, Pulaski County; and Cuttler Hammer, Warren County. These facilities have current VOC emission from solvent metal cleaning of 282 tons per year. Assuming an average of 55 percent emission reduction by complying with the regulations, the estimated VOC emissions reduction from these facilities would be 155 tons per year. This reduction was used as the basis to estimate the cost of controlling these facilities. The aggregate impact of controlling these facilities and those in the four urban counties is presented in the summary exhibit (Exhibit 11-17) at the end of this chapter.

The rest of this chapter is divided into five sections:

- Specific methodology
- Industry statistics
- Estimated costs of RACT implementation
- Direct economic impacts
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analysis of the RACT guidelines; previous studies of metal degreasing; interviews with degreaser users, equipment and material suppliers; and a review of pertinent published literature.

11.1 SPECIFIC METHODOLOGY

11.1.1 Background

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.

Solvent metal cleaning can be divided into three categories, cold cleaning, open top vapor degreasing and conveyorized degreasing.

Cold cleaner operations include spraying, brushing, flushing and immersion of articles in a solvent. The solvent is occasionally heated but always remains well below its boiling point.

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 automative 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 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 are thus difficult to classify.

Cold cleaners are estimated to result in the largest total emission of the three categories of degreasers 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.

Open top vapor degreasers clean only one workload at a time. They clean through the condensation of hot solvent vapor on colder metal parts. 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. One section of the degreaser 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 which are supplied with a coolant such as water. Nearly all vapor degreasers are equipped with a water separator 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.

The third category of degreasers is conveyorized degreasers. There are several types operating both with cold and vaporized solvents. The types of conveyorized degreasers include crossrod, rotating wheels, conveyor belts, and monorails as well as other systems which convey the parts through the degreasing medium.

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.

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.

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1 Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

As recently as 1974, degreasing operations were exempt from regulation in 16 states, since they rarely emitted more than the 3,000 pounds per day of volatile organic compounds (VOC) which was the regulatory level then in effect in these states. 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 VOC 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 retrofitted 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 in manufacturing or service firms not included in one of the eight SIC groups or in firms with less than 20 employees.

To determine the number of open top and conveyorized vapor metal degreasers in the state, first the number of plants with more than 19 employees 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 11-1, 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 the eight metal working SIC groups by the ratio of 22,200/15,200 (the ratio of total open top units in the U.S. to those used in the eight SIC groups in the U.S.)

Because of their expense and function, conveyorized vapor degreasing units are most likely to be used in

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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.

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[1] estimated ratio of total conveyorized cleaners to vapor conveyorized cleaners in the U.S.

The number of cold cleaners in the state was based on the Dow estimates of cold cleaning done in plants in the eight SIC metal working industries and the EPA estimate of 1,300,000 cold metal cleaners in the U.S., which include 390,000 in manufacturing use and 910,000 in maintenance or service use.[2] Then:

- The EPA estimates of all cold cleaners in manufacturing use 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.

- 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.

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1 Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

2 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.

- 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 7694 applies to industries categorized as armature rewinding shops.

The estimates of the total number of cold cleaners in the affected state obtained by these calculations are tabulated in Exhibit 11-2.

11.1.3 Method of Estimation of Affected Degreasers

The state regulations propose several exemptions for degreasers based on size and 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 not be affected.

- 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.

- 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]

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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.

The resulting estimate of the total number of degreasers in the state and those exempt from the proposed regulations by size are summarized in Exhibit 11-3, 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 affected 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 affected 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 affected 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 11-14, 11-15 and 11-16, of this chapter, summarize estimates of the percentage of non-exempt 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 type of control 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 affected cleaners in the state. For purposes of estimation, a 50 percent reduction was used for cold cleaners. For open top vapor and conveyorized cleaner, 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 Organic Emissions from Solvent Metal Cleaning, for average-sized, cold, open top vapor and conveyorized cleaners. These 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 made 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:

- Safety switches, minimizing conveyorized cleaner openings, and downtime cover capital costs 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.
- $300 was used as an average cost for increasing freeboard of cold cleaners using high volatility solvents.

- 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 Kentucky. 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 was not available in secondary literature and was extrapolated from hard data (i.e., data that is published for the base year) and "C" indicates data was estimated based on interviews, analyses of previous studies and best engineering judgement. Exhibit 11-1A, on the following page, rates each study output and overall quality of the data.

EXHIBIT 11-1A
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 affected in the state determined by the methods discussed in section 11.1.2 of this report. As shown in Exhibits 11-1 and 11-2, on the following pages, a total of 79 open top vapor degreasers, 19 conveyorized degreasers and 5,026 cold cleaners are estimated to be in use in Kentucky[1] in manufacturing, maintenance or service. As discussed earlier, not all of these will be subject to RACT regulations because of size. About 30 percent of open top vapor degreasers, 10 percent of conveyorized degreasers and 20 percent of cold cleaners are expected to be exempt on the basis of size. Applying these factors results in the total of affected cleaners shown in Exhibit 11-3, following Exhibit 11-2.

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 11-1, 185 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 11-2, following Exhibit 11-1, there are a total of 437 plants in SIC groups 25 and 33-39 and an additional 916 plants in service industries; all of these are expected to have some type of solvent degreasers and could be potentially affected.

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[1] In the four urban non-attainment counties.

EXHIBIT II-1 (1)
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF VAPOR DEGREASERS
IN KENTUCKY

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 Kentucky plants with more than 19 employees[a]	14	9	53	50	18	12	4	15	185
Percent of U.S. plants using solvent degreasing[b]	46	40	42	52	55	50	65	39	
Percent of Kentucky plants using solvent degreasing[b]	44	38	40	50	53	48	62	37	
Number of Kentucky plants using solvent degreasing	6	4	26	26	10	6	3	6	87
Percent of U.S. plants using vapor degreasing[b]	48	42	41	33	67	43	62	56	
Percent of Kentucky plants using vapor degreasing[b]	40	35	34	27	55	36	51	46	
Number of Kentucky plants using vapor degreasing	3	2	11	9	7	3	2	3	40
Average number of vapor degreasers per U.S. plant[b]	1.98	2.21	1.62	1.61	2.03	3.25	2.27	1.02	
Average number of vapor degreasers per Kentucky plant[b]	1.76	1.96	1.44	1.43	1.80	2.88	2.01	0.90	
Number of vapor degreasers in Kentucky	6	4	17	14	13	9	4	3	70
Percent in U.S. as open top degreasers	73	79	79	81	87	87	94	89	

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

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 Kentucky as open top degreasers	67	72	72	74	80	80	86	82	
Number of open top vapor degreasers in Kentucky[e]	4	3	13	11	11	7	3	2	79[c]
Number of conveyorized vapor degreasers in Kentucky[e]	2	1	4	3	2	2	1	1	19[d]

NOTE: All data based on plants with more than 19 employees in the four urban non-attainment counties

a. Source. County Business Patterns, U.S. Department 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 open top 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.

e. Number of degreasers rounded to the nearest whole integer.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-2
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF COLD
CLEANERS IN KENTUCKY

	U.S.	Kentucky
Total number of plants in SIC Groups 25,33,34,35,36,37,38,39[a]	125,271	437
Estimated number of cold cleaners in manufacturing[b]	390,000	1,360
Total number of plants in service industries SIC 551,554,557,7538,7539, 7694[a]	227,350	916
Estimated number of cold cleaners in maintenance and service use [b,c]	910,000	3,666
Estimated total number of cold cleaners[a]	1,300,000	5,026

Notes: Data for the four urban non-attainment counties

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 in both manufacturing and repair firms.

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-3
U.S. Environmental Protection Agency
ESTIMATE OF AFFECTED SOLVENT METAL
CLEANERS IN KENTUCKY

	Number of Cleaners by Type		
Exemption	Cold	Open Top Vapor	Conveyorized
Total number of cleaners	5,026	79	19
Number exempt by size	3,518	24	1
Number affected by size	1,508	55	18
Number further exempted by type of solvent used	-	-	-
Total number of affected cleaners	1,508	55	18

Source: Booz, Allen & Hamilton, Inc.

11.2.1 Proposed Emission Control Systems for Solvent Metal Cleaners

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 11-4, 5 and 6, on the following pages, and are briefly discussed below. In general, use of control system B has been proposed to maximize emission reductions.

11.2.1.1 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 11-4) is not large because most of the cold cleaning emissions are controlled in system A. If the requirements of system A 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 additional

EXHIBIT 11-4
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 as that greater than 20 percent of the waste (by weight) can evaporate into the atmosphere.* 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

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* 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 11-5(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 aleast 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 shut down 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).

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 11-6
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 waster (by weight) can evaporate into the atmosphere. Store waste solvent only in covered containers.

4. Repair solvent leaks immediately, or shut down 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 adsorption 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 either 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 shut down and removed just before they are started up.

Source: EPA-450/2-77-022, op. cit.

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.

11.2.1.2 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 11-5.

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.

EPA estimates that system A may reduce open top vapor degreasing emissions by 45 (± 15) percent, and system B by 60 (± 15) percent. For an average-sized open top vapor degreaser, systems A and B would reduce emissions from 9.5 m tons/year down to about 5.0 and 3.8 m tons/year, respectively. It is clear that system B is appreciably more effective than system A.

11.2.1.3 Conveyorized Degreasing Control Systems

Control devices tend to work most effectively on conveyorized degreasers, mainly because they are enclosed. Since these control devices can usually result in solvent savings, they often will net an annualized profit. Two control systems for conveyorized degreasers as recommended by EPA are in Exhibit 11-6. Control system A requires only proper operating procedures which can be implemented, in most cases, without large capital expenditures. Control system B, on the other hand, requires a major control device.

Major control devices can provide effective and economical control for conveyorized degreasers. A refrigerated chiller will tend to have a high control efficiency, because room drafts generally do not disturb the cold air blanket. A carbon adsorber also tends to yield a high control efficiency, because collection systems are more effective and inlet streams contain higher solvent concentrations for conveyorized degreasers than for open top vapor degreasers.

11.2.2 Emissions and Expected Emission Reduction

In Exhibit 11-7, 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 non-exempt 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 11-8, following Exhibit 11-7, 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 3,050 short tons per year to a total of 2,350 short tons per year. The major portion of these reduced emissions, 1,450 tons, are from solvent metal cleaners exempt from the proposed RACT regulations by size. Implementation of the regulations will reduce emissions by 700 tons per year (3,050-2,350).

EXHIBIT 11-7
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.

EXHIBIT 11-8
U.S. Environmental Protection Agency
ESTIMATED CURRENT AND REDUCED EMISSIONS FROM SOLVENT METAL CLEANING IN KENTUCKY[b]

Type of Cleaner	Estimated Current Emissions	Estimated from Nonexempt Cleaners After RACT	Estimated Emissions From Exempt Cleaners After RACT[a]	Estimated Total Emissions After RACT[a]
Open top vapor	850	350	250	600
Conveyorized	550	300	50	350
Cold	1,650	250	1,150	1,400
Total	3,050	900	1,450	2,350

a. Includes emissions from cleaners exempt by size or using 1,1,1-trichloroethane or Freon 113

b. All numbers rounded to nearest 50 tons/year

Source: Booz, Allen & Hamilton Inc.

11.3 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 11-9 and 11-10, on the following pages.

Costs of implementation of the RACT regulations are summarized in Exhibits 11-11, 11-12 and 11-13 on the assumption that control methods B are used to maximize emission reduction on nonexempt cleaners. Exhibits 11-14, 11-15, and 11-16 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 $0.9 million in capital and about $0.10 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 no case are the regulations expected to present a severe 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 any particular firm.

EXHIBIT 11-9
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 ($)	25.00	365.00
Direct operating costs ($/yr.)	1.00	2.6
Capital related charges ($/yr.)	4.30	91.25
Solvent cost (credit) ($/yr.)	(4.80)	(39.36)
Annualized cost (credit) ($/yr.)	0.50	54.49

a. Costs include only a drainage facility for low volatility solvents.

b. Includes $65 for drainage facility, a mechanically assisted cover, and $300 for extension of freeboard.

c. Capital charges used in study estimate were 25 percent of capital instead of 17 percent used in EPA report.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-10
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 related charges ($/yr.)	75	2,575	1,625	2,000
Solvent cost (credit) ($/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 (4)	17,600	8,550	17,600	7,460
Direct operating costs ($/yr.)	970	430	754	334
Capital related charges ($/yr.)				
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
ESTIMATED CONTROL COSTS FOR COLD CLEANERS
FOR THE STATE OF KENTUCKY

1. CAPITAL COSTS

Item	Number of Degreasers Needing Conversion	Costs
Capital	1,026	$348,650

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 2,546
Capital related charges	87,162
Solvent cost (credit)	(35,757)
Net annualized costs	$ 53,951

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-12
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR OPEN TOP
VAPOR DEGREASERS FOR THE STATE OF KENTUCKY

1. CAPITAL COSTS

Item	Costs
Safety switches	$ 1,100
Powered covers	400,000
Manual covers	5,100
Total	$406,200

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 5,170
Capital related charges	101,550
Solvent cost (credit)	(67,510)
Net annualized costs	$ 39,210

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-13
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR CONVEYORIZED DEGREASERS FOR THE STATE OF KENTUCKY

1. CAPITAL COSTS

Item	Costs
Refrigerator chillers	
Monorail degreasers	$ 59,850
Crossrod degreasers	74,600
Safety switches	1,000
Drying tunnel	5,000
Reduce openings	16,000
Downtime covers	4,800
Total	$ 161,250

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 30,350
Capital related charges	40,312
Solvent cost (credit)	(62,011)
Net annualized cost	$ 8,651

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-14
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF COLD CLEANERS
NEEDING CONTROLS IN THE STATE
OF KENTUCKY

Type of Control	Estimated Percent of Cleaners Needing Control	Estimated Number of Cleaners Needing Control
Drainage Facility Only[a]	5	76
Freeboard and Drainage[b]	63	950

a. Based on 10 percent of cleaners using low volatility solvents and half of these needing drainage facilities.

b. Based on 90 percent of cleaners using high volatility solvents and 70 percent of these needing additional freeboard and drainage.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-15
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF OPEN TOP VAPOR
DEGREASERS NEEDING CONTROL IN THE
STATE OF KENTUCKY

Type of Control	Estimated Percent of Cleaners Needing Control	Estimated Number of Cleaners Needing Control
Manual covers	30	17
Safety switches	20	11
Powered cover	90	50

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-16
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF CONVEYORIZED
DEGREASERS NEEDING CONTROLS
IN THE STATE OF KENTUCKY

Type of Control	Estimated Percent of Cleaners Needing Control	Estimated Number of Cleaners Needing Control
Refrigerated chillers for monorail and miscellaneous type cleaners[a]	36	7
Refrigerated chillers for crossrod type cleaners	54	10
Safety switches	20	4
Drying tunnel	10	2
Minimized openings	90	16
Downtime covers	90	16

a. Refrigerated chillers were estimated to be needed only on about 90 percent of all conveyorized vapor degreasers; thus, the percent of units needed by monorail-miscellaneous and crossrod types add only to 90 percent.

Source: Booz, Allen & Hamilton Inc.

11.4 DIRECT ECONOMIC IMPLICATIONS

11.4.1 Time Required To Implement Proposed RACT Regulations

Because many degreasers are affected under the proposed regulation (55 open top vapor degreasers, 18 conveyorized degreasers and 1,508 cold cleaners) 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. 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.

11.4.2 Effect of Compliance Upon Selected Economic Indicators

Implementation of the proposed regulations is expected to have a negligible effect on economic indicators. Low capital and annual operating costs required by the solvent metal cleaner owners in meeting the proposed regulations are responsible for this minimal impact.

For example, total capital expenditures in SIC groups 25 and 33-39 in the four counties exceeded $100 million for 1976. Total capital expenditures for retrofitting are estimated to be $0.9 million for all SIC groups in Kentucky, less than 1 percent of Kentucky's total capital expenditures.

Similarly implementation will have a negligible impact on total shipments, prices and the state economy as a whole. The total net annual operating costs of the proposed regulations ($0.10 million) are negligible compared to the 1976 total shipments of $4.5 billion in SIC groups 25 and 33-39 in the four counties. Considering that these expenditures are spread over service industries and other industries not included in SIC's 25 and 33-39, the overall economic impact is even less significant.

Although solvent metal cleaners are particular to certain industries the impact of the proposed regulations are not expected to impact the structure of the state industry. This is due to the dispersion of solvent metal cleaners over many industries and the minimal importance of solvent metal cleaning to the manufacturing processes.

Implementation of the regulations will reduce demand for metal cleaning solvents. This would result in a reduction in solvent sales of about $0.16 million annually which may result in a loss of employment for firms supplying metal cleaning solvents.

11.4.3 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 16 of these currently do not have chillers. Assuming 2,250 hours per year operation, total additional energy consumption annually would be about 18,000 kw-hours to 180,000 kw-hours. This is equal to $720 to $7,200 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. A portion of the increase in energy consumption will be offset by reduced production and consumption of solvents; production because it takes energy to produce solvents and consumption because there is embodied energy in feedstocks such as petroleum distillates.

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[1] EPA-450/2-77-022, op. cit.

11.5 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 is expected to 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-sized firms.

*   *   *   *

Exhibit 11-17, on the following page, summarizes the conclusions presented in this report.

EXHIBIT 11-17
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING
IN THE STATE OF KENTUCKY[1]

Current Situation	Discussion
Number of potentially affected cleaners	About 1,600.
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is in the range of 9.7 billion.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents.
1977 VOC emissions (actual)	3,350 ton/year.
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 to meet RACT guidelines	Equipment modifications as specified by the RACT guidelines.

Affected Areas in Meeting Ract	Discussion
Capital investment (statewide)	$1.0 million.
Annualized cost (statewide)	$0.12 million (less than 0.002 percent of the 1977 affected facilities' value of shipments).
Price	Metal cleaning is only a fraction of manufacturing costs; price effect expected to less than 0.002 percent.
Energy	Less than 100 equivalent barrels of oil per year increase.
Productivity	5-10 percent decrease for manually operated degreasers. Will not affect conveyorized cleaners.

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 KENTUCKY

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 KENTUCKY

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 refineries in the State of Kentucky. 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 analysis.

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 refineries in the State of Kentucky.

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 National Petroleum News Fact Book, 1978.

- The number of employees in 1977 was obtained from interviews with refinery operators.

- The crude oil operating capacity in barrels per day was obtained from the National Petroleum News Fact Book, 1978.

- 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.

12.1.2 VOC Emissions

Uncontrolled emissions from vacuum producing systems, wastewater separators and process unit turnarounds were estimated using factors obtained from U.S. EPA in interviews. Emissions at existing levels of control were determined from data obtained from industry interviews. Emissions at complete control were estimated based on percent recoveries estimated in Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025 and from interviews with U.S. EPA.

12.1.3 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 Kentucky. The specific studies analyzed were: Human Exposures to Atmospheric Emissions from Refineries, American Petroleum Institute, July 1973; Economic Impact of EPA's Regulations on the Petroleum Refining Industry; and Technical Support Document, Petroleum Refinery Sources, Illinois Environmental Protection Agency.

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 Kentucky required knowledge of the level of current controls, the number of refineries and characteristics of uncontrolled refinery processes. These data were obtained by interviewing refinery operators.

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 Kentucky.

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 Kentucky. 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 and statistics and business trends for refineries in Kentucky 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 3 refineries in Kentucky which are affected by RACT, each listed in Exhibit 12-2, on the following page, along with location and crude capacity. The combined employment, output, and estimated value of shipments for Kentucky 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 Kentucky by comparing industry statistics to state economic indicators. Employees in the affected refining industry represent 0.4 percent of the total state civilian labor force of Kentucky. The value of refined products from Kentucky refineries represents approximately 10 percent of the total value of wholesale trade in Kentucky 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.

Exhibit 12-2
U.S. Environmental Protection Agency
PETROLEUM REFINERIES IN KENTUCKY

Name of Firm	Location	Crude Capacity (Barrels per Day)
Ashland Oil, Inc.	Catlettsburg	135,800
	Louisville	25,200
Somerset Refinery, Inc.	Somerset	5,000
TOTAL		166,000

Source: National Petroleum News Fact Book, 1978

Exhibit 12-3

U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR
REFINERIES IN KENTUCKY

Establishments	Estimated Number of Employees	Output (000, barrels per day)	Yearly Value of Shipments ($ Million, 1977)
3	620[a]	165,000[b]	840[c]

a. Estimated Booz, Allen & Hamilton Inc., based on industry interviews.

b. Based on data supplied in the National Petroleum News Fact Book, 1978.

c. Assumes a value of $13.95 per barrel as average for 1977 (source: National Petroleum News Factbook, 1978)

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 prices had, until 1973, been lower than prices for domestic crude oil. Since the advent of the OPEC cartel in 1975, imported crude oil prices have risen sharply.

The largest refinery in Kentucky is the Ashland Oil Refinery in Catlettsburg. This refinery will be expanded by 40,000 to 45,000 barrels per day of crude oil capacity in the near future.

12.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on refinery operation, estimated VOC emissions from selected refinery operations in Kentucky, the extent of current control 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 Kentucky.

12.3.1 Refinery Operations

The refinery operations considered in this report are:

- Vacuum producing systems
- Wastewater separators
- Process unit turnarounds.

These operations are discussed in detail in the RACT guideline document, Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025.

12.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from selected refinery operations in Kentucky in 1977 and the current level of emission control already implemented in the state. Exhibit 12-4, on the following page, shows total estimated emissions from the 3 affected refineries in Kentucky, if there were no emission controls for vacuum producing units, wastewater separators or process unit turnarounds. The emissions at the existing level of control are also shown, along with estimated emissions at the complete level of control.

In Kentucky, refineries have already implemented control measures for process unit turnarounds by piping emissions to a flare.

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 uncertain emission factors in Kentucky.

Exhibit 12-4
U.S. Environmental Protection Agency
ESTIMATED HYDROCARBON EMISSIONS FROM
SELECTED REFINERY OPERATIONS IN KENTUCKY

Number of Refineries		Estimated Hydrocarbon Emissions (TPY) Without Control[a]	At Estimated Existing Level of Control[bc]	At Complete Control[c]
3	Vacuum Producing Systems	562	562	Negligible
	Wastewater Separators	6,387	6,387	Negligible
	Process Unit Turnarounds	18,523	Negligible	Negligible
		25,472	6,949	Negligible

a. Emissions are estimaed using factors obtained from interviews with U.S. EPA and Revision of Evaporative Hydrocarbon Emission Factors, EPA-450/2-76-039.

b. Current level of emissions was determined using data obtained through interviews with refinery operators.

c. Assumes the percent recoveries estimated in Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds.

12.3.3 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—The process for controlling 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.

12.3.4 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.

12.3.4.1 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) by 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. VOC emissions which are controlled from vacuum producing systems at the Ashland Oil refinery in Catlettsburg will be diverted to the SO_2 recovery unit where SO_2 is recovered and the hydrocarbons are incinerated.

12.3.4.2 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. Refiners in Kentucky are not planning to recover VOC emissions from covered wastewater separators.[1]

12.3.4.3 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 the atmosphere.

In Kentucky process unit turnarounds are presently controlled and VOC emissions are piped to the flare.

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1. Conversation with Ashland Oil Company, Ashland, Kentucky.

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The sections which follow discuss the costs of implementing these control techniques at refineries in Kentucky.

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 a determination of costs for the uncovered wastewater separators and uncontrolled vacuum producing systems.

12.4.1 Costs for Emission Control Systems

The installed capital costs for the three emission control systems (summarized in Exhibit 12-5, 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 mechanical 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 either 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 feet.

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. 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 12-5

U.S. Environmental Protection Agency

INSTALLED CAPITAL COSTS OF VAPOR CONTROL SYSTEMS FOR VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS

Vacuum Producing Systems		Wastewater Separators ($, 1977)	Process Unit Turnarounds ($, 1977)
Surface Condensers or Mechanical ($, 1977)	Contact Condensers ($, 1977)		
24,000[a]	52,000[b]	63,000[c]	100,000[d]

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 450/2-77-025, pp. 4-10.

Equipment required for controlling emissions from process unit turnarounds basically includes 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.

Cost estimates obtained from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025 and verified through interviews will vary from one refinery to another, reflecting the variability in refinery size, configuration, age, product mix and degree of control.

In Kentucky, the two refineries with process units have already incurred costs for control of process unit turnarounds.

The remainder of this section, therefore, presents the costs for covering four uncovered wastewater separators and five vacuum producing systems.

12.4.2 Costs to the Statewide Industry

Exhibit 12-6, on the following page, shows the vapor recovery costs for covering wastewater separators and controlling vacuum producing units to the statewide industry in Kentucky. The estimates are based on the following criteria:

- The total area of the uncovered wastewater separators is 5,500 square feet
- There are five uncontrolled vacuum producing systems
- Installed capital cost includes parts and labor
- Annualized direct operating costs, expected to be 3 percent of installed capital costs, 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

Exhibit 12-6
U.S. Environemntal Protection Agency
STATEWIDE COSTS FOR VAPOR CONTROL
SYSTEMS FOR REFINERY WASTEWATER SEPARATORS

Characteristics/Cost Item	Data
Total refinery capacity (barrels per day)	166,000
Emission reduction (tons/year)	6,949
Installed capital ($, 1977)	119,300
Direct annual operating cost ($, 1977)	3,579
Annual capital charges ($, 1977)	29,825
Annual gasoline credit ($, 1977)	0
Net annual cost ($, 1977)	33,404
Annual cost per ton of emissions reduced ($ per ton)	4.80

Source: Booz, Allen & Hamilton Inc.

- 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.

Based on the above assumptions, the total cost to the industry for installing vapor recovery equipment is expected to exceed $119,000. The annual cost per ton of emissions controlled is estimated to be $4.80.

12.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing RACT to refineries in Kentucky. Impacts include capital availability, technical feasibility and value of shipments.

- Capital availability—It is expected that refiners in Kentucky will be able to raise the estimated $119,300 to cover their wastewater separators and control emissions from vacuum producing units.

- Technical feasibility—Wastewater separators have been successfully covered and vacuum producing unit emissions have been controlled at several refineries in the United States. Therefore, it is expected that Kentucky refiners will be able to comply technically with RACT.

- Value of shipments—The net annualized cost for implementing RACT is estimated to be an insignificant percent of the value of refined products in Kentucky.

The section which follows describes secondary impacts which may result from implementing RACT in Kentucky.

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 Kentucky.

- Market structure—The market structure will remain unchanged when RACT is implemented in Kentucky.

- Productivity—Worker productivity will be unaffected by implementing RACT in Kentucky.

* * * *

Exhibit 12-7, on the following page, summarizes the findings of this report.

Exhibit 12-7
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 KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	Three
Indication of relative importance of industrial section to state economy	1977 industry sales were $840 million. The estimated annual crude oil throughput was 60 million barrels
Current industry technology trends	All three refineries comply with RACT for process unit turnarounds
1977 VOC actual emissions	6,950 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 covering wastewater separators
Assumed method of VOC control to meet RACT guidelines	Vapor recovery of emissions from process unit to flare, cover wastewater separators and piping emissions from process units to flare.

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$120,000
Annualized cost (statewide)	$33,000
Price	No major impact
Energy	Assuming full recovery of emissions —net savings of 48,600 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	Negligible
Cost effectiveness of control	$5 annualized cost/annual ton of 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.

Petroleum Products Handbook, Virgil B. Guthrie, Editor, Mcgraw-Hill Book Company, New York, 1960.

National Petroleum News Fact Book, 1978.

13.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN THE STATE OF KENTUCKY

13.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN THE STATE OF KENTUCKY

This chapter presents a detailed analysis of the impact of implementing RACT controls for tank truck gasoline loading terminals in the State of Kentucky.[1] Under the proposed Kentucky regulations, bulk gasoline terminals in urban counties designated nonattainment for ozone and also major sources of VOC emissions would be affected. It is assumed that all bulk gasoline facilities in Kentucky would be potentially affected by the proposed regulation. 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 the RACT guidelines, previous studies of tank truck gasoline loading terminals, interviews and analysis.

1. One terminal with barge loading is not included in this 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 Kentucky.

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 the following sources. All data are presented in a base year, 1977:

- The number of establishments for 1977 was obtained from the Kentucky emissions inventory.

- 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 for 1977.

- The number of gallons of gasoline sold in 1977 in the State of Kentucky was obtained from the Kentucky emissions inventory.

- 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 (42.5¢/gallon), which was reported in the National Petroleum News Fact Book, 1978.

13.1.2 VOC Emissions

VOC emissions were determined for tank truck gasoline loading terminals in Kentucky based on data from the Kentucky emissions inventory and U.S. EPA emission factors reported 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 Trucks 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 at terminals in Kentucky. The specific studies analyzed were: Demonstration of Reduced Hydrocarbon Emissions from Gasoline Loading Terminals, PB-143 363; 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 uncontrolled terminals in Kentucky

- Aggregating costs to the total affected industry in Kentucky.

Costs were determined mainly from analyses of the RACT guidelines and from interviews with petroleum markets' associations, terminal operators and vapor control equipment manufacturers.

The assignment of the estimated cost of control to Kentucky required a profile of tank truck gasoline loading terminals in the state by size of gasoline throughput and those facilities already equipped with vapor recovery equipment. The data were available in the Kentucky emissions inventory and from interviews with terminal operators.

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 Kentucky.

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 Kentucky. 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 Kentucky 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 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 Kentucky.

13.2.1 Size of the Industry

There were an estimated 33 tank truck gasoline loading terminals, as of 1977, in Kentucky. Industry sales were in the range of $805 million, with an estimated yearly throughput of 1.894 billion gallons of gasoline. The estimated number of employees in 1977 was 375. 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 Kentucky 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 Kentucky. The value of gasoline sold from terminals represented less than 14 percent of the total value of wholesale trade in Kentucky 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 KENTUCKY

Number of Establishments	Number of Employees	Sales ($ Billion, 1977)	Gasoline Sold (Billions of Gallons)
33[a]	375[b]	0.805[a]	1.894[c]

a. Kentucky emissions inventory

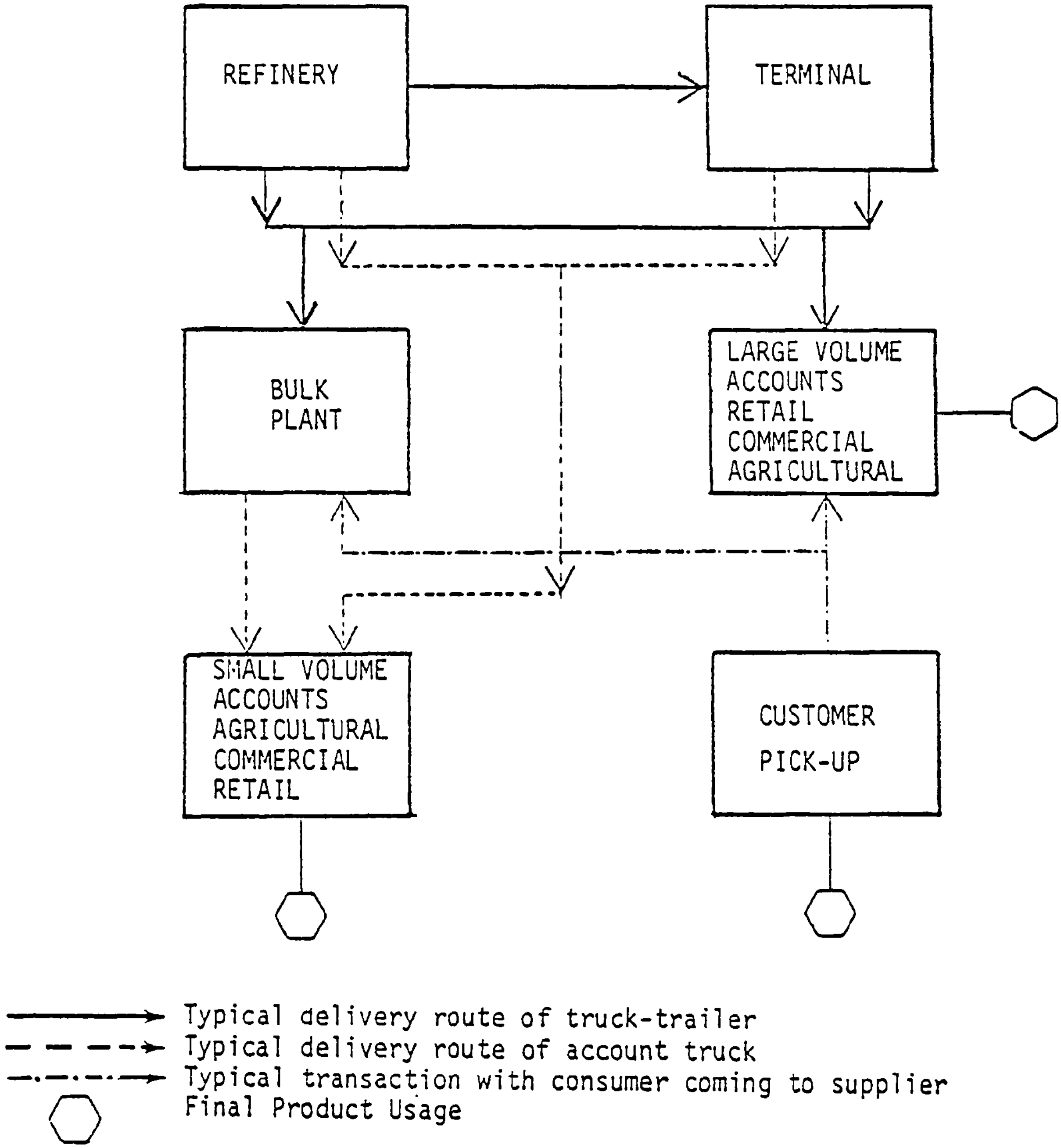
b. Booz, Allen & Hamilton Inc. estimate based on the ratio of the number of employees to the number of establishments in 1972.

c. Number of gallons of motor gasoline sold in 1977 multiplied by the national dealer tankwagon price in 1977 (42.51¢/gallon).

Exhibit 13-3

U.S. Environmental Protection Agency

GASOLINE DISTRIBUTION NETWORK



Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 240/1-77-013, September 1976, p. 3-2.

Gasoline terminals load all of the petroleum product they receive into truck transports at the terminals' loading racks. 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 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 20,000 gallons per day to over 600,000 gallons per day.

Exhibit 13-4, on the following page, shows an estimated distribution of gasoline terminals by throughput in the State of Kentucky.

Exhibit 13-4

U.S. Environmental Protection Agency
DISTRIBUTION OF TANK TRUCK GASOLINE
LOADING TERMINALS BY AMOUNT OF THROUGHPUT
IN THE STATE OF KENTUCKY

Gasoline Throughput (gallons per day)	Percentage of Plants
Less than 200,000	48
200,000 to 399,000	30
400,000 to 599,000	10
Over 600,000	12
TOTAL	100

Source: Kentucky Emissions Inventory

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 Kentucky, 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 gasoline terminals in Kentucky.

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. Facilities and operations are discussed in detail in the RACT guideline document Control of Hydrocarbons from Tank Truck Gasoline Loading Terminals, EPA-450/2-77-026.

13.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from tank truck gasoline loading terminals in Kentucky 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 Kentucky. The estimated VOC emissions from the 32 tank truck gasoline loading terminals are 5,491 tons per year.

It is estimated from data in the Kentucky emissions inventory and through interviews with terminal operators that five facilities currently bottom load tank trucks and all other terminals top submerge fill tank trucks. It was also found that nine facilities are currently equipped with vapor recovery systems.

13.3.3 RACT Guidelines

The RACT guidelines for VOC emission control from tank truck gasoline loading terminals require the following control systems:

Exhibit 13-5
U.S. Environmental Protection Agency
VOC EMISSIONS FROM TANK TRUCK GASOLINE
LOADING TERMINALS IN KENTUCKY

Number of Facilities	Estimated Annual Throughput (millions of gallons)	Total Emissions (tons /year)
32[a]	2,204[a]	5,491[b]

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a. Based on Kentucky Emissions Inventory.

b. Booz, Allen & Hamilton Inc. estimated based on data from the Kentucky Emissions Inventory and industry interviews.

Source: Booz, Allen & Hamilton Inc. and the Kentucky Department for Natural Resources and Environmental Protection

- 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, on the following page, 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 recovery of the loading of outgoing trailer-transport trucks. There are several alternative means of achieving vapor recovery at tank truck gasoline loading terminals, based on the type of vapor recovery equipment installed.

Four likely alternatives for vapor recovery are:

- Adsorption/absorption
- Compression refrigeration absorption
- Refrigeration
- Thermal oxidation.

Each type of vapor recovery system is briefly described below.

13.3.4.1 Adsorption/Absorption (AA)

Vapor recovery 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

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 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 recovery 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. This system is becoming less popular than the more recently developed refrigeration system described below and it is not expected that this type of system will be used in Kentucky.

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 ozidizer. It is not expected that this type of vapor control system will be used in uncontrolled terminals in Kentucky since there are fire hazards with a flame and terminal operators are also reportedly 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 a projection 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 Kentucky. 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 estimated 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 50 percent of the terminals currently without vapor recovery in Kentucky can be characterized by Model Terminal A; the remaining 50 percent of the terminals without vapor recovery are assumed to be characterized by Model Terminal B.

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

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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	19,800
. 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 (not including maintenance)	51,600	51,600	71,000	71,000
Net annualized cost (not including gasoline credit)	70,200	76,200	98,950	109,350

a. Terminals which currently bottom load may incur costs of approximately 2 percent higher to equip the terminals with vapor control than for terminals which top fill.

The costs for the model terminals are used in Section 13.4.3 to project 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 20 percent of the installed capital cost

- Net annualized 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.

13.4.3 Projection to the Statewide Industry

Exhibit 13-9, on the following page, shows the projection of vapor recovery costs to the statewide industry in Kentucky. The estimates are based on the following data:

- In Kentucky, 50 percent of the uncontrolled tank truck gasoline loading terminals can be characterized by Model Terminal A and the remaining uncontrolled terminals can be characterized by Model Terminal B.

- Fifty percent of the uncontrolled terminals will implement the adsorption/absorption vapor control system to comply with RACT and the other 50 percent of the uncontrolled terminals will implement the refrigeration system to comply with RACT.

Exhibit 13-9
U.S. Environmental Protection Agency
KENTUCKY COSTS OF VAPOR CONTROL SYSTEMS
FOR TANK TRUCK GASOLINE LOADING TERMINAL

Characterization/Cost Item	Data
Number of affected facilities	32[a]
Total annual throughput (billions of gallons)	2.204
Actual emissions (tons/year)	5,491
Emission reduction (tons/year)	4,941
Installed capital cost ($ million, 1977)	6.819
Direct annual operating cost ($ millions, 1977)	0.630
Annual capital charges ($ millions, 1977)	1.364
Annual gasoline credit[b] ($ millions, 1977)	0.822
Net annualized cost ($ millions, 1977)	1.172
Annual cost per ton of emissions reduction at the terminal ($ per ton)	237
Annual cost per ton of emissions reduced from gasoline marketing ($ per ton)	182

a. Nine of the 32 affected facilities are reported to have vapor control systems in place. The cost of these systems is not included in this analysis.

b. Based on 6,430 tons of emissions recovered which includes 1,448 tons collected from gasoline service stations, 40 tons collected from bulk plants and 4,941 tons collected at the terminal. Valued at $0.39 per gallon.

Source: Booz, Allen & Hamilton Inc.

- RACT is implemented at bulk gasoline plants and gasoline service stations in the state. Ninety percent of 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 previous assumptions, the total cost to the industry for installing vapor recovery equipment is estimated to be $6.8 million. The amount of gasoline recovered is valued at $0.822 million. The annual cost per ton of emissions controlled from terminals is estimated to be $237 The overall cost per ton of emissions controlled from gasoline marketing in the state is estimated to be $182

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 must be implemented statewide by January 1, 1981. This implies that tank truck gasoline loading terminal operators must have vapor control equipment installed and operating within the next two 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 that sufficient leadtime is available to meet the increased demand, thus making the implementation of RACT feasible.

In the area of economic feasibility it has been reported that terminal operators have access to capital to purchase vapor control equipment and that no terminal will cease operations because of the cost of implementing RACT.

13.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net annualized cost 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 cost to the tank truck gasoline loading terminals resulting from RACT represents 0.11 percent of the total gasoline sold in the state. When compared to the statewide value of wholesale trade, the annualized cost is less than 0.02 percent.

13.6 SELECTED SECONDARY ECONOMIC IMPACTS

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

- Employment—No decline in employment is predicted since no terminal will 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 chapter.

Exhibit 13-10

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	32
Indication of relative importance of industrial section to state economy	1977 industry sales were $805 million, with annual throughput of 1,894 billion gallons.
Current industry technology trends	New terminals will be designed with vapor recovery equipment
1977 VOC actual emissions	5,491 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Submerge fill or bottom fill vapor recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$6.819 million
Annualized cost (statewide)	$1.172 million (approximately 0.14 percent of value of shipment)
Price	No change in price is anticipated
Energy	Assuming full recovery of gasoline—net savings of 33,750 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 emission after control	550 tons per year
Cost effectiveness of control	$237 annualized cost/annual ton of VOC reduction from terminals

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

"Kentucky Emissions Inventory," Kentucky Department for Natural Resources and Environmental Protection.

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.

Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017, April 1978.

14.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF KENTUCKY

14.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF KENTUCKY

This chapter presents the estimated economic impact of implementing RACT controls for bulk gasoline plants in Kentucky. The analysis presented in this chapter is based on the methodologies developed to assess the impact of RACT guidelines developed by the U.S. EPA, with some modifications to address the revised Kentucky regulations for existing bulk gasoline plants (401 KARG 1:056). These modifications are as follows:

- The proposed Kentucky regulations for the control of VOC emissions from bulk gasoline plants in urban nonattainment counties is similar to the RACT guidelines. The four urban nonattainment counties for ozone in Kentucky are:
    - Boone
    - Campbell
    - Jefferson
    - Kenton.
- In other counties of Kentucky designated as non-attainment or unclassified major sources of VOC emissions would be subject to regulation. However, by the definition of a bulk gasoline plant--facility with maximum daily throughput of 20,000 gallons or less--the VOC emissions from these facilities would not be considered a major source.
- Therefore, the economic impact of the control of VOC emissions for bulk gasoline plants in the state of Kentucky is limited to the four county urban non-attainment areas. The statewide industry for bulk gasoline plants is also shown in this chapter--however, the regulations would only apply to those bulk gasoline plants in the urban nonattainment counties.

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 alternatives

- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on 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 Kentucky.

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 the Kentucky emissions inventory. All data are presented in a base year, 1977:

- The number of establishments for 1977 was determined from the Kentucky emissions inventory.

- 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 from bulk plants in 1977 in the State of Kentucky was estimated from throughput data presented in the Kentucky emissions inventory.

- 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 for bulk gasoline plants were estimated from data in the Kentucky emissions inventory on tank capacity, throughput of gasoline and current controls. U.S. EPA emission factors reported in Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035 were used to calculate emissions for each affected bulk gasoline plant.

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 Kentucky. 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 plants costs to uncontrolled bulk gasoline plants in Kentucky
- Aggregating costs to the total industry in Kentucky.

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 Kentucky required a profile of bulk plants for the state, showing the percentage of plants for:

- Various ranges of throughput
- Plants with vapor control equipment already installed.

Detailed data on bulk gasoline plant characteristics were available for Kentucky in the Kentucky emissions inventory.

14.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibiltiy 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 Kentucky.

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 Kentucky. 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 emission control		●	
Economic impact			●
Overall quality of data		●	

Source: Booz, Allen & Hamilton Inc.

14.2 INDUSTRY STATISTICS

Industry characteristics, statistics, and business trends for bulk gasoline plants in Kentucky 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 Kentucky.

14.2.1 Size of the Industry

There were an estimated 160 bulk gasoline plants, as of 1977, in Kentucky. Only three of those facilities are located in the urban nonattainment counties. Industry sales statewide were in the range of $113 million, with an estimated yearly throughput of 266.7 million gallons of gasoline. The estimated number of employees in 1977 was 669. 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 Kentucky is shown in this section by comparing industry statistics to state economic indicators. Employees in the bulk gasoline plant industry represent less than 0.4 percent of the total state civilian labor force of Kentucky. The value of gasoline sold from bulk plants represented less than one percent of the total value of wholesale trade in Kentucky 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 KENTUCKY

Area	Number of Establishments	Number of Employees	Sales ($ Million, 1977)	Gasoline Sold (Millions of Gallons)
Statewide	160[a]	669[b]	113.4[c]	266.7[a]
4 County (Urban nonattainment)	3[a]	-	2.1[c]	5.1[a]

a. Kentucky emissions inventory.

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 Factbook, 1978.

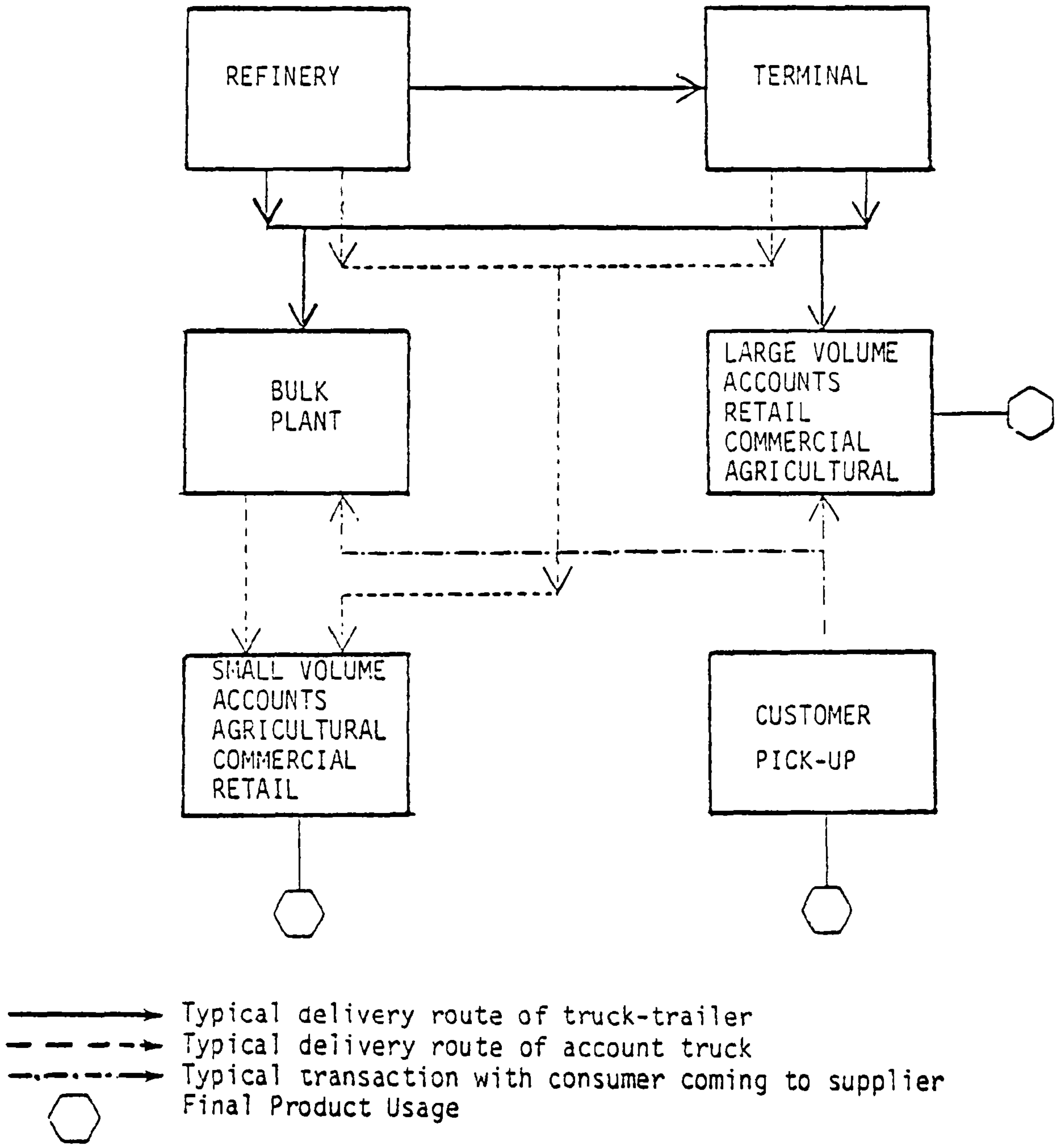
Note: The number of bulk plants in Kentucky has also been confirmed by the Kentucky Petroleum Marketers Association. This number of establishments reported is significantly less than reported in the Census of Wholesale Trade.

Source: Booz, Allen & Hamilton Inc.

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 include 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 the distribution of bulk gasoline plants by plant throughput in Kentucky.

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
DISTRIBUTION OF BULK GASOLINE PLANTS
BY AMOUNT OF THROUGHPUT

Gasoline Throughput (gallons per day)	Percentage of Plants
Less than 2,000	11
2,000 to 3,999	14
4,000 to 5,999	24
6,000 to 7,999	19
8,000 to 9,999	12
10,000 to 11,999	11
12,000 to 13,999	6
14,000 to 15,999	2
16,000 to 17,999	2
18,000 to 20,000	1

Note: In the four urban nonattainment designated counties, the throughput distribution is:

- 10,000 to 11,999 -- one plant
- 4,000 to 5,999 -- two plants

Source: Kentucky Department for Natural Resources and Environmental Protection Division.

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 Kentucky 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 Kentucky.

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. Bulk gasoline plant facilities and operations are described in detail in Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

14.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from bulk gasoline plants in Kentucky in 1977 and the current level of emission control already implemented in the state. Exhibit 4-5, on the following page, shows the total estimated emissions in tons per year from bulk plants in Kentucky. The estimated VOC emissions from the 160 bulk plants are 2,935 tons per year. The estimated VOC emissions from the three facilities in the urban nonattainment counties for ozone is 64 tons per year.

Forty percent of the loading facilities are currently equipped with submerged loading equipment in Kentucky. Names of the three facilities in the urban nonattainment counties are reported to have vapor control equipment.

14.3.3 RACT Guidelines

The RACT guidelines for VOC emission control from bulk gasoline plants require the following control system:

- 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

Exhibit 14-5
U.S. Environmental Protection Agency
VOC EMISSIONS FROM BULK GASOLINE PLANTS IN KENTUCKY

	Number of Facilities	Average Daily Throughput (gallons)	Total Emissions (tons/year)
Statewide	160	1,066,672	2,935
4 Counties	3	20,524	64

Source: Kentucky emissions inventory.

- Vapor balancing between the gasoline storage tank and the outgoing account truck

- Proper operation and maintenance of equipment.

Exhibit 14-6, on the following page, summarizes the RACT guidelines for VOC emissions control from bulk gasoline plants.

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, following 14-6, are discussed separately in the paragraphs which follow.

14.3.4.1 Alternative I

Control Alternative I involves converting existing top loading bulk plants to 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 Kentucky would select Control Alternative I to achieve vapor recovery to meet the state requirements. During interviews, the

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.

Exhibit 14-7
U.S. Environmental Protection Agency
ALTERNATIVE CONTROL METHODS
FOR VAPOR CONTROL AT BULK GASOLINE PLANTS

Alternative Number	Description of Control Method
I	Convert existing top filled plant to 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 and Hamilton analysis of Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

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 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.

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. This additional cost may be attributable to improved bulk plant operations, according to U.S. EPA.

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 Alternative I is expected to be the most widely applied system for bulk plants in Kentucky since it is assumed that most bulk gasoline plants in Kentucky employ top filling. 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 Kentucky that any bulk gasoline plant in Kentucky 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,

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 bottom 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.

reported by Pacific Environmental Services, Inc. for bulk plants in the Houston/Galveston area. Several other 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.

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, record-keeping, and training costs.

- Annualized capital charges, estimated to be 25 percent of installed capital costs, including costs for depreciation, interest, maintenance, taxes, and insurance.

- Net annualized 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.

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		
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.

14.4.3 Extrapolation to the Statewide Industry

Exhibit 14-10, on the following page, shows the projection of vapor recovery costs to the statewide industry in Kentucky. The costs are based on the following estimates:

- In Kentucky only three plants will be affected in the urban nonattainment counties for ozone. Two can be characterized by Model Plant A and one can be characterized by Model Plant B

- All uncontrolled bulk plants will implement the Control Alternative I vapor control system to comply with RACT

- The three plants must be equipped with submerge fill pipes.

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 generalized estimates, the total cost to the three plants potentially affected for installing vapor recovery equipment is estimated to be $47,000. The amount of gasoline prevented from vaporizing using vapor control is valued at approximately $6,000. Ten 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 $274 per ton.

Exhibit 14-10
U.S. Environmental Protection Agency
KENTUCKY COSTS OF VAPOR CONTROL
SYSTEMS FOR BULK GASOLINE PLANTS

Characteristic/Cost Item	Data
Number of potentially affected facilities	3
Total annual throughput (millions of gallons)	5.1
Uncontrolled emissions (tons/year)	64
Emission reduction (tons/year)	46
Net emissions (tons/year)	18
Installed capital ($ thousands, 1977)	47
Direct annual operating cost ($ thousands, 1977)	1.4
Annual capital charges ($ thousands, 1977)	11.8
Annual gasoline credit[a] ($ thousands, 1977)	0.6
Net annualized cost ($ thousands, 1977)	12.6
Annual cost per ton of emissions reduced ($ per ton)	274

a. Based on 10 percent of emissions reduction accrued to bulk plants at 40¢ per gallon.

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 in nine counties by January 1, 1981 and statewide by January 1, 1983. This requires that bulk gasoline plant operators must have vapor control equipment installed and operating within the next two years in the four affected counties. 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 ensure 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 United States 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.

Since most of the bulk gasoline plants in Kentucky are in rural areas and not affected by the proposed regulation, only three plants will be affected. Availability of equipment should not be a problem for only three facilities.

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 by these facilities, the value of wholesale trade in the state, and the unit price of gasoline.

The next increase in the annualized cost to the three bulk gasoline plants due to RACT represents 0.6 percent of the total gasoline sold by the bulk plant facilities studied. 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. This annualized cost of control represents a compliance cost of 0.24 cents per gallon at the three facilities affected.

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[1] Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976.

14.6 SELECTED SECONDARY ECONOMIC IMPACTS

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

For bulk gasoline plants that comply with the RACT requirements, no additional manpower requirements are expected. Overall bulk gasoline plant industrial sector employment is expected to continue to decline since the number of bulk gasoline plants operating in the state is forecast to decline.

The impact on the market structure for bulk plants differs significantly in urban and rural areas. The importance of bulk plants in the urban areas is declining because of competition from retailers and tank truck terminals and will 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. In Kentucky, the proposed regulations would not affect rural counties, since these facilities would not be considered major sources.

The productivity of a specific bulk plant will be 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 14-11 presents a summary of the findings of this report.

Exhibit 14-11

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN URBAN NONATTAINMENT COUNTIES OF KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	Three
Indication of relative importance of industrial section	1977 industry sales were $113 million, with annual throughput of 0.27 billion gallons. The three facilities potentially affected represented less than 2 percent of 1977 industry sales.
Current industry technology trends	Only small percent of industry has new/ modernized plants
1977 VOC actual emissions	64 tons per year (three potentially affected facilities)
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 (four counties)	$47,000
Annualized cost (four counties)	$12,600 (approximately 0.6 percent of value of shipment from three facilities)
Price	Assuming a "direct cost passthrough" Three facilities--$0.0024 per gallon increase
Energy	Assuming full recovery of gasoline--net savings of 350 barrels annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	18 tons per year (28 percent of current emissions)
Cost effectiveness	$274 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

"Kentucky Emissions Inventory," Kentucky Department for Natural Resources and Environmental Protection.

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.

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, Maryland, and Houston, Texas, 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, Counsel, 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 Escondidc, 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 KENTUCKY

15.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR STORAGE OF PETROLUEM LIQUIDS IN FIXED-ROOF TANKS IN THE STATE OF KENTUCKY

This chapter presents an economic analysis of the impact of implementing RACT controls for the storage of petroleum liquids in fixed-roof tanks.

- The proposed Kentucky regulations are similar to the RACT guidelines for storage tanks over 40,000 gallons in capacity. The analysis in this chapter assumes that all those tanks would be potentially affected except in Jefferson, Boone, Campbell and Kenton counties (already in control as a result of the regulations promulgated in 1972).

- For tanks smaller than 40,000 gallons and subject to the proposed regulations, a permanent submerged fill pipe is required. The cost of a submerged fill pipe is approximately $150 per tank. This potential control cost is not included in this analysis.

The major sections of the chapter include:

- Specific methodology and quality of estimates

- Technical characteristics of fixed-roof tanks for storing petroleum liquids

- 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 with industry representatives 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-4501/2-77-036, 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 Kentucky Department for Natural Resources and Environmental Protection provided a listing of all fixed-roof tanks greater than 40,000 gallon capacity used for storing petroleum liquids in Kentucky. The capacity of each tank, the type of petroleum liquid stored, and for some facilities, the annual throughput, were provided. Where not available, the annual throughput was calculated based on an estimated turnover rate of 25 cycles per year.

15.1.3 VOC Emissions

Statewide VOC emissions were calculated based on the emission factors for working and breathing losses of various types of petroleum liquids obtained from Ravision of Evaporative Hydrocarbon Emission Factors, EPA-450/3-76-039.

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 annual cost
- Aggregating costs to the total industry in Kentucky.

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 extrapolation of the estimated cost of control to Kentucky required a profile of fixed-roof tanks for storing petroleum liquids for the state, showing the capacity of each tank. These data were provided by the Kentucky Department for Natural Resources and Environmental Protection for 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 those 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 of 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 fixed-roof tanks in Kentucky. 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 output 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 AND RACT GUIDELINES FOR FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS

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 emission from fixed-roof tanks are described in the EPA guidelines series, Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-450/2-77-036.

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 1.5 psia.

The Kentucky regulations call for control of storage vessels:

- If the storage vessel has a storage capacity greater than 40,000 gallons and if the true vapor pressure of the petroleum liquid, as stored, is equal to or greater than seventy-eight (78) mm Hg (1.5 psia) but not greater than 570 mm Hg (11.1 psia) the storage vessel shall be equipped with a floating roof, a vapor recovery system, or their equivalents.

- If the storage vessel has a storage capacity greater than 40,000 gallons and if the true vapor pressure of the petroleum liquid as stored is greater than 570 mm Hg (11.1 psia), the storage vessel shall be equipped with a vapor recovery system or its equivalent.

- If the storage vessel has a storage capacity greater than 580 [500] gallons, and if the true vapor pressure of the petroluem liquid, as stored, is equal to or greater than 1.5 psia, as a minimum it shall be equipped with a permanent submerged fill pipe.

15.3 PROFILE OF FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS AND ESTIMATED VOC EMISSIONS

This section contains a profile of fixed-roof tanks used for storing petroleum liquids in the State of Kentucky greater than 40,000 gallons and the estimated annual VOC emissions from these tanks.

The Kentucky Department for Natural Resources and Environmental Protection compiled a list of fixed-roof tanks from their emissions inventory. The capacity of each tank and the type of petroleum liquid stored were provided in the listing. In summary, there are 82 fixed-roof tanks greater than 40,000 gallons capacity and not equipped with an internal floating roof in Kentucky. The total storage capacity of these tanks is 34.6 million gallons and the annual throughput of petroleum liquid is estimated to be 891 million gallons.

It is estimated that annual VOC emissions from the storage petroleum liquids in fixedroof tanks in Kentucky are 2,655 tons per year.

It is further estimated that these emissions could be reduced by 90 percent or to 266 tons per year by implementing RACT in Kentucky.

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 for controlling VOC emissions.

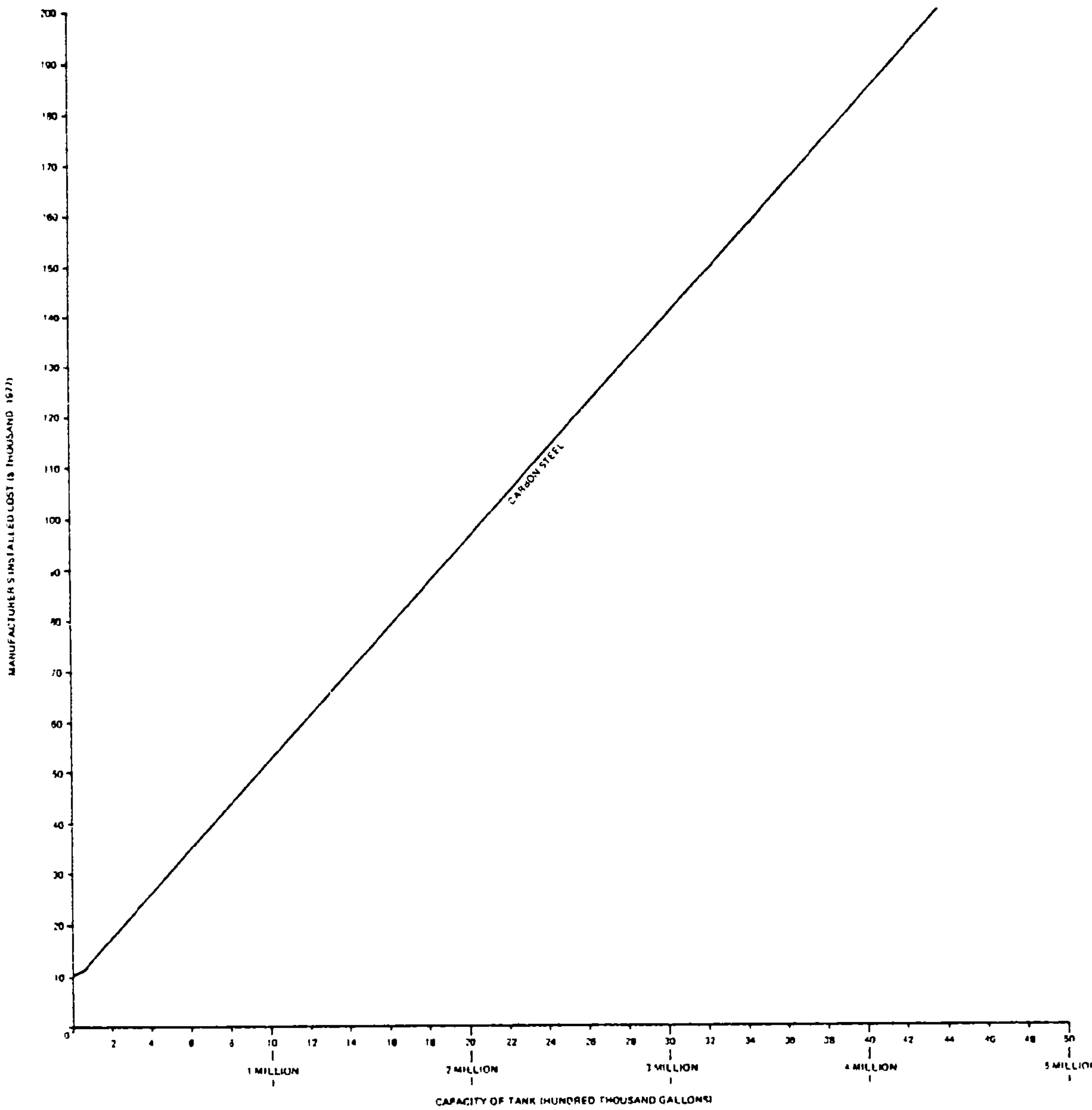
The cost factors for emission control equipment include:

- 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
- Annual direct operating costs, estimated to be 2 percent of installed capital cost including costs for inspection and recordkeeping
- Annual petroleum liquid credit calculated by multiplying emission reduction by the volume of the petroleum liquid divided by the liquid density and multiplied by a value of $0.39 per gallon
- Net annualized costs, the sum of the capital charges and direct operating costs less the petroleum liquid credit.

Capital costs were determined for each tank from the graph in Exhibit 15-2, 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. All costs are for 1977.

A summary of the cost aggregated statewide for the control of emissions from petroleum liquids stored in fixed-roof tanks is shown in Exhibit 15-3, following Exhibit 15-2. The total installed capital costs for equipping the 82 fixed-roof tanks affected by RACT with internal floating roofs is approximately $3.3 million. The net annualized cost is approximately $610,000 taking into account a liquid petroleum credit of $296,000. The annualized cost per ton of emissions reduced is $256.

Exhibit 15-2
U.S. Environmental Protection Agency
INSTALLED COST OF SINGLE SEAL
FLOATING ROOF TANKS
(Prices Approximate)



Source: Communications with Ultra-Float Inc., Booz, Allen & Hamilton Inc. analysis

EXHIBIT 15-3

U.S. Environmental Protection Agency
VOC EMISSIONS CONTROL COSTS FOR
STORAGE OF PETROLEUM LIQUIDS IN
FIXED-ROOF TANKS IN KENTUCKY

SUMMARY

Plant Characteristics	
Number of tanks	82
Total capacity (millions of gallons)	34.6
Estimated annual throughput (millions of gallons)	891
Uncontrolled emissions (tons per year)	2,655
Emissions reduction (tons per year)	2,389
Emissions after control (tons per year)	266
Costs	
Installed capital cost ($, millions, 1977)	3.34
Annualized capital charges ($, thousands, 1977)	840
Annual direct operating costs ($, thousands, 1977)	66.8
Annual petroleum credit ($, thousands, 1977)	296[a]
Net annualized cost ($, thousands, 1977)	610
Cost per ton of emissions reduced ($, 1977)	256

[a] Assume value of petroleum liquid saved is $.39 per gallon and density of petroleum liquid is 6.3 lbs. per gallon.

Source: Booz, Allen & Hamilton Inc.

15.5 DIRECT ECONOMIC IMPACT

This section discusses the economic impact of equipping fixed-roof tanks used for storing petroleum liquids with internal floating roof to control VOC emissions. The impacts analyzed include: total cost statewide; identification of industries that may be affected and their ability to raise the capital needed for the controls.

- Installed Capital Cost in Kentucky. An estimated $3.3 million will be required statewide in Kentucky to equip fixed-roof tanks for storing petroleum liquids with internal floating roofs.

- Industries Affected. Fixed-roof tanks affected by RACT guidelines are owned by major oil companies, large petrochemical firms and bulk gasoline tank terminal companies. It is predicted 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.

15.6 SECONDARY ECONOMIC IMPACTS

It is expected that secondary economic impacts as a result of implementing RACT guidelines in Kentucky will be minimal. Employment, worker productivity, and market structure should remain unchanged.

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Exhibit 15-4 on the following page presents a summary of the findings of this report.

EXHIBIT 15-4

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUID IN THE STATE OF KENTUCKY

Current Situation	Discussion
Number of potentially affected storage tanks over 40,000 gallons	82
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 891 million gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
VOC emissions	2,655 tons per year
Preferred method of VOC control meet RACT guidelines	Single seal and internal floating roof
<u>Affected Areas in Meeting RACT</u>	
Capital investment (statewide)	\$3.3 million
Annualized cost (statewide)	\$0.6 million
Price	Assuming a "direct cost passthrough"--less than 0.1 cents per gallon of throughput
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 16,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market Structure	No major impact
Problem area	Potentially availability of equipment to implement RACT standard
VOC emission after control	266 tons per year
Cost effectiveness of control	\$256 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

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 SERVICE STATIONS IN THE STATE OF KENTUCKY

16.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT STAGE I FOR GASOLINE SERVICE STATIONS IN THE STATE OF KENTUCKY

This chapter presents a detailed analysis of implementing RACT Stage I controls pertaining to gasoline dispensing facilities[a] in the State of Kentucky. The scope of this chapter is limited in coverage. Kentucky RACT guidelines exempt facilities which dispense less than 250,000 gallons of gasoline per year. In addition, under RACT guidelines, only four counties are classified as non-attainment areas. They are: Boone, Campbell, Jefferson and Kenton counties.

The impact of RACT in these counties is investigated in six sections as follows:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and hydrocarbon reduction benefit evaluations for Stage I RACT requirements
- 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.

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[a] Gasoline dispensing facility is a generic term which encompasses both retail facilities and private outlets. The latter are primarily establishments maintained by governmental, commercial or industrial consumers for their own fleet operations. The latter category also includes rural convenience stores, parking garages, marinas and other retail outlets not classified as service stations.

16.1 SPECIFIC METHODOLOGY

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 gasoline dispensing facilities in the State of Kentucky.

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

The focal year of the analysis is 1977 and all hard industry statistics are reported on this basis. When hard data for the base year are not available, appropriate scaling factors are applied to existing confirmed data to derive base year estimates.

To derive the total number of gasoline dispensing facilities in the four non-attainment counties a two-stage procedure is used. First, the number of statewide retail service stations is identified[a] and the figure is then scaled by a factor of 1.37[b] to produce an estimate of the number of private dispensing facilities. Next, these two statewide totals are disaggregated to the county level using coefficients developed from a Bureau of Census publication.[c] In addition to providing a basis for estimating the total number of dispensing facilities at the county level, the census publication is also used to calculate total county employment levels.

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a National Petroleum News Fact Book, 1978, p. 105.

b The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, Department of Labor, OSHA, C79911, March 1978, pp. 4-7.

c County Business Patterns 1976: Kentucky U.S. Department of Commerce, CBP-76-12, 1978.

Finally to derive the volume of gasoline sold in the non-attainment counties, existing data on state sales totals[d] are disaggregated using coefficients reflecting the ratio of county establishments to state establishments. A value is assigned to this sales volume using the 1977 average national service station price (50.7¢/gal. excluding tax.)[e]

16.1.2 VOC Emissions

The Illinois EPA estimated VOC emissions for gasoline service stations by applying an emission factor to the 1977 gasoline throughput. This emission factor and procedure was used to calculate emissions in Kentucky.

16.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from gasoline service stations are described in Design Criteria for Stage I Vapor Control Systems, Gasoline Service Stations. This document provides the base data on alternative methods available for controlling VOC emissions from gasoline service stations. In addition, several studies of VOC emission control were analyzed 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 service stations in Kentucky. The specific studies analyzed were: Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042; 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 service station including:

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d. Federal Highway Administration Forms, MF 25, 26, 21.

e. National Petroleum News Fact Book, 1978, p. 100.

- Installed capital cost
- Direct operating costs
- Annual capital charges
- Gasoline credit
- Net annual cost

Aggregating costs to the countywide gasoline dispensing establishment 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 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 service station discussed in Section 16.4.1. Non-attainment county costs were extrapolated from model costs.

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 county 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, costs, and economic impact of implementing RACT controls on gasoline service stations. 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		●	
Countywide costs of Emissions			●
Economic impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamiliton Inc.

16.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for gasoline service stations 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 service station industry to state economic indicators, an 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 gasoline dispensing facilities in Kentucky.

16.2.1 Size of Industry

In 1977, the four non-attainment counties contained an estimated 759 retail gasoline dispensing facilities. Of these 759 facilities, an estimated 82%[a] or 622 had annual throughputs in excess of 250,000 gallons. Put differently, 18% of retail facilities could be exempted under the proposed regulation. In addition to the 759 retail facilities, there are an estimated 1,048 private dispensing facilities. Of these 1,048 outlets, only about 1% or 11 outlets had annual throughputs in excess of the proposed exemption. Together these 633 private and retail establishments dispensed an estimated 388,000,000 gallons of gasoline valued at $197,000,000 in 1977. These same stations employed approximately 3,300 workers. Total capital investments associated with the gasoline dispensing facilities could not be identified. For further details the reader is referred to Exhibit 16-2 on the following page.

16.2.2 Comparison of Industry to State Economy

Employment and sales are used as reference indicators in order to gain a perspective on the economic significance of the gasoline dispensing industry. The estimated 3,300 employees and $197,000,000 in sales constitute approximately one percent of the civilian labor force and 5.8 percent of retail trade during 1977 in the four counties. In evaluating these percentages, it should be remembered that transportation is a vital linking element in the economy and any

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a U.S. Department of Labor, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, Appendix tables B-1 and B-2.

b Ibid., p. 42.

EXHIBIT 16-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR GASOLINE
SERVICE STATIONS IN KENTUCKY

Number of Facilities		Number of Employees			
Retail Dispensing Facilities	Private Dispensing Facilities	Retail	Private	Sales ($Billion, 1977)	Gasoline Sold (Billions of Gallons)
622[a]	11[b]	3,278[c]	22[d]	$0.197[e]	0.388[f]

a. National Petroleum News Fact Book, 1978., County Business Patterns 1976: Kentucky, The Economic Impact of of Vapor Recovery Regulations on the Service Station Industry.

b. Includes gasoline dispensing facilities such as marinas, general aviation facilities, commercial and industrial gasoline consumers and rural convenience store operations with gas pumps.

c. Estimate based on the ratio of the number of employees to the number of establishments (scaled appropriately) in the four counties as of 1976.

Boone	11.0	employees per retail outlet
Campbell	4.68	"
Jefferson	4.85	"
Kenton	4.95	"

(Source: U.S. Department of Commerce, Bureau of the Census, County Business Patterns 1976): Kentucky CBP-76-12, 1978

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 (50.7¢/gallon), National Petroleum News Fact Book, 1978.

f. Estimate based on Federal highway statistics for 1977.

Source: Booz, Allen & Hamilton Inc.

significant disruption to the gasoline dispensing sector could have indirect consequences for other sectors of the economy.

16.2.3 Characterization of the Industry: Structure and Trends

Gasoline dispensing establishments are the final distribution point in the petroleum marketing network. Exhibit 16-3 shows the position of both retail and private dispensing facilities with the former located in the bottom row and the latter primarily in the source marked "Commercial/Industrial Consumer Accounts." As the graphic indicates, all petroleum marketers retail their gasoline through one of the following type operations:

- Direct-salary operation: supplier-"controlled"/supplier-operated
- Lessee dealer: supplier-"controlled"/lessee-dealer operated
- Open dealer: dealer-"controlled"/dealer-operated
- Convenience store.

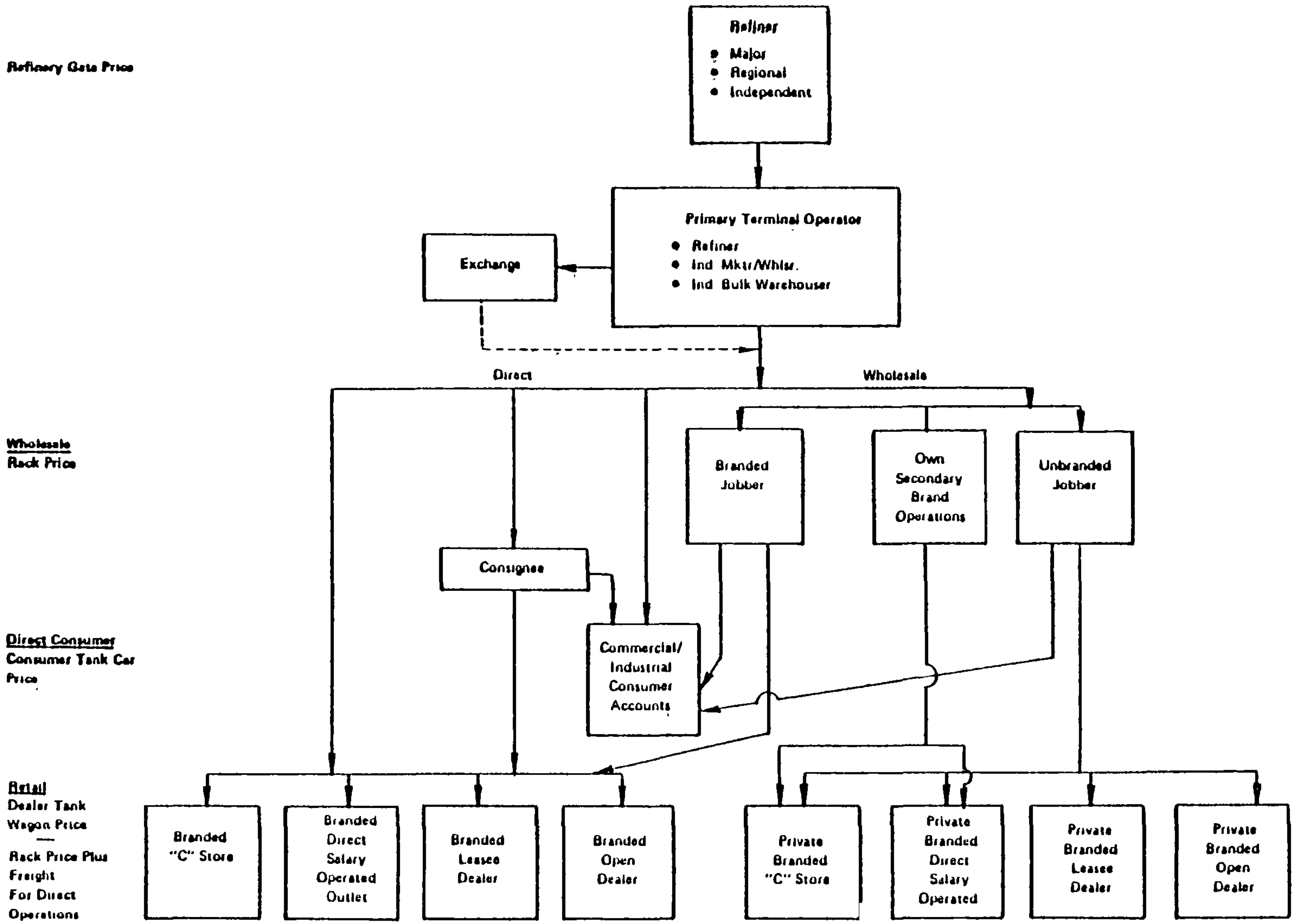
According to this classification, the retail gasoline dispensing sector has the following dimensions: 18 percent direct outlets, 5.4 percent convenience stores, 46.9 percent lessee dealers and 29.7 percent open dealers. See Exhibit 16-4 for more details.

By way of contrast the private dispensing establishments have the following breakdown by end use: agriculture trucking and local service, government, taxis, school busses, and miscellaneous. See Exhibit 16-5 for more details.

Regardless of ownership pattern or end use category, 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.

Finally, no discussion of the industry would be complete wihtout a characterization of major trends. The number of gasoline dispensing facilities, and in particular

EXHIBIT 16-3
U.S. Environmental Protection Agency
GASOLINE DISTRIBUTION NETWORK



Source: U.S. Department of Labor, "The Economic Impact of Vapor Recovery Regulations on the Service Station Industry," C-79911, March, 1978 p. 56.

EXHIBIT 16-4
U.S. Environmental Protection Agency
U.S. RETAIL GASOLINE DISPENSING FACILITIES

% TOTAL OUTLETS

	Direct Outlets[a]	Convenience Stores	Leasee Dealer[b]	Open Dealer[c]	Total Directly Supplied
Major Oil Company	3.5	0.4	28.2	15.7	47.8%
Regional Refiner	2.3	0.1	5.3	1.1	8.8%
Independent Marketer/"Super Jobber:	9.3	4.3	2.5	0.6	16.7%
Small Jobber	2.9	0.6	10.9	12.3	26.7%
% Total Outlets	18.0%	5.4%	46.9%	29.7%	100.0%
Total Number of Outlets	32,070	9,600	83,690	53,030	178,390

a Company "investment"/company operated
b Company "investment"/leasee dealer
c Dealer "investment"/dealer operated

Source: U.S. Department of Labor, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, p. 58.

EXHIBIT 16-5
U.S. Environmental Protection Agency
U.S. PRIVATE GASOLINE DISPENSING FACILITIES

End-Use Sector	Number of "Private" Gasoline-Dispensing Outlets	Annual Gasoline Consumption (Million Gal)	% Total U.S. Private Gasoline Volume	% Total U.S. Gasoline Volume
Agriculture	32,600	3,801.3	15%	3%
Trucking and local service	21,900	5,241.6	21%	5%
Government	85,450		11%	2%
- Federal		227.6	0.9%	
- Military		174.1	0.6%	
- Other*		2,266.4	9.0%	
Taxis	5,380	882.1	3%	0.8%
School Busses	3,070	144.7	1%	0.1%
Miscellaneous**	94,530	12,497.2	49%	11%
Total Non-Service Station Segment	242,930	25,235.0	100%	23%
Retail Service Station Segment	178,390	84,412.0		77%
All Segments —	421,320	109,647.0		100%

*State and municipal governments.

**Auto rental, utilities, and other.

Source: U.S. Department of Labor, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, p. 47.

the retail service stations, has been declining nationally since 1972. At the same time throughput per station has been rising reflecting the switch to high volume self-service "gas and go" establishments.[a] This trend also appears in Kentucky and is predicted to continue. In 1972 there were 3,921 service stations and in 1977 this number fell to 3,054.

16.2.4 Gasoline Prices

Gasoline prices vary among types of gasoline stations within a geographical area. Convenience stores are apt to have higher pump prices than large self-service "gas and go" stations. The pump price less the dealer tank wagon price represents the gross margin on a gallon of gasoline. Retail gasoline service station 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 service station. Operating costs vary substantially among the various types of service stations. It is reported that some service stations operate with nearly zero net margin or profit on the sale of gasoline, while others may enjoy up to four to five cents profit per gallon. Insufficient detail is available on service stations in Kentucky to present a thorough analysis of existing price structures and degree of competition in the industry within the state.

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a "Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda," EPA-450/3-76-042, November 1976, p. 2. By 1980 one-half of all retail gasoline stations are expected to be self-service.

b National Petroleum News Fact Book, 1978, p. 105.

16.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on gasoline dispensing outlet operations, estimated VOC emissions from these operations in the non-attainment areas, 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 Kentucky.

16.3.1 Gasoline Dispensing

Gasoline service stations are the final distribution point in the gasoline marketing network. Taking retail and private outlets together, the average monthly throughput per station in the four counties is 51,000 gallons. These facilities are all subject to RACT regulations and will be required to comply with Stage I vapor control by February 1, 1981.

16.3.1.1 Facilities

Equipment at gasoline dispensing facilities includes: gasoline storage tanks, piping and gasoline pumps. The most prevalent type of gasoline storage tank is the underground tank. It was assumed that there are typically three storage tanks per facility. 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, Emissions and Controls

Uncontrolled VOC emissions at dispensing facilities come from loading and unloading losses from tank trucks and underground tanks, refueling losses from vehicle tanks and breathing losses from the underground tank vent. 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 consist of:

- Organic liquid that evaporates into the air that is drawn in during the withdrawal of the tank compartment contents
- Losses from refilling the underground tank that occur as vapors are displaced from the tank
- Vapors vented into the atmosphere from underground storage tanks as a result of changes in temperature and pressure

Exhibit 16-6 shows the estimated emissions in tons per year from all dispensing facilities in non-attainment counties. To arrive at this estimate it is assumed that 90 percent[a] of all storage tank loading is by the submerge fill method and 10 percent by the splash fill method. Given this assumption, emissions based on throughput are estimated to be 1,498 tons.

16.3.2 RACT Guidelines

The RACT guidelines for Stage I VOC emission control from gasoline service stations 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 16-7 summarizes the RACT guidelines for VOC emissions control from gasoline service stations.

16.3.3 Selection of the Most Likely RACT Control Techniques

Stage I control of VOC emissions from gasoline dispensing facilities can be achieved by using vapor balancing between the unloading of incoming tank trucks and the gasoline storage tank and by submerged filling of storage tanks. There

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[a] Source: Booz, Allen interviews with industry representatives.

EXHIBIT 16-6
U. S. Environmental Protection Agency
VOC EMISSIONS FROM GASOLINE
IN THE STATE OF KENTUCKY

Estimated Number of Facilities	Average Yearly Throughput (Millions of Gallons)	Total Emissions[a] (Tons/Year)
633	388	1,498

[a] Splash fill emissions: 11.5 lbs/1000 gallons throughput
Submerge fill emissions: 7.3 lbs/1000 gallons throughput; assumes no vapor balancing with either method

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 16-7
U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR
GASOLINE DISPENSING FACILITIES

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; instructions to operator of facility on maintenance procedures; repair and replacement of malfunctioning or worn equipment; maintenance of meters and test devices

Source: "Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources," pp. 28-31.

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 are the two point connection and coaxial or concentric connection (often referred to as tube-in-tube connection). The two point connection method involves using two risers with the storage tank: one for fuel delivery and the other for returning vapors to the tank truck. The coaxial system uses a concentric liquid vapor return line and thus requires only one tank riser. EPA tests have shown the two point system to be more effective than the coaxial system in transferring displaced vapors, but at the same time the two point system is more expensive. It is judged that 25 percent of gasoline dispensing facilities will install the two point system,[1] bearing a higher installed cost but achieving greater efficiency. Submerged fill is required by Stage I vapor control. It is achieved by using a drop tube extending to within six inches of the storage tank bottom.

1 Booz, Allen interviews with industry representatives.

16.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR STAGE I RACT REQUIREMENTS

Costs for VOC emission control equipment are presented in this section. The costs for a typical gasoline service station are described, followed by an extrapolation to the non-attainment county industry.

16.4.1 Costs for Vapor Control Systems

The costs for vapor control systems were developed from information provided by petroleum marketing trade associations and from previous cost studies of gasoline dispensing facilities. These costs are summarized for a typical gasoline dispensing facility in Exhibit 16-8. The monthly throughput of an affected facility averages out at 51,000 gallons or 12,000 gallons above the average for all retail facilities in the United States.[a] Though Kentucky facilities are somewhat above the U.S. average, in general, service station equipment requirements (number of storage tanks) are not very sensitive to throughput over a large gallon range. Therefore, it appears that Kentucky facilities should be quite similar to the prototype facility described in Exhibit 16-8. Given this observation, Stage I vapor control costs have been estimated as follows.

Capital costs of installing the two point vapor-balancing equipment at existing service stations are about $2,000 per station. This cost includes equipment costs ($300-$500) and installation ($1,300-$1,600).[b] 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.

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a U.S. Department of Labor, OSHA, "The Economic Impact of Vapor Recovery Regulations on the Service Station Industry," C-79911, March 1978, p. 29.

b "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 storage tanks.)

EXHIBIT 16-8
U.S. Environmental Protection Agency
STAGE I VAPOR CONTROL COSTS FOR A
TYPICAL RETAIL GASOLINE DISPENSING FACILITY

Description of Model Gasoline Station

Monthly throughput (gallons)	39,000[a]
Number of storage tanks	3[b]

Costs
($, 1977)

	Two Point System	Coaxial or Concentric System
Installed capital	2,000[c]	600
Annualized capital charges[d]	500	150
Direct operating cost	0	0
Annualized cost[e]	500	150

a 39,000 is the national average. In Kentucky's non-attainment counties the average is 51,000 for retail dispensing outlets and 20,000 for private outlets.

b In private dispensing outlets, the number of tanks is assumed to be one as opposed to three. On the average, private stations have monthly throughput flows of only 22 percent of throughput in retail service stations.

c Includes cost of repaving but does not account for lost sales due to down time.

d Twenty-five percent of installed capital cost. Includes depreciation, interest, taxes, insurance and maintenance.

e Does not include credit for recovered gasoline.

Source: Booz, Allen & Hamilton Inc.

Based on these figures, the annualized cost[a] at a typical gasoline dispensing facility with 51,000 gallons/month throughput is estimated to be $500 for the two point system and $150 for the concentric or coaxial system. It is worth noting that direct operating costs should not increase due to Stage I controls and thus the annualized cost will reflect only the capital changes associated with the control equipment.

In addition to the cost incurred at the gasoline dispensing facility, there are also the costs of vapor balancing borne by the owners of the tank trucks. The costs to bulk gas plants and terminals of Stage I vapor modifications of fleet trucks have been discussed in other chapters. Here the focus is on independent fleet operators subject to RACT vapor controls. By approximating the total number of tank trucks needed to service the gasoline dispensing facilities in the non-attainment counties, and by subtacting from this total the estimated number of trucks controlled by bulk terminals and gas plants, the size of the independent fleet is derived. Booz, Allen estimates that only a nominal percentage of the total fleet is independent. Thus costs to independents are approximately zero.

16.4.2 Extrapolation to the Industry in Non-Attainment Areas

The total cost to the industry of installing vapor control equipment is estimated to be approximately $595,000. The amount of gasoline prevented from vaporizing by converting to submerged filling of the gasoline storage tank is estimated to be worth approximately $13,500. Based on these estimates, the annual cost per ton of emissions controlled was $95 per ton. (See Exhibit 16-9 for details.)

[a] Gasoline recovery credit has not been accounted for here, but will be when the results are extrapolated to the county-wide industry.

EXHIBIT 16-9

U.S. Environmental Protection Agency
NON-ATTAINMENT AREA COSTS FOR STAGE I VAPOR
CONTROL OF GASOLINE DISPENSING FACILITIES

SUMMARY OF COSTS

Number of facilities	633
Total annual throughput (billions of gallons)	0.388
Uncontrolled emissions (tons/year)	1,498
Emissions reduction (tons/year)	1,423[a]
Uncontrolled emissions (tons/year)	75
Installed capital ($ millions)	$0.595
Annualized capital cost ($ millions)	$0.149
Annual gasoline credit ($ millions)	0.014[b]
Net annualized cost ($ millions)	$0.135
Net annualized cost per ton of emission reduced ($ per ton/year)	$94.87

a Estimate based on 95 percent reduction in emissions.

b Gasoline credit to dispensing outlets is based on the conversion from splash to submerged filling. The actual formula relates throughput in splash fill facilities to potential captured vapors resulting from equipment conversion, and values the recoverable gasoline at its retail selling price (50.7¢/gallon). Bulk terminals also receive a gasoline credit for the recovered vapors brought back by tank trucks. This gasoline is estimated to be worth $186,000 when valued at the bulk wholesale price (42¢/gallon).

Source: Booz, Allen & Hamilton Inc.

16.5 DIRECT ECONOMIC IMPLICATIONS

This section discusses the direct economic implications for the non-attainment counties of implementing Stage I RACT controls.

16.5.1 RACT Timing

RACT must be implemented statewide by February 1, 1981. This means that gasoline service station operators must have vapor control equipment installed and operating within the next three years. The timing deadlines of RACT impose several requirements on service station operators including:

- Determining the appropriate method of vapor balancing
- Raising capital to purchase equipment
- Generating sufficient income from current operators 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.

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 U.S. 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 service stations. 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 establishment 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 establishment
- Age of the establishment.

A major finding in a study on gasoline service station vapor control was that small service stations 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 could cause the closing of some service stations.[a]

Service stations that are owned by major oil companies may have better access to capital than privately owned service stations. A private service station owner may have to borrow capital from local banks, friends or relatives, whereas a station owned by a major oil company may receive funding out of the oil company's capital budget.

It is estimated that gasoline service stations with throughput less than 30,000 gallons per month will experience a cost increase of nearly 0.10 cents per gallon to implement RACT, using the two point vapor balance system. Larger service stations will experience a cost increase only one-third as much. This will put the smaller stations at competitive disadvantage in terms of passing on a price increase.

Recent experience indicates that temporary disruption due to Stage I RACT control can have serious impacts on the service stations profitability. In an interview, the Greater Washington/Maryland Service Station Association reported that several service stations experienced a loss

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a "Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda," EPA-450/3-76-042, November 1976.

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 service stations reportedly will experience greater costs than new service stations when implementing Stage I vapor control requirements. This is because older stations will have more extensive retrofit requirements and will probably experience more temporarily lost business during the retrofit.

The number of gasoline service stations have been declining nationally over the past few years for a number of reasons, reflecting a trend towards reducing overhead costs by building high throughput stations. This trend is likely to continue whether or not vapor control is required. Implementation of Stage I RACT control may simply accelerate this as marginal operators may opt not to invest in the Required capital equipment. Sufficient data for Kentucky are not available to quantify the magnitude of this impact.

16.5.3 Comparison of Direct Cost With Selected Direct Economic Indicators

The net increase in the annual operating cost to the gasoline service stations industry from RACT represents 0.14 percent of the value of the total gasoline sold from the affected facilities in the non-attainment counties. Compared to the county-wide value of retail trade, this annual cost increase would be insignificant. The impact on the unit price of gasoline varies with the gasoline service station throughput. As discussed in the preceding section, the stations, with less than 30,000 gallons per month throughput, may experience an annualized cost increase of up to 0.10 cents per gallon of gasoline sold, whereas the larger service stations may experience an annualized cost increase only one-third as large.

16.6 SELECTED SECONDARY ECONOMIC IMPACTS

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

Employment is expected to decline, if a number of small marginally profitable gasoline service stations cease operating rather than invest capital for compliance with RACT. Based on the county-wide estimates of number of employees and the number of facilities, approximately three jobs will be lost with the closing of each gasoline dispensing outlet. 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 dominant industry trend is towards fewer stations with higher throughputs. This trend will continue with or without RACT. Those marginal facilities which do close because of RACT will merely enhance the existing industry trend towards greater concentration.

The impact on a specific service station operation is expected to be slight. Fill rates for loading gasoline storage tanks may marginally decline if coaxial or concentric vapor hose connections are used.

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Exhibit 16-10, on the following page, presents a summary of the findings of this report.

EXHIBIT 16-10 (1)
U.S. Environmental Protection Agecny
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS
OF IMPLEMENTING RACT FOR
GASOLINE DISPENSING FACILITIES
IN THE STATE OF KENTUCKY

Current Situation	Discussion
Number of potentially affected facilities	633
Indication of relative importance of industrial sector to county economy	4 county industry sales from the affected facilities are $0.197 million with a yearly throughput of 0.388 billion gallon_
Current industry technology trends	Number of stations has been declining and throughput per station has been increasin By 1980, one-half of stations in U.S. are predicted to become totally self-serv e
1977 VOC emissions (actual)	1,500 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACT guidelines	Submerged fill and vapor balance
Assumed method of control to meet RACT guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (4 counties)	$0.6 million
Annualized cost (4 counties)	$0.14 million (less than 0.1 percent of the value of gasoline sold at those affected facilities)
Price	Assuming a "direct cost pasthrough" --less than $0.001 per gallon of gasoline sold at the affected facilities
Energy	Assuming full recovery: 460,000 gallons/year (9,500 barrels of oil equivalent) saved[a]
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 shut down)

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[a] One gallon of gasoline has 125,000 BTU's. One barrel of oil equivalent has 6,050,000 BTU's.

RACT timing requirements (1982)	Retrofitting all service stations within time constraints may be difficult in a few instances
Problem area	Older stations face higher retrofit costs—potential concerns are dislocations during installations
VOC emission after RACT control	75 tons per year from tank loading operation
Cost effectiveness of RACT control	$95 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

17.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF KENTUCKY

17.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF KENTUCKY

This chapter presents a detailed analysis of the impact of implementing RACT for use of cutback asphalt in the nonattainment counties in the state of Kentucky. Presently, only four counties in Kentucky are classified as non-attainment areas. They are Boone, Campbell, Jefferson, and Kenton counties. The impact of RACT in these counties is investigated in five sections as follows:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and hydrocarbon VOC reduction benefit evaluations for RACT requirements
- Economic impacts.

Each section presents detailed data and findings based on review 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
- Control of VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control
- Data quality

for the use of cutback asphalt in Kentucky.

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 1977. The value of shipments was 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 Kentucky 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 described in Control of Volatile Organic Compounds from the 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 in order 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 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 Asphat Institute; "Technical Support for RACT Cutback Asphalt,"

1. Control of Volatile Organic Compounds From Use of Cutback Asphalt; EPA-450/2-77-037, p. 1-3.

State of Illinois; "World Use of Asphalt Emulsion," paper by Cyril C. Landis, Armak Company, "A Brief Introduction to Asphalt and Some of its Uses," the Asphalt Institute; and "Asphalt: Its Composition, Properties and Uses," Reinhold Publishing Corporation.

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:

- 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 in the previous section and from interviews with asphalt trade associations, government agencies and producers and users of cutback asphalt and emulsions. These differential costs of replacing cutback asphalt with asphalt emulsions were then extrapolated to the non-attainment counties in the state.

17.1.5 Economic Impacts

The economic impacts were determined by examining the effects of conversion to emulsion asphalts on: the costs of paving and road maintenance; the price of cutback and emulsion asphalts; the supply and demand for these asphalts; the employment of workers in end-use application; and on labor productivity in end-use applications.

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		•	
4 county 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 is also discussed. Data in this sectio… form the basis for assessing the technical and economic impacts of implementing RACT in Kentucky.

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 as asphalt from crude oil. 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 the end users, primarily state highway organizations and construction contractors.

17.2.2 Size of the Cutback Asphalt User Industry

This report addresses the size of the cutback asphalt user industry in Kentucky. Although cutback asphalt may be produced in Kentucky, the production industry is not the focus of this study since RACT requires control of the use of cutback asphalt. Twenty-four thousand five hundred and sixty-one tons of cutback asphalt were purchased in Kentucky in 1977 at a value of $2.3 million. An estimated 6,631 tons of cutback asphalt worth $0.5 million were sold in the four non-attainment counties. The value is based on an estimated average price per gallon of $0.36.

Though the uses of cutback asphalt in Kentucky are well documented, hard data on the number of employees involved in cutback paving operations are not currently available. Still, it is possible to make a reasonable estimate of the number of employees based on data found in the Department of Commerce County Business Patterns. It is estimated that in the four non-attainment counties approximately 93[a] people are engaged in operations where cutback can be used.

17.2.3 Comparison to Statewide Economy

The value of shipments of cutback asphalt to the statewide value of wholesale trade in Kentucky is less than 0.02 percent. In the four county area the ratio is estimated to be less than 0.01 percent.

17.2.4 Demand for Cutback Asphalt

In the 1920's and 1930's, the increasing sales of automobiles stimulated highway construction. The need for low cost pavement binders which provided weather resistance and dust free surfaces became apparent during this building cycle. Cutback asphalts emerged to fill this need. After World War II, the sale of cutback asphalts remained at an almost constant level. Since 1973, the use of cutback asphalt has decreased. Exhibit 17-2, on the following page, shows national sales from 1970 to 1976 of cutback asphalt, asphalt cement, and asphalt emulsions.

17.2 Prices of Products and Costs of Usage

Historically, cutback asphalts have been up to 10 percent more expensive per gallon than asphalt emulsions. In recent years, this differential has been negligible; however, in the past two years the historical price disadvantage has begun to reemerge.

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[a] In the non-attainment counties approximately 620 people were employed in highway and street construction. It is assumed that the number of people employed in cutback and emulsion applications is proportional to the 620 people in the same ratio as most of 1977 state sales of cutbacks and emulsions to 1977 state sales of all petroleum asphalts and road oils. At an estimated ratio of 15 percent, the employment in these counties is approximately 93. At the state level, the 15 percent ratio implies a labor force between 375-750. See: County Business Patterns 1976: Kentucky, U.S. Department of Commerce CBP-76-12, 1978, p. 3.

EXHIBIT 17-2
U.S. Environmental Protection Agency
HISTORICAL NATIONAL SALES OF ASPHALT CEMEMT, 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

The comparison between cutbacks and emulsions is somewhat different when one looks at quantity requirements. Though technically interchangeable in many applications, it is typically the case that more emulsion must be applied than cutback for an identical task. This is because emulsions have a lower asphalt content than cutbacks on a per gallon basis. Estimates on quantity conversions (substitutability) range from one-to-one to one-to-two in favor of cutbacks depending on the type of emulsion and the given application.

However, in terms of average cost of usage, currently, price and quantity differentials tend to be offsetting. Thus the cost of usage should be approximately the same.

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a Interview materials from The Asphalt Institute, College Park, Maryland

b Ibid. Contentions that the price per mile of emulsions is cheaper than oil based asphalts are currently being made. Though true, the contention is misleading because the comparison is between hot mix asphalts and emulsions in overlay applications. Cutbacks are not used in overlay applications.

Source: Booz, Allen & Hamilton, Inc.

17.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on the use and production of asphalt. The sources and characteristics of VOC emissions from the use of cutback asphalt are then described and are followed by: estimated state and nonattainment area 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 Kentucky.

17.3.1 Asphalt: Its Production and Uses

Asphalt is a product of the distillation of crude oil. It is found naturally and is also produced by petroleum refining. In the latter instance, the crude oil is distilled at atmospheric pressure to remove lower boiling materials. 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 a residue. Asphalts can be produced in a variety of types and grades ranging from hard brittle solids to almost water thin liquids. The type of asphalt produced depends on its ultimate use.

Asphalt is used as a paving material and in a wide range of construction applications. The cutback and emulsion asphalts that are the object of RACT legislation are paving materials used primarily in spraying and cold mix patching operations. For further information on asphalt production and use the reader is referred to: A Brief Introduction to Asphalt and Some of its Uses, The Asphalt Institute, 1977.

17.3.2 Sources and Characteristics of VOC Emissions From the Use 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 themselves. At the mixing plant, hydrocarbons are released during mixing and stockpiling. The largest source of emissions, however, is the road surface itself. In Kentucky, cutback asphalt is used in the 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 evaporating diluent in the three types of cutback asphalt constitutes the following percent of the asphalt mix by weight:

- Slow cure—25 percent
- Medium cure—70 percent
- Rapid cure—80 percent.

17.3.3 Statewide and Non-Attainment Area Emissions

Total emissions from the use of cutback asphalt in Kentucky during 1977 are estimated to be 5,087 tons. In non-attainment counties approximately 1,373 tons of VOC were emitted. But given permitted RACT exemptions on cutback curtailment, only 891 tons will be subject to control.[a] See Exhibit 17-3 for details.

17.3.4 RACT Guidelines and the Implications of Their Implementation

Presently, the State of Kentucky is preparing draft legislation on the use of cutback asphalt which will be modeled after the RACT guidelines.

The RACT guidelines specify that the manufacture, storage and use of cutback asphalts may not be permitted unless: long life storage is necessary; application at ambient temperatures below 50°F is nececcary; or application as a penetrating prime coat is necessary.

The Kentucky guidelines are quite similar in most respects, but there are some minor differences. Rather than specify conditions regarding length of storage or ambient temperatures, Kentucky exempts cutbacks from regulation during winter maintenance (December, January and February). Kentucky also exempts cutbacks used for dust suppression operations whereas RACT does not. Both RACT and Kentucky guidelines permit the use of cutbacks in penetrating prime coat applications.

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a Representatives of the Kentucky State Highway Department have indicated that RACT exemptions could account for 35% of current cutback usage. By 1983, that percentage could fall to 15% if certain technical improvements occur.

EXHIBIT 17-3
U.S. Environmental Protection Agency
ESTIMATED HYDROCARBON EMISSIONS
FROM USE OF CUTBACK ASPHALT IN KENTUCKY

	Sales[a] of Cutback Asphalt (000 Tons)			Estimated Hydrocarbon Emissions in 1977 (000 Tons)				Estimated Non-Exempted Hydrocarbon Emissions in 1977 (000 Tons)
	Rapid Cure	Medium Cure	Slow Cure	Rapid Cure	Medium Cure	Slow Cure	Total	
State	8.60	15.97	0.04	1.75	3.33	0	5.08	
4 Non-Attainment Counties[b]	2.32	4.31	0.01	0.47	0.90	0	1.37	0.891[c]

a Source: U.S. Department of Energy, Bureau of Mines

b Sales in the 4 non-attainment counties are assumed to be proportional to total state sales. The factor of proportionality is the fraction of the state population living in the 4 counties.

c 65 percent of emissions are from non-exempted cutbacks. See footnote (a) to section 17.3.3.

Given these exemptions, general experience with asphalt emulsions in several regions of the U.S. indicates that emulsions are adequate substitutes for cutbacks.[b] Moreover, the same equipment that is used to apply cutback asphalt can be used with asphalt emulsions after minor modification. The few changes necessary to replace cutback asphalt with emulsion asphalt are as follows:

- Retrain employees on the use of asphalt emulsions.
- Modify cutback asphalt equipment to accommodate asphalt emulsions, including:
  - Providing new nozzles on the distributor truck which applies the asphalt
  - Adjusting the pumps which 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.

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[b] It is reported that emulsions cannot be applied in the rain. This is also true for rapid and medium cure cutbacks.

17.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR RACT REQUIREMENTS

Costs for using asphalt emulsions in place of cutback asphalts are presented in this section. Each cost item is discussed, quantified, and then the total cost is calculated in the non-attainment areas.

17.4.1 Costs Associated With Using Asphalt Emulsions in Place of Cutback Asphalt

The information on the costs of using asphalt emulsions in place of cutback asphalt was gained from interviews with asphalt trade association members, asphalt manufacturers, and from analysis of existing studies on asphalt.

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 comparative 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 non-attainment counties for converting from the use of cutback asphalt to asphalt emulsion.

17.4.2 Extrapolation to the Industry in the Non-Attainment Counties

Converting from cutback asphalts to asphalt emulsions in the non-attainment counties is estimated to cost $15,227. This translates into $17 per ton of hydrocarbon emissions reduced. A summary of these costs is given in Exhibit 17-4 on the following page.

EXHIBIT 17-4
U.S. Environmental Protection Agency
COSTS IN KENTUCKY FOR APPLYING
RACT TO THE USE OF CUTBACK ASPHALT

Direct Cost Summary

Cutback asphalt used in non-attainment counties (tons per year)	6,631
Potential emissions reduction[a] from converting to use of emulsion asphalt (tons per year)	890
Retraining costs[b]	$8,252
Equipment modification costs[c]	$6,975
Total one-time costs	$15,227
One-time costs per ton of emissions reduced	$17.00
Annualized operating cost per ton of emission reduced	0.0

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a Assumes 35% of cutback usage will be exempted, and estimated asphalt substituted will have no VOC emissions.

b Retraining costs are calculated in two stages. First, it is assumed that the percent of the labor force unfamiliar with emulsion application will be roughly equal to a proxy ratio which relates sales of cutbacks to sales of cutback plus emulsions in 1977. Since the sales of cutbacks were 24,561 short tons and those of emulsions 58,480, the proxy ratio is about one-third. Second, this proxy ratio is multiplied by the estimated total labor force (93) and the cost per person ($300).

c Representatives of national asphalt organizations have suggested that for every two workers there is approximately one distributor truck. This implies that 46.5 trucks will need modification at a cost of $150 per truck.

Source: Booz, Allen & Hamilton Inc..

17.5 ECONOMIC IMPACTS

This section discusses the economic impacts associated with applying RACT to the use of cutback asphalt in Kentucky. The direct economic impacts include:

- User Cost—The estimated one-time cost of $15,227 distributed over four counties in Kentucky is small compared to the $409,600,000 spent on highway construction and maintenance during 1977[a].

- Price—The prices of cutback and emulsion asphalts may be marginally affected by RACT to the extent that demand and supply shifts for both products are not offsetting. However, it is not RACT but rather the increasing cost of diluents used in cutbacks which will have the most decisive impact on price differentials in the future.

- Demand—If current usage patterns prevail through 1981 when RACT is scheduled for implementation, then the demand for cutbacks might fall off by 65% while the demand for emulsions rises by 27%

- Employment—No change in employment is predicted from implementing RACT, although it will be necessary to retrain approximately 93 employees in Kentucky on the use of asphalt emulsions.

- Productivity—Given appropriate retraining, worker productivity is not expected to be affected by handling more emulsion asphalts.

In addition to direct impacts there may also be indirect effects. Implementing RACT may cause a strain on current industry capacity to meet the increased demand for emulsion asphalts. To the extent that a supply-demand imbalance is inherent, it may be necessary for producers to invest in new plant capacity. Presently, it is anticipated that sufficient lead time exists for any supply-demand imbalance to be redressed. Insufficient data are available to quantify these potential costs in Kentucky.

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Exhibit 17-5 presents a summary of the findings in this report.

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[a] Source: Federal Highway Administration. A small fraction of this cost includes depreciation on equipment.

EXHIBIT 17-5(1)

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF KENTUCKY

Current Situation	Discussion
Use potentially affected	In 1977, use of cutback asphalt was 24,561 tons statewide and an estimated 6,631 tons in non-attainment counties.
Indication of relative importance of industrial section to non-attainment county economies	1977 sales of cutback asphalt were estimated to be $2.3 million statewide and $0.5 million in non-attainment counties.
Current industry technology trends	Nationally, use of cutback asphalt has been declining.
1977 VOC emissions (actual)	5,087 tons annually statewide; 1,370 in non-attainment counties, 890 of which would be controlled under the proposed regulation.
Industry preferred method of VOC control to meet RACT guidelines	Replace with asphalt emulsions
Assumed method of control to meet RACT guidelines	Replace with asphalt emulsions

Affected Areas in Meeting RACT	Discussion
Capital investment in non-attainment areas	$0.02 million
Annualized cost in non-attainment areas	No change in paving costs are expected.
Price	No change in paving costs are expected.
Energy	1,800 barrels of oil equivalent saved[a]
Productivity	No major impact
Employment	No major impact

[a] The saving accrues to manufacturer, not user. The total energy associated with manufacturing, processing and laying one gallon of cutback is approximately 50,200 BTUs/gallon. For emulsified asphalts, it is 2,830 BTUs/gallon. One barrel of oil equivalent is assumed to have 6.05 million BTUs, and one ton of cutback asphalt is assumed to have 256 gallons.

EXHIBIT 17-5(2)

RACT timing requirements (1981)	Long range supply of asphalt emulsions are expected to be available.
Problem area	Winter paving Short range supply of asphalt emulsions
VOC emission after RACT control	Net VOC emission reduction is estimated to be 890 tons annually
Cost effectiveness of RACT control	The cost is $17 per ton in the first year. In subsequent years the cost/ton is zero.

Source: Booz, Allen & Hamilton Inc.

18.0 THE ECONOMIC IMPACT OF PROPOSED SO_2 EMISSION CONTROL REGULATIONS FOR EXISTING SOURCES IN KENTUCKY

18.0 THE ECONOMIC IMPACT OF PROPOSED SO_2 EMISSION CONTROL REGULATIONS FOR EXISTING SOURCES IN KENTUCKY

The objective of this task is to determine costs and direct economic impacts of controls needed to comply with the proposed SO_2 emission control regulations in Kentucky. These regulations include a reclassification of Boyd and Muhlenburg Counties which in effect requires two existing coal fired power plants (Green River and Paradise) in Muhlenburg County and an existing refinery (Cattlesburg) in Boyd County to meet more stringent SO_2 emissions standards. The proposed regulations are summarized in Exhibit 2-2 in Chapter 2.

The economic impact analysis of each affected facility is presented separately followed by a summary of statewide impacts of the SO_2 regulations. This chapter is divided into four sections:

- Economic Impact on the Paradise Plant
- Economic Impact on the Green River Plant
- Economic Impact on the Cattlesburg Refinery
- Summary of Statewide Impacts.

Each section presents detailed study methodology, data and findings based on analyses of the proposed regulations, previous studies of the affected facilities, interviews, and analysis.

18.1 ECONOMIC IMPACT OF PROPOSED SO_2 REGULATIONS ON PARADISE STEAM PLANT

This section presents an assessment of the economic impact of the proposed SO_2 emissions control regulations in Muhlenburg County on Tennessee Valley Authority's Paradise Steam Plant. This section is organized into eight parts:

- Methodology
- Industry Statistics
- Technical Situation
- Proposed Regulation
- Proposed Control and Estimated Emission Reduction
- Cost of Compliance
- Direct Economic Impacts
- Selected Secondary Impacts.

18.1.1 Methodology

The proposed SO_2 regulations for Muhlenburg County identify the proposed control technique to be the installation of a coal washing operation as well as a flue gas desulfurizer (FGD). Engineering cost estimates of these two systems have been prepared for EPA by PEDCo. These estimates differ from those prepared by TVA but since it was not within the scope of this study to prepare engineering cost estimates, the PEDCo estimates prepared for TVA were used. These estimates are used to assess the impacts of the proposed regulation. All cost estimates are provided in 1980 dollars and are deflated into 1977 dollars to be consistent with the rest of this report.

18.1.2 Industry Statistics

Tennessee Valley Authority is a permanent, independent corporate agency of the Federal government. TVA operates 29 hydro plants, 12 fossil-fueled steam plants, one nuclear, and three gas turbine installations in the Southeast U.S. In Kentucky, TVA operates two plants—Shawnee and Paradise. The Paradise plant is one of the largest power plants in the U.S. with a total capacity of 2,558 MW. It represents 9 percent of TVA's total generating capacity of 28,295 MW.

18.1.3 Technical Situation

The Paradise Plant has three boilers which all have electrostatic precipitators but currently no SO_2 control devices. Two boilers have maximum installed capacity of 704 MW each and each has a 600 foot stack. The other boiler has 1150 MW of installed capacity and has an 800 foot stack. The plant burned 4,925 thousand tons of coal in 1977, and SO_2 emissions were estimated to be 568,000 tons per year.[1]

18.1.4 Proposed Regulation

The proposed Kentucky regulations call for a reclassification of Muhlenburg County from 4 to 4A. This would limit sources with hourly heat inputs of 1500 MMBtu or greater to SO_2 emissions of 2.1 lbs/MMBtu for liquid fuels and 3.1 lbs/MMBtu for solid fuels.[2] This reclassification will affect two facilities in the county. This section discusses the impact on the TVA Paradise Steam Plant, and Section 18.2 discusses the impact on the Green River Steam Plant.

18.1.5 Proposed Control and Estimated Emission Reduction

The proposed technique for reducing the SO_2 emissions from the Paradise Plant is identified in the proposed regulation. A limestone flue gas desulfurizer system is to be installed, as well as a coal washing operation. The estimated emissions after the proposed control are 220,000 tons SO_2 per year.[3]

18.1.6 Cost of Compliance

The costs of compliance with the proposed SO_2 regulations to TVA have been estimated for EPA Region IV by PEDCo.[4] The total costs to TVA involve the costs of the FGD as well as the coal

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1 Kentucky Division of Air Pollution Control.

2 MMBtu = million Btu.

3 Kentucky Division of Air Pollution Control.

4 Based on personal communication with PEDCo—Environmental Specialists, Inc., who is under contract with U.S. EPA Region IV, to develop cost estimates for the TVA plant.

washing operation. Exhibit 18-1, on the following page, depicts the estimated costs of the FGD and Exhibit 18-2, following Exhibit 18-1, depicts the estimated costs of the coal washing. Exhibit 18-3 combines these costs and provides a total cost to TVA of complying with the proposed SO_2 regulations. In all three of these exhibits the costs have been discounted from 1980 dollars (the year PEDCo used for their estimate) to 1977 dollars assuming a seven percent inflation rate per year.

The cost estimates for the FGD are based on the following assumptions:

- Six 140 watt modules to be installed on each of two units (one module is spare per unit)
- Labor rate is $11/hr
- Land is $1,000/acre
- Limestone costs $4/ton
- Electricity cost is 10 mills/kwh
- Tax rate is 3 percent
- Water is 12 cents/1,000 gallons
- Cost of capital is 8 percent
- Reheat steam is 1.59 Btu
- Twenty-year life of unit
- Coal usage is 555.4 tons/hr
- Air flow is 434,000 cubic feet per minute (cfm)
- 80 percent efficiency needed on scrubber to achieve 0.9 lbs SO_2/MMBtu emission rate to meet the regulation for the entire plant.

18.1.7 Direct Economic Impact

The capital requirements of complying with the proposed Kentucky regulation have been estimated to be $151 million. This compares to TVA's total assets of more than $9 billion

Exhibit 18-1
U.S. Environmental Protection Agency
CAPITAL AND OPERATING COSTS OF FLUE GAS DESULFURIZER AT PARADISE PLANT

	Mid-1980 Dollars[1] (millions)	1977 Dollars[2] (millions)
Capital Investment		
Limestone preparation	$ 5.716	$ 4.666
SO_2 scrubbers	75.176	61.366
Sludge disposal	2.674	2.183
Raw material inventory	0.187	0.153
Other[3]	34.482	28.148
Contingency	23.647	19.303
Contractor fee	7.094	5.791
Land cost	0.188	0.153
Total capital costs	$149.164	$121.762
Annualized Costs		
Limestone	$ 1.447	$ 1.181
Fixation chemicals	2.040	1.665
Water	0.062	0.051
Electricity	2.340	1.910
Reheat	2.050	1.673
Direct labor	0.482	0.393
Supervision	0.072	0.059
Maintenance	7.462	6.091
Overhead	4.119	3.362
Depreciation	7.458	14.302[4] (Depreciation and Interest combined)
Interest	11.933	
Insurance	0.447	0.365
Taxes	4.457	3.653
Total annualized cost	$ 44.387	$34.705

1 PEDCo—Environmental Specialists, Inc.

2 Booz, Allen estimate based on 7 percent inflation rate.

3 Includes interest during construction, fixed overhead, engineering, offsite, taxes, spares and allowance for shakedown.

4 Using EPA's capital recovery factor for 20 year life and 10 percent interest.

Source: Booz, Allen & Hamilton Inc.

Exhibit 18-2
U.S. Environmental Protection Agency
CAPITAL AND OPERATING COSTS OF
COAL WASHING SYSTEM AT PARADISE PLANT

	1980 (millions)	1977[1] (millions)
Capital Costs	$36.0[2]	$29.386
Annualized Costs		
Annualized operating and maintenance[3]	$ 7.5	$ 6.122
Rejected coal cost	7.0[4]	5.714
Total annualized cost	$14.5	$11.836

1 Booz, Allen estimate based on 7 percent inflation rate.

2 PEDCo—Environmental Specialists, Inc.

3 Based on a 20 year life, 3.3 percent for taxes and insurance, 3 percent maintenance, 3 percent operating and labor and 10 percent interest.

4 PEDCo—Environmental Specialists, Inc.

Source: Booz, Allen & Hamilton Inc.

Exhibit 18-3

U.S. Environmental Protection Agency

CAPITAL AND OPERATING COSTS OF SO_2 EMISSION CONTROLS AT PARADISE PLANT

	1980[1]	1977[2]
Capital Costs		
FGD ($ million)	$149.164	$121.762
Coal washing ($ million)	36.000	29.386
Total capital costs ($ million)	$185.164	$151.148
Capital costs per kw ($/kw)	$132.260	$107.960
Annualized Costs		
FGD ($ million)	$ 44.387	$ 34.705
Coal washing ($ million)	14.400	11.836
Total annualized cost ($ million)	$ 58.787	$ 46.541
Annualized cost per kwh[3] (mills/kwh)	5.45	4.31

1 PEDCo—Environmental Specialists, Inc.

2 Booz, Allen estimate based on 7 percent inflation rate.

3 This represents the cost per kwh at Paradise Plant only. When total TVA generation is considered, the cost per kwh would be 0.36 mills. See Section 18.1.7.

Source: Booz, Allen & Hamilton Inc.

18.2 ECONOMIC IMPACT OF PROPOSED SO_2 REGULATIONS ON GREEN RIVER STEAM PLANT

This section presents an assessment of the economic impacts of the proposed SO_2 emissions control regulations in Muhlenburg County on Kentucky Utilities' Green River Steam Plant. This section is organized into eight parts:

- Methodology
- Industry statistics
- Technical situation
- Proposed regulation
- Proposed control and estimated emission reduction
- Cost of compliance
- Direct economic impacts
- Selected secondary impacts.

18.2.1 Methodology

The SO_2 emission control technique was identified in the proposed regulations. The method proposed is to use low sulfur coal. There are no capital costs involved in this procedure. The operating costs are estimated as the price differential between the high sulfur coal and low sulfur coal. The impacts of these costs are assessed and selected secondary impacts of the proposed regulation are also discussed.

18.2.2 Industry Statistics

Kentucky Utilities operates five steam plants, two hydro and one gas turbine generating station. The stations are located mostly in eastern Kentucky particularly around Lexington. Green River, in Muhlenburg County, is the only power station operated by Kentucky Utilities in western Kentucky. Green River is a small facility in relation to Kentucky Utilities' total electrical generation, with a net generation of 265 million kwh compared to the utility's total of 8470 million kwh in 1977.[1]

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1 Booz, Allen interviews with Kentucky Utility representatives.

2 Moody's Public Utilities Manual.

18.2.3 Technical Situation

The Green River Steam Plant has five dry-bottom coal-fired boilers. Three of the boilers share a common stack and each has an electrostatic precipitator as well as a lime scrubber to control particulate and SO_2 emissions respectively. The maximum operating capacity of these boilers is 25 MW each. The other two boilers have maximum operating capacities of 75 MW and 113 MW; these units have particulate control devices but do not have SO_2 control devices. The entire plant used 400,300 tons of coal from September 1977 through August 1978, with an average heating value of 11,307 Btu per pound[1]. The three units with scrubbers together used 20 percent of the total coal with the scrubbers operating at an 81 percent SO_2 removal efficiency[2]. The annual SO_2 emissions for the entire plant are estimated at 23,500 tons[3].

18.2.4 Proposed Regulation

The proposed Kentucky regulations call for a reclassification of Muhlenburg County from Class 4 to 4A. This limits sources with heat inputs of 1500 MMBtu/hr or greater to SO_2 emissions of 2.1 lbs/MMBtu for liquid fuels and 3.1 lbs/MMBtu for solid fuels. This reclassification would affect two facilities in the county: the Green River facility and the Paradise plant, Section 18.2 discussed the TVA Paradise plant and this section discusses the other affected facility.

18.2.5 Proposed Control and Estimated Emission Reduction

The proposed technique for reducing SO_2 emissions from the Green River plant is to burn low sulfur coal. Since three of the five boilers have scrubbers the most cost effective approach to achieve the plantwide SO_2 limitation of 3.1 lbs/MMBtu would be to continue to use high sulfur coal in these three boilers and switch to low sulfur coal in the remaining two boilers. The maximum allowable sulfur content

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1 Kentucky Division of Air Pollution Control

2 Ibid.

3 Booz, Allen estimate based on meeting the existing plantwide SO_2 limitation of 5.2 lbs/MMBtu. The actual emissions could be lower depending upon the actual sulfur content of the coal used.

in the low sulfur coal will depend upon:

- The quantity, sulfur content, and heating value of the coal burned in the three boilers with scrubbers and the scrubber efficiency
- The heating value and quantity of coal burned in the remaining two boilers.

The coal quantities required depend upon the heat input to the boilers and the heating value of the coal. For the purpose of this analysis, it is assumed that the total annual heat input to the plant and its proportion to the controlled and uncontrolled boilers would be the same as those during September 1977 and August 1978. Based on this assumption, the total annual heat input to the plant would be 9.04×10^{12} Btu, of which 20 percent would be the controlled boilers and the rest to the uncontrolled boilers. If the controlled boilers continue to use western Kentucky coal with typical heating value of 11,300 Btu/lb, the amount of high sulfur coal required would be 79,950 tons per year. The uncontrolled boilers are likely to use low sulfur eastern Kentucky coal with typical heating value of 11,800 Btu/lb, thus requiring 306,450 tons per year of eastern Kentucky coal.

The plantwide SO_2 emissions after control are estimated to be 14,000 tons per year based on total plant heat input of 9.04×10^{12} Btu and the proposed emissions limitation of 3.1 lbs/MMBtu. Therefore, the plantwide reduction in SO_2 emissions after control would be 9,500 tons per year.

18.2.6 Cost of Compliance

The method of control identified in the proposed regulation is to burn a lower sulfur coal. Since this coal can be burned in the existing facility, no capital costs are incurred[1].

The increased operating costs identified with the proposed control technique are due to the higher price for low sulfur coal. Although the Green River steam plant is located in the midst of western Kentucky coal mines, this

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1 Based on Booz, Allen discussions with Kentucky Utilities' representatives.

western Kentucky coal is high in sulfur content. In order for Green River to burn low sulfur coal, it must be shipped in from eastern Kentucky or Indiana with added rail transportation cost.

Currently, Green River uses both the high sulfur, western and low sulfer eastern Kentucky coal. However, with the use of the scrubbers on the three boilers, the existing plantwide SO_2 emissions limitation of 5.2 lbs/MMBtu can be met without using the eastern Kentucky coal. Therefore, for the purpose of establishing a baseline for estimating the economic impact of the proposed regulations it is assumed that the plant currently burns only western Kentucky coal. As discussed in the previous section, the plant could annually burn 306,450 tons of eastern Kentucky coal with the uncontrolled boilers and 79,950 tons of western Kentucky coal with the controlled boilers instead of burning 400,399 tons of western Kentucky coal plantwide to comply with the proposed regulation. The cost of the western coal is projected at $26 per ton delivered for mid-1979, whereas that of the eastern Kentucky coal is estimated at $31 per ton delivered[1]. Using these mid-1979 cost estimates, the cost of compliance is estimated to be $1.2 million/year in mid-1979 dollars. Using an annual inflation rate of 7 percent, the estimated cost in 1977 dollars would be $1.05 million.

18.2.7 Direct Economic Impact

Kentucky's fuel adjustment clause allows adjustment for transporation costs and raw coal cost differences. Therefore, if the entire costs are passed through to Kentucky Utilities' customers, the effect will be seen in the price of electricity. To estimate the effect on the price of electricity, the percentage increase in operating revenues due to higher fuel costs is used as an estimate for the price increase.

To measure the increase in revenues, estimates are needed for operating revenue before the proposed control and after the proposed control. The before control estimate should be based on the assumption of all western Kentucky coal being used since this is possible

1 Based on interviews with Kentucky Utilities representative.

under the current regulation. Since some eastern Kentucky coal is being used by Kentucky Utilities, an adjustment to operating revenue is needed. After this adjustment the before control operating revenue is estimated to be $259.12 million for 1977[1].

In section 18.2.6 the increase in coal costs was estimated to be $1.05 million in 1977 dollars. Adding this to the before control reveneues produces an estimate of $260.17 million for after control operating revenue. If the increase in operating revenues is used as an estimate of price increase, a 0.41% increase is estimated. This estimate attributes the entire price difference to the proposed control method. Since Green River is currently burning some eastern Kentucky coal the price increase the customers experience may be lower.

The $1.05 million annualized cost to Kentucky Utilities translates into $111 per ton of SO_2 emissions reduced.

18.2.8 Selected Secondary Impacts

Currently, Kentucky Utilities is using western Kentucky coal; the switch to eastern Kentucky coal may benefit both eastern Kentucky coal mines and railroads at the expense of western Kentucky coal mines and railroads.

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1 The operating revenues for Kentucky Utilities in 1977 was reported as $257 million in Moody's Public Utility Manual. To get the operating revenue based on the exclusive use of western Kentucky coal the $6.96 million reported to the Federal Energy Regulation Commission for 1977 is subtacted from the operating revenues and the estimated western Kentucky coal costs are added to the operating revenue. The western Kentucky coal costs are based on an estimate of $26 a ton in mid 1979 deflated at 7% a year to 1977 dollars.

18.3 ECONOMIC IMPACT OF PROPOSED SO_2 REGULATIONS ON CATTLESBURG REFINERY

This section presents an assessment of the economic impact of the proposed SO_2 emissions control regulations in Boyd County on Ashland Petroleum Inc. This section is organized into eight parts:

- Methodology
- Industry statistics
- Technical situation
- Proposed regulation
- Proposed control and estimated emission reduction
- Cost of compliance
- Direct economic impact
- Selected secondary impact.

18.3.1 Methodology

The methodology developed identifies those costs attributable to compliance with Kentucky's proposed SO_2 regulations on existing sources. The method of control is identified in the regulation as fuel blending. The blend of distillate to be mixed with residual fuel oil is determined based on the emission limitation prescribed in the proposed regulations. Operating costs are derived from the price variation between distillate and residual. Capital requirements are estimated based on a report by the Kentucky Division of Air Pollution Control. The economic impact is analyzed by comparing the cost of compliance with normal capital expenditures and product price and by assessing selected secondary impacts.

18.3.2 Industry Statistics

Ashland Petroleum Company, a subsidiary of Ashland Oil Incorporated, operates an integrated petroleum refinery in Cattlesburg, Kentucky with a current throughput capacity of 135,000 barrels per day (BPD). The Cattlesburg refinery is the largest of four refineries in Kentucky. Cattlesburg accounts for approximately 80 percent of the state's total throughput capacity. With a second refinery operated by Ashland in Louisville, Ashland accounts for 97 percent of the state's total throughput capacity. Ashland also operates five more refineries in other states.

Refining is an important part of Ashland Oil, accounting for 57 percent of Ashland's total operating income. Petroleum refining is slated to become even more important in Ashland's future. The company has recently announced a new corporate strategy which emphasizes its refinery operations.

18.3.3 Technical Situation

The Ashland refinery in Kentucky is not only affected by the proposed Kentucky SO_2 regulations but also by other Federal regulations. Therefore, to understand the impact of the proposed Kentucky SO_2 regulations, the effects of this regulation must be separated from those of Federal regulations. A brief description of Ashland's unique situation is therefore given, followed by an estimate of current emissions.

18.3.3.1 Current Situation

Under the U.S. Environmental Protection Agency's leaded gasoline phasedown program, Ashland is required to switch to production of a greater quantity of unleaded gasoline by October 1, 1979. To achieve this, Ashland has proposed the installation of a new 70,000 BPD crude unit while simultaneously retiring a 25,000 BPD crude unit at the Cattlesburg refinery. The construction will be completed by 1980 and will include: a 20,000 BPD continuous catalytic regenerating reformed unit (CCR), a naptha desulfurizer, a stripper unit with a dehexanizer reboiler and an additional fluid catalytic cracking unit.

This proposed construction requires permission from the Kentucky Division of Air Pollution Control. However, under state regulation 401 KAR 3:010 Section 7(3)(c), no permit to construct may be issued if the proposed source interferes with or prevents the attainment of any National Ambient Air Quality Standards (NAAQS). Since the refinery is located in a nonattainment area for SO_2, to obtain the permit Ashland must comply with the U.S. EPA guidelines for construction in a nonattainment area. According to these guidelines, the allowable SO_2 emissions are governed by the best available control technology (BACT) criterion required for new sources together with emission offsets required for the attainment and maintenance of the NAAQS from the existing refinery. However, before Ashland can qualify for obtaining an offset from the existing refinery emissions, it must comply with the proposed state SO_2 regulations for the existing refinery.

Ashland and the state have agreed to a compliance program to control SO_2 emissions from the proposed expansion and the existing operations. Since this compliance program includes control techniques designed not only to meet the proposed state regulations but also to meet the emissions offset requirements and the control of the expansion, separating emission reductions, controls, and costs which pertain to proposed Kentucky regulations is difficult. The approach followed in this analysis is to estimate those costs due to proposed Kentucky regulations for the existing facility, recognizing that it is part of an overall action by Ashland.

18.3.3.2 Current Emissions

According to the data provided by the State Air Pollution Control Division, SO_2 emissions from the existing operations are 8800 pounds per hour or 33,918 tons per year based on an 88 percent annual capacity factor. Assuming that all of these emissions result from fuel combustion in the indirectly heated heat exchangers with a heat input of 3994 MMBtu/hour, the emissions are equivalent to 2.2 lbs/MMBtu heat input. The fuel is assumed to be 15,264 bbl/day of residual oil (#6 oil) with sulfur content of 2.11 percent.

18.3.4 Proposed Regulation

The proposed Kentucky regulations call for a reclassification of Boyd County from Class 5 to 5A. This limits SO_2 emissions from sources with hourly heat input of 1500 MMBtu or greater to 0.4 lbs/MMBtu for liquid fuels and 0.6 lbs/MMBtu for solid fuels. The only facility identified as affected by the proposed regulation is the Cattlesburg refinery.

18.3.5 Proposed Control and Emissions Reduction

The proposed control method for reducing SO_2 emissions from the refinery is to burn low sulfur fuels. Currently the refinery uses residual oil with 2.11 percent sulfur by weight, and some natural gas on an intermittent basis. Since the availability of natural gas cannot be reliably predicted, it is assumed that fuel oil would be the only fuel used at the refinery for purposes of this analysis. The sulfur content of the fuel oil is assumed to be reduced by blending low sulfur distillate from the refinery with residual oil.

The amount of distillate needed to be blended with the residual oil to achieve 0.4 pounds of SO_2 emission per MMBtu heat input is determined by solving the following two equations:

Hd x D + Hr x R = total heat input per hour from fuel oil
= 3,994 MMBtu/hr

Ed x D + Er x R = allowable SO_2 emissions from fuel oil combustion
= 0.4 x 3,994 lbs/hr

where Hd = heating value of distillate, 5.824 MMBtu/bbl
Hr = heating value of residual oil, 6.285 MMBtu/bbl
D = amount of distillate used, bbl/hour
R = amount of residual oil used, bbl/hour
Ed = SO_2 emission factor for distillate, lbs/bbl
= 0.11 percent sulfur x 0.142 lbs/gal[1] x 42 gal/bbl
Er = SO_2 emission factor for residual oil, lbs/bbl
= 2.11 percent sulfur x 0.157 lbs/gal[1] x 42 gal/bbl

Using the above values in the two equations, the amount of distillate is estimated as 633 bbl/hr or 15,192 bbl per day and the amount of residual oil is estimated as 49 bbl/hr or 1173 bbl per day. The average sulfur content of the blended oil is estimated to be approximately 0.4 percent. The emissions after compliance would be 1598 lbs/hr, which is equivalent to 81.9 percent reduction from the existing emission rate of 8800 lbs/hr.

18.3.6 Cost of Proposed Control

This section presents capital, operating and annualized cost of the proposed SO_2 control measures.

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1 Compilation of Air Pollution Emission Factors, AP-42, U.S. EPA, April 1977.

18.3.6.1 Capital Costs

The portion of the costs of the expansion which is due to fuel blending has been estimated by the Kentucky Division of Air Pollution Control. Recognizing that these estimated capital costs of fuel blending are part of the expansion and not a retrofit of the existing facility, some determination of the costs attributable to the existing facility needs to be made. It is assumed that the capital costs can be allocated in proportion to the throughput capacity before and after the expansion. Kentucky Division of Air Pollution Control estimated the capital costs of fuel blending to be ½ percent of the total costs of the expansion. This is for expenditure of additional piping, valves, pumps and blending tanks; installation costs are assumed to be another ½ percent. With these assumptions, Kentucky Division of Air Pollution control estimated the capital costs of fuel blending to be $767,000 installed. Allocating the portion applicable to the existing facility yields an installed capital cost of $591,686, calculated as 135,000 BPD/175,000 BPD x $767,000.

The installed capital costs for fuel blending are derived under the assumption of a single system for fuel blending for which 1 percent of the total plant capital costs represents an upper bound on the estimate. If, however, the system is designed to selectively blend for each crude unit, the capital costs could be somewhat higher.[1] Since no estimate is available for higher capital costs or possible benefits from selective blending, the estimate made by the Kentucky Division of Air Pollution Control for single blending is used in this analysis.

18.3.6.2 Operating Costs

The total annual operating cost of fuel blending is simply the difference between the fuel cost before the control versus the fuel cost after control. The difference between the price of distillate and residual fuel was reported to be 5 cents per gallon.[2]

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1 Based on Booz, Allen interviews with Ashland representatives.

2 Ibid.

The prices of distillate and residual fuel oil are dependent on market conditions of supply and demand. The difference per gallon can be as high as 7 cents. For purposes of this analysis, 37 cents per gallon for distillate and 32 cents for residual was used as reported by Ashland. Multiplying these prices by the appropriate quantities before and after the control yields an increase of $13.86 million per year assuming 88 percent utilization.

18.3.6.3 Annualized Cost

For purposes of annualizing costs, a 15 year straight line depreciation period is assumed. Interest is assumed to be 10 percent. This produces a capital carrying charge of 13.147 percent. Taxes and insurance are 4 percent. Exhibit 18-4 summarizes the components of the total annualized cost of the proposed SO_2 regulation for the existing refinery. The total annualized costs are $13.96 million.

The increase in costs to Ashland of $13.96 million a year corresponds to an emission reduction of 27,759 tons of SO_2 per year or $503 per ton of SO_2 emission reduced if all fuel needs are to be met with fuel oil. A 40 percent utilization of natural gas would lower the cost to $302 per ton of SO_2 reduced.

18.3.7 <u>Economic Impacts</u>

The economic impacts of the proposed SO_2 regulation on Ashland Petroleum are assessed in terms of increases in capital and operating costs. The increased capital costs of $0.59 million should not significantly affect Ashland Petroleum whose capital additions were $149 million in 1977.

Assuming 88 percent average annual utilization, increased annualized costs to Ashland would be $13.96 million if only fuel oil were burned. If 40 percent of the Cattlesburg fuel needs are met by natural gas, the increase would be reduced to $8.4 million.

Exhibit 18-4

U.S. Environmental Protection Agency

ANNUALIZED COST TO ASHLAND PETROLEUM INC. FOR COMPLYING WITH PROPOSED SO_2 REGULATION FOR EXISTING REFINERY

Item	Cost (thousand dollars)
Annualized capital costs	$ 101
Increase in fuel cost/year	$13,860
Total annualized cost	$13,961

Source: Booz, Allen & Hamilton Inc.

Increased costs to Ashland could add 10 cents to each barrel of oil refined if no natural gas is used. If 40 percent of the fuel needs are met by natural gas, the increase would be 6 cents per barrel. The 10 cents increase per barrel is estimated to cause less than a 1 percent increase in the price of the refined products.

The economic impacts on Ashland depend to a great extent on the availability of natural gas for use as a fuel. The cost and emission estimates which were derived for Ashland assumed that the refinery met its fuel need entirely with fuel oil. However, natural gas is currently used on an intermittent basis depending on availability. The more natural gas used the lower the emissions would be and therefore the lower the amount of fuel blending required to meet the proposed limitations. The future availability of natural gas would determine the extent to which it may be used.

The cost estimates are also sensitive to changes in the estimated price difference between the high sulfur and low sulfur fuel.

18.3.8 Selected Secondary Impacts

A factor which could impact Ashland is its ability to sell the residual fuel oil which is displaced by the distillate. No significant problems are foreseen in this respect.

The distillate fuel oil used would displace an equal amount of distillate available for sale. Although this means some fuel used as diesel fuel and home heating will be displaced, alternate supplies should be available with no significant impact on prices of these products.

18.4 STATEWIDE IMPACT OF PROPOSED SO_2 REGULATION

This section aggregates the impact of the proposed SO_2 control regulations in Boyd and Muhlenburg counties in Kentucky. The aggregate costs of compliance are discussed first, followed by a summary of the statewide economic impacts.

18.4.1 Statewide Cost of Control

Each of the three facilities studied in this chapter has proposed a different technique for complying with the proposed Kentucky SO_2 emissions regulation. In the case of the Paradise steam plant, the proposed technique is to install a flue gas desulfurizer and a coal washing operation. The estimated capital costs of these two systems is $152 million. The total annualized cost for the Paradise plant is estimated to be $46.5 million. For the Green River steam plant, the proposed control technique involves switching to a low sulfur coal. There are no capital costs involved, but the difference in the cost of high and low sulfur coal was estimated at $5 per ton. The total annual costs of the control was therefore, estimated at $1 million. The Cattlesburg refinery in Boyd County has proposed fuel blending of #2 low sulfur fuel oil with the presently used #6 high sulfur fuel oil. The annualized costs of this process for the existing facility is estimated to be $14 million. Exhibit 18-5 summarizes these costs along with the emission reduction. Based on these results the annualized cost per ton of SO_2 emissions reduced is estimated to be $160.

18.4.2 Statewide Economic Impact of Proposed Regulation

The total capital expenditures of $152 million represents a significant capital investment in Kentucky. By way of comparison, capital expenditures in 1976 for all manufacturing excluding utilities (SIC group 20-39) in Kentucky was $521 million. Construction of the flue gas desulfurizer and coal washing operation comprise most of the capital expenditure. This construction will cause a temporary increase in employment.

Assuming a full cost pass through (which is reported to be a standard procedure for utilities in Kentucky) the

Exhibit 18-5
U.S. Environmental Protection Agency
SUMMARY OF CAPITAL, AND ANNUAL
COSTS AND EMISSION REDUCTION FOR
THE STATE OF KENTUCKY OF
THE PROPOSED SO_2 REGULATION

	Capital Cost $ millions	Annualized Cost $ millions	Emission Reduction tons/year	Annualized Cost Per Ton SO_2 Emission Reduced
Paradise Steam Plant	151.2	46.5	348,000	$133
Green River Plant	-	1.1	9,500	$111
Cattlesburg Refinery	.6	14.0	27,759	$503
Total	151.8	61.6	385,259	$160

Source: Booz, Allen & Hamilton Inc.

cost of compliance with the proposed SO_2 regulations would represent:

- For TVA customers an average of 2.4% increase in the price of electricity

- For Kentucky Utilities customers an average of 0.4% increase in the price of electricity over what they would have to pay if the Green River plant met the existing SO_2 emissions limitation. However, since Green River is currently emitting less SO_2 than that allowed under the existing regulations by using more expensive eastern Kentucky coal, most of the cost of compliance with the proposed regulation is already reflected in the current price of electricity. The customers, therefore, may experience a much lower increase in the current price of electricity.

- For Ashland Petroleum customers an average of less than 1% increase in the price of refined products.

The two steam plants involved account for 9 percent of the state's total utility generated electricity[1]. The refinery accounts for 80 percent of the states total refinery throughput capacity.

These increased prices may have secondary impacts on the industries who consume the products of these three facilities. Energy prices in the service areas of the affected facilities may be raised relative to other areas due to the proposed regulation.

1 Comparison with state total supplied by Edison Electric Insititute.