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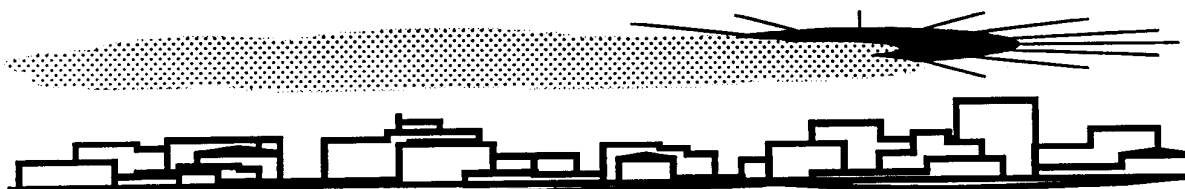
Office of Air Quality
Planning and Standards
Research Triangle Park, NC 27711

EPA-454/R-93-046
March 1994

Air



LOCATING AND ESTIMATING AIR EMISSIONS FROM SOURCES OF METHYL ETHYL KETONE



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FROM SOURCES OF METHYL ETHYL KETONE

Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
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EXECUTIVE SUMMARY

Emissions of methyl ethyl ketone (MEK) into the atmosphere are of special significance because of the Clean Air Act Amendments of 1990. These amendments mandate that MEK emissions be subject to standards that allow for the maximum degree of reduction of emissions and that, by 1995, a list of source categories be established that accounts for no less than 90 percent of MEK emissions. This document is designed to assist groups interested in inventorying air emissions of MEK by providing a compilation of available information on sources and emissions of this substance.

MEK is a colorless organic liquid with an acetone-like odor. In the U.S., MEK is produced using dehydrogenation of secondary butyl alcohol (approximately 86%) and as a by-product of butane oxidation (remaining 14%). U.S. production in 1990 was about 215 million kilograms (473 million pounds).

MEK is used as a solvent in the manufacture of adhesives, protective coatings, inks and magnetic tapes. It is also the preferred extraction solvent for dewaxing lube oil.

At the time of publication of this document, estimates of nationwide emissions of MEK were not available. Updates to this document will attempt to incorporate any nationwide emission estimates subsequently developed.

SECTION 1.0
PURPOSE OF DOCUMENT

The Environmental Protection Agency (EPA) and State and local air pollution control agencies are becoming increasingly aware of the presence of substances in the ambient air that may be toxic at certain concentrations. This awareness, in turn, has led to attempts to identify source/receptor relationships for these substances and to develop control programs to regulate emissions. Unfortunately, very little information is available on the ambient air concentrations of these substances or on the sources that may be discharging them to the atmosphere.

To assist groups interested in inventorying air emissions of various potentially toxic substances, EPA is preparing a series of documents such as this that compiles available information on sources and emissions of these substances. Prior documents in the series are listed below:

<u>Substance</u>	<u>EPA Publication Number</u>
Acrylonitrile	EPA-450/4-84-007a
Carbon Tetrachloride	EPA-450/4-84-007b
Chloroform	EPA-450/4-84-007c
Ethylene Dichloride	EPA-450/4-84-007d
Formaldehyde (Revised)	EPA-450/2-91-012
Nickel	EPA-450/4-84-007f
Chromium	EPA-450/4-84-007g
Manganese	EPA-450/4-84-007h
Phosgene	EPA-450/4-84-007i
Epichlorohydrin	EPA-450/4-84-007j
Vinylidene Chloride	EPA-450/4-84-007k
Ethylene Oxide	EPA-450/4-84-007l
Chlorobenzenes	EPA-450/4-84-007m
Polychlorinated Biphenyls (PCBs)	EPA-450/4-84-007n
Polycyclic Organic Matter (POM)	EPA-450/4-84-007p
Benzene	EPA-450/4-84-007q
Organic Liquid Storage Tanks	EPA-450/4-88-004
Coal and Oil Combustion Sources	EPA-450/2-89-001
Municipal Waste Combustors	EPA-450/2-89-006
Perchloroethylene and Trichloroethylene	EPA-450/2-90-013

<u>Substance</u>	<u>EPA Publication Number</u>
1,3-Butadiene	EPA-450/2-89-021
Chromium (supplement)	EPA-450/2-89-002
Sewage Sludge	EPA-450/2-90-009
Styrene (revised)	EPA-450/4-91-029
Methylene Chloride	EPA-454/R-93-006

This document deals specifically with methyl ethyl ketone (MEK). Its intended audience includes Federal, State, and local air pollution personnel and others who are interested in locating potential emitters of MEK, and making gross estimates of air emissions therefrom.

Because of the limited amounts of data available on potential sources of MEK emissions, and since the process configurations, control equipment, and operating procedures of many sources will not be the same as those described here, this document is best used as a primer to inform air pollution personnel about (1) the types of sources that may emit MEK, (2) process variations and release points that may be expected within these sources, and (3) available emissions information indicating the potential for MEK to be released into the air from each operation.

The reader is strongly cautioned against using the emissions information contained in this document to develop an exact assessment of emissions from any particular facility. Because insufficient data are available to develop statistical estimates of the accuracy of these emission factors, no estimate can be made of the error that could result when these factors are used to calculate emissions from any given facility. It is possible, in some extreme cases, that order-of-magnitude differences could result between actual and calculated emissions, depending on differences in source configurations, control equipment, and operating practices. Thus, in situations where an accurate assessment of MEK emissions is necessary, source-specific information should be obtained to confirm the existence of particular emitting operations, the types and effectiveness of control measures, and the impact of operating practices. A source test and in some cases a material balance should be considered as the best means to determine air emissions directly from an operation.

In addition to the information presented in this document, another potential source of emissions data for MEK is the Toxic Chemical Release Inventory (TRI) form required by Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA 313).¹ SARA 313 requires owners and operators of certain facilities that manufacture, import, process, or otherwise use certain toxic chemicals to report annually their releases of these chemicals to any environmental media. As part of SARA 313, EPA provides public access to the annual emissions data. The TRI data include general facility information, chemical information, and emissions data. Air emissions data are reported as total facility release estimates, broken out into fugitive and point components. No individual process or stack data are provided to EPA. The TRI requires the use of available stack monitoring data or measurement of emissions to comply with SARA 313. If monitoring data are unavailable, emissions are to be quantified based on the use of best engineering judgement to estimate releases to the environment.

The reader is cautioned that the TRI will not likely provide facility, emissions, and chemical release data sufficient for conducting detailed exposure modeling and risk assessment. In many cases, the TRI data are based on annual estimates of emissions (*i.e.*, on emission factors, material balances, engineering judgement) rather than on direct measurement of emissions. The reader is urged to obtain TRI data in addition to information provided in this document to locate potential emitters of methyl ethyl ketone, and to make preliminary estimates of air emissions from these facilities. To obtain an exact assessment of air emissions from processes at a specific facility, source tests or in some cases detailed material balance calculations should be conducted, and detailed plant site information should be compiled.

Each L&E document, as standard procedure, is sent to government, industry, and environmental groups wherever EPA is aware of expertise. These groups are given the opportunity to review the document, comment, and provide additional data where applicable. Where necessary, the documents are then revised to incorporate these comments. Although these documents have undergone extensive review, there may still be shortcomings. Comments subsequent to publication are welcome and will be addressed based on available time and resources. In addition, any information is welcome on process descriptions, operating parameters,

control measures, and emissions information that would enable EPA to improve the contents of this document. Comments and information may be sent to the following address:

Chief, Emission Factor and Methodologies Section
Emission Inventory Branch, (MD-14)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

1.1 REFERENCE FOR SECTION 1.0

1. Toxic Chemical Release Reporting: Community Right-To-Know. Federal Register 52(107): 21152-21208. June 4, 1987.

SECTION 2.0 OVERVIEW OF DOCUMENT CONTENTS

As noted in Section 1.0, the purpose of this document is to assist Federal, State and local air pollution agencies and others who are interested in locating potential air emitters of MEK and making gross estimates of air emissions therefrom. Because of the limited background data available, the information summarized in this document does not and should not be assumed to represent the source configuration or emissions associated with any particular facility.

This section provides an overview of the contents of this document. It briefly outlines the nature, extent, and format of the material presented in the remaining sections of this report.

Section 3.0 of this document briefly summarizes the physical and chemical characteristics of MEK, and provides an overview of its production and use. This background section may be useful to someone who needs to develop a general perspective on the nature of this substance and how it is manufactured and consumed.

Section 4.0 of this document focuses on major production source categories that may discharge air emissions containing MEK. Section 5.0 discusses the uses of MEK as industrial feedstocks and major solvent uses, particularly paint and ink manufacturing, degreasing, and coating operations. Section 6.0 addresses residual emissions from industry and Section 7.0 describes emissions from industries which may produce MEK as a by-product of processes (*e.g.*, burning of fuel oil). Example process descriptions and flow diagrams are provided, where applicable, in addition to available emission factor estimates for each major industrial source category described in Sections 4.0, 5.0, 6.0, and 7.0. Individual companies involved with either the production or use of MEK are reported throughout the document. The reported information was extracted primarily from trade publications.

Section 8.0 of this document summarizes available procedures for source sampling and analysis of methyl ethyl ketone. The summaries provide an overview of applicable sampling and

analytical procedures, citing references for those interested in conducting source tests. Although a National Institute of Occupational Safety and Health (NIOSH) procedure is provided, no EPA endorsement of this method is given or implied.

Appendix A identifies potential source categories of MEK emissions by Standard Industrial Classification (SIC) code and associated description. These potential source categories do not necessarily denote significant sources of MEK emissions. For those interested in cross referencing SICs with Source Classification Codes (SCCs) and associated descriptions, the reader should consult the *Crosswalk/Air Toxic Emission Factor Database Management System, Version 1.2* (October 1991).¹ The *Volatile Organic Compound (VOC)/Particulate Matter (PM) Speciation Database Management System, Version 1.4* (October 1991) also provides SCC level emission source identification.² Appendix B presents paint and ink manufacturing facilities and printing facilities with annual sales greater than \$1,000,000. Appendix C summarizes, in table format, all emission factors listed in this document.

Each emission factor listed in Sections 4.0 through 7.0 has been assigned an emission factor grade based on the criteria for assigning data quality and emission factor ratings as presented in the document *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections*. These criteria for rating test data used to develop emission factors are presented below.³ The data used to develop emission factors are rated as follows:

- A - Tests performed by a sound methodology and reported in enough detail for adequate validation. These tests are not necessarily EPA reference test methods, although such reference methods are certainly to be used as a guide.
- B - Tests that are performed by a generally sound methodology but lack enough detail for adequate validation.
- C - Tests that are based on a nonvalidated or draft methodology or that lack a significant amount of background data.
- D - Tests that are based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

Because of the almost impossible task of assigning a meaningful confidence limit to industry-specific variables (*i.e.*, sample size vs. sample population, industry and facility variability, method of measurement), the use of a statistical confidence interval for an emission factor is not practical. Therefore, some subjective quality rating is necessary. The following emission factor quality ratings are applied to the emission factor tables.

A - Excellent. The emission factor was developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category* is specific enough to minimize variability within the source category population.

B - Above average. The emission factor was developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. As in the A rating, the source category is specific enough to minimize variability within the source category population.

C - Average. The emission factor was developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As in the A rating, the source category is specific enough to minimize variability within the source category population.

D - Below average. The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are footnoted in the emission factor table.

E - Poor. The emission factor was developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are always footnoted.

U - Unrated or Unratable. The emission factor was developed from suspect data with no supporting documentation to accurately apply an A through E rating. A "U" rating may be applied in the following circumstances:⁴

- a gross mass balance estimation
- QA/QC deficiencies found with C- and D-rated test data

*Source category: A category in the emission factor table for which an emission factor has been calculated; generally a single process.

- gross engineering judgement
- technology transfer

This document does not contain any discussion of health or other environmental effects of MEK. It does include a discussion of ambient air monitoring techniques; however, these ambient air monitoring methods may require modifications for stack sampling which may affect data quality.

2.1 REFERENCES FOR SECTION 2.0

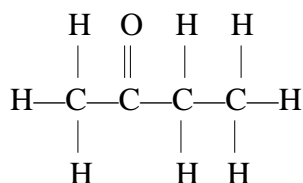
1. U.S. Environmental Protection Agency. *Crosswalk/Air Toxic Emission Factor Database Management System, Version 1.2*. EPA-450/4-91-028. Office of Air Quality Planning and Standards. Research Triangle Park, NC. October 1991.
2. U.S. Environmental Protection Agency. *Volatile Organic Compound (VOC) Particulate Matter (PM) Speciation Database Management System, Version 1.4*. Research Triangle Park, NC. October 1991.
3. U.S. Environmental Protection Agency. *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections*. Draft Document. Office of Air Quality Planning and Standards, Research Triangle Park, NC. March 1992.
4. Group discussion meeting on applying "U" rating to emission factors. Anne Pope, EIB; Robin Baker Jones, Midwest Research Institute; Garry Brooks, Radian Corporation; and Theresa Moody, TRC Environmental Corporation.

SECTION 3.0 BACKGROUND

3.1 NATURE OF POLLUTANT

Methyl ethyl ketone, also known as 2-butanone, is a colorless organic liquid with an acetone-like odor and a low boiling point.¹ It is partially miscible with water and many conventional organic solvents and forms azeotropes with a number of organic liquids.² MEK is distinguished by its exceptional solvency, which enables it to formulate higher-solids protective coatings.^{1,2}

The molecular formula of methyl ethyl ketone is $\text{CH}_3\text{COCH}_2\text{CH}_3$; its molecular structure is represented as:



Some physical and chemical properties of MEK are presented in Table 3-1. Because of MEK's high reactivity, it is estimated to have a short atmospheric lifetime of approximately eleven hours. Atmospheric lifetime is defined as the time required for the concentration to decay to 1/e (37 percent) of its original value.³

3.2 OVERVIEW OF PRODUCTION AND USE

Methyl ethyl ketone production in the United States is accomplished by one of two processes: (1) dehydrogenation of secondary butyl alcohol or (2) as a by-product of butane oxidation. Approximately 86 percent of the total 1991 production capacity in the United States (280 million kg or 617 million lbs) utilized dehydrogenation of secondary butyl alcohol while

**TABLE 3-1.
PHYSICAL AND CHEMICAL PROPERTIES OF MEK**

Property	Value
Structural formula: $\text{CH}_3\text{COCH}_2\text{CH}_3$	
Synonyms: 2-butanone, ethyl methyl ketone, MEK, methyl acetone	
CAS registry number: 78-93-3	
Molecular weight (grams)	72.1
Melting point, °C	-86.3
Boiling point, °C	79.6
Density at 20°C, g/L	804.5
Vapor density (air at 101 kPa, 0°C = 1)	2.41
Critical temperature, °C	260
Critical pressure, MPa	4.4
Surface tension at 20°C, dyne/cm	24.6
Dielectric constant at 20°C	15.45
Heat of combustion at 25°C, kJ/mol	2,435
Heat of fusion, kJ/(kg*K)	103.3
Heat of formulation at constant pressure, kJ/mol	279.5
Specific heat: vapor at 137°C, J/(kg*K) liquid at 20°C, J/(kg*K)	1,732 2,084
Latent heat of vaporization at 101.3 kPa, kJ/mol	32.8
Flashpoint (closed cup), °C	-6.6
Ignition temperature, °C	515.5
Explosive limits, volume % MEK in air lower upper	2 12
Threshold limit, ppm	200
Vapor pressure at 20°C, mm Hg	77.5
Viscosity, MPa*s (=cP) at 0°C at 20°C at 40°C	0.54 0.41 0.34
Solubility at 90°C, g/L of water	190

Source: References 2-4.

the remaining 14 percent utilized butane oxidation.^{1,5} Actual domestic production in 1990 was about 215 million kg (473 million lbs).¹

Figure 3-1 illustrates the production and use of MEK. Major end-users of MEK include protective coating solvents (61 percent), adhesives (13 percent), and magnetic tapes (10 percent). Vinyls are the primary resins that employ MEK as a solvent. Methyl ethyl ketone is commonly used as a solvent in rubber cements, as well as in natural and synthetic resins for adhesive use. It is also the preferred extraction solvent for dewaxing lube oil and is used in printing inks.¹

Overall, the projected use of MEK is expected to gradually decline during the 1990s. The growing trend towards water-based, higher-solids, and solventless protective coatings, inks, and adhesives should reduce the demand for MEK. The installation of solvent recycling facilities will also reduce requirements for fresh solvent production. Although MEK is favored as a solvent due to its low density, low viscosity, and high solvency, its recent addition on the EPA's hazardous air pollutants list will likely cause potential users to consider other comparative solvents such as ethyl acetate.¹

3-4

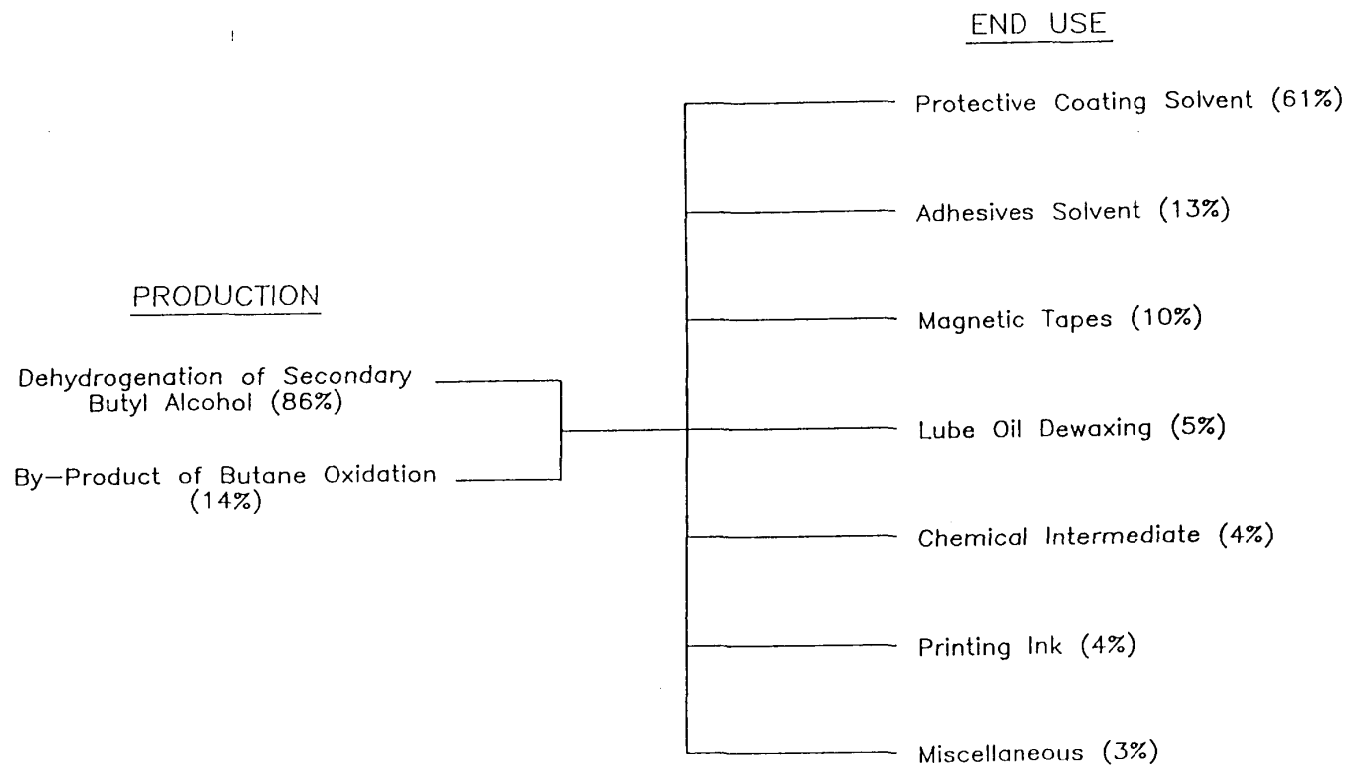


Figure 3-1. MEK production and use tree.¹

3.3 REFERENCES FOR SECTION 3.0

1. *Chemical Products Synopsis for Methyl Ethyl Ketone*. Mannsville Chemical Products Corporation. Asbury Park, NJ. January 1991.
2. *Kirk-Othmer Encyclopedia of Chemical Technology*. Third Edition, Volume 13. John Wiley and Sons. New York, NY. 1983.
3. Lowenheim, Fredrick A. and Marguerite K. Moran. *Faith, Keyes, and Clark's Industrial Chemicals*. Fourth Edition. 1975.
4. Verschveren, Karel. *Handbook of Environmental Data on Organic Chemicals*. Second Edition. Van Nostrand Reinhold Company. New York, NY. 1983.
5. *1990 Directory of Chemical Producers - United States of America*. SRI International.

SECTION 4.0

EMISSIONS FROM METHYL ETHYL KETONE PRODUCTION

Methyl ethyl ketone production and the associated air emissions are described in this section. Process flow diagrams are included as appropriate, with specific streams or vents labeled to correspond with the discussion in the text. Emission factors for the production processes are presented when available, and control technologies are described. The reader should contact the specific facility being included in an emissions inventory to verify the nature of the process used, production volume, and controls in place before applying any of the emission factors presented.

Methyl ethyl ketone is currently produced at three separate facilities in the United States. The production locations, capacities (for 1991), and manufacturing process type are presented in Table 4-1. The total domestic production for MEK during 1990 was 215 million kg (473 million lbs).¹ Figure 4-1 illustrates that all domestic MEK manufacturing facilities are located in States that border the Gulf Coast. Two of the three facilities, Exxon Chemicals, and Shell Chemical, manufacture MEK by dehydrogenation of secondary-butyl alcohol (also known as sec-butyl alcohol or 2-butanol). The other facility (Hoechst-Celanese) produces MEK as a by-product during the oxidation of n-butane in the production of acetic acid.^{1,2} Both of these processes are described in this section.

As mentioned in Section 3.0, the projected use of MEK is expected to gradually decline during the 1990s. United States' demand has been projected to drop to less than 159 million kg (350 million lbs) by 1995. Table 4-2 lists historical and projected figures for domestic MEK capacity, production, imports, exports, and demand.¹

Sections 4.1 and 4.2 discuss processes and process emissions from secondary-butyl alcohol dehydrogenation and n-butane oxidation, respectively. Section 4.3 contains a brief description of n-butene oxidation, which is a relatively new MEK production process not currently commercialized in the United States. Finally, Sections 4.4 and 4.5 discuss storage and handling emissions and equipment leak emissions which are applicable to processes described in both

**TABLE 4-1.
PRODUCERS AND CAPACITIES OF MEK^a**

Producer	Location	Method of Manufacturing MEK	1991 Capacity	
			million kg	(million lbs)
Exxon Chemicals	Baton Rouge, LA	DSBA ^b	104	(230)
Hoechst-Celanese	Pampa, TX	OB ^c	39	(85)
Shell Chemical	Norco, LA	DSBA	104	(230)
Total			280	(617)

^a Based on announced capacities and trade estimates. Exxon began operation at its new Baton Rouge, LA plant in late 1988. Exxon's Linden, NJ facility, with an annual capacity of 136 million kg (300 million lbs), was shut down in 1988. In 1988, Union Carbide reportedly began interim production of MEK at Institute, WV in a unit with an annual capacity of less than 4.5 million kg (10 million lbs).

^b Dehydrogenation of secondary-butyl alcohol.

^c Oxidation of butane.

Source: Reference 1.



LEGEND OF PLANT NAMES AND LOCATIONS
1. Exxon Chemicals in Baton Rouge, LA
2. Hoechst-Celanese in Pampa, TX
3. Shell Chemical in Norco, LA

Figure 4-1. Locations of plants manufacturing MEK.¹

**TABLE 4-2.
MEK HISTORICAL AND PROJECTED DATA (MILLION LBS)**

									Projected	
	1970	1975	1980	1985	1987	1988	1989	1990	1991	1993
Capacity	565	600	878	700	692	622	622	617	617	545
Production	480	425	587	537	672	482	449	473 ^a	N/A ^b	N/A
Imports	33	40	8	61	38	102	74	47	N/A	N/A
Exports	22	47	69	77	101	57	79	83	N/A	N/A
Demand	491	418	526	521	609	527	444	437	430	380

^a Preliminary projection

^b N/A - not available

Source: Reference 1.

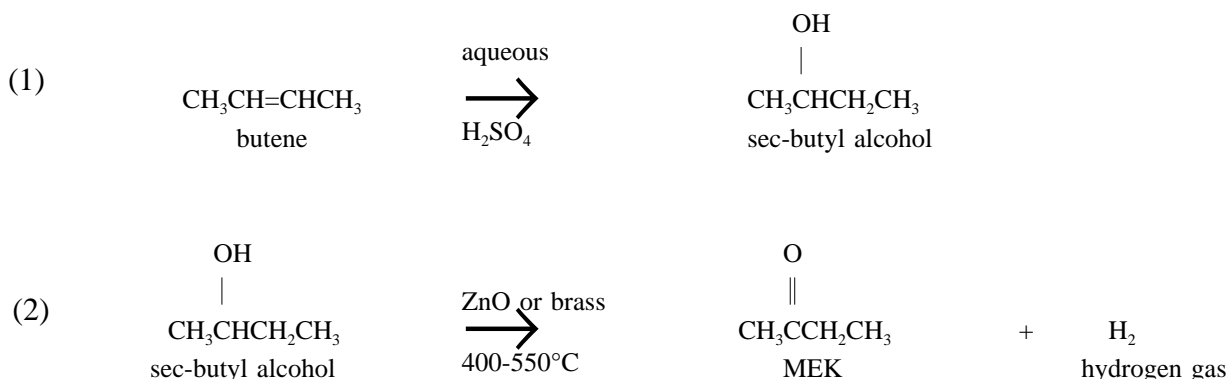
Sections 4.1 and 4.2. The reader should note that this section discusses production process oriented emissions only and that secondary MEK sources such as waste treatment disposal facilities are discussed in Section 6.0 of this document.

4.1 SECONDARY-BUTYL ALCOHOL DEHYDROGENATION

The majority of MEK manufactured in the United States is produced by dehydrogenation of secondary-butyl alcohol. The two operating facilities in the United States using this production method have the capacity to produce an annual total of 241 million kg (532 million lbs), based on 1991 data, from the dehydrogenation process.¹ This subsection discusses the 2-butanol dehydrogenation process.

4.1.1 Dehydrogenation Process Description

Methyl ethyl ketone manufacture by secondary-butyl alcohol dehydrogenation is a two-step process where the first step involves the hydration of butenes to produce secondary-butyl alcohol. The second step consists of the dehydrogenation of secondary-butyl alcohol yielding MEK and hydrogen gas. These steps are illustrated by the following reactions:³



Since the first reaction (1) does not involve MEK as a product, this discussion will focus on the second step of the reaction. Figure 4-2 illustrates the process of secondary-butyl alcohol dehydrogenation. Initially, preheated vapors of secondary-butyl alcohol are passed through a reactor (Step 1) containing a catalytic bed of zinc oxide or brass (zinc-copper alloy) which is maintained between 400° and 550°C (750° and 1,025°F). A mean residence time of two to eight seconds at normal atmospheric pressures is required for conversion from secondary-butyl alcohol to MEK.^{3,4}

Product gases from the reaction vessel are then condensed via a brine-cooled condenser (Step 2) and sent to a distillation column for fractioning (Step 3). The main fraction (methyl ethyl ketone) is typically obtained at an 85 to 90 percent yield based on the mass of secondary-butyl alcohol charged. The uncondensed gas may be scrubbed with water or a nonaqueous solvent to remove any entrained ketone or alcohol from the hydrogen-containing gas (Step 4). The hydrogen may then be re-used, burned in a furnace, or flared.⁵

A liquid-phase process for converting secondary-butyl alcohol to methyl ethyl ketone has been developed and is used in Europe. In this process, secondary-butyl alcohol is mixed with a high-boiling solvent containing suspended finely divided Raney or copper chromite catalyst. The reaction occurs at a temperature of 150°C (300°F) and at atmospheric pressure allowing MEK and hydrogen to be driven off in vapor form and separated as soon as each is formed.⁴ The advantages of this process include a better yield (typically 3 percent better), longer catalyst life, simpler product separation, and lower energy consumption.³

4.1.2 Emissions from Secondary-Butyl Alcohol Dehydrogenation

Process emissions from secondary-butyl alcohol dehydrogenation are noncondensable VOC (including MEK) and hydrogen from the reactor vents and distillation column condenser, each labeled with an emission point A in Figure 4-2. Fugitive emissions can occur at the scrubber, labeled as emission point B. Other fugitive losses occur from equipment leaks, which are discussed in Section 4.5 of this document. These process and fugitive emissions can be collected

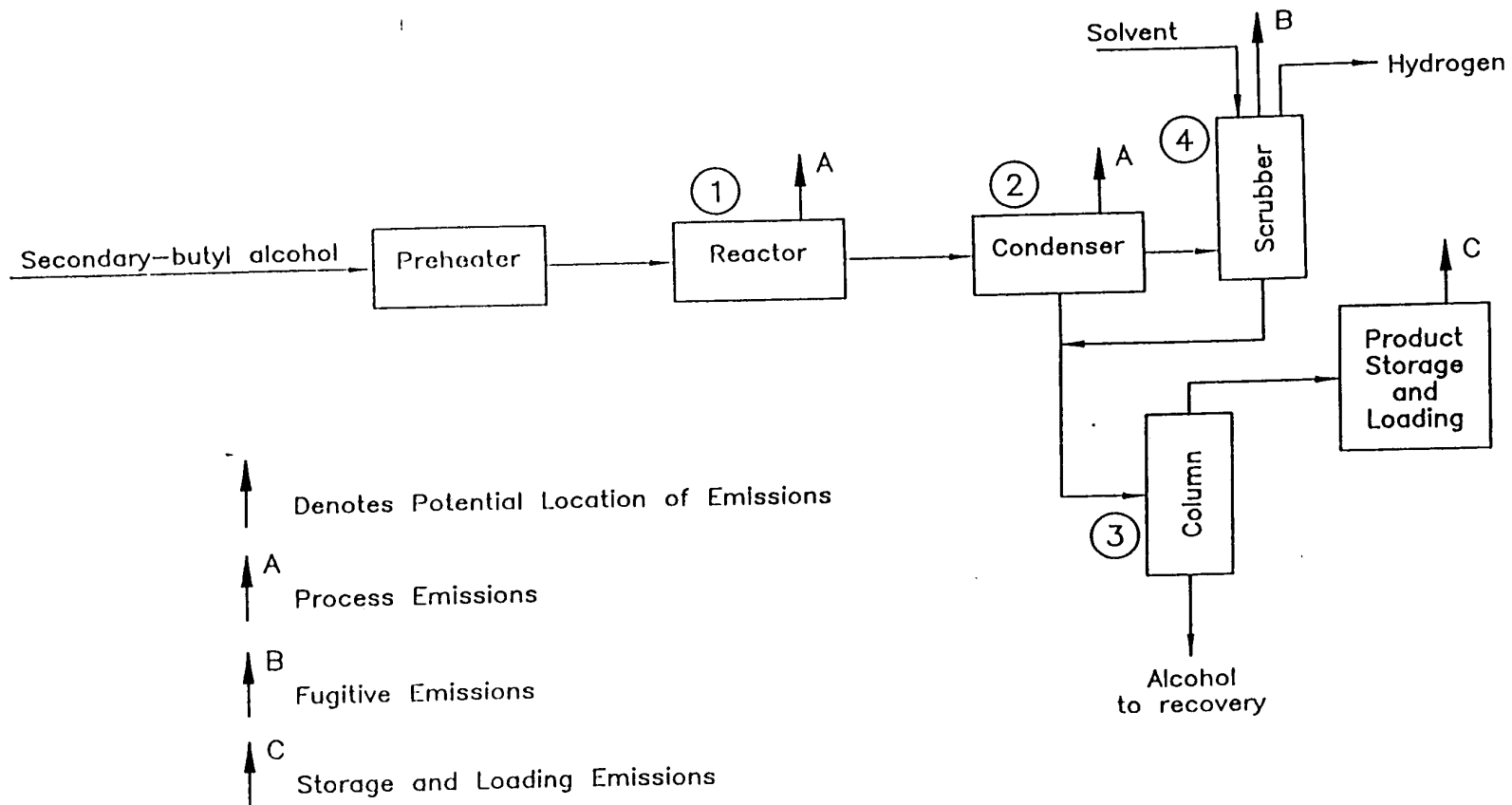


Figure 4-2. Methyl ethyl ketone from secondary-butyl alcohol by dehydrogenation.⁶

and either burned as fuel or used elsewhere in the plant complex. The emissions may be continuous or periodic, depending on the method used to purge noncondensibles from the condensers. Storage and loading emissions (emission point C) are discussed separately in Section 4.4.

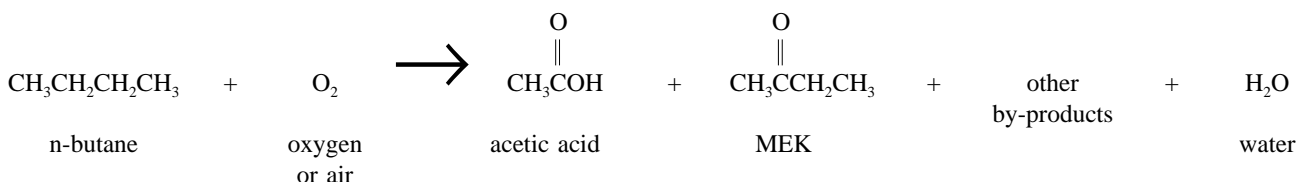
At present, no emission factors are available for MEK production processes. Also, little information on emissions controls used in MEK production is available. One type of control used is incineration, which can potentially reduce MEK emissions by 99 percent.⁵

4.2 n-BUTANE OXIDATION

Methyl ethyl ketone is currently manufactured by liquid-phase oxidation of n-butane at only one facility (Hoescht-Celanese) in the United States, which had a 1991 operating capacity of 39 million kg (85 million lbs).¹ However, MEK has occasionally been commercially available in significant quantities from the liquid-phase oxidation of butane to acetic acid. Depending on the demand for acetic acid, this by-product methyl ethyl ketone can be marketed or recycled.³ This subsection discusses MEK production via n-butane oxidation.

4.2.1 n-Butane Oxidation Process Description

Figure 4-3 illustrates the liquid-phase oxidation of n-butane.⁴ Initially, n-butane and compressed air or oxygen are fed into a reactor (Step 1) along with a catalyst, typically cobalt, manganese or chromium acetate to produce acetic acid, MEK and other by-products such as ethanol, ethyl acetate, formic acid, and propionic acid.⁵ This process produces the following chemical reaction:



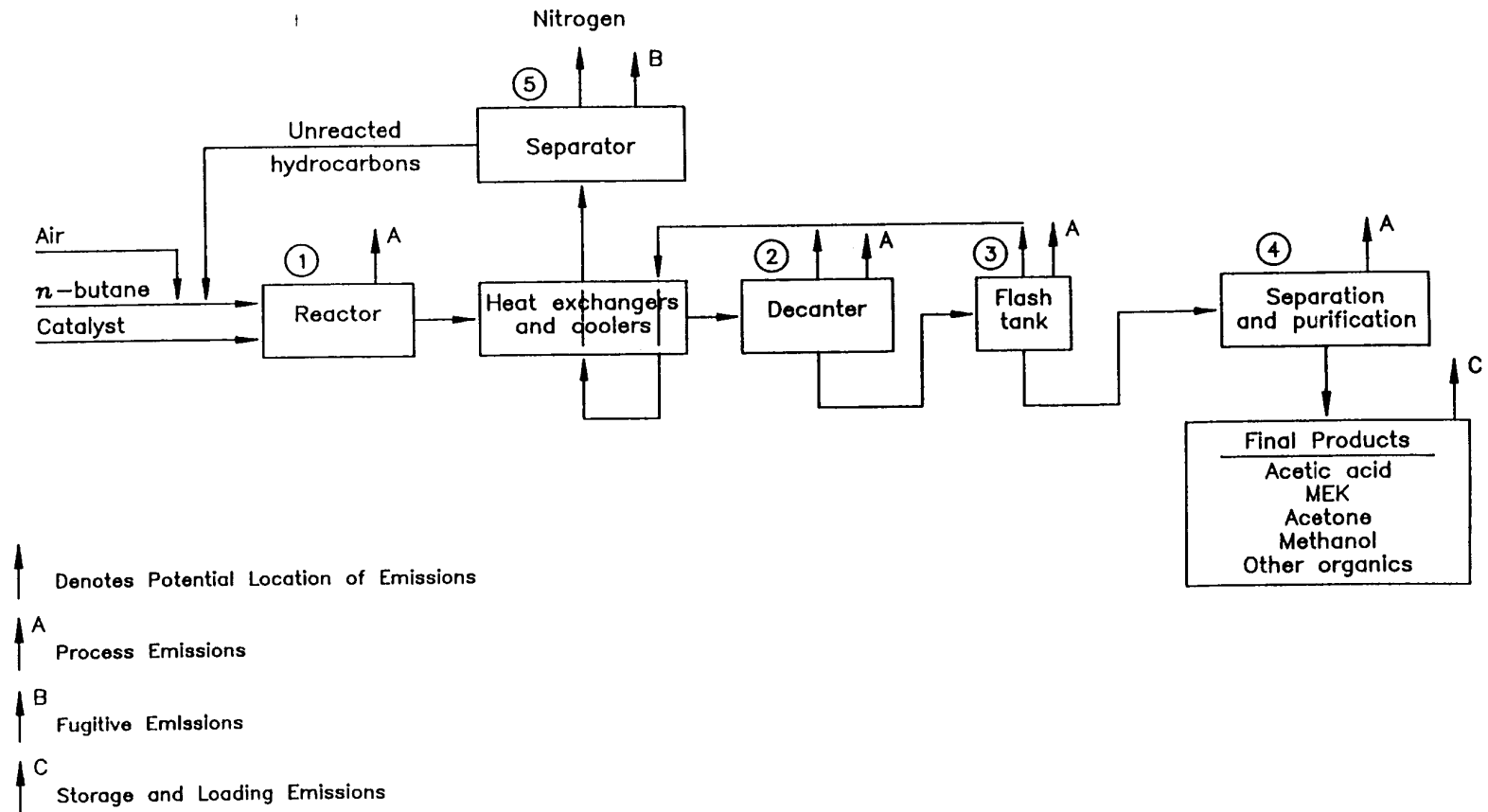


Figure 4-3. Methyl ethyl ketone from n-butane by liquid-phase oxidation.⁶

Air is bubbled through the reactant solution at 150° to 225°C (300° to 440°F) with pressures of about 5.5 MPa (800 psi). Conditions must be carefully controlled to facilitate MEK production and prevent competing reactions that form acetic acid and other by-products. Process conditions can be varied producing different ratios of product components through the choice of raw material, reaction conditions, and recovery methods.⁶

Vapors containing crude acetic acid and the various by-products including MEK are separated from unreacted n-butane and inert gases (Step 2), then stripped or flashed to remove dissolved butane and inert gases (Step 3), and sent to the purification section (Step 4). Unreacted nitrogen leaving the reactor carries various oxidation products (formic, acetic, and propionic acids; acetone, MEK, methanol, etc.) and some unreacted butane and is sent to a separator (condenser) for removal/recycling of unreacted hydrocarbons (Step 5).⁵

The purification section of the plant is complex and highly specialized utilizing three-phase distillation in conjunction with straight extraction.⁶ The low-boiling organics such as MEK are separated from the crude acetic acid by conventional distillation. Azeotropic distillation is used to dry and purify the crude acetic acid. Recovery and purification of the various by-products require several distillation columns and involve extractive distillation or azeotrope breakers or both. Liquid organic wastes are typically burned in boilers to recover their heat value.⁵

4.2.2 Emissions from n-Butane Oxidation

Process emissions from n-butane oxidation include the vent gases from the reactor, decanter, flash tank, and several distillation columns, labeled with an emission point A in Figure 4-3. Fugitive emissions occur from the separator (emission point B) and from equipment leaks (see Section 4.5). Storage and loading emissions (emission point C) are discussed separately in Section 4.4. At present, no emission factor data are available for MEK emissions

from n-butane oxidation processes. Also, little information is available on emissions controls used in this MEK production method.

4.3 n-BUTENE OXIDATION

A new one-step process that converts olefins to ketones called OK technology was developed by Catalytica, Inc., of Mountain View, CA, in 1986. Specifically, MEK is produced via direct oxidation of n-butenes at about 85°C (185°F) and 690 kPa (100 psi), using a proprietary, homogenous nonchloride catalyst. Advantages of this process are that it is non-corrosive, environmentally clean, and economical because of low capital investment and low energy needs. The process is currently in lab-scale operation; however, plans are underway to design a facility outside the United States.¹

4.4 STORAGE AND HANDLING EMISSIONS

Methyl ethyl ketone emissions also occur from storage tank and handling losses during product loading/unloading into drums, tank trucks, tank cars, barges, and ships. These losses are labeled with an emission point C in Figures 4-2 and 4-3. The three most prominent designs of liquid storage vessels are fixed roof, external floating roof, and internal floating roof. Each of these designs and their types of emissions are discussed here.

A typical fixed roof tank consists of a cylindrical steel shell with a permanently affixed roof, which may vary in design from cone- or dome-shaped to flat. Storage losses from fixed roof tanks are referred to as breathing and working losses. Breathing loss is the expulsion of vapor from a tank through vapor expansion and contraction, which are the result of changes in temperature and barometric pressure. The combined loss from filling and emptying the tank is called the working loss.⁷

External floating roof tanks are cylindrical and have a roof that floats on the surface of the liquid being stored. Emissions from external floating roof tanks are the sum of standing

storage loss and withdrawal loss. Standing storage loss can be estimated as the sum of rim seal loss and roof fitting loss. Withdrawal loss occurs as the liquid that clings to the tank wall is exposed to the atmosphere and vaporized when the floating roof is lowered by reducing amounts of stored liquid.⁷

An internal floating roof tank has both a permanent fixed roof and an internal floating deck, which eliminates the vapor space in the tank, thereby reducing the amount of stored liquid that evaporates and can be emitted. Losses from internal floating roof tanks are the sum of withdrawal and standing losses. Withdrawal losses for internal floating roof tanks include vaporization of liquid that clings to the tank wall and any columns present. Standing storage losses include rim seal, deck fitting, and deck seam losses.⁷

Both standing losses and withdrawal losses from storage tanks can be estimated using equations given in the Environmental Protection Agency's report *Estimating Air Toxic Emissions from Organic Liquid Storage Tanks*.⁷

4.5 EQUIPMENT LEAK EMISSIONS

Emissions occur from liquid or gas streams leaking from process equipment components such as pump seals, process valves, compressors, safety relief valves, flanges, open-ended lines, and sampling connections. Emission estimates can be calculated from various methodologies described in the EPA publication *Protocols for Generating Unit-Specific Emission Estimates for Equipment Leaks of VOC and VHAP*.⁸ These methodologies differ in level of complexity; the more complex, the more accurate the emissions estimate.

The simplest methodology, using average emission factors, requires the following input data: number of components by type, MEK percent weight of the stream, and the number of hours per year the component is in service. These data are then multiplied by EPA's average emission factors for the Synthetic Organic Chemical Manufacturing Industry (SOCMI) shown in Table 4-3. Emissions can be estimated by using the formula shown below.⁸

TABLE 4-3.
AVERAGE EMISSION FACTORS FOR FUGITIVE
EQUIPMENT LEAK EMISSIONS

Equipment	Service	Emission Factor (kg/hr/source)	Emission Factor (lb/hr/source)
Valves	Gas	0.0056	0.0123
	Light Liquid	0.0071	0.0157
	Heavy Liquid	0.00023	0.00051
Pump Seals	Light Liquid	0.0494	0.1089
	Heavy Liquid	0.0214	0.0472
Compressor Seals	Gas/Vapor	0.228	0.503
Pressure Relief Seals	Gas/Vapor	0.104	0.229
Flanges	All	0.00083	0.00183
Open-Ended Lines	All	0.0017	0.0037
Sampling Connections	All	0.0150	0.0331

Source: Reference 8.

$$\left[\begin{array}{c} \text{No. of} \\ \text{equipment components} \end{array} \right] \times \left[\begin{array}{c} \text{Weight percent} \\ \text{MEK in the stream} \end{array} \right] \times \left[\begin{array}{c} \text{Component-specific} \\ \text{emission factor} \end{array} \right] \times \left[\begin{array}{c} \text{No. hrs/yr in} \\ \text{MEK service} \end{array} \right]$$

This method should be used only if no other emissions data are available, as it may result in overestimating equipment leak emissions. More complex methodologies may be used to obtain more accurate equipment leak emission estimates. However, these methodologies require that some level of emission measurements (leak concentrations) be made for the facility's process equipment components. These methodologies are briefly described here, and the reader is referred to the EPA Protocols document or *Fugitive Emission Sources of Organic Compounds--Additional Information on Emissions, Emission Reductions, and Costs* for calculation details.^{8,9}

The first method, the leak/no leak approach, is based on a determination of the number of leaking and non-leaking components. A leaking component is defined by a measured or estimated leak concentration greater than or equal to 10,000 ppmv.⁸ Once the number of leaking/nonleaking equipment components have been determined, the fugitive equipment leak emissions are estimated using the appropriate emission factors and the equation identified previously for the average emission factor method.

The second method differentiates fugitive equipment leak emissions into three leak concentration ranges: 0 - 1,000 ppmv; 1,000 - 10,000 ppmv; and greater than 10,000 ppmv. The number of components falling into a particular range is then multiplied by the component-specific emission factor for that range. The component-specific emission factors can be found in EPA's Protocols document.⁸

The third method uses screening data in correlation equations derived by EPA. Correlation equations are only available for flanges, pump seals, and valves in light-liquid and gas service. Finally, the fourth method gives each facility an option to develop its own correlation equations, but requires more rigorous testing, bagging, and analysis of equipment leaks to determine mass emission rates.⁹

Although no specific information on emissions controls used by the industry was identified, equipment components in MEK service typically have some type of control. Generally, control of fugitive emissions requires the use of low-emission or leakless process equipment, an inspection and maintenance program, and routine replacement of chronic leaking components. Typical controls for equipment leaks are listed in Table 4-4.⁹ In addition, other leakless process equipment is available such as leakless valves and sealless pumps.

**TABLE 4-4.
CONTROL TECHNIQUES AND EFFICIENCIES APPLICABLE
TO EQUIPMENT LEAK EMISSIONS**

Equipment Component (Emission Source)	Control Technique	Percent Reduction
Pump Seals		
Packed and mechanical	Seal area enclosure vented to a combustion device	100 ^a 61
	Monthly LDAR ^b	32
	Quarterly LDAR	0
	Semiannual LDAR	0
	Annual LDAR	0
Double mechanical ^c	N/A ^d	--
Compressors	Vent degassing reservoir to combustion device	100 ^a
Flanges	None available	0
Valves		
Gas	Monthly LDAR	73
	Quarterly LDAR	64
	Semiannual LDAR	50
	Annual LDAR	24
Liquid	Monthly LDAR	59
	Quarterly LDAR	44
	Semiannual LDAR	22
	Annual LDAR	0
Pressure Relief Devices		
Gas	Monthly LDAR	50
	Quarterly LDAR	44
	Rupture Disk	100
Sample Connections	Closed-purge sampling	100
Open-ended Lines	Caps on open ends	100

^a Combustion devices approach 100 percent control efficiency.

^b LDAR (Leak detection and repair program).

^c Assumes the seal barrier fluid is maintained at a pressure above the pump stuffing box pressure and the system is equipped with a sensor that detects failure of the seal and/or barrier fluid system.

^d N/A (Not applicable). There are no VOC emissions from this component.

Source: Reference 9.

4.6 REFERENCES FOR SECTION 4.0

1. *Chemical Products Synopsis for Methyl Ethyl Ketone*. A Reporting Service of Mannsville Chemical Products Corporation. Asbury Park, NJ. January 1991.
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4. Lowenheim, Fredrick A. and Marguerite K. Moran. *Faith, Keyes, and Clark's Industrial Chemicals*. Fourth Edition. 1975.
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8. U.S. Environmental Protection Agency. *Protocols for Generating Unit-Specific Emission Estimates for Equipment Leaks of VOC and VHAP*. EPA-450/3-88-010. Office of Air Quality Planning and Standards. Research Triangle Park, NC. 1988.
9. U.S. Environmental Protection Agency. *Fugitive Emission Sources of Organic Compounds--Additional Information on Emissions, Emission Reductions, and Costs*. EPA-450/3-82-010. Office of Air Quality Planning and Standards. Research Triangle Park, NC. April 1982.

SECTION 5.0

EMISSIONS FROM INDUSTRIES USING METHYL ETHYL KETONE AS A SOLVENT

This section discusses emissions from major processes using MEK as a solvent. Potential emission sources are identified and available emission factors are presented. Figure 3-1 (in Section 3.2) presents estimated 1990 data for end-use patterns of MEK.¹ Of these end-uses, only lube oil dewaxing and chemical intermediates are not included here. No process information or emission factor data were available for either of these two end-uses. For end-uses that are discussed here, the reader is advised to contact the specific sources in question to verify the nature of the process, production volume, and control techniques used before applying any of the emission factors presented in this section.

5.1 PAINT, COATING, AND INK MANUFACTURING

Methyl ethyl ketone is one of the many solvents used as a raw material in the manufacture of paints and inks. In 1989, MEK accounted for 7 percent of the 1,972 million kg (4,349 million lbs) of solvents consumed in paints and coatings.² During 1990, paints, coatings, and inks accounted for approximately 65 percent of total MEK domestic consumption.¹

In 1987, Paint and Allied Products facilities (SIC 2851) were composed of 1,123 companies operating 1,426 plants, two-thirds of which were located in 10 states. Also, 1987 Census of Manufacturers data show 504 Printing Ink manufacturing facilities (SIC 2893) in the United States owned by 224 companies in 19 states and the District of Columbia. Over 50 percent of paint manufacturing plants and 60 percent of ink manufacturing facilities were small, employing less than 20 people and specializing in a limited product line marketed within a small geographic region. *Ward's Business Directory* listed 364 paint and allied products facilities in

SIC 2851 with 1990 sales greater than \$1,000,000. *Ward's* also listed 56 ink manufacturing facilities in SIC 2893 with 1990 sales greater than \$1,000,000. These lists are given in Appendix B, Table B-1 and Table B-2.³

Methyl ethyl ketone is only one of several vehicle solvents used by paint and ink manufacturers. One method used to categorize the products of paint manufacturing is end-use (*e.g.*, markets served). The end-use categories are architectural coatings, product coatings for original equipment manufacturers (OEM), and special purpose coatings. Special purpose coatings include industrial construction and maintenance paints designed for extreme conditions, traffic marking paints, marine paints, auto refinishing paints, aerosol paint concentrates, and others.⁴ A summary of MEK consumption in the paint and coating end-use categories and subcategories is found in Table 5-1. MEK is most often used in OEM product coatings such as those for wood furniture and fixtures, containers and closures, automotive finishes, and machinery and equipment.² Paint products may also be classified by the type of vehicle or carrier incorporated in the paint formulation.

The total annual production of paint in the United States consists of 60 percent solvent-borne products, 35 percent water-borne paints, and 5 percent allied products. While more than 70 percent of architectural coatings are water-borne, the majority of product and special purpose coatings are solvent-borne.³

Like paints, inks may also be classified by either end-use or the type of vehicle used in the formulation. The five primary ink categories are letterpress, offset lithography, gravure, flexographic and screen printing. Typically, flexographic, rotogravure, and screen printing inks employ a solvent-based vehicle, while letterpress, lithographic, and offset inks use an oil- or paste-based vehicle. It should be noted that EPA classifies all of these as solvent-based inks. A summary of ink product shipments classified by end-use category and subcategory is given in Table 5-2.³

TABLE 5-1.
ESTIMATED CONSUMPTION OF METHYL ETHYL KETONE
IN PAINTS AND COATINGS, BY MARKET - 1988 AND 1989

Paints and Coatings	MEK Use			
	1988		1989	
	million kg	(million lbs)	million kg	(million lbs)
Wood Furniture and Finishes	7.3	(16)	6.8	(15.0)
Wood Flat Stock	0	(0)	0.1	(0.3)
Metal Furniture and Fixtures	2.3	(5)	2.2	(4.9)
Containers and Closures	5	(11)	4.8	(10.5)
Sheet, Strip and Coil	1.4	(3)	1.4	(3.1)
Major Appliances	1.4	(3)	1.3	(2.8)
Other Appliances	0.9	(2)	0.7	(1.5)
Automotive				
Topcoat	2.7	(6)	2.6	(5.7)
Primer	0.5	(1)	0.6	(1.3)
Underbody Components and Parts	0.5	(1)	0.4	(0.9)
Trucks and Buses	0.9	(2)	0.9	(2.0)
Railroad	0	(0)	0.2	(0.4)
Other Transportation	0.5	(1)	0.4	(0.8)
Machinery and Equipment	0.9	(2)	1.1	(2.4)
Electrical Insulation	0.5	(1)	0.5	(1.0)
Paper, Foil, and Film	1.8	(4)	1.8	(3.9)
Other Product Finishes	5.4	(12)	5	(11.1)
Maintenance	1.4	(3)	1.5	(3.3)
Marine				
Commercial and Maintenance	0.9	(2)	0.7	(1.6)
Auto Refinishing	9.1	(20)	8.5	(18.8)
Traffic Paints	3.6	(8)	3.4	(7.5)
Other	5.4	(12)	5.3	(11.7)
Total Special Purpose	20.4	(45)	19.5	(43)
Thinner and Miscellaneous	90	(199)	86	(190)
TOTAL	162.8	(359)	155.7	(343.5)

Source: Reference 2.

**TABLE 5-2.
INK END-USE CATEGORIES**

Product	1987 Product Shipments ^a	
	Quantity ^b	Value (million dollars)
Letterpress inks	(NA)	164.1
New inks mil lbs	203.1	100.7
Publication inks mil lbs	(S)	9.8
Packaging inks mil lbs	12.1	27.4
Other letterpress inks mil lbs	16.5	20.9
Letterpress inks, n.s.k.	(NA)	5.2
Lithographic and offset inks	(NA)	987.3
News inks mil lbs	314.3	256.9
Publication inks:		
Web types mil lbs	*179.9	311.0
Sheet types mil lbs	**20.0	68.5
Packaging inks mil lbs	18.2	77.7
Web commercial type mil lbs	39.3	73.0
Other lithographic and offset inks, including sheet commercial type mil lbs	*50.8	162.8
Lithographic and offset inks, n.s.k.	(NA)	37.4
Gravure inks	(NA)	414.5
Packaging inks mil lbs	111.3	153.6
Publication inks mil lbs	293.8	248.2
Other gravure inks mil lbs	*0.9	1.4
Gravure inks, n.s.k.	(NA)	11.2
Flexographic inks	(NA)	424.8
Packaging inks:		
Solvent types mil lbs	117.7	189.3
Water types mil lbs	125.0	172.4
Other flexographic inks:		
Solvent types mil lbs	5.2	8.9
Water types mil lbs	19.8	31.0
Flexographic inks, n.s.k.	(NA)	23.1
Printing inks, n.e.c.	(NA)	140.4
Textile printing inks mil lbs	36.0	45.3
Screen printing inks mil lbs	(S)	59.6
Other printing inks, including stencil inks mil lbs	(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
TOTAL	(NA)	2,360.7

^a Data reported by all producers, not just those with shipments of \$100,000 or more.

^b 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).

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

Source: Reference 3.

5.1.1 Paint, Coating and Ink Production Process Description

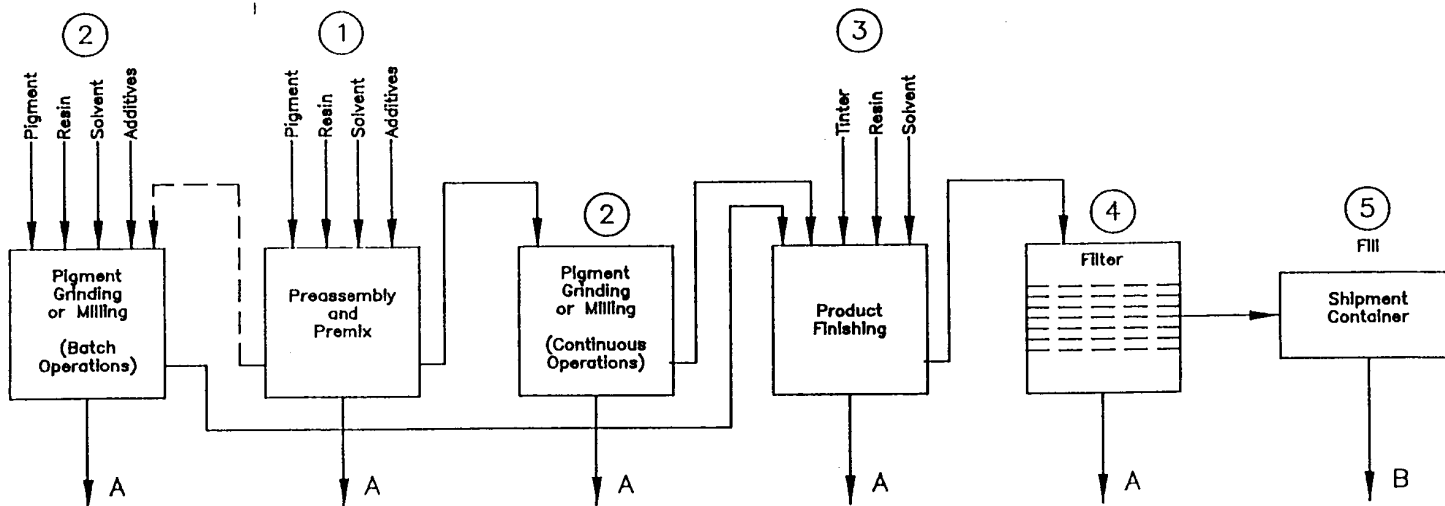
Paint and ink facilities use similar processes to manufacture their respective products in batch-scale fashion. Most small plants (*i.e.*, facilities employing fewer than 20 people) produce paint in 40 to 1,900 liter (10 to 500 gallon) batches, while larger facilities produce paint in 760 to 11,360 liter (200 to 3,000 gallon) batches and some stock items in 37,850 liter (10,000 gallon) runs.^{5,6} Inks are produced in batches ranging from 3.8 liters (1 gallon) to over 3,785 liters (1,000 gallons).⁶

In most cases, paint and ink manufacturing facilities purchase raw materials (*e.g.*, pigments, solvents, resins, and other additives) and then formulate, or blend, a finished product. Normally, no chemical reactions occur during the process.⁶ Batch process production of paint and ink involves four major steps:

- preassembly and premix
- pigment grinding/milling
- product finishing/blending
- product filling/packaging³

Figure 5-1 is a flow diagram for paint and ink manufacturing processes.

The first step in the manufacturing process (Step 1) is preassembly and premix where 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 incorporation of the pigment into the paint or ink vehicle to yield a fine particle dispersion is referred to as pigment grinding or milling (Step 2). Final product specifications are achieved in the product finishing step (Step 3) which consists of three intermediate stages: thinning, tinting and blending. 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 (Step 4).³ The final step in paint and ink manufacturing is product filling operations (Step 5).



↑ Denotes Potential Location of Emissions

↑^A Process Emissions

↑^B Fugitive Emissions

Note: Emissions may result from equipment cleaning at any step in the manufacturing process.

Figure 5-1. Flow diagram of the paint and ink manufacturing process.³

5.1.2 Emissions from Paint and Ink Production

There are three primary factors expected to affect the magnitude of MEK emissions from paint and ink manufacturing. They include the types of solvents and resins used in the manufacturing process, the temperature at which these compounds are mixed, and the methods and materials used during cleanup operations.³

Methyl ethyl ketone may be released from several process steps (each labeled with an emission point A), handling operations (labeled with an emission point B), and cleanup operations throughout the paint and ink manufacturing process, as shown in Figure 5-1. During the preassembly and premix stage (Step 1), emissions may arise from mix tanks or drums while resins are being thinned and other materials are being added. Methyl ethyl ketone emissions can also occur during the pigment grinding step (Step 2) when materials are added to the dispersion equipment. Emissions that occur in the product finishing step (Step 3) are mainly a result of material additions during the thinning and tinting stages; however, MEK emissions from product filling operations (Step 5) result from material transfer and free-fall into the receiving container. Another emission source is the product filtering device (Step 4). As product flows through this device, the material is often exposed to air, resulting in release of incorporated MEK. Fugitive emissions occur as leaks from flanges, valves, and pumps used to transfer material from process equipment in one stage to process equipment in the next stage.³

In addition to emissions from process operations, MEK is also released from a variety of cleaning operations following the manufacture of solvent-based products. In many facilities, manufacturing equipment is cleaned manually (with solvents, brushes, and/or rags) on the production floor on an as-needed basis. The standard method of cleaning grinding mill equipment involves emptying the mill of product and then adding solvent to the vessel to capture remaining product residue. Emissions here occur from cleaning solvent addition and removal as well as the cleaning process.³

Methyl ethyl ketone emissions that occur during the manufacturing steps may be reduced by implementing equipment and process modifications such as use of tank lids or closed-system milling equipment. Emissions from cleaning equipment may be reduced by using rubber wipers, high-pressure spray heads, or automatic tub washers.³

An extensive literature search revealed little current available emission factor data for the manufacture of paints and inks. Solvent losses ranged from 1 to 2 percent under well-controlled conditions to nearly 100 percent for some volatile organic compounds.⁷ The 100 percent loss estimate is conservative, as enough volatile components remain in the paint or ink to keep it fluid and workable. 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 plant emissions, therefore, reflect solvent losses during manufacturing, cleaning operations, and storage.³ At present, solvent losses from most facilities are less than 10 percent.⁴

5.2 SURFACE COATING - GENERAL

According to 1990 data, consumption of MEK in paints and coatings accounted for approximately 61 percent (131 million kg or 288 million lbs) of total MEK solvent sales.¹ Specific details of MEK use in paints and coatings by industrial categories are presented in Section 5.1. Section 5.2 concentrates on the application of these coatings to many different types of surfaces. Sections 5.3 and 5.4 discuss, respectively, Adhesives/Sealants and Magnetic Tape manufacture, two specialized types of surface coatings.

The potent solvency of MEK makes it attractive for the formulation of lower-VOC materials, including higher-solids coatings, to reduce solvent emissions. As stated previously, there are no growth prospects for MEK in paint manufacturing as environmental factors force the

trend toward higher solids, waterborne, solventless, ultraviolet, or electron beam cured systems. Vinyls continue to be the major resins employing MEK as a solvent.¹

Methyl ethyl ketone emissions from surface coating operations are associated with many varied industrial categories. Table 5-3 lists these source categories and their respective SIC codes. Each of these source categories exhibits various application methods, emission sources, and emissions reduction techniques. A summary of these is provided in Table 5-4 along with additional references for each category. Since surface coating is a very broad category, detailed process information and flow diagrams for each source are not included in this document, but may be found in the additional references listed in Table 5-4. Instead, the reader is provided with general coating and finishing techniques, and emissions sources.

5.2.1 Surface Coating Process Description

Industrial surface coating operations use several different methods to apply coatings to substrates. Some of the more commonly used techniques include spraying, dipping, rolling, flow coating, and knife coating. Table 5-4 lists the possible application methods by source category. In addition to the application of coatings to substrates, many surface coating operations also include surface preparation steps (*e.g.*, cleaning and degreasing), drying and curing stages. Spraying operations are normally performed in a spray booth using one of the following spray application methods: air atomization; airless atomization; air-assisted airless atomization; high-volume, low-pressure (HVLP); and electrostatic methods. Dip coating involves immersing the substrate in a tank containing a bath of paint. The object is slowly removed from the tank, allowing excess paint to drain back into the tank. Roller coating is used to apply coatings to flat surfaces. A typical roller coating machine contains three or more power driven rollers, one of which is partially immersed in the coating material. The paint is transferred to a second, parallel roller by direct contact. The sheet to be coated is run between the second and third rollers, and is coated by transfer of paint from the second roller. Flow coating is used on articles which

**TABLE 5-3.
SIC CODES ASSOCIATED WITH SURFACE COATING
PROCESSES**

General Source Category	SIC Codes
Large Appliances and Miscellaneous Metal Parts and Products	2514, 2522 3400, 343 Group, 347 Group, 358 Group, 363 Group, 3651, 3652
Magnet Wire	3351, 3357
Automobiles and Light Duty Trucks ^a	3711, 3713
Cans	3411, 3412
Metals Coils	3353, 3354
Paper and Paperboard	2670
Fabrics	2211, 2221, 2231, 2241, 2261, 2262, 2269, 2281, 2282, 2284, 2295
Wood Products	2420, 2511, 2512, 2517, 2521
Flatwood Products	2435
Plastic Products	3069, 3080
Ship Building and Repairing	3731
Aircraft	3721

^aLocomotives and heavy-duty trucks, hopper car and tank interiors, and paint and drum interiors are covered under metal products.

**TABLE 5-4.
DESCRIPTION OF COATING OPERATIONS, EMISSION SOURCES, AND EMISSION
REDUCTION METHODS FOR SURFACE COATING GROUPS**

General Source Category	Application Methods	Emission Sources	Emissions Reduction Methods ^a	Additional References
Large Appliances	Dip coating Flow coating Spray coating	[1] Cleaning/pretreatment [2] Application area: Prime spray, flow or dip coating operation Topcoat spray [3] Flashoff [4] Oven areas [5] Coating mixing [6] Coating and solvent storage [7] Equipment cleanup [8] Other: All solvent used and not recovered or destroyed may be considered potential emissions.	[1] Thermal incineration ^b [2] Catalytic incineration ^b [3] Carbon adsorbers ^b [4] Waterborne coatings ^c [5] Higher-solids solventborne materials. ^c [6] Electrostatic spray coating ^c [7] Powder coatings ^c	4, 8, 9
Magnet Wire	Coating bath	[1] Cleaning/pretreatment [2] Coating application (low emissions) [3] Exhaust oven (high emissions) [4] Coating mixing [5] Coating and solvent storage [6] Equipment cleanup [7] Other: All solvent used and not recovered or destroyed can be considered potential emissions.	[1] Thermal incineration ^c 90% [2] Catalytic incineration ^c 90% [3] Ultraviolet cure coating ^b [4] Waterborne coating ^b [5] Powder coating ^c	4, 10

(continued)

**TABLE 5-4.
DESCRIPTION OF COATING OPERATIONS, EMISSION SOURCES, AND EMISSION
REDUCTION METHODS FOR SURFACE COATING GROUPS (Continued)**

General Source Category	Application Methods	Emission Sources	Emissions Reduction Methods ^a	Additional References
Automobiles and Light Duty Trucks	Electrodeposition (primer) Manual or automatic spray coating with or without use of electrostatic techniques. Spray applicators include electrostatic rotary atomizers(minibells), robot electrostatic airspray guns, automatic electrostatic air spray guns, hand held electrostatic air spray guns, hand held conventional air spray guns and automatic air spray guns.	[1] Cleaning/pretreatment [2] Application area: Prime application, (electrodeposition) Prime surfacing operation Topcoat operation Repair topcoat application [3] Flashoff area [4] Oven areas for the above [5] Coating mixing [6] Coating and solvent storage [7] Equipment cleanup [8] All solvent used and not recovered or destroyed can be considered potential emissions.	[1] Thermal incineration ^c [2] Catalytic incineration ^c [3] Carbon adsorber ^b [4] Waterborne coatings ^c [5] Powder coatings ^c [6] Higher-solids coating [7] Electrodeposition primer ^c	4, 11, 13

(continued)

**TABLE 5-4.
DESCRIPTION OF COATING OPERATIONS, EMISSION SOURCES, AND EMISSION
REDUCTION METHODS FOR SURFACE COATING GROUPS (Continued)**

General Source Category	Application Methods	Emission Sources	Emissions Reduction Methods ^a	Additional References
Cans	Reverse roll coating Roll coating Spray coating	[1] Cleaning/pretreatment [2] Coating area: Two piece can exterior base coating Interior spray coating Sheet basecoating (interior) Sheet basecoating (exterior) Side seam spray coating End sealing compound Lithography Over varnish [3] Flashoff [4] Oven areas for the above [5] Coating mixing [6] Coating and solvent storage [7] Equipment cleanup [8] All solvent used and not recovered or destroyed can be considered potential emissions.	[1] Thermal incineration ^c 90% [2] Catalytic incineration ^c 90% [3] Waterborne coatings-two piece cans, ^c other processes ^b 60-90% [4] Higher solids coating. ^c [5] Powder coating-side seam coating of uncemented three piece cans, ^b other processes. ^b 100% [6] Carbon adsorption-low temperature processes ^b 90%, other processes ^b [7] Radiation-cured coatings ^b	4, 11, 14, 15

(continued)

**TABLE 5-4.
DESCRIPTION OF COATING OPERATIONS, EMISSION SOURCES, AND EMISSION
REDUCTION METHODS FOR SURFACE COATING GROUPS (Continued)**

General Source Category	Application Methods	Emission Sources	Emissions Reduction Methods ^a	Additional References
Metal Coils	Reverse roll coating	[1] Application area: Prime coating Finish coating [2] Flashoff area [3] Exhaust oven area [4] Quench area [5] Fugitive emissions [6] Solvent mixing [7] Solvent storage [8] Equipment cleanup [9] All solvent used and not recovered or destroyed can be considered potential emissions.	[1] Thermal incineration ^c 95% [2] Catalytic incineration ^c 95% [3] Waterborne coatings ^c	11, 16, 17
Paper and Paperboard	Knife coating Reverse roll coating Gravure (graphic arts)	[1] Application area [2] Oven areas [3] Coating mixing [4] Coating and solvent storage [5] Equipment cleanup [6] All solvent used and not recovered or destroyed can be considered potential emissions.	[1] Carbon adsorber ^c 90% [2] Thermal incinerator ^c 95% [3] Catalytic incinerator ^c 95% [4] Condensers ^b [5] Waterborne ^c [6] Radiation-cured coatings ^c [7] Hot melt adhesives ^c	4, 10,

(continued)

**TABLE 5-4.
DESCRIPTION OF COATING OPERATIONS, EMISSION SOURCES, AND EMISSION
REDUCTION METHODS FOR SURFACE COATING GROUPS (Continued)**

General Source Category	Application Methods	Emission Sources	Emissions Reduction Methods ^a	Additional References
Fabrics	Knife coating Roll coating Roller Rotary screen Flat screen	[1] Fabric scouring [2] Coating application area [3] Flashoff area [4] Drying ovens [5] Fugitive emissions [6] Coating mixing [7] Coating and solvent storage [8] Equipment cleanup [9] All solvent used and not recovered or destroyed can be considered potential emissions.	[1] Carbon adsorber ^c 80% [2] Thermal incineration ^c 95% [3] Catalytic incineration ^c 95% [4] Condensers ^c 80%	11
Wood Products	Spray coating Dip coating Flow coating	[1] Clean/pre-treatment [2] Application area [3] Flashoff [4] Oven areas [5] Coating mixing [6] Coating and solvent storage [7] Equipment cleanup [8] All solvent used and not recovered or destroyed can be considered potential emissions.	[1] Waterborne coatings ^c [2] Carbon adsorption ^b [3] Thermal incineration ^b [4] Catalytic incineration ^b [5] Higher solids coatings ^c [6] Radiation-cured coatings ^c	4, 18

(continued)

**TABLE 5-4.
DESCRIPTION OF COATING OPERATIONS, EMISSION SOURCES, AND EMISSION
REDUCTION METHODS FOR SURFACE COATING GROUPS (Continued)**

General Source Category	Application Methods	Emission Sources	Emissions Reduction Methods ^a	Additional References
Flatwood Products	Reverse roll coating Direct roll coating Lithography and gravure printing	[1] Application area [2] Flashoff area Filler Sealer Basecoat Topcoat Inks [3] Oven areas for the above [4] Coating mix [5] Coating and solvent storage [6] Equipment cleanup [7] All solvent used and not recovered can be considered potential emissions	[1] Waterborne coatings especially in filler and basecoat ^c [2] Ultraviolet curing ^c [3] Afterburners ^b [4] Carbon adsorption ^b	12, 19
Plastic Parts	Roll coating Spray coating	[1] Clean/pretreatment [2] Coating application [3] Flashoff area Coating operations, flow, dip, spray [4] Coating mixing [5] Coating and solvent storage [6] Equipment cleanup [7] All solvent used and not recovered can be considered potential emissions.	[1] Carbon adsorber ^b [2] Thermal incinerator ^b [3] Catalytic incinerator ^b [4] Waterborne coatings ^c [5] Higher solids coatings ^c	4, 20

(continued)

**TABLE 5-4.
DESCRIPTION OF COATING OPERATIONS, EMISSION SOURCES, AND EMISSION
REDUCTION METHODS FOR SURFACE COATING GROUPS (Continued)**

General Source Category	Application Methods	Emission Sources	Emissions Reduction Methods ^a	Additional References
Ship Building and Repairing	Spray coating	[1] Clean/pretreatment [2] Coating application Prime coat operation Topcoat operation [3] Flashoff [4] Oven areas for the above [5] Coating mixing [6] Coating and solvent storage [7] Equipment cleanup [8] All solvent used and not recovered or destroyed can be considered potential emissions	Information currently under development by EPA	
Aircraft	Spray coating Flow coating	[1] Clean/pretreatment [2] Coating application [3] Flashoff Prime coat operation Topcoat operating [4] Oven areas for the above [5] Coating and solvent storage [6] Equipment cleanup [7] All solvent used and not recovered or destroyed can be considered potential emissions.	Information currently under development by EPA	

^a % is the approximate control efficiency of total VOC emissions.

^b Current technology that may be used or is used occasionally.

^c Frequently used current technology.

cannot be dipped due to their buoyancy, such as fuel oil tanks, gas cylinders, or pressure bottles. In this operation, the coating material is fed through overhead nozzles which cause the paint to flow in a steady stream over the article to be coated. Excess paint is allowed to drain from the coated object and is then recycled. Knife coating is used primarily to coat paper or fabric webs. The adjustable blade or "knife" distributes a liquid coating evenly over a moving surface.

5.2.2 Emissions from Surface Coating Operations

There are many potential MEK point and fugitive emissions sources in the surface coating industry. Figure 5-2 is a flow diagram of a typical surface coating operation depicting the operations, auxiliary facilities, and emission points. This figure is generic and may differ significantly from any specific coating operation. Point source emissions include controlled and uncontrolled emissions from the degreasing, surface coating, and drying and curing operations.²¹ Degreasing operations and emissions are discussed separately in Section 5.5.1 of this document. Emissions from the coating application area result from the evaporation of solvent around the application equipment and from the exposed substrate as it travels from the applicator to the drying oven entrance (flashoff). Bake oven emissions result from the remaining solvent that is vaporized in the oven and from by-products of chemical reactions that occur as the coating cures. Emissions from curing or vulcanizing of the coating are usually negligible compared to the total emissions from the operation.²²

Other point sources include the degreasing solvent storage tank vent, surface coating solvent storage vent, and the surface coating blending tank vent. Fugitive emission sources include solvent evaporation losses from degreased, coated and dried products as well as losses from leaking process equipment and transfer of organic liquids within the plant.

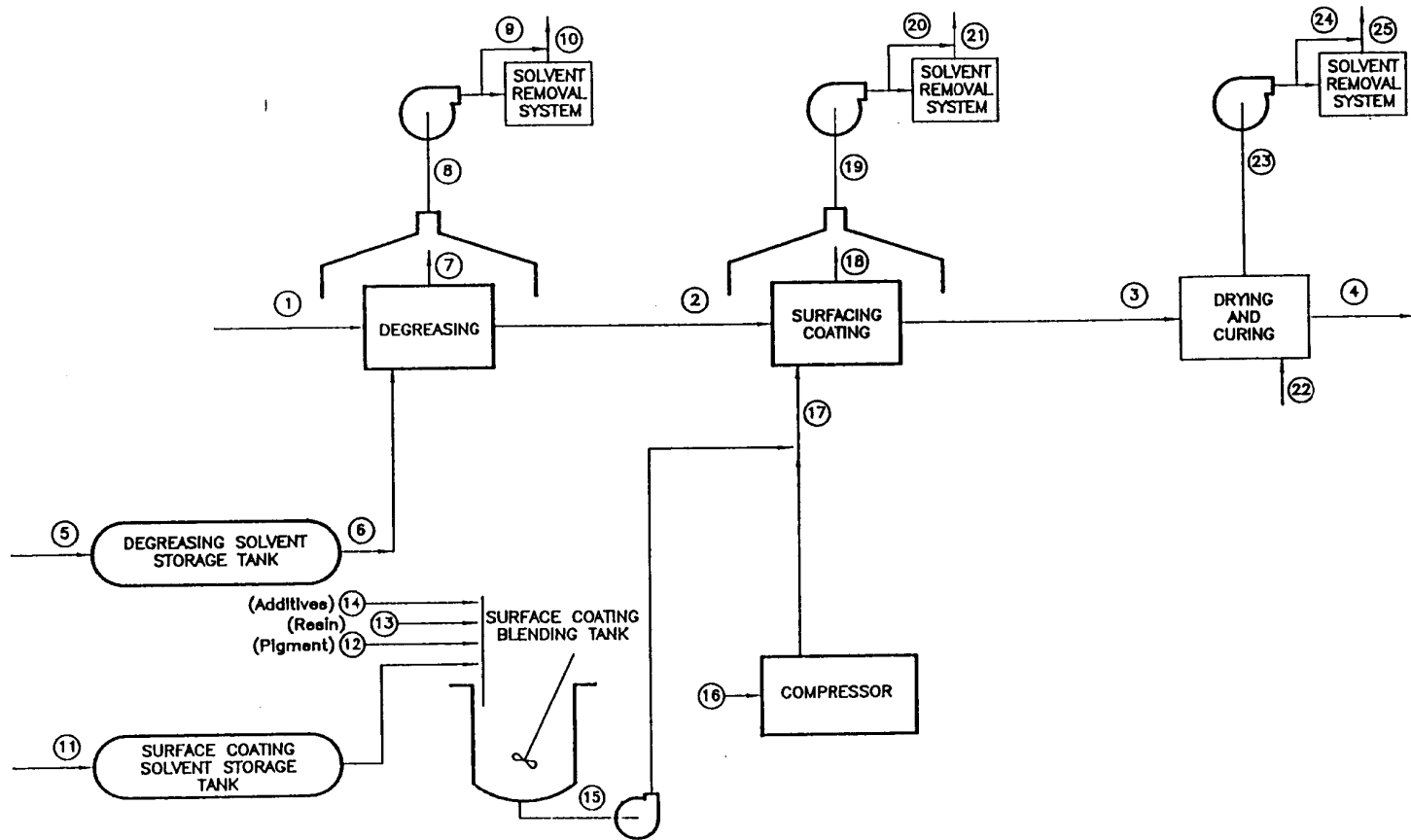


Figure 5-2. Flow diagram of a typical surface coating operation.²¹

Streams 1, 2, 3, and 4 in Figure 5-2 depict the flow of products through the plant. Stream 1 represents the input of uncoated products to the surface coating system. Stream 2 represents the flow of degreased or scoured products to the surface coating operation. Stream 3 represents the product flow to the drying and curing operation. Stream 4 represents the flow of coated finished products from the surface coating section of a manufacturing plant.

Streams 5 through 10 represent the flow of degreasing solvent through the surface coating section of a manufacturing plant. Streams 5 and 6 depict the flow of solvent into the plant and to the degreasing unit. Streams 7 and 8 represent the flow of solvent vapors from the degreasing unit through the fume handling system. Uncontrolled and controlled emissions are represented by streams 9 and 10, respectively. As stated previously, MEK emissions data for degreasing operations are presented in Section 5.5.1.

Streams 11 through 21 represent the flow of surface coating raw materials through the plant. Streams 11, 12, 13, and 14 represent the flow of solvent, pigment, resin, and additives to the surface coating blending tank. Stream 15 is the flow of coating to the surface coating unit. For those operations that use spray painting, stream 16 is the flow of compressed air. Streams 18 and 19 represent the flow of solvent and resin from the surface coating unit through the fume handling equipment. Uncontrolled and controlled coating solvent emissions are depicted by streams 20 and 21, respectively.²¹

Streams 22 through 25 represent the flow of gases (*e.g.*, fuel, steam or electrically heated air) to the drying and curing operation. Drying and curing operations occur in flashoff areas and curing ovens. Flashoff areas are the places between application areas, or between an application area and an oven, in which solvent is open to the atmosphere and able to volatilize from the coated piece. Portions of the emissions from a flashoff area are exhausted through application area and oven vents; the amount exhausted through these vents depends on the total length of the flashoff area. Ovens are used between some coating steps to cure the coating prior to the next

step in the finishing sequence. Streams 24 and 25 represent drying and curing uncontrolled and controlled emissions, respectively.^{18,21}

Methyl ethyl ketone can be used in solvent formulations as a thinner to dilute coatings or as a medium to dissolve resins. Methyl ethyl ketone may also be included in formulations used to clean coating application equipment. The extent to which MEK is employed in either of these formulations is unknown.

An extensive literature search revealed some emission factor data for coating applications. However, because the references for these data were unavailable for review, no emission factors are presented here. No emissions data were found in current literature for degreasing, drying and curing, or cleanup/dilution operations using MEK. The reader is directed to Table 5-4 for additional sources of information.

One method of reducing MEK emissions from surface coating operations is to modify the coating formulation. Conventional coatings typically contain 70 to 85 percent VOC by weight. Minimizing or eliminating the use of these solvents in surface coating formulations can be an effective way to reduce VOC emissions, including MEK. Water-borne and higher-solids coatings contain less solvent by volume. Waterborne coatings contain water as the main solvent or dispersant, although most include 5 to 20 percent organic solvent to aid in wetting, viscosity control, and pigment dispersion. Two important coatings in the higher-solids category are powder coatings and radiation curable coatings, which may emit only small amounts of VOC during the curing operation.²³ More typical higher-solids coatings use reduced polymer chain lengths to control viscosity while allowing a reduction in solvent content.

Larger surface coating facilities may use add-on control systems to capture and control solvent emissions. A capture device is used to contain emissions from surface coating operations and direct them to a stack and/or control device. Commonly used capture devices include covers,

vents, hoods, bake ovens and partial or total enclosures. Control devices typically used in the surface coating industry include carbon adsorbers, condensers, and incinerators with control efficiencies between 95 and 98 percent. Overall control system efficiency is the product of capture and control efficiencies.

5.3 SURFACE COATING - ADHESIVES AND SEALANTS

Adhesives are substances designed to hold materials together by surface attachment. Generally, adhesives are considered as coatings for the surfaces being bonded. Five basic coating types are used in adhesives and include solvent-based coatings, waterborne (emulsion) coatings, 100 percent solids (hot melt) coatings, calendar coatings, and prepolymer coatings. Essentially all solvent emissions from this industry result from solvent-based coatings, therefore, further discussion will be limited to this class of adhesives.

Solvent-based adhesive formulations contain approximately 65 percent by weight solvent and 35 percent by weight coating solids.²⁵ Emissions releases from solvent-based adhesive formulations average about 95 weight percent solvent and 5 weight percent coatings solids. Methyl ethyl ketone is one of the solvents used as a raw material in the manufacture of adhesives and sealants (SIC 2891). In 1990, MEK consumption in adhesive formulations accounted for 13 percent (28 million kg or 61 million lbs) of total MEK solvent sales.¹

5.3.1 Adhesive and Sealant Process Description

Many methods of application are used for solvent adhesive cementing of surfaces. They include brush application, spraying, dipping, roll coating, felt pad, and pressure sensitive tapes and labels. Each of these is briefly described in this subsection.

During brush application, the adhesive is brushed onto both adherents, and the parts are joined while wet. Uniform application of the adhesive is a prime advantage of spraying, however, masking of the pieces being cemented together is normally required. Surfaces to be bonded are often dipped into the adhesives for complete surface coating before being joined. Roll coating is a method of applying adhesive to a flat sheet or strip where the coating is transferred by a roller or series of rollers. The felt pad method involves the use of a thick felt pad partially immersed in a pan of solvent where the solvent "wicks" through the felt fibers by capillary action, keeping the surface of the pad constantly wet.

An example diagram of a pressure sensitive tape and label (PSTL) coating line is presented in Figure 5-3. During the coating of PSTL, some backing material (paper, cloth, or film) is coated to create a tape or label product that will stick on contact. First, solvent-based adhesives are applied (Step 1). Next, the product is transferred to the drying oven, where the solvents evaporate, leaving a sticky surface (Step 2). After evaporation, the coated material is removed (Step 3) and prepared for packaging and shipment. The adhesive side is usually wound against a non-stick surface (release coat) for ease in final product use.²⁶

5.3.2 Emissions from Adhesive and Sealant Processes

Methyl ethyl ketone emissions from solvent-based adhesives are expected to result from the evaporation of solvent contained in the adhesives. These emissions arise mainly at the point of application and the drying oven area each labeled with emission points B in Figure 5-3. In an uncontrolled facility, essentially all of the solvent used in the coating formulation is emitted to the atmosphere. Some solvent (up to five percent) can remain in the final product (labeled with an emission point B in Step 3), although this solvent will eventually evaporate into the atmosphere as residual emissions.

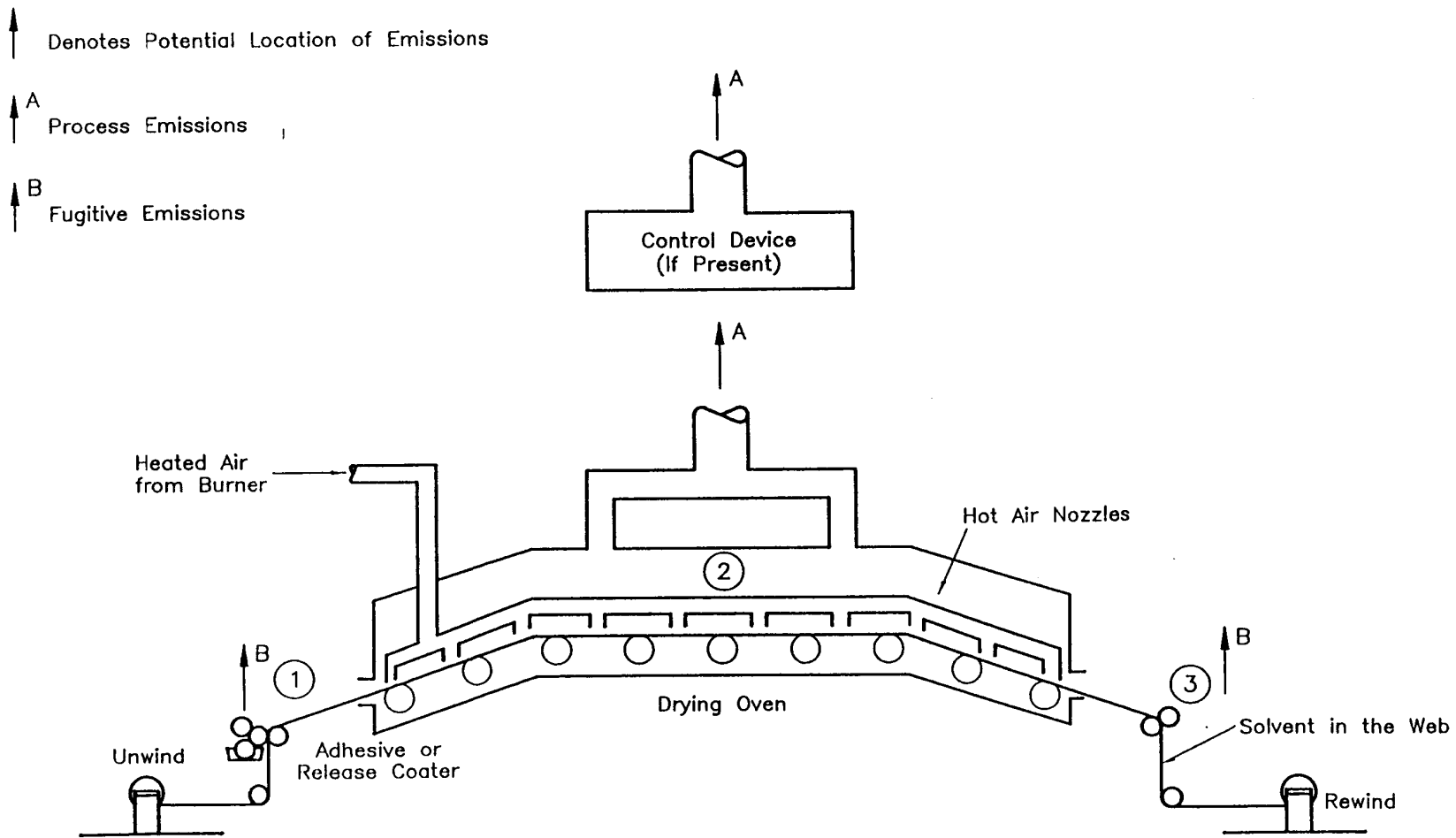


Figure 5-3. Diagram of a pressure sensitive tape and label coating line.²⁷

There are additional losses from solvent storage and handling, equipment cleaning, miscellaneous spills, coating formulation mixing tanks, and cleaning operations. These emissions are relatively small compared to application and drying oven area emissions. Types of emission control used in this industry are similar to those discussed for the surface coating industry. Waterborne coatings, incineration, and carbon adsorption are some control techniques used; however, the reader is encouraged to review Section 5.2 (Surface Coating) for further information.

An extensive literature search revealed some emission factor data for adhesive and sealant operations, however, references for these data were unavailable for review. Based on available literature and engineering judgment, the major industrial categories that may be involved in MEK emissions from the adhesive industry have been summarized in Table 5-5.²⁶ It should be noted, however, that some of these industrial categories could also be emitting MEK from other uses of the solvent described in this document.

5.4 SURFACE COATING - MAGNETIC TAPE MANUFACTURING

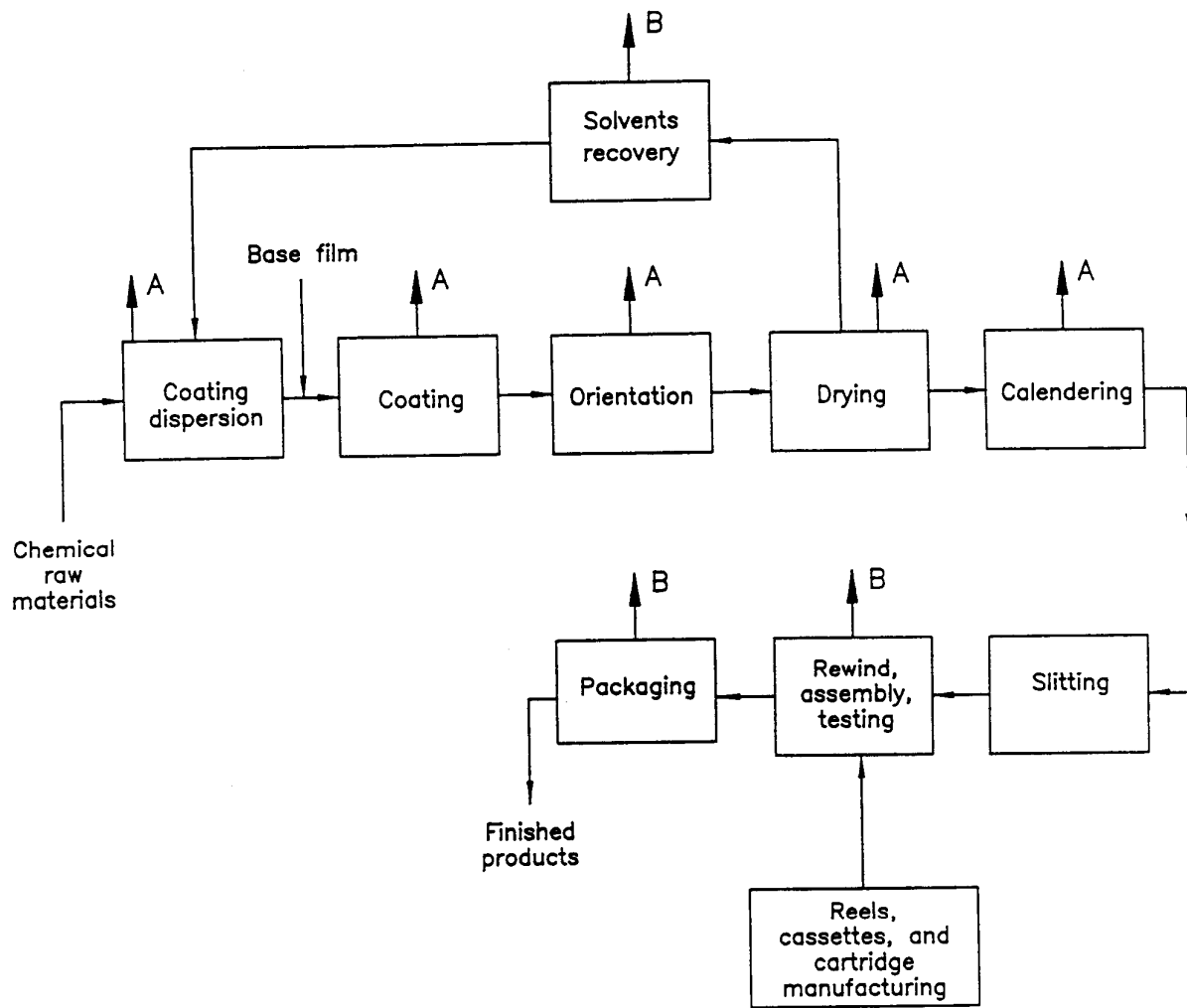
Solvents such as MEK are used in magnetic coatings to dissolve raw binder polymers and to provide a fluid medium for pigment dispersion in the coating mix.²⁸ In 1990, magnetic tape manufacturing accounted for nearly 10 percent (21 million kg or 47 million lbs) of total domestic MEK consumption.¹

Magnetic tape consists of two basic components: base film or support, and a magnetic coating. Both the support and coating vary with the intended use of the tape. In order for magnetic tape to perform adequately, the magnetic pigment must be thoroughly and completely dispersed in the magnetic coating mix. The dispersion process is responsible for breaking up agglomerates to obtain a uniform coating mix. Figure 5-4 illustrates the process steps and potential MEK release points from magnetic tape manufacturing.

**TABLE 5-5.
SIC CODES ASSOCIATED WITH ADHESIVES AND
SEALANTS**

General Source Category	SIC Codes
Adhesive Manufacture	2981
Pressure Sensitive Tapes and Labels	2672, 3069
Wood Products Industries	2420, 2426, 2429, 2430, 2431, 2434, 2435, 2436, 2439, 2452, 2492, 2493, 2499
Leather and Leather Products	3131, 3143, 3144, 3149, 3199
Stone, Clay, Glass and Concrete Products	3211, 3221, 3229, 3231, 3241, 3253, 3255, 3264, 3271, 3274, 3275, 3291, 3292, 3293, 3295, 3299
Rubber and Plastic Products	3000, 3021, 3041, 3052, 3053, 3061, 3069, 3079, 3080, 3081, 3082, 3083, 3086, 3087, 3088, 3089
Miscellaneous Manufacturing Industries	2297, 2298, 3465, 3841, 3842, 3942, 3944, 3949, 3961, 3965, 3991

As noted in Figure 5-4, process steps in magnetic tape manufacturing which have the potential to emit MEK include the coating dispersion, coating, orientation, drying, and calendaring operations, each labeled as emission points A. Fugitive losses, labeled as emission points B, may occur during product rewinding, testing, solvent recovery, cleaning, and finished product packaging as noted in Figure 5-4. Emission factor data specifically for MEK from magnetic tape manufacturing are not currently available. Actual emissions will depend on the level of MEK in the solvent, the amount of solvent used, and the level of control. TRI data suggest that magnetic tape manufacturing is a significant source of MEK emissions.



↑ Denotes Potential Location of Emissions

↑ A Process Emissions

↑ B Fugitive Emissions

Figure 5-4. Processing steps in magnetic-tape production.²⁹

5.5 PRINTING AND PUBLISHING INDUSTRY

The printing and publishing industry falls under general SIC code 27, encompassing fourteen subcategories. These fourteen subcategories can be combined into three major groups: publishing (SICs 2711, 2721, 2731, 2732, and 2741), commercial printing (SICs 2752, 2754, 2759, 2761, 2771, 2782, and 2789), and trade services (SICs 2791 and 2796).

Methyl ethyl ketone consumption in the printing and publishing industry during 1990 was approximately 4 percent (8.6 million kg or 19 million lbs) of total MEK solvent sales. The term "graphic arts" is often used to describe the commercial printing sector of the industry. Graphic arts printing processes include letterpress, flexography, rotogravure, offset lithography, and screen printing. All of these process are likely to use MEK to varying degrees. Letterpress, lithographic, and screen printing inks do not use MEK, but these industries may use it as a clean-up solvent. Gravure and flexographic printing may use MEK in inks as well as clean up solvents.

The majority of publishing and printing groups are concentrated in four states: California, New York, Pennsylvania, and Illinois. An overall characterization of the printing industry is given in Table 5-6, which lists the number of establishments from each printing category.³⁰ Companies in the printing and publishing industry grossing one million dollars or greater in annual sales are presented in Table B-3 of Appendix B.³¹

5.5.1 Process Descriptions for Printing and Publishing

The gravure process is used in printing four product categories: packaging, specialties, publications, and advertisements. Gravure printing can be performed using either a continuous roll of substrate or individual sheets fed to the press. Printing with a web (continuous roll) is referred to as the rotogravure process and is the most common method of gravure printing.³²

TABLE 5-6.
PRINTING INDUSTRY CHARACTERIZATION

Printing Category	SIC	Number of Establishments
Newspaper	2711	9,091
Periodicals	2721	4,020
Book Publishing	2731	2,298
Book Printing	2732	561
Misc. Publishing	2741	2,369
Commercial Printing Letterpress	2751	10,371 ^a
Commercial Printing Lithographic	2752	24,980
Engraving and Plate Printing	2753	869 ^a
Commercial Printing Gravure	2754	322
Commercial Printing, nec ^b	2759	10,796
Manifold Business Forms	2761	853
Greeting Cards	2771	162
Blankbooks and Loose-Leaf Binders	2782	511
Bookbinding and Related Work	2789	1,035

^a 1982 statistics

^b nec - not elsewhere classified

Source: Reference 30.

Flexographic printing is used to print flexible packaging, milk cartons, gift wraps, folding cartons, paperboard, paper cups and plates, labels, tapes, and envelopes. The majority of flexographic printing is web-fed and uses an image carrier that is made of either rubber or a photopolymer. The image, or print, area is raised above the surface of the image carrier, which wraps around the plate cylinder.³³

Lithography is the predominant printing process in the graphics arts industry, accounting for just under half of all printing applications.²⁶ It is characterized by a planographic image carrier in which the image and non-image areas are on the same plane. The image area is water repellent and the non-image area is chemically repellent to ink. When the image is applied to a rubber covered "blanket" cylinder and then transferred onto the substrate, the process is known as "offset" lithography.

5.5.2 Emissions from Printing and Publishing

Fugitive emissions from rotogravure and flexography printing occur from the ink fountain, press, and chill rolls, each labeled with an emission point B in Figure 5-5. The dryer vent (emission point A) is nearly always controlled with some type of add-on equipment. Emissions are influenced by press and job variables, solvent concentration in the ink, and solvent added as make-up during operations. Press and job variables include cylinder width, cylinder circumference, web width, line speed, dryer temperature, dryer air flow, dryer exhaust VOC concentration, solvent blend, ink type, ink color, ink coverage, and type of paper.

Volatile organic compound emission points from the web offset lithography are shown in Figure 5-6. Fugitive sources include the ink fountain, dampening system, plate and blanket cylinders, chill rolls, and the product, each labeled with an emission point B. Process emissions occur from the dryer vent which is nearly always controlled (emission point A).

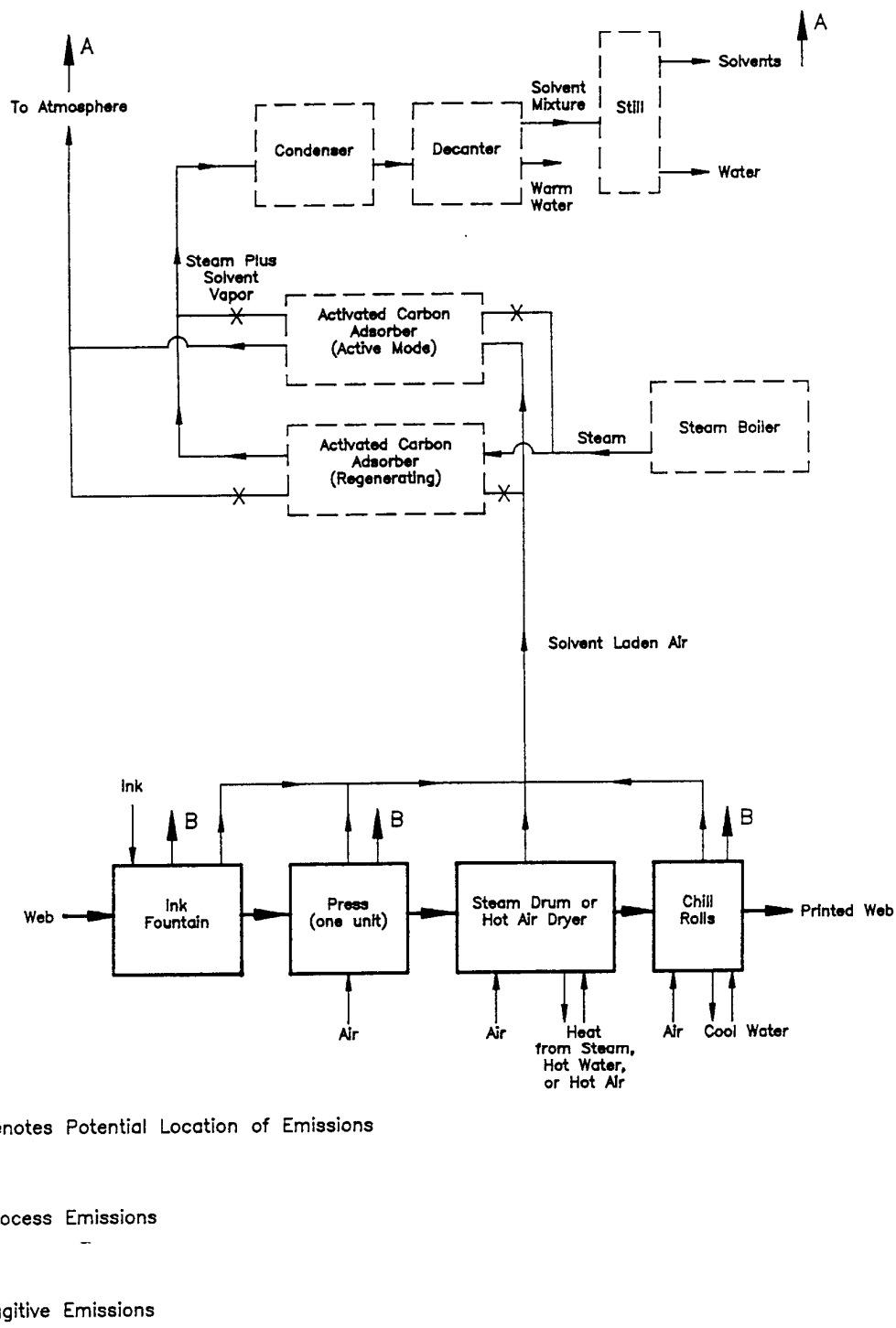


Figure 5-5. Rotogravure and flexography printing process (chill rolls not used in rotogravure publication printing).²⁶

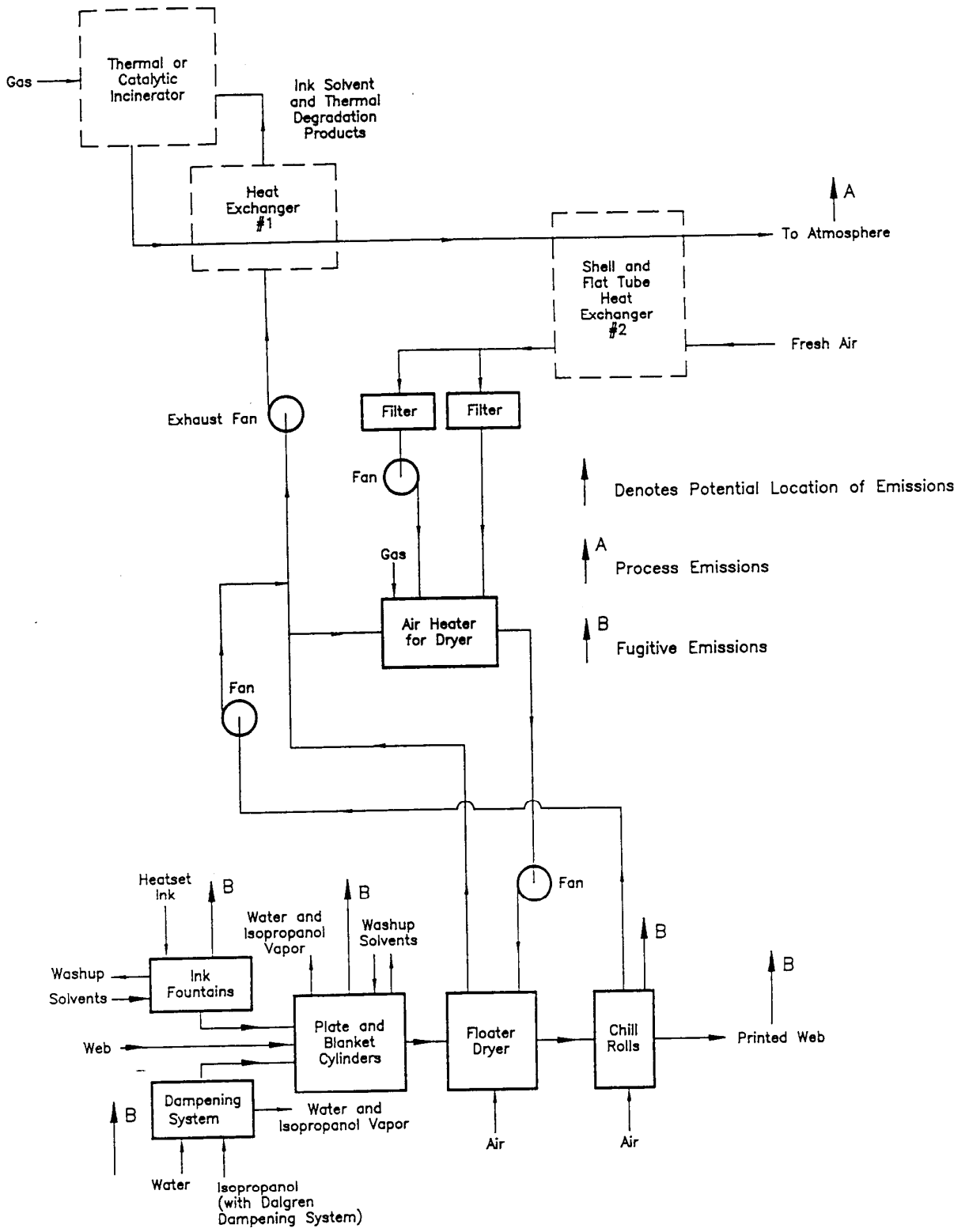


Figure 5-6. Web offset lithography printing process.²⁶

No reliable MEK emission factor data were found in current literature for the printing and publishing industry, although VOC emissions data are available from various sources. Ink and solvent consumption numbers have also been published and are presented in Section 5.1. A local survey may provide the needed information on the proportion of MEK used relative to total solvent consumption. Methyl ethyl ketone emissions may then be estimated by multiplying the percentage MEK by the ink consumption rate and solvent content of the ink. Similar techniques may be applied to known VOC emission rates or emission factors. Based on available literature and engineering judgement, the printing categories that may emit MEK are included in Appendix A.

5.5.3 Emissions Reduction By Process Modification

A control system for VOC (including MEK) emissions from printing operations consists of two components: a capture device and a control device. The total control efficiency of the system is determined by the combined efficiencies of the two components. A capture device is used to collect and contain emissions from a process operation and direct them toward reuse, recycling, or to a control device. Approximately 2.5 to 7 percent of the solvents used in printing are retained in the printed product. The remaining solvents are reclaimed for reuse, recycled, and sold back to suppliers, or lost as fugitive emissions.^{34,35}

The Gravure Association of America (GAA) conducted a survey of their members which recorded total solvent purchased, reused, and recovered in various segments of the industry during 1987.³⁶ Table 5-7 presents a summary of these statistics for publication, folding cartons, flexible packaging, and product gravure printing. These numbers are presented to provide an overview of solvent purchase, reuse, and recovery, but these numbers vary tremendously depending on the type of printing and substrates. The GAA membership reported a total of 18.8 million kg (41.4 million lbs) of virgin solvent purchased, 112 million kg (246 million lbs) of solvent recovered, and 81 million kg (179 million lbs) of solvent reused. More solvent is

**TABLE 5-7.
GRAVURE ASSOCIATION OF AMERICA INDUSTRY SURVEY RESULTS**

	Reported Results						Projected Gravure Estimates for Industry			
	Total Solvents Purchased		Total Solvents Recovered		Total Solvents Reused		Total Solvents Purchased or Reused		Total Solvents Recovered	
Printing Process	kg	(lbs)	kg	(lbs)	kg	(lbs)	kg	(lbs)	kg	(lbs)
Publication Plants	1.0	(2.2)	101	(23)	73	(162)	182	(401)	247	(544)
Folding Cartons	2.9	(6.4)	0.7	(1.6)	0.7	(1.6)	22	(49)	4.4	(9.7)
Flexible Packaging	7.2	(15.9)	2.8	(6.2)	1.9	(4.1)	78	(173)	24	(53)
Product Gravure	7.7	(16.9)	7.0	(15.5)	5.1	(11.3)	--	(--)	--	(--)

Source: Reference 36.

recovered than purchased due to solvent recovery from ink formulations. The portion of solvent that is recovered but not reused is sold back to the manufacturers, lost as fugitive emissions, or destroyed by incineration. When the survey results are projected to the entire gravure industry, these figures total 282 million kg (622 million lbs) of solvent purchased or reused, and 275 million kg (606 million lbs) of solvent recovered. The GAA projected total gravure publication plants' solvent consumption and fate based upon the percentage (by sales) of this segment responding to the survey. The EPA-projected solvent consumption and fate for the folding carton and flexible packaging segments is based upon the same principle. The estimated ratio of solvent recovered to solvent consumed for the publication segment of the industry was 73 percent. The respondents in this portion of the industry reported using solvent recovery systems, but none reported using incineration as an emission control technique. Labels and wrappers and product printing plants reported using water-based inks, solvent recovery, and incineration to reduce VOC emissions.³⁶

Packaging gravure plants and label and wrapping gravure plants did not have solvent consumption and fate reported as did other segments of the industry. However, ink, coating, and lacquer consumption data were reported. The solvent content for these applications is required to produce a rough estimate of solvent usage by these segments of the industry. Solvent recovery and reuse could not be calculated from available information. Packaging gravure member plants reported using 13.9 million kg (30.7 million lbs) of inks, 1.8 million kg (3.9 million lbs) of which were water-based; and 6.6 million kg (14.6 million lbs) of coatings and lacquers. The labels and wrappers member plants reported using 3.2 million kg (7.0 million lbs) of inks, 0.3 million kg (0.7 million lbs) of which were water-based; and 2.3 million kg (5.0 million lbs) of coatings and lacquers. The EPA-projected industry use estimates for labels and wrappers plants are 16.4 million kg (36.2 million lbs) of inks, 1.7 million kg (3.7 million lbs) of which were water-based; and 11.7 million kg (25.9 million lbs) of coatings and lacquers.³⁶

Carbon adsorption and incineration systems have traditionally been employed to control VOC emissions from the gravure printing process. Carbon adsorption systems may be applied to achieve an overall VOC reduction efficiency of 75 percent. This estimate is based on the carbon adsorption system operating at a recovery efficiency of 90 percent, after 75 to 85 percent of the VOC has been captured. Incineration systems may be applied to gravure printing operations to achieve an overall reduction efficiency of approximately 65 percent. Incinerators are estimated to achieve 90 percent VOC destruction, with a capture efficiency of 70 to 80 percent.³³

A recent study demonstrated that capture and control systems may be applied to gravure printing presses and achieve greater than 90 percent overall VOC control.³⁷ The average VOC control efficiency at these demonstration facilities ranged from 94 to 99.5 percent. The facilities included in the study used total enclosure capture systems and one of the following add-on control devices:

- catalytic incinerator
- regenerative thermal incinerator
- carbon adsorber
- recuperative thermal incinerator

The Environmental Protection Agency has developed and published standard criteria for the design and operation of permanent total enclosure systems (PTE). The PTE criteria have been published in the following sources:

- *Guidelines for Developing a State Protocol for the Measurement of Capture Efficiency.* Environmental Protection Agency. Policy Statement. April 16, 1990.
- *Magnetic Tape Manufacturing Industry-Background Information for Promulgated Standards* (EPA-450/3-85-029b).

- *Polymeric Coating of Supporting Substrates-Background Information for Promulgated Standards* (EPA-450/3-85-022b).

Capture efficiencies of 100 percent may be achievable if all the EPA PTE criteria are met.

Incineration and carbon adsorption emission control techniques are also feasible for use in the flexographic and lithographic printing processes. In the flexographic printing process, effective capture systems are often difficult to install on the presses which may be two to three floors in height. Overall control efficiencies for this process are approximately 60 percent.³³ Recent studies have indicated that flexographic printing presses controlled by catalytic and regenerative thermal incineration may achieve a 95 percent VOC control efficiency.^{37,38}

Overall, these studies reflect that VOC in the printing and publication industry can be well controlled. While the CTG recommended control efficiency for publication gravure is 75 percent and the NSPS is 84 percent, industry routinely reports 90 percent efficiency or better.⁴

5.5.4 Emissions Reduction By-Product Modification

Emissions reduction by-product modifications may be achieved in the printing industry by using water-based inks. Typical ink formulations contain approximately 50 to 85 percent solvents by volume. Water-based inks, used in packaging and product printing, contain approximately 5 to 30 percent solvents by volume and account for 30 to 40 percent of all inks used. The package printing sector in the gravure printing process has achieved significant VOC reductions through the use of water-based printing inks. Water-based inks account for approximately 15 percent of all inks used in all gravure printing processes.^{32,39} The use of water-based inks may contribute to an overall VOC reduction of 65 to 75 percent, if the solvent content of the inks is maintained below 25 percent by volume.³³

5.6 MISCELLANEOUS USES OF MEK

5.6.1 Solvent Cleaning (Degreasing)

Surface cleaning or degreasing includes the solvent cleaning or conditioning of metal surfaces and parts, fabricated plastics, electronic and electrical components, and other nonporous substrates. These cleaning processes are designed to remove foreign materials such as grease, oils, waxes, carbon deposits, and moisture, usually in preparation for further treatment such as painting, electroplating, galvanizing, anodizing, or applying conversion coatings.⁴⁰

Data on the current use of MEK in solvent cleaning operations are scarce.⁴⁰ A 1992 report from the Air and Waste Management Association showed that in 1974, 0.73 million kg (1.6 million lbs) of solvent were used for solvent cleaning, with 62 percent used in cold cleaning operations. Methyl ethyl ketone was used only in cold cleaning operations, accounting for approximately 8,000 kg (17,600 lbs).⁴¹ For reference, this section discusses several kinds of cleaning operations, including cold cleaning. Although cold cleaning is the only type of cleaning operation likely to use MEK, discussions of other types are included for comparison.

Solvent Cleaning Process Description--

The three most commonly used organic solvent cleaners are open top vapor cleaners (OTVCs), in-line cleaners, and cold cleaners. OTVCs are primarily used in metalworking operations and other manufacturing operations. The vapor cleaning process is one in which solvent vapors are generated by boiling liquid solvent in the bottom of an open tank. These vapors rise to the level of the condensing coils and there form a controlled vapor zone that prevents vapors from escaping the tank. Parts are immersed into this zone where solvent vapors condense and dissolve foreign materials contained on the parts.⁴⁰

In-line cleaners (also called conveyORIZED cleaners) employ a continuous feed of soiled parts into the cleaning unit. The majority of in-line cleaners operate in the vapor phase, however, they may also operate in the nonvapor or liquid phase. In-line cleaners are typically used in large-scale operations and are normally enclosed except for parts inlet and exit openings. With these exceptions, in-line cleaning techniques are the same as those used in vapor or cold cleaning.⁴⁰

Cold cleaning is a batch process in which parts are immersed in a closed tank that contains cleaning solvents that are at room temperature or slightly heated. The solvents and parts are then agitated by either compressed air, vertical motion, or ultrasonics. This agitation enhances the cleaning efficiency of cold cleaning, however, it may also result in higher emissions.⁴⁰

Emissions from Solvent Cleaning--

In general, solvent evaporation occurs both directly and indirectly with all types of solvent cleaning equipment, though MEK is typically only emitted from cold cleaning. The emission mechanisms include losses of solvent vapor from the tank via diffusion and convection, and evaporation of solvent on cleaned parts as they are withdrawn from cleaning equipment.⁴² Other significant emission sources are leaks from cleaning or associated equipment, and losses from solvent storage and transfer. The quantity of emissions vary depending upon the type, design, and size of equipment, hours of operation, operating techniques, and type of material being cleaned. Emissions are ultimately a function of solvent use, therefore, techniques and practices designed to conserve solvent use are beneficial in reducing atmospheric emissions.

Potential control methods for organic solvents include add-on equipment and improved operating practices.⁴² Add-on equipment includes covers for equipment openings, enclosing equipment, increasing freeboard height, adding freeboard refrigeration devices, and use of automated parts handling systems. These devices limit diffusional and convective losses from

solvent tanks and evaporative losses from solvent carry-out. More sophisticated control techniques include add-on equipment such as carbon adsorption systems to recover solvent vapors.

The best method for determining MEK emissions from solvent cleaning processes is through mass balance calculations. A crucial factor in the use of mass balance calculations is the percentage of MEK in the solvent. The following formula describes the necessary factors required to perform a mass balance determination.

$$E = S(P) - W (Q)$$

where:

E = Emissions of MEK

S = Amount of solvent used (purchased)

P = Percentage MEK of the solvent used

W = Waste solvent disposed

Q = Percentage MEK of the waste

Units for E, S, and W must be consistent (*e.g.*, all in kgs) before performing any calculations. These calculations may require the conversion of volume (*e.g.*, cubic meters) to mass (*e.g.*, kgs) which is readily accomplished by multiplying solvent density (*e.g.*, kgs/m³) by volume.

5.6.2 Research and Development Laboratories

TRI data indicate that MEK is emitted from research and development laboratories. This category includes Engineering Services (SIC 8711), Commercial Physical and Biological Research (SIC 8731), and Testing Laboratories (SIC 8734). Various laboratory processes may be sources of emissions including: chemical mixing and reactions during experiments or testing, glassware and equipment cleaning and washing, and chemical storage. These emissions are

transported to the atmosphere either from stacks attached to chemical fume hoods or from vents used to ventilate the building.⁴² No MEK-specific emission factor data were found in current literature.

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SECTION 6.0

RESIDUAL METHYL ETHYL KETONE EMISSIONS FROM INDUSTRY

The only industry identified and having available data where MEK is considered a residual emission is the operation of refuse systems. Potential emission sources from refuse operations are identified and available emission factors are presented. The reader is advised to contact the specific sources of interest to verify the nature of the process and control techniques used before applying the emission factor presented in this section.

The reader should note that TRI data indicate that MEK is also emitted from facilities within SIC codes 5171 and 5172 (Petroleum and petroleum products). Available literature has not indicated where these MEK emissions originate, and therefore further discussion is omitted from this section.

6.1 REFUSE SYSTEMS

Methyl ethyl ketone may be a residual contaminant in several operations from refuse systems (SIC 4953). Possible operations include wastewater treatment, incineration, landfills, and other sites for disposal of refuse. Process information and an emission factor (provided in Section 6.1.2) are included here for solid waste disposal (emission factor is for sludge incineration).

6.1.1 Solid Waste Disposal Process Description

The general term "solid waste disposal" includes disposal of garbage, refuse, and other discarded solid materials from industrial, municipal, commercial, mineral, and agricultural operations. Various methods have been employed to dispose of solid wastes, including solid waste incineration, composting, landfilling, and recycling. Incineration can be a major source

of atmospheric emissions during solid waste disposal. Common air pollution control technologies include electrostatic precipitators, dry fabric filters, dry scrubbers, and wet scrubbers.¹

6.1.2 Emissions from Solid Waste Disposal

The majority of air pollutant emissions from the various solid waste disposal methods result from incineration. In general, solid waste incinerators have the capacity to emit large quantities of air pollutants into the atmosphere. Particulate matter is a major constituent of the emissions produced by the turbulent movement of combustion gases through the burning sludge and the resultant ash. In addition, other air pollutants are emitted such as volatile organic compounds (MEK and others) and carbon monoxide. These are commonly emitted via incomplete combustion of the solid waste due to improper combustor design or poor operating conditions. Particle sizes, emission rates, concentrations, and general characteristics of the released air pollutants vary depending on the composition of the refuse being burned and the nature and operation of the incineration process.²

One source of MEK emissions identified from the literature search is government sludge incineration (SCC 5-01-005-06) which reports an emission factor of 0.00538 kg MEK/Mg dry sludge (0.01076 lbs MEK /ton dry sludge).³ This emission factor is based on test data from operations using scrubber controls. The corresponding grade for the emission factor is D according to criteria used from *AP-42* in assigning emission factor grades. According to TRI data, this SIC source category is a relatively small source of MEK emissions.

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SECTION 7.0
EMISSIONS FROM INDUSTRIES WHICH MAY PRODUCE METHYL ETHYL KETONE
AS A BY-PRODUCT

This section discusses air emissions from industrial processes where MEK is produced as a by-product. Potential emission sources are identified and available emission factors are presented. The reader is advised to contact the specific sources in question to verify the nature of the process, production volume, and control techniques used before applying any of the emission factors presented in this section.

7.1 FOOD AND KINDRED PRODUCTS

Methyl ethyl ketone may be formed as a by-product in some of the food and kindred product categories. Possible categories for MEK emissions include SIC codes 2011 (Meat packing plants), 2013 (Sausages and other prepared meats), 2044 (Rice milling), 2079 (Edible fats and oils, nec), 2082 (Malt beverages), 2087 (Flavoring extracts and syrups, nec), 2111 (Cigarettes), and 5153 (Grain and field beans).

7.1.1 Meat Smoking

Smoking is performed on meat and sausage products to preserve the meat, as well as improve the flavor, aroma, and appearance. The smoke used to treat the meat is a mixture of gases, aerosols, and vapors of incomplete combustion. Methyl ethyl ketone can be formed as one of these by-products in the smoke.¹ An extensive literature search revealed no specific MEK emissions data; however, TRI data indicate that facilities with SIC 2013 are a major source of MEK emissions.

7.1.2 Breweries

Breweries are principally an urban source of pollutants and emit VOC from various brewing process steps. Emissions vary according to brewery size. The emission points in a small brewery are the fermenters (usually the largest source of VOC vented emissions), brew kettle, hot wort tank, mash tun, lauter tun, and the spent grain tank. Emission points in a large brewery are the brew kettle (the largest source of VOC emissions), strainmaster, waste beer sump, activated carbon regeneration, mash cooker, and rice cooker.² An extensive literature search revealed little data for MEK emissions from breweries; however, TRI data indicate that breweries are a significant source of MEK by-product emissions.

7.2 PAPER AND ALLIED PRODUCTS

Methyl ethyl ketone may be formed as a by-product in some of the paper and allied product categories. Possible categories for MEK emissions include SICs 2611 (Pulp mills), 2621 (Paper mills), and 2631 (Paperboard mills). Pulping consists of converting raw materials into fibers which can be used in products, such as paper, paperboard, or building materials.

The primary emissions from pulping operations are reduced sulfur compounds such as hydrogen sulfide, methylmercaptan, dimethyl sulfide, and dimethyl disulfide.³ TRI data indicate that facilities within SIC 2611 (Pulp mills) emit significant amounts of MEK. However, an extensive literature search revealed minor emissions of MEK from the pulping process. Two references indicated that VOCs are found in the noncondensable gases from digester relief and spent liquor evaporation; however, neither of these references specifically mentioned MEK.^{1,4} Another reference reported MEK in digester vent condensate at a level of 27 ppm; in evaporator condensate at 1 to 3 ppm; and in stripper feed at 20 to 25 ppm.⁵ Upon contacting facilities within SIC 2611, it was discovered that the majority of MEK emissions are believed to occur from secondary processes such as paper coating or equipment cleaning. One facility did report

that emissions of MEK resulted from reactions occurring in the pulping digestors and evaporators. The facility has verified these emissions through source testing.⁶ This facility also cited the *Handbook of Chemical Specific Information for SARA 313 Form R Reporting*, a publication distributed by the National Council (of the Paper Industry) for Air and Stream Improvement (NCASI), as documenting these emissions and describing the environmental fate of MEK.⁷

Table 7-1 presents emission factors developed by NCASI for the kraft pulping process. According to NCASI, MEK is not an input, but is instead coincidentally manufactured in the kraft pulping process. The emission factors are based on data from tests performed by NCASI during 1990 and 1991.

7.3 PETROLEUM AND COAL PRODUCTS

Methyl ethyl ketone is formed as a by-product in some petroleum and coal products. Possible categories for MEK emissions include SIC codes 2911 (Petroleum refining), 2951 (Asphalt paving mixtures and blocks), 2992 (Lubricating oils and greases), and 2999 (Petroleum and coal products, nec).

7.3.1 Petroleum Refining

Petroleum refining (SIC 2911) converts crude oil into refined products, including liquefied petroleum gas, gasoline, kerosene, aviation fuel, diesel fuel, fuel oils, lubricating oils, and feedstocks for the petrochemical industry. Petroleum refining employs a wide variety of processes, the arrangement of which depends on the final product desired. Petroleum refining processes most likely to produce by-product MEK emissions include separation processes (*i.e.*, distillation) and petroleum conversion processes.⁸

**TABLE 7-1.
METHYL ETHYL KETONE EMISSION FACTORS FOR KRAFT PULPING
OPERATIONS**

Emission Source	Average Emission Factor		Emission Factor Quality Rating ^a
	<u>kg MEK</u> Mg pulp	<u>lb MEK</u> ton pulp	
Black Liquor Oxidation Vent Gases	0.005	0.010	D
Brown Stock Washer Vent Gases	0.0135	0.027	D
Oxygen Deliquification System Vents	0.0015	0.003	D
Direct Contact Evaporators	0.0075	0.015	D
Non-condensable Gases from Evaporator and Digester Vents	0.0165	0.033	D
Batch Digester Blow Condensates	0.007	0.014	D
Turpentine Condenser Condensates	0.0045	0.009	D
Evaporator Combined Condensate	0.0135	0.027	D

^aBased on AP-42 criteria selection discussed in Section 2.0 of this document.

Source: References 7,9.

Emissions from petroleum refining operations contain petroleum distillates and derivatives. An extensive literature search revealed no specific information on MEK by-product emissions from the refining processes. However, TRI data indicate that facilities with SIC 2911 (Petroleum refineries) emit a substantial amount of MEK.

7.3.2 Asphalt Paving

The asphalt paving mixtures and blocks (SIC 2951) category consists of two types of asphalt paving used for road paving and repair: cutback asphalt and emulsified asphalt.² It has been estimated that approximately 75 percent of total asphalt production is used for paving.¹⁰

Cutback asphalt is a type of liquefied road surface that is prepared by blending or "cutting back" asphalt cement with various blends of petroleum distillates. Emissions from cutback asphalt operations occur during mixing of asphalt batches, stockpiling, equipment application, and the curing of the road surface when petroleum distillates evaporate. The curing process is the largest individual source of VOC emissions in this operation.¹⁰

Emissions from asphalt paving mixtures and blocks are considered to be 100 percent VOC. However, an extensive literature search revealed no specific information of MEK by-product emissions from either asphalt paving process. TRI data indicate that facilities within SIC 2951 (Asphalt paving mixtures and blocks) can emit significant amounts of MEK.

7.4 PLASTICS MATERIALS AND RESINS

Methyl ethyl ketone may be formed as a by-product in some of the production processes for plastics materials and resins (SIC 2821). The major sources of air contamination in plastics manufacturing are the emissions of raw materials; the emissions from drying operations; the emissions of solvents or other volatile liquids from the reactor trains; and the emissions of

solvents during storage and handling of thinned resins. Most emissions control equipment in the plastics manufacturing industry is a basic part of the system and is often used to recover a reactant or product. These controls include floating roof tanks or vapor recovery systems (adsorbers or condensers), purge lines that vent to a flare system, and recovery systems on vacuum exhaust lines or reactor vessels.

Emissions during plastics production processing contain various solvents or other volatile liquids including MEK. An extensive literature search revealed no specific information of MEK by-product emissions from plastics production processes. However, TRI data indicate that facilities within SIC 2821 (Plastics materials and resins) emit a substantial amount of MEK.

7.5 SYNTHETIC RUBBER MANUFACTURING

Methyl ethyl ketone may be formed as a by-product during the manufacture of styrene butadiene copolymers or synthetic rubber (SIC 2822). Two types of reactions used to manufacture synthetic rubber are emulsion and solution. This discussion focuses on the emulsion type processes which can be either in a solid granular form (crumb) or a liquid form (latex). Major emissions sources for the emulsion crumb process include reactor trains, monomer recovery units, and dryers. The condenser vent for emulsion latex monomer recovery is the largest emissions source for latex production. Emissions from dryers in the crumb process and the monomer removal part of the latex process are normally not controlled. Plant emissions vary depending on facility age, size, and plant modification factors.¹¹

An extensive literature search revealed no specific information of MEK by-product emissions from synthetic rubber production processes. However, TRI data indicate that facilities within SIC 2822 (Synthetic rubber) emit a large amount of MEK.

7.6 CELLULOSIC MANMADE FIBERS

Although no process information or specific MEK emissions sources are described here for the cellulosic manmade fibers category (SIC 2823), it is mentioned separately due to the potentially large MEK emissions, according to TRI data. There are several production processes which comprise this category, and after an extensive literature search, no specific data on MEK emissions were located. The reader should therefore consult specific industries in this category in order to verify the nature of the process, possible MEK emissions, production volume, and control techniques used.

7.7 PHARMACEUTICALS PREPARATION

Methyl ethyl ketone may be formed and/or emitted as a by-product during production of the thousands of pharmaceutical products (SIC 2834) manufactured by a typical pharmaceutical plant. The major equipment contributors of emissions from pharmaceuticals production are MEK-containing organic solvents from dryers, reactors, distillation systems, extractors, centrifuges, and storage tanks. Since solvents are expensive and are typically recovered and reused for economic reasons, solvent emissions are controlled as part of the normal operating procedures in a pharmaceutical industry. Also, most manufacturing is performed inside buildings where solvent losses must be minimized based on industrial hygiene requirements. Condensers are used as a solvent recovery method and scrubbers and incinerators are used for emission control. Control systems are usually designed to operate intermittently and targeted to remove a specific chemical associated with the typical batch process in pharmaceuticals preparation. It is difficult to make a quantitative estimate of the effectiveness of available control methods since control efficiency is dependent on the process being controlled. However, control efficiencies of greater than 95 percent have been reported.¹²

An extensive literature search revealed no specific information on MEK by-product emissions from pharmaceuticals preparation; however, TRI data indicate that facilities within SIC 2834 (Pharmaceutical preparations) emit a significant amount of MEK.

7.8 SOAP AND OTHER DETERGENTS

Methyl ethyl ketone may be formed as a by-product during the production of soap and other detergents (SIC 2841). Odor, in the form of organic compounds, is the predominant atmospheric pollution concern in the manufacture of soap. Potential emission (odor) sources include vent lines, vacuum exhausts, product and raw material storage, and waste streams. Control of these emissions may be achieved by scrubbing all exhaust fumes and incinerating the remaining compounds.¹³

An extensive literature search revealed no specific information on MEK by-product emissions from soap manufacturing; however, TRI data indicate that facilities within SIC 2841 (Soaps and other detergents) emit a small amount of MEK.

7.9 CYCLIC ORGANIC CRUDES AND INTERMEDIATES

Methyl ethyl ketone is formed as a by-product during the production of phenol from cumene. This process is present at many establishments which manufacture cyclic organic crudes and intermediates, and organic dyes and pigments included in SIC 2865. Although specific process information for the production of phenol was not available, emission factors for MEK from some of the process steps were found.

One source of MEK emissions is the cumene oxidation vent, with an emission factor of 0.05 kg MEK/Mg of phenol produced (0.10 lbs MEK/ton phenol). A second source of MEK emissions is the cleavage section vent with an emission factor of 1.8×10^{-5} kg MEK/Mg phenol

(3.6×10^{-5} lbs MEK/ton phenol).¹⁴ Both of these emission factors are based on test data with unspecified controls. The corresponding emission factor quality ratings are D according to criteria used for AP-42 emission factors. Note that according to TRI data, this SIC source category is potentially a relatively large source of MEK emissions.

7.10 SYNTHETIC ORGANIC CHEMICAL MANUFACTURING INDUSTRIES

Methyl ethyl ketone is formed as a by-product during the production of several synthetic organic chemicals. Manufacturers of these synthetic organic chemicals are classified under SIC 2869. Chemicals which may form MEK as a by-product during their manufacture include ethanamines, lead alkyl, chloroprene, acetic acid, acrylates, glycerin (glycerol), propylene, caprolactam, glycol ethers, nitriles, allyl chloride, and allyl alcohol.

The broadest categories of synthetic organic chemical manufacturing processes are the conversion and separation production processes. Conversion processes include reactor and air oxidation processes. The distinguishing characteristic of conversion processes is the alteration of a chemical's molecular structure through chemical reactions. Separation processes include distillation, stripping, absorption, filtration, crystallization, and extraction. A separation process is characterized by the division of a chemical mixture into its distinct components. The resultant components often represent the manufactured product, or may be process by-products or reactants.¹⁵

The main emission sources found in SOCOMI facilities include process vents, transfer and loading operations, storage tanks, wastewater treatment, and equipment leaks. Although no specific MEK emission data were found in current literature, TRI data suggest that several of these sources emit significant amounts of MEK.

7.11 OTHER POSSIBLE MEK BY-PRODUCT SOURCES

MEK may be formed as a by-product from other sources within many different product categories. One possible source of MEK emissions is the drum burning furnace within SIC 5085 (Industrial supplies). According to TRI data, this drum burning/drum cleaning source is an emitter of MEK. Other MEK emissions sources may be included in some mining operations. Possible sources are crushing, hauling, and loading of coal in SIC 1231 (Anthracite mining). Others include drying in SICs 1411 (Dimension stone) and 1499 (Miscellaneous nonmetallic minerals) and calcining in SIC 1475 (Phosphate rock). Note that the specific operations mentioned here may not be the only ones to emit MEK from these SIC categories.

The SIC Major Groups 32 (Stone, Clay, and Glass Products) and 33 (Primary Metal Industries) are also large potential emitters of MEK as a by-product. Primary sources of MEK in Major Groups 32 and 33 are kilns, melting furnaces, and process boilers. These are considered to be external combustion sources and produce MEK as a combustion by-product in fuel firing. Note, however, that these are not the only MEK by-product sources to be found in Major Groups 32 and 33. Each industry is different and may have other sources of MEK by-products besides those mentioned here. For example, SIC codes 3351, 3353, 3354, and 3357 also contain surface coating operations and MEK emissions, as were discussed in Section 5.2 of this document.

7.12 REFERENCES FOR SECTION 7.0

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SECTION 8.0

AMBIENT AIR AND STATIONARY SOURCE TEST PROCEDURES

Methyl ethyl ketone emissions can be measured from ambient air and stationary sources utilizing the test methods presented below. If applied to stack sampling, the ambient air monitoring methods may require adaptation or modification. To ensure that results will be quantitative, appropriate precautions must be taken to prevent exceeding the capacity of the methodology.

- EPA Method TO-5: Determination of Aldehydes and Ketones in Ambient Air Using High Performance Liquid Chromatography (HPLC)
- EPA Method 0030: Volatile Organic Sampling Train (VOST) with EPA Method 5040: Analysis of Sorbent Cartridges from VOST
- EPA Draft Method 0011: Sampling for Aldehyde and Ketone Emissions from Stationary Sources with EPA Draft Method 8315: Determination of Formaldehyde by DNPH Derivatization, Solid Sorbent Extraction, and HPLC Detection
- NIOSH Method 2500: 2-Butanone

The following subsections briefly describe the recommended sampling and analytical methods for determining MEK emissions.

8.1 EPA METHOD TO-5¹

Ambient air concentrations of MEK can be measured using EPA Method TO-5 from the *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*.² Ambient air is drawn through a midjet impinger train that contains equal parts of 2N HCl/0.05 percent 2,4-dinitrophenylhydrazine (DNPH) and isooctane solution at an approximate flow rate of 100 to 1,000 mL/minute. Aldehydes and ketones, especially MEK, form stable 2,4-dinitrophenylhydrazones (DNPH derivatives). The total volume of air collected should not

exceed 80 L. The impinger solutions are then placed in a sample vial and sent to a laboratory for analysis.

The DNPH derivatives are recovered by removing the isooctane layer and extracting the aqueous layer with a hexane/methylene chloride mixture. The combined organic layers are then evaporated to dryness and the residue is dissolved in methanol. The DNPH derivatives are separated using reversed phase high performance liquid chromatography and detected and quantified with an ultraviolet detector operated at 370nm. The specified analytical column is a Zorbax[®] ODS column, 25 cm x 4.6 mm ID.

8.2 EPA METHOD 0030²

The volatile organic sampling train from SW-846, (third edition), is designed for the collection of volatile organic compounds from the stack gas effluents of hazardous waste incinerators. The VOST method was designed to collect volatile organics with boiling points in the range of 30° to 100°C (86° to 212°F). Many compounds with boiling points above 100°C (212°F) may also be effectively collected using this method. Methyl ethyl ketone concentrations can be measured using this method. Figure 8-1 presents a schematic of the principle components of the VOST.

In most cases, 20 L (0.7 ft³) of effluent stack gas are sampled at an approximate flow rate of 1 L/minute (0.04 ft³/min) using a glass-lined heated probe. The gas stream is cooled to 20°C (68°F) by passage through a water-cooled condenser and the volatile organics are collected on a pair of sorbent resin traps. Liquid condensate is collected in the impinger located between the two resin traps. The first resin trap contains about 1.6 g (0.06 ounce) Tenax[®] and the second trap contains about 1 g (0.04 ounce) each of Tenax[®] petroleum-based charcoal.

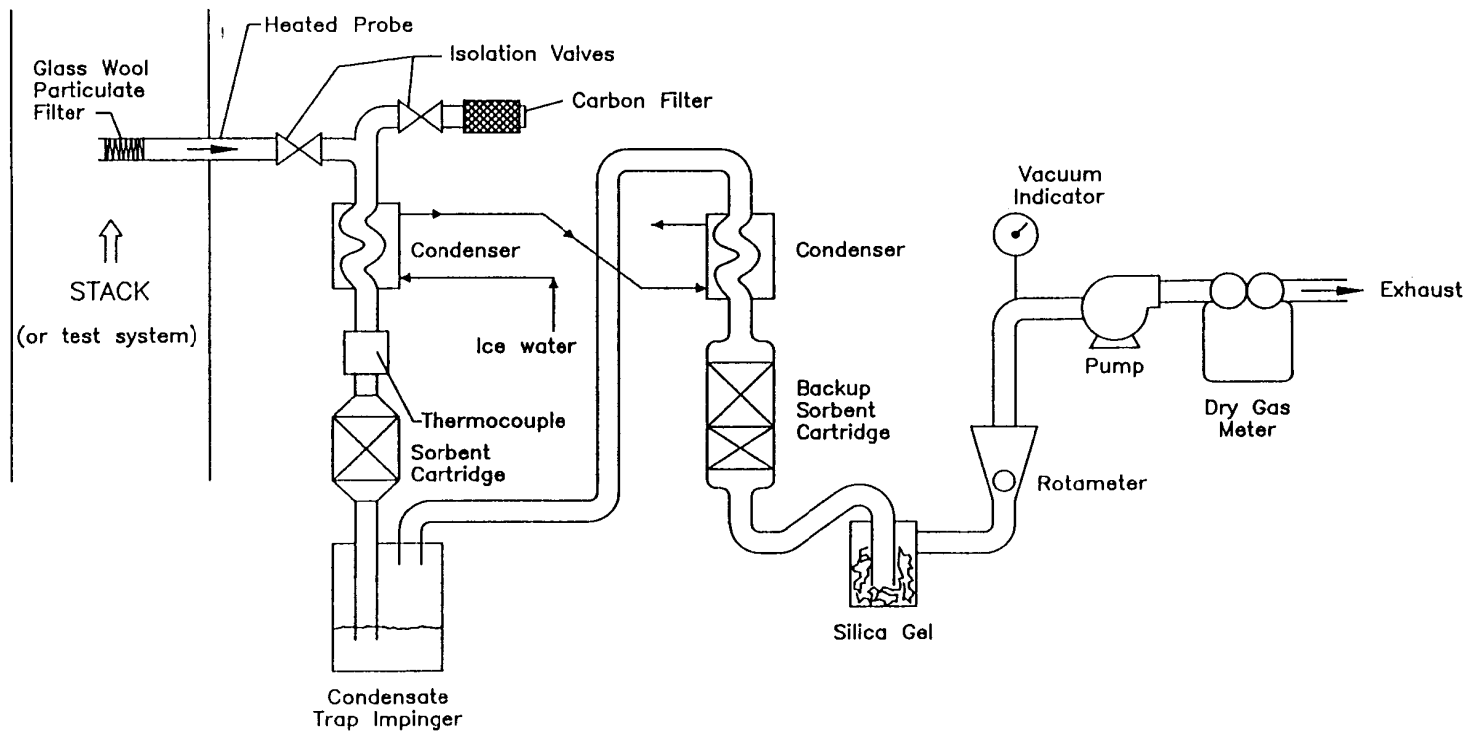


Figure 8-1. Schematic of volatile organic sampling train.¹

The Tenax[®] cartridges are then thermally desorbed and analyzed by purge-and-trap GC/MS along with the condensate catch as specified in EPA Method 5040. Analysis should be conducted within 14 days of sample collection.

8.3 EPA METHOD 5040²

The contents of the sorbent cartridges (collected from EPA Method 0030) are spiked with an internal standard and thermally desorbed for 10 minutes at 80°C (176°F) with organic-free nitrogen or helium gas [at a flow rate of 40 mL/min (2.4 in³)], bubbled through 5 mL (0.3 in³) of organic-free water, and trapped on an analytical adsorbent trap. After the 10 minute desorption, the analytical adsorbent trap is rapidly heated to 180°C (356°F), with the carrier gas flow reversed so that the effluent flow from the analytical trap is directed into the GC/MS. The volatile organics are separated by temperature-programmed gas chromatography and detected by low resolution mass spectrometry. The concentrations of the volatile organics are calculated using the internal standard technique.

EPA Methods 5030 and 8240 may be referenced for specific requirements for the thermal desorption unit, purge-and-trap unit, and GC/MS system.

A diagram of the analytical system is presented in Figure 8-2. The Tenax[®] cartridges should be analyzed within 14 days of collection. The desired detection limit of this method is 0.1 ng/L (20 ng per Tenax[®] cartridge).

8.4 EPA DRAFT METHOD 0011^{2,3}

EPA Draft Method 0011 from the *Methods Manual for Compliance with the BIF Regulations*, is very similar to EPA Method TO-5. Method 0011 is used to determine the Destruction and Removal Efficiency (DRE) of aldehydes and ketones from stationary sources.

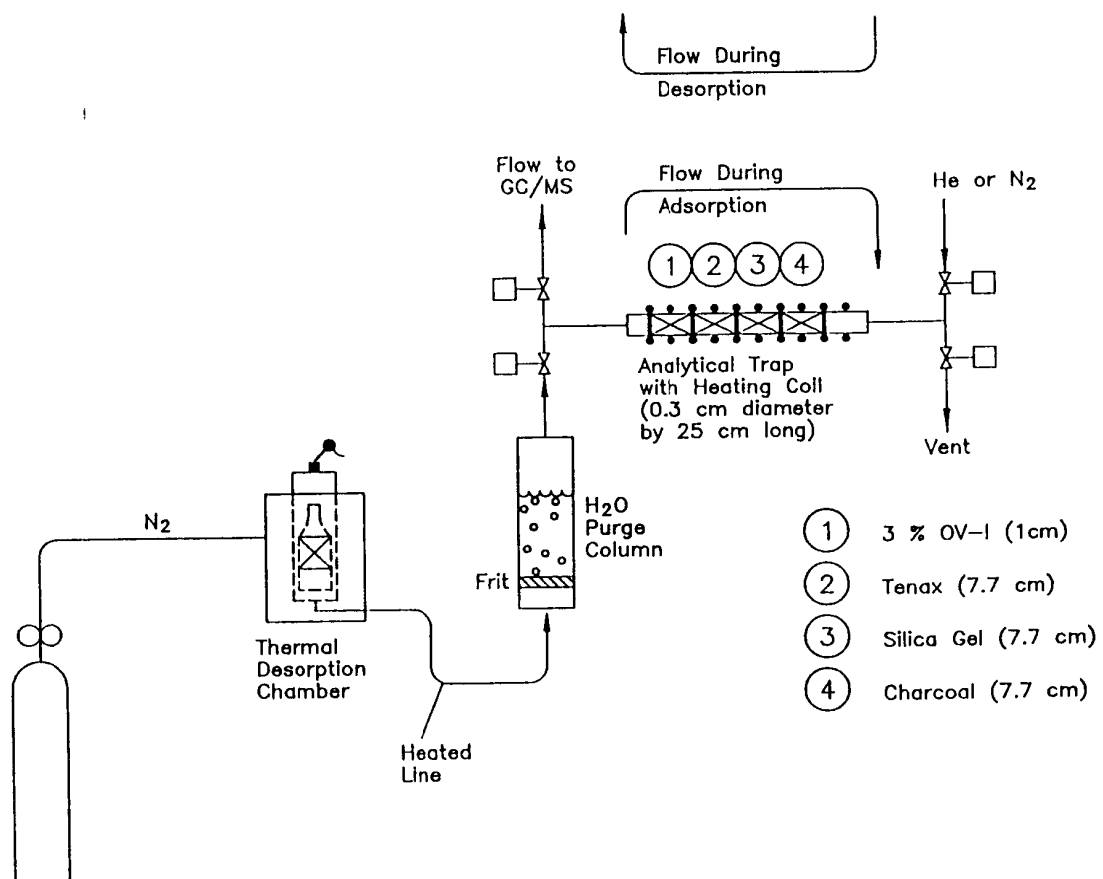


Figure 8-2. Schematic of trap desorption/analysis system.²

The method was specifically developed for the determination of formaldehyde; however, many laboratories have expanded the application to also include other aldehydes and ketones.

In general, exhaust gases are withdrawn isokinetically from a stationary source and are collected in an aqueous solution of acidic 2,4-dinitrophenylhydrazine. The aldehydes and ketones that are present react with the DNPH to form DNPH derivatives. The impinger solutions are then recovered and sent to the laboratory for analysis. The samples are extracted, concentrated, and analyzed by high performance liquid chromatography.

8.5 EPA DRAFT METHOD 8315²

EPA Draft Method 8315 was designed for the determination of free formaldehyde in aqueous samples and leachates. This method can be modified to include the detection and quantification of MEK from aqueous samples collected via EPA Method TO-5 and EPA Draft Method 0011.

The ambient air or exhaust gas samples are collected in an acidic 2,4-dinitrophenylhydrazine solution using either EPA Method TO-5 or EPA Draft Method 0011. Any MEK that is present reacts with the DNPH to form a DNPH derivative. The solution is then extracted with a methylene chloride solution, concentrated using the Kuderna-Danish (KD) procedure, and mixed with methanol. The DNPH derivatives are separated using reversed phase high performance liquid chromatography and detected and quantified with an UV detector operated at 360 nm.

8.6 NIOSH METHOD 2500⁴

Ambient air and exhaust gas concentrations of MEK can also be measured using NIOSH Method 2500. The levels of detection using this method are much higher than the other procedures discussed. NIOSH methods are designed for worker exposure studies usually over an eight-hour period.

Ambient air or exhaust gas samples are collected on a solid sorbent tube containing Ambersorb[®] XE-347 with 160 mg on the front-half portion and 80 mg on the back-half. One to 12 L of air are collected, depending on the expected concentrations, using a vacuum pump set at an approximate flow rate of 0.01 to 0.2 L/minute.

The samples are then capped and sent to the laboratory and desorbed with carbon disulfide (CS₂) and analyzed by GC/FID. The column specified in NIOSH Method 2500 is a 4.0m x 2mm glass or stainless steel with 20 percent SP-2100/0.1 percent Carbowax 1500 on Supelcoport 100/120 or equivalent. The sorbent sample should be stable for at least six weeks at 25°C.

8.7 REFERENCES FOR SECTION 8.0

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APPENDIX A

POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE EMISSIONS

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
1411	Mining operations nonmetallic minerals stone quarrying
1475	Mining operations nonmetallic minerals phosphate rock
1499	Mining operations miscellaneous nonmetallic minerals
1611	Highway and street construction
1721	Painting and paper hanging
2011	Meat packing plants
2013	Sausages and other prepared meats
2044	Rice milling
2076	Vegetable oil mills, nec ^a
2079	Edible fats and oils, nec ^a
2082	Beer production - malt beverages
2087	Flavoring extracts and syrups, nec ^a
2111	Cigarettes
2211	Broadwoven fabric mills, cotton
2221	Broadwoven fabric mills, manmade
2231	Broadwoven fabric mills, wool
2241	Narrow fabric mills
2261	Finishing plants, cotton
2262	Finishing plants, manmade
2269	Finishing plants, nec ^a
2281	Yarn spinning mills
2282	Throwing and winding mills

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
2284	Thread mills
2295	Coated fabrics, not rubberized
2297	Nonwoven fabrics
2298	Cordage and twine
2299	Textile goods, nec ^a
2353	Hats, caps, and millinery
2390	Misc. fabricated textile products
2396	Automotive and apparel trimmings
2399	Fabricated textile products, nec ^a
2420	Sawmills and planing mills
2426	Hardwood dimension and flooring mills
2429	Special product sawmills, nec ^a
2430	Millwork, plywood and structural members
2431	Millwork
2434	Wood kitchen cabinets
2435	Hardwood veneer and plywood
2436	Softwood veneer and plywood
2439	Structural wood members, nec ^a
2452	Prefabricated wood buildings
2493	Reconstituted wood products
2499	Wood products, nec ^a
2510	Household furniture

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
2511	Wood household furniture
2512	Upholstered household furniture
2514	Metal household furniture
2517	Wood TV and radio cabinets
2519	Household furniture, nec ^a
2520	Office furniture
2521	Wood office furniture
2522	Office furniture, except wood
2531	Public building and related furniture
2541	Wood partitions and fixtures
2542	Partitions and fixtures, except wood
2591	Drapery hardware and blinds and shades
2599	Furniture and fixtures, nec ^a
2600	Paper and allied products
2611	Pulp mills
2621	Paper mills
2631	Paperboard mills
2652	Setup paperboard boxes
2655	Fiber cans, drums and similar products
2656	Sanitary food containers
2657	Folding paperboard boxes
2670	Miscellaneous converted paper products

(continued)

**TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)**

SIC Code	Source Description
2671	Paper coated and laminated, packaging
2672	Paper coated and laminated, nec ^a
2673	Bags: plastics, laminated and coated
2674	Bags: uncoated paper and multiwall
2675	Die-cut paper and board
2679	Converted paper products, nec ^a
2731	Book publishing
2732	Book printing
2741	Miscellaneous publishing
2752	Commercial printing, lithographic
2754	Commercial printing, gravure
2759	Commercial printing, nec ^a
2761	Manifold business forms
2771	Greeting cards
2780	Blankbooks and bookbinding
2789	Bookbinding and related work
2791	Typesetting
2796	Platemaking services
2810	Industrial inorganic chemicals
2812	Alkalies and chlorine
2813	Industrial gases
2816	Inorganic pigments

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
2819	Industrial inorganic chemicals, nec ^a
2821	Plastics materials and resins
2822	Synthetic rubber
2823	Cellulosic manmade fibers
2824	Organic fibers, noncellulosic
2833	Medicinals and botanicals
2834	Pharmaceuticals preparations
2841	Soap and other detergents
2842	Polishes and sanitation goods
2843	Surface active agents
2850	Paints and allied products
2851	Paints and allied products
2860	Industrial organic chemicals
2865	Cyclic crudes and intermediates
2869	Industrial organic chemicals, nec ^a
2873	Nitrogenous fertilizers
2874	Phosphatic fertilizers
2879	Agricultural chemicals, nec ^a
2891	Adhesives and sealants
2892	Explosives
2893	Printing ink
2895	Carbon black

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
2899	Chemical preparations, nec ^a
2911	Petroleum refining
2951	Asphalt paving mixtures and blocks
2992	Lubricating oils and greases
2999	Petroleum and coal products, nec ^a
3021	Rubber and plastics footwear
3052	Rubber and plastics hose and belting
3053	Gaskets, packing and sealing devices
3061	Mechanical rubber goods
3069	Fabricated rubber products, nec ^a
3080	Miscellaneous plastics products, nec ^a
3081	Unsupported plastics film and sheet
3082	Unsupported plastics profile shapes
3083	Laminated plastics plate and sheet
3086	Plastics foam products
3087	Custom compound purchased resins
3088	Plastics plumbing fixtures
3089	Plastics products, nec ^a
3111	Leather tanning and finishing
3131	Footwear cut stock
3143	Men's footwear, except athletic
3144	Women's footwear, except athletic

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3149	Footwear, except rubber, nec ^a
3199	Leather goods, nec ^a
3211	Flat glass
3221	Glass containers
3229	Pressed and blown glass, nec ^a
3231	Products of purchased glass
3241	Cement, hydraulic
3253	Ceramic wall and floor tile
3255	Clay refractories
3264	Porcelain electrical supplies
3271	Concrete block and brick
3274	Lime
3275	Gypsum products
3291	Abrasive products
3292	Asbestos products
3295	Minerals, ground or treated
3299	Nonmetallic mineral products, nec ^a
3312	Blast furnaces and steel mills
3313	Electrometallurgical products
3315	Steel wire and related products
3316	Cold finishing of steel shapes
3317	Steel pipe and tubes

(continued)

**TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)**

SIC Code	Source Description
3321	Gray and ductile iron foundries
3324	Steel investment foundries
3325	Steel foundries, nec ^a
3334	Primary aluminum
3341	Secondary nonferrous metals
3351	Copper rolling and drawing
3353	Aluminum sheet, plate, and foil
3354	Aluminum extruded products
3355	Aluminum rolling and drawing, nec ^a
3357	Nonferrous wiredrawing and insulating
3363	Aluminum die-castings
3364	Non ferrous die castings, exc. aluminum
3365	Aluminum foundries
3366	Copper foundries
3398	Metal heat treating
3399	Primary metal products, nec ^a
3410	Metal cans and shipping containers
3411	Metal cans
3412	Metal barrels, drums, and pails
3423	Hand and edge tools, nec ^a
3429	Hardware, nec ^a
3431	Metal sanitary ware

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3432	Plumbing fixture fittings and trim
3433	Heating equipment, except electric
3441	Fabricated structural metal
3442	Metal doors, sash, and trim
3443	Fabricated plate work (boiler shops)
3444	Sheet metal work
3446	Architectural metal work
3448	Prefabricated metal buildings
3449	Miscellaneous metal work
3451	Screw machine products
3452	Bolts, nuts, rivets, and washers
3460	Metal forgings and stampings
3462	Iron and steel forgings
3465	Automotive stampings
3469	Metal stampings, nec ^a
3470	Metal services, nec ^a
3471	Plating and polishing
3479	Metal coating and allied services
3480	Ordnance and accessories, nec ^a
3482	Small arms ammunition
3483	Ammunition, exc. for small arms, nec ^a
3489	Ordnance and accessories, nec ^a

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3491	Industrial valves
3493	Steel springs, except wire
3494	Valves and pipe fittings, nec ^a
3495	Wire springs
3496	Misc. fabricated wire products
3497	Metal foil and leaf
3499	Fabricated metal products, nec ^a
3519	Internal combustion engines, nec ^a
3523	Farm machinery and equipment
3524	Lawn and garden equipment
3531	Construction machinery
3532	Mining machinery
3533	Oil and gas field machinery
3534	Elevators and moving stairways
3536	Hoists, cranes, and monorails
3537	Industrial trucks and tractors
3541	Machine tools, metal cutting types
3542	Machine tools, metal forming types
3543	Industrial patterns
3544	Special dies, tools, jigs and fixtures
3545	Machine tool accessories
3546	Power-driven hand tools

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3553	Woodworking machinery
3554	Paper industries machinery
3555	Printing trades machinery
3556	Food products machinery
3559	Special industry machinery, nec ^a
3561	Pumps and pumping equipment
3562	Ball and roller bearings
3563	Air and gas compressors
3564	Blowers and fans
3565	Packaging machinery
3566	Speed changers, drives, and gears
3567	Industrial furnaces and ovens
3568	Power transmission equipment, nec ^a
3569	General industrial machinery, nec ^a
3571	Electronic computers
3572	Computer storage devices
3575	Computer terminals
3577	Computer peripheral equipment, nec ^a
3578	Calculating and accounting equipment
3579	Office machines, nec ^a
3581	Automatic vending machines
3582	Commercial laundry equipment

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3585	Refrigeration and heating equipment
3586	Measuring and dispensing pumps
3589	Service industry machinery, nec ^a
3594	Fluid power pumps and motors
3599	Industrial machinery, nec ^a
3612	Transformers, except electronic
3613	Switchgear and switchboard apparatus
3621	Motors and generators
3624	Carbon and graphite products
3625	Relays and industrial controls
3629	Electrical industrial apparatus, nec ^a
3631	Household cooking equipment
3632	Household refrigerators and freezers
3633	Household laundry equipment
3634	Electric housewares and fans
3635	Household vacuum cleaners
3639	Household appliances, nec ^a
3643	Current-carrying wiring devices
3644	Noncurrent-carrying wiring devices
3645	Residential lighting fixtures
3646	Commercial lighting fixtures
3647	Vehicular lighting equipment

(continued)

**TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)**

SIC Code	Source Description
3648	Lighting equipment, nec ^a
3651	Household audio and video equipment
3652	Prerecorded records and tapes
3660	Communications equipment
3661	Telephone and telegraph apparatus
3663	Radio and TV communications equipment
3669	Communications equipment, nec ^a
3670	Electronic components and accessories
3671	Electron tubes
3672	Printed circuit boards
3674	Semiconductors and related devices
3675	Electronic capacitors
3676	Electronic resistors
3677	Electronic coils and transformers
3678	Electronic connectors
3679	Electronic components, nec ^a
3691	Storage batteries
3692	Primary batteries, dry and wet
3694	Engine electrical equipment
3695	Magnetic and optical recording media
3699	Electrical equipment and supplies, nec ^a
3710	Motor vehicles and equipment

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3711	Motor vehicles and car bodies
3713	Truck and bus bodies
3714	Motor vehicle parts and accessories
3715	Truck trailers
3716	Motor homes
3721	Aircraft
3724	Aircraft engines and engine parts
3728	Aircraft parts and equipment, nec ^a
3731	Ship building and repairing
3732	Boat building and repairing
3743	Railroad equipment
3751	Motorcycles, bicycles, and parts
3761	Guided missiles and space vehicles
3764	Space propulsion units and parts
3769	Space vehicle equipment, nec ^a
3792	Travel trailers and campers
3795	Tanks and tank components
3799	Transportation equipment, nec ^a
3812	Search and navigation equipment
3821	Laboratory apparatus and furniture
3822	Environmental controls
3824	Fluid meters and counting devices

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3825	Instruments to measure electricity
3826	Analytical instruments
3827	Optical instruments and lenses
3829	Measuring and controlling devices, nec ^a
3841	Surgical and medical instruments
3842	Surgical appliances and supplies
3844	X-ray apparatus and tubes
3845	Electromedical equipment
3851	Ophthalmic goods
3861	Photographic equipment and supplies
3870	Watches, clocks, watchcases and parts
3931	Musical instruments
3942	Dolls and stuffed toys
3944	Games, toys, and children's vehicles
3949	Sporting and athletic goods, nec ^a
3951	Pens and mechanical pencils
3952	Lead pencils and art goods
3955	Carbon paper and inked ribbons
3961	Costume jewelry
3965	Fasteners, buttons, needles, and pins
3991	Brooms and brushes
3993	Signs and advertising specialties

(continued)

TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)

SIC Code	Source Description
3995	Burial caskets
3996	Hard surface floor coverings, nec ^a
3999	Manufacturing industries, nec ^a
4173	Bus terminal and service facilities
4491	Marine cargo handling
4499	Water transportation services, nec ^a
4931	Electric and other services combined
4953	Refuse systems
5021	Furniture
5065	Electronic parts and equipment
5072	Hardware
5078	Refrigeration equipment and supplies
5085	Industrial supplies
5113	Industrial and personal service paper
5160	Chemicals and allied products
5169	Chemicals and allied products, nec ^a
5171	Petroleum bulk stations and terminals
5172	Petroleum products, nec ^a
5198	Paints, varnishes, and supplies
5211	Lumber and other building materials
5511	New and used car dealers
5712	Furniture stores

(continued)

**TABLE A-1.
POTENTIAL SOURCE CATEGORIES OF METHYL ETHYL KETONE
EMISSIONS (Continued)**

SIC Code	Source Description
6512	Nonresidential building operators
6513	Apartment building operators
6514	Dwelling operators, exc. apartments
7361	Employment agencies
7372	Prepackaged software
7378	Computer maintenance and repair
7379	Computer related services, nec ^a
7530	Automotive repair shops
7532	Top and body repair and paint shops
7629	Electrical repair shops, nec ^a
7641	Reupholstery and furniture repair
7699	Repair services, nec ^a
8211	Elementary and secondary schools
8220	Colleges and universities
8244	Business and secretarial schools
8711	Engineering services
8731	Commercial physical research
8734	Testing laboratories
9711	National security
9999	Nonclassifiable establishments

^anec = not elsewhere classified

Based on 1987 SIC codes.

REFERENCES FOR APPENDIX A

1. *Toxic Chemical Release Inventory (TRI)*, 1987-1990. On-line access through the databases. National Library of Medicine, Bethesda, MD.
2. U.S. Environmental Protection Agency. *Crosswalk/Air Toxic Emission Factor Database Management System, Version 1.2*. Office of Air Quality Planning and Standards. Research Triangle Park, NC. October 1991.
3. *Volatile Organic Compound (VOC) Particulate Matter (PM) Speciation Database Management System, Version 1.4*. Office of Air Quality Planning and Standards. Research Triangle Park, NC. October 1991.

APPENDIX B

**LISTS OF PAINT, INK, AND PRINTING FACILITIES WITH ANNUAL SALES
GREATER THAN \$1 MILLION**

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

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

(continued)

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

Name	Address	Sales in \$ Millions
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
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
Courtaulds 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

(continued)

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

Name	Address	Sales in \$ Millions
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
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 & Reynolds 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

(continued)

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

Name	Address	Sales in \$ Millions
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 Bernardino CA 92408	12
Fuller O'Brien Corp.	450 E Grand Ave, South San Francisco CA 94080	140
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

(continued)

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

Name	Address	Sales in \$ Millions
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
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

(continued)

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

Name	Address	Sales in \$ Millions
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
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

(continued)

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

Name	Address	Sales in \$ Millions
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
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
Plectone 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

(continued)

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

Name	Address	Sales in \$ Millions
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
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*

(continued)

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

Name	Address	Sales in \$ Millions
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 B-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

(continued)

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

Name	Address	Sales in \$ Millions
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
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, Westfield 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
Zehrunge 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: Gale Research, Inc. *Ward's Business Directory of U.S. Private and Public Companies-1991*, Volume 4. Detroit, MI. 1991.

TABLE B-2.
PRINTING INK MANUFACTURING FACILITIES (SIC 2893) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

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*

(continued)

TABLE B-2.
PRINTING INK MANUFACTURING FACILITIES (SIC 2893) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Name	Address	Sales in \$ Millions
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*
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: Gale Research, Inc. *Ward's Business Directory of U.S. Private and Public Companies-1991*, Volume 4. Detroit, MI. 1991.

TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Company	Location	Sales (millions)
2711 Newspapers		
Advance Publications Inc.	Staten Island, NY	2,200*
Affiliated Publications Inc.	Boston, MA	542
Chicago Tribune Co.	Chicago, IL	500
Cox Enterprises Inc.	Atlanta, GA	1,970
Dow Jones & Co. Inc.	Washington, DC	1,444
EW Scripps Co.	Wilmington, DE	1,266
Freedom Newspapers Inc.	Irvine, CA	500
Gannett Co. Inc.	Arlington, VA	3,518
Hearst Corp.	New York, NY	1,900*
Ingersoll Publications Co.	Princeton, NJ	1,010*
Knight-Ridder Inc.	Miami, FL	2,268
Media Gen Inc.	Richmond, VA	606
New York Times Co.	New York, NY	1,769
News America Publishing Inc.	New York, NY	3,000
Thomson Newspapers Corp.	Des Plaines, IL	550*
Times Mirro Co.	Los Angeles, CA	3,475
Tribune Co.	Chicago, IL	2,455
2721 Periodicals		
ABC Publishing	New York, NY	310*
Billboard Publications Inc.	New York, NY	100
BPI Communications Inc.	New York, NY	105
Cahners Publishing Co. New York Magazine Div.	New York, NY	102
Chilton Co.	Radnor, PA	150
CMP Publications Inc.	Manhasset, NY	187*
Conde Nast Publications Inc.	New York, NY	280*

(continued)

TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Company	Location	Sales (millions)
Crain Communicating Inc.	Chicago, IL	145
Diamonds Communications Inc.	New York, NY	470*
Edgell Communications Inc.	Cleveland, OH	205
Forbes Inc.	New York, NY	200
International Data Group Inc.	Framingham, MA	500
Meredith Corp.	Des Moines, IA	792
Meredith Corp. Ladies' Home Journal	New York, NY	100
National Enquirer Inc.	Lantana, FL	180
National Geographic Soc.	Washington, DC	425
Newsweek Inc.	New York, NY	256
Official Airline Guides Inc.	Oak Brook, IL	130*
Penthouse Intl. Ltd.	New York, NY	160*
Penton Publishing Inc.	Cleveland, OH	151
Peterson Publishing Co.	Los Angeles, CA	140*
Playboy Enterprises Inc.	Chicago, IL	160
Reader's Digest Assn. Inc.	Pleasantville, NY	1,832
Reed Publishing (USA) Inc. Cahners Publishing Co.	Newton, MA	430
Reed Publishing (USA) Inc.	Newton, MA	600
Rodale Press Inc.	Emmaus, PA	150*
Scholastic Inc.	New York, NY	250*
Simon & Shuster Inc. Bur of Bus Practice	Waterford, CT	100*
Standard & Poor's Corp.	New York, NY	260*
Thompson Corp. Thompson Bus. Info.	Stamford, CT	160*
Time Inc. Magazine Co.	New York, NY	1,500*
Times Mirror Magazines Inc.	New York, NY	470*

(continued)

TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Company	Location	Sales (millions)
Trader Publications Inc.	Clearwater, FL	270*
US News & World Report Inc.	New York, NY	140*
Warren Gorham & Lamont Inc.	New York, NY	130
Whittle Communications Inc.	Knoxville, TN	210*
Ziff Communications Co.	New York, NY	340*
Ziff Communications Co. Zif-Davis Publishing Co.	New York, NY	160*
2731 Book Publishing		
Addison-Wesley Publishing Co.	Reading, MA	120*
Bantam Doubleday Dell Publishing Group Inc.	New York, NY	180*
David C. Cook Publishing Co.	Elgin, IL	100
Encyclopedia Britannica Inc.	Chicago, IL	624
Field Publications	Middletown, CT	100*
Grolier Inc.	Danbury, CT	440*
Harcourt Brace Jovanovich Inc.	Orlando, FL	1,341
Harper Collins Publishers Inc.	New York, NY	450
Houghton Mifflin Co.	Boston, MA	370
Insilco Corp.	Midland, TX	450*
John Wiley & Sons Inc.	New York, NY	282
Lawyers Co-Operative Publishing Co. Inc.	Rochester, NY	150*
Macmillan Inc.	New York, NY	950*
Macmillan Inc. Info Svcs & Instruction	New York, NY	416
MacMillan Intl. Inc.	New York, NY	146*
Macmillan-McGraw-Hill School Publishing Co. School Div.	New York, NY	200

(continued)

TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Company	Location	Sales (millions)
Macmillian-McGraw-Hill School Publishing Co.	Lake Forest, IL	390*
McGraw-Hill Inc. McGraw-Hill Intl Book Group	New York, NY	115
Mosby Year Book Inc.	St. Louis, MO	150
Prentice Hall Inc.	New York, NY	970*
Putnam Publishing Group, Inc.	New York, NY	100
Rand McNally & Co.	Skokie, IL	430*
Random House, Inc.	New York, NY	325
RR Donnelley & Sons Co. Willard Div.	Willard, OH	150
Simon & Schuster Inc.	New York, NY	1,320
South-Western Publishing Co.	Cincinnati, OH	112
Sunday School Bd of the Southern Baptist Convention	Nashville, TN	172
Time-Life Books Inc.	Alexandria, VA	350
West Publishing Co.	St. Paul, MN	450*
Western Publishing Group Inc.	Racine, WI	480
World Book Inc.	Chicago, IL	330*
Zondervan Corp.	Grand Rapids, MI	100*
2732 Book Printing		
Arcata Graphics Co. Arcata Graphics Book Group	Kingsport, TN	170*
Banta Corp.	Menasha, WI	568
Bertelsmann Printing & Mfg. Corp.	Berryville, VA	220*
Brown Printing Co. (Waseca Minnesota)	Waseca, MN	363
Great Lakes Color Printing Corp.	Brentwood, TN	210*
Harper & Row Publishers	New York, NY	450

(continued)

TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Company	Location	Sales (millions)
Jostens Inc. Printing & Publishing Div.	Minneapolis, MN	121
RR Donnelley & Sons Co.	Chicago, IL	3,122
2741 Misc Publishing		
Commerce Clearing House Inc.	Riverwoods, IL	678
Donnelley Directory	New York, NY	1,300*
GTE Telephone Operations Inc. GTE Directories Corp.	Dallas-Fort, TX	360*
McGraw-Hill Info. Svcs. Co.	New York, NY	668
NYNEX Info Resources Co.	Middleton, MA	800
RL Polk & Co.	Detroit, MI	280
Simplicity Holdings, Inc.	New York, NY	110*
Simplicity Pattern Co.	New York, NY	101
Southwestern Bell Yellow Pages Inc.	St. Louis, MO	240*
Southwestern Bell Publications Inc.	St. Louis, MO	280*
U.S. West Direct (U.S. West Marketing Resources Group Inc.)	Aurora, CO	160*
Wonderland Music Co. Inc.	Burbank, CA	200*
2752 Commercial Printing-Lithographic		
American Signature Graphics Foote & Davies Div.	Atlanta, GA	195
American Bank Stationary Co.	Baltimore, MD	110*
Avery Intl Corp. Avery Label Co.	Azusa, CA	110*
Graphic Controls Corp.	Buffalo, NY	140
Graphisphere Corp.	Des Plaines, IL	110
HS Crocker Co. Inc.	South San Francisco, CA	140*
Judd's Inc.	Washington, DC	114
NMG Inc.	Los Angeles, CA	105

(continued)

TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Company	Location	Sales (millions)
Perry Printing Corp.	Waterloo, WI	175
Quebecor Printing (USA) Inc.	St. Paul, MN	770
Queens Group Inc.	Long Island, NY	100
Ringler America Inc.	Itasca, IL	700
RR Donnelley & Sons Co. Mattoon Mfg. Div.	Mattoon, IL	110*
RR Donnelley & Sons Co. Lancaster Mfg. Div.	Lancaster, PA	190*
Shea Communications Co.	Louisville, KY	120
Taylor Corp.	Mankato, MN	540*
Treasure Chest Advertising Co. Inc.	Glendora, CA	550*
Valassis Inserts Inc.	Livonia, MI	400*
World Color Press Inc.	Effingham, IL	650
2754 Commercial Printing-Gravure		
All-State Legal Supply Co.	Cranford, NJ	43
Arcata Graphics Co.	Baltimore, MD	500*
Beck Co. (Langhorne Pennsylvania)	W, Langhorne, PA	10
Clark Printing Co. Inc.	North Kansas, MO	14*
ColorArt Inc.	St. Louis, MO	30
Dennison Mfg. Co. IPC Dennison Co.	Rogersville, TN	60
Dinagraphics Inc.	Cincinnati, OH	20
Golden Belt Mfg. Co.	Durham, NC	70
Graphic Ctr. Cos. Inc. Blake Printery	St. San Luis Obi, CA	11
International Label Co.	Clarksville, TN	30
JW Fergusson & Sons	Richmond, VA	34
Maxwell Communications Corp. Atglen	Atglen, PA	50*
McCleery-Cumming Co.	Washington, IA	22

(continued)

**TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)**

Company	Location	Sales (millions)
Meredith-Burda Corp.	Des Moines, IA	500
Perry Printing Corp. Norway Div.	Norway, MI	25*
Printing House Inc. (Quincy Florida)	Quincy, FL	24
Ringier America Inc. Corinth Div.	Corinth, MS	80
Sheridan Press	Hanover, PA	15
Southern Gravure Svc. Inc.	Louisville, KY	58*
Stevens Graphics Inc.	Atlanta, GA	150
Technographic Inc. Decotone	Lexington, SC	30
World Color Press Inc. Salem Gravure Div.	Salem, IL	80
2759 Commercial Printing Nec		
Alden Press Inc.	Elk Grove Village, IL	170*
Avery Intl. Corp. Soabar Products Group	Philadelphia, PA	100*
Bowne & Co. Inc.	New York, NY	190
Curtis 1000 Inc.	Atlanta, GA	160*
Data Documents Inc. (Omaha)	Omaha, NE	200
Deluxe Corp.	St. Paul, MN	1,316
Duplex Products Inc.	Sycamore, IL	327
Graphic Indus. Inc.	Atlanta, GA	310
John H. Harland Co.	Atlanta, GA	345
Maxwell Commun Corp.	St. Paul, MN	720*
Meehan-Tooker Inc.	East Rutherford, NJ	110
Quad Graphics Inc.	Pewaukee, WI	380
RR Donnelley & Sons Co. Warsaw Mfg. Div.	Warsaw, IN	160*
Webcraft Technologies Inc.	North Brunswick, NJ	220*
Williamhouse-Regency Inc.	New York, NY	230

(continued)

TABLE B-3.
PRINTING AND PUBLISHING FACILITIES (SIC 27) WITH
ANNUAL SALES GREATER THAN \$1 MILLION (Continued)

Company	Location	Sales (millions)
World Color Press Inc. Spartan Printing Co.	Sparta, IL	100*
2761 Manifold Business Forms		
Allied Paper Inc. Allied-Energy Syss Inc.	Dayton, OH	130*
American Bus Products Inc.	Atlanta, GA	387
Arnold Corp.	Dayton, OH	200
CST Group Inc.	Wheeling, IL	110
Ennis Bus. Forms Inc.	Ennis, TX	130
McGregor Printing Corp.	Washington, DC	125
Moore Corp. Ltd. Moore Bus. Forms & Syss. Div.	Glenview, IL	1,675
New England Bus. Svc. Inc.	Groton, MA	226
Office Electronic Inc.	Itasca, IL	105
Standard Register Co.	Dayton, OH	709
Uarco Inc.	Barrington, IL	520*
Vanier Graphics Corp. (American Bus. Products Inc.)	Santee, CA	133
Wallace Computer Svcs. Inc.	Hillside, IL	429
2771 Greeting Cards		
American Greetings Corp.	Cleveland, OH	1,309
American Greetings Corp. Seasonal Div.	Oscoola, AR	110
Current Inc. (Colorado Springs Colorado)	Colorado Springs, CO	160
Gibson Greetings Inc.	Cincinnati, OH	463
Hallmark Cards Inc.	Kansas City, MO	2,500
Hallmark Cards Inc. Topeka Products	Topeka, KS	120*

* Indicates an estimated financial figure

Source: Gale Research, Inc. *Ward's Business Directory of U.S. Private and Public Companies-1991*, Volume 4. Detroit, MI. 1991.

APPENDIX C

SUMMARY OF EMISSION FACTORS LISTED IN THIS DOCUMENT

**TABLE C-1.
SUMMARY OF METHYL ETHYL KETONE EMISSION FACTORS**

SIC	SIC Description	SCC	SCC Description	Emission Factor	Quality Rating	Reference	Note
2611	Pulp Mills	30700101	Pulp and Paper-Kraft Pulping-Digester	0.0165 kg MEK/Mg Pulp	D	7-7 7-9	Non condensible gases from evaporator and digester vents
2611	Pulp Mills	30700103	Pulp and Paper-Kraft Pulping-Evaporator	0.0135 kg MEK/Mg Pulp	D	7-7 7-9	Evaporator combined condensate
2611	Pulp Mills	307001	Pulp and Paper-Kraft Pulping	0.0015 kg MEK/Mg Pulp	D	7-7 7-9	Oxygen deliquification system vents
2611	Pulp Mills	30700102	Pulp and Paper-Kraft Pulping-Washer/Screens	0.0135 kg MEK/Mg Pulp	D	7-7 7-9	Brown stock washer vent gases
2611	Pulp Mills	30700107	Pulp and Paper-Kraft Pulping-Turpentine Condenser	0.0045 kg MEK/Mg Pulp	D	7-7 7-9	Turpentine condenser condensates
2611	Pulp Mills	30700101	Pulp and Paper-Kraft Pulping-Digester/Blow Tank	0.007 kg MEK/Mg Pulp	D	7-7 7-9	Batch digester blow condensates
2611	Pulp Mills	30700104	Pulp and Paper-Kraft Pulping-Furnace with direct contact evaporators	0.0075 kg MEK/Mg Pulp	D	7-7 7-9	Direct contact evaporators
2611	Pulp Mills	30700109	Pulp and Paper-Kraft Pulping-Liquor Oxidation Tower	0.005 kg MEK/Mg Pulp	D	7-7 7-9	Black liquor oxidation vent gases
4953	Refuse Systems	50100506	Solid Waste Disposal-Sludge Incinerator	0.00538 kg MEK/Mg of dry sludge	D	6-3	Controlled with scrubber

TABLE C-2.
SUMMARY OF VOC EMISSION FACTORS*

SIC	SIC Description	SCC	SCC Description	Emission Factor	Quality Rating	Reference	Note
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.104 kg/hr/source	U	4-8	Fugitives-Gas/vapor pressure relief seals
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.00083 kg/hr/source	U	4-8	Fugitives-Flanges
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.0017 kg/hr/source	U	4-8	Fugitives-Open ended lines
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.015 kg/hr/source	U	4-8	Fugitives-Sampling connections
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.0056 kg/hr/source	U	4-8	Fugitives-Gas valves
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.0071 kg/hr/source	U	4-8	Fugitives-Light liquid valves
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.00023 kg/hr/source	U	4-8	Fugitives-Heavy liquid valves
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.0494 kg/hr/source	U	4-8	Fugitives-Light liquid pump seals
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.0214 kg/hr/source	U	4-8	Fugitives-Heavy liquid pump seals
2869	Industrial Organic Chemicals	30109105	Ketone Production - MEK	0.228 kg/hr/source	U	4-8	Fugitives-Gas/vapor compressor seals

Note: To obtain methyl ethyl ketone leak emission factor for each component, multiply VOC emission factor above by the fraction of methyl ethyl ketone in the stream.

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16. ABSTRACT To assist groups interested in inventorying air emissions of various potentially toxic substances, EPA is preparing a series of documents such as this to compile available information on sources and emission of these substances. This document deals specifically with Methyl Ethyl Ketone and in making gross estimates of air emissions therefrom. This document presents information on (1) the types of sources that may emit Methyl Ethyl Ketone , (2) process variations and release points for these sources, and (3) available emissions information indicating the potential for Methyl Ethyl Ketone releases into the air from each operation.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
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Methyl Ethyl Ketone Air Emission Sources Locating Air Emission Sources Toxic Substances Emission Estimation		
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