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CONTROL OF VOC EMISSIONS FROM INK AND PAINT MANUFACTURING PROCESSES

control technology center

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CONTROL TECHNOLOGY CENTER

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DISCLAIMER

This final report was prepared for the Control Technology Center, U.S. Environmental Protection Agency, by Alliance Technologies Corporation, 100 Europa Drive, Chapel Hill, NC 27514, in partial fulfillment of Contract No. 68-D0-0121, Work Assignment No I-29. The opinions, findings and conclusions expressed are those of the authors and not necessarily those of the Environmental Protection Agency.

PREFACE

This report was prepared for and funded by the Control Technology Center (CTC), U.S. Environmental Protection Agency. The CTC was established by EPA's Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to State and local air pollution control agencies. Several levels of assistance are available through the CTC: a CTC HOTLINE provides telephone assistance on matters relating to air pollution control technology; in-depth engineering assistance is provided when needed by EPA and its contractors; and the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters. The fourth assistance program sponsored by the CTC is the CTC Bulletin Board System (BBS), a part of the EPA OAQPS Technology Transfer Network. Users of the BBS can retrieve CTC information through one of four major area menu selections. The four areas included are Utilities, Help Center, Documents/Software, and CTC Projects.

Technical guidance projects, such as this one, focus on topics of national or regional interest that are identified through contact with State and local agencies. In this case, the CTC received a number of calls on controlling volatile organic compound (VOC) emissions from processes used to manufacture ink and paint. Controlling VOC emissions at various source types that have not been addressed by Control Techniques Guidelines (CTG's) is of interest to many States and local air pollution control agencies due to on-going ozone nonattainment problems (VOC is a precursor of ozone) and requirements in Title I of the Clean Air Act Amendments of 1990. This report presents the results of a study to identify and collect information on paint and ink manufacturing processes and the VOC emissions generated during these operations.

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EXECUTIVE SUMMARY

In the United States today there are approximately 1,123 companies operating 1,426 paint plants and 224 companies operating 504 ink facilities. Many of these manufacturing facilities produce solvent-based products. Together the two industries consume an estimated 2,750 million pounds of organic solvent which accounts for 0.05 percent of total volatile organic compound (VOC) emissions. The application of these paints and inks accounts for an additional 13 percent of VOC emissions.

The products of the paint manufacturing industry include architectural coatings, product coatings for original equipment manufacturers (OEM), and special-purpose coatings. The four primary types of inks are letterpress inks, lithographic and offset inks, gravure inks, and flexographic inks. All of these products are made with the same basic raw materials: pigments, solvents, resins (or binders), and other additives. In most cases, the manufacturing facilities purchase these raw materials and then formulate or blend, rather than react, to produce a finished product. The batch process production of paint and ink involves four major steps: preassembly and premix, pigment grinding/milling, product finishing/blending, and product filling/packaging. Some of the equipment used to accomplish these manufacturing steps include roller mills; ball and pebble mills; attritors; sand, bead, and shot mills; horizontal media mills; and high-speed disk dispersers.

Releases of volatile organic compounds from paint and ink manufacturing include those from the process steps and from cleanup operations. However, very little information is available which quantifies these emissions. Many paint and ink manufacturing facilities calculate total plant VOC emissions based on raw material consumption rather than calculating emissions from processes or equipment by an alternative method. Emission values therefore reflect solvent losses from manufacturing, cleaning, and storage. Because emissions have not been quantified, there are no publicly available emission factors for paint and ink manufacturing processes. Emission factor data contained in facility permits is most likely based on theoretical equations rather than on actual test data. These values vary significantly from State to State.

Similarly, regulatory requirements vary from State to State as paint and ink facilities are not identified by any current Control Technique Guideline (CTG). In many States only those non-CTG facilities emitting more than 100 tons per year are controlled, while in other States the

VOC limit may be 15 pounds per day. Several of the requirements common to the States with rules regulating VOC emissions from paint and ink facilities include the following: covers must be used on all open equipment and equipment must be monitored and inspected regularly for leaks. Most States also exclude from regulation those facilities emitting less than 100 tons per year VOC and those plants manufacturing primarily water-based products.

Regardless of State regulations, paint and ink facilities must use some method to control the VOC emissions that are generated throughout the manufacturing process. If left uncontrolled, these emissions can cause high concentrations of VOC in the work area compromising worker health, safety, and productivity. Some of the methods used by paint and ink facilities in reducing emissions are tank lids, horizontal media mills, equipment cleaning devices, recycling techniques, and improved operating practices. Many facilities have also invested research and development time and dollars in new product lines with lower VOC concentrations. Powder coatings, waterborne paints and inks, radiation-curable paints and inks, and high-solids products are slowly replacing some of the markets once dominated by solvent-borne formulations.

Few facilities use VOC reduction methods other than those previously mentioned. However, control systems including capture devices and thermal incinerators are technically feasible for the low VOC concentrations and the wide variety of contaminants found in paint and ink waste streams.

Before a thorough assessment of control systems can be conducted, more emissions data must be accumulated or generated. There is a general lack of data presented in literature and State permit information concerning the quantity, composition, and breakdown of the emissions generated by the various stages in the paint and ink manufacturing process.

CHAPTER 1
INTRODUCTION

This report presents the results of a study to collect and report information on processes used to manufacture paint and ink, volatile organic compound (VOC) emissions generated during these operations, emission control techniques and their effectiveness, and costs associated with process changes and emission control options. State agencies and other government-sponsored programs, as well as equipment manufacturers, professional and trade organizations, and paint and ink manufacturers were contacted to assess production methods, available control technologies, and current emission rates from the manufacturing processes.

Many paint and ink manufacturing facilities produce solvent-based products. In the United States today, there are approximately 1,123 companies operating 1,426 paint plants and 224 companies operating 504 ink facilities. Almost half of these plants are small, employing fewer than 20 people. Most of the facilities are located in population centers because of high transportation costs. It is also estimated that more than half of these plants are located in ozone nonattainment areas.

This report is divided into five chapters and three appendices. Chapter 2 characterizes the two areas of primary focus, the paint manufacturing industry and the ink manufacturing industry, and also provides a general description of the raw materials these facilities use, the products they make, and the markets they serve. Chapter 2 also provides a description of the manufacturing process and processing equipment common to both ink and paint manufacturers.

The sources of process VOC emissions are identified and characterized in Chapter 3. Also included in this section are emission factor data which are divided into three sections: information retrieved from current State regulations, information obtained from State permit files, and data received from plant trips.

Chapter 4 discusses methods of reducing and controlling VOC emissions resulting from the ink and paint manufacturing process. Areas addressed include equipment and process modifications, improved operating practices, recycling techniques, product reformulations, and add-on control techniques. Chapter 5 estimates the costs associated with several of these reduction and control methods.

The report also includes three appendices. Appendix A lists paint and ink facilities with annual sales greater than one million dollars. Appendix B contains tables which have a selection of permit requirements from several States. Appendix C contains copies of the trip reports for the two paint and two ink facilities visited during the course of this work assignment.

CHAPTER 2
INDUSTRY STRUCTURE AND PROCESS DESCRIPTION

2.1 GENERAL

This chapter gives an overview of the paint and ink manufacturing industries. The chapter is divided into three sections: Paint Manufacturing Industry Structure, Ink Manufacturing Industry Structure, and Manufacturing Process Description. Both of the industry structure sections address the current market, materials used in the manufacturing process, products manufactured, and product end-uses. The last section in this chapter focuses on the four steps in both the paint and ink manufacturing processes with emphasis on equipment and procedure.

2.2 PAINT MANUFACTURING INDUSTRY STRUCTURE

2.2.1 Introduction

This section gives an overview of the paint manufacturing industry, including geographic distributions, production trends, industry issues, and the major subdivisions within the industry. Also included in this section is information relating to manufacturing raw materials, finished products, and product end-uses. Much of the data is based on the Standard Industrial Classification (SIC) 2851.

2.2.2 Market, Raw Materials, and Products

The paints and allied products industry, as defined by SIC 2851, consists of firms that manufacture paints, varnishes, lacquers, enamels, shellacs, putties, wood fillers and sealers, paint and varnish removers, paint brush cleaners, and allied paint products. Facilities which manufacture pigments, resins, printing inks, adhesives and sealants, and artists' paints are not included under SIC code 2851. According to the 1987 Census of Manufactures, the paints and allied products industry employed 55.2 thousand people with nearly 40 percent of the industry's employment in the States of California, Ohio, Illinois, and New Jersey. In 1987, SIC 2851 facilities were composed of 1,123 companies operating 1,426 plants, two-thirds of which were located in ten states. Over 50 percent of paint manufacturing plants are small, privately owned facilities employing less than 20 people and specializing in a limited product line marketed within a small geographic region. Some companies, however, own multiple manufacturing facilities and distribute products nationwide. Regardless of ownership, the paint manufacturing industry tends to concentrate in population centers because of high transportation costs. An estimated 50 percent of the manufacturing facilities are located in ozone nonattainment areas.[1]

The raw materials used in the paint manufacturing process include pigments, solvents, and resins. Some commonly used paint raw materials are listed in Table 2-1. The chemical composition of paint varies depending on the desired paint properties. Pigments provide the coating with color, opacity, and a degree of durability. Pigmented coatings are more weather-resistant than unpigmented paints. In the case of metal primers, pigments are used to check or inhibit corrosion of the metal. Pigments may be either organic or inorganic. Almost all of the organic pigments used today are manufactured, while inorganic pigments may be either natural or manufactured. Most natural pigments are oxides or hydroxides of iron. Manufactured pigments span the entire color spectrum with a wide range of brilliance and opacity.[2]

The fluid component of a coating, consisting of nonvolatile binders and volatile solvents, is called the vehicle. Binders are those components which form a continuous phase, hold the pigment in the dry film, and cause it to adhere to the surface to be coated. The majority of binders in modern paint films are composed of resins and drying oils which are largely responsible for the protective and general mechanical properties of the film. Most resins and oils used in paint manufacturing are organic, although some are inorganic. Alkyds, acrylics, and vinyls are three of the more commonly used resins.[2,3]

The vehicle solvents are used to keep paints in liquid form so they can be applied easily. When a coating is deposited on a substrate, the solvent should evaporate completely. It is used to transfer the pigment/binder mixture to a surface in a thin, uniform film and plays no role in film formation. Materials used as solvents include aliphatic hydrocarbons (white spirit and the Special Boiling Point (SBP) solvents), aromatic hydrocarbons (toluene, xylene, and the trimethyl benzenes), alcohols, esters, ketones, esters and ether-esters of propylene glycol. Water is the solvent in water based and emulsion paints.[2,3]

TABLE 2-1. PAINT RAW MATERIALS CONSUMED IN 1987

Material		Quantity[1]
Vegetable oils	mil lb	*183.0
Pigments:		
Titanium dioxide, composite and pure (100% TiO_2)	mil lb	763.7
Other inorganic pigments, including chrome colors, whiting, white and red lead, litharge, lithopone, zinc oxide, calcium carbonate precipitated, etc.		(NA)
Organic color pigments, lakes, and toners		(NA)
Solvents:		
Hydrocarbons (toluene, xylene, etc.)	mil lb	**818.2
Alcohols (butyl, ethyl, isopropyl, etc.)	do	*283.6
Ketones and esters (methyl ethyl ketone, ethyl acetate, etc.)	do	435.2
Other	do	*382.5
Plastics resins:		
Alkyds	mil lb	*626.3
Acrylics	do	627.9
Vinyl	do	**595.0
Other plastics resins	do	*764.5
Petroleum thinners (naphtha)	mil gal	(S)
Nonmetallic minerals and earths, ground or otherwise treated (calcium carbonate, talc, silica, kaolin, mica, barite, soapstone, clay, and other clay minerals) for use as extenders		(NA)
All other organic and inorganic chemicals, n.e.c.		(NA)

[1]For some establishments, data have been estimated from central unit values which are based on quantity-cost relationships of the data reported by the establishment. The following symbols are used when the percentage of each quantity figure estimated in this manner equals or exceeds 10 percent of the figure published in this table: *10 to 19 percent estimated; **20 to 29 percent estimated. If 30 percent or more is estimated, figure is replaced by (S).

Source: Adapted from Reference 1
do - Ditto
n.e.c. - Not elsewhere classified
(NA) - Not available
(S) - Withheld because estimate did not meet publication standards

Another category of paint raw materials, present only in small concentrations in the 0.2 to ten percent range, is additives. These chemicals perform a special function or impart a certain property to the coating. Additives include driers, thickeners, biocides, surfactants, dispersing agents, antifoams, and catalysts.[3]

The products of the paint manufacturing industry are categorized according to their use, the type of vehicle or carrier used in manufacture, and the method of curing. The use categories are architectural coatings, product coatings for original equipment manufacturers (OEM), and special purpose coatings.[4] Architectural coatings are products used to coat interior and exterior surfaces. OEM coatings include finishes which provide the first coating on newly manufactured equipment and products. Special purpose coatings are products formulated to meet specific use requirements such as extreme temperatures or heavy wear. A summary of the paint use divisions by use category and subcategory is found in Table 2-2. In 1987, the value of all coating shipments was $9.91 billion dollars ($4.25 billion for architectural coatings, $3.64 billion for product coatings, and $2.02 billion for special purpose coatings).[1] *Ward's Business Directory* lists 364 paint and allied products facilities in SIC 2851 with 1990 sales greater than $1,000,000. This list is given in Appendix A, Table A-1.[5]

Paint products may also be classified by the type of vehicle or carrier incorporated in the paint formulation. This classification normally refers to the volatile solvent portion of the vehicle rather than to the combined solvent and binder. The volatiles, typically water or solvent, evaporate after the paint has been applied to the substrate. The total annual production of the average paint plant in the United States consists of 60 percent solvent based product, 35 percent water based paint, and 5 percent allied products. While more than 70 percent of architectural coatings are water based, the majority of product and special purpose coatings are solvent based.[1]

The third method used to categorize coatings is curing. This system applies to nonvolatile coating systems which do not rely on the evaporation of solvent or water to achieve the desired finish. Coatings included in this category are powder coatings, radiation-curable coatings, and two-part catalyzed paints.

TABLE 2-2. PAINT CATEGORIES BY USE

Product		1987 Product Shipments Quantity	Value (million dollars)
ARCHITECTURAL COATINGS	mil gal	527.0	4,245.4
Exterior, solvent-type:			
Solvent thinned paints and tinting bases, including barn and roof paints	mil gal	20.2	216.5
Solvent thinned enamels and tinting bases, including interior-exterior floor enamels	do	14.5	152.7
Solvent thinned undercoaters and primers	do	8.2	78.3
Solvent thinned clear finishes	do	10.3	83.6
Solvent thinned stains, including shingle and shake	do	17.8	165.4
Other exterior solvent thinned coatings, including bituminous paints	do	11.6	120.3
Exterior, water-type:			
Water thinned paints and tinting bases, including barn and roof paints	mil gal	95.9	732.0
Water thinned undercoaters and primers	do	7.7	58.7
Water thinned stains	do	9.2	61.9
Other exterior water thinned coatings	do	11.4	100.1
Interior, solvent-type:			
Flat solvent thinned wall paints and tinting bases, including mill white paints	mil gal	8.3	81.5
Gloss and quick drying enamels and other gloss solvent thinned paints and enamels	do	4.4	53.6
Semigloss, eggshell, satin solvent thinned paints, and tinting bases	do	15.0	155.7
Solvent thinned undercoaters and primers	do	7.0	64.3
Solvent thinned clear finishes	do	8.6	100.7
Solvent thinned stains	do	7.6	83.7
Other interior solvent thinned coatings	do	5.8	63.6
Interior, water-type:			
Flat water thinned paints and tinting bases	mil gal	125.5	834.3
Semigloss, eggshell, satin, and other gloss water thinned paints and tinting bases	do	81.3	614.1
Water thinned undercoaters and primers	do	10.2	64.9
Other Interior water thinned coatings	do	15.9	106.8
Architectural lacquers	do	10.5	81.7
Architectural coatings, n.s.k.	do	19.9	170.9

(continued)

TABLE 2-2. PAINT CATEGORIES BY USE (continued)

Product	1987 Product Shipments	
	Quantity	Value (million dollars)
PRODUCT FINISHES FOR ORIGINAL EQUIPMENT MANUFACTURERS (OEM), EXCLUDING MARINE COATINGS .... mil gal	**327.1**	**3,637.0**
Automobile finishes .... do	55.4	987.7
Truck, bus, and recreational vehicle finishes .... do	14.9	280.3
Other transportation equipment finishes, including aircraft and railroad .... do	3.2	54.3
Appliances, heating equipment, and air-conditioner finishes .... do	5.8	70.1
Wood furniture, cabinet, and fixture finishes .... do	43.1	276.6
Wood and composition board flat stock finishes .... do	7.3	53.2
Sheet, strip, and coil coatings, including siding .... do	20.3	303.4
Container and closure finishes .... do	60.2	413.1
Machinery and equipment finishes, including road building equipment and farm implement .... do	16.2	181.3
Nonwood furniture and fixture finishes, including business equipment finishes .... do	14.3	187.7
Paper, paperboard, film, and foil finishes, excluding pigment binders .... do	11.0	66.7
Electrical insulating coatings .... do	3.6	34.1
Powder coatings .... do	19.1[1]	193.2
Other industrial product finishes, excluding semimanufactured products, such as pigment dispersions and ink vehicles .... do	27.6	333.0
Product finishes for original equipment manufacturers (OEM), excluding marine coatings, n.s.k. .... do	24.9	202.4
SPECIAL PURPOSE COATINGS, INCLUDING ALL MARINE COATINGS .... mil gal	**137.3**	**2,018.6**
Industrial new construction and maintenance paints (especially formulated coating for special conditions of industrial plants and/or facilities requiring protection against extreme temperatures, fungi, chemicals, fumes, etc.):		
Interior .... do	13.0	169.8
Exterior .... do	28.5	323.6

(continued)

TABLE 2-2. PAINT CATEGORIES BY USE (continued)

Product		1987 Product Shipments	
		Quantity	Value (million dollars)
SPECIAL PURPOSE COATINGS, INCLUDING ALL MARINE COATINGS, Continued			
Traffic marking paints (all types, shelf goods, and highway department)	do	19.8	98.7
Automotive, other transportation, and machinery refinish paints and enamels, including primers	do	44.3	903.8
Marine paints, ship and offshore facilities and shelf goods for both new construction and marine refinish and maintenance, excluding spar varnish	do	9.1	144.1
Aerosol-paint concentrates produced for packaging in aerosol containers	do	12.8	239.8
Special purpose coatings, n.s.k.	do	9.9	138.9

[1]In 1987, quantity was collected in pounds and converted to gallons using a conversion factor of 3 lb:1 gal.

Source: Adapted from Reference 1
do - Ditto
n.s.k. - Not specified by kind

2.2.3 Paint Product End-Uses

Paint is a suspension of finely separated pigment particles in a liquid, which when spread over a surface in a thin layer will form a solid, cohesive, and adherent film. Paints have been used for many centuries for decorative purposes. The Industrial Revolution expanded the end-uses of paint and can be thought of as the beginning of the modern paint industry.[2] Today, paints are used to solve both aesthetic and protective problems on a variety of surfaces which include wood, masonry, metal, plastics, and fiberglass. The end-uses of paint are defined by the markets served (See Table 2-2).

2.3 INK MANUFACTURING INDUSTRY STRUCTURE

2.3.1 Introduction

This section gives an overview of the ink manufacturing industry, including geographic distributions, production trends, industry issues, and the major subdivisions within the industry. Also included in this section is information relating to manufacturing raw materials, finished products, and product end-uses. Much of the data is based on the Standard Industrial Classification (SIC) 2893.

2.3.2 Market, Raw Materials, and Products

The ink manufacturing industry includes those facilities classified under SIC code 2893 which manufacture letterpress, lithographic and offset inks, gravure, and flexographic inks. This category does not include the addition of solvents to inks by printers to reduce ink viscosity (i.e., press side reduction). The 1987 Census of Manufactures shows that the 504 ink manufacturing facilities in the United States are owned by 224 companies which employ a total of 11,100 people in nineteen States and the District of Columbia. More than 60 percent of the manufacturing facilities employ fewer than 20 people.[6] Like paint manufacturing facilities, ink plants concentrate in population centers. Nearly 60 percent of all ink facilities and 75 percent of all persons employed by ink facilities are located in ozone nonattainment areas.[6]

Printing inks are a mixture of pigments, oils, resins, solvents, and driers. Some commonly used ink raw materials are listed in Table 2-3. The fluid component of the ink, made of binders (oils and resins) and solvents, is called the vehicle. The vehicle serves as the dispersing and carrying agent for the pigment particles and gives the ink the required rheological properties of flow and plasticity. Vehicles carry pigments through printing presses and transfer and bind the ink to the surface to be printed.[7,8]

Pigments are the solid, colored part of printing inks which are visible to the eye when viewing printed material. As in paints, pigments provide inks with color, opacity, durability, and body or consistency. Pigments, as well as binders, determine whether or not a print will bleed in water, oil, alcohol, fats, acid, or alkali. Thus, pigments are partially responsible for determining the end use of the ink. Ink pigments, like paint pigments, may be classified as either organic or inorganic and natural or manufactured.[7,8]

Oils serve as one of the film-forming agents in letterpress, lithographic, and offset inks. Most oils used in the manufacture of printing inks are classified by their origin as mineral oils, vegetable oils, animal oils, and synthetic oils. Vegetable oils are further categorized into the drying oils and the non-drying oils. Non-drying oils are used in vehicles which dry by the absorption of the vehicle into the paper. These oils penetrate the substrate, soft absorbent papers such as news and comic paper, rather than evaporate from the substrate's surface. Drying oils dry by oxidation.[8] Vegetable drying oils are most often used in printing inks. The primary vegetable drying oils are linseed oil, chinawood oil, perilla oil, and soya bean oil. Steadily replacing the natural oils are synthetic oils such as dehydrated castor oil, re-esterified fish oil acids, and long-oil alkyds.[7]

Resins are one of the primary components in printing ink vehicles. Along with oils, they serve as film-forming ingredients (binders) and impart to the ink gloss, drying speed, improved hardness, toughness, and scuff-resistance. Resins are divided into two classes: natural resins and synthetic resins. All natural resins, with the exception of shellac, are formed by solidifying the viscous sap of trees. Fresh sap contains both resins and volatile oils. Although the oils are normally removed by distillation or evaporation, residual volatiles may remain in the treated resin and eventually contribute to the volatile content of the ink product. Several synthetic resins

TABLE 2-3. INK RAW MATERIALS CONSUMED IN 1987

Material		Quantity[1]
Materials, containers, and supplies		**(NA)**
Organic and inorganic pigments	mil lb	228.6
Carbon black	do	*283.0
Plastics resins consumed in the form of granules, pellets, powders, liquids, etc., but excluding sheets, rods, tubes, and shapes	do	*60.7
Paints, varnishes, lacquers, shellacs, japans, enamels, and allied products (includes all ink vehicles and varnishes)	1,000 lb	*457.6
Wood rosin, turpentine, and other wood chemicals	mil lb	85.1
Hydrocarbon oils and solvents	mil gal	**92.7
Oxygenated solvents	do	**24.9
Metal containers		(NA)
All other materials and components, parts, containers, and supplies		(NA)
Materials, containers, and supplies, n.s.k.[2]		(NA)

[1]For some establishments, data have been estimated from central unit values which are based on quantity-cost relationships of the data reported by the establishment. The following symbols are used when the percentage of each quantity figure estimated in this manner equals or exceeds 10 percent of the figure published in this table: *10 to 19 percent estimated; **20 to 29 percent estimated. If 30 percent or more is estimated, figure is replaced by (S).

[2]Total cost of materials of establishments that did not report detailed materials data, including establishments that were not mailed a form.

Source: Adapted from Reference 6
do - Ditto
n.s.k. - Not specified by kind
(NA) - Not available

include phenol formaldehyde resins, alkyds, polyesters, vinyls, silicones, and polyurethanes.[7]

The ink industry refers to solvents as any organic liquid used to dissolve film-forming materials and keep them in solution until the ink is applied to the surface to be printed. When the ink has been applied, the solvent should be removed quickly to allow the ink to dry. Ink formulators use a number of different solvents including ketones, ethers, esters, alcohols, alcohol-ethers, chlorinated compounds (methylene chloride, carbon tetrachloride, and trichloroethylene), and some aromatic hydrocarbons such as toluene and xylene.[7]

Driers are used in inks which contain oxidizable oils or vehicles which form films by oxidation. The driers, most often organic salts of metals such as lead, manganese, and cobalt, act as catalysts and are added to drying oils to increase their normal drying rate. The metal constituent imparts the drying action, while the organic portion of the salt carries the metal into solution, or dispersion, with the oil. Too much drier causes the ink to skin and dry on the press, fill in halftones, and causes the sheets to stick and offset in the pile.[7,8]

Inks, like paints, may contain small concentrations of additives. Additives perform a special function or impart a certain property to the coating. Additives include biocides, surfactants, antifoams, and waxy or greasy components. The waxy and greasy components are used to improve the working and setting qualities of the ink, and to eliminate offsetting, sticking, and picking problems. Waxes may be cooked directly into the vehicle, or prepared as a compound and added to the ink.[7,8]

Inks may also be classified by use and according to the type of vehicle used in the formulation. The four primary types of inks are letterpress inks, lithographic and offset inks, gravure inks, and flexographic inks. Typically, flexographic and rotogravure inks employ a solvent carrier, while letterpress, lithographic, and offset inks are of an oil or paste base. A summary of the ink classifications by use category and subcategory is found in Table 2-4. In 1987, the value of all ink shipments was $2.36 billion dollars ($164.1 million for letterpress inks, $987.3 million for lithographic and offset inks, $414.5 million for gravure inks, $424.8 million for flexographic inks and $370.1 million for otherwise classified inks).[6] *Ward's Business Directory* lists 56 ink manufacturing facilities in SIC 2893 with 1990 sales greater than $1,000,000. This list is given in Appendix A, Table A-2.[5]

TABLE 2-4. INK CATEGORIES BY USE

Product	1987 Product Shipments[1]	
	Quantity[2]	Value (million dollars)
TOTAL	(NA)	**2,360.7**
Letterpress inks	(NA)	**164.1**
New inks ... mil lb	203.1	100.7
Publication inks ... do	(S)	9.8
Packaging inks ... do	12.1	27.4
Other letterpress inks ... do	16.5	20.9
Letterpress inks, n.s.k.	(NA)	5.2
Lithographic and offset inks	(NA)	**987.3**
News inks ... mil lb	314.3	256.9
Publication inks:		
Web types ... mil lb	*179.9	311.0
Sheet types ... do	**20.0	68.5
Packaging inks ... do	18.2	77.7
Web commercial type ... do	39.3	73.0
Other lithographic and offset inks, including sheet commercial type ... mil lb	*50.8	162.8
Lithographic and offset inks, n.s.k.	(NA)	37.4
Gravure inks	(NA)	**414.5**
Packaging inks ... mil lb	111.3	153.6
Publication inks ... do	293.8	248.2
Other gravure inks ... do	*0.9	1.4
Gravure inks, n.s.k.	(NA)	11.2
Flexographic inks	(NA)	**424.8**
Packaging inks:		
Solvent types ... mil lb	117.7	189.3
Water types ... do	125.0	172.4
Other flexographic inks:		
Solvent types ... mil lb	5.2	8.9
Water types ... do	19.8	31.0
Flexographic inks, n.s.k.	(NA)	23.1
Printing inks, n.e.c.	(NA)	**140.4**
Textile printing inks ... mil lb	36.0	45.3
Screen printing inks ... do	(S)	59.6
Other printing inks, including stencil inks ... do	(S)	34.0
Printing inks, n.e.c., n.s.k.	(NA)	1.4
Printing ink, n.s.k.	(NA)	**229.7**
Printing inks, n.s.k., typically for establishments with 10 employees or more (see note)	(NA)	160.5
Printing inks, n.s.k., typically for establishments with less than 10 employees (see note)	(NA)	69.2

[1]Data reported by all producers, not just those with shipments of $100,000 or more.

[2]For some establishments, data have been estimated from central unit values which are based on quantity-cost relationships of the data reported by the establishment. The following symbols are used when the percentage of each quantity figure estimated in this manner equals or exceeds 10 percent of the figure published in this table: *10 to 19 percent estimated; **20 to 29 percent estimated. If 30 percent or more is estimated, figure is replaced by (S).

Source: Adapted from Reference 6
do - Ditto
n.e.c. Not elsewhere classified
n.s.k. - Not specified by kind
(NA) - Not available
(S) - Withheld because estimate did not meet publication standards

2.3.3 Ink Product End-Uses

The end-uses of ink correspond to the use categories (i.e., the type of printing process for which the ink is manufactured): letterpress inks, lithographic and offset inks, gravure inks, and flexographic inks. Letterpress, relief, or typographic inks (except flexographic inks) are those inks used in printing processes employing raised characters or plates. Letterpress printing is the oldest printing method, and until the mid 1970s, it was the major consumer of printing inks. Now, ink facilities manufacture more of both gravure and lithographic inks. The primary uses of letterpress inks include high-speed, long-run magazine and newspaper printing. Other letterpress inks are used in the packaging industry, particularly on corrugated containers. Many letterpress inks are black: almost all black inks use carbon black as the pigmenting agent.[7,8] The majority of letterpress inks dry by absorption or penetration and are, therefore, oil based.[6,7]

According to the 1987 Census, lithographic ink accounts for almost 40 percent of ink shipments in the United States and slightly over 40 percent of product shipment value.[6] Lithographic printing processes include all processes of printing from flat, or slightly etched, surfaces, such as stone lithography, offset lithography, dry offset printing, and offset tin printing.[7] Lithographic inks are used in the newspaper, publication, and packaging industries.[6] The vehicle in lithographic inks normally consists of one or more lithographic varnishes (linseed oil that has been bodied by heat alone) or high-boiling solvents combined with oils and resins.[7,8]

Gravure inks, and the gravure processes, are used in the production of fine, engraved stationery and announcements, postage stamps, paper money, and illustrations in some books. Gravure printing is also used in newspaper, magazine, and booklet supplements, and on a wide range of packaging materials such as plastic films and foil. Ink is transferred from an etched flat or cylindrical plate to the stock. Gravure inks consist of pigments, binders, and solvents. The solvents incorporated in gravure inks are very volatile, allowing them to evaporate completely from the ink film. The most important branches of gravure printing are the copper and steel plate processes, the steel die stamping process, and the photogravure and rotary photogravure (rotogravure) processes.[7,8]

Flexography, a branch of rotary letterpress printing, uses flexible, rubber relief plates with fluid, volatile inks. As of 1987, water has acted as the solvent in slightly more than 50 percent of flexographic inks.[6] The remaining inks use volatile alcohols and glycol ethers.[6,7] The flexographic printing process was developed in Germany in the 1920s primarily for printing grocery bags during their manufacture. Since that time, flexography has spread to other packaging areas and has been adapted to print on cellophane, foil, Mylar, polystyrene, and polyethylene. Flexographic inks also print well on glassine, tissue, sulphite, kraft and other paper stocks, paperboard, corrugated liners, bags, paper labels, box coverings, folding cartons, gift and trademark wrappings, corrugated boxes, paper cups and containers. Flexographic printing provides attractive, economical packaging materials and is seen in all grocery stores on prepackaged items from snack foods to clothing, cigarettes, toiletries, and industrial products.[7,8,9]

In addition to the conventional inks (i.e., letterpress inks, lithographic and offset inks, gravure inks, and flexographic inks), there are several other types of specialty ink products including textile and silk screen inks, invisible inks, powdered inks, and carbon paper, typewriter, and duplicating inks.

2.4 MANUFACTURING PROCESS DESCRIPTION

2.4.1 Introduction

Paint and ink facilities use similar manufacturing processes to produce their respective products. Most small plants (i.e., facilities employing less than 20 people) produce paint in 10 to 500 gallon batches, while larger facilities produce paint in 200 to 3,000 gallon batches with stock items made in 10,000 gallon runs.[10,11] Inks are produced in batches ranging from one gallon to over 1000 gallons.[11]

The raw materials used in the manufacture of paints and inks include pigments, solvents, resins (or binders), and other additives. In most cases, the manufacturing facilities purchase these raw materials and then formulate, or blend, a finished product. Normally, no chemical reactions take place during the process.[11] Batch process production of paint and ink involves four major steps:[9,12,13,14]

- preassembly and premix

- pigment grinding/milling
- product finishing/blending
- product filling/packaging

The manufacturing process is summarized in Figure 2-1.

2.4.2 Preassembly and Premix

The first step in the manufacturing process is preassembly and premix. In this step, the liquid raw materials (e.g., resins, solvents, oils, alcohols, and/or water) are "assembled" and mixed in containers to form a viscous material to which pigments are added. The pigment and liquid mixture forms a thicker material, which is then sent to the grinding operations. At this stage, the particles in the concentrate are rather large (250 μm) and not consistently mixed.[9] The premix stage results in the formation of an intermediate product which is referred to as the base or mill base. With further processing, this base with high pigment concentration may become any one of a variety of specific end products.[9,12]

2.4.2.1 *Resin production and cooking*

Resin production is typically considered the first step in the manufacturing process. However, few paint facilities, and even fewer ink plants, currently manufacture their own resins. This step is now being accomplished in closed reactors in chemical plants. Once the resin has been manufactured, it must be cooked and then converted to a usable vehicle. Over the last decade, this step, like resin production, has become increasingly performed by chemical plants. Chemical facilities cook resins with oils, fatty acids, or alcohols in indirectly heated, closed stainless steel vessels.[15] These reactors are normally vented through a fractional distillation column and a condenser, so that vaporized compounds are recycled back into the reactor. After the resin has been cooked and then cooled, it is thinned with solvent to produce the vehicle.[15,16] The thinning stage is often the point at which paint and ink plants begin their manufacturing process.

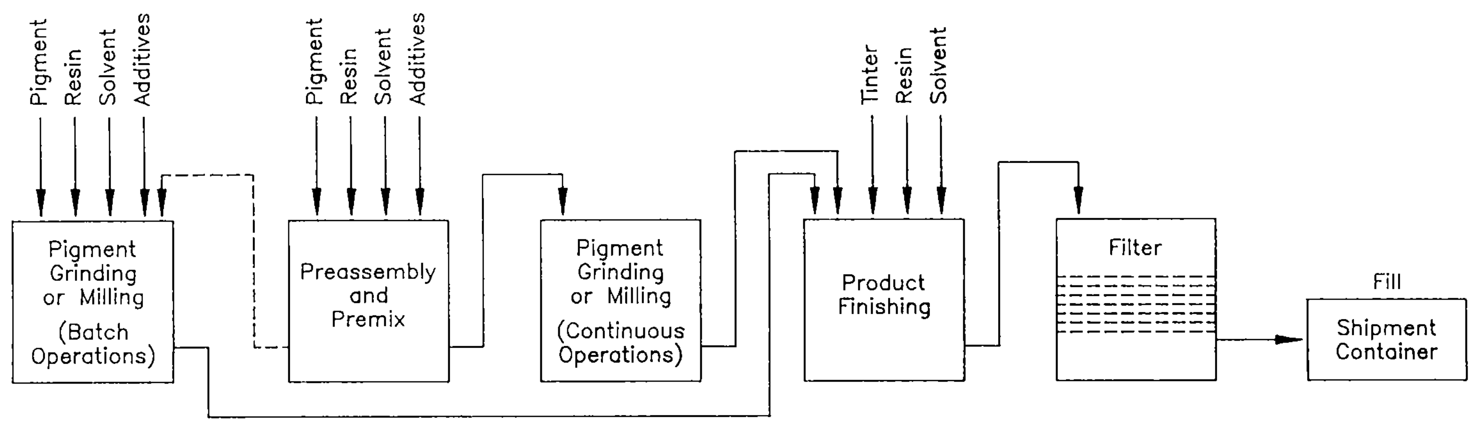

Figure 2-1. Flow diagram of the paint and ink manufacturing process.

2.4.2.2 *Equipment selection*

Premixing is necessary to keep the pigment in suspension in the resin, alcohol, solvent, and oil mixture and to supply the dispersion equipment with a consistently mixed material. A wide variety of equipment may be used in the premix process. Choosing which to use depends in part on batch size. Drum-sized batches made in the drum itself may be blended with a portable mixer which clamps onto the rim of the drum. These mixers normally have a three or four blade impeller and may be either hydraulic or electric.[17] Other materials made in portable mix tanks may be blended using larger, permanent high-speed dispersers or variable-speed mixers fitted with paddle, propellor, turbine, or disc-type agitators.[16] In some cases, a paint or ink will be moved to a dispersion mill for grinding and milling, and then transferred back to the same premix mixer for blending operations.[9]

Other facilities use typical grinding equipment to accomplish premix operations. One paint manufacturing plant uses dispersers and mixers to achieve high-sheared mixing when working with insoluble powders (i.e., pigments and additives). The same plant uses ball/pebble mills or Kady mills when mixing soluble powders. In this case, the facility may eliminate the need to transfer the material to another type of grinding equipment as the premix and milling steps are accomplished in one piece of equipment.[13]

2.4.3 Pigment Grinding or Milling

The incorporation of the pigment into the paint or ink vehicle to yield a fine particle dispersion is referred to as pigment grinding or milling. This process occurs in three stages (i.e., wetting, grinding, and dispersion) which may overlap in any grinding operation. To wet the pigment particles, the wetting agent, normally a surfactant, must displace all contaminants (e.g., air, moisture, and gases) adsorbed on the surface of the pigment particles. The wetting process actually begins in the premix step, when the pigment is charged to the liquid vehicle.[16,18] Grinding is the mechanical breakup and separation of the pigment particle clusters into isolated primary particles. Dispersion is the movement of the wetted particles into the body of the liquid vehicle to produce a permanent particle separation.[18]

The goal of pigment grinding is to achieve fine, uniformly-ground, smooth, round pigment particles which are permanently separated from other pigment particles. The degree to which this is realized determines the coating effectiveness and permanency of the paint or ink. Grinding equipment must work effectively with the vehicle to accomplish this end. Just as there is a variety of pigment vehicles, so there is an array of dispersion (milling) equipment. Some of the more common equipment is described in the following nine sections.

2.4.3.1 *Roller mills*

Roller mills may have from one to five rolls which grind pigments into vehicles. Most paint and ink facilities that use roller mills operate with conventional three-roll mills. A schematic diagram of a three-roll mill is shown in Figure 2-2. The premixed pigmented paste is charged to the space between the feed and center rolls called the feed bank. End plates prevent the material in the feed bank from spilling out the sides. The mill base is carried into the feed nip region by the inward rotation of the feed and center rolls which are turning at different speeds. Some of the material remains in the feed bank while another portion transfers through the feed nip to the underside of the rolls. Here the material splits. Part transfers to the center roll while the remaining portion stays on the feed roll to return to the feed bank. The material that was transferred to the center roll passes through the apron nip, after which a second split takes place. One amount remains with the center roll, returning to the feed nip, while the other transfers to the apron roll where it is removed from the roller mill by the takeoff apron. As the material moves through both the feed and apron nips, it is subjected to very high shear. This shearing action serves to disperse the pigment throughout the vehicle, while the nip space determines the degree of this dispersion.[2,16,18]

Roller mills are labor intensive, requiring highly skilled operators. Their lack of speed and high operating cost make them unsuitable for large-volume production. The use of roller mills is confined to the manufacture of very high-quality paints and inks and viscous pigmented products which require fine dispersion and clean color.[16]

2.4.3.2 *Ball and pebble mills*

Ball and pebble mills, probably the oldest pigment dispersion equipment, are cylindrical containers mounted horizontally and partially filled with either pebbles or ceramic, glass, or

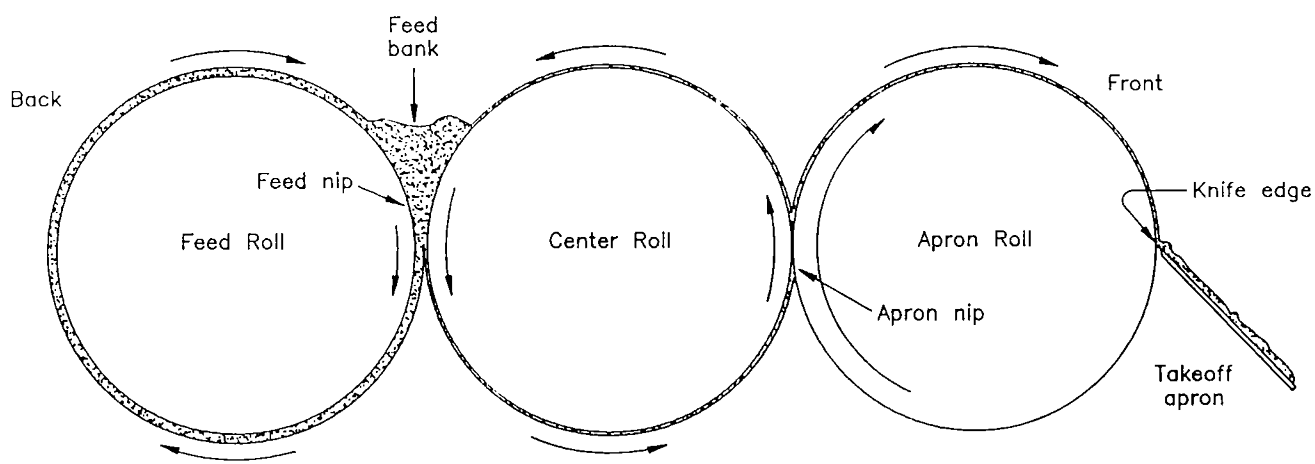

Figure 2-2. Schematic diagram of a three-roll mill.

metallic balls which serve as the grinding media. Paint and ink components, either in raw material or in premix form, are charged to the mill through a top chute. The ball mill and its contents then rotate about the horizontal axis at a rate sufficient to lift the grinding media to one side and then cause them to cascade to the lower side. The tumbling action results in pigment dispersion.[2,16,18]

Ball and pebble mills are distinguished only by their interior lining and grinding media. The paint and ink industries conventionally define pebble mills as those mills containing a nonmetallic grinding media such as ceramic, porcelain, silica balls and flint pebbles, and having an inside surface lined with a nonmetallic liner such as burrstone, porcelain block, or rubber. Ball mills, on the other hand, contain steel, alumina, iron, or nickel balls and have an interior surface of alloy steel or another metallic liner. Because of these minor differences, the terms "ball mill" and "pebble mill" are used rather loosely and the former is often used to describe both types of mills.[2,16,18]

The size and type of the grinding media will determine the type of paint or ink manufactured. Small, dense grinding media tend to be more efficient at dispersing pigment than larger, more porous media. Steel-lined mills charged with steel balls can be used only for dark colors, as erosion results in the discoloration of whites and pale shades. Normally, lighter colors are made in pebble mills using ceramic media.[2,16,18]

Ball mills offer paint and ink manufacturers the following advantages:

- Normally no product premixing is required. The vehicle is often charged directly to the mill followed by the pigment charge. This offers an economic advantage as many grinding processes require premixing.[18]
- The milling process does not require skilled attention or supervision, yielding minimal labor costs. Ball mills can operate on a timer, thus completing the dispersion process outside of normal working hours (i.e., at night or on weekends).[9,13,18]
- Low maintenance costs.[18]
- Ball mills are adaptable to the grinding of most paint dispersions and of all pigments. Only highly viscous products are not amenable to ball mill grinding.[18]
- Ball mills offer product standardization and consistency.[18]

- Ball mills have the capability of providing substantial physical size reduction of oversized particles, thereby upgrading pigment opacity and/or color development.[18]

Several disadvantages of ball mills include relatively long processing times ranging from 8 to more than 36 hours and lengthy cleaning times requiring considerable amounts of solvents.[16]

2.4.3.3 *Attritors*

An attritor is a stationary, vertical, cylindrical grinding tank fitted with a centralized, rotating agitator shaft to which are attached evenly-spaced spokes. The spokes extend into the ball media and mill base mixture which fills the attritor during the milling process. As the spokes rotate through the attritor tank contents, they agitate the ball charge. The agitation provides the required shear and impact to effectively disperse the pigment into the vehicle.[16,18]

Attritors are available in sizes up to approximately 100 gallons total capacity. They may operate on a batch or on a continuous process basis and usually contain small ceramic or steel balls (i.e., 1/4 inch diameter). Raw materials may be added by hand or by a manifold system. An attritor achieves pigment dispersion approximately three times faster than a ball mill, but requires constant supervision. Attritors can also handle higher viscosity materials than a ball mill.[16,18]

2.4.3.4 *Sand mills*

Sand mills, vertical cylinders filled with grinding media, operate on the principle that the dispersion efficiency increases with the decreasing diameter of grinding media. These mills attain dispersion by rapidly stirring small spheres in the presence of the pigment slurry. Paint and ink manufacturers have used sand mills for the dispersion of pigmented mill bases since the early 1950s. Originally, manufacturers used fine-grained Ottawa sand as the grinding media. Now, however, many facilities use small beads or balls ranging from 1/32 to 1/8 of an inch. Because the size of sand mill media approaches that of bead, shot and ball mill media, the terms "sand mill," "ball mill," "shot mill," and "bead mill" are often used interchangeably. Sand, bead, and shot mills are frequently called media mills.[2,16,18]

In vertical sand mills, the premixed slurry is pumped in at the bottom of the cylinder and rises through the sand, which is kept fluid by the quickly rotating shaft impeller. Dispersion takes place as a result of pigment shearing as it rises through the chamber. Most pigments are sufficiently dispersed when they reach the top of the chamber. The dispersed product is then allowed to filter from the mill through a mesh which retains the sand. Older sand mills operate with an exposed filtering screen which often becomes encrusted with dry mill base. Many newer mills, however, have a submerged screen that eliminates plugging problems. With an ample supply of premixed material, the sand milling process can be continuous.[2,16,18] Figure 2-3 is a schematic of a vertical sand mill.

2.4.3.5 *Bead and shot mills*

Bead mills look and operate like sand mills. The only difference between the two is the type of grinding media employed. While conventional sand mills ordinarily use Ottawa sand, bead mills use a wide variety of synthetic media including glass, ceramic, and zirconium oxide or zirconium silicate beads.[14,16] The term "beadmilling" developed in the 1960s when manufacturers started using synthetic grinding media rather than sand. Many former "sand" mills are now "bead" mills.[16]

The latest bead mills are closed agitated ball mills with a stationary horizontal cylindrical grinding container enclosing a driven shaft which agitates 1 to 3 mm diameter grinding beads. The small size of the grinding media necessitates that particle size in the mill base feedstock be ground and dispersed to below 250 µm. A properly set up bead mill can disperse to below 20 µm in a single pass through the mill.[19] Bead milling systems are available in sizes ranging from 1.5 to 1,900 gallons.[16] Most bead mill manufacturers, with few exceptions, use glass, zirconium oxide or zirconium silicate, ceramic, alumina, and in certain cases, steel ball grinding media. They may be used either for batch or continuous processing.[2,14,18]

Shot mills are also similar to sand mills. These rugged units have a narrow, upright, cylindrical tank equipped with a rotating vertical shaft that sustains a series of evenly spaced, stainless alloy, circular platforms. The platforms rotate through the media/mill base mixture. High-speed shot mills work best with small steel or ceramic grinding media. The mill operates under internal pressure and therefore is able to grind materials with high viscosities. The mill also has a variable-speed pump and submerged filter which rotates with the shaft.[18]

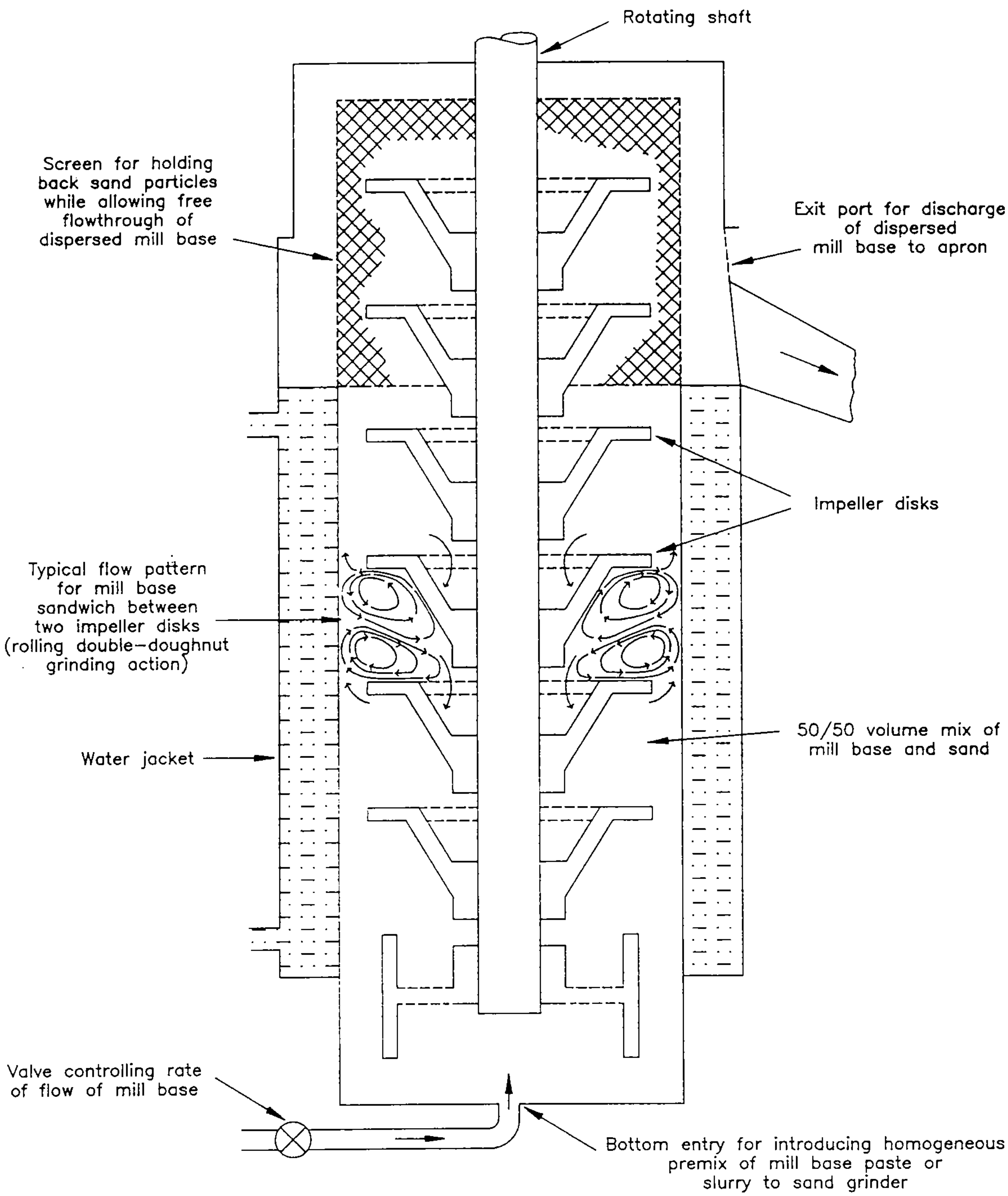

Figure 2-3. Schematic drawing of conventional sand mill.

2.4.3.6 *High-speed stone and colloid mills*

High-speed stone and colloid mills, although not as common as many of the other pigment grinding mechanisms, are another method of achieving pigment dispersion. Modern stone (Carborundum) mills consist of two precisely shaped Carborundum stones working against each other, as illustrated in Figure 2-4a. One stone, the stator, is held stationary while the other stone, the rotor, is rotated at high speed from 3,600 to 5,400 rpm. The premixed mill base is fed by gravity or under pressure into the charge area above the rotor. A viscous laminar flow, yielding pigment dispersion, results as the material moves through the grinding gap or the small space separating the two stone surfaces. Because the material spends only a fraction of a second between the stones, the dispersing action of the stone mill serves to refine rather than as a pure mixing and grinding operation. Stone mills produce the best quality product when they are fed a well-mixed, viscous premix.[18]

Colloid mills differ from stone mills in their material of construction and their gap configuration. Figure 2-4b illustrates the truncated cone arrangement distinguishing the two mills. The rotor and stator are designed with smooth, ground, and lapped faces which ensure a uniform cross section in the material in the grinding gap. Mill base consistency results in maximum shear and efficient milling. The rotor and stator in colloid mills may be constructed of Carborundum stones, high-nickel alloys, or Invar, an alloy with a low coefficient of expansion. Like stone mills, colloid mills must be provided with a well-mixed, viscous material feed.[18,20]

Both the stone mills and the colloid mills traditionally operate as open systems. However, both may be converted to closed systems using an accessory pump to provide the material feed.[18]

2.4.3.7 *High-speed disk dispersers*

High-speed disk dispersers are the most universally used method of dispersion in the paint and ink manufacturing industry. Their popularity continues to increase as compact, efficient, heavy-duty power sources and readily dispersible pigments become more available. Some paint and ink blends are manufactured entirely in one piece of equipment using high-speed disk-type impellers. Essentially, the high-speed disk disperser consists of a circular, steel, saw-blade-type impeller attached to the end of a steel shaft. The disk is suspended in a mixing pot which may be jacketed for water-cooling. Because there is no grinding media present in the mixing vat, the

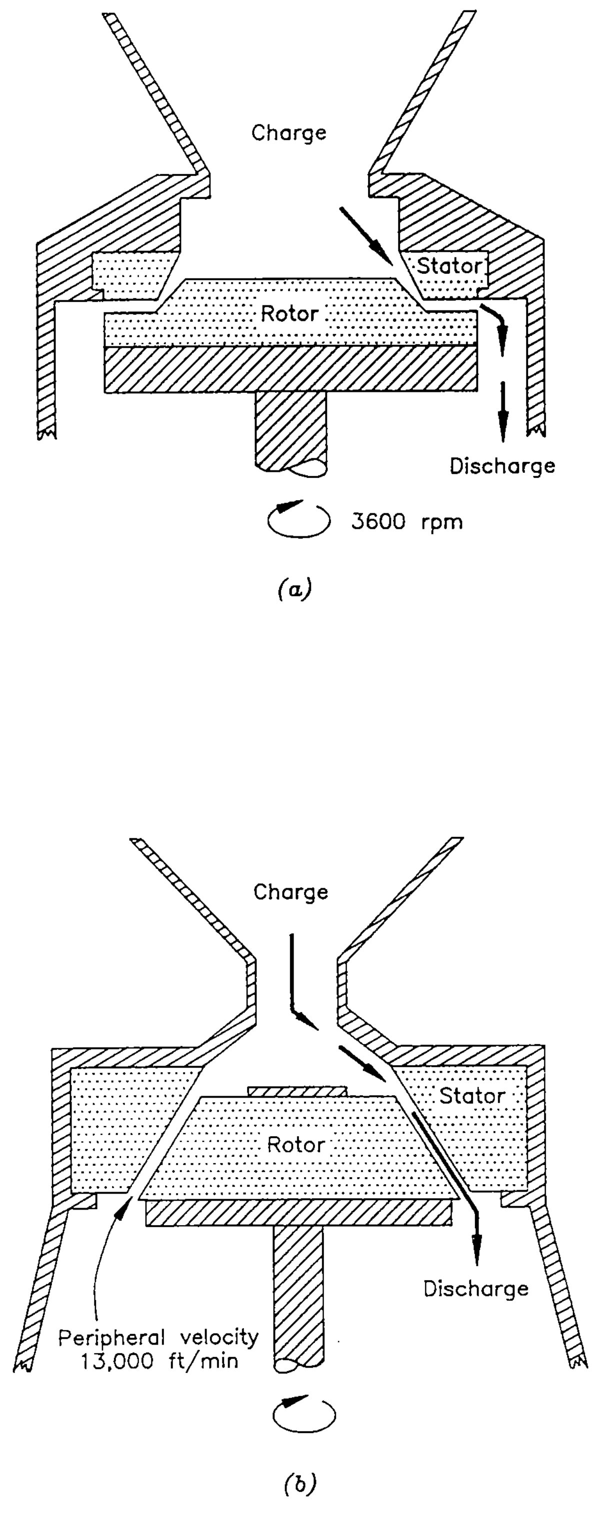

Figure 2-4. (a) Schematic drawing of the stator/rotor assembly in a high-speed stone mill (grinding region has the shape of a flat annular ring).
(b) Schematic drawing of the stator/rotor assembly in a colloid mill (grinding region has the shape of a truncated cone).

pigment disperses on itself and against the surfaces of the rotor. While high-speed disk dispersion may work well with some products such as undercoats and primers, it may not be appropriate for high-quality paints and inks. It can, however, be used for premix operations of high-quality paints, thus reducing the number of passes in a media mill or reducing the amount of time spent in a ball mill.[2,16,18,21]

High-speed dispersers provide a simple, quick, and relatively inexpensive means of distributing easy-to-disperse pigments in conventional vehicles on a batch processing basis. These dispersers are also capable of handling all phases in the preparation of some paints and inks (i.e., preassembly and premix, pigment grinding and dispersion, and product finishing) in one piece of equipment. In addition to its dispersion abilities, the high-speed disperser can be used in premix and blending (postmix) operations. Another advantage is the comparatively low initial capital investment and low maintenance costs. The primary disadvantage of the high-speed disperser is its inability to disperse hard agglomerates.[18]

A modification of the high-speed disperser is a variable speed disperser. Variable speed systems allow the incorporation of dry powders into a liquid medium at low speed with minimum dusting. The speed is increased once initial wetting is complete.[19]

A second variation of the high-speed disperser is a rotor stator type machine similar to the set-up found in stone and colloid mills. Instead of disk type impellers, this disperser operates with a rotor stator unit. The stator is mounted on several shafts extending from the equipment housing, while the rotor is attached to a center disperser shaft which would typically hold a disk type impeller. The rotor stator unit may be either high-speed or variable-speed. In addition, newer models are quiet and more efficient than conventional high-speed dispersers.[22,23]

Another variation of the high-speed disperser/portable mix tank operation is the Kady mill. This mill consists of a high-speed disperser or agitator in combination with a fixed mix tank. The tank is jacketed, allowing for heating capability. It is also equipped with a permanent lid which can be opened during product filling operations and sealed during the mixing and dispersion process. As with disperser/portable tank operations, Kady mills contain no grinding media in the mix tank allowing the pigment to disperse on itself and against the surfaces of the rotor. Kady mills are often used in the production of high-gloss paints and inks which require heat to develop the gloss characteristics.[13,14]

2.4.3.8 *High-speed impingement mills*

High-speed impingement mills or kinetic dispersion mills disperse pigment agglomerates by impact. This mill consists of a slotted rotor and stator as shown in Figure 2-5. Material is sucked in at both the top and the bottom of the mill and is thrown outward by the rotating slots on the rotor against the close-fitting stator. The high velocity and forceful impact of the particles results in dispersion.[18]

Impingement mills are most efficient when they are fed with a low-viscosity, easily dispersible pigment/vehicle mixture. As impingement mills are a batch process operation, no material premixing is required. The fluid vehicle (low solids content) is placed in the mill tank prior to starting the milling process. Once the rotor has started, pigment is rapidly fed into the tank. Batch grinding time averages less than 25 minutes.[18]

2.4.3.9 *Horizontal media mills*

The horizontal media mill is basically a vertical mill turned 90 degrees. This configuration improves the performance of the mill by creating better material flow and by increasing the media loading capacity from 85 to 90 percent of the chamber volume. The increase in media loading from 50 percent in vertical mills to 90 percent in horizontal mills provides increased milling efficiency.[24] When provided with the proper premix feed, a standard horizontal media mill offers the most efficient one-pass operation. Properly equipped horizontal mills provide three times the productivity on an equal volume basis as the open-top sand and bead mills.[25]

Horizontal media mills are closed systems. The filtering screen is enclosed by a sheet metal cover which controls solvent losses and expands the range of products that can be processed. Although the mill base moving through the chamber should be of low viscosity to allow the grinding media to move with maximum velocity, manufacturers using horizontal mills are no longer concerned about solvent evaporation and the mill base drying on the screen (causing the mill to overflow).[24,26]

Horizontal mills range in size from 1.5 liters (0.4 gallons) to 500 liters (132 gallons). Most mills are equipped with a secondary jacket which allows for water cooling. The mills are able to use any of the common media currently manufactured including glass beads, ceramic beads, zirconium silicate beads, and steel shot.[24]

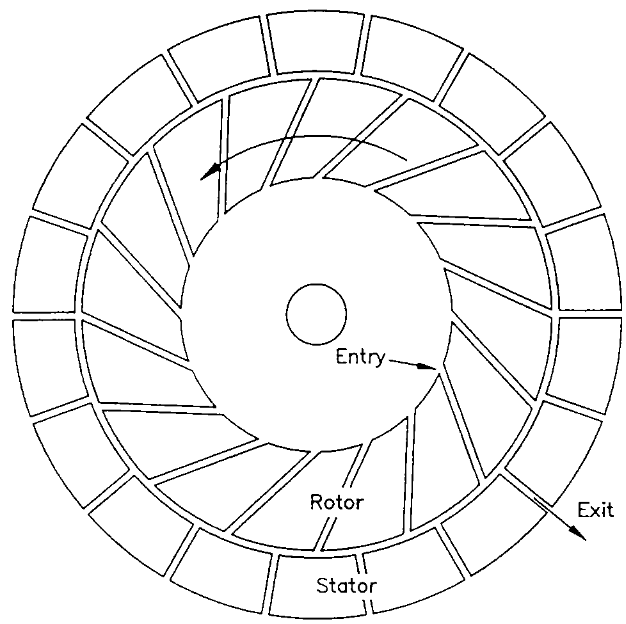

Figure 2-5. Schematic drawing of the milling head of a high-speed impingement (kinetic dispersion) mill.

2.4.4 Product Finishing

Final product specifications are achieved in the product finishing step which consists of three intermediate stages: thinning, tinting and blending.

2.4.4.1 *Thinning (letdown)*

Material letdown, or thinning, is the process by which a completed mill base dispersion is let down or reduced with solvent and/or binder to give a coating which is designed to provide a durable, serviceable film that is easily applied to the substrate.[18] The volume of the paint or ink may increase significantly at this point depending on the final product specifications.

2.4.4.2 *Tinting*

Tinting is the process of adjusting the color of completed mill base dispersions. Normally, an operator will collect a sample of the paint or ink once it exits the milling equipment. This sample will be taken to the laboratory and compared to the desired color standard. Various combinations of pigments, solvents, resins, and pastes are added to the material to meet the color requirements.[9,12,13]

2.4.4.3 *Blending*

Blending operations occur once the necessary additions have been made to the completed mill base dispersion. Blending is the process of incorporating the additions into the material in order to meet the desired product specifications. In the case of batch operations, blending may simply consist of additional milling in a ball mill or added mixing and dispersing in a portable mix tank/high-speed disperser set-up. In other cases, the mill base dispersion is transferred to fixed agitated blend tanks or additional mix tank/disperser operations. In each case, material adjustments for thinning and tinting are added through top openings, agitated, and gravity fed or pumped out bottom or side spigots for filling operations.[9,12,13,14]

2.4.5 Product Filling

The final step in paint and ink manufacturing is product filling operations. After the material has been blended, it is transferred from the blend tanks into containers for product shipment. The transfer step normally involves product filtration.

2.4.5.1 *Filtering*

Filtering acts to screen out impurities (e.g., dust, gelled resin, and pigment aggregates) and to enhance the quality and uniformity of the product. In the case of media mills, filters prevent the grinding media from exiting the mill and entering shipment containers.[2,14]

Paints and inks may be filtered in a variety of ways. Some facilities simply attach cheese cloth or cloth socks to the exiting blend tank spigot.[9,13,14] Other plants use filtering equipment such as strainers or sieves. The Russel Finex strainer consists of a vibrated screen and hopper through which product flows prior to entering shipment containers. The screens may be either metal mesh, supported nylon, or another synthetic fiber. Another strainer, the Jenag strainer, has a vertical chamber holding fiber filters. The paint is fed by gravity or pump to the chamber and drawn through by vacuum.[2] High quality finishes, such as those used for automobiles and industrial products, may be pumped through wound polypropylene or other resin cartridge filters.[2,12] Bag filters, made from felts (rayon, polypropylene, or nylon) or gauzes (polypropylene, nylon, or polyester), can be attached to the flanged end of a supply line and supported by a vibrating wire basket. These bags are usually washable and used only for small batches.[2,13]

2.4.5.2 *Material transfer*

Once the material has been filtered, it can be transferred into pails, drums, tote tanks, tote wagons, or another container for shipment. Although most paints are sold by volume, most manufacturing facilities find it more convenient to fill the shipping containers by weight using the specific gravity of the paint or ink. Filling may be accomplished either manually or mechanically depending on the number and size of the containers to be filled.[2,12]

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CHAPTER 3
VOLATILE ORGANIC COMPOUND EMISSIONS, REGULATIONS, AND PERMITS

3.1 GENERAL

This chapter describes the potential sources of VOC emissions in ink and paint manufacturing facilities. Potential emission sources are identified and characterized based on available literature and plant visit results. This chapter also discusses current industry emissions as defined and described by published documents, State permit information, State VOC regulations, and individual industry sites.

In 1987, the paint and ink industries consumed an estimated 2,750 million pounds of solvent.[1,2] Although this number is expected to decrease as paint and ink manufacturers continue to move toward products with lower VOC contents, it still accounts for 0.05 percent of total VOC emissions. Other statistics indicate that the application of paints is the fourth-largest VOC source.[3] The United Kingdom attributes solvent emissions of 94,000 tons per year to the paint and paint application industries.[4]

The primary factors affecting the emission of organic compounds are the types of solvent used in the manufacturing process, the temperature at which these compounds are mixed, and the methods and materials used during cleanup operations. According to EPA publication AP-42, even under well controlled conditions, approximately 1 to 2 percent of the solvent brought into the facility is lost during manufacturing operations.[5]

3.2 SOURCE IDENTIFICATION AND CHARACTERIZATION

3.2.1 Introduction

Volatile organic compounds are released from several types of equipment and handling operations throughout the paint and ink manufacturing process and during cleanup operations. Emissions can be categorized according to the four manufacturing processes (i.e., preassembly and premix, pigment grinding or milling, product finishing, and product filling) and cleaning operations.

3.2.2 Preassembly and Premix

The vast majority of paint and ink facilities begin the manufacturing process by thinning resins with solvents, alcohols, oils, and/or water. The equipment items most often used in this premix and preassembly operation are drums and portable tanks in combination with mixers. Emissions from other premix equipment, such as grinding and milling devices, will be discussed in Section 3.2.3.

Portable mix tanks, either alone or in combination with an agitator, are a common emissions source. Portable mix tanks are used to mix product and to keep the pigment in suspension. They are also used to transfer material from one manufacturing stage to the next. While they are being used for mixing, the tanks are often, but not always, covered with lids. If a cover is used on a mix tank during mixing, it will have a small opening through which the agitator shaft extends. In some cases, only a splash guard is used to cover the back half of the mix tank. If mix tanks are used for temporary storage, they are often covered with a solid lid. None of the lids seal with the mix tanks.[6-8]

In some cases, products are premixed in 55 gallon drums. Like the portable mix tanks, the drums are often covered with non-sealing lids. If a cover is used on a drum during mixing, it will have a small opening for the agitator shaft.[6,9]

Emissions occur during material loading when the tank or drum is uncovered or when the lid is open. VOCs may also be released through the agitator shaft opening and from around the edges of the lid during the mixing process. The quantity of material released varies with type of solvent, agitator mixing speed, material temperature, and type of cover. More organics will be released with highly volatile solvents, increased agitator speed, and warmer temperatures.

3.2.3 Pigment Grinding or Milling

The equipment used in grinding operations includes roller mills, ball and pebble mills, attritors, sand mills, bead and shot mills, stone and colloid mills, high-speed dispersers, impingement mills, and horizontal media mills. Emissions of VOCs from dispersers were discussed in the previous section.

Roller mills are used to manufacture high-quality paints and inks with a high solids content. The mill base vehicles used on roller mills normally contain from zero to 40 percent volatile content. Because the rolling cylinders on roller mills are exposed to the atmosphere, the majority of the volatile content in the mill base vehicle is expected to evaporate during the course of the grinding process.[9,10]

Grinding with ball and pebble mills approaches a closed system operation. The only opening in these mills is the chute through which raw materials or premixes are added and the spigot which is used for product filling operations. VOC emissions occur during these processes.[6,8,9]

Attritors also approximate closed systems. Emissions may occur from the opening surrounding the agitator shaft and/or at product outfall.[7]

Older vertical media mills (i.e., sand mills, bead mills, and shot mills) operate with an exposed filtering screen. As the mill base rises through the chamber and becomes exposed to the air, the solvent constituent evaporates, often leaving the screen encrusted with dry mill base.[10,11] Media mill operators may apply solvent to unclog the screen or they may scrape down the filter with a coarse, dry brush.[6-8] Fewer emissions occur from newer vertical media mills which have submerged filtering screens.[10] Additional emissions of VOCs result from adding raw materials and from product filling operations.

Both the stone and the colloid mills traditionally operate as open systems. Emissions normally occur as the mill base feedstock is added to the charge chute on top of the rotor/stator arrangement. Similarly, emissions may occur after grinding as the material exits through the mill spillway. Enclosing the spillway and using a closed charge chute with an accessory pump will reduce overall emissions.[10,12]

One variation of the high-speed disperser is the Kady mill. As with the emissions from other dispersers, emissions from Kady mills occur during material additions and product filling. However, unlike other dispersers, the Kady mill may be heated, resulting in additional solvent volatilization.[9]

The majority of the emissions from impingement mills also occur during the addition of raw materials and while emptying the mill of product. Impingement mills are potentially high-emission processing equipment because they require low-viscosity (low solids) vehicles. Ideally, the first vehicle addition would contain only ten percent by weight solids. Subsequent additions might contain a higher solids content.[10]

Horizontal media mills are efficient, closed-system milling devices. The filtering screen is enclosed by a sheet metal cover which controls solvent losses and expands the range of products that can be processed. Although the mill base used in a horizontal mill should be of low viscosity, paint and ink manufacturers do not have to worry about VOC emissions during the grinding process. The mill base for most horizontal mills is pumped from containers or premix equipment through an enclosed piping system. Material discharge is also through enclosed pipes or hoses.[6,13]

3.2.4 Product Finishing

The emissions that occur during the product finishing step are mainly a result of material additions during the tinting and thinning stages. If a product is finished in a mix tank/disperser set-up, emissions are similar to those mentioned in Section 3.2.2. When material is finished in a fixed blend tank, releases occur during product additions through the top hatch, which normally does not seal with the blend tank.[7,8]

3.2.5 Product Filling[6-9]

Emissions occur during almost all product filling operations. The extent of these emissions is determined by the volatility of the solvent in the paint or ink formulation, the temperature at which the product enters the shipment container, the method of material transfer, and the method of filling. Emissions increase with temperature and highly volatile solvents.

One source of emissions is scale systems, where solvent and resin raw materials are measured and transferred from storage tanks to the process tanks, between process tanks, or from process tanks to shipment containers. Emissions may occur during transfer and hose connecting and disconnecting. Another type of scale system consists of a floor scale, a drum, a drum dispenser, and a receiving container. Material is pumped out of the drum into the receiving container. Emissions occur during material transfer and free-fall into the receiving container.

In some cases, material is transferred by bucket and dip method. Here, emissions occur while the product is exposed to the air and while it is being scooped and transferred to the second container.

Another emission source is product filtering. As product flows through a filtering device, it is often exposed to the air, resulting in releases of VOCs.

Filling operations also result in VOC emissions. In one plant, portable mix tanks are mechanically lifted and tilted, allowing the finished product to gravity feed into containers for shipment. Some facilities allow product to gravity feed from processing equipment through filters into shipment containers. Emissions result from product free-fall and material splashing.

3.2.6 Equipment Cleaning

In addition to emissions from process operations, VOCs are also released from a variety of cleaning operations. Solvent based materials are used to clean equipment in which solvent based products are manufactured, while water based supplies are used to clean after water based production. Emissions occur during solvent addition and removal as well as during the cleaning process.

In many facilities, manufacturing equipment is cleaned manually on the production floor on an as-needed basis. In some cases, cleaning is performed after each batch, and in other cases equipment is cleaned after a series of batches. The cleaning frequency depends on the number and size of batches processed, the size of the equipment to be cleaned, and the color and type of product manufactured. The standard method of cleaning grinding equipment involves emptying the mill of product and then adding solvent to the vessel to capture remaining product residue. The wash solvent is normally drained from the tank and either disposed of as hazardous waste or recycled.[6-9] Mix tanks and agitator blades may be cleaned with solvents, brushes, and/or rags.[6] Roller mills are often cleaned by hand using rags and solvent.[9]

Larger facilities may have areas designed specifically for cleaning operations. In these facilities, equipment cleaning may be more automated (i.e., automatic tank washers and spray guns), but emissions still occur during the process.[7]

Equipment cleaning operations account for over 80 percent of the paint industry's waste. Although solvents are not the only waste generated during cleaning processes, they are a major contributor.[14]

3.3 EMISSION FACTOR DATA

3.3.1 Introduction

There is little emission factor information available for the manufacture of paints and inks. Figures range from process solvent losses of one to two percent under well controlled conditions to losses of 100 percent for specific volatile organic compounds.[5,15] The 100 percent loss figure is obviously a "worst case" estimate, as enough volatile components remain in the paint or ink to allow it to remain fluid and workable. Some studies indicate that a coating film which is dry to the touch may retain five to ten weight percent solvent for several years because of the slow diffusion rates encountered at the air-film interface.[16] Many paint and ink manufacturing facilities calculate total plant VOC emissions based on raw material consumption rather than calculating emissions from processes or equipment by an alternative method. Total emissions therefore reflect solvent losses during manufacturing, cleaning operations, and storage.[17]

Emission factors for specific equipment could be developed using theoretical equations, mass balance, or emission testing. The development of a theoretical equation could be based on solvent volatility, vapor pressure, equipment size, and degree of agitation. Other variables to be considered include equipment heating/cooling capabilities, ambient conditions, and exposed surface area and tank cover efficiency (in the case of mixing vats and/or drums). Both the mass balance and the emission testing methods would require industry trials.[17]

Much of the currently available emission factor data is based on U.S. EPA's *Compilation of Air Pollutant Emission Factors (AP-42)*. Data for paint and ink manufacturing are found in Table 3-1. The table indicates that the majority of the VOC emissions result from varnish production (for paints) and vehicle cooking (for inks). Because these processes are typically performed in chemical facilities rather than in paint and ink manufacturing facilities, their emissions are not addressed in this report.[5]

TABLE 3-1. UNCONTROLLED EMISSION FACTORS FOR PAINT, VARNISH, AND PRINTING INK MANUFACTURING[a,b]

Type of Product/Process	Emission Factor Rating	Nonmethane VOC	
		kg/Mg of product	lb/ton of product
Paint[c]	C	15	30
Varnish[c]	C		
Bodying Oil		20	40
Oleoresinous		75	150
Alkyd		80	160
Acrylic		10	20
Ink Vehicle Cooking[d]	E		
General		60	120
Oils		20	40
Oleoresinous		75	150
Alkyds		80	160

Source: Reference 3
[a]Ink manufacturing data is based on paint & varnish information
[b]Afterburners can reduce VOC emissions by 99%
[c]Expressed as undefined organic compounds whose composition depends upon the type of solvents used in the manufacture of paint & varnish
[d]Ink nonmethane VOC emissions are a mix of volatilized vehicle components, cooking decomposition products and ink solvent

A = Ten or more tests at different plants with a single, standard method. These tests are not necessarily EPA reference method tests, although such reference methods are certainly to be used as a guide.

B = Several test results using an accepted method that reflect a large portion of the population.

C = A small number of tests or tests employing several different or nonstandard methods.

D = A few or a single source test that may be of questionable quality; or a factor derived for a different source type that has been "transferred."

E = Engineering judgment

Also included in the Table 3-1 is an emission factor data quality rating which may range from A to E, with A being most reliable. *AP-42* indicates that high quality ratings are given to emission factors based on multiple observations at many different plants, while low ratings are given to emission factors based on single observations of questionable quality or extrapolated from other emission factors for similar processes. The ratings given in *AP-42* are considered a general indicator of the accuracy and precision of a given factor used to estimate emissions from a large number of sources. The rating system for a particular emission factor test data set is based on the data standards developed by the U.S. EPA's Office of Air Quality Planning and Standards for inclusion in *AP-42*. The rating system is included in Table 3-1.

3.3.2 Current Regulations[7,18-25]

Regulatory requirements for VOCs vary from State to State and within some jurisdictions of certain States. At the very least, VOC regulations should be in place in non-attainment areas where source size may be a basis for control. VOC emission limits are often determined by end use categories commonly called EPA Control Technique Guideline (CTG) Sources and by EPA established Reasonably Available Control Technology (RACT) Limits. Because paint and ink manufacturing facilities are not identified by any current CTGs, individual States may develop RACT limits. In many States only those non-CTG facilities emitting more than 100 tons per year are controlled, while in other States the limit may be 15 pounds per day. Plants releasing less than the specified limit are exempt. The Clean Air Act Amendments of 1990 will require non-CTG sources in ozone non-attainment areas to control VOC sources that emit 10, 25, 50, or 100 tons per year VOC depending on the severity of the problem.

Several States currently have rules regulating VOC emissions from paint and ink manufacturing facilities. Most of these regulations have the following common requirements and exemptions:

- Covers must be used on all stationary and portable mix tanks, dispersion mills, and tanks containing VOC used for cleanup.

- Grinding mills installed after the date of regulatory enactment must be equipped with fully enclosed screens.

- Equipment must be monitored and inspected for leaks on a regular basis.
- Facilities emitting less than 100 tons per year VOC are exempt from regulation.
- Facilities manufacturing primarily water based paints and inks are exempt.

The State of Ohio is one State that has developed an RACT case-by-case regulation. In 1988, Ohio enacted Ohio Air Pollution Control (OAC) rules 3745-21-01 and -09, which subjected the Cleveland PPG Industries, Inc. (PPG), paint manufacturing facility to site-specific requirements for VOC emissions based on RACT. Because the emissions from the manufacturing facility and the paint laboratory met or exceeded 100 tons of VOC annually prior to rule enactment, the facility (manufacturing and laboratory) was classified as a "major" source. As such, Ohio wrote non-CTG rules for the paint manufacturing operations and paint laboratory operations specifically for PPG. Ohio's paint manufacturing RACT rules and the paint manufacturing rules from other States are summarized in Table 3-2. Table 3-3 summarizes similar rules for the ink manufacturing industry.

3.3.3 Permits[26-30]

Selected permits for equipment at paint and ink manufacturing facilities were retrieved from the State of Ohio. Many pieces of manufacturing equipment (e.g., mixers, grinding mills, dispersers, and filling equipment) are classified as stationary sources which are subject to the Best Available Technology (BAT) requirement of OAC Rule 3745-31-07 (G)(2), "The control of emissions of organic materials from stationary sources." This rule limits VOC emissions from stationary sources to 8 pounds per hour and 40 pounds per day. In addition to these emission limits, some equipment is subject to other special terms and conditions including the following:[26]

- *Bottom fill requirements*: All solvent additions to the designated equipment (mainly tanks) shall be accomplished by bottom fill, with the exception of a small amount of solvent per batch (i.e., 50 gallons) for making adjustments for product specifications.
- *Operational limits*: Some sources are limited to processing time each day where processing includes all periods in which the tank is being filled, materials are being added, mixing is occurring and/or cleaning of the tank. Holding time is not

TABLE 3-2. STATE REGULATIONS FOR PAINT AND RESIN MANUFACTURING FACILITIES

EPA Region	State	Regulation No.	State EPA Approval Status/Date	State Limit or Requirement	Exemptions/Cutoffs	Comments
III	PA		Under development			
III	MD	26.11.15	Approved	(a) Covers on all open top vessels and tanks used to mix paint, disperse pigment, and adjust viscosity and color. (b) Covers used on tanks and vessels must be VOC impermeable and must be kept closed at all times except to permit operator access. (c) Clean manufacturing vessels and tanks with detergent, hot alkali, high pressure water, or other precautions which minimize VOC emissions. (d) Use submerged filling when transferring VOC containing materials. (e) Visually inspect equipment for leaks on monthly basis.	(a) Applicable only in Areas III and IV. (b) Facilities emitting ≤100 tpy VOC.	(a) Applies to manufacture of paints, resins, adhesives and adhesive applications
IV	AL	8.29	Approval pending	(a) Equip storage vapor tanks of >10 kPa vapor pressure with pressure/vacuum conservation vents set at ±0.2 kPa. (b) Tanks >250 gallons must use submerged fill-pipe, bottom-fill. (c) Covers on open-top tanks where non-water based coating produced, and on tanks storing VOC-containing cleaning substances. (d) Operate and maintain grinding mills according to manufacturer's specifications. (e) Visually inspect pumps weekly; repair ≤15 days. (f) Collect gases and vapors from varnish cooking operations and control by ≥85% before discharge.	(a) Facilities emitting ≤100 tpy VOC. (b) Tanks where more effective control used.	(a) Jefferson County, AL regulation. (b) Applies to manufacture or processing of paints, varnishes, lacquers, enamels, and other allied coating products.
V	MI	6-336.1630	Approved	(a) Covers on all stationary and portable mix tanks and high-speed dispersion mills, and on all tanks containing VOC used for cleanup. (b) Clean print manufacturing equipment and paint shipping containers by methods and materials which minimize VOC emissions.	(a) Tanks used in manufacturing paint with a volume of less than 56 gallons. (b) Tanks used only for the purpose of storing resins. (c) Equipment used at a stationary source having a total paint production of ≤500,000 gpy.	(a) Applies to manufacture of paint by existing facilities. (b) Separate rule covering resin manufacturing.

(continued)

TABLE 3-2. STATE REGULATIONS FOR PAINT AND RESIN MANUFACTURING FACILITIES (continued)

EPA Region	State	Regulation No.	State EPA Approval Status/Date	State Limit or Requirement	Exemptions/Cutoffs	Comments
V	WI	421.06	Approved	(a) Covers on all stationary and portable mix tanks. (b) Clean all portable tanks, stationary vats, high-speed dispersion mills, grinding mills, and roller mills by methods which minimize VOC emissions. (c) Equip any grinding mill installed after 10/1/86 with fully enclosed screens. (d) Monitor valves, pumps, sealed agitators, compressors, flanges, and relief valves each quarter or year (as specified). (e) Visually inspect valves, pumps, sealed agitators, compressors, flanges, and relief valves bimonthly; repair ≤15 days.	(a) Facilities emitting ≤100 tpy VOC. (b) Tanks where more effective control used.	(a) Applies to manufacture of paints, varnishes, lacquers, enamels, and other allied surface coating products. (b) Applies to facilities in Kenosha, Milwaukee, Ozaukee, Racine, Washington, and Waukesha counties.
V	IL	35-B-AA Section 215.620	Approved	(a) Covers on all stationary and portable mills, tanks, vats, and vessels and on all equipment being cleaned with VOCs. (b) Operate grinding mills in accordance with manufacturers specifications which must be kept on file and made available upon request. (c) Equip any grinding mill installed after 4/1/89 with fully enclosed screens. (d) Visually inspect pumps each week for leaks; repair ≤15 days. (e) Identify leaking pumps, valves, pressure relief valves, sampling connections, open-ended valves, and flanges and repair in ≤15 days; maintain records for two years. (f) Store organic wash solvent in closed containers.	(a) Facilities emitting <100 tpy VOC. (b) Facilities producing ≤2,000,000 gpy of paints or ink formulations with >10 percent (wt) water. (c) Equipment used to produce paint or ink formulations with ≥10% (wt) water or inks containing Magie oil and glycol as the primary solvent.	(a) Applies to facilities in Cook, DuPage, Kane, Lake, Macoupin, Madison, McHenry, Monroe, St. Clair, and Will Counties. (b) Applies to mixing, blending, and compounding of enamels, lacquers, sealers, shellacs, stains, varnishes, or pigmented surface coatings. (c) Applies to ink manufacturing facilities.
V	OH	3745-21-09 (MM)		(a) VOC emissions from mixing tanks, grinding mills, thinning tanks, filling equipment, cleaning equipment, solvent recovery equipment, and paint laboratory equipment shall be vented to control equipment which shall be maintained as described. (b) Covers on all stationary and portable mixing and blending tanks.	(a) Rule requirements do not apply to specific equipment during periods of no production activity or during periods of water-based paint production.	(a) State has developed RACT rules on a case by case basis.

(continued)

TABLE 3-2. STATE REGULATIONS FOR PAINT AND RESIN MANUFACTURING FACILITIES (continued)

EPA Region	State	Regulation No.	State EPA Approval Status/Date	State Limit or Requirement	Exemptions/Cutoffs	Comments
VII	MO (KC)	10 CSR 10-2.300	Approved	(a) Pressure/vacuum conservation vents set at 0.2 kPa on tanks storing VOC with vapor pressure >10 kPa. (b) Submerged-fill pipe or bottom fill for stationary VOC storage containers with capacity >250 gallons. (c) Covers closed on open-top tanks used in production of non-waterbase coating products, and on all tanks containing VOC used for cleanup. (d) Collect gases and vapors from varnish coating operations and control by ≥85% before discharge. (e) Operate and maintain grinding mills according to manufacturers' specifications. (f) Polymerization of synthetic varnish or resin to occur in enclosed operation using surface condenser exit stream ≤ temperature at which vapor pressure is 3.5 kPa for any organic component.	(a) Installations with potential to emit ≤250 kg/day or ≤100 tpy VOC. (b) Tanks where more effective control used.	(a) Applies to manufacture of paints, varnishes, lacquers, enamels, and other allied surface coating products.
VII	MO (St.L.)	10 CSR 10-5.390	Approved	(a) Pressure/vacuum conservation vents set at 0.2 kPa on tanks storing VOC with vapor pressure ≥10 kPa. (b) Submerged-fill pipe or bottom fill for stationary VOC storage containers with capacity >250 gallons. (c) Covers closed on open-top tanks used in production of non-waterbase coating products, and on all tanks containing VOC used for cleanup. (d) Collect gases and vapors from varnish coating operations and control by ≥85% before discharge. (e) Operate and maintain grinding mills according to manufacturers' specifications. (f) Polymerization of synthetic varnish or resin to occur in enclosed operation using surface condenser exit stream ≤ temperature at which vapor pressure is 3.5 kPa for any organic component.	(a) Installations with potential to emit ≤250 kg/day or ≤100 tpy VOC. (b) Tanks where more effective control used.	(a) Applies to manufacture of paints, varnishes, lacquers, enamels, and other allied surface coating products. (b) Applies to South St. Louis area.
IX	CA (SC)	1141.1	Approved	(See Coatings and Inks Manufacture)		
IX	CA (BA)	8-35	Approved	(See Coatings and Inks Manufacture)		

TABLE 3-3. STATE REGULATIONS FOR COATINGS AND INK MANUFACTURING FACILITIES

EPA Region	State	Regulation No.	State EPA Approval Status/Date	State Limit or Requirement	Exemptions/Cutoffs	Comments
IV	AL	8.29	Approval Pending	(See Paints and Resin Manufacturing)		
V	IL	35-B-AA 215.620	Approved	(See Paints and Resin Manufacturing)		
V	MI		Approved	(See Paints and Resin Manufacturing)		
V	WI		Approved	(See Paints and Resin Manufacturing)		
VII	MO (KC)	10 CSR 10-5.300	Approved	(See Paints and Resin Manufacturing)		
VII	MO (St.L)	10 CSR 10-5.390	Approved	(See Paints and Resin Manufacturing)		
IX	CA (BA)	8-35	Approved	(a) Cover all portable mixing vats with lids as described and cover all stationary mixing operations. *(b) Minimize VOC cleaning emissions from portable mixing vats, high speed dispersion mills, grinding mills & roller mills by one or more of the following methods: (1) cleaning materials containing < 1% VOC, (2) an approved closed system cleaning system, (3) collection & venting of equipment cleaning emissions to an approved emission control system. (c) Fully enclosed screens on grinding mills installed after 11/1/85. *(d) <15 lb VOC/day from stationary vat unless emissions controlled with overall efficiency of 85% (w) or where > 90% of organic carbon is oxidized to carbon dioxide by incineration.	(a) Manufacturer producing <500 gal/day. *(b) Equipment being used for water-based coatings, paste inks, and low VOC coatings, inks or adhesives (<1% VOC wt). (c) Vats ≤ 12 gal volume.	*(a) Includes adhesive manufacturing facilities *(b) Cleaning requirements effective 1/1/93.
IX	CA (SC)	1141.1	Approved	(a) Cover portable mixing vats with lids as described and cover stationary mixing vats. (b) Minimize reactive organic gases when cleaning portable and stationary mixing vats, high speed dispersion mills, grinding mills, and roller mills. (c) Grinding mills installed after 1/1/85 shall have fully enclosed screens.	(a) Manufacturers of <500 gal/day. (b) For limit (a), equipment producing water-based coatings and/or paste inks. (c) For limits (a) and (b), equipment used to produce coating in vats ≤12 gallons.	(a) Includes establishments under SIC 2851.

*Proposed amendments/changes

considered to be processing time. Solvent use per day or quarter may also be limited.

- *Recordkeeping and reporting*: Some facilities are required to maintain daily records of individual source processing time with product identified and batch start and stop times indicated. Other recordkeeping requirements include tracking daily solvent use with amount and type indicated. In addition, a facility may be required to conduct routine inspections of equipment and record the results of the inspections and any necessary repairs.

- *New product notification*: Prior to manufacturing any new products, for other than process development and/or testing, some facilities must submit written notification to the Ohio EPA.

- *Equipment modifications*: In most facilities equipment is required to be covered or enclosed during manufacturing operations.

Additional requirements will apply if a given facility operates add-on air pollution control equipment. The Cleveland PPG manufacturing facility, which is mentioned in Section 3.3.2, controls VOC emissions by venting fumes from individual sources to a REECO (Regenerative Environmental Equipment Company) thermal incinerator. PPG's permits (and the RACT rule) name the following requirements:

> "... the VOC emissions from the equipment included within the paint manufacturing operations shall be vented either directly or by means of a building or local area exhaust to a control system which shall maintain compliance with any of the following requirements:[7,26]
>
> (a) A minimum control efficiency of 98.0 percent by weight for the VOC emissions;
>
> (b) A maximum outlet VOC concentration of twenty parts per million by volume (dry basis); or
>
> (c) A minimum incineration temperature of one thousand five hundred degrees Fahrenheit."

Similar permit requirements apply to other facilities operating air pollution control devices. Appendix B contains tables which have a selection of permit requirements from several States. The States included are Ohio (Table B-1), California (Table B-2), Illinois (Table B-3), Texas

(Table B-4), and other States (Table B-5). The information included in these tables gives a general idea of the quantity of VOC emissions occurring at different size facilities. In some cases, the emission data is divided by source category (Tables B-1, B-4, and B-5). The emission data listed in the tables is most likely based on theoretical equations rather than on actual test data.

Information retrieved from the State of Ohio lists vessel capacity, vessel size, abatement methods, VOC emission limits, control efficiencies, and applicable operational limits. Two methods of abatement used to control VOC emissions are carbon absorption and carbon adsorption. Both the adsorbers and the absorbers operate at 95 percent efficiency.

California information lists facility size and organic emission limits in both tons per year and pounds per day. The data indicate facilities with applicable abatement devices, but does not describe the type of device.

Information included in the Illinois table indicates estimated organic emissions in tons per year. The abatement devices in this table include control techniques for both VOCs and particulate matter.

Texas data includes facility size, emission sources, speciation data, organic emissions in tons per year, and abatement devices. Like Illinois, Texas includes information on both VOC and particulate controls. Some of the methods used to control VOC emissions are vapor condensors and scrubbers.

The information included in the final table, Table B-5, lists emission sources, emissions, and abatement devices for several States.

3.3.4 Plant Trips

The trip reports for the four facilities visited during the course of this project are located in Appendix C. All of the manufacturing facilities visited calculate total plant VOC emissions based on raw material consumption rather than calculating emissions from processes or equipment by an alternative method. Total emissions therefore reflect solvent losses during manufacturing, cleaning operations, and storage.[6-9]

Each of the four facilities visited is required to submit annual emission reports under the Superfund Amendments and Reauthorization Act of 1986 (SARA) Section 313. In 1990, the facilities reported releases as indicated in Table 3-4.[6,8,9] Please note that the term fugitives as used in this table indicates primarily evaporative losses. These emissions may be controlled if they occur within a structure or enclosure.

TABLE 3-4. EMISSIONS FOR 1990

Facility	Chemical	1990 Releases (lbs)	
		Fugitive	Point Sources
The Perry & Derrick Company	n-Butanol	1600	1-10
	Ethyl Benzene	11-499	-
	Ethylene Glycol	11-499	-
	Glycol Ethers	500-999	11-499
	Methyl Ethyl Ketone	13,000	1-10
	Methyl Isobutyl Ketone	2,000	1-10
	Toluene	19,000	11-499
	Xylene	1,100	11-499
ICI Specialty Inks (Regent Drive Facility)	Toluene	11-499	11-499
Borden Packaging and Industrial Products	Glycol Ethers	1,100	500-999
	Methyl Ethyl Ketone	500-999	7,800
	1,1,1-Trichloroethane	7,830	-
	Toluene	11-499	500-999

Section 313 submissions for the PPG Industries, Inc., site are found in the facility trip report located in Appendix C.

3.4 REFERENCES

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CHAPTER 4
EMISSION CONTROL TECHNIQUES

4.1 INTRODUCTION

In paint and ink facilities, VOC vapors are generated throughout the manufacturing process. If these emissions are left uncontrolled, high concentrations of VOC can build up in the work area, compromising workers' health, safety, and productivity. Release of VOC to the atmosphere can result in increased levels of tropospheric ozone (O_3), a pollutant that causes negative health effects in the human pulmonary system.

The amount of VOC present in the indoor and outdoor atmospheres can be reduced in the following ways: minimizing the manufacture and use of products containing VOC, reducing the amount of VOC emitted during the manufacturing process, and removing VOC from the air once it has been emitted. Paints and inks may be reformulated to eliminate or minimize the amount of VOC contained in the product. Reductions in process VOC emissions may be achieved by equipment and process modifications, improved operating practices, and recycling. Reduction of VOC emissions to the indoor and outdoor atmospheres can be achieved by ventilating the manufacturing area through use of well-designed capture devices and subsequently removing VOC from the ventilation air by appropriate control devices.

The concentrations of organics found in the emission streams from the process equipment are often very low. The organics in these streams consist of alcohols, ketones, cellosolves, acetone, toluene, xylene, and others.[1,2] The low organic concentrations, the variety of organic constituents, and the paint and ink batch process operations often make add-on control devices for individual sources unattractive. The following sections describe more effective emission reduction and removal methods.

4.2 VOC EMISSION REDUCTION METHODS

Paint and ink manufacturing facilities can take several steps to minimize VOC emissions without employing add-on controls. The methods discussed in this section will reduce waste in addition to reducing emissions. These VOC-minimizing methods include process and equipment modifications, improved operating practices, and recycling. Source reduction through product reformulation is covered in Section 4.3. It is difficult, however, to determine the overall efficiency or impact of these VOC-minimizing methods on individual emission sources because many paint and ink manufacturing facilities estimate total plant emissions rather than estimating or testing emissions by process or source (i.e., filling operations, grinding operations, cleaning processes).

4.2.1 Equipment or Process Modifications

Two stages which are amenable to equipment and process modifications are paint and ink manufacturing and equipment cleaning.

4.2.1.1 *Tank Lids*

Tank lids are the most common equipment modification used during the manufacturing process to control VOC emissions. Mix and blend tanks are a primary source of manufacturing VOC emissions because the solvent-containing materials spend a significant amount of time in this equipment. All of the States that regulate paint and ink manufacturers require that all open-top equipment be covered during the manufacturing process (See Tables 3-2 and 3-3). Illinois, like most of the States, requires the following of equipment lids:[3]

1. The mill, tank, vat, or vessel is equipped with a cover which completely covers the mill, tank, vat, or vessel opening, except for an opening no larger than necessary to allow for safe clearance for a mixer shaft. Such a cover shall extend at least 1/2 inch beyond the outer rim of the opening or be attached to the rim.

2. The cover remains closed, except when production, sampling, maintenance, or inspection procedures require access.

3. The cover is maintained in good condition, such that when in place, it maintains contact with the rim of the opening for at least 90 percent of the circumference of the rim.

Many of the lids currently used in industry are flat and some are conical. Flat lids control emissions relatively well, but they do have some inherent flaws. The lids do not form a seal with the mix tank and the hinged door product add chute does not always remain closed. A typical flat lid is illustrated in Figure 4-1. Conical lids, a better engineering design, are considered a more efficient means of controlling emissions. However, they too have associated difficulties caused by added weight and bulky shape. The conical lids are more difficult to handle and damage more easily than the flat lids.[4]

Lids may be constructed of either plastic, wood, aluminum, or stainless steel.[4-7] Plastic and wooden lids are normally one piece except for the center agitator shaft opening, while aluminum and stainless steel lids normally have hinged openings for product additions and sampling. Some facilities currently using aluminum lids question their safety.[4] A study conducted in Germany indicates that having steel (e.g., carbon steel mix tank) scraping against aluminum containing silicon (e.g., mix tank cover) could be a potential source of sparks. A fire may break out if the sparks contact possible flammable vapors from solvent-containing paints and inks.[8]

The control efficiency of covers on mix tanks ranges from 40 to 96 percent depending on the method used to determine emissions.[4,9,10] These values represent the ratio of the emission reduction to the uncontrolled emissions. They do not account for any subsequent venting to control devices. The 96 percent value arose from studies conducted with mix tanks in the polymeric coating industry. In this case, the demonstrator considered only evaporative losses during the mixing process. This method of emission determination fails to include the working losses that occur during filling and emptying a vessel containing a solvent-saturated air space.[9]

A study of the efficiency of covers used in the magnetic tape manufacturing industry indicated an efficiency of 40 percent. This study, which is considered representative of the paint and ink manufacturing industries, accounted for both evaporative and working losses. The analysis indicated that the covered tank would release almost no evaporative losses. The study also stated that working losses would be 75 percent of those calculated for an open tank (i.e., when the covered tank is filled, only 75 percent of the solvent-saturated air is pushed out into the surrounding air). As described by the magnetic tape study, the total emission reduction is determined to be the difference between the emissions of the open and covered tanks.[10]

A description of a third study on mix tank covers is found in the ICI trip report in Appendix C. This study, which accounts only for evaporative losses, indicates a cover efficiency of 88.6 percent.[4]

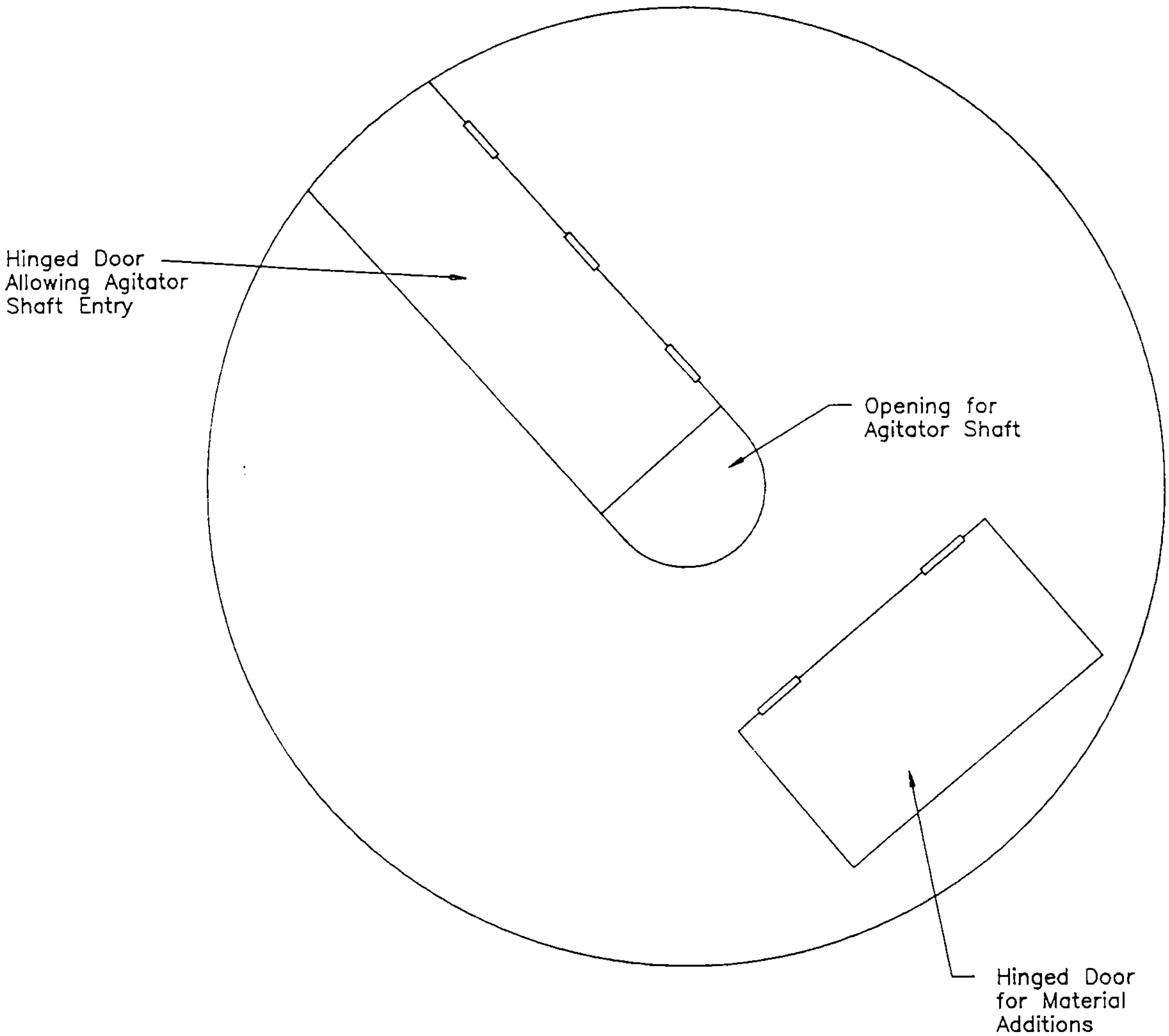

Figure 4-1. Typical flat mix tank cover.

Studies conducted by the polymeric coating industry indicate that no significant increase in cover efficiency is achieved by using vapor-tight covers with conservation vents rather than tight-fitting covers. The primary benefit of conservation vents is the control of breathing losses which result from diurnal temperature changes. Mix tanks in paint and ink manufacturing, like mix tanks in the polymeric coating industry, are not normally exposed to these temperature changes.[10]

4.2.1.2 *Modified Milling Equipment*

In some cases paint and ink manufacturers could reduce total VOC emissions by converting some of their older milling equipment to newer, more efficient closed-systems such as horizontal media mills. Although a wide range of products can be processed in the horizontal mills, some cannot. The mill base must be of a low viscosity to allow the grinding media to move with maximum velocity. The low viscosity requirement prevents some materials currently made in other types of milling equipment from being manufactured in horizontal mills. The viscosity of a product, along with other characteristics such as color, gloss, type of raw materials, and processing time, often determines the appropriate type of milling equipment.[11,12]

4.2.1.3 *Equipment Cleaning*

Equipment cleaning generates a high percentage of the waste associated with paint and ink manufacturing. Because much of this cleaning is performed with solvents, equipment cleaning is also a major source of VOC emissions. Any methods that reduce the need or frequency of tank cleaning will also reduce emissions. Several process and equipment modifications follow.

- *Rubber wipers*: Facilities can use rubber wipers to scrape the sides of the tank to reduce the amount of clinging paint or ink, therefore reducing the amount of solvent needed to clean the tank. Wipers can be either manual or automatic.[13,14]

- *High-pressure spray heads*: High pressure spray heads can be used to clean process tanks. These heads can reduce cleaning material use by 80 to 90 percent.[13,14]

- *Teflon™ lined tanks*: Teflon™ lined tanks will reduce the amount of paint and ink clinging to the side of the tank and will make cleaning easier.[13,14]

- *Plastic pigs*: Plastic or foam "pigs" may be used to clean paint and ink from process pipes. The "pig" moves through the pipes and pushes ahead paint from a previous batch which has been left clinging to the pipe walls. This process reduces solvent needed to clean the pipes and increases product yield.[13,14]

- *Automatic tub washers*: Some facilities have successfully used automatic tub washers to clean process tanks. These washers form a seal with the tank, pull a vacuum, and circulate cleaning solvent on a timed schedule.[4]

Another method to reduce emissions from solvent cleaning operations is to use larger media in milling equipment. Larger media rinses more easily than small media, and therefore requires less cleaning solvent.[15] Glass and ceramic media and sand are also easier to clean than steel shot.[16]

4.2.2 Improved Operating Practices

In addition to process and equipment modifications, VOC emissions may be reduced by following good operating procedures. Several paint manufacturing facilities in Ohio are required by permit to abide by the following good housekeeping procedures:[17]

1. All open-ended paint manufacturing vessels shall be securely covered during periods of operation, except when adding raw materials.

2. During the transfer of material to different containers, steps shall be taken to reduce and prevent splashes and spills. Any liquid or dry material spilled shall be cleaned as expeditiously as possible, but not later than the end of the daily work shift.

3. Waste solvent shall be collected and stored in closed containers. The closed containers may contain a device that would allow pressure relief, but would not allow liquid solvent to drain from the container prior to disposal.

4. The permitted facility shall provide a permanent sign or signs for the paint manufacturing equipment which states the required work and operating practices. The sign or signs shall be placed in a prominent location and be kept visible and legible at all times.

Another good operating procedure which can reduce emissions is dedicating process lines and equipment. Equipment dedication eliminates cleaning between each product batch. Scheduling compatible batches or batches from light to dark colors also reduces the need for equipment cleaning. Production scheduling and dedicating equipment may be impossible, however, in small paint and ink facilities that operate on a batch schedule in order to meet customer demands. In some cases, facilities operate on a same-day shipment schedule.[4-7]

4.2.3 Recycling Techniques

One common recycling technique among paint and ink manufacturers is using spent cleaning solvent in subsequent compatible batches. After a mill or tank has been emptied of product, solvent is added to the vessel to capture remaining product residue. The wash solvent is drained from the tank, staged, and recycled into the next compatible product batch. Mills may be cleaned by replacing the residual heel of the exiting product with an equivalent amount of solvent which is compatible with both the preceding and the ensuing batches.[4,6,7]

Another recycling technique which reduces total solvent consumption and VOC emissions is using countercurrent rinsing sequences. This method uses recycled "dirty" solvent to initially clean the tank. Following this step, "clean" recycled or virgin solvent is used to rinse away the "dirty" solvent. The countercurrent sequence, as illustrated in Figure 4-2, extends the life of cleaning solvents.[4,6,14]

4.3 PRODUCT REFORMULATION

Eliminating or minimizing the manufacture and use of products containing VOCs is the most effective way to reduce VOC emissions. In many cases, alternatives to high-solvent containing paints and inks do exist. However, because many end users (i.e., finishing facilities) are reluctant to invest the time and effort required to change to these new and developmental technologies, manufacturers continue to make the higher solvent products. As more technically feasible low-VOC coatings become available, regulations covering their use will be developed. For instance, a Control Technique Guideline (CTG) is currently being developed for architectural and industrial maintenance coatings. The production trends for these lower solvent product formulations are illustrated in Figure 4-3. The following sections briefly discuss several coatings which have been successfully manufactured and applied by end-users.

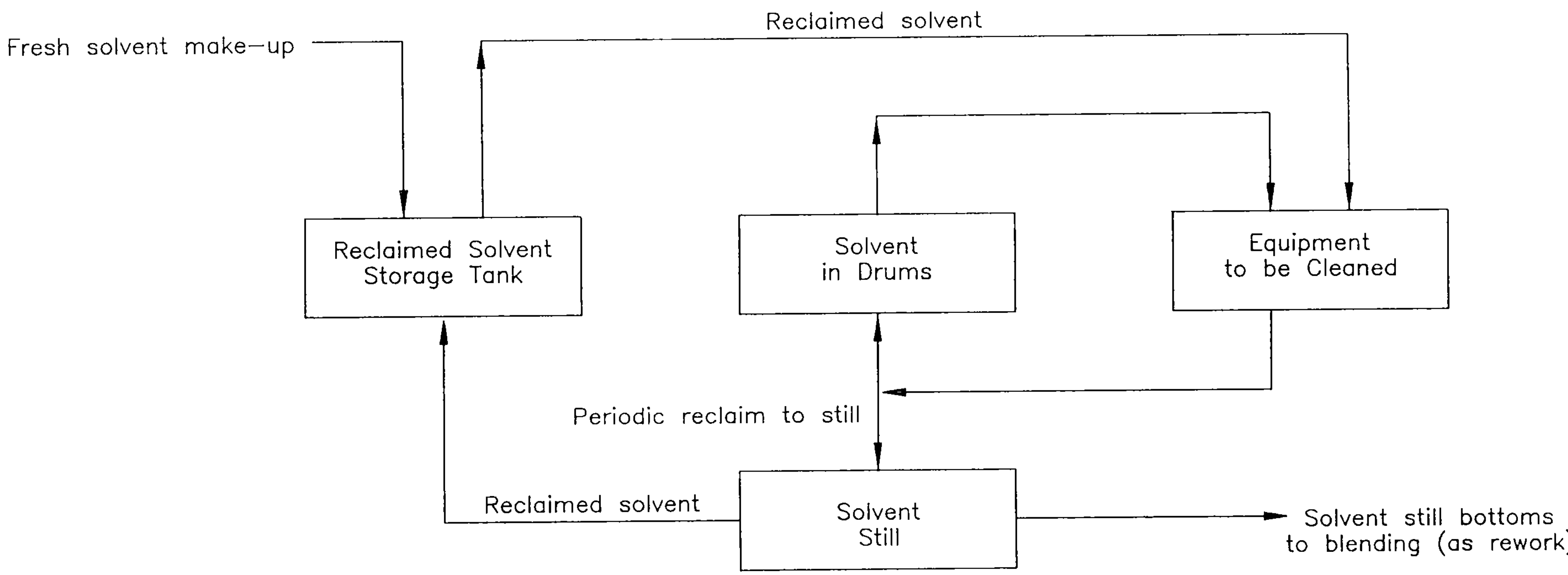

Figure 4-2. Recycling and reusing cleaning solvent.

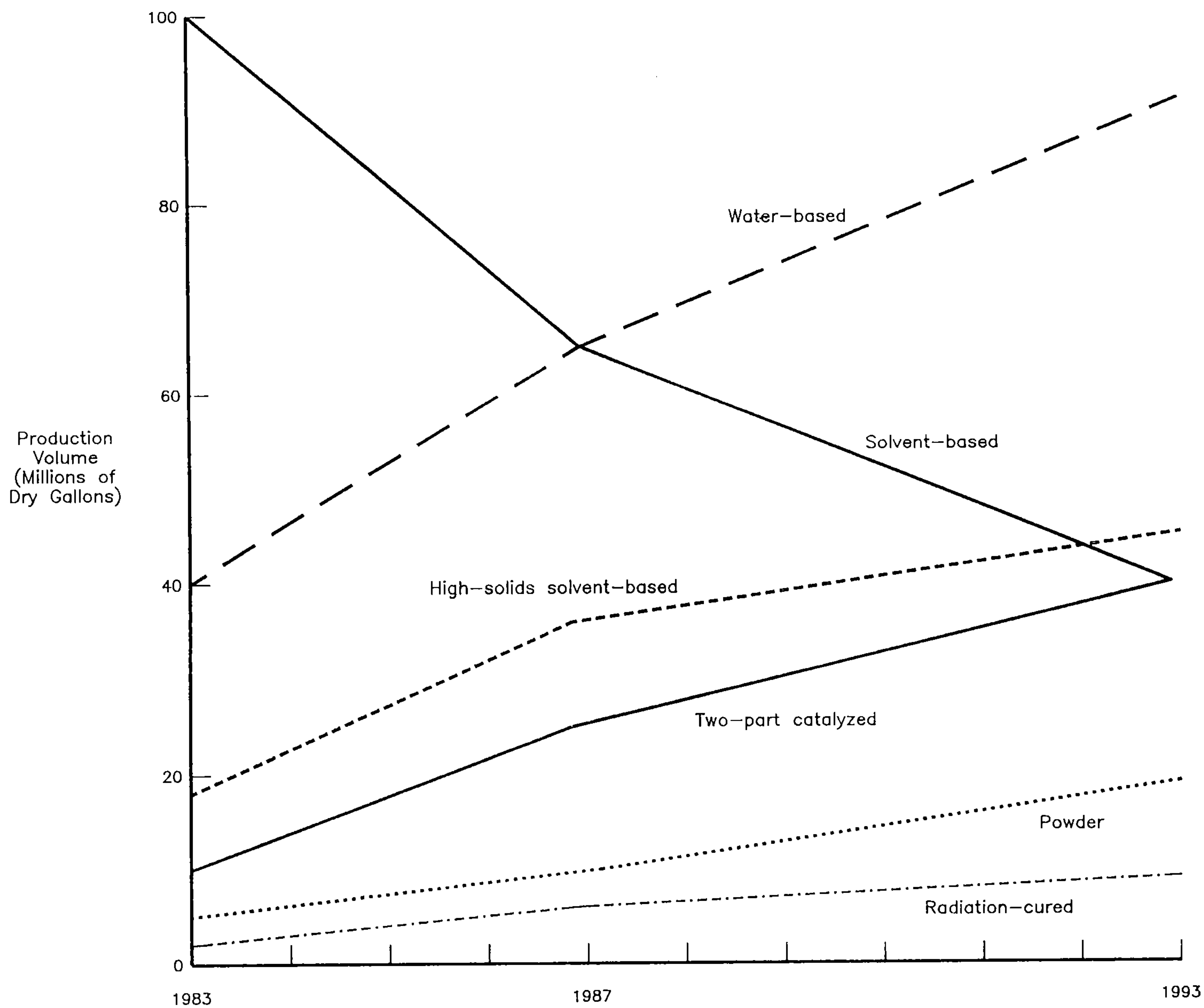

Figure 4-3. Production trends in coating systems.

4.3.1 Powder Coatings

Powder coatings are mixtures of dry synthetic resins, pigments, solid additives, and from zero to ten percent entrapped volatiles. Because these coatings contain no liquid solvents, they do not emit VOC. Powder coatings are of two general resin types: thermoplastic and thermosetting. Thermoplastic powders are comprised mainly of vinyl, nylon or fluoroplastics. Thermosetting coatings are normally epoxy, polyester or acrylic powders.[18,19]

Powder coatings currently account for 15 percent, or an estimated 118 million pounds, of the coatings market, and future growth is expected particularly with thermoset powder coatings.[20] Epoxy systems, because of their versatility in both decorative and functional areas, have anticipated expansion of 14 percent per year to 105 million pounds by 1995.[21]

Powders can now be used in many paint end-user industries because of the technological advances in the powder coating industry and because powder coating suppliers have developed custom-formulated powders. They are a feasible alternative to many OEM paints, although they are less viable in architectural and special-purpose markets.

4.3.2 Waterborne Paints and Inks

Waterborne paints and inks contain water as the main solvent or dispersant, although most contain 5 to 20 percent organic solvent to aid in wetting, viscosity control, and pigment dispersion.[22]

Waterborne paints are of several types: latex or emulsion paints, partially solubilized dispersions and water soluble coatings. Emulsions are the most commonly used coatings because they can form relatively thick films without blistering. Emulsions are particularly common in the consumer architectural market.[18]

Waterborne inks are also penetrating solvent markets. The traditional solvent categories (flexographic and gravure inks) are seeing increasing production of waterborne formulations.[23]

4.3.3 Radiation-Curable Paints and Inks[24]

Radiation-curable coatings are coatings formulated to cure at room temperature with the assistance of a radiation source, either an ultraviolet (UV) light or an accelerated electron beam (EB). The electromagnetic radiation energy effects a chemical and physical change in the coating materials by forming cross-linked polymer networks. Radiation-curable coatings typically have higher solids contents than their conventional solventborne counterparts. The majority of current radiation-curable systems contain none of the organic solvents found in conventional paints and inks. The film-forming components in a radiation-curable system may approach 100 percent reactivity, which means that most (i.e., 98 to 99 percent) of the material is converted into the polymer network and very little evaporates before the coating or ink is considered dry.

Radiation-curable paints and inks have been used successfully in several areas. The graphic arts industry, a large user of UV-curable inks and varnishes, accounts for almost 50 percent of the radiation-curable market. For 1985, it is estimated that the graphic arts industry used 13 million pounds of UV-curable materials.

4.3.4 High-Solids Paints and Inks

The normal solids content for conventional coatings ranges from 8 to 30 percent, while high-solids coatings typically contain greater than 60 percent solids by volume.[25-27] The contributing solids' components in high-solids coatings are pigments and binders (resins).[26,28] Because high-solids coatings contain less solvent and more solids, they help to lower VOC emissions. Some high-solids materials are used in almost all of the paint and ink markets.

High-solids coatings are modifications of their solvent-based counterparts and are classified into two general groups: two-component/ambient cured and single-component/heat converted.[18,28] Both groups are chemically composed of synthetic resins, pigments, additives and a reduced quantity of solvent. Epoxy, acrylic, polyester and alkyd resins have been developed for single-component systems; acrylic, polyester, epoxy and urethane resins are used in two-component coatings. The two-component systems offer the advantage of ambient curing, thereby eliminating the need for an oven. When mixed shortly before application, the components crosslink to form a solid film.[18]

4.4 VOC EMISSIONS REDUCTION BY CONTROL SYSTEMS

VOC emissions can be removed from the atmosphere by an add-on control system consisting of a capture device and a removal device. The capture device (such as a hood or enclosure) captures the VOC-laden air from the emission area and ducts the emission stream to removal equipment such as a recovery device (e.g., an adsorber) or a combustion device (e.g., an incinerator) which removes the VOC from the air. The overall efficiency of a control system is calculated by multiplying the capture system efficiency by the removal device efficiency. Thus, the combination of a capture device which captures 80 percent of the VOC emissions at the emission source ducted to a removal device which removes 90 percent of the VOC in the emission stream would yield an 72 percent overall efficiency.

Many removal devices (such as adsorbers or incinerators) have removal efficiencies well above 90 percent. Capture devices, in comparison, have a much larger range of capture efficiencies.

Designing a capture system for a facility can be a more complex task than designing a removal system. A capture system must be designed around equipment functions and layout that can vary significantly from plant to plant. In contrast, removal systems are typically "packaged" systems designed by the removal device manufacturer and placed away from the process equipment, thereby reducing facility-specific demands.

4.4.1 Capture Devices

Several capture devices such as enclosures, hoods, and other devices may be used in the paint and ink manufacturing industry to remove vapor and liquid VOC from the manufacturing area and to transport them to an appropriate removal device.[29]

Several factors are important in the design of a good capture system. A primary capture system criterion is that the system should maximize VOC capture at the minimum cost. Optimum cost effectiveness is generally achieved by increasing the degree of closure around the emission area, because airflow volume is the primary factor influencing capture system cost.[29]

Other necessary considerations in addition to airflow and cost include fire and explosion hazards, and visibility requirements.[29] To prevent the risk of fire or explosion, the maximum VOC concentration within capture and removal systems should be kept below 25 percent of the VOC's lower explosive limit (LEL). Visibility must be maintained so that operators can clearly observe the manufacturing equipment when necessary.[29]

A "total enclosure" device is defined as a structure that is constructed around a source of emissions so that all VOC emissions are collected and exhausted through a stack or duct to a control device. With a total enclosure, there will be no fugitive emissions, only stack emissions.[10] A paint or ink manufacturing facility may be well-suited to using the "total enclosure" approach to VOC capture. The mixing tank lid could be constructed with a surficial flange which could be connected to a second flange at the end of flexible ductwork. The ductwork, which is connected to a combustion or recovery device, is installed at the mixing station and is attached to the mix tank lid during mixing operations. Although it is infeasible to duct emissions from a portable tank while it is being temporarily stored or staged, it is feasible to duct emissions from this equipment when it is being held stationary during manufacturing operations. This technique can be applied to lids fitting mix tanks and drums of all sizes. Employing this arrangement allows the covered tank to become, in effect, a total enclosure capture device. Exhausting the tank emissions to a removal devices completes the control system.

A second option is to use a room-type total enclosure or a small-process total enclosure. In the paint and ink manufacturing industry, it may be possible to enclose defined areas within the production facility and vent the area emissions to a combustion or recovery device. The capture efficiency for complete enclosures can be close to 100 percent.[10] Total enclosures may be used in areas housing automated equipment and where personnel activities are minimized. Although partial enclosures, such as hoods installed over processing equipment, can be used in more areas than total enclosures, their efficiencies are not as great.

The following points summarize the design and operational criteria set forth by EPA for total enclosures in the polymeric coating industry:

1. The only opening in the enclosure shall be forced makeup air and exhaust ducts and natural draft openings such as those through which raw materials enter and exit the coating operation.

2. The total area of all natural draft openings shall not exceed 5 percent of the total surface area of the total enclosure's walls, floor, and ceiling.

3. All access doors and windows shall be closed during normal operation of the enclosed coating operation, except for brief, occasional openings to accommodate process equipment adjustments. If such openings are frequent, or if the access door or window remains open for a significant amount of time during the process operation, it must be considered a natural draft opening.

4. Average inward face velocity (FV) across all natural draft openings is a minimum of 3,600 meters per hours (200 feet per minute) and demonstrably inward at all times.

5. All sources of emissions within the enclosure shall be a minimum of four equivalent diameters away from each natural draft opening.[10]

Although the criteria listed above were included in the polymeric coating and magnetic tape coating new source performance standards, they may be considered a guide to the appropriate design of a tank-and-lid total enclosure capture device.

4.4.2 Recovery Techniques

Recovery devices are those which physically remove a compound from an emission stream and convert the compound into a form (normally a liquid) for future use. The removal efficiencies of recovery techniques normally depend on the chemical and physical characteristics of the compound to be removed. Some of the recovery control devices used in industry include carbon adsorbers, absorbers, and condensers.

4.4.2.1 *Carbon Adsorption*

In the carbon adsorption process, VOC emission streams are passed through a bed of activated carbon in which the VOC molecules are captured on the porous carbon surfaces by non-chemical Van der Waals forces. The adsorptive capacity of the carbon bed tends to increase with the gas phase VOC concentration, molecular weight, diffusivity, polarity, and boiling point of the VOC.[30] After the working VOC capacity of the carbon is reached, the VOC can be desorbed from the carbon and collected for reuse.

Desorption of the solvent VOC from the used carbon bed is typically achieved by passing low-pressure steam through the bed.[31] In the regeneration cycle, heat from the steam forces the VOC to desorb from the carbon, where it is entrained in the steam. After the carbon bed has been sufficiently cleared of VOC, it is cooled and replaced on-line with the emission stream. Meanwhile, the VOC-laden steam is condensed, and the VOC is separated from the water by decanting or, if necessary, by distillation; if the VOC is not recovered for reuse or reprocessing, it may be incinerated.[32]

Carbon adsorbers are commonly used for air pollution control and/or solvent recovery from dilute (less than 10,000 ppmv) streams of VOC in air. Adsorption provides a very low outlet concentration as well as the opportunity to recover the VOC. Removal efficiencies range from 95 to 99 percent for well-operated systems, and outlet concentrations of 50 to 100 ppmv can be routinely achieved. Packaged systems are available with flow rate capacities beyond 100,000 scfm.[33]

The principal advantage of carbon adsorption is that it is very cost effective with low concentrations of VOCs. VOC recovery may offset operation costs. Operation of the adsorber is relatively simple for both continuous and intermittent use. However, at concentrations below the 500 to 2,500 ppm range, adsorption may become uneconomical.[34]

Certain types of VOCs, such as those which are difficult to strip from carbon or those which are miscible with water, do present disadvantages. If the VOC involved is miscible with water, additional distillation measures are necessary to recover the VOC. If steam-stripping is conducted with chlorinated hydrocarbons, corrosion and wastewater treatment problems may occur.[35] Also, carbon adsorption is relatively sensitive to emission stream humidity and temperature. Dehumidification is necessary if the emission stream has a high humidity (relative humidity > 50 percent) and cooling may be required if the emission stream temperature exceeds 120° to 130°F.[33]

Two carbon adsorption systems currently in use are the fixed-bed system and the fluidized-bed system. In the fixed-bed system, non-moving beds of carbon are alternately placed on-line and regenerated. When a continuous emission stream is being treated, at least one bed is on-line and one bed is regenerating at any given time. In the fluidized-bed system, loose, clean carbon is constantly metered into the bed while loose, VOC-laden carbon is removed for regeneration.[33]

4.4.2.1.1 Fixed-Bed Systems. In a continually operating fixed-bed system, the VOC emission stream is passed through two or more non-mobile carbon beds. In a two-bed system, one bed is on-line with the emission stream while the other bed is being regenerated or on standby. When the first bed reaches its working VOC capacity, the emission stream is redirected to the second bed, and the first bed is regenerated. While two beds are common, three or more beds can be used in a variety of configurations, with more than one bed on-line at a time.[31]

4.4.2.1.2 Fluidized-Bed Systems. The fluidized-bed adsorber system contains one or more beds of loose, beaded activated carbon. The VOC emission stream is directed upward through the bed where the VOCs are adsorbed onto the carbon. The flow of the emission stream stirs the carbon beads, causing them to "fluidize" and flow within the adsorber. The VOC-cleaned air exiting the adsorber is passed through a dust collector, then released into the atmosphere.[31] Fresh carbon is continually metered into the bed while VOC-laden carbon is removed for regeneration.

Fluidized-bed adsorbers can capture more VOC with a given quantity of carbon because the fluidized bed mixes newly regenerated carbon and VOC more thoroughly, and because the system continually replaces used carbon with regenerated carbon. This increased VOC-capacity reduces costs for steam regeneration. Fluidized-bed adsorbers are less common than fixed-bed adsorbers because fluidized-bed adsorption technology has been commercially feasible only since the early 1970s.[36]

Because VOC concentrations in the paint and ink industry are generally lower than the acceptable range for economically feasible control by carbon adsorption, it is unlikely that the carbon adsorber is a viable choice for the industry. Also, the wide mixture of organics that may be emitted at a paint and ink facility will tend to reduce the control efficiency of carbon adsorption.[34]

4.4.2.2 *Absorption (Scrubbing)*

In the physical absorption process, VOCs are removed from the emission stream by absorption in a liquid solvent such as a high molecular weight oil. Spray towers, venturi scrubbers, or other methods are used to bring the absorbent into contact with the emission stream. After the VOCs dissolve into the solvent, the cleaned gas is released from the absorber.[31] After the VOCs have been captured in the absorbent, fractional distillation or some other method can be used to recover the VOC from the absorbent.[37]

Absorption is most efficient when the VOC is soluble in the absorbent, and when the absorbent's boiling point is significantly higher than the VOC to be absorbed. Absorbers have been shown to remove from 86 to greater than 99 percent of the waste stream VOC for various species.[32,35]

Absorbers can be used with a wide variety of organic compounds without many of the problems associated with other VOC removal devices such as the carbon adsorber, incinerator, or condenser. A closed-loop system has been developed that demonstrates no deterioration with use and does not generate steam, or wastewater or cause corrosion.[35]

Despite its advantages, the closed-loop adsorption system is not cost effective with very low inlet concentrations of VOCs or with airflows less than 1,000 cfm.[35] These restrictions make the absorber a less-frequently used option for VOC control. For most industrial processes, including paint and ink manufacturing, the waste stream VOC concentrations are generally low, making absorption less desirable than adsorption or incineration unless the absorbent is easily regenerated or the solution can be used as a process make-up stream.[31]

4.4.2.3 *Condensation*

Condensers remove VOCs from the emission stream by causing the VOC to condense and separate from the gas. The VOC can be condensed by decreasing or increasing the pressure at a given temperature. Surface condensers and contact condensers are two common systems that condense VOCs by cooling the emission stream at atmospheric pressure. The removal efficiency of a condenser is dependent on the VOC characteristics, concentration, and airflow design.[33]

In the surface condenser, the emission stream is passed by a tube or manifold containing a chilled liquid. When the emission stream contacts the chilled surface, the VOCs condense, then drain to storage or disposal.[31] No contact occurs between the coolant and the emission stream, thus the condensate is strictly composed of the species condensing on its surface.

Contact condensers typically condense the VOC by spraying a liquid (such as water) that is at ambient temperature or slightly chilled liquid directly into the gas stream in a simple spray chamber or similar device.[31] In contrast to the surface condenser, the contact condenser intimately mixes the cooling agent with the VOC to be removed. The VOC and coolant mixture is collected for reprocessing or disposal.

Condensers are widely used as raw material and/or product recovery devices.[33] Often, condensers are not used alone but are used in conjunction with other VOC removal devices. Condensers may be placed upstream of absorbers, adsorbers, or incinerators to reduce the material load entering these more expensive or sensitive devices. Used in this way, the condenser can remove components harmful to the other devices (such as chlorine or sulfur) or remove valuable components that would otherwise be destroyed.

Condensers can be used alone for controlling waste streams containing high VOC concentrations (>5,000 ppmv). In these cases, condenser VOC removal efficiencies usually vary between 50 and 95 percent.[33] Flow rates up to about 2,000 scfm are typical for condensers used as emission control devices. At larger flowrates, prohibitively large heat transfer areas become required.[33]

Surface and contact condensers each have merits relative to the other. Surface condensers may more easily recover marketable condensate while minimizing waste disposal problems. However, surface condensers are more expensive to operate than contact condensers.[31] Contact condensers are generally less expensive, more flexible, and more efficient in removing VOC than are surface condensers. Condensate from contact condensers cannot be reused and may require wastewater treatment prior to disposal.[31]

The condenser does not remove VOCs as efficiently as other VOC control devices such as the incinerator, adsorber, or absorber. As the sole method of VOC control, the condenser may not be sufficient for removing VOCs from the waste stream, particularly at high airflows. The condenser may be best applied as an auxiliary VOC removal device placed upstream from other removal devices and used to remove moisture, substances (such as chlorine or sulfur) harmful to other devices, or to recover easily captured materials that would be destroyed if an incinerator were used downstream.

A disadvantage of the condenser is that VOC outlet concentrations below 10,000 to 20,000 ppmv are difficult to achieve due to saturation conditions. If extremely low outlet concentrations are necessary, condensation will usually be economically infeasible.[33]

Because much of the process equipment in paint and ink manufacturing facilities handles a variety of substances with a wide range of VOC concentrations and components, condensers would not be a feasible control device.[34]

4.4.3 Combustion Techniques

The most common combustion technique is incineration. Incinerators remove VOCs from the emission stream by combustion, converting the VOCs into carbon dioxide, water vapor, and small amounts of other compounds. The VOC-laden emission stream enters the incinerator chamber where the VOCs are burned, sometimes with the assistance of a catalyst. Incinerator performance is a function of the waste gas heating value, inert content, waste gas water content, and the amount of excess combustion air.[31] Other design variables include degree of mixing, residence time, and the type of auxiliary burning used.

In contrast to adsorbers, absorbers, or condensers, incinerators do not recover the VOC for reuse; however, heat is generated during the combustion reaction, and this heat may be recovered for use elsewhere in the plant. The two most common means of incineration are thermal incineration and catalytic incineration, in which the emission streams are ducted to a combustion device primarily designated for control of organic emissions. The thermal incinerator and catalytic incinerator are illustrated in Figures 4-4 and 4-5. In a third means of incineration, the emission stream can be vented to the combustion chamber of an industrial boiler or process heater. The destruction method efficiency of a boiler or process heater is similar to that of the thermal incinerator. The distinction between the two devices is that the boiler or process heater is designated primarily as a heat source, and secondarily as a control device.

Both thermal and catalytic incinerators are often well-suited for removal of VOCs from emission streams. Heat recovery is readily attained with both thermal and catalytic incinerators, and this feature enhances the economy of using an incinerator rather than another VOC removal device.[32]

There are some disadvantages to using incinerators. Incinerators destroy the VOCs rather than recovering them; in some cases, the energy benefit may not be as great as the lost value of the VOC. Incinerators may not be practical choices for VOC removal if certain types of VOCs or other materials are burned. Incineration of VOCs that contain halogens or sulfur will produce

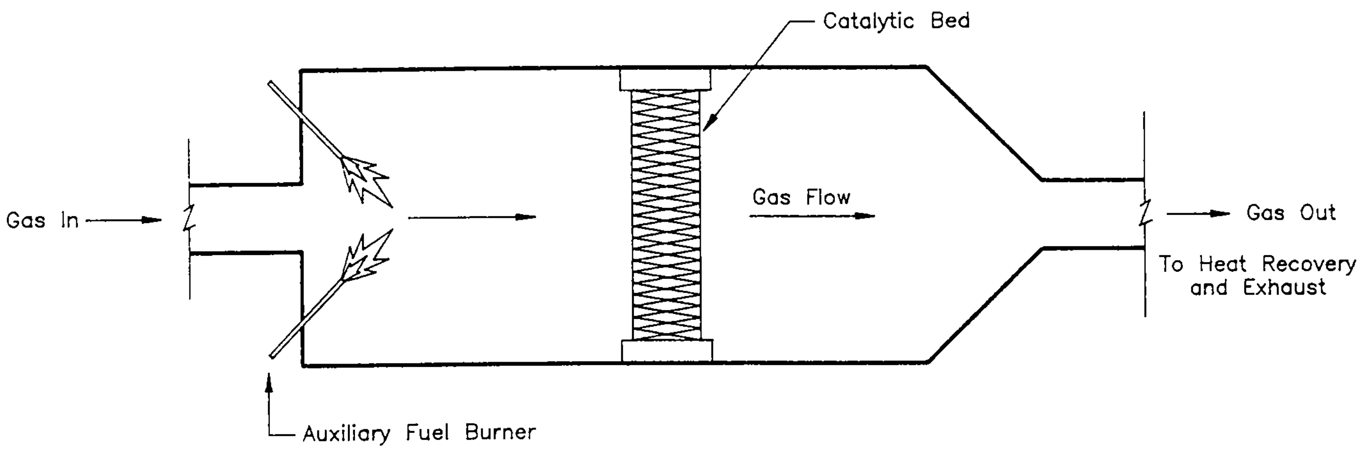

Figure 4-4. Catalytic incinerator.

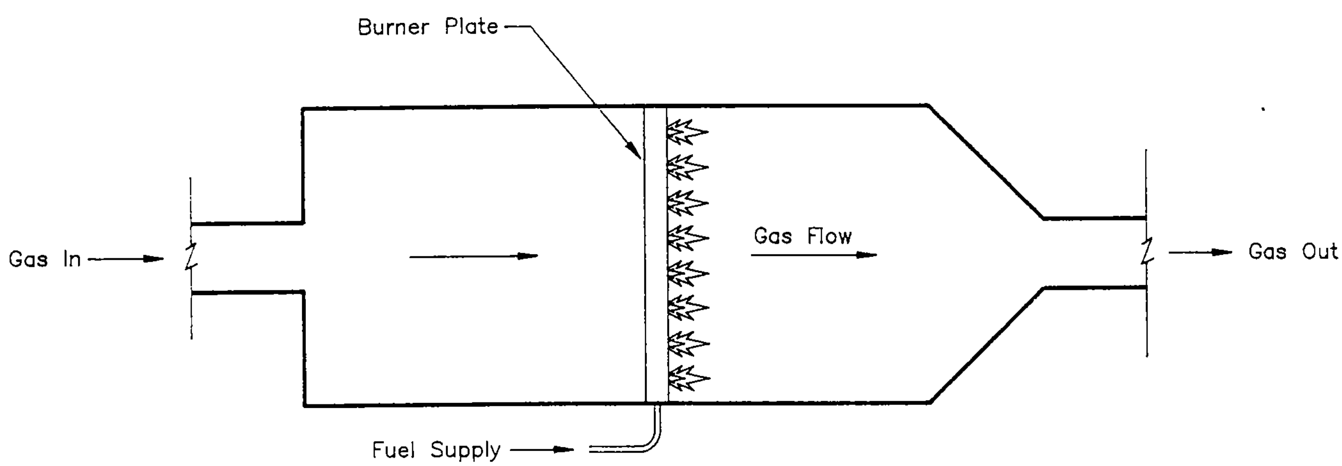

Figure 4-5. Thermal incinerator.

acidic compounds such as HCl or H_2SO_4. These streams are likely to require removal of the acid components by a scrubber unit, greatly adding to the cost of the VOC control system.[30] Catalytic incinerators are very sensitive to materials that can reduce the effectiveness of the catalyst. Phosphorous, lead, sulfur, and halogens can poison typical catalysts and severely affect their performance.[33] If it is necessary to use catalytic incineration to control waste streams containing these materials, special catalysts or other measures must be employed. Liquid or solid particles that deposit on the catalyst and form a coating also reduce the catalyst's usefulness by preventing contact between the catalyst and the VOC.[32,33]

For safety reasons, both thermal and catalytic incinerators may require large amounts of dilution air to reduce the VOC concentration in the emission stream. Heating the dilution air to the ignition point of the VOC may be prohibitively expensive, particularly if a waste gas contains entrained water droplets which must be vaporized and raised to combustion chamber temperatures. However, it is unlikely that dilution air would be necessary at a paint and ink facility due to the relatively low VOC concentrations typically encountered.

4.4.3.1 *Thermal Incinerators*

Thermal incinerators pass the emission stream through a combustion chamber where the VOCs are burned at temperatures typically ranging from 700° to 1,300°C (1,300° to 2,370°F).[31] Initially, burning is started with the assistance of a natural gas flame or similar heat source. If the VOC in the emission stream has a sufficient heating value and concentration, ignition temperatures can be sustained by the combustion of the VOC, and the auxiliary heat can be turned off. If the ignition temperature cannot be maintained by combustion only, the auxiliary heat must be left on. Auxiliary heat can be provided by fuels such as natural gas, and from recovery of heat released during combustion. The waste gases from the thermal incinerator are usually vented to the atmosphere.

Thermal incineration is widely used to control continuous, dilute VOC emission streams with constituents from a number of compounds. Thermal incinerators can achieve VOC removal efficiencies of 98 percent or greater depending on the design of the equipment. These efficiencies may not be possible in cases where the inlet VOC concentration is less than approximately 2,000 ppm. For inlet concentrations lower than 2,000 ppm, the performance of an incinerator is more appropriately indicated as a maximum exit concentration of 20 ppmv.[31]

For safety considerations, VOC concentrations are usually limited to 25 percent of the lower explosive limit (LEL) for the VOC. If the VOC concentration is higher in the waste gas, dilution may be required. Packaged, single-unit thermal incinerators are available to control emission streams with flow rates up to about 100,000 scfm.[33]

Thermal incinerators, via combustion, remove particulates and other organics in addition to VOCs, thus enhancing their utility.[32]

One paint manufacturing facility currently uses regenerative thermal incineration to control odors and VOC emissions.[5] The contaminated gases enter the system through an upper ring-shaped manifold. The air from this manifold is directed into inlet stoneware (i.e., ceramic) beds which act as energy recovery chambers. As the gases pass through the ceramic beds towards the incineration chamber, they are heated to a temperature nearing that of incineration. The VOC present in the fumes will autoignite in the beds. Oxidation is completed in the central incineration chamber where a gas or oil burner maintains a preset temperature. The purified air then passes through a second set of ceramic beds which absorb much of the gas's internal heat. The flow is periodically reversed to continually feed the inlet stream to the hot bed. The energy which is stored in the stoneware bed during the outlet mode is subsequently used to preheat inlet gases. Thermal efficiencies can exceed 95 percent. Although capital costs are high, they are generally offset by a decreased need for auxiliary fuels.[5,38]

4.4.3.2 *Catalytic Incinerators*

Catalytic incinerators are similar to thermal incinerators in that they eliminate VOCs from the waste stream via combustion. The distinguishing feature of a catalytic incinerator is the presence of a catalyst (such as platinum or copper oxide) that allows the VOC combustion reaction to take place at a temperature lower than the normal ignition temperature exhibited by the VOC in air.[31,33] By allowing the combustion reaction to take place at lower temperatures than required for a thermal incinerator, less preheating of the emission stream from auxiliary heat is necessary, and significant fuel savings are achieved.

In the catalytic incinerator, the emission stream is preheated to approximately 320°C (600°F) by recovered incinerator heat or by auxiliary burners.[31] The preheated emission stream is passed through the catalyst bed where combustion takes place on the activated catalytic surface. The incinerators are operated from 320° to 650°C (600° to 1,200°F), significantly lower than operating temperatures for thermal incinerators. Higher temperatures can shorten the life of the catalytic bed. Properly operated catalytic converters can be satisfactorily operated for three to five years before replacement of the catalyst is necessary.[33]

Catalytic incinerators have been applied to emission streams in many industries. Packaged, single-unit catalytic incinerators are available to control emission streams with flow rates up to about 100,000 scfm at efficiencies greater than 98 percent.[32]

Low energy costs make the catalytic incinerator an important option for removal of VOC from emission streams; however, the catalytic incinerator cannot be used in as many applications as the thermal incinerator. Catalytic materials can be quickly degraded by many elements or compounds present in industrial emissions such as sulfur or particulates. Many of these materials are burned without difficulty in thermal incinerators.

Some of the issues which must be addressed when applying catalytic incineration techniques are the incinerator's ability to handle the large variety of vapor phase organics that would be emitted from a paint and ink facility, the wide variety of organic concentrations in process waste streams, and the changing speciation of organic emissions that would occur with adjustments of paint and ink product formulations over time.[34] In many cases, one catalyst cannot handle all of the waste stream variations encountered in paint and ink manufacturing facilities.

4.4.3.3 *Industrial Boilers and Process Heaters*

In industrial boilers and process heaters, hot combustion gases (typically from natural gas or fuel oils) are placed into contact with heat transfer tubes that contain water or process liquids. Heat from the combustion gases is transferred across the tube to the liquids to produce steam or to heat the process material. In addition to their function as steam generators and heaters, industrial boilers and process heaters are currently used in industry to control organic emissions from manufacturing operations. Both devices are most applicable where high heat recovery potential exists.[31]

Because the combustion of organic emissions can affect the performance of a boiler, the emission characteristics must be considered. Such factors as variable flow rates, variable heat contents, pressure, and the presence of corrosive compounds may require changes in the operation of the boiler or heater. Boilers currently operating in a facility may not be able to control all of the emissions from the plant, and an additional incineration device may be required. When a new boiler or other incineration device is to be purchased, the operating and design parameters can be calculated to fit specific facility needs.[31,38]

If a boiler or process heater is applicable and available for use as a control device, they may provide excellent control efficiencies comparable to a thermal incinerator, while reducing capital and operating costs. The only capital investments involved are those associated with capture system ductwork, fans, and boiler or process heater modifications required to direct emissions to the boiler/process heater. One difficulty associated with boilers and process heaters is that they must operate continuously and concurrently with the emission source unless other control devices or strategies are available.[31,38]

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CHAPTER 5
CONTROL COST ANALYSIS

5.1 INTRODUCTION

This chapter presents the estimated costs for controlling VOC emissions from paint and ink manufacturing facilities. The VOC reduction methods discussed in Chapter 4 are summarized in Table 5-1, along with their applicability and current use in paint and ink manufacturing industries. Of the methods presented in Table 5-1, the following are both applicable and used by paint and ink manufacturing plants for reducing emissions: tank lids, horizontal media mills, equipment cleaning devices, improved operating practices, recycling techniques, product reformulation, capture devices, and thermal incinerators. These methods are presented with their available associated costs in subsequent sections in this chapter.

5.2 EQUIPMENT OR PROCESS MODIFICATIONS

Tank lids, horizontal media mills, and equipment cleaning devices all reduce VOC emissions by modifying manufacturing equipment.

5.2.1 Equipment Tank Lids

The most common method of controlling VOC emissions during the paint and ink manufacturing process is the use of equipment tank lids. Mix and blend tanks are a primary source of manufacturing VOC emissions because the solvent-containing materials spend a significant amount of time in this equipment. All of the States that regulate paint and ink manufacturing facilities require that all open-top equipment be covered during the manufacturing process. In most cases, the State or local agencies have adopted rules defining process controls, such as lids, as RACT for paint and ink manufacturing industries (See Tables 3-2 and 3-3).

Lids reduce VOC emissions by retaining the solvent in the product in the mix tank. This action serves to keep the product fluid and workable, thus preventing future solvent additions.

TABLE 5-1. APPLICABILITY AND USE OF VOC EMISSION REDUCTION METHODS IN PAINT AND INK FACILITIES

Reduction Method	Applicability to Industry	Current Use in Industry
Tank Lids	• Used extensively • Considered by States as RACT • Not normally vented to control devices	Most facilities
Horizontal Media Mills	• Require low viscosity products • Highly efficient, closed milling system	Some facilities
Equipment Cleaning Devices (rubber wipers, high-pressure spray heads, Teflon™ lined tanks, pigs, automatic tub washers)	• Efficiency of use depends on product manufactured and level of employee training • Some installations may require equipment modifications	Some facilities
Improved Operating Practices	• Used extensively	Most facilities
Recycling Techniques	• Used extensively	Most facilities
Product Reformulation	• Applicability depends on end use and customer requirements • Some States have regulations requiring lower VOC coatings • Reformulation requires extensive research and development	Many facilities
Capture Devices	• Applicable according to data collected from other similar industries • Capture devices are commonly used for particulate control	Extent of use is unknown. Only one facility with documented use.

(Continued)

TABLE 5-1. APPLICABILITY AND USE OF VOC EMISSION REDUCTION METHODS IN PAINT AND INK FACILITIES (continued)

Reduction Method	Applicability to Industry	Current Use in Industry
Carbon Adsorbers	• Not applicable to industry because of low VOC inlet concentrations and variety of contaminants in wastestream	Few facilities[*]
Absorbers	• Not applicable to industry because of costs associated with low VOC inlet concentrations • May be used by very specialized plants	Few facilities[*]
Condensers	• Not applicable to industry because of efficiency and costs associated with waste-stream concentration and composition variability • May be used in very specialized plants	Few facilities[*]
Thermal Incinerators	• Applicable, capable of destroying contaminants in process wastestreams	Few facilities[*]
Catalytic Incinerators	• Not applicable to industry because of low VOC inlet concentrations and variety of contaminants in wastestream	No documented use found
Industrial Boilers and Process Heaters	• Applicable according to data collected from other similar industries	No documented use found

[*]Few - Documentation shows use by less than 20 facilities.

Lids also reduce excess VOC emissions entering the work area. Because the primary objective of tank lids is to keep the solvent in the product, ducting lids to control devices is uncommon.

The lids that are currently used in industry for covering process mix tanks can be either plastic, wooden, aluminum, or stainless steel.[1-4] Plastic lids consist of a thin sheet of plastic which is placed across the tank in question and then taped or otherwise attached to the side of the tank. Normally, plastic lids are used for one product batch and then are thrown away. Other facilities use homemade plywood lids. After several uses, the underside of the plywood becomes saturated with product and the lid must be discarded. The most frequently used lids are those constructed of either aluminum or stainless steel. Flat aluminum lids, which are made by a sheet metal contractor, cost $20 to $25 for drums and $300 for a 250 gallon mix tank. Similar stainless steel lids often cost twice as much as the aluminum lids.[2] The efficiency of mixer lids has been estimated to be approximately 40 percent (See discussion of lid efficiency in Chapter 4).[5] This value represents the ratio of the emission reduction to the uncontrolled emissions.

Using the lid efficiency of 40 percent, assuming an average batch size of 250 gallons, and employing some additional data from the PPG RACT study (discussed below), the cost efficiency of equipment lids can be determined as indicated in Table 5-2.

As part of their RACT determination, the PPG facility determined total VOC emissions released from each of their manufacturing buildings.[6] In 1983, Building 19 used nine portable mix tanks with agitators to accomplish premix operations. During that year, the tanks emitted 25 tons of VOC to the atmosphere. Assuming a normal operating schedule of 24 hours a day, 5 days per week, and 52 weeks per year, this calculates to approximately 0.89 pound of VOC per hour from each tank.[1,6] This factor is specific to the PPG facility and its products, as emission rates will vary with many factors including the type of product manufactured, the type of solvent used, and the capacity of the manufacturing equipment.

5.2.2 Horizontal Media Mills

Installing horizontal media mills is a second way to reduce VOC emissions generated during the manufacturing process. Although these mills are more efficient milling devices than mix tanks and can be considered nearly 100 percent effective in controlling VOC emissions, they cannot be used to manufacture every type of paint and ink.

TABLE 5-2. EQUIPMENT COVER COST FIGURES[a]

Cost Item (in dollars)	Number	Cost	Total Cost
Aluminum equipment covers (replaced annually)	9	300	2,700
Cost Efficiency			
Total Annualized Operating Cost for Equipment Lids			2,700
Total Emissions			
25 tons/year at 40% control efficiency = 10 tons/year			
Cost Efficiency			$270/ton

[a]Cost figures and were taken from References 1, 2, and 6 and are assumed to be current dollars.

A typical 15 liter horizontal media mill with a 20 horsepower motor can produce 13 to 78 gallons of product per hour depending on the type of product produced.[7] With an average production capacity of 50 gallons per hour, a horizontal mill will produce 250 gallons of product in 5 hours. Similar production quantities in other equipment may take 15 hours of processing time. These numbers would indicated that horizontal media mills are approximately three times as efficient as other equipment (e.g., a 250 gallon mix tank equipped with a high-speed disperser or a 15 liter open-top sandmill).[1,2,8]

Table 5-3 presents cost information for a horizontal media mill. To determine the cost effectiveness of the process change as a control measure, the annual cost of the control equipment (or mills) it replaces must first be subtracted from the cost of a horizontal mill. This incremental cost divided by the amount of VOC emissions reduced would indicate the cost effectiveness of the process change.

5.2.3 Equipment Cleaning Devices

Many equipment cleaning processes performed in the paint and ink manufacturing industry use organic solvents as the cleaning agent. Although equipment cleaning is a major source of VOC emissions, it is difficult to determine the overall efficiency or impact that equipment cleaning devices have on reducing VOC emissions from equipment cleaning processes because no data is available which quantifies these process emissions. Therefore, an equipment cost efficiency cannot be calculated.

5.3 VOC EMISSION REDUCTION METHODS

Two additional methods which may be used to reduce VOC emissions during the manufacturing process are improving operating practices and recycling. Discussions of both of these methods are included in Chapter 4. Both of these techniques are very popular within the paint and ink manufacturing industry because they are easily implemented at low cost. The only costs involved with either of these techniques are those for operator training. In return, solvent emissions and waste can be significantly decreased. One manufacturer of trade sales paints in

TABLE 5-3. HORIZONTAL MEDIA MILL COST FIGURES

Cost Item (in dollars)	Factor	Cost
Capital Costs:		
Equipment, Installation, and Indirect Cost Totals (Not included in total below)	As estimated	180,000
Annualized Costs:		
Annual Capital Cost Recovery (15 year life, 10% effective interest rate)	As estimated	23,670
Direct Operating Costs:		
Utilities	0.059/kWhr	1,830
Operating Labor	12.96/hr	10,110
Operating Supervision	15% of operator labor	1,520
Maintenance		
Labor	12.96/hr	3,370
Materials	100% of maintenance labor	3,370
Indirect Operating Costs:		
Overhead	0.60 (operating labor + maintenance)	11,020
Property Tax	1% of capital cost	1,800
Insurance	1% of capital cost	1,800
Administration	2% of capital cost	3,600
GRAND TOTAL (Annualized Cost)		62,090

[a]Original cost figures were taken from References 2 and 6 and are in current dollars. Factors are adapted from Reference 9 (fabric filters).

North Carolina reduced waste solvent production from 25,000 gallons to 400 gallons in the course of a year by implementing a recycling program. In addition to reducing ultimate hazardous waste disposal costs, the facility also reduced the amount of virgin solvent purchased.[10] These actions, in turn, will reduce overall emissions.

5.4 PRODUCT REFORMULATION

It is extremely difficult to assess the costs associated with product reformulation. The primary cost is the research and development that is required by each facility to reformulate current products using lower VOC raw materials. Although waterbornes, powders, radiation-curables, and higher-solids formulations are currently available, they may not meet the specific end-user requirements and needs. In addition to absorbing development costs, industries wishing to reformulate must also invest in pilot studies, product testing, and additional operator training. Reformulated coatings often act differently than solvent based products and require increased levels of process control.[10]

5.5 CAPTURE DEVICES

According to data collected from the polymeric coating industry and from the Cleveland PPG facility, capture devices are expected to be applicable to the paint and ink manufacturing industry.[6,11] However, only one paint facility is known to have a plant-wide capture system and the capital and operating costs for this facility are unavailable.[6] The costs associated with a complete capture system are relatively inexpensive when compared to those of a control device.

5.6 THERMAL INCINERATION[1,6]

The costs associated with thermal incineration presented here are based on actual costs incurred by one facility known to employ thermal incineration as their control technique. The costs are based on purchase, installation, and operation of two thermal incinerators at the Cleveland PPG Industries, Inc., facility. One incinerator, the REECO I, controls VOC emissions from the manufacturing facility. A second REECO incinerator, REECO II, controls emissions from the PPG paint laboratory also located at the Cleveland site. Both of the nine-chamber fume incinerators were originally installed as odor control devices.

The 95 percent destruction and removal efficiency of the incinerators depends on the capture efficiency of the ventilation system. A study conducted in 1983 indicated that plantwide emissions for the Cleveland facility are 1,085.9 tons per year. Of these releases, 25 tons per year are lost to the atmosphere. This represents a fugitive emission capture efficiency of approximately 96 percent. The capital and operating costs and cost efficiency for thermal incineration at the Cleveland PPG facility are presented in Table 5-4.

TABLE 5-4. CLEVELAND FACILITY THERMAL INCINERATION COST FIGURES[a]

Cost Item (in dollars)	REECO I	REECO II	Total
Capital Costs:			
Equipment, Installation, and Indirect Cost Totals (Not included in total below)	7,071,760	5,407,975	12,479,735
Annualized Costs:			
Annual Capital Cost Recovery (10 year life, 10% effective interest rate)	1,150,897	880,123	2,031,020
Direct Operating Costs:			
Utilities	522,888	530,430	1,053,318
Operating Labor	25,666	25,666	51,332
Operating Supervision (based on 15% of operator labor)	3,827	3,827	7,654
Maintenance - Contracted:			
Labor	16,886	16,886	33,772
Materials	16,886	16,886	33,772
Indirect Operating Costs:			
Overhead	20,488	20,488	40,976
Property Tax (pollution abatement equipment is exempt)	-0-	-0-	-0-
Insurance (1% of capital cost)	70,700	54,000	124,700
Administration (2% of capital cost)	141,400	108,200	249,600
GRAND TOTAL	1,969,638	1,656,506	3,626,144
Cost Efficiency: Total Annualized Operating Cost for Incinerators			3,626,144
Total Emissions: 1085.9 tons/year at an overall efficiency of 91.2% = 990.3 tons/year			
Cost Efficiency:			$3,662/ton

[a]Original cost figures were taken from Reference 1 and are assumed to have been 1987 dollars. The costs were then adjusted to 1992 dollars using published *Chemical Engineering* cost indices.

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9. U.S. Environmental Protection Agency. *Handbook: Control Technologies for Hazardous Air Pollutants*, EPA-625/6-91-014. Office of Research and Development. Washington, DC. June 1991.

10. Kohl, Jerome, Phillip Moses, and Brooke Triplett. *Managing and Recycling Solvents*. North Carolina Practices, Facilities, and Regulations. December 1984.

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APPENDIX A

LISTS OF FACILITIES WITH ANNUAL SALES GREATER THAN $1 MILLION

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION

Name	Address	Sales in $ Millions
Aervoe-Pacific Co. Inc.	PO Box 485, Gardnerville NV 89410	11
AExcel Corp.	7373 Production Dr, Mentor OH 44060	20
Agri-Blend Inc.	PO Box 957, Rowlett TX 75088	1*
Akron Paint & Varnish Inc.	1390 Firestone Parkway, Akron OH 44301	4*
Akzo Coatings Inc. Reliance Universal Inc.	1930 Bishop Ln, Louisville KY 40218	300
Akzo Coatings Inc. Akzo Resins & Vehicles	21625 Oak St, Matteson IL 60443	13
Akzo Coatings Inc.	1600 Watterson Towers, Louisville KY 40218	550*
Allentown Paint Manufacturing Co.	PO Box 597, Allentown PA 18105	4
Also Indus Inc. Morton Paint Co.	Box 6208, Canton OH 44706	3
Ameritone Paint Corp.	PO Box 190, Long Beach CA 90801	40
Ameron Inc. Enmar Finishes Div.	PO Box 9610, Little Rock AR 72219	15
Ameron Inc. Ameron Protective Coatings Div.	201 N Berry St, Brea CA 92621	112
Amsterdam Color Works Inc.	1546 Stillwell Ave, Bronx NY 10461	7
Aspen Paints	1128 SW Spokane St, Seattle WA 98134	4
Atlas Coating Corp.	820 E 140th St, Bronx NY 10454	7*
Automotive Finishes Inc.	6430 Wyoming Ave, Dearborn MI 48126	4
Baker Sealants & Coating	234 Suydam Ave, Jersey City NJ 07304	5
Barrett Varnish Co.	1532 S 50th Ct, Cicero IL 60650	3
Bee Chem Co.	2700 E 170th St, Lansing IL 60438	66
Behr Process Corp.	PO Box 1287, Santa Ana CA 92702	33*
Benjamin Moore & Co.	51 Chestnut Ridge Rd., Montvale NJ 07645	370*
Bennette Paint Manufacturing Co.	PO Box 9088, Hampton VA 23670	5
Best Bros Paint Manufacturing Co.	PO Box 2056, Sinking Spr PA 19608	1
Beverly Manufacturing Co. (Los Angeles)	9118 S Main St, Los Angeles CA 90003	2
Birk Paint Manufacturing Inc.	230 Kearny Ave, Jersey City NJ 07305	2
Blue Ridge Talc Co. Inc.	PO Box 39, Henry VA 24102	9
Brewer Chem Corp.	PO Box 48, Honolulu HI 96810	50
Brod-Dugan Co.	2145 Schuetz Rd, St. Louis MO 63146	15
Bruning Paint Co.	601 S Haven, Baltimore, MD 21224	30
Burkes Paint Co. Inc.	727 S 27th St, Washougal WA 98671	3
Buten Paint & Wallpaper	5000 Ridge Ave, Philadelphia PA 19128	40
Cabot Stains	100 Hale St, Newburyport MA 01950	30
Cal Western Paint Corp.	11748 Slauson Ave, Santa Fe Spr CA 90670	5
Calbar Inc.	2626 N Martha St, Philadelphia PA 19125	4
California Products Corp.	PO Box 569, Cambridge MA 02139	32
Carbit Paint Co.	927 W Blackhawk St, Chicago IL 60622	5
Carboline Co.	350 Hanley Indus Ct, St. Louis MO 63144	65
Cardinal Color Co.	50-56 1st St, Paterson NJ 07524	7
Cardinal Indus Finish Inc.	1329 Potrero Ave, South El Mon CA 91733	18
Century Chem Co.	5 Lawrence St, Bloomfield NJ 07003	5

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Certified Coating Products	2414 S Connor Ave, Los Angeles CA 90040	1
CF Jameson & Co. Inc.	PO Box 197, Bradford MA 01835	1
Charles A Crosbie Labs Inc.	PO Box 3497, Van Nuys CA 91407	1
Chemical Technology Labs Inc.	12150 S Alameda St, Lynwood CA 90262	3
Chemical Coating Corp.	7300 Crider Ave, Pico Rivera CA 90660	3
Ciba-Geigy Corp. Drakenfeld Colors	PO Box 519, Washington PA 15301	28
Clement Coverall Inc.	PO Box 557, Camden NJ 08101	4
CM Athey Paint Co.	1809 Bayard St, Baltimore MD 21230	6
Coatings & Chems Corp.	3067 N Elston Ave, Chicago IL 60618	5
Colonial Refining & Chem Co.	20575 Ctr Ridge Rd, Cleveland OH 44116	3
Columbia Paint Corp.	PO Box 2888, Huntington WV 25728	5
Columbia Paint Co.	PO Box 4569, Spokane WA 99202	17
Colwell Gen Inc.	PO Box 329, Fort Wayne IN 46801	20
Commercial Chem Co. Inc.	PO Box 2126, Santa Ana CA 92707	4
Con-Lux Coatings Inc.	PO Box 847, Edison NJ 08818	25
Cook & Dunn Paint Corp. Pure All Paint Coatings Co.	700 Gotham Ave, Carlstadt NJ 07072	8*
Cook & Dunn Paint Corp.	700 Gotham Parkway, Carlstadt NJ 07072	20
Cook & Dunn Paint Corp. Adelphi Coating	700 Gotham Parkway, Carlstadt NJ 07072	3
Cook Paint & Varnish Co.	PO Box 419389, Kansas City MO 64141	100
Coronado Paint Co. Inc.	PO Box 308, Edgewater FL 32032	28
Cosan Chem Corp.	400 14th St, Carlstadt NJ 07072	10*
Cotter & Co. Gen Paint & Chem Co.	201 Jandus Rd., Cary IL 60013	120
Courtlaulds Coatings USA Inc.	PO Box 1439, Louisville, KY 40201	160*
Cowman & Campbell	PO Box 70328, Seattle WA 98107	3
CP Inc.	PO Box 333, Connersville IN 47331	5
Crest Chem Indus Ltd.	PO Box 85, New Lenox IL 60451	1*
Crosby Coatings Inc.	PO Box 1038, Chico CA 95927	6
CWC Indus Inc.	2686 Lisbon Rd, Cleveland OH 44104	5
Dalys Inc.	3525 Stone Way N, Seattle WA 98103	5
Dampney Co. Inc.	85 Paris St, Everett MA 02149	4
Daniel Products Co.	400 Claremont Ave, Jersey City NJ 07304	20
Davis Paint Co.	1311 Iron St, Kansas City MO 64116	13
Davlin Paint Co. Inc.	700 Allston Way, Berkely CA 94702	3*
DC Franche & Co.	1401 W Wabansia Ave, Chicago IL 60622	3
De Boom Paint Co.	645 Texas St, San Francisco CA 94107	5
Dean & Barry Co.	296 Marconi Blvd, Columbus OH 43215	15
Decratrend Paints	251 Mason Way, City of Indu CA 91746	17
Deft Inc.	17451 Von Karman Ave, Irvine CA 92714	15

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Del Paint Corp.	3105 E Reno St, Oklahoma City OK 73117	4
Delrac Manufacturers of Bisonite Products Co. Inc.	PO Box 764, Tonawanda NY 14151	3*
DeSoto Inc.	PO Box 5030, Des Plaines IL 60017	408
Devoe & Raynolds Co.	PO Box 7600, Louisville KY 40207	120*
Dexter Corp. Dexter Specialty Coatings Div.	1 E Water St, Waukegan IL 60085	80
Diamond Products Co. Inc.	709 S 3rd Ave, Marshalltown IA 50158	18*
DJ Simpson Co.	PO Box 2265, South San Francisco CA 94080	5
Dover Sales Co. Inc.	PO Box 2479, Berkeley CA 94702	3*
Duncan Enterprises	PO Box 7827, Fresno CA 93747	30
Dunn Edwards Corp.	PO Box 30389, Los Angeles CA 90039	150*
Dupli-Color Products Co.	1601 Nicholas Blvd, Elk Grove Vi IL 60007	50
Duralac Inc.	84 Lister Ave. Newark NJ 07105	4
Duron Inc.	10406 Tucker St, Beltsville MD 20705	150
Dye Specialties Inc.	PO Box 1447, Secaucus NJ 07096	8
Egyptian Lacquer Manufacturing	PO Box 4449, Lafayette IN 47903	10
Ellis & Everard (US Holdings) Inc. Prillaman Chem Corp.	PO Box 4024, Martinsville VA 24112	96*
Elpaco Coatings Corp.	PO Box 447, Elkhart IN 46515	8
Emco Finishing Products Inc.	470 Cresent St, Jamestown NY 14701	2
Empire State Varnish Co.	38 Varick St, Brooklyn NY 11222	5
Environmental Coatings Inc.	6450 Hanna Lake SE, Caledonia MI 49316	5
Epoca Co.	5 Lawrence St, Bloomfield NJ 07003	1
Epoxy Coatings Co.	PO Box 1035, Union City CA 94587	1
Evans Paint Inc.	PO Box 4098, Roanoke VA 24015	4*
Everseal Manufacturing Co. Inc.	475 Broad Ave, Ridgefield NJ 07657	12
Fabrionics Inc.	Route 130 S, Camargo IL 61919	13
Farboil Co.	8200 Fischer Rd, Baltimore MD 21222	11
Farwest Paint Manufacturing Co. Inc.	PO Box 68726, Tukwila WA 98168	3
Federated Paint Manufacturing Co.	1882 S Normal St, Chicago IL 60616	8*
Ferro Corp. Coatings Div.	PO Box 6550, Cleveland OH 44101	73*
Fiber-Resin Corp.	PO Box 4187, Burbank CA 91503	10
Fine Line Paint Corp.	12234 Los Nietos Rd, Santa Fe Spr CA 90670	5
Finishes Unlimited Inc.	PO Box 69, Sugar Grove IL 60554	3
Finnaren & Haley Inc.	2320 Haverford Rd, Ardmore PA 19003	25*
Flecto Co. Inc.	PO Box 12955, Oakland CA 94608	20
Frank W Dunne Co.	1007 41st St, Oakland CA 94608	7
Frazee Indus Inc.	PO Box 2471, San Diego CA 92112	100
Fredericks-Hansen Paint	PO Box 5638, San Bernardi CA 92408	12
Fuller O'Brien Corp.	450 E Grand Ave, South San Francisco CA 94080	140

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Gilbert Spruance Co.	Richmond St & Tioga St, Philadelphia PA 19134	10
Given Paint Manufacturing Co. Inc.	111 N Piedras St, El Paso TX 79905	7*
GJ Nikolas & Co. Inc.	2810 Washington Blvd, Bellwood IL 60104	2
Glidden Co. Eastern Region	PO Box 15049, Reading PA 19612	140
Glidden Co. Southwest Region	PO Box 566, Carrollton TX 75011	59
Glidden Co. Resin Div.	1065 Glidden St NW, Atlanta GA 30318	30
Gloss-Flo Corp.	135 Jackson St, Brooklyn NY 11211	4
Glyptal Inc.	305 Eastern Ave, Chelsea MA 02150	5
Gordon Bartels Co.	2600 Harrison Ave, Rockford IL 61108	7
Graham Paint & Varnish Co.	4800 S Richmond St, Chicago IL 60632	10*
Grow Group Inc. US Paint Div.	831 S 21st St, St. Louis MO 63103	30*
Grow Group Inc. Natl Aerosol Products Co.	2193 E 14th St, Los Angeles CA 90021	5
Grow Group Inc.	200 Park Ave, New York NY 10166	413
Guardsman Products Inc.	3033 Orchard Vista Dr, Grand Rapids MI 49501	190
Guardsman Chems Inc.	13535 Monster Rd, Seattle WA 98178	6
H Behlen & Brother Inc.	Route 30 N Perth Rd, Amsterdam NY 12010	10
Hancock Paint & Varnish	109 Accord Dr, Norwell MA 02061	10
Hanna Chem Coatings Inc.	PO Box 147, Columbus OH 43216	25
Harco Chem Coatings Inc.	208 DuPont St, Brooklyn NY 11222	6
Harrison Paint Corp.	PO Box 8470, Canton OH 44711	20
Hartin Paint & Filler	PO Box 116, Carlstadt NJ 07072	3
Hempel Coatings USA	201 Route 17 N, Rutherford NJ 07070	15
Hentzen Coatings Inc.	6937 W Mill Rd, Milwaukee WI 53218	12
Heresite Protective Coatings Inc.	PO Box 250, Manitowoc WI 54221	15
Hoboken Paint Co. Inc.	40 Indus Rd, Lodi NJ 07644	17
Hoffers Inc.	PO Box 777, Wausau WI 54401	47
Hy-Klas Paints Inc.	1401 S 12th St, Louisville KY 40210	6
Hydrosol Inc.	8407 S 77th Ave, Bridgeview IL 60455	30
ICI Americas Inc. ICI Paints	925 Euclid Ave, Cleveland OH 44115	843
Illinois Bronze Paint Co.	300 E Main St, Lake Zurich IL 60047	25
Indurall Coatings Inc.	PO Box 2371, Birmingham AL 35201	8
Industrial Coatings Intl.	7030 Quad Ave, Baltimore MD 21237	14*
Insilco Corp. Sinclair Paint Co.	6100 S Garfield Ave, Los Angeles CA 90040	100*
International Paint Co. USA Inc.	6001 Antoine, Houston TX 77091	50
International Paint Co. USA Inc. Southwest Div.	PO Box 920762, Houston TX 77292	18
International Coatings Co.	13929 E 166th St, Cerritos CA 90701	5
Irathane Syss Inc.	PO Box 276, Hibbing MN 55746	8*
IVC Indus Coatings Inc.	PO Box 18163, Indianapolis IN 46218	9
J Landau & Co. Inc.	PO Box 135, Carlstadt NJ 07072	4

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
James B Day & Co.	Day Ln, Carpentersville IL 60110	8
James Bute Co.	PO Box 1819, Houston TX 77251	3*
Jasco Chem Corp.	PO Drawer J, Mountain View CA 94040	7
John L Armitage & Co.	1259 Route 46 E, Parsippany NJ 07054	8*
Johnson Paints Inc.	PO Box 061319, Fort Myers FL 33906	9
Jones Blair Co. Gilman Paint & Wallcovering Div.	PO Box 1257, Chattanooga TN 37401	38
Kalcor Coatings Co.	37721 Stevens, Willoughby OH 44094	6
Kaufman Products Inc.	1326 N Bentalov St, Baltimore MD 21216	1*
Keeler & Long Inc.	PO Box 460, Watertown CT 06795	10
Kelly-Moore Paint Co. Inc. Hurst Div.	301 W Hurst Blvd, Hurst TX 76053	15
Kelly-Moore Paint Co.	987 Commercial St, San Carlos CA 94070	230*
King Fiber Glass Corp. Fiber Resin Supply Div.	366 W Nickerson St, Seattle WA 98119	2
Komac Paint Inc.	1201 Osage St, Denver CO 80204	10
Kop-Coat Co. Inc.	480 Frelinghuysen Ave, Newark NJ 07114	15
Kop-Coat Co. Inc. Pettit Paint Co.	36 Pine St, Rockaway NJ 07866	11
Kurfees Coatings Inc.	201 E Market St, Louisville KY 40202	16
Kwal-Howells Inc.	PO Box 39-R, Denver CO 80239	23
L & H Paint Products Inc.	PO Box 7311, San Francisco CA 94120	4
Lasting Paints Inc.	PO Box 4428, Baltimore MD 21223	6
Lenmar Inc.	150 S Calverton Rd, Baltimore MD 21223	13
Lilly Chem Products Inc.	PO Box 188, Templeton MA 01468	11
Lilly Industrial Coatings Inc.	733 S West St, Indianapolis, IN 46225	212
Lily Co. Inc.	PO Box 2358, High Point NC 27261	30
Linear Dynamics Inc.	400 Lanidex Plz, Parsippany NJ 07054	30
Lyle Van Patten Co. Inc.	321 W 135th St, Los Angeles CA 90061	3
MA Bruder & Sons Inc.	PO Box 600, Broomall PA 19008	140*
Maas & Waldstein Co.	2121 McCarter Highway, Newark NJ 07104	15
MAB Paints Inc.	630 N 3rd St, Terre Haute IN 47808	32
Magruder Color Co. Inc. Radiant Color Div.	PO Box 4019, Richmond CA 94804	30
Major Paint Co.	4300 W 190th St, Torrance CA 90509	65
Mansfield Paint Co. Inc.	169 W Longview Ave, Mansfield OH 44905	2
Martec Inc.	760 Aloha St, Seattle WA 98109	3
Martin-Senour Co.	101 Prospect Ave, Cleveland OH 44115	44*
Mautz Paint Co.	PO Box 7068, Madison WI 53707	19
McCormick Paint Works Co.	2355 Lewis Ave, Rockville, MD 20851	18*
McWhorter-McCloskey Inc.	5501 E Slauson Ave, Los Angeles CA 90040	5
Mercury Paint Co. Inc.	14300 Schaefer Highway, Detroit MI 48227	18
Mid-States Paint Co.	9315 Watson Indus Park, St. Louis MO 63126	3

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Midwest Lacquer Manufacturing Co.	9353 Seymour Ave, Schiller Par IL 60176	5
Midwest Paint Manufacturing Co.	2313 W River Rd N, Minneapolis MN 55411	2
Millmaster Onyx Group Inc. Mantrose-Haeuser Co.	500 Post Rd E, Westport CT 06880	15
Mobile Paint Manufacturing Co.	4775 Hamilton Blvd, Theodore AL 36582	45
Mohawk Finishing Products	Route 30 N, Amsterdam NY 12010	35*
Moline Paint Manufacturing Co.	5400 23rd Ave, Moline IL 61265	17
Moling Paint Manufacturing	5400 23rd Ave, Moline IL 61265	125
Monarch Paint Co.	PO Box 55604, Houston TX 77255	29*
Morton Intl Inc. Norris Paint/TMT	PO Box 2023, Salem OR 97308	5
Muralo Co. Inc.	PO Box 455, Bayonne NJ 07002	42
Muralo Co. Inc. Olympic Paint & Chem Co.	5928 S Garfield Ave, Los Angeles CA 90040	2*
N Siperstein Inc.	415 Montgomery St, Jersey City NJ 07302	40
National Paint Co. Inc.	3441 E 14th St, Los Angeles CA 90023	3
National Lacquer & Paint Co.	7415 S Green St, Chicago IL 60621	2
Nelson Tech Coatings Inc.	2147 N Tyler Ave, South El Mon CA 91733	2
New York Bronze Powder Co. Inc.	519 Dowd Ave, Elizabeth NJ 07201	30
Niles Chem Paint Co.	PO Box 307, Niles MI 49120	16*
Norton & Son Inc.	148 E 5th St, Bayonne NJ 07002	15*
Nu-Brite Chem Co. Inc. Kyanize Paints	2nd & Boston St, Everett MA 02149	20
O'Brien Corp.	450 E Grand Ave, South San Francisco CA 94080	150*
O'Brien Corp. Powder Coatings Div.	5300 Sunrise Rd, Houston TX 77021	40
O'Brien Corp. Southeast Region	PO Box 864, Brunswick GA 31521	11*
Old Quaker Paint Co.	2209 S Main St, Santa Ana CA 92707	31
Orelite Chem Coatings	62 Woolsey St, Irvington NJ 07111	4
Pacific Coast Lacquer Co. Inc.	3150 E Pico Blvd, Los Angeles CA 90023	3
Palmer Paint Products Inc.	PO Box 1058, Troy MI 48099	7
Pan Chem Corp.	1 Washington Ave, Hawthorne NJ 07506	5
Paragon Paint & Varnish Corp.	5-49 46th Ave, Long Island NY 11101	14*
Parker Paint Manufacturing Co.	PO Box 11047, Tacoma WA 98411	26
Parks Corp.	PO Box 5, Somerset MA 02726	20
Parks Paint & Varnish Co. Inc.	660 Tonnelle Ave, Jersey City NJ 07307	3*
Passonno Paints	500 Broadway, Watervliet NY 12189	10
Pave-Mark Corp.	PO Box 94108, Atlanta GA 30318	20
PavePrep Corp.	141 Central Ave, Westfield NJ 07090	14*
Penn Color Inc.	400 Old Dublin Pike, Doylestown PA 18901	40
Pentagon Chem & Paint Co.	24 Woodward Ave, Ridgewood NY 11385	16*
Perfection Paint & Color Co.	715 E Maryland St, Indianapolis IN 46202	6*
Performance Coatings Inc.	PO Box 1569, Ukiah CA 95482	3
Perry & Derrick Co.	2510 Highland Ave, Cincinnati OH 45212	15

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Pervo Paint Co.	6624 Stanford Ave, Los Angeles CA 90001	13
PFI Incorporated-Paints for Industry	921 Santa Fe Springs Rd, Santa Fe Spr CA 90670	2
Pierce & Stevens Corp.	710 Ohio St, Buffalo NY 14203	50
Plasti-Kote Co. Inc.	PO Box 708, Medina OH 44258	50
Plasticolors Inc.	2600 Michigan Ave, Ashtabula OH 44004	17
Plextone Corp. of America	2141 McCarter Highway, Newark NJ 07104	3
PMC Inc. Gen Plastics Div.	55-T La France Ave, Bloomfield NJ 07003	4
Ponderosa Paint Manufacturing Co. Inc.	PO Box 5466, Boise ID 83705	10
Porter Paint Co.	PO Box 1439, Louisville KY 40201	121
Potter Paint Co. Inc.	PO Box 265, Cambridge Ci IN 47327	2*
PPG Indus Architectual Finishes Inc.	2233 112th Ave NE, Bellevue WA 98004	110*
PPG Indus Inc. Automotive Products Group	PO Box 3510, Troy MI 48007	20*
Pratt & Lambert Inc.	75 Tonawanda St, Buffalo NY 14207	246
Pratt & Lambert Inc. Western Div.	PO Box 668, Marysville CA 95901	10
Premier Coatings Inc.	2250 Arthur Ave, Elk Grove Vi IL 60007	20
Preservative Paint Co. Inc.	5410 Airport Way S, Seattle WA 98108	13
Pro-Line Paint Manufacturing Co. Inc.	2646 Main St, San Diego CA 92113	7*
Proctor Paint & Varnish	38 Wells Ave, Yonkers NY 10701	20
Progress Paint Manufacturing Co.	PO Box 33188, Louisville KY 40232	10
Pruett-Schaffer Chem Co.	PO Box 4350, Pittsburgh PA 15204	4
Pyrolac Corp.	55 Schoon Ave, Hawthorne NJ 07506	4*
Quality Coatings Inc.	1700 N State, Chandler IN 47610	2
Raffi & Swanson Inc.	100 Eames St, Wilmington MA 01887	15
Randolph Products Co.	Park Place E, Carlstadt NJ 07072	9
Red Spot Paint Varnish Co. Red Spot Westland Inc.	550 S Edwin St, Westland MI 48185	15
Red Spot Paint Varnish Co.	PO Box 418, Evansville IN 47703	56
Reliable Coatings Inc.	13108 Euless St, Euless TX 76040	14*
Republic Clear Thru Corp.	211 63rd St, Brooklyn NY 11220	6
Republic Powdered Metals Inc.	PO Box 777, Median OH 44258	15
Riley Bros Inc.	860 Washington Ave, Burlington IA 52601	3
River Valley Coatings Inc.	PO Box 580, Aurora IL 60507	2*
Riverside Labs Inc.	411 Union St, Geneva IL 60134	3*
RJ McGlennon Co. Inc.	198 Utah St, San Francisco CA 94103	3
Roymal Inc.	Route 103, Newport NH 03773	4
RPM Inc.	PO Box 777, Medina OH 44258	380
Rudd Co. Inc.	1630 15th Ave W, Seattle WA 98119	10
Rust-Oleum Corp.	11 Hawthorne Parkway, Vernon Hills IL 60061	89
Rutland Fire Clay Co.	PO Box 340, Rutland VT 05702	2
Sampson Paint Manufacturing Co.	1900 Ellen Rd, Richmond VA 23224	42

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Sampson Coatings Inc.	PO Box 6625, Richmond VA 23230	9
Sandstrom Products Co.	218 S High, Port Byron IL 61275	7
Saxon Paint & Home Care Centers Inc. Dreeblan Paint Co.	3729 W 49th St, Chicago IL 60632	15*
Schalk Chems Inc.	2400 Vauxhall Rd, Union NJ 07083	7
Scott Paint Corp.	5940 Palmer Blvd, Sarasota FL 34232	16*
Seagrave Coatings Corp. Clover Leaf Paint & Varnish	320 Paterson Plank Rd, Carlstadt NJ 07072	14*
Seaside Inc.	PO Box 2809, Long Beach CA 90801	3
Seibert-Oxidermo Inc.	6455 Strong Ave, Detroit MI 48211	11
SEM Products Inc.	120 Sem Ln, Belmont CA 94002	7
Sentry Paint Technologies Inc.	237 Mill St, Darby PA 19023	10
Seymour of Sycamore Inc.	917 Crosby Ave, Sycamore IL 60178	10
Sheboygan Paint Co.	PO Box 417, Sheboygan WI 53082	12
Sheffield Bronze Paint Corp.	17814 S. Waterloo Rd, Cleveland OH 44119	3
Sherwin-Williams Co.	101 Prospect Ave NW, Cleveland OH 44115	2,124
Sherwin-Williams Co. Automotive Div.	101 Prospect Ave NW, Cleveland OH 44115	160
Sherwin-Williams Co. Consumer Div.	101 Prospect Ave NW, Cleveland OH 44115	170*
Sherwin-Williams Co. Oakland	1450 Sherwin Ave, Oakland CA 94608	32*
Sherwin-Williams Co. Chem Coatings Div.	11541 S Champlain Ave, Chicago IL 60628	250
Sigma Coatings Co.	PO Box 816, Harvey LA 70059	15
Smiland Paint Co.	620 Lamar St, Los Angeles CA 90031	10
Snyder Bros Co.	PO Box 760, Toccoa GA 30577	7
Southern Coatings Inc.	PO Box 160, Sumter SC 29151	40
Southwestern Petroleum Corp.	PO Box 961005, Fort Worth TX 76161	26
Spatz Paints Inc.	1439 Hanley Industrial Ct, St. Louis MO 63144	5
Specialty Coating & Chem	7360 Varna Ave, North Hollywood CA 91605	3
Spectra-Tone Paint Corp.	9635 Klingerman St, South El Mon CA 91733	7
Spraylat Corp. Los Angeles	3465 S La Cienega, Los Angeles CA 90016	5
Stanchem Inc.	401 Berlin St, East Berlin CT 06023	10
Standard Detroit Paint Co.	8225 Lyndon Ave, Detroit MI 48238	8
Standard T Chem Co. Inc.	290 E Joe Orr Rd, Chicago Heights IL 60411	14*
Star Finishing Products Inc.	360 Shore Dr, Hinsdale IL 60521	15
Star Bronze Co.	PO Box 2206, Alliance OH 44601	11
STD Coating Corp.	461 Broad Ave, Ridgefield NJ 07657	3
Steelcote Manufacturing Corp.	3418 Gratiot St, St. Louis MO 63103	4
Sterling Twelve Star Paint	PO Box 791, Little Rock AR 72203	15
Sterling-Clark-Lurton	184 Commercial St, Malden MA 02148	9
Stevens Paint Corp.	38 Wells Ave, Yonkers NY 10701	15
Stonhard Inc.	PO Box 308, Maple Shade NJ 08052	62

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Strathmore Products Inc.	1970 W Fayette St, Syracuse NY 13204	6
Sullivan Coatings Inc.	410 N Hart St, Chicago IL 60622	2*
Sunnyside Corp	225 Carpenter Ave, Wheeling IL 60090	14
Superior Varnish & Drier Co.	PO Box 1310, Merchantville NJ 08109	7*
Superior Sealants Inc.	1135 Sylvan SW, Atlanta GA 30310	11*
Supro Corp.	2650 Pomona Blvd, Pomona CA 91768	4
Technical Coatings Laboratory Inc.	PO Box 565, Avon CT 06001	6
Technical Coatings Inc.	PO Box 3337, Austin TX 78764	8
Technical Coatings Co.	1000 Walsh Ave, Santa Clara CA 95050	6
Tenax Finishing Products	390 Adams St, Newark NJ 07114	6*
Tera Lite Inc.	1631 S 10th St, San Jose Ca 95112	3
Testor Corp.	620 Buckbee St, Rockford IL 61106	43*
Thompson & Formby Inc.	825 Crossover Ln, Memphis TN 38117	44*
Ti-Kromatic Paints Inc.	2492 Doswell Ave, St. Paul MN 55108	3
Tnemec Co. Inc.	PO Box 411749, Kansas City MO 64141	50
Touraine Paints Inc.	1760 Revere Beach Parkway, Everett MA 02149	17
Tower Paint Manufacturing	620 W 27th St, Hialeah FL 33010	10
Trail Chem Corp.	9904 Gidley St, El Monte CA 91731	4
Triangle Coatings Inc.	1930 Fairway Dr, San Leandro CA 94577	5
United Paint & Chem Corp.	24671 Telegraph Rd, Southfield MI 48034	11*
United Coatings Inc.	2850 Festival Dr, Kankakee IL 60901	65
United Paint Co.	404 E Mallory, Memphis TN 38109	25
United Gilsonite Labs	PO Box 70, Scranton PA 18501	22*
Universal Paint Corp.	PO Box 1218, La Puente CA 91749	20
Universal Chems & Coatings Inc.	1975 Fox Ln, Elgin IL 60123	10
Universe Paint Co.	PO Box 668, Marysville CA 95901	3*
Valspar Corp. MCI Quality Coatings	6110 Gunn Highway, Tampa FL 33625	12
Valspar Corp. Colony Paints Div.	PO Box 418037, Kansas City MO 64141	15
Valspar Corp.	1101 S 3rd St, Minneapolis MN 55415	527
Valspar Corp. Masury Paint Co.	1401 Severn St, Baltimore MD 21230	8
Vanex Color Inc.	1700 Shawnee St, Mount Vernon IL 62864	4
VJ Dolan & Co. Inc.	1830 N Laramie Ave, Chicago IL 60639	5
Vogel Paint & Wax Inc. Marwin Paints Inc.	2100 N 2nd St, Minneapolis MN 55411	8*
Vogel Paint & Wax Inc.	Industrial Air Park Rd., Orange City IA 51041	100
Voplex Corp. Allerton Chem Div.	763 Linden Ave, Rochester NY 14625	1
Waterlox Chem & Coatings Corp.	9808 Meech Ave, Cleveland OH 44105	4
Watson-Standard Co. Jordan Paint Manufacturing Co.	7250 Franklin St, Forest Park IL 60130	4
Watson-Standard Co.	PO Box 11250, Pittsburgh PA 15238	29*
Wattyl Group Precision Paint Group	5275 Peachtree, Atlanta GA 30341	15

(continued)

TABLE A-1. PAINT AND ALLIED PRODUCTS FACILITIES (SIC 2851) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
WC Richards Co. Inc.	3555 W 123rd St, Blue Island IL 60406	15*
Welco Manufacturing Co. Inc.	1225 Ozark St, North Kansas MO 64116	10
Wellborn Paint Manufacturing Co.	215 Rossmoor Rd SW, Albuquerque NM 87102	15
Western Automotive Finishes	1450 Ave R, Grand Prairi TX 75050	17*
Westfield Coatings Corp.	PO Box 815, Westfiled MA 01086	7
Westinghouse Elec Corp. Insulating Materials Div.	Route 993, Manor PA 15665	15
Whittaker Corp. Whittaker Decatur Coatings	PO Box 2238, Decatur AL 35602	12*
William Zinsser & Co.	31 Belmont Dr, Somerset NJ 08873	16
Wiltech Corp.	PO Box 517, Longview WA 98632	2
Wisconsin Protective Coatings Corp.	PO Box 216, Green Bay WI 54305	10
WM Barr & Co. Inc.	PO Box 1879, Memphis TN 38113	95
Yenkin Majestic Paint Corp.	PO Box 369004, Columbus OH 43236	80
Zehrung Corp	3273 Casitas Ave, Los Angeles CA 90039	2*
Zolatone Process Inc.	3411 E 15th St, Los Angeles CA 90023	6
ZPC Indus Coatings Inc.	120 E Minereal St, Milwaukee WI 53204	2
Zynolyte Products Co.	PO Box 6244, Carson CA 90749	25

* Indicates an estimated financial figure.
Source: Reference 5, Chapter 2.

TABLE A-2. PRINTING INK FACILITIES (SIC 2893) WITH ANNUAL SALES GREATER THAN $1 MILLION

Name	Address	Sales in $ Millions
Acme Printing Ink Co. Packaging Inc. Corp.	5001 S Mason Ave, Chicago IL 60638	100
Acme Printing Ink Co.	165 Bond St, Elk Grove Vi IL 60007	140*
AJ Daw Printing Ink Co.	3559 S Greenwood Ave, Los Angeles CA 90040	13
American Inks & Coatings Corp.	PO Box 803, Valley Forge PA 19482	15
Autoroll Machine Corp.	11 River St, Middleton MA 01949	12
BASF Corp. Coatings & Colorants Div.	1255 Broad St, Clifton NJ 07015	105*
Bomark Inc.	601 S 6th Ave, City of Indu CA 91746	3
Borden Inc. Coatings & Graphics Group	630 Glendale - Milford, Cincinnati OH 45215	17*
Braden Sutphin Ink Co.	3650 E 93rd St, Cleveland OH 44105	25
Celia Corp.	320 Union St, Sparta MI 49345	15
Central Ink & Chem	1100 N Harvester Rd, West Chicago IL 60185	9
Colonial Printing Ink Corp	180 E Union Ave, East Rutherford NJ 07073	17
Converters Ink Co.	1301 S Park Ave, Linden NJ 07036	16*
Croda Inks Corp.	7777 N Merrimac, Niles IL 60648	32*
Custom Chem Corp.	30 Paul Kohner Pl, Elmwood Park NJ 07407	40
Del Val Ink & Color Co. Inc.	1301 Taylors Ln, Riverton NJ 08077	5
Excello Color & Chem	1446 W Kinzie St, Chicago IL 60622	84*
Flint Ink Corp.	25111 Glendale Ave, Detroit MI 48234	235
Flint Ink Corp. Capitol Printing Ink	806 Channing Pl NE, Washington DC 20018	23
Flint Ink Corp.	1404 4th St, Berkeley CA 94710	30*
Gans Ink & Supply Co. Inc.	1441 Boyd St, Los Angeles CA 90033	18
Gotham Ink & Color Co. Inc.	5-19 47th Ave, Long Island NY 11101	4
Graphic Color Corp.	750 Arthur Ave, Elk Grove Vi IL 60007	18
Handschy Ink & Chems Inc.	120 25th Ave, Bellwood IL 60104	30
Ink Masters Inc.	2842 S 17th Ave, Broadview IL 60153	3
James River Corp. of Virginia CZ Inks Div.	4150 Carr Ln, St. Louis MO 63119	28
JM Huber Corp. Carbon Div.	9300 Needlepoint Rd, Baytown TX 77521	18*
Kerley Ink Engineers Inc.	2839 19th Ave, Broadview IL 60153	4*
Kohl & Madden Printing Ink Corp.	222 Bridge Plz Sq, Hackensack NJ 07601	45
Lakeland Laboratory Inc. Alfa Ink Div.	655 Washington Ave, Carlstadt NJ 07072	2*
Lakeland Laboratory Inc.	655 Washington Ave, Carlstadt NJ 07072	3
Lawter Intl Inc.	990 Skokie Blvd, Northbrook IL 60062	136
Merit Printing Inc. Co.	1451 S Lorena St, Los Angeles CA 90023	4*
Midland Color Co.	651 Bonnie Ln, Elk Grove Vi IL 60007	85
Miller-Cooper Co.	1601 Prospect Ave, Kansas City MO 64127	6
Morrison Printing Ink Co.	4801 W 160th St, Cleveland OH 44135	14*
Naz-Dar Co.	1087 N Northbranch St, Chicago IL 60622	15*

(contined)

TABLE A-2. PRINTING INK FACILITIES (SIC 2893) WITH ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Nor-Cote Intl Inc.	PO Box 668, Crawfordsville IN 47933	5
North American Printing Ink	1524 David Rd, Elgin IL 60123	14
Northern Printing Ink Corp.	8360 10th Ave N, Minneapolis MN 55427	8
Polypore Inc.	4601 S 3rd Ave, Tucson AZ 85714	10
Polytex Color & Chem	820 E 140th St, Bronx NY 10454	3
PPG Indus Inc. PPG Ink Products Co.	1835 Airport Exchange Blvd, Covington KY 41018	15
Rexart Chem Corp.	1183 Westside Ave, Jersey City NJ 07306	6*
Ron Ink Co. Inc.	61 Halstead St, Rochester NY 14610	7
Sicpa Indus of America Inc.	8000 Research Way, Springfield VA 22153	25
Sinclair & Valentine LP	2520 Pilot Knob Rd, St. Paul MN 55120	186
Sun Chem Corp.	PO Box 1302, Fort Lee NJ 07024	1,100
Sun Chem Corp. Gen. Printing Ink Div.	135 W Lake St, Northlake IL 60164	410*
Superior Printing Ink Co. Inc.	70 Bethune St, New York NY 10014	50
United States Printing Ink Corp. Leber Ink Div.	PO Box 88700, Seattle WA 98138	6
United States Printing Ink Corp.	343 Murray Hill Pkwy, East Rutherford NJ 07073	65
Van Son Holland Corp. of America	92 Union St, Mineola NY 11501	42
Vivitone Inc.	110 E 27th St, Paterson NJ 07514	8
Walter W Lawrence	9715 Alpaca St, South El Mon CA 91733	1
Wikoff Color Corp.	PO Box W, Fort Mill SC 29715	45*

*Indicates an estimated financial figure.
Source: Reference 5, Chapter 2.

APPENDIX B

PERMIT REQUIREMENTS FROM SEVERAL STATES

TABLE B-1. SELECTION OF OHIO PERMIT INFORMATION

Capacity	Equipment	Method of Abatement	VOC Emission Limit lb/ hr	VOC Emission Limit lb/day	VOC Emission Limit tons/yr	Control Efficiency	Operational Limits
5000 gal	Paint Thindown Tank	Carbon Absorption	0.5			95	
2250 gal	Paint Mix Tank	N/A	8.0	40		N/A	• bottom fill of solvents • 9 hrs/day processing
2000 gal	Paint Thindown Tank	Carbon Adsorption	0.5			95	
1000 gal	Paint Thindown Tank	Carbon Adsorption	0.5			95	
1 gal	Paint Filler	N/A	8.0	40		N/A	
5 gal	Paint Filler	N/A	8.0	40		N/A	
750 gal	Paint Mix Tank	N/A	8.0	40		N/A	• bottom fill of solvents • 9 hrs/day processing
All Sizes	Paint Batch Mixers, Mills, Filter and Fill Equipment	N/A	8.0	40		N/A	• keep lids closed
	Paint with Agitator Process Tank	N/A	8.0	40	2	N/A	
	Paint Mixer	N/A	8.0	40	2	N/A	
550 gal	Paint Portable Agitators Mixers	N/A	1.0		5	N/A	• covers at all times • vapor return system when filling totes • agitators should be color dedicated
	Paint Mixer	Fabric Filter	3.6	40	5	N/A	
	Ink Mixer	N/A	8	40		N/A	
	Ink Sandmill	N/A	8	40		N/A	• maximum production in mill ≤8000 lbs/day
	Ink Shotmill	N/A	0.46		2.02	N/A	
	100 HP Traffic Paint Disperser	N/A	38		30.7	N/A	• solvent usage limited to 1633.5 tons/quarter
	60 HP Traffic Paint Disperser	N/A	16.75		13.4	N/A	• solvent usage limited to 726 tons/quarter
	50 HP Traffic Paint Disperser	N/A	3.2		3.2	N/A	• solvent usage limited to 321.6 tons/quarter
	60 HP Industrial Paint Disperser	N/A	3.1		3.2	N/A	• solvent usage limited to 312.8 tons/quarter

TABLE B-2. STATE OF CALIFORNIA PERMIT INFORMATION

Plant Number	SIC	Number of Employees	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
CA-01	2893	160	90.69	496.94	YES
CA-02	2893	22	13.66	74.85	NO
CA-03	2893		0.00	0.00	NO
CA-04	2893	2	5.39	29.55	NO
CA-05	2851	55	67.49	369.79	YES
CA-06	2851	239	28.90	158.37	YES
CA-07	2851	244	27.12	148.59	YES
CA-08	2851		0.18	1.01	NO
CA-09	2851	160	90.69	496.94	YES
CA-10	2851	10	0.00	0.00	NO
CA-11	2851	62	30.65	167.94	YES
CA-12	2851	28	12.24	67.04	YES
CA-13	2851	300	62.52	342.56	YES
CA-14	2851	34	9.12	49.96	YES
CA-15	2851		1.01	5.56	YES
CA-16	2851	30	11.83	64.81	NO
CA-17	2851		0.72	3.96	NO
CA-18	2851	18	8.57	46.97	NO
CA-19	2851	125	99.41	544.74	YES
CA-20	2851	50	4.96	27.16	NO
CA-21	2851	100	4.86	26.65	YES
CA-22	2851	25	16.14	88.43	YES
CA-23	2851		0.00	0.02	NO
CA-24	2851	12	20.96	114.86	NO
CA-25	2851		4.77	26.16	NO
CA-26	2851	6	5.13	28.11	NO
CA-27	2851	6	0.00	0.00	NO
CA-28	2851	14	12.24	67.06	NO
CA-29	2851	3	0.28	1.54	NO
CA-30	2851	20	0.00	0.00	YES
CA-31	2851	35	43.15	236.44	NO
CA-32	2851	45	6.70	36.74	YES
CA-33	2851	8	0.04	0.20	NO
CA-34	2851	27	6.81	37.29	NO
CA-35	2851	8	1.21	6.62	NO
CA-36	2851	3	0.00	0.01	YES
CA-37	2851	30	1.57	8.60	YES
CA-38	2851	115	879.52	4819.30	YES

TABLE B-3. STATE OF ILLINOIS PERMIT INFORMATION

Plant Number	SIC	Number of Employees	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
IL-01	2851		6.1620		
IL-02	2851		8.9677		VENTURI SCRUBBER KNOCK OUT TANKS CONDENSOR CATALYTIC AFTERBURNER
IL-03	2851		82.1184		
IL-04	2893		14.2071		CARTRIDGE FILTER CONDENSOR SCRUBBER
IL-05	2893		8.1484		
IL-06	2893		0.0000		
IL-O7	2851		27.9200		CYCLONE
IL-08	2893		0.0000		
IL-09	2893		0.0000		
IL-10	2893		0.0000		
IL-11	2851		39.8964		CONDENSOR & SCRUBBER CONDENSORS (PRIMARY & SECONDARY)
IL-12	2851		3.9000		CYCLONE
IL-13	2851		0.0000		
IL-14	2851		0.0000		
IL-15	2851		64.4000		
IL-16	2851		56.8817		CONDENSORS SCRUBBERS CHILLER
IL-17	2893		0.0000		
IL-18	2893		24.9061		CONDENSORS
IL-19	2851		180.6560		CONDENSORS
IL-20	2893		1.9520		
IL-21	2851		0.0000		
IL-22	2893		0.0008		SCRUBBERS CYCLONE & BAGHOUSE KNOCKOUT TANKS
IL-23	2851		7.7103		
IL-24	2851		0.0000		
IL-25	2851		7.9592		VAPOR RECOVERY SYSTEM
IL-26	2851		1.3632		CARBON ADSORBERS
IL-27	2851		14.1180		
IL-28	2851		33.6365		

(continued)

TABLE B-3. STATE OF ILLINOIS PERMIT INFORMATION (continued)

Plant Number	SIC	Number of Employees	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
IL-29	2893		280.9783		FUME SCRUBBER CONDENSOR/ELIMINATOR PLATE SCRUBBER
IL-30	2851		45.2446		CONDENSORS SCRUBBERS
IL-31	2893		0.0000		
IL-32	2893		0.0000		CONDENSORS
IL-33	2851		49.4400		SCRUBBERS
IL-34	2851		15.4713		CONDENSORS SEPARATORS
IL-35	2851		0.0000		
IL-36	2851		11.3100		CHARCOAL ADSORBER CHARCOAL FILTER
IL-37	2851		6.2400		ROTOCLONE
IL-38	2851		12.2460		SCRUBBER
IL-39	2893		13.3120		
IL-40	2851		3.9610		
IL-41	2851		0.0000		ROTOCLONE
IL-42	2851		43.8604		AFTER BURNER
IL-43	2893		17.3750		
IL-44	2851		15.6600		
IL-45	2851		0.0000		
IL-46	2851		18.9280		RECYCLING STILL
IL-47	2851		34.9440		
IL-48	2851		3.5569		VENTURI EDUCTOR CARBON ADSORBERS
IL-49	2851		94.1300		
IL-50	2851		9.8000		CONDENSORS
IL-51	2893		17.4985		SCRUBBER CONDENSORS VACUUM PUMPS
IL-52	2851		9.0892		SCRUBBERS KNOCKOUT TANKS CATALYTIC AFTERBURNER CONDENSORS
IL-53	2851		0.0000		SCRUBBERS
IL-54	2851		0.0000		
IL-55	2851		2.6208		
IL-56	2851		17.2680		

(continued)

TABLE B-3. STATE OF ILLINOIS PERMIT INFORMATION (continued)

Plant Number	SIC	Number of Employees	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
IL-57	2851		143.2435		SCRUBBERS CONDENSOR SOLN-ABSORBER
IL-58	2893		86.8543		CONDENSORS
IL-59	2851		200.5087		CONDENSORS SCRUBBERS
IL-60	2851				
IL-61	2851		8.3956		
IL-62	2851		83.5848		
IL-63	2851		30.2640		
IL-64	2851		28.2880		SETTLING CHAMBERS CENTRIFUGAL COLLECTOR
IL-65	2851		37.5000		
IL-66	2851		217.1960		SCRUBBERS CONDENSORS VAPOR RECOVERY
IL-67	2851		1.9207		SPEED REDUCTION EQUIPMENT

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-01	2851	10	CTG MFG	NONMETHANE	14.6000		
				METH.CHLORIDE	9.9000		
				TCE	8.4000		
TX-02	2851	17	PRO. FUG.	NONMETHANE	0.0000		
				ALCOHOLS	0.0100		
				TOLUENE	2.2000		
				XYLENE	19.5000		
				ALKYL ACET.	0.0000		
				ETHYL ACET.	0.1200		
				GLYCOL ETH.	0.0000		
				CELLOSOLVE	0.0300		
				1,1,1 TRICH.	2.9000		
				KETONES	0.0000		
				MEK	0.1300		
				MIBK	4.7500		
				2-NITROPRO.	0.0000		
				NAPHTHA	0.1100		
TX-03	2851		FAN STACK	NONMETHANE	2.0000		
			FAN STACK	NONMETHANE	2.0000		
			TANK STACK	NONMETHANE	1.7000		
TX-04	2851	18	TANK STACK	AROMATICS	0.3500		
				TOLUENE	1.0000		
				XYLENE	1.0000		
				MINERAL SPR.	1.0000		
				NAPHTHA	1.0000		
			EXH. STACK	AROMATICS	2.7600		
			ROOF STK.	AROMATICS	5.5800		
			EXH. STACK	AROMATICS	5.5800		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05	2851	100	BAG.VENT	TOLUENE	0.0008		FILTERS BAGHOUSE (FABRIC)
				XYLENE	0.0004		
				MEK	0.0005		
				MIBK	0.0008		
				MINER. SPIRT	0.0006		
				NAPHTHA	0.0019		
			EXHAUST FAN	TOLUENE	0.0015		
				XYLENE	0.0030		
				MEK	0.0417		
				MIBK	0.0180		
				MINER. SPIRT	0.0005		
			PAINT CONT.	TOLUENE	0.0015		
				XYLENE	0.0030		
				MEK	0.0417		
				MIBK	0.0180		
				MINER. SPIRT	0.0005		
			MFG.EXH.FAN	TOLUENE	0.0015		
				XYLENE	0.0030		
				MEK	0.0417		
				MIBK	0.0180		
				MINER. SPIRT	0.0005		
			MFG.EXH.FAN	TOLUENE	0.0015		
				XYLENE	0.0030		
				MEK	0.0417		
				MIBK	0.0180		
				MINER. SPIRT	0.0005		
			BAGH.VENT	ISOPROPANOL	0.1247		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.2526		
				XYLENE	0.0969		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			BAGH.VENT	MEK	0.1810		FILTERS BAGHOUSE (FABRIC)
				MIBK	0.2163		
				MINER. SPIRT	0.1196		
				NAPHTHA	0.4975		
			BAGH.VENT	ISOPROPANOL	0.0904		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.1178		SINGLE CYCLONE
				XYLENE	0.0663		
				MEK	0.1296		
				MIBK	0.1479		
				MINER. SPIRT	0.0891		
				NAPHTHA	0.3371		
			BAGH.VENT	ISOPROPANOL	0.4577		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.8262		
				XYLENE	0.2913		
				MEK	0.6207		
				MIBK	0.6508		
				MINER. SPIRT	0.1702		
				NAPHTHA	1.4563		
			BAGH.VENT	ISOPROPANOL	0.0235		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.0480		SINGLE CYCLONE
				XYLENE	0.0177		
				MEK	0.0353		
				MIBK	0.0394		
				MINER. SPIRT	0.0234		
				NAPHTHA	0.0317		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			BAGH.VENT	ISOPROPANOL	0.0279		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.0552		
				XYLENE	0.0206		
				MEK	0.0402		
				MIBK	0.0406		
				MINER. SPIRT	0.0278		
				NAPHTHA	0.1050		
			BAGH.VENT	ISOPROPANOL	0.0261		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.0926		
				XYLENE	0.0352		
				MEK	0.0404		
				MIBK	0.0786		
				MINER. SPIRT	0.0484		
				NAPHTHA	0.1802		
			EXHAUST FAN	ISOPROPANOL	0.0280		
				TOLUENE	0.0880		
				XYLENE	0.0364		
				MEK	0.0570		
				MIBK	0.0128		
				MINER. SPIRT	0.0970		
				NAPHTHA	0.4200		
			PAINT CONTA.	ISOPROPANOL	0.0280		
				TOLUENE	0.0880		
				XYLENE	0.0364		
				MEK	0.0570		
				MIBK	0.0128		
				MINER. SPIRT	0.0970		
				NAPHTHA	0.2099		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			EXHAUST FAN	ISOPROPANOL	0.0561		
				TOLUENE	0.1174		
				XYLENE	0.0377		
				MEK	0.0877		
				MIBK	0.0853		
				MINER. SPIRT	0.0195		
				NAPHTHA	0.2091		
			PAINT CONT.	ISOPROPANOL	0.0561		
				TOLUENE	0.1174		
				XYLENE	0.0377		
				MEK	0.0877		
				MIBK	0.0853		
				MINER. SPIRT	0.0195		
				NAPHTHA	0.2091		
			EXHAUST FAN	ISOPROPANOL	0.1651		
				TOLUENE	0.3729		
				XYLENE	0.1280		
				MEK	0.2750		
				MIBK	0.2200		
				MINER. SPIRT	0.1318		
				NAPHTHA	0.7189		
			PAINT CONT.	ISOPROPANOL	0.1651		
				TOLUENE	0.3720		
				XYLENE	0.1280		
				MEK	0.2750		
				MIBK	0.2200		
				MINER. SPIRT	0.1318		
				NAPHTHA	0.7180		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			TANK TRK LD	XYLENE	0.0015		
				MIBK	0.0006		
			ROOF VENT 7	MEK	0.0064		
			ROOF VENT 8	MEK	0.0064		
			ROOF VENT 7	MEK	0.0074		
			ROOF VENT 8	MEK	0.0074		
			MFG.EXH.FAN	TOLUENE	0.0102		
				XYLENE	0.0170		
				MEK	0.3137		
				MIBK	0.0905		
				MINER. SPIRT	0.0017		
			MFG.EXH.FAN	TOLUENE	0.0102		
				XYLENE	0.0170		
				MEK	0.3137		
				MIBK	0.0905		
				MINER. SPIRT	0.0017		
			BAGH. VENT	ISOPROPANOL	0.0278		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.0461		SINGLE CYCLONE
				XYLENE	0.0073		
				MEK	0.0332		
				MIBK	0.0497		
				MINER. SPIRT	0.0210		
				NAPHTHA	0.0760		
			BAGH. VENT	ISOPROPANOL	0.0284		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.0471		SINGLE CYCLONE
				XYLENE	0.0172		
				MEK	0.0340		
				MIBK	0.0590		
				MINER. SPIRT	0.0326		
				NAPHTHA	0.08		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			BAGH. VENT	ISOPROPANOL	0.0494		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.0819		SINGLE CYCLONE
				XYLENE	0.0299		
				MEK	0.0591		
				MIBK	0.0884		
				MINER. SPIRT	0.0374		
				NAPHTHA	0.1353		
			BAGH. VENT	ISOPROPANOL	0.0242		FILTERS BAGHOUSE (FABRIC)
				TOLUENE	0.0402		
				XYLENE	0.0147		
				MEK	0.0290		
				MIBK	0.0403		
				MINER. SPIRT	0.0183		
				NAPHTHA	0.0644		
			BAGH. VENT	NONMETHANE	3.3000		FILTERS BAGHOUSE (FABRIC)
							SINGLE CYCLONE
			PAINT & CAN	NONMETHANE	0.0000		
				TOLUENE	0.2500		
				MEK	0.6000		
				MIBK	0.2400		
				MINER. SPIRT	0.0100		
			EXHAUST FAN	NONMETHANE	0.0000		
				TOLUENE	0.3100		
				XYLENE	0.4000		
				MEK	0.2300		
				MIBK	0.1500		
				MINER. SPIRT	0.1800		
				NAPHTHA	0.7100		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			PAINT CONT.	NONMETHANE	0.0000		
				TOLUENE	0.3100		
				XYLENE	0.4000		
				MEK	0.2300		
				MIBK	0.1500		
				MINER. SPIRT	0.1800		
				NAPHTHA	0.7000		
			TANK STACK	XYLENE	0.0000		
			TANK STACK	TOLUENE	0.0000		
				XYLENE	0.0000		
			BAGH. VENT	TOLUENE	0.0003		FILTERS BAGHOUSE (FABRIC)
				XYLENE	0.0001		
				MEK	0.0021		
				MIBK	0.0003		
				MINER. SPIRT	0.0003		
				NAPHTHA	0.0030		
			MIX & THIN	ISOPROPANOL	0.0166		
				TOLUENE	0.0323		
				XYLENE	0.0122		
				MEK	0.0238		
				MIBK	0.0271		
				MINER. SPIRT	0.0141		
				NAPHTHA	0.0615		
			TANK	MINER. SPIRT	0.0150		
			MIXING	ISOPROPANOL	0.0575		
				TOLUENE	0.1120		
				XYLENE	0.0424		
				MEK	0.0826		
				MIBK	0.0941		
				MINER. SPIRT	0.0563		
				NAPHTHA	0.2138		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			TANK	MINER. SPIRT	0.0150		
			MIX & THIN	ISOPROPANOL	0.0190		
				TOLUENE	0.0395		
				XYLENE	0.0156		
				MEK	0.0284		
				MIBK	0.0347		
				MINER. SPIRT	0.0244		
				NAPHTHA	0.0795		
			TANK	MINER. SPIRT	0.0150		
			TANK STOR.	NAPHTHA	0.0410		
			TANK	N-BUTYL ALC.	0.0090		
				TOLUENE	0.0380		
				XYLENE	0.0180		
				ACETONE	0.1120		
				MEK	0.0700		
				MIBK	0.0340		
				MINER. SPIRT	0.0200		
			TANK	MIBK	0.0250		
			TANK	TOLUENE	0.0380		
				XYLENE	0.0180		
				ACETONE	0.1120		
				MEK	0.0700		
				MIBK	0.0340		
				MINER. SPIRT	0.0200		
			MIX & THIN	ISOPROPANOL	0.0108		
				TOLUENE	0.0128		
				XYLENE	0.0085		
				MEK	0.0158		
				MIBK	0.0188		
				MINER. SPIRT	0.0118		
				NAPHTHA	0.0430		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			TANK STOR.	MEK	0.0420		
			TANK VENT	MIBK	0.0250		
			MIX & THIN	ISOPROPANOL	0.0306		
				TOLUENE	0.0648		
				XYLENE	0.0259		
				MEK	0.0462		
				MIBK	0.0575		
				MINER. SPIRT	0.0378		
				NAPHTHA	0.1323		
			MIX & THIN	ISOPROPANOL	0.0535		
				TOLUENE	0.1134		
				XYLENE	0.0454		
				MEK	0.0810		
				MIBK	0.1007		
				MINER. SPIRT	0.0663		
				NAPHTHA	0.2314		
			MIX & THIN	ISOPROPANOL	0.0082		
				TOLUENE	0.0151		
				XYLENE	0.0055		
				MEK	0.0113		
				MIBK	0.0122		
				MINER. SPIRT	0.0175		
				NAPHTHA	0.0274		
			MIX & THIN	ISOPROPANOL	0.0176		
				TOLUENE	0.0365		
				XYLENE	0.0139		
				MEK	0.0260		
				MIBK	0.0240		
				MINER. SPIRT	0.0087		
				NAPHTHA	0.0708		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			STOR.TK.	TOLUENE	0.0050		
			STOR.TK.	TOLUENE	0.0050		
			STOR.TK.	TOLUENE	0.0050		
			TANK 35	NAPHTHA	0.0020		
			TANK 36	NAPHTHA	0.0020		
			TANK 43-46	XYLENE	0.0010		
				MIBK	0.0030		
			TANK 43-46	XYLENE	0.0010		
				MIBK	0.0030		
			TANK	MINER. SPIRT	0.0140		
			TANK	XYLENE	0.0030		
			MIX & THIN	ISOPROPANOL	0.0517		
				TOLUENE	0.0978		
				XYLENE	0.0361		
				MEK	0.0729		
				MIBK	0.0803		
				MINER. SPIRT	0.0433		
				NAPHTHA	0.1342		
			MIX & THIN	ISOPROPANOL	0.0194		
				TOLUENE	0.0367		
				XYLENE	0.0135		
				MEK	0.0274		
				MIBK	0.0301		
				MINER. SPIRT	0.0162		
				NAPHTHA	0.0503		
			TANK	XYLENE	0.0270		
			TANK	TOLUENE	0.0660		
			TANK	MINER. SPIRT	0.0110		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-05			TANK	MINER. SPIRT	0.0120		
			PAINT & CAN	MINER. SPIRT	0.0050		
			TANK	XYLENE	0.0030		
			PAINT MIX	ISOPROPANOL	0.0308		
				TOLUENE	0.0604		
				XYLENE	0.0229		
				MEK	0.0444		
				MIBK	0.0509		
				MINER. SPIRT	0.0306		
				NAPHTHA	0.1157		
			MIX & THIN	ISOPROPANOL	0.0088		
				TOLUENE	0.0173		
				XYLENE	0.0065		
				MEK	0.0127		
				MIBK	0.0145		
				MINER. SPIRT	0.0088		
				NAPHTHA	0.0330		
			MIX & THIN	MEK	0.0080		
			MIX & THIN	MEK	0.0060		
			TANK 84	MINER. SPIRT	0.0010		
			WASTE SOL.	TOLUENE	0.0340		
				XYLENE	0.0180		
				MEK	0.0790		
				MIBK	0.0370		
				MINER. SPIRT	0.0090		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-06	2851	225	PAINT PROC.	AROMATICS	0.6700		
			S-2	AROMATICS	0.0000		MISC. METHODS
				XYLENE	0.2500		
			S-1	NONMETHANE	0.1110		
				AROMATICS	0.0000		
			RESIN PLANT	AROMATICS	2.0000		
				POLYNUCL. AR.	0.0000		
				PHTHALIC ANHY.	0.0100		
			RESIN CONDE.	AROMATICS	0.0500		VAPOR CONDENSORS
			RT-1	AROMATICS	1.0000		VAPOR CONDENSORS
			VENT. SCRUB	AROMATICS	0.1000		SCRUBBERS - CYCLONE VENT
				POLYNUCL. AR.	0.0000		
				PHTHALIC ANHY.	0.0100		
TX-07	2851		PAINT PROC.	NONMETHANE	0.0000		FABRIC FILTER
				TOLUENE	26.2000		
				XYLENE	30.7000		
				MINER. SPIRT.	967.1000		
TX-08	2851		FUGITIVE EM.	NONMETHANE	16.9000		
TX-09	2851	80	AREA STACK	METHY.CHLORIDE	2.1600		
TX-10	2851	122	DISPER. FUG.	NONMETHANE	0.0000		FABRIC FILTER (BAGHOUSE)
				XYLENE	0.0300		
				MINER. SPIRT.	0.3800		
				NAPHTHA	0.5500		
			THIN/TINT	ETHYLENE GLY.	0.0020		
				PROPYLENE GLY.	0.0020		
				XYLENE	0.0300		
				MINER. SPIRT.	0.3800		
				NAPHTHA	0.5500		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-10			PACKAGING	ETHYLENE GLY.	0.0020		
				PROPYLENE GLY.	0.0020		
				XYLENE	0.0300		
				MINER. SPIRT.	0.3800		
				NAPHTHA	0.5500		
			BULK STOR.	ETHYLENE GLY.	0.0020		
				PROPYLENE GLY.	0.0020		
				XYLENE	0.0300		
				MINER. SPIRT.	0.2300		
				NAPHTHA	0.2700		
TX-11	2851		COLL. STACK	AROMATICS	5.7200		
			DUST COL.	AROMATICS	4.9800		
			DUST COL.3	AROMATICS	0.9400		
			FUME STK	AROMATICS	2.8800		
			ROOF STK	AROMATICS	18.9200		
			TANK FUG.	AROMATICS	4.0000		
TX-12	2851	16	MIXER	N-BUTYL ALC.	4.3700		
				PROP. GLY.	0.0800		
				ISOPROP.	0.0800		
				METHANOL	0.0800		
				AROMATICS	0.0000		
				TOLUENE	9.8600		
				XYLENE	13.4900		
				ETHYL PROPION.	1.5700		
				CELLOSOLVE	0.4200		
				MEK	2.1700		
				MIBK	3.5100		
				MIAK	0.2800		
				MINER. SPIRIT.	1.1700		
				NAPHTHA	1.2800		
			SOLV. FUG.	NONMETHANE	7.0000		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-13	2851	50	GRIND.MILL	NONMETHANE	2.9800		
			PAINT MIX.	NONMETHANE	1.3500		
			PROCESS TK	NONMETHANE	0.1900		
			PREMIX UNIT	NONMETHANE	0.1900		FILTERS FABRIC (BAGHOUSE)
TX-14	2851		PAINT & DEG.	NONMETHANE	74.0000		
			STORE.TANK	GASOLINE	0.0500		
			STORE TANK	GASOLINE	0.8400		
			GAS TK LOAD.	GASOLINE	0.6500		
TX-15	2851	125	DUST COL.	NONMETHANE	0.0000		
			DUST COL.	NONMETHANE	0.0200		FILTERS FABRIC (BAGHOUSE)
				ETHYLENE GLY.	0.0400		
			DUST COL.	NONMETHANE	0.0000		
				NAPHTHA	0.5000		
				STODD SOLVENT	0.4500		
			DUST COL.	NONMETHANE	0.0000		FILTERS FABRIC (BAGHOUSE)
				NAPHTHA	0.6200		
				STODD SOLVENT	0.5500		
			DUST COL.	NONMETHANE	0.0200		FILTERS FABRIC (BAGHOUSE)
			DOORS	NONMETHANE	0.0500		COLLECTOR-DRY, INTERTL
				NAPHTHA	0.6000		
				STODD SOLVENT	0.5500		
			DISPERS.FUG.	ALCOHOLS	0.0000		
				ETHYL. GLYC.	0.0200		
TX-16	2851	50	PAINT MIX	NONMETHANE	4.2900		
				ALCOHOLS	0.0000		
				N-BUTANOL	0.3400		
				ETHANOL	0.0100		
				ISOPROPANOL	0.8100		

TABLE B-4. STATE OF TEXAS PERMIT INFORMATION, Continued

Plant Number	SIC	Number of Employees	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
TX-16				METHANOL	0.1000		
				AROMATICS	0.2000		
				TOLUENE	3.8200		
				XYLENE	3.3200		
				ALKYL ACETATES	0.2800		
				AMYL ACETATE	0.1100		
				PROPYL ACETATE	0.0300		
				BUTYL ACETATE	0.1300		
				ISOBUT.ACETATE	0.5900		
				GLYCOL ETHERS	0.0000		
				BUTYL CELLOS.	0.1300		
				BUTYL CELL.ACE	0.0100		
				CELLO. SOLVENT	0.0100		
				KETONES	0.3000		
				ACETONE	0.5400		
				MEK	0.8500		
				MIBK	1.3400		
				MINER.SPIRITS	0.6500		
				NAPHTHA	0.6000		
TX-17	2851	50	PAINT MFG.	NONMETHANE	0.0000		FABRIC FILTERS (BAGHOUSE)
				NAPHTHA	1.5000		MECHANICAL SHAKING
TX-18	2851		PROD. STACK	NONMETHANE	1.5000		

TABLE B-5. PERMIT INFORMATION FOR OTHER STATES

State	Plant Number	SIC	Source	Type	Organic Emissions tons/yr	lb/day	Abatement Devices
INDIANA	IN-01	2893	COOKING OIL	VOC	483.577		
			PIGMENT MIX	VOC	15.422		
OHIO	OH-01	2893	COOKING GEN.	VOC	33.280		PROCESS CHANGES
			PIGMENT MIX	VOC	1.719		
VIRGINIA	VA-01	2893	COOKING GEN.	VOC	131.000		
ALABAMA	AL-01	2851	MIXING & HAND.	VOC	215.000		
ARKANSAS	AR-01	2851	MIXING & HAND.	VOC	42.000		
CALIFORNIA	CA-39	2851	MIXING & HAND.	VOC	92.076		
COLORADO	CO-01	2851	MIXING & HAND.	VOC	12.000		
			MIXING	VOC	83.000		
	CO-02	2851	MIXING	VOC	4.000		
	CO-03	2851	MIXING	VOC	22.000		
			OTHER OPER.	VOC	1.000		
	CO-04	2851	MIXING	VOC	17.000		
	CO-05	2851	MIXING	VOC	10.000		
	CO-06	2851	MIXING	VOC	7.000		
GEORGIA	GA-01	2851	MIXING	VOC	41.000		
	GA-02	2851	MIXING	VOC	28.000		
INDIANA	IN-02	2851	MIXING	VOC	17.000		
	IN-03	2851	MIXING	VOC	88.000		
	IN-04	2851	MIXING	VOC	46.000		
	IN-05	2851	OTHER OPER.	VOC	1.000		
	IN-06	2851	MIXING	VOC	30.000		
	IN-07	2851	MIXING	VOC	97.500		
			OTHER OPER.	VOC	0.550		
	IN-08	2851	MIXING	VOC	14.000		
KANSAS	KS-01	2851	MIXING	VOC	240.000		
	KS-02	2851	MIXING	VOC	2.000		
KENTUCKY	KY-01	2851	MIXING	VOC	245.000		
MARYLAND	MD-01	2851	MIXING	VOC	28.000		
	MD-02	2851	MIXING	VOC	63.000		VENTURI SCRUBBER
	MD-03	2851	MIXING	VOC	9.000		
	MD-04	2851	MIXING	VOC	16.000		

(continued)

TABLE B-5. PERMIT INFORMATION FOR OTHER STATES (continued)

State	Plant Number	SIC	Source	Type	Organic Emissions tons/yr	Organic Emissions lb/day	Abatement Devices
MICHIGAN	MI-01	2851	MIXING	VOC	203.000		
	MI-02	2851	MIXING	VOC	206.000		
	MI-03	2851	MIXING	VOC	175.000		
	MI-04	2851	MIXING	VOC	76.000		
MISSOURI	MO-01	2851	MIXING	VOC	144.000		
	MO-02	2851	MIXING	VOC	73.000		
			OTHER OPER.	VOC	28.000		
	MO-03	2851	MIXING	VOC	309.000		
			OTHER OPER.	VOC	9.000		
	MO-04	2851	MIXING	VOC	257.000		
	MO-05	2851	MIXING	VOC	62.000		
			OTHER OPER.	VOC	37.000		
NORTH CAROLINA	NC-01	2851	MIXING	VOC	138.000		
	NC-02	2851	MIXING	VOC	498.000		
	NC-03	2851	MIXING	VOC	319.000		
	NC-04	2851	MIXING	VOC	181.000		
NEW JERSEY	NJ-01	2851	MIXING	VOC	30.000		CONSERVATION
			OTHER OPER.	VOC	10.000		SUBMERGED FILLING
							REFRIG. CONDENSOR
	NJ-02	2851	PIGMENT HDLG.	VOC	81.000		CONDENSOR
			MIXING	VOC	6.000		CYCLONE
							SEPARATOR
OHIO	OH-01	2851	OTHER OPER.	VOC	1.000		
	OH-02	2851	MIXING	VOC	44.000		
	OH-03	2851	MIXING	VOC	204.000		VAPOR RECOVERY SYSTEM
			OTHER OPER.	VOC	14.000		SPRAY TOWER
	OH-04	2851	MIXING	VOC	675.000		
PENNSYLVANIA	PA-01	2851	MIXING	VOC	79.000		
	PA-02	2851	MIXING	VOC	353.000		CARBON ADSORPTION
			OTHER OPER.	VOC	88.000		
	PA-03	2851	MIXING	VOC	34.000		
	PA-04	2851	MIXING	VOC	56.000		
SOUTH CAROLINA	SC-01	2851	MIXING	VOC	149.000		
VIRGINIA	VA-01	2851	MIXING	VOC	259.000		

APPENDIX C

TRIP REPORTS

ALLIANCE
Technologies Corporation

Date: 6 January 1992

Subject: Site Visit--ICI Specialty Inks
Ink Manufacturing
EPA Contract 68-D0-0121; Work Assignment I-29
Alliance Reference No. 1638029

From: Beth W. McMinn
Alliance Technologies Corporation

To: Joseph Steigerwald
OAQPS/ESD/CTC (MD-13)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

The purpose of the visit was to gather information on the ink manufacturing process including information necessary to characterize the process parameters, emissions, control techniques, and control costs.

II. Place and Date

ICI Specialty Inks
120 Regent Drive
Winston-Salem, NC 27103
(919) 760-1011

December 18, 1991

III. Attendees

ICI Specialty Inks

Randy Besaw, Plant Superintendent
Templeton A. Elliott, Jr., Vice President/Director Safety, Health, & Environmental Affairs

Tony Martin, Branch Manager
Stephen W. Paine, Environmental Engineer

U.S. Environmental Protection Agency (EPA)

Joseph Steigerwald, CTC

Alliance Technologies Corporation (Alliance)

Beth W. McMinn

IV. Discussion

A meeting was held with the personnel from ICI Specialty Inks to discuss the ink manufacturing process. The discussion focused on market profile, manufacturing supplies, manufacturing process parameters, volatile organic compound (VOC) control experience, and emission characterization. This discussion was followed by a tour of the production facility in Winston-Salem, North Carolina, and then by a short closing meeting.

A. ICI Specialty Inks Market Profile

The ICI Specialty Inks facility in Winston-Salem manufactures flexographic and rotogravure inks for the packaging industry. Many of their inks are used in the printing of packages for food and snack food products such as Frito Lay, Lance, Hershey, and Mars. ICI Specialty Inks also produces ink used on the packaging of R.J. Reynolds cigarettes and textile soft goods packaging such as that used to package pantyhose. The facility places a heavy emphasis on inks for lamination (i.e., ink printed between two layers of film). Approximately 99 percent of the inks manufactured by this location of ICI Specialty Inks are solvent based, while the remaining one percent is water based. This location of ICI Specialty Inks produces colored, clear, and white inks. All of their water based inks are flexographic white inks and top lacquers. In the flexible packaging industry, white inks are high-volume, low profit margin products. They are, consequently, the first type of ink to be converted from solvent based ink because the high volume usage by printers results in the largest reduction on VOC emissions by the printers for switching a single ink.

Very few of the ICI Specialty Inks printed products come in direct contact with food, therefore, approval from the Food and Drug Administration (FDA) is not a major concern. Food packagers are, however, sensitive about the inks used in packaging and restrict ink manufacturers from using heavy metal pigments (i.e., lead, hexavalent chromium, cadmium, and mercury).

The printing/packaging operations that the Winston-Salem ink facility services are located within a 300 to 400 mile radius. Some of these packaging facilities supply products to a regional area while others service the nation. ICI Specialty Inks takes pride in the quality of its final product and its "Just In Time" manufacturing policy. In many cases customers like the Charlotte, North Carolina based Venture Packaging and Package Products will receive same day shipment of ink orders.

The Regent Drive ICI Specialty Ink facility was known as Converters Inks until January 1, 1992. Throughout its history, the former Converters Ink has manufactured solvent based flexographic and rotogravure inks for the packaging industry. Carl Bear founded the Converters Ink Company in the 1950's. During the next thirty years, Converters Ink expanded to a total of 12 manufacturing plants, of which nine are located in the United States and three in Canada. In 1971, Beatrice Foods purchased the Converters Ink facilities. The plants were purchased a second time in late 1984 by ICI Americas, Inc. (ICI). Shortly after the 1984 buyout, ICI constructed the current Converters Ink facility. Production in the new 12,000 square feet manufacturing facility began in early 1985. Eventually, a 5,000 to 6,000 square feet addition was added. In 1988, ICI bought five Thiele-Engdahl ink manufacturing plants. The Winston-Salem based Thiele-Engdahl plant concentrates its production efforts in gravure inks used in box and cardboard packaging. Converters Ink and Thiele-Engdahl merged in early 1992 and are now called ICI Specialty Inks.

B. Manufacturing Supplies

ICI Specialty Inks uses more than 200 raw materials in their manufacturing processes. In addition to the solvents described in Attachment 1, ICI Specialty Inks also purchases and uses a variety of resins, pigments, and additives. Corporate headquarters regularly determines product ink VOC content based on raw material safety data sheets and finished good calculations. Some finished goods are tested for flashpoint determination.

C. Manufacturing Process Parameters

The ink manufacturing process at the Winston-Salem facility is basically a batch process materials handling operation. Products are formed by mixing and blending rather than by reacting materials chemically. No heating of materials is necessary during the processing. A process description and simplified flow diagram are found in Attachment 2. The main manufacturing operations are completed in the following order:

- premix
- pigment grinding/milling
- product blending
- product filtering
- product filling/packaging

The first step in the manufacturing process is material premix. This is the production of an intermediate product referred to as the base. The base or premix is made by combining vehicles (e.g., solvents, alcohols, resins, and/or water) with pigments and any other necessary additives. The materials are mixed in portable containers to form a viscous material which acts as a concentrate. At this stage, the particles in the concentrate are rather large (250 μm) and not consistently mixed. With further processing, the concentrate may become any one of a variety of specific end products.

The grinding or milling stage serves to further disperse the pigment throughout the base by pumping it through dispersion equipment. Once the customer-requested grind specifications are met, the resulting base is transferred to the product blending tanks.

Final product specifications are achieved in the blending or product finishing step. The base from the dispersion operation is mixed with other intermediates and raw materials to produce a finished ink. Blending may occur in the same or in a different tank used for premix.

Once the ink has been blended, it is filtered through various filter media to enhance the quality and uniformity of the product. Filtering also acts to screen out impurities.

After the ink has been filtered, it is pumped or emptied into shipping containers. Whites are normally shipped in 400 gallon tote bins while most other products are shipped in 55 gallon drums.

The ICI Specialty Inks facility currently manufacturers over 200 blended products. Formulas change daily, so ICI Specialty Inks keeps a computerized database of several thousand active product formulations. Because of the wide variety of products and because 65 to 70 percent of business is same day shipments, ICI Specialty Inks does not dedicate manufacturing equipment to specific products. Some equipment is dedicated to certain colors (e.g., whites and clears) while other equipment is dedicated to ink type (i.e., water or solvent) products.

ICI Specialty Inks uses a variety of equipment during the premix and blending stages. The facility has many mixers, which are used depending in part on batch size. Drum-sized batches made in the drum itself may be blended with a portable mixer called a Lightning Mixer. Other materials made in portable mix tanks may be blended using larger, permanent high-speed or variable-speed mixers. In some cases, an ink will be premixed with one mixer, moved to a dispersion mill for grinding and milling, and then transferred back to the same premix mixer for blending operations.

ICI Specialty Inks operates several types of dispersion mills including three ball mills, a sand mill, horizontal small media mills, and mix tanks. ICI Specialty Inks makes solvent based inks in the ball mills. Two ball mills are dedicated to the manufacture of black and blue inks while the other mill is used for colored ink production. Ball mills are rotating cylinders, mounted horizontally, and filled with grinding media. Because these mills are used to make solvent based inks, they contain steel ball media used to disperse pigment. These mills generate heat during the grinding process, so they are jacketed and water cooled. Production personnel manually load raw materials (i.e., premix liquids, powders/pigments, and additives) into the mills from a catwalk through a top chute. Solvents are either pumped from drums or from bulk storage tanks through a manifold system into the ball mills. Other materials are added directly from bags or drums into the mill. In some cases (e.g., material adjustment), material is dispensed with buckets. Material loading is done during the day and the grinding process, which is noisy, is done during the night and is controlled by a timer. The following day, the product is inspected, properly adjusted, and then unloaded by gravity feed, filtered, and packaged into containers for shipment or for further use as intermediates in the facility. Ball mills approach a closed system as they are open only during addition of raw material and product filling operations.

Horizontal mills are similar to ball mills except that they are much smaller and operate continuously rather than by batch although they are fed by batches. Rather than using steel balls, ICI Specialty Inks's horizontal shot mills use tiny various grinding media. Rather than having a rotating hollow cylinder tumble media as in the case of the ball mills, the shot mills feature a stationary hollow cylinder with a rotating internal shaft which has pegs affixed to vigorously agitate the media. The Winston-Salem facility manufactures water based inks in one mill and solvent based inks in the other. Some of the products manufactured in the water based shot mill are shipped to customers while other products are sent to sister ICI Specialty Inks facilities. ICI recently chose the Winston-Salem facility to begin producing waterborne base concentrates for use in other ICI owned ink plants.

ICI Specialty Inks also operates a sand mill to manufacture solvent based inks. This mill uses fine-grained Ottawa sand to accomplish pigment dispersion. Material enters through the bottom of the mill and is forced up through the sand to an open-top filtering screen. The screen often clogs as the material filters out of the mill and into a receiving hopper. Because the mill must be scraped down regularly, enclosing the filter would create processing difficulties.

In addition to the mills, ICI Specialty Inks operates a number of fixed mix tanks with agitators which are used for mixing, milling, and blending both water and solvent based white inks and varnishes. Two of these mix tanks are dedicated to the production of white inks. Material is added through the top, agitated, and gravity fed out the bottom. The top openings on the mix tanks are covered with permanent aluminum lids which are opened only during the addition of product components. The lids contain a center opening through which the agitator shaft extends. The lids also have a small hinged opening to allow for gradual product additions.

The ICI Specialty Inks facility operates 9 hours per day, 5 days per week, 52 weeks per year. A typical batch can take 3 to 20 hours to complete. More time is required to manufacture colored rotogravure inks than other inks. Viscous or dry materials take longer to grind and achieve proper dispersion than less viscous materials. Batch sizes range from five gallons to 1,100 gallons.

Equipment is cleaned manually on an as-needed basis. Cleaning frequency depends on the number and size of batches processed, the size of the equipment to be cleaned, and the color and type of ink manufactured. After a mill or tank has been emptied, solvent is added to the vessel to capture remaining product residue. The wash solvent is drained from the tank and recycled into the next product batch of that particular product whenever possible. Disperser blades are cleaned with ethanol and n-propyl-acetate, which is used repeatedly until it is pigment saturated. Once becoming unusable as a cleaning solvent, the wash material is sent off-site as hazardous waste. Mills are cleaned by replacing the residual heel of the exiting product with an equivalent amount of solvent which is compatible with both the preceding and the ensuing batches. Some base raw materials and solvents are handled via a manifold system using dedicated process lines. Therefore, cleaning of these lines is limited. ICI Specialty Inks is unable to schedule consecutive production batches of similar products to reduce equipment cleaning frequency because they operate on a same day shipment schedule.

D. Volatile Organic Compound Control Experience

The ICI Specialty Inks facility has no add-on control devices for the capture and destruction of VOCs. Volatile organic compounds emitted from the manufacture of solvent based inks are controlled through equipment modifications such as tank covers.

Drop hoses are used around all mixing and some milling equipment to capture and remove VOC material from the work area. Captured emissions are routed through the hoses to a central ventilation system and eventually to the outside. The facility also uses fans operating at 6000 cfm to achieve approximately six air exchanges per hour in the manufacturing area.

ICI Specialty Inks operates under permit no. 00758-001-P in accordance with Section 3-166 of the Forsyth County Air Quality Technical Code, which restricts the ink facility from emitting more than 40 pounds of photochemically reactive compounds in a 24-hour day. This permit also requires that all ink manufacturing vessels be covered at all times while mixing, storing, transferring, and handling.

Because the facility's VOC control emphasis has been on lids, ICI Specialty Inks has tried several different types. Initially, the facility used homemade plywood covers on both drums and mix tanks. The wooden covers were difficult to clean, so ICI Specialty Inks stapled plastic to the bottom. The plastic frequently came loose and would be pulled into the mix tank, tangling with the mixing blade. ICI Specialty Inks then tried using Kraft paper in hopes that the lighter weight would prevent the staples from pulling away from the wood. The paper did remain attached to the wood, but it became saturated with ink.

ICI Specialty Inks then moved to aluminum lids. Flat lids, which are made by a sheet metal contractor, cost $20 to $25 dollars for drums and $300 dollars for a 250 gallon mix tank (see Attachment 3). The flat lids have worked relatively well, but they do have some inherent flaws. The lids do not form a complete seal with the mix tank and the hinged door product addition chute does not always remain closed. For these reasons, ICI Specialty Inks moved to conical lids which are a better engineering design. The conical aluminum lids cost $1500 dollars. The added weight and bulky shape led to worker ergonomic difficulties. Because these lids were difficult to handle, they were damaged more often than the flat lids. The increased replacement and upkeep costs prompted ICI Specialty Inks to return to flat lids.

ICI Specialty Inks may now change to stainless steel lids because of the recent information released by the Bureau of Mines in England dealing with the reactions of aluminum and steel. Many of the facility's portable mix tanks and permanent blend vessels are carbon steel. In addition, almost all of the 55 gallon drums are steel.

Attachment 4 contains a description of a cover efficiency test conducted at one of the ICI Specialty Inks's sister facilities. Although the test proved sensitive to weigh scale calibration (one of two tests done in 1991 proved unrepresentative), it does provide a lid testing methodology and initial results comparing an uncovered mix tank and a tank covered with a sealing conical lid.

E. Emission Characterization

The ICI Specialty Inks facility uses ball mills, a sand mill, shot mills, mix tanks and drums with mixers in the manufacture of solvent based inks. Releases of VOCs come from several types of equipment used in the ink manufacturing process.

Some solvent ink production is accomplished by blending in 55 gallon drums. The drums are used to mix product and to keep the pigment in suspension. Covers are used on the drums during the mixing process but emissions still occur from the small opening through which the agitator shaft extends and from around the edges of the lid. All of the solvent based inks that are made in mix tanks are made in tanks covered with lids. These lids have a four to six inch opening through which the agitator shaft extends and a hinged opening for delayed product additions. Emissions can result from both areas.

Ball mills are also used in the manufacture of solvent based inks. These mills approach a closed system, as they are open only during raw material adds and product filling operations. It is during these operations that VOC emissions can occur.

Sand mills are used to disperse pigment throughout the ink. Emissions result from the exposed screen through which warm product filters, often clogging the screen. The open screen, warm product, and scraping down of the filter with a solvent-ladened brush add to total emissions.

Both of the horizontal shot mills are closed systems, thus significantly reducing VOC emissions from processing equipment. Purchasing these mills, however, is rather expensive. ICI Specialty Inks's 15 liter continuous feed mill cost approximately $160,000. The smaller five liter mill, was almost $80,000. Both mills are jacketed for cooling.

Another source of emissions is the manifold system, where solvents are weighed and transferred from storage tanks to mix tanks, mills, or drums. Emissions may occur during transfer and hose connecting and disconnecting.

In addition to emissions from process operations, VOCs are also released from a variety of cleaning operations. Emissions occur during cleaning solvent addition and removal, as well as during manual cleaning of tanks and mixing blades with solvents and brushes. ICI Specialty Inks has tried to use automatic tub washers which seal with a tank, pull a vacuum, and circulate cleaning solvent on a timed schedule. The washers have not worked well at the Thiele-Engdahl Winston-Salem facility. The washer did not seal with the tank, and consequently did not attain the required vacuum. The timer did not work correctly, resulting in insufficient cleaning. In addition, the automatic washer required a large air supply to operate the pumps and produced a high noise level.

The Regent Drive Site calculates SARA Section 313 releases based on consumption figures, and only limited studies have been done to determine emission breakdown by specific process or product. The facility has not examined emission contribution from janitorial supplies.

Attachment 1

TOTAL 1991 VOC PURCHASES (IN POUNDS)

TOLUOL	53433
ETHANOL	711650
ISOPROPYL-ACETATE	112530
LACTOL SPIRITS	669
BUTYL CARBITOL	11004
ETHYL ACETATE	17272
ISOPROPYL-ALCOHOL	13600
N PROPYL-ALCOHOL	197950
VM&P NAPTHA	8909
DOWANOL PM	5550
MEK	366
HEPTANE	142175
N PROPYL-ACETATE	281575
TOTAL POUNDS IN INTERMED. VARNISHES	444175
TOTAL PURCHASES OF VOC'S/1991	2000858

INK MANUFACTURING OVERVIEW

1. Raw Material Receiving/Storage. Liquid materials are received in drums or in bulk: solvents used in large quantities are stored in above or below ground storage tanks and/or in portable "tote" tanks. Dry materials are received and stored in bags or drums.

2. Dispersing. This is the production of an intermediate product, usually referred to as a base. A 'premix' is performed in which vehicles (i.e., solvent, alcohol and/or water) are added to a mixing vessel, along with any dry pigments and other chemicals. The batch is mechanically mixed with a special slotted blade. Typically the mixing vessel has a cover with an orifice which the mixer shaft goes through, and a small hinged opening to allow delayed addition of certain raw materials, after mixing has already commenced. The result of the dispersion/mixing operation is a raw concentrate which has the potential to become any of a family of specific end products (inks), but which requires further processing to do so.

3. Grinding/Milling. This is the step of taking a raw base, which still contains fairly large particles (250 μm) and incompletely mixed pigment, and grinding it. The premix is pumped through a chamber containing sand, steel shot or other small spherical media. Mechanically driven discs, or a rotor, is used to churn the media and break up the pigment agglomerates. The result is a more homogeneous product with improved gloss and other physical properties. The operation is a batch one, in which a pre-mixed base is pumped through the mill and into a receiving vessel. Using a 4,000 lb. batch as an example, the process can take from 3-4 hours up to 20, depending on whether re-grinding is needed. Mill types include semi-closed (as in the attached flow diagram) and closed units. Ball mills are a special type of closed unit which does not feature continuous product feed. Instead, raw materials are added to a hollow vessel containing approximately 1" diameter spheres; the vessel is closed and slowly turns, tumbling the contents to mix them. The result is usually an intermediate (base) rather than a finished product.

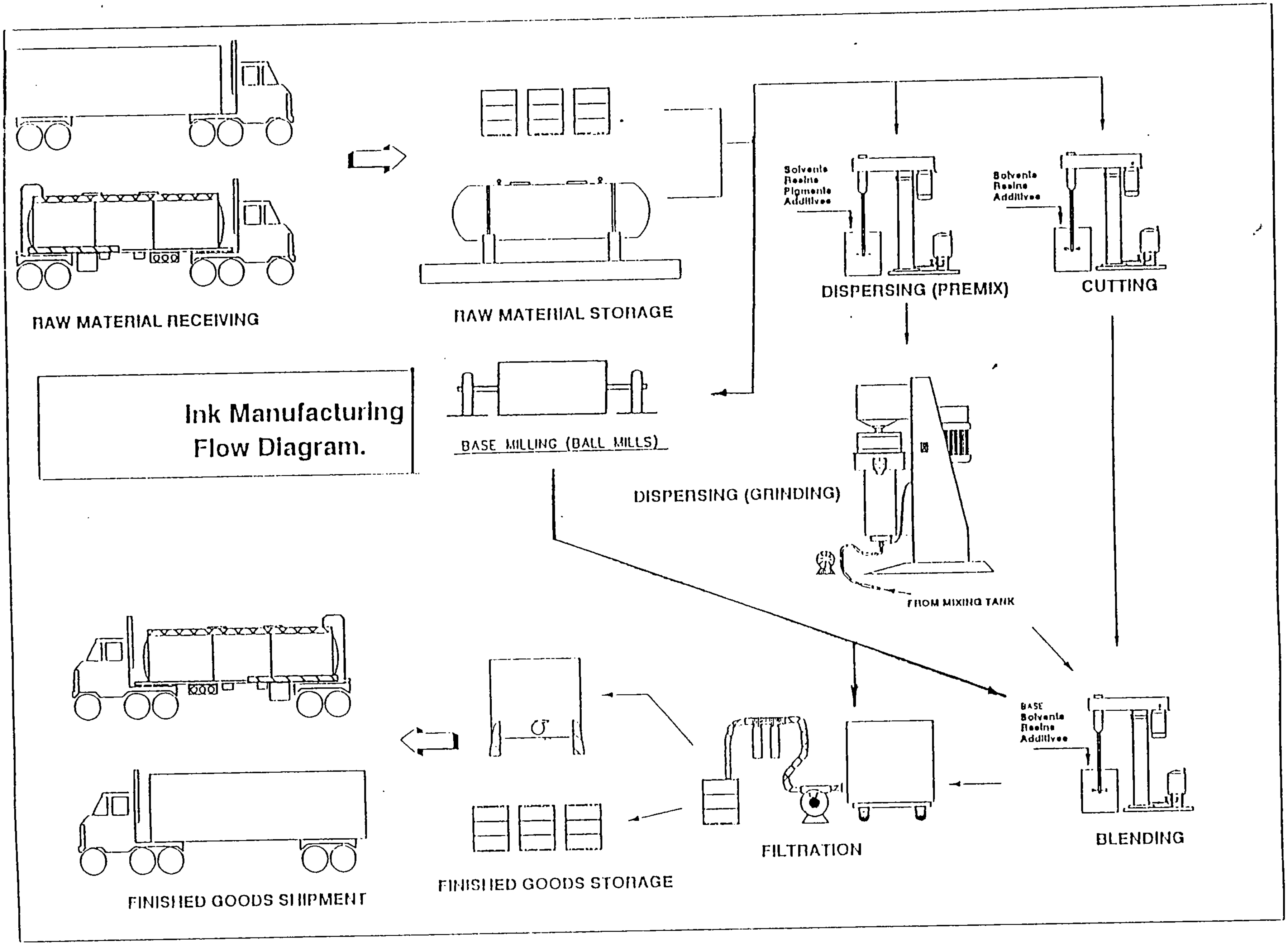
4. Blending. Intermediates and any raw materials not needing previous processing are mixed in specific quantities to produce a finished ink. The blending occurs in the same vessel, or a vessel similar to that used in the dispersing/premix step.

5. Filtering. Finished product is strained through cloth or other filters to enhance quality and uniformity of the product.

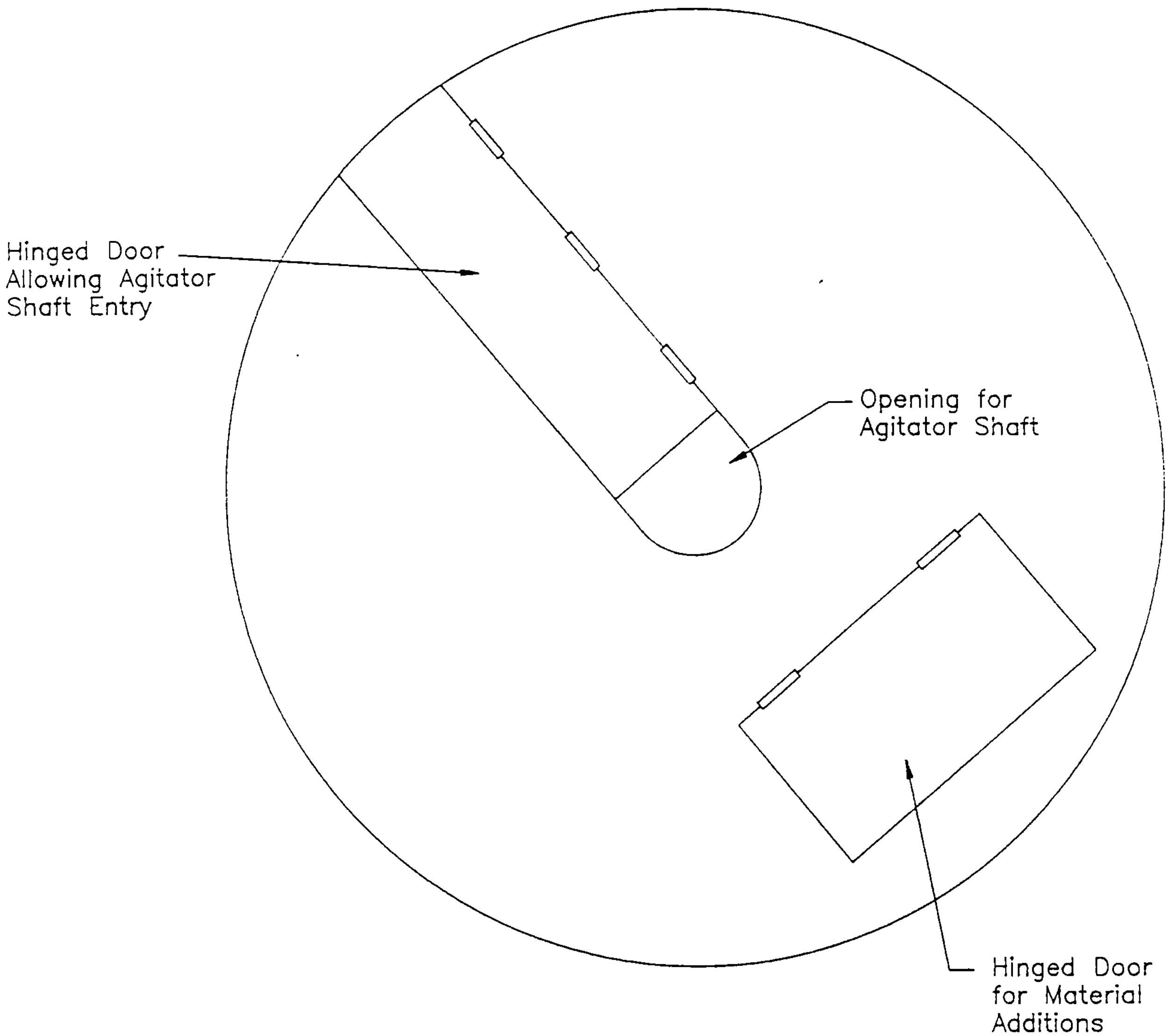
6. Packaging. After filtration, finished product is pumped or emptied into the final shipping container: pails, drums, portable tanks or occasionally tank trucks.

7. Cleaning. Blending vessels, mills, filter screens and other equipment is routinely cleaned with solvent after production of an ink formulation. In a few plants, only one color or a limited number of colors are produced, eliminating the need for cleaning between color changeovers. With mixers, the vessel will be completely cleaned and emptied; with mills, typically a residual 'heel' of finished product is replaced by an equivalent quantity of clean solvent which is compatible with both the preceding and ensuing batches.

Attachment 2



Typical Flat Mix Tank Cover



Thiele-Engdahl

Attachment 4

September 23, 1991

Thiele-Engdahl
7830 North Point Blvd.
Suite 101
Winston-Salem
North Carolina 27106-3209

Telephone (919) 759-0354
Fax (919) 759-0381

Mr. Mike Kirkland
Engineer
Forsyth County Environmental Affairs Department
539 N. Spruce Street
Winston-Salem, NC 27105

Dear Mr. Kirkland:

This is to report to you concerning the results of the emission test observed by you at our Fairchild Road Plant on September 16, 1991. For your information, spread sheets are attached for both this test and the August 19, 1991 run (which proved to be unrepresentative due to weigh scale calibration problems).

The processing sequence, in review, can be described as follows:

a) Empty mix tank weighed

b) Pre-mix ingredients added to mix tank (to achieve respective proportions in batch), while tank is still on weigh scales:

1) Toluene
2) Liquid and dry ingredients, designated 'A', 'B', and 'C'

c) Transfer mix tank to work station, start mix

d) Determine weight of additives to be introduced at mixer

1) Weigh pallet of additives #1 and #2
2) Hand carry bags of additive #1 to mixer, add, and return empty bags to pallet
3) Record weight of pallet after target weight of additive #1 achieved in mix tank
4) Hand carry bags of additive #2 to mixer, add, and return empty bags to pallet
5) Sweep up any spillage of additives #1 and #2 and return to pallet
6) Record weight of pallet including unused bags of product, subtract (d)(1), above

7) Add net weight of any quantity of additive #1 or additive #2 not included on the original pallet, i.e., if it did not have enough of one of these and it was necessary to supplement from a bag not on the original pallet, etc.

e) Complete mix cycle, take samples for quality control

f) Record weight of full mixing vessel at scales*

This concludes the process cycle for batch mixing, the operation for which the control equipment effectiveness is being measured. As you observed, an ancillary operation, drum-off of a finished batch, occurs immediately after the mixing. The data associated with this is appended for completeness.

However, it is emphasized that the drum-off data should not be considered applicable in evaluating the effectiveness of the mixing vessel covers. As you may recall, the staging of the mixing vessel during drum-off required the vessel to be tilted, so that the cover was only partially in place (the material charging hatch was open). More importantly, the solvent loss during drum-off came, in large part, from the open drums during the fill. Also contributing was the operation and manipulation of the filter bags attached to the tap near the bottom of the vessel. Neither the drums nor the filter bags were able to be affected by the mixer cover - only the mixing operation was. For this reason, the percent emissions reduction achieved by this control equipment is evaluated for the process steps during which it is "doing something", (b) through (f), above.

Reviewing the results of the September 16, 1991 test, the total weight of all batch ingredients and of the 10 drum mix vessel was 4789.5 lbs., using the cover. The weight immediately after the mix was completed was 4787.5 lbs; after waiting on the scales due to QA/QC approval and to a rush order being run, it was 4786.5 lbs. Allowing for two (2) 4 oz. quality control samples that were withdrawn, the net loss during the test was (4789.5 - 4786.5 + 0.25 + 0.25), or 2.5 lbs.

For the test without a cover, the weight of the mix vessel and of all ingredients was 4,702 lb. The weight after the mix and after a waiting period approximately the same as that following the covered-mixer test was 4679.5 lbs. Allowing for the 0.5 lb. withdrawal for quality control samples, the net loss was (4702 - 4679.5 + 0.25 + 0.25), or 22.0 lbs.

* May be done either before or after QA/QC clearance, but should be consistent for both covered and uncovered mixing vessels.

Based on the above, the control efficiency of the mixer cover is $\frac{22.0 - 2.5}{22.0}$ x 100%, or 88.6%.

This is consistent with previous data, though we would not have been surprised by higher numbers given improvements in the cover design.

We believe this data indicates compliance with Forsyth County Environmental Affairs Department regulations. Please let us know if you have any questions regarding the report. Thanks for your time and attention.

Sincerely,

Stephen W. Paine
Environmental Engineer

cc: (with attachments)

T. A. Elliott
Scott Trethaway
John Tanner
Steve Sutton
Bruce Gammon
Hank Greenwood

MIX VESSEL COVER TEST - SEPTEMBER 16, 1991

	VESSEL WITH COVER			VESSEL WITHOUT COVER		
	Item Wt. Pounds	Batch Total Lb.	Time *	Item Wt. Pounds	Batch Total Lb.	Time
Tank	930.5	930.5	9:41 a.m.	848.0	848.0	10:54 a.m.
Toluene	2753.5	3684.0	10:02 a.m.	2756	3604.0	11:19 a.m.
Ingredient A	151.0	3835.5	10:06 a.m.	151.0	3755.0	11:25 a.m.
Ingredient B	76.5	3912.0	10:11 a.m.	76.0	3831.0	11:29 a.m.
Ingredient C	38.0	3950.0	10:17 a.m.	38.0	3869.0	11:32 a.m.
(Start Mix)			10:29 a.m.			11:42 a.m.
Pallet incl. mix additives #1 & #2	988.0			991.5		
Pallet less mix additive #1	537.5	4400.5	10:35 a.m.	538.5	4322.0	11:41 a.m.
Pallet less mix additive #2	148.5	4789.5	10:44 a.m.	178.5	4682.0	11:50 a.m.
Partial bag supplement	N/A	N/A	N/A	20.0	4702.0	11:52 a.m.
Mix complete; Quality control sample taken	(0.5)	4789.0 (assumed)	11:34 a.m.	(0.5)	4701.5 (assumed)	12:52 p.m.
Weight after mix		4787.5	11:39 a.m.		**4688.5 (extrapolated)	N/A**
Weight after QA/QC holding Time & wait on scales		4786.5	1:58 p.m.		4679.5	3:23 p.m.

Net loss with cover
4789.0
4786.5
2.5

Net loss without cover
4701.5
4679.5
22.0

$$\text{Control efficiency of covers} = \frac{22.0 - 2.5}{22.0} \times 100\% = 88.6\%$$

* When one time recording is made for an activity, the time indicates completion.

** Vessel not weighed immediately after mix due to employee lunch break. Solvent loss between completion of mixing and later weighing of vessel assumed proportional to total loss during mixing and waiting times, combined. It is emphasized that a 2+ hour wait for drumming-off is unusual and was caused by trying to fit this test into a given time slot, then having a rush order come up from a customer, tying up the scales.

DRUM OFF OPERATION - 9/16/91

FROM BATCH MIXED WITH VESSEL COVER

	ITEM WT. POUNDS		TOTAL POUNDS	TIME *
Empty Drums (Net)	51		4,786.5 **	1:58 p.m.
	51			
	48			
	51			
	48			
	59			
	51			
	49			
	51			
	49			
	508			
		4358		
		508		
		3,850	(3850)	
			936.5	
Vessel weight incl. final clingage (0.5 lb)		931		
solvent retained by filter ****		1		
		932	(932)	2:49 p.m
		4.5 Actual loss during drumoff		

FROM BATCH MIXED WITHOUT VESSEL COVER

	ITEM WT POUNDS		TOTAL POUNDS	TIME
Empty Drums (Net)	49		4,679.5 ***	3:23 p.m.
	50			
	50			
	50			
	50			
	51			
	51			
	49			
	51			
	50			
	501			
		4322.5		
		501.0		
		3821.5	(3821.5)	
			858.0	
Vessel weight incl. final clingage (0.5 lb)		848.5		
Solvent retained by filter ****		0.25		
		848.75	(848.75)	4:08 p.m.
		9.25 actual loss during drumoff		

*	Time of completion, if not otherwise indicated
**	At end of mixing time and QA/QC wait time
***	Extrapolated from batch measurements after mix cycle, and after drum off.
****	to nearest 0.25 lb.

ALLIANCE
Technologies Corporation

Date: 6 January 1992

Subject: Site Visit--The Perry & Derrick Company
Paint Manufacturing
EPA Contract 68-D0-0121; Work Assignment I-29
Alliance Reference No. 1638029

From: Beth W. McMinn
Alliance Technologies Corporation

To: Joseph Steigerwald
OAQPS/ESD/CTC (MD-13)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

The purpose of the visit was to gather information on the paint manufacturing process including information necessary to characterize the process parameters, emissions, control techniques, and control costs.

II. Place and Date

The Perry & Derrick Company
2510 Highland Avenue
Cincinnati, OH 45212
(513) 351-5800

December 13, 1991

III. Attendees

The Perry & Derrick Company (Perry & Derrick)

John J. Jones, Plant Manager
Hugh W. Lowrey, Technical Director
Gregory P. Schott, Production Manager

U.S. Environmental Protection Agency (EPA)

Joseph Steigerwald, CTC

Alliance Technologies Corporation (Alliance)

Beth W. McMinn
Stephen A. Walata

IV. Discussion

A meeting was held with the personnel from Perry & Derrick to discuss the paint manufacturing process. The discussion focused on market profile, manufacturing supplies, manufacturing process parameters, volatile organic compound (VOC) control experience, and emission characterization. This discussion was followed by a tour of the production facility in Cincinnati, Ohio, and then by a short closing meeting.

A. Perry & Derrick's Market Profile

The Cincinnati facility produces both water (latex) and solvent (oil) based industrial and consumer paints. Perry & Derrick's industrial coatings are used in many markets including metal cans and containers, metal furniture, general metal, machinery and equipment, and electronics. Perry & Derrick does not sell paints into coil coating, exterior car coating, wood finishing, or major appliance coating areas. The company's consumer paints are sold over the counter under manufacturer and private labels to customers for interior and exterior painting needs.

Perry & Derrick began manufacturing resins and solvent based consumer paints in 1913 in Dayton, Kentucky, with sales offices in Cincinnati, Ohio. The family-owned business gradually expanded into the industrial market. In the late 1950's, a fire in the Dayton facility raw material warehouse caused the company to move paint manufacturing operations to Cincinnati. This move also prompted Perry & Derrick to begin manufacturing latex consumer paints. The resin facility remained in Dayton. As environmental and Occupational Safety and Health Administration (OSHA) rules became more stringent, Perry & Derrick made the decision to leave the resin manufacturing business. Since 1987, Perry & Derrick has manufactured only consumer and industrial paints.

Water based paints currently account for 59 percent of total production with 55 percent being consumer products and 4 percent being industrial products. The remaining 41 percent of manufacturing is solvent (oil) based; 17 percent of this market is for consumer use while 24 percent is for industrial use. Two years ago the Perry & Derrick sales team asked thier industrial solvent based paint customers to move to water based coatings. Although the customers demanded, and some still require, solvent based products, Perry & Derrick has concentrated new product development in the area of waterborne coatings. Some product development still occurs in the area of solvent based products. The majority of Perry & Derrick's consumer products contain less than one pound per gallon VOC, but some gloss and semi-gloss latex paints contain nearly three pounds. Industrial coatings range from water thinned products with almost zero VOC to conventional lacquer-type coatings (manufactured for unregulated customers) with as much as six pounds per gallon VOC.

The Perry & Derrick facility produces just under 1,000,000 gallons of paint annually. They also employ a total of 77 people, 48 of whom are production employees.

B. Manufacturing Supplies

Perry & Derrick uses approximately 700 raw materials in their paint manufacturing processes. In addition to the solvents and alcohols described in Attachment 1, Perry & Derrick also purchases and uses a variety of resins, pigments, and additives. Perry & Derrick regularly calculates VOC content using a finished product rather than a raw material standpoint.

C. Manufacturing Process Parameters

Since Perry & Derrick left the resin production business in 1987, the paint manufacturing process at the Cincinnati based facility has been a batch process materials handling operation. The method of product formation is by mixing and blending rather than by reacting materials chemically. The four main manufacturing operations are completed in the following order:

- preassembly and premix
- pigment grinding/milling
- product finishing/blending
- product filling/packaging

The first step in the manufacturing process is preassembly and premix. In this step, the liquid raw materials (e.g., resins, solvents, alcohols, and/or water) are mixed in portable containers to form a honey-like material to which pigments are added. The pigment and liquid mixture form a viscous material which is then sent to the grinding operations.

The grinding or milling stage serves to further disperse the pigment throughout the paste. Once the customer-requested grind specifications are met, the paint mixture is transferred to the product finishing tanks. Normally, this step serves to disperse insoluble solid materials. If insoluble materials are not present, the grinding/milling stage may be omitted as sufficient blending will have occurred in premix.

Final product specifications are achieved in the blending or product finishing step. Here, the paint mixture from the dispersion operation is tinted, if necessary, and further reduced, or letdown, with resins, solvents, and alcohols or water in agitated tanks.

Once the paint has been "finished," it can be transferred from the finishing tanks into pails, drums, tote tanks or tank wagons for shipment. The paint is normally filtered during the transfer step.

Perry & Derrick offers their customers more than 1000 different products. Many of these products are manufactured for specific customer needs. Paint formulations change as customer requirements change. New product development and product revisions typically occur several times per week. One base product may have several different variations which may be manufactured in a variety of equipment. Because of this, Perry & Derrick is unable to dedicate manufacturing equipment to specific products. Most of the equipment is, however, dedicated to paint type (i.e., water/latex or solvent/oil). In several cases, equipment is further reserved for industrial solvent based paints or consumer latexes.

Perry & Derrick uses high speed dispersers, mixers, Kady mills and ball/pebble mills in the preassembly and premix stage. The agitation keeps the pigment in suspension and supplies the dispersion equipment with a consistently mixed material. Dispersers and mixers are used with insoluble powders prior to the milling stage. If the dry materials are soluble, transfer to another type of dispersion equipment is unnecessary. Product milling, Step 2, and premix, Step 1, may be accomplished in a single process.

Perry & Derrick currently operates four types of dispersion equipment: Kady mills, media mills, ball/pebble mills, and high speed dispersers. Ball/pebble mills are rotating cylinders, mounted horizontally, and filled with grinding media. The company operates one steel ball mill which is used to disperse pigment in solvent based paints. The pebble mills, which use flint pebbles as grinding media, disperse both oil and water based products. Certain paints can be made in entirety in ball mills and packaged directly into containers. The mills are loaded through a top chute with raw materials (i.e., premix liquids, powders/pigments, and additives) during the day and the grinding process is completed during the night. The following day the product is inspected, properly adjusted, and then unloaded by gravity feed, filtered, and packaged into containers for shipment. The mills run at night because of the noise generated during the grinding process. They approach a closed system as they are open only during additions of raw materials and product filling operations.

The media mill at the Perry & Derrick facility is a sand mill. Rather than using sand, this vertical mill uses tiny glass, ceramic, or zirconia media to accomplish pigment dispersion. Material enters through the bottom of the mill and is forced up through the media to an open-top filtering screen.

Kady mills are unlike most of the other dispersion mills in that they are jacketed allowing for heating capability. These mills have permanent lids which allow them to be covered during grinding operations. Perry & Derrick uses Kady mills for the production of solvent based material. The largest of the facility's three Kady mills is used in the manufacture of a high-solids paint.

The Perry & Derrick facility also uses high speed dispersers to grind pigment into paint. These dispersers are adjustable and are used with portable mix tanks. The portable tanks are covered during the manufacture of solvent based products. Covers are normally made of stainless steel with openings for the agitator shaft.

The Perry & Derrick facility uses ball/pebble mills, Kady mills, vertical media mills, mix tanks, and blend vessels in the manufacture of solvent based paints. Releases of VOCs come from several types of equipment used in the paint manufacturing process.

Ball/pebble mills are used in the manufacture of solvent based paints. These mills approach a closed system, as they are open only during additions of raw materials and product filling operations. It is during these operations that VOC emissions can occur.

VOCs may be emitted during solvent based paint blending and milling operations in the Kady mills. The mixing operations generate friction which causes product temperatures to rise resulting in the volatilization of organics in the paint formulation. Emissions may also be released during material additions when the mill covers are open.

Vertical media mills, or sand mills, are used to disperse pigment throughout the paint. Emissions result from the exposed screen, through which warm product filters, possibly clogging the screen. An operator might apply solvent to unclog the screen, adding to total emissions.

Another emission source is portable mix tanks and blend vessels. Portable mix tanks are used to mix product and to keep the pigment in suspension. They are also used to transfer material from one manufacturing stage or area to the next. While they are being used for mixing, the tanks are often, but not always, covered. If a cover is used on a mix tank during mixing, it will have a four to six inch opening through which the agitator shaft extends. In some cases (e.g., water based paint manufacturing), only a splash guard is used to cover the back half of the mix tank. When mix tanks are used for temporary storage, they are covered with a solid lid. None of the lids seal with the mix tank. Blend vessels not equipped with sealing lids are another source of VOC emissions. Emissions may occur during product addition through the top opening. Because the lids do not form a seal with the tank, gradual emissions during paint processing are possible.

Emissions are also possible from the scale systems where solvent and resin raw materials are measured and transferred from storage tanks to mix tanks or other containers. Emissions may occur during transfer and hose connecting and disconnecting.

In addition to emissions from process operations, VOCs are also released from a variety of cleaning operations. Solvents are used to clean the Kady mills and other equipment used to manufacture solvent based paints. Emissions occur during cleaning solvent addition and removal.

Perry & Derrick calculates SARA Section 313 releases based on consumption figures, so no studies have been done to determine emission breakdown by process. The facility has not examined emission contribution from janitorial supplies.

Some products manufactured by Perry & Derrick are finished in the equipment in which they completed the dispersion process. Others are transferred to permanent blend vessels for product adjustment and letdown. In the permanent vessels, material is added through the top, agitated, and gravity fed out the bottom. The top openings on the tanks are covered with permanent lids, which are opened only during the addition of product components. When the product is ready to be packaged, it is transferred to the filling department where it is filtered using a Vorto-Siv, a nylon mesh or felt bag, or a cartridge filter.

The Cincinnati based facility operates eight hours per day, 298 days per year. Batch sizes range from less than one gallon to 1600 gallons, with most of the production volume coming from batches in the 300 to 1600 gallon range. Process tanks range from a 270 gallon ball mill to a 1600 gallon mix tank.

Equipment is cleaned after each batch. The degree of cleaning depends on the size of batches processed, the size of the equipment to be cleaned, and the color and type of product manufactured. Every effort is made to minimize equipment cleaning. The Production Manager attempts to schedule similar product batches while Perry & Derrick's in-house laboratory determines the degree of cleaning required based on the compatibility of consecutive batches. Equipment used to manufacture water based products is cleaned with a water based cleaner while equipment used to manufacture solvent based products is cleaned with solvent. In most cases, the spent cleaning liquid is retained and used as a vehicle or thinner in the next similar product batch. Filter bags and other straining equipment used in product filling operations are also cleaned with the recyclable wash liquid. Process lines are dedicated to certain raw materials and therefore are cleaned only on a limited basis. The amount of wash solution used for equipment cleaning ranges from 2 to 50 gallons.

D. Volatile Organic Compound Control Experience

The Perry & Derrick facility has no add-on control devices for the capture and destruction of VOCs. Volatile organic compounds emitted from the manufacture of solvent based paints are controlled through equipment modifications such as tank covers. In addition to modifying equipment to reduce solvent emissions, the company has altered their cleaning procedures and focused much of their new product development in the area of waterbornes.

Although management at the Cincinnati based Perry & Derrick facility feels that they have significantly reduced VOC emissions over the past few years, they will have difficulty proving this if they are required to do so. As with many small paint and ink manufacturing facilities, Perry & Derrick has not performed any VOC measuring or testing of stacks primarily because of the cost involved with conducting EPA-approved test methods.

Drop hoses are used around mixing and milling equipment to capture particulate matter. These hoses are routed to a dust collector and then to dust collection drums. Pigment particles transferred to drums are accumulated and are eventually recycled back into similar paint batches.

E. Emission Characterization

SOLVENTS

TOLUOL OR TOLUENE
NORMAL BUTYL ALCOHOL
BUTANOL NORMAL
BUTYL ACETATE
BUTYL ACETATE NORMAL
METHYL ETHYL KEYTONE
METHANOL
LACOLENE
LACTOL SPIRITS
ANHYDROL ANHYDROUS (PM4081)
TEXOL A-2 ANHYDROUS
ANHYDROUS ISOPROPANOL 99%
TEXOL A-2 ANHYDROUS
ANHYDROUS ISOPROPANOL 99%
ISOPROPYL ALCOHOL ANHYDROUS
ETHYLENE GLYCOL REG. SP
HI-INITIAL V.M.&P. (R-66)
SC SOLVENT NO. 150
HI SOL 15F
EXKIN NO. 2
SKIN O
TROYKD ANTI SKIN B
METHYL ISOBUTYL KETONE
BUTYL CARBITOL-GLYCOL ETHER DB
LOW ODOR BASE SOLVENT R66
TURPENTINE
MINERAL SPIRITS (R-66)
SOLVENOL NO. 3
SC SOLVENT #28
HI SOL #70
KWIK DRI OHIO APC R-66
HI SOL 10
140 SOLVENT (R-66)
XYLOL OR XYLENE

GLYCOL ETHER EB
UCAR FILMER IBT
TEXANOL
PROPYLENE GLYCOL IND.
ETHYL BENZENE
METHYL NORMAL ANYL KETONE
AMYL ALCOHOL
#2 ETHYL HEXANOL
GYLCOL ETHER PM ACETATE
GLYCOL ETHER PM
DI PROPYLENE GLYCOL
NIPAR S-10
GLYCOL ETHER EP (EKTASOLVE)
METHYL CARBITOL
GLYCOL ETHER DM
SUNTHENE 410
HEXYL ACETATE (MIXED ICOMERS)
ISOPROPYL ACETATE
MAGIE EXK 385 (SP 6325)
NIPAR 640
RECLAIMED SOLVENT

Attachment –

12-12-91

DESCRIPTION OF PAINT MANUFACTURING PROCESS AT THE PERRY & DERRICK COMPANY

All paints and coatings manufactured by Perry & Derrick are made by the same batch process, with batch sizes covering the range from one gallon or less to 1600 gallons, but with most of the production volume coming from batches in the range of 300 to 1600 gallons. The number of products offered by the company at any one time is of the order of one thousand. The number of ingredients used at any one time, including equivalent materials purchased from different suppliers, is probably in the range of 1500 to 2000. Many products are manufactured to meet the specific needs of individual industrial customers. New product developments and product revisions occur several times in a typical week. Because different kinds of equipment may be used for the same purpose and because the potential number of products requiring slightly different variations of the process is virtually without limit, the number of process variations is too large to permit a detailed description of each one.

Liquid storage of paint ingredients is in bulk tanks of 2500 to 8000 gallons, in tote tanks of 200-300 gallons, in 55 gallon drums and to a minor degree in smaller containers. Measurement of liquids is by metering or weighing. Soluble solid ingredients are stored in flaked, prilled, solid or powder form in paper bags or fiber or steel drums of 50 to 500 pounds net weight. Measurement is by weight or by counting preweighed packages. Insoluble dry powder ingredients are stored in paper bags or fiber drums of 10 to 200 pounds net weight. Measurement is by the same methods as for soluble solids.

Production scheduling and control are exercised by issuing a factory batch ticket and a separate filling ticket for each batch prior to manufacture. These documents accompany the batch through the factory. They identify the product and the quantity to be manufactured, the amount of each ingredient, equipment to be used, and they carry any special instructions, safety/health information and packaging instructions. Pertinent information is recorded on them during manufacturing, and they become permanent records of the production of the batch. When a batch requiring paper labels is scheduled, a separate written instruction goes to the print shop where the required number of labels is printed. For non-consumer products, a separate written instruction goes to the regulatory computer operator, where the required number of hazard communication labels is printed.

The initial manufacturing step is to transfer material from storage to a tank or mill, premix liquids and insoluble powders and dissove soluble solids. The equipment used may be a mixer, high speed dissolver/disperser, KD mill or ball/pebble mill. If insoluble powders are present, the next step is to disperse the powder to the desired degree using a high speed disperser, KD mill, media mill or ball/pebble mill. Satisfactory dispersion is confirmed by laboratory test. If insoluble powders are not present, the dispersion step is omitted, and in either case the next step is to reduce the batch with the balance of the liquids to be used, with small amounts withheld in some cases for later adjustment of physical properties. If color adjustment is required, concentrated dispersions of dry color are added as necessary. Each batch is then sampled and the sample is laboratory tested for physical properties, composition and performance according to a test protocol established separately for each product. If test results do not show the batch to be within specified limits, adjustments are made under laboratory direction by adding small amounts of ingredients to the batch. Straining instructions are confirmed or revised by the laboratory.

The batch then goes to the filling department where it is strained using a Vorto-Siv, a nylon mesh or felt bag, or a cartridge filter. The mesh or micron size of the straining media is selected as specified on the filling ticket. The next step is labeling with one or more preprinted paper labels, mechanically or by hand, depending on the size of container, or else the container is stenciled or placarded. Container sizes range from pint cans to tank trucks. If the container size is one gallon or less, the cans are mechanically packed in corrugated board cases and stenciled. All containers are then transferred to the warehouse/shipping department, where additional labeling is done if required for transportation.

ALLIANCE
Technologies Corporation

Date: 6 January 1992

Subject: Site Visit--Borden Packaging and Industrial Products
Ink Manufacturing
EPA Contract 68-D0-0121; Work Assignment I-29
Alliance Reference No. 1638029

From: Beth W. McMinn
Alliance Technologies Corporation

To: Joseph Steigerwald
OAQPS/ESD/CTC (MD-13)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

The purpose of the visit was to gather information on the ink manufacturing process including information necessary to characterize the process parameters, emissions, control techniques, and control costs.

II. Place and Date

Borden Packaging and Industrial Products
630 Glendale-Milford Road
Cincinnati, OH 45215
(513) 782-6384

December 12, 1991

III. Attendees

Borden Packaging and Industrial Products (Borden)

A. A. (Tony) Stambolos, Director of Manufacturing - Coatings
John Edelbrock, Plant Manager - Coatings

U.S. Environmental Protection Agency (EPA)

Joseph Steigerwald, CTC

Alliance Technologies Corporation (Alliance)

Beth W. McMinn
Stephen A. Walata

IV. Discussion

A meeting was held with the personnel from Borden Packaging and Industrial Products to discuss the ink manufacturing process. The discussion focused on market profile, manufacturing supplies, manufacturing process parameters, volatile organic compound (VOC) control experience, and emission characterization. This discussion was followed by a tour of the production facility in Cincinnati, Ohio, and then by a short closing meeting.

A. Borden's Market Profile

The Borden Cincinnati facility acts as both a base manufacturing plant and a local service facility. The base plant manufacturers waterborne ink bases and acrylic polymers. The bases and the polymers may or may not be pigmented. These "finished products" are then sent to smaller Borden facilities which act as local blend houses. The plants receive the bases and polymers and blend them to the specifications of local customers.

The second manufacturing area at the Borden facility is a blend house to service local customers. The products from the base plant are used as raw materials and are blended with additional raw materials, pigments, resins, solvents, and additives to form a finished ink.

Borden manufactures water based inks for the corrugated market, high-gloss solvent based paste inks for folding packages (e.g., Mrs. Smith's pies), and some rotogravure products such as those inks used for Christmas packaging. The facility also does some carbon black dispersion for non-Borden facilities. Approximately 90 percent of the products manufactured are water based, while the remaining ten percent are solvent based. The majority of the water based products are inks for the corrugated market.

The Cincinnati Borden facility was originally established as a solvent based gravure manufacturing plant. Production was entirely solvent based until the mid-1980s. In 1985, Borden decided to leave the gravure market and concentrate on water based products. Making this change involved some process modifications. Borden relined most of their stainless steel tanks with epoxy coatings to prevent the new water based products from rusting the metal. The facility also purchased new media for the ball mills. Solvent based products had been manufactured using small steel ball media. Water based products required larger ceramic or zirconium balls.

Borden's annual sales are in the $50 to $100 million dollar range, classifying the company as a large ink manufacturer.

B. Manufacturing Supplies

Borden uses between 1200 and 1500 raw materials in their manufacturing processes. Some of the solvents used include methyl ethyl ketone (MEK), 1,1,1-Trichloroethane, toluene, methanol, xylene, and acetone. Borden also uses many alcohols, although plant officials say that there is a general push in the printing industry to move away from inks with a high alcohol content (i.e., high volatility). For this reason, Borden has replaced some of their alcohols with glycol ether products. In addition to solvents and alcohols, Borden also purchases and uses a variety of resins, pigments, and additives. Borden addresses VOC content from a raw material rather than a finished product standpoint. Borden calculates VOC content in finished products based on component composition.

C. Manufacturing Process Parameters

The ink manufacturing process at the Cincinnati facility is basically a batch process materials handling operation. Products are formed by mixing and blending rather than by reacting materials chemically. The main manufacturing operations are completed in the following order:

- premix
- pigment grinding/milling
- product blending
- product filtering
- product filling/packaging

The first step in the manufacturing process is material premix. This is the production of an intermediate product referred to as the base. The base or premix is made by combining vehicles (e.g., solvents, alcohols, and/or water) with pigments and any other necessary additives. The materials are mixed in portable containers to form a viscous material which acts as a concentrate. At this stage, the particles in the concentrate are rather large and not consistently mixed. With further processing, the concentrate may become any one of a variety of specific end products.

The grinding or milling stage serves to further disperse the pigment throughout the base by pumping it through dispersion equipment. Once the customer-requested grind specifications are met, the resulting base is transferred to the product blending tanks.

Final product specifications are achieved in the blending or product finishing step. The base from the dispersion operation is mixed with other intermediates and raw materials to produce a finished ink. Blending may occur in the same tank or in a different tank used for premix.

Once the ink has been blended, it is filtered through cheese cloth or other filters to enhance the quality and uniformity of the product. Filtering also acts to screen out impurities.

After the ink has been filtered, it is pumped or emptied into the shipping container.

With over 10,000 blended products, Borden does not dedicate manufacturing equipment to specific products except for large quantity materials. Some equipment may be dedicated periodically to seasonal products, such as during the fall, when Christmas reds and greens are in high demand. Different equipment is used for the manufacture of water based inks, solvent based inks, and paste inks, so certain equipment may be reserved for these product families.

Borden uses a variety of equipment during the premix and blending stages. The facility has many mixers, and choosing which to use depends in part on batch size. Drum-sized batches made in the drum itself may be blended with a portable mixer called a Lightning Mixer. Other materials made in portable mix tanks may be blended using larger permanent mixers. In some cases, an ink will be premixed with one mixer, moved to a dispersion mill for grinding and milling, and then transferred back to the same premix mixer for blending operations.

Borden operates several types of dispersion mills including two roll mills, three roll mills, ball mills, kady mills, shot mills, and pebble mills. The three roll mills are used to grind pigment into water based paste inks. All three rollers are exposed to the air.

Borden makes both water and solvent based inks in ball mills. These mills are rotating cylinders, mounted horizontally, and filled with grinding media. Typically, steel balls are used to disperse pigment in solvent based inks and ceramic or zirconium balls are used for water based materials. Certain inks can be manufactured entirely in ball mills and packaged directly into drums for shipment. These mills approach a closed system, as they are open only during additions of raw materials and product filling operations.

Pebble mills are identical to ball mills except for the grinding media. Originally, pebble mills used flint pebbles while ball mills used steel balls. The pebble mills at the Borden facility use ceramic beads to disperse white and clear inks.

Shot mills are similar to ball mills, except that they are vertical. Material enters through the bottom of the mill and is forced up through the media to a submerged filtering screen. The upward action results in wear on the internal rotor and on the filtering media, which are normally glass, ceramic or steel. At the Borden facility, shot mills are used primarily in the manufacture of light-colored water-based inks.

Both the Kady mills and the two roll mills are used in the production of high-gloss solvent based paste inks for folding packages. Two roll mills operate in the same fashion as three roll mills. The Kady mill is unlike most of the other dispersion mills, as it is jacketed, allowing for heating capability. This mill has a permanent lid which allows the mill to be covered during grinding operations.

In addition to the mills, Borden operates a number of fixed mix tanks which are used for mixing, milling, and blending both solvent and water based inks. Material is added through the top, agitated, and gravity fed out the bottom. The top of the mix tank may be either open or covered with lids.

The Borden facility normally operates 24 hours per day, five days per week, 52 weeks per year. A typical batch can take eight to twenty hours to complete. More time is required to manufacture black inks than other colored inks. Viscous or dry materials take longer to grind and achieve proper dispersion than less viscous materials. Batch sizes range from five gallons (50 pounds) to 2,500 gallons (20,000 pounds), and process tanks range from pails and drums to 4,100 gallon (33,000 pounds) ink mixers. The larger batches are normally black inks for the corrugated packaging market, while the smaller batches are typically solvent based specialty inks.

Equipment is cleaned on an as-needed basis. Cleaning frequency depends on the number and size of batches processed, the size of the equipment to be cleaned, and the color and type of ink manufactured. Equipment used to manufacture water based inks is cleaned with water. After a mill or tank has been emptied, water is added to the equipment to capture remaining product residue. The wash water is drained from the tank and recycled into the next product batch. Equipment used to manufacture solvent based products is cleaned with solvent which is captured and reused. The three roll mills are cleaned by hand, using rags and 1,1,1-Trichloroethane, while the Kady mills are cleaned with a petroleum distillate which is also captured and reused. Some base raw materials and all solvents are handled via a manifold system using dedicated process lines. Therefore, cleaning of these lines is limited. Borden also schedules consecutive production batches of similar products to reduce equipment cleaning frequency.

D. Volatile Organic Compound Control Experience

The Borden facility has no add-on control devices for the capture and destruction of VOCs. Volatile organic compounds emitted from the manufacture of solvent based inks are controlled through equipment modifications such as tank covers. Drop hoses are also used around mixing tanks to capture both particulate matter and VOCs. These hoses are then routed to a baghouse. In the area where solvent based paste inks are ground on the two roll mills, emissions are captured through exhaust hoods and then vented to a fabric filter (i.e., baghouse). Borden operates a venturi scrubber in addition to fabric filters for the capture of particulate matter.

E. Emission Characterization

The Cincinnati Borden facility uses ball mills, pebble mills, Kady mills, two roll mills, and some mix tanks and drums with mixers in the manufacture of solvent based inks. Releases of VOCs come from several types of equipment used in the ink manufacturing process.

Some solvent color work is accomplished by blending in 55 gallon drums. The drums are used to mix product and to keep the pigment in suspension. While they are being used for mixing, the drums are often open to the atmosphere. If a cover is used on a drum during mixing, it will have a small opening through which the agitator shaft extends. Most of the solvent based inks that are made in mix tanks are made in tanks covered with metal lids. These lids have a four to six inch opening through which the agitator shaft extends.

Both ball and pebble mills are used in the manufacture of solvent based inks. These mills approach a closed system, as they are open only during additions of raw materials and product filling operations. It is during these operations that VOC emissions can occur.

The two roll mills, used to disperse pigment in solvent based paste ink, are another source of VOC emissions. Because they are exposed to the atmosphere, solvents are emitted during the rolling process. The material exiting the two roll mill is a sheet of flexible ink. This sheet is folded into a transport bin for temporary storage. While in the staging bin, the sheet may cause further emissions of organic compounds.

VOCs may be emitted during solvent based paste ink chip melting and blending operations in the Kady mills. These tanks can be heated, resulting in the volatilization of organics in the ink chips. Emissions may also be released during material additions when the mill covers are open.

Another source of emissions is the manifold system where solvents are weighed and transferred from storage containers to mix tanks, mills or other containers. Emissions may occur during transfer and hose connecting and disconnecting.

In addition to emissions from process operations, VOCs are also released from a variety of cleaning operations. Solvents are used to clean the Kady mills and other equipment used to manufacture solvent based inks. Emissions occur during cleaning solvent addition and removal. The solvents are collected and reused, reducing overall emissions from virgin solvent. The three roll mills are cleaned by hand, using rags and 1,1,1-Trichloroethane. During cleaning procedures, some 1,1,1-Trichloroethane is released.

Most of the emission areas, with the exception of the staging of drums and storage bins, are equipped with exhaust fans or drop hoses connected to headers which lead to particulate control devices.

Borden calculates SARA Section 313 releases based on mass balance and consumption figures, so no studies have been done to determine emission breakdown by specific process or product. The facility has not examined emission contribution from janitorial supplies. The Cincinnati facility is engaging in pollution prevention activities and succeeded in reducing overall emissions by 43 percent from 1989 to 1990.

John C. Richter, Plant Superintendent
Maura C. Tinter, Environmental Engineer

U.S. Environmental Protection Agency (EPA)

Joseph Steigerwald, CTC

Alliance Technologies Corporation (Alliance)

Beth W. McMinn
Stephen A. Walata

IV. Discussion

A meeting was held with the personnel from PPG Industries, Inc. to discuss the paint manufacturing process. The discussion focused on market profile, manufacturing supplies, manufacturing process parameters, and volatile organic compound control experience. This discussion was followed by a tour of the production facility in Cleveland, Ohio, and then by a short closing meeting.

A. PPG's Market Profile

The Cleveland facility produces automotive coatings for automotive Original Equipment Manufacturers (OEM). The three families of products PPG produces are cationic electrocoats ("E" coats), solvent based topcoats, and water based topcoats. The "E" coats account for 47 percent of the facility's production and 24 percent of its business. Solvent based topcoats account for 51 percent of production and 70 percent of business, while water based coatings account for 2 percent of production and 6 percent of business. Annually, the PPG Cleveland facility produces 4,000,000 gallons of both solvent based topcoat and cationic electrocoat and manufacturers 250,000 gallons of water based paints. PPG expects the demand for water based coatings to increase in the future.

The Cleveland PPG facility was originally established in 1907 as the Banner Varnish Company under the guidance of C.J. Forbes. During the next forty years, the facility operated as the Forbes Varnish Company, a producer of varnish for the carriage trade. PPG Industries, then Pittsburgh Plate Glass, purchased the original seven acre operation in 1947, operating under the Forbes Finishes Division title. Major building expansions and local property acquisitions followed during the 1960s and 1970s to reach the current 17 acre complex. Today the facility produces 8 to 12 million gallons per year of original automotive coatings, a great increase over the 2 million gallons produced in 1948.

ALLIANCE
Technologies Corporation

Date: 10 January 1992

Subject: Site Visit--PPG Industries, Inc.
Paint Manufacturing
EPA Contract 68-D0-0121; Work Assignment I-29
Alliance Reference No. 1638029

From: Beth W. McMinn
Alliance Technologies Corporation

To: Joseph Steigerwald
OAQPS/ESD/CTC (MD-13)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

The purpose of the visit was to gather information on the paint manufacturing process including information necessary to characterize the process parameters, emissions, control techniques, and process and control costs.

II. Place and Date

PPG Industries, Inc.
3800 W. 143rd Street
Cleveland, OH 44111
(216) 464-5710

December 10, 1991

III. Attendees

PPG Industries, Inc. (PPG)

Dennis A. Kovalsky, Plant Manager
David P. Mazzocco, Environmental Engineer - Air Programs

B. Manufacturing Supplies

PPG uses more than 400 raw materials in their manufacturing processes. In addition to the solvents and alcohols described in Attachment 1, PPG also purchases and uses a variety of resins, pigments, and additives. The company regularly calculates VOC content in finished products.

C. Manufacturing Process Parameters

The paint manufacturing process at the Cleveland facility is basically a batch process materials handling operation. The method of product formation is by mixing and blending rather than by reacting materials chemically. The four main manufacturing operations are completed in the following order:

- preassembly and premix
- pigment grinding/milling
- product finishing/blending
- product filling/packaging

The first step in the manufacturing process is preassembly and premix. In this step, the liquid raw materials (e.g., resins, solvents, alcohols, and/or water) are mixed in portable containers to form a honey-like material to which pigments are added. The pigment and liquid mixture forms a paste, which is then sent to the grinding operations.

The grinding or milling stage serves to further disperse the pigment throughout the paste. Once the customer-requested grind specifications are met, the paint mixture is transferred to the product finishing tanks.

Final product specifications are achieved in the blending or product finishing step. Here, the paint mixture from the dispersion operation is tinted, if necessary, and further reduced, or letdown, with resins, solvents, and alcohols in agitated tanks.

Once the paint has been "finished," it can be transferred from the finishing tanks into pails, drums, tote tanks or tote wagons for shipment. The paint is normally filtered during the transfer step.

The Cleveland PPG facility has three manufacturing lines which correspond to the three families of products: solvent based topcoat, water based topcoat, and "E" coat. The equipment in each of these lines is dedicated both to product family and to color. Equipment dedication prevents product contamination and allows for fewer equipment cleanings (i.e., less solvent use). The equipment for each manufacturing operation for each family is located in a separate building (i.e., solvent based grinding occurs in one building while "E" coat filling occurs in another). This segregation of family manufacturing operations requires that material be transferred from one building to another in portable tanks. During the transfer process, the tanks are covered with either plastic or stainless steel covers.

PPG uses portable mixers and agitators in the preassembly and premix stage. In some cases, premix equipment is combined with dispersion equipment. The product circulates between mixer and disperser. The agitator keeps the pigment in suspension and supplies the dispersion equipment with a consistently mixed material.

PPG currently operates three types of dispersion equipment (vertical media mills, horizontal media mills, and attritors) with the goal of reducing to two (horizontal mills and attritors). The reasons for limiting equipment types to two are many. Vertical mills are an older technology. Material enters through the bottom of the mill and is forced up through the media to an exposed filtering screen. The upward action results in wear on the internal rotor and on the filtering media. It also generates heat which causes the material to become warm. As the product filters through the screen it may be 150°F, frequently causing the screen to clog. An operator might brush on solvent to unclog the screen. The older mills are also noisy and may require hearing protection for workers. In contrast, horizontal mills are closed systems. Because they are closed, they have fewer emissions and less yield loss. The horizontal position makes these mills more efficient than their vertical counterparts. There is less wear on the grinding media and rotor and therefore the horizontal mills produce a cooler product (100°F). In addition, horizontal mills produce a more consistent product for fewer manhours.

PPG also has begun to replace some of their rectangular blend vessels with cylindrical tanks. The vessels being replaced require that material additions be made through the top. Resins and pigment pastes are added manually while solvent is piped into the tank. In the past, the hatches through which material is added were left uncovered during blending operations. PPG has since purchased covers which are removed only during add times. The rectangular tanks are difficult to clean because of their shape. Product accumulates in corners, requiring additional wash solvent and generating more waste. Similarly, agitation is not as efficient in the rectangular vessels as it is in the cylindrical tanks. The addition of material into cylindrical tanks is also through the top. Material is added through the top, agitated, and gravity fed out the bottom. The top openings on the cylindrical tanks are covered with sealing lids. The stainless steel design and cylindrical shape makes cleaning more efficient both in terms of required labor and generated waste.

The Cleveland PPG facility normally operates 24 hours per day, five days per week, 365 days per year, with a potential for operating seven days a week. On average, it takes five days to complete one product batch and follow it from scheduling through the filling operations. Each batch in each family of products spends approximately 24 hours in grinding operations and 16 hours in blending operations. The remaining time is spent in adding, transferring, color matching, filtering, and filling material and in dead time. More labor hours are required to produce the colored topcoats than the primers or clearcoats. The average batch size is 200 gallons, but process tanks range from 500 gallon rectangular vessels to a 14,000 gallon rectangular vessel. All of the solvent based topcoats that PPG produces are considered to be high-solids, with a solids content greater than 50 percent and a VOC content less than five percent. The water based products are three percent organic.

Equipment is cleaned on an as-needed basis. Cleaning frequency depends on the number and size of batches processed, the size of the equipment to be cleaned, and the color and type of product manufactured. Equipment used to manufacture water based products is cleaned with a water based cleaner, while equipment used to manufacture solvent based products is cleaned with wash solvent. Process lines are dedicated to certain raw materials and therefore are cleaned only on a limited basis. The amount of wash solvent used for equipment cleaning ranges from 1 to 100 gallons. PPG cleans equipment such as tote tanks, filter presses, portable mix tanks, and grinding mills with wash solvent recycled on site using a rototherm distillation unit and two Luwa thin film evaporators. This continuous operation recovers from 3,000 to 12,000 gallons of solvent per day at an average cost of $2.00 per gallon, as compared to an average cost of $2.80 for virgin solvent. Wash solvent consists of a mixture of solvents with methyl ethyl ketone (MEK) predominating at a concentration of 50 to 60 percent. Waste generated by the solvent recovery system (i.e., still bottoms with a solids content of approximately 60 percent) is sent off site to the PPG coatings and resins incinerator in Circleville, Ohio.

D. Volatile Organic Compound Control Experience

Volatile organic compound emissions from the Cleveland PPG manufacturing facility are controlled by a REECO (Regenerative Environmental Equipment Company) thermal incinerator, REECO I. A second REECO incinerator, REECO II, controls emissions from the PPG paint laboratory also located at the Cleveland site. The nine chamber fume incinerators were installed in 1984 and 1985 as odor control devices. The primary purpose of the incinerators changed in 1988 with the enactment of Ohio Air Pollution Control (OAC) rules 3745-21-01 and -09, which subjected the Cleveland PPG facility to site-specific requirements for VOC emissions based on reasonably available control technology (RACT). Because combined emissions from the manufacturing facility and the paint laboratory met or exceeded 100 tons of VOC annually prior to rule enactment, the facility (manufacturing and laboratory) was classified as a "major" source. As such, Ohio wrote non-CTG rules for the paint manufacturing operations and paint laboratory operations specifically for PPG (Attachment 2). The rule requires that "... the VOC emissions from the equipment included within the paint manufacturing operations shall be vented either directly or by means of a building or local area exhaust to a control system which shall maintain compliance with any of the following requirements:

(a) A minimum control efficiency of 98.0 percent by weight for the VOC emissions;
(b) A maximum outlet VOC concentration of twenty parts per million by volume (dry basis); or
(c) A minimum incineration temperature of one thousand five hundred degrees Fahrenheit."

PPG has chosen to comply with the 1500°F incineration temperature. Process emissions are supplemented by natural gas with the option to burn fuel oil. Results from recent compliance tests are included in Attachment 3.

OAC originally included a control device capture efficiency clause in the PPG rule. However, after receiving and reviewing PPG's comments addressing the difficulty in measuring capture efficiency, OAC removed these requirements.

Following is a schedule of current installation and annual costs:

Installation Cost:		
Base Unit	$2,400,000.00	
Ductwork and Interfacing Control	3,800,000.00	
Annual Costs:		
Maintenance	$50,000.00	
Media Topoff	3,000.00	
Fire Protection	14,000.00	
Gas	250,000.00	@ $5.20/thousand cubic feet
Electricity	183,000.00	@ $8.13/kilowatt hour

In addition to add-on control technology, PPG has implemented the following techniques to reduce solvent evaporation:

1. Retrofit of manufacturing facilities with closed process equipment and tanks. (Each closed system 45 liter horizontal grinding mill costs $65,000 to $70,000.)
2. Clean process equipment by purging with resin from the next batch.
3. Develop of water based line with reduced VOC content.

PPG has calculated VOC emissions based on compliance testing to be 921 tons per year before control and 92.1 tons per year after control. Releases for Section 313 reporting under the Superfund Amendment and Reauthorization Act (SARA) of 1986 are calculated based on consumption figures. Rather than breaking emissions into fugitive and point source categories, PPG reports total air releases according to the following formula:

$$\% \text{ loss} = \frac{\ln \text{ vapor pressure of VOC}}{100} \times \text{Consumption}$$

Final releases are calculated using a 90 percent destruction/removal efficiency (DRE). Actual compliance testing has shown a 98.2 percent DRE.

E. Emission Characterization

The Cleveland PPG facility releases VOCs from several types of equipment used in the manufacturing process.

Portable mix tanks, either alone or in combination with an agitator, are a common emission source. Portable mix tanks are used to mix product and to keep the pigment in suspension. They are also used to transfer material from one manufacturing stage to the next. While they are being used for mixing, the tanks are often, but not always, covered with either plastic or stainless steel lids. If a cover is used on a mix tank during mixing, it will have a four to six inch opening through which the agitator shaft extends. In some cases, only a splash guard is used to cover the back half of the mix tank. When mix tanks are used for temporary storage, they are covered with a solid lid, either plastic or stainless steel. None of the lids seal with the mix tanks.

Vertical media mills, or sand mills, are used to disperse pigment throughout the paint. Emissions result from the exposed screen through which warm product filters, possibly clogging the screen. An operator might apply solvent to unclog the screen, adding to total emissions.

Attritors are vertical, stationary, cylindrical grinding tanks also used to disperse pigment throughout the product mixture. Emissions may occur from the opening surrounding the agitator shaft and/or at product outfall.

Rectangular blend vessels not equipped with sealing lids are another source of VOC emissions. Emissions may occur during product adds through the top hatch.

Another source of emissions is the scale system, where solvent and resin raw materials are measured and transferred from storage tanks to portable mix tanks or other containers. Emissions may occur during transfer and hose connecting and disconnecting. A second scale system consists of a floor scale, a drum, a drum dispenser, and a receiving container. Material is pumped out of the drum into the receiving container. Emissions occur during material transfer and free-fall into the receiving container.

Emissions may also occur from process tanks used for final letdown and tinting prior to filling operations.

During some product filling operations, portable mix tanks are mechanically lifted and tilted, allowing a finished product to gravity feed into containers for shipment (i.e., pails, drums, and tote bins).

In addition to emissions from process operations, VOCs are also released from a variety of cleaning operations. The areas where portable mix tanks, mix tank lids, and portable pumps are washed are sources of VOC emissions. The tote bin cleaning area and filter cleaning station also contribute to plant releases, as does the still itself.

All of the areas, with the exception of the temporary storage of portable mix tanks, are equipped with exhaust ducts connected to headers and/or the central ventilation system. Emissions captured by the ducts in the manufacturing area are burned in the REECO I incinerator.

PPG calculates SARA Section 313 releases based on consumption figures, so no studies have been done to determine emission breakdown by process. Attachment 4 contains SARA Section 313 air releases for 1988 to 1990. The facility has not examined emission contribution from janitorial supplies.

TYPICAL PRODUCTION SOLVENTS

SOLVENT BASE TOPCOAT	WATER BASE TOPCOAT	CATIONIC PRI. R
Toluene	Hexyl Cellosolve	Butyl Cellosolve
Xylene	Mineral Spirits	Methyl Isobutyl K e
Ethyl Alcohol	Propylene Diisopropyl Amine	Deionized Water
Isobutyl Alcohol	Dimethyl Ethanolamine	
Ethylene Glycol	Propylene Glycol Monomethyl Ether	
Methyl Isobutyl Ketone	Methyl Ether	
Heptane	Isobutyl Alcohol	
Isobutyl Acetate	Ethylene Glycol	
Isopropyl Alcohol	Xylene	
Butyl Acetate	Deionized Water	
Methyl Ethly Ketone		

[redacted] "PPG Industries, Inc." or any subsequent owner or operator of the "PPG Industries, Inc." facility located at 3800 West 143rd street, Cleveland, Ohio shall comply, on and after May 25, 1988, with the following requirements for the VOC emissions from the paint manufacturing operations and associated paint laboratory operations:

(1) The paint manufacturing operations shall include the following equipment: mixing tanks for paint liquids and pigments, grinding mills, paint thinning and tinting tanks, paint filling equipment for shipping containers, cleaning equipment for paint processing equipment, and recovery equipment for the cleaning solvents. The paint laboratory operations shall include the following equipment: paint spray booths and associated ovens within the paint manufacturing quality control laboratory and the paint research laboratory.

(2) Except as otherwise provided in paragraph (MM)(4) of this rule, the VOC emissions from the equipment included within the paint manufacturing operations shall be vented either directly or by means of a building or local area exhaust to a control system which shall maintain compliance with any of the following requirements:

(a) A minimum control efficiency of 98.0 per cent by weight for the VOC emissions;

(b) A maximum outlet VOC concentration of twenty parts per million by volume (dry basis); or

(c) A minimum incineration temperature of one thousand five hundred degrees Fahrenheit.

(3) Except as otherwise provided in paragraph (MM)(4) of this rule, the VOC emissions from the equipment included within the paint laboratory operations shall be vented to a control system which shall maintain compliance with a minimum control efficiency of ninety per cent by weight for the VOC emissions or a maximum outlet VOC concentration of twenty parts per million by volume (dry basis).

(4) The requirements of paragraphs (MM)(2) and (MM)(3) of this rule shall not apply to any specific piece of equipment included within the paint manufacturing operations or the paint laboratory operations during each of the following situations:

(a) During any period in which there is no production activity or laboratory activity at said equipment; and

(b) During the processing or use of a waterbased paint material in said equipment, provided the following two conditions are met:

(i) The VOC content of the waterbased paint material is less than or equal to 12.0 per cent VOC by weight, as determined under paragraph (B) of rule 3745-21-10 of the Administrative Code; and

(ii) Any VOC emissions from the processing or use of the waterbased paint material that are not vented to the control systems specified in paragraphs (MM)(2) and (MM)(3) of this rule are included (accounted for) in a permit to install issued by the director after the effective date of this rule pursuant to Chapter 3745-31 of the Administrative Code.

(5) The VOC control efficiency or outlet VOC concentrations shall be determined in accordance with paragraph (C) of rule 3745-21-10 of the Administrative Code.

(6) For a control system identified in paragraph (MM)(2) or (MM)(3) of this rule that employs incineration, the incineration temperature shall be determined by means of a continuous measurement and recording of such temperature.

(7) Any mixing or blending tank containing a paint material shall be equipped with a cover or lid that completely covers the opening of the tank, except for an opening no larger than necessary to allow for safe clearance for the mixer's shaft. Such tank shall be covered at all times in which the tank contains a paint material except when operator access is necessary to add ingredients or take samples.

(NN) "Midwest Mica and Insulation Company" or any subsequent owner or operator of the "Midwest Mica and Insulation Company" facility located at 4853 West 130th street, Cleveland, Ohio shall not cause, allow or permit the discharge into the ambient air of any VOC from any mica coating or laminating line after the date specified in paragraph (C)(48) of rule 3745-21-04 of the Administrative Code unless the VOC emissions from the associated oven are vented to a control system that is designed and operated to achieve a control efficiency which is at least ninety-eight per cent by weight or an outlet VOC concentration which is less than or equal to twenty parts per million by volume (dry basis), either of which is determined under paragraph (C) of rule 3745-21-10 of the Administrative Code. This requirement shall not apply to any mica coating or laminating line which employs less than five tons of VOC per year.

REECO I AND II COMPLIANCE TEST RESULTS

		Inlet Concentration	Outlet Concentration	Reduction Efficiency
REECO I	Test 1	872.0 ppm	11.7 ppm	98.7%
7/12/84	Test 2	749.8 ppm	26.5 ppm	96.5%
1500°F	Test 3	1080.0 ppm	52.4 ppm	95.2%
REECO I	Test 1	920.4 ppm	27.8 ppm	97.0%
7/13/84	Test 2	899.0 ppm	63.3 ppm	93.0%
1400°F	Test 3	1208.0 ppm	59.6 ppm	95.1%
REECO II	Test 1	91.0 ppm	6.0 ppm	93.0%
1/26/87	Test 2	88.0 ppm	6.0 ppm	92.8%
1500°F	Test 3	89.0 ppm	4.0 ppm	95.1%
REECO II	Test 1	60.0 ppm	7.0 ppm	88.4%
1/27/87	Test 2	98.0 ppm	12.0 ppm	88.2%
1400°F	Test 3	97.0 ppm	10.0 ppm	89.3%

SARA 313 REPORTED AIR RELEASES

Chemical	1988	1989	1990
Acetone	200	301	214
Ethylbenzene	1000	920	754
Formaldehyde	0	20	124
Glycol Ethers	69	58	45
Methanol	2700	2711	3367
Methyl Ethyl Ketone	4843	3704	2152
Methyl Isobutyl Ketone	664	571	494
Butyl Alcohol	0	67	41
Toluene	1334	1023	1132
Xylene	5000	4603	2447
Barium	933	579	573
Chromium	140	215	47
Copper	0	41	50
Lead	677	454	489

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16. ABSTRACT

This document presents the results of a study to collect and report information on processes used to manufacture paint & ink, volatile organic compounds (VOC) emissions generated during these operations, emission control techniques and their effectiveness, and costs associated with process changes and emission control options.

17. KEY WORDS AND DOCUMENT ANALYSIS

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