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EVALUATION OF VOLATILE ORGANIC EMISSIONS DATA FOR NONPROCESS SOLVENT USE IN 15 COMMERCIAL AND INDUSTRIAL BUSINESS CATEGORIES

Prepared for

Office of Air Quality Planning and Standards

Prepared by

Air and Energy Engineering Research Laboratory
Research Triangle Park NC 27711

EPA REVIEW NOTICE

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EVALUATION OF VOLATILE ORGANIC EMISSIONS DATA FOR NONPROCESS SOLVENT USE IN 15 COMMERCIAL AND INDUSTRIAL BUSINESS CATEGORIES

Prepared by:

C. M. Northeim
G. W. (Bill) Deatherage
L. A. Hollar, Jr.
Center for Environmental Analysis
Pollution Prevention Program

Research Triangle Institute
P. O. Box 12194
Research Triangle Park, NC 27709-2194

EPA Cooperative Agreement No. CR 819541-01-0
Project Officer, Michael Kosusko
U.S. Environmental Protection Agency
Air and Energy Engineering Research Laboratory
Research Triangle Park, NC 27711

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EXECUTIVE SUMMARY

Ozone nonattainment and air toxic issues are among the most difficult environmental problems facing the United States. Significant contributors to these environmental issues are the volatile organic compound (VOC) emissions that result from the use of a wide range of commercial and consumer products. Consumer products, as defined by the Clean Air Act Amendments of 1990, include paints, coatings, and solvents. For the purposes of this research, this definition has been interpreted as including the use of such products in industrial applications when the product is not directly incorporated into a specific process (nonprocess solvents).

The primary purpose of this project is to gather and evaluate existing data on nonprocess solvents. An additional objective of this project is to identify pollution prevention approaches and technology demonstration opportunities to enhance VOC emission reduction efforts. This research report presents the data and information gathered for nonprocess solvent use in the following industrial/commercial business categories:

- automotive repair;
- bakeries;
- building renovation;
- chemical manufacturing;
- electrical equipment maintenance and repair;
- florists;
- furniture repair/restoration;
- heating, ventilation, and air conditioning services;
- machine shops;
- mold release agents;
- office products;
- quick print shops;
- road paving;
- roofing; and
- textile manufacturing.

Significant effort was put into obtaining information and data on the types and quantities of nonprocess solvents used within the 15 selected categories. Literature searches provided little specific information on nonprocess solvent use. Contacts with trade associations and industry representatives proved to be the best source. Even so, most individuals that were contacted had not previously considered nonprocess solvent usage. Therefore, information and data on specific solvent types and quantities used within the above industrial/commercial business categories were not readily available. The information obtained tends to be qualitative and may include subjective extrapolations.

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SECTION 1

BACKGROUND

The United States ozone nonattainment and air toxic issues are among the most difficult environmental problems facing this country today. Although most of the large stationary sources of VOC emissions are covered by existing or upcoming regulations with the intent of reducing ambient ozone concentration. One U.S. Environmental Protection Agency (EPA) source (Kosusko, 1990) has stated that, "collectively small area sources may contribute as much as 50 percent of VOC emissions." One of the single-largest, unregulated, stationary sources of VOC emissions is thought to be the use of a wide range of consumer/commercial products.

Because VOC emissions from most consumer/commercial products cannot be controlled by traditional add-on control devices, they must be mitigated by pollution prevention measures. Therefore, pollution prevention techniques, such as product substitution, product reformulation, altered use procedures, and other approaches that reduce or eliminate VOC and air toxic emissions, are ideally suited to small stationary area sources. As defined by the Clean Air Act Amendments (CAAA) of 1990:

> The term consumer or commercial product means any substance, product (including paints, coatings and solvents), or article (including any container or packaging) held by any person, the use, consumption, storage, disposal, destruction, or decomposition of which may result in the release of volatile organic compounds. The term does not include fuels or fuel additives regulated under Section 211, or motor vehicles, nonroad vehicles, and nonroad engines as defined under Section 216.

One of the first steps in solving the environmental problems associated with the use of consumer/commercial products is to conduct a study to determine types and quantities of VOC emissions from such products. By doing so, researchers will be able to determine their potential to contribute to increased urban ozone levels and to establish criteria for reducing environmental impacts. Researchers have initiated numerous studies of the emissions from various categories of traditional consumer products. The research summarized in this report was a preliminary investigation of VOC emissions from 15 non-traditional consumer/ commercial product categories.

Traditional consumer products for the purposes of this report are considered to be such items as personal care products (e.g., hair spray, deodorants, mouthwash), household products (e.g., cleaners, laundry products, air fresheners), automotive care products (e.g., brake cleaners, polishes, antifreeze), adhesives and sealants (e.g., household glue, wallpaper paste, caulking compounds), lawn and garden care products (e.g., insecticide sprays and foggers,

wood preservatives, herbicides), coatings (e.g., spray paints, paint removers and thinners), and other miscellaneous products.

The definition of consumer/commercial products contained in the CAAA is broad in the sense that it includes traditional consumer products as well as nontraditional consumer products, such as paints, coatings, and solvents, used in commercial and industrial facilities. Within this definition is some uncertainty or "gray area" concerning the types of materials, products, and/or processes that should be included. Examples of this gray area include solvent-containing roofing materials and paving asphalt. It is anticipated that as efforts proceed in this area, the gray area will be better defined.

The focus of this report is on the use of nonprocess solvents in selected industrial and commercial operations. Nonprocess solvents are used by industry, commercial operations, and/or individual consumers and are not part of a manufacturing production line or incorporated into a product (or chemically modified) as part of the manufacturing process. Nonprocess solvents usually evaporate either during or shortly after their use. Cleaning and lubricating solvents are generally considered nonprocess solvents. An exception to this is in-process parts cleaning, such as vapor degreasing.

Although this research focuses on emissions of nonprocess solvents that are defined as VOCs, information concerning the nonprocess use of 1,1,1-trichloroethane (1,1,1-TCA) and methylene chloride ($MeCl_2$) also has been gathered. By definition, VOCs are organic compounds which participate in atmospheric photochemical reactions thereby contributing to the formation of tropospheric ozone. Because these two chemicals have negligible photochemical reactivity, they are not classified as VOCs. However, 1,1,1-TCA and $MeCl_2$ are used in a variety of nonprocess operations. Moreover, both compounds are classified in Section 112(a) of the CAAA of 1990 as hazardous air pollutants. 1,1,1-TCA also is classified as a Class 1, Group V controlled substance for the purpose of protection of stratospheric ozone while $MeCl_2$ is considered a possible carcinogen. Therefore, for these reasons, information concerning these two compounds has been included in the report (*Federal Register,* 1992 and Sigma-Aldrich Corporation, 1993).

In previous studies of solvent use (Jones et al., 1986; Kersteter et al., 1992; Ostojic, 1979; U.S. EPA, 1989), nonprocess solvents generally were not considered or reported. Therefore, existing information on the VOC emissions from nonprocess solvent use is not available. In cases where a "miscellaneous solvent use" category is used, this quantity can be significant. For example, one study (Ostojic, 1979) estimated that total solvents consumed that cannot be attributed to any specific end use were approximately $2{,}000 \times 10^6$ lb/yr.

Emissions from nonprocess solvent uses are anticipated to become a more significant percentage of overall VOC emissions as emissions from other sources decrease due to regulatory and/or voluntary reductions. The overall objective of this project is, therefore, not

only to assess the uses and emissions from nonprocess solvents in selected industries, but to identify pollution prevention and control measures that could be used to reduce these emissions.

The primary purpose of this project is to gather and evaluate readily available data on nonprocess solvents. Then, pollution prevention approaches and technology demonstration opportunities will be identified to enhance research and development, facilitate industrial efficiency, and aid in technology transfer. The purpose of this report is to summarize the preliminary evaluation of 15 source categories, information that has been collected in the initial steps of this project, and highlight key issues leading to further study.

Section 2 of this report describes the process used by the EPA and Research Triangle Institute (RTI) to select the industrial/commercial business categories to be investigated in this first-phase effort. Section 3 outlines the steps taken to obtain information and data. Section 4 presents the preliminary information and data obtained for each of the solvent use categories. These categories are:

- automotive repair;
- bakeries;
- building renovation;
- chemical manufacturing;
- electrical equipment maintenance and repair;
- florists;
- furniture repair/restoration;
- heating, ventilation, and air conditioning (HVAC) services;
- machine shops;
- mold release agents;
- office products;
- quick print shops;
- road paving;
- roofing; and
- textile manufacturing.

Section 5 presents criteria for selecting industries for the next phase of this project (detailed industry evaluations) and an evaluation, based on these criteria, of the 15 categories in this report. Section 6 lists documents referenced in this report, and Section 7 is a bibliography of relevant documents and phone contacts made in the course of this effort.

SECTION 2

CATEGORY SELECTION PROCEDURE

The first part of this project involved the development of a definition of nonprocess solvent use and a list of industrial/commercial business categories thought to use large quantities of nonprocess solvents. The first step that was taken in the development of definitions and the list of industrial categories to be considered for this effort was to meet with other researchers at EPA working on issues related to consumer/commercial products.

In an initial meeting, a representative from EPA's Office of Air Quality Planning and Standards (OAQPS) suggested three categories of consumer/commerical products for further investigation as part of the nonprocess solvent effort: commercial service business products, industrial use products, and office products. The representative also described a current OAQPS project that is being conducted on industrial cleanup solvents.

An additional meeting was held to discuss the industrial cleanup solvents project and the potential for overlap and cooperation between that project and the nonprocess solvent project. The scope of the cleanup solvents project includes industrial cleaning of internal surfaces, external surfaces, and nonmetallic removable parts. The scope does not include routine janitorial cleaning of bathrooms and offices. However, floor cleaning within industrial facilities may be investigated. OAQPS is obtaining information for this project directly from nine different industries, as well as from the information gathering associated with control techniques guideline (CTG) efforts for other industries. Information is also being obtained from a maximum achievable control technology (MACT) standard that is being developed for use as a national emission standard for hazardous air pollutants. The methodology used to select the nine industries was described as qualitative, not quantitative. These nine industries and other industry categories being investigated by projects that will provide input to the cleanup solvents project include:

- manufacture of electrical equipment;
- truck/bus body assembly;
- manufacture of scientific equipment;
- railroad maintenance;
- office furniture manufacture;
- rotogravure printing;
- photographic supplies/film;
- automotive manufacturing;
- paints and coatings manufacture;
- aerospace coatings (CTG);
- shipbuilding (CTG);
- plastic parts coating (CTG);
- automotive refinishing (CTG);

- wood furniture coating (CTG);
- offset lithography (CTG); and
- magnetic tape coating (MACT).

Additional industry categories could be evaluated as a means of confirming and/or adding to the information that will be collected.

Using the information from these two meetings, as well as other less formal meetings and discussions with others at EPA, information from literature sources (Jones et al., 1986; Kersteter et al., 1992; Ostojic, 1979; U.S. EPA, 1989), and the *Standard Industrial Classification Manual* (1987), a draft list of industrial/commercial categories to be considered for the nonprocess solvent project was developed. The list includes (in alphabetical order):

- bakeries;
- building construction/renovation;
- chemical manufacturing;
- florists;
- HVAC service/repair;
- quick print facilities (including office products);
- roofing tars and/or road paving; and
- textile manufacturing.

As information and data were obtained, these categories were further divided into 13 different industry groups that are presented in Section 4 of this report. Two additional categories, automotive repair and use of mold release agents, were added at the specific request of OAQPS at a project briefing on the first 13 categories.

SECTION 3

INFORMATION GATHERING

3.1 LITERATURE SEARCHES

3.1.1 Introduction

To gather existing published information, several literature searches were conducted. At the Technical Information Center (TIC) on the RTI campus, seven on-line computer data bases were utilized. At the EPA library in Research Triangle Park, North Carolina, the Air Clearinghouse for Inventories and Emission Factors (Air CHIEF) data base was searched. An additional EPA source, the Pollution Prevention Information Clearinghouse (PPIC), was also searched. The Office of Waste Reduction (OWR) of the North Carolina Department of Environment, Health, and Natural Resources maintains a library of materials related to pollution prevention and waste minimization. A computerized index of materials enabled a search for particular industry segments of interest. Finally, data assembled in census publications from 1987 and earlier census years were used to ascertain the size of each industry segment.

3.1.2 Summary

Two separate computerized literature searches were conducted at the RTI TIC. The first search employed the following data bases: Enviroline, Environmental Bibliography, Paperchem, Pollution Abstracts, Textile Technology Digest, and World Textiles. Enviroline and Environmental Bibliography include references to a variety of environmental issues. Paperchem was selected for coverage in the graphic arts. Pollution Abstracts records refer to documents with technical information on pollution, its sources, and its control. Textile Technology Digest and World Textiles cover the various aspects of textile manufacturing and processing.

These data bases reference such sources as dissertations, patents, books, periodicals, papers, pamphlets, trade publications, and proceedings. Each file contains records numbering from a few hundred thousand to nearly half a million. Key words used in the literature searches are contained in Appendix 1.

On a separate occasion, the data base Predicasts Overview of Markets and Technology (PTS PROMT) was searched. PTS PROMT records are indexed on event and product codes. Event codes allow information retrieval to be limited to particular areas of concern. Product codes are more commonly known as standard industrial classification (SIC) codes. The search can then be limited by key words. PTS PROMT abstracts, excerpts, and full-text records are from sources such as periodicals, news releases, and annual reports. Approximately one-half million records are added to the data base each year.

For this search, event codes keyed on science and research, use of materials and supplies, and pollutants produced and recycled. Appendix 2 lists the SIC codes used in the search and their descriptors. To further focus the search, combinations of the key words VOC, emissions, solvent, clean, pollution, and pollution prevention were entered.

At the EPA library, the Air CHIEF data base is stored on compact disk-read only memory (CD-ROM) format. Several sources of information are combined on the disk. This allows easy access to information on the types and quantities of pollutants emitted from a variety of sources. Air CHIEF includes the first volume of the EPA AP-42 document, *Compilation of Air Pollutant Emission Factors* (U.S. EPA, 1991). The Crosswalk/Air Toxic Emission Factor data base management system is on Air CHIEF. Another source of information on the CD-ROM is the VOC/Particulate Matter Speciation data base management system. The first 24 reports in the series, *The Locating and Estimating Emissions of...Series* (U.S. EPA, 1984), are also included on the disk. These documents focus on 24 toxic pollutants and their associated source categories.

PPIC was established by the EPA in 1989 as a computerized clearinghouse dedicated to reducing industrial pollutants through technical information transfer, education, and public awareness. PPIC is intended to be accessible to all individuals interested in obtaining information on pollution prevention. There are many different components of PPIC. For the purposes of information gathering on nonprocess solvent use, the features of PPIC that were searched were the industrial case study descriptions and the literature repository.

The OWR at the North Carolina Department of Environment, Health, and Natural Resources has collected over 5,000 documents pertaining to waste minimization and pollution prevention. This library consists of such sources as trade show presentations and proceedings, journal publications, product information brochures, books, pamphlets, and video tapes. The department maintains an index of approximately 2,800 documents in PROCITE, a data base program for the personal computer.

Since 1967, the Census Bureau has taken an economic census every five years. Data in the 1987 census were reported on the basis of SIC codes. The information obtained was used to determine the relative size of each industry segment. Data from the Census of Retail Trade, Service Industries, Manufactures, and Construction Industries were gathered.

3.2 TRADE ASSOCIATIONS AND INDUSTRY CONTACTS

The majority of the information in this report was a result of contacts with trade associations and industrial representatives. Telephone conversations with a brief, initial list of contacts often yielded new information. At other times, the individuals were able to provide or list additional sources of written material. Several references to other organizations, companies, or individuals were made. Individuals and the organizations that were contacted are grouped by industry segment in Table 1.

TABLE 1
TRADE ASSOCIATIONS/INDUSTRY CONTACTS

INDUSTRY	TRADE ASSOCIATION/COMPANY	CONTACT
Automotive Repair	Automotive Service Association	Don Randall
	Convenient Automotive Services Institute	Larry Northup
	Crabtree Valley Exxon Service Station	Woody Barbor
	Cricket Service Center	Jarrel Spencer
	Independent Lubricant Manufacturers Association	Nancy Demarko
	Independent Garage Owners of North Carolina	Tom Barry
		Lewis Huff
	King Auto Service	Delmar King
	Motor Vehicles Manufacturers Association	Jim Stiger
	National Institute for Automotive Service Excellence	receptionist
	New York State Association of Service Stations and Repair Shops	Ralph Bombardier
Baking	American Bakers Association	Anne Giesecke
	American Institute of Baking	Bill Pursley
	American Society of Baking Engineers	Bob Fischer
	Bakery Equipment Manufacturing Association	Rolce Ricker
	Campbell Taggard	Perry Fischer
	Independent Bakers Association	receptionist
	Independent Bakers Cooperative	Rela Twire
	Research Triangle Institute, Center for Environmental Analysis	Wally Sanford
	Retail Bakers Association	Peter Howstle
Building Renovation	American Institute of Architects	Patrick Lalley
		Christine Nimbrowski
	American Institute of Constructors	Cheryl Harris
	Associated Builders and Contractors	Don Whyte
	Associated General Contractors of America	William Hickman
	Building Research Board	Andy Lemer
	Construction Specification Institute	George Hockett
	Environmental Outfitters	Paul Bierman-Lytle
	National Institute of Building Sciences	Neil Sandler
	Scientific Consulting Group	Joel Todd
	Siegal Environmental	David Gottfried
	Virginia Polytechnic Institute	Jim Woods
Chemical Manufac-turing	American Chemical Society	Henry Saxe
	Chemical Manufacturers Association	Diana Artemis
	Materials Technology Institute of the Chemical Process Industries	Albert Krisher
	Research Triangle Institute, Center for Environmental Analysis	Jeffrey Portzer

(continued)

TABLE 1
TRADE ASSOCIATIONS/INDUSTRY CONTACTS
(Cont'd)

INDUSTRY	TRADE ASSOCIATION/COMPANY	CONTACT
Electrical Equipment Maintenance	Channel Master	Bernard Hendricks
	Chemical Specialties Manufacturers Association	Paul Pierpoint
		Doug Fratz
	ChemTronics	customer service
	Circuit City Service	Wendell Welch
	National Association of Service Dealers	receptionist
	National Center for Manufacturing Science	Clair Vinton
	Research Triangle Institute, Facilities and Maintenance Department	Edd Lovette
	United Electrical, Radio, and Machine Workers of America	Bob Sopansic
		Carolyn Falk
Florist	Society of American Florists	Steve Daigler
Furniture Repair/ Restoration	American Furniture Manufacturing Association	Larry Runyan
	Business and Institutional Manufacturers Association	Pete Wilcox
	CFR Corporation	Bob Bary
	Conservation Technician	Terry Neely
	Furniture Medic	Todd Vieyra
	Grand Rapids Area Furniture Manufacturers Association	receptionist
	National Home Furnishings Association	Angela Arrington
	National Office Products Association	Dan Scott
	Smithsonian Institution	Don Williams
	Unfinished Furniture Association	Nancy Branka
	Y & J Furniture Company, Inc.	Matt Yarbrough
Heating, Air Conditioning, and Refrigeration Service	Air-Conditioning and Refrigeration Institute	receptionist
	Air Conditioning Contractors of America	Elaine Smith
		Bob Axelrod
	American Society of Refrigerating and Air Conditioning Engineers	Jim Norman
	Fomo-Products, Inc.	Mary Williams
	La-Co Industries, Inc.	customer service
	National Association of Plumbing-Heating-Cooling Contractors	Russ Chaney
	Nu-Calgon Wholesaler, Inc.	Lynn White
	Refrigeration Engineers and Technicians Association	Jim Marrela
	Refrigeration Service Engineers Society	Wilton Harris
		Ed Mastin
	Research Triangle Institute, Facilities and Maintenance Department	Edd Lovette
		Bobby Rives
	Stewart Hall	customer service
	Virginia Chemical	customer service

(continued)

TABLE 1
TRADE ASSOCIATIONS/INDUSTRY CONTACTS
(Cont'd)

INDUSTRY	TRADE ASSOCIATION/COMPANY	CONTACT
Machine Shops	Association for Manufacturing Technology	Beth Stahmer
	Durham Technical Community College	Dwight Tichenor
	National Tooling and Machining Association	Bill Ruxton
		Owen Henderson
Mold Release Agents	Air Products & Chemicals, Inc.	Gary Andrews
		Kedar Murphy
	Hickory Springs Manufacturing Company	Graham Walmsley
	North Carolina Department of Environment, Health, and Natural Resources	Bob Carter
	Society of the Plastic Industry	Thomas Southall
Paving	American Concrete Paving Association	Bob Risser
	American Road and Transportation Builders Association	Kent Starwalt
	American Association of State Highway and Transportation Organization	Amy Steiner
	Asphalt Institute	Bob McGinnis
		Fred Waller
	Illinois Tollway	John Benda
	International Bridge, Tunnel and Turnpike Association	Maureen Gallagher
	National Asphalt Pavement Association	Campbell Crawford
	Research Triangle Institute, Center for Environmental Analysis	Greg Carter
		Kevin Ours
Office Products	3M	Deborah Bergh
	Borden, Inc.	customer service
	Consumer Product Safety Commission	reference assistant
	Dennison Stationary Products Company	Barbara Aquino
	Faber-Castell Corporation	customer service
	The Gillette Company	Joe DiMaddio
		John Thompson
	International Business Forms Association	Jim Weller
	International Rotex, Inc.	Shawn Jones
	Meade Corporation	Anne Crone
		Robert Fetters
	National Association of Printing Ink Manufacturers	receptionist
	National Business Forms Association	receptionist
	Pilot Corporation	customer service
	Research Triangle Institute, Center for Environmental Analysis	Bob Hetes
	Research Triangle Institute, Center for Aerosol Technology	Phil Lawless
		Kathleen Owen
	Research Triangle Institute, Analytical and Chemical Sciences	Roy Fortman
	Sanford Corporation	Patricia Lhotka
	Toxic Substances Control Act Assistance Information Service	reference assistant

(continued)

TABLE 1
TRADE ASSOCIATIONS/INDUSTRY CONTACTS
(Cont'd)

INDUSTRY	TRADE ASSOCIATION/COMPANY	CONTACT
Quick Print Shops	A.B. Dick Company	customer service
	Anchor Lithkemko	Gloria Larson
	Association of Reproduction Materials Manufacturers	Philip Nowers
	Buyers' Lab Incorporated	receptionist
	Copy Pro	Brian Hecker
	International Reprographics Association	Mary-Jo Sager
	National Association of Quick Printers	Dan Witty
		Violet Lustgarten
	National Printing Equipment and Supply Association	receptionist
	Research Triangle Institute, Copy Center	Vicki Snipes
	Ricoh	customer service
	Riso, Inc.	Andrew Adelson
		James Dougherty
	Savin Corporation	Kevin Costigan
	Van Son Holland Ink Corporation of America	customer service
Roofing	GAF	Bill Woodring
	Georgia Pacific	Donald Shaw
	National Roofing Foundation	Tom Shanahan
	Research Triangle Institute, Structures Department	John Short
	Roof Coatings Manufacturers Association	receptionist
	Roofing Industry Educational Institute	customer service
Textiles	American Association for Textile Technology	receptionist
	American Association of Textile Chemists & Colorists	Jerry Tew
	American Fiber Manufacturers Association	Bob Barker
	American Textile Manufacturers Institute	Karil Kochenderfer
		Chip Moore
	North Carolina State University	Brent Smith
	Textured Yarn Association	Jim Conner
	West Point Pepperell	Jean Roberts

In addition to the telephone contacts made as part of the data gathering effort for the automotive repair category, visits were made to two local establishments. Trip reports from these visits are included in Appendix 3 of this report.

SECTION 4

CURRENTLY AVAILABLE INFORMATION

Literature searches yielded little specific information on nonprocess solvent usage at the industrial/commercial business categories. Contacts with trade associations and industry members proved to be the best source. Even so, most individuals who were contacted had not previously considered nonprocess solvent usage. Therefore, information and data on specific solvent types and quantities used within the categories were not readily available.

Census data are tabulated by SIC codes. For the purposes of this report, when referring to SIC industry numbers, the terms code, industry number, and number are synonymous. By convention, segment will denote a more generic set.

4.1 AUTOMOTIVE REPAIR

4.1.1 Introduction

A large variety of services may be offered by an automotive repair facility. In addition to engine maintenance, these facilities may repair and service brake, cooling, air conditioning, and electrical systems. Vehicle maintenance procedures, such as fluid and filter changes, are also commonplace at many facilities.

These type of facilities are listed under SIC code 7538, which is described as "establishments primarily engaged in general automotive repair." Facilities primarily engaged in transmission repair, industrial truck repair, or lubricating services are not included in this code (*Standard Industrial Classification Manual*, 1987). The 1987 census lists 55,348 general automotive repair establishments. These facilities employed 202,564 workers and had receipts of $11,872 million (Census of Service Industries, 1987).

4.1.2 Nonprocess Solvent Usage

Parts cleaning is common in many facilities and this often involves the use of a parts washer. These washers, which may be maintained and serviced by the facility itself or by an outside company, usually consist of a sink which covers a drum that contains solvent and a pump with a filtered intake. The pump circulates solvent from the drum to the sink through a flexible hose. A brush, sometimes mounted to the nozzle of the hose, is used to aid cleaning. Many models in use have a lid that closes to reduce solvent loss through evaporation. Some older parts washers consist of a grate over an open reservoir of solvent. Self-contained systems for immersing parts in solvent for several hours are also widely used (T. Barry, Independent Garage Owners of North Carolina, personal communication, November 10, 1992).

The solvents used in parts washers can vary but most are based on petroleum distillates. One commonly used solvent contains 85 percent petroleum distillates (Safety-Kleen, 1990). Carburetors are usually cleaned by immersion in cleaners that may contain other solvents. One facility that was contacted uses a product, Hydro Seal II, that is based on 2-butoxy-1-ethanol and n-methyl-pyrolidine (Radiator Specialty Company). Other carburetor cleaners may contain $MeCl_2$ (Jones Engineering Group, 1991).

Pellet blasting and high pressure washers (i.e., jet spray washers) are used by some facilities to clean oil and grease from engines and transmissions (T. Barry, Independent Garage Owners of North Carolina, personal communication, November 10, 1992). Hot tanks are also used to clean parts. Hot aqueous detergent or caustic solution is used in jet spray washers and hot tanks (Jones Engineering Group, 1991). Citrus-based cleaners are also being developed; these products have yet to gain acceptance as parts cleaners in the automotive repair industry (R. Bombardier, New York State Association of Service Stations & Repair Shops, personal communication, November 10, 1992).

A variety of prepackaged, solvent-containing products are used at automotive repair facilities. These include products such as brake, choke, carburetor, and fuel injection cleaners. Fuel additives and starting fluids are also used. Many of the cleaners are in aerosol form (see Appendix 3). Aerosol cleaners are used because they propel solvents to hard-to-reach parts without requiring disassembly (R. Bombardier, New York State Association of Service Stations & Repair Shops, personal communication, November 10, 1992).

Two factors affect emissions from parts washers: evaporation from the sink and evaporation of depleted solvent. Because the exposed solvent in some older washers permits evaporation, emissions due to this effect could be significant, whether the machine is in use or not. In newer models, the solvent returns to the reservoir by gravity; so these emissions are likely to be much less. The second source of emissions is a result of solvent depletion as parts are cleaned due to evaporation, splattering, and incomplete draining or carry-off. Representatives of two facilities that were visited used sinks that were approximately 20 gallons in capacity. These representatives do not know the quantity of solvent that is lost during use, but they stated the level of solvent is not noticeably depleted at the replacement interval, typically 30 days (see Appendix 3). An estimate could be made using the arbitrary assumption that 10 percent of the solvent is lost during the usage interval. One commonly used cleaner contains 6.4 to 6.7 lb/gal of VOC (Safety-Kleen, 1990). Assuming the depleted solvent evaporates, a sink with 10 percent of the capacity evaporating each month would emit approximately 157 pounds of VOC per year.

Data collected at the two facilities that were visited were extrapolated using 1987 census data to obtain industry emissions. The assumptions, data, and calculations are included in Appendix 3. Average annual VOC losses from the solvent sinks would be 236 pounds per facility. This estimate neglects the emission contribution from older, open sinks because the prevalence of such equipment is not known. Facility emissions from prepackaged

products average approximately 1,300 pounds of VOC per year. An estimate of total industry emissions can be obtained by multiplying the contribution from these sources by 55,348 facilities. The result, approximately 42,000 tons of VOC per year, compares to the published estimate that 37,143 tons per year were emitted by this industry in 1986 (Kersteter et al., 1992).

4.2 BAKERIES

4.2.1 Introduction

The 1987 Census of Manufactures enumerates 22,477 facilities in the SIC codes 2051, 2052, and 2053 and industry group 546. Code 2051 corresponds to facilities that produce items such as: breads (fresh and frozen), cakes, pies, and related products. This segment represents 11 percent of all facilities. The second code, representing 1.7 percent of the total, includes cookie and cracker manufacturers. Manufacturers of frozen bakery products, with the exception of bread, are included in SIC code 2053. Approximately 0.5 percent of facilities are in this segment. Industry group 546 accounts for retail establishments where baked goods are prepared and sold. This group represents 87 percent of all facilities. The 161,600 employees in the baking industry produce shipments valued at nearly $28 billion (Census of Manufactures--Industry, 1987; Census of Retail Trade--Geographic, 1987; *Standard Industrial Classification Manual,* 1987).

The census divides the SIC code 2051 into wholesale bakeries, grocery chain bakeries, and retail outlet bakeries. Wholesale bakeries account for 94 percent of facilities in the segment. Only 37 facilities are retail outlet bakeries. Neither the SIC manual nor the census documents make any qualitative distinctions between the retail outlet and the retail baking and selling establishments. The census indicates that the former employs an average of 68 people per facility, while the latter averages nine employees per facility (Census of Manufactures--Industry, 1987; Census of Retail Trade--Geographic, 1987).

Whether the goods are manufactured in the retail or wholesale industry, one of two basic processes is employed. In the first process, yeast serves as the leavening agent by metabolizing the carbohydrates in the bread dough. Carbon dioxide, among other products, is produced during fermentation which increases the volume of the baked good. The dough ferments 2 to 4 hours prior to baking. Typical yeast-leavened products include breads, sweet rolls, crackers, and pretzels (Radian Corporation, 1988).

Other products are chemically leavened with baking powder. The baking powder is essentially sodium bicarbonate. This is reacted with an acid species which produces a gas. Chemically-leavened goods include products such as cakes, cookies, corn bread, and some donuts and biscuits (Radian Corporation, 1988).

Cleaning processes at a bakery are dictated by the nature of the feed materials. Flour, the chief ingredient, is more difficult to clean when wet than when dry. Individuals contacted stated that cleaning is most efficiently performed without liquids. The American Bakers Association (ABA), focusing on SIC codes 2051, 2052, and 2053, emphasizes proper cleaning techniques. As an example, sweeping is preferred to mopping, which is preferred to using a water spray (A. Giesecke, American Bakers Association, personal communications, July 28, September 25, and October 28, 1992).

The ABA estimates that most bakeries (in SIC codes 2051, 2052, and 2053) use from 10,000 to 300,000 gallons of water per day for production processes and cleanup. This corresponds to 0.2 gallons of water per loaf of bread. Up to 70 percent of the incoming water is discharged to the sewer. The average bakery spends about $250,000 each year for water. Association publications emphasize the potential savings that can be attained by reducing water use. Some bakeries have cut their effluent volume by 33 to 50 percent (A. Giesecke, American Bakers Association, personal communications, July 28, September 25, and October 28, 1992; Environmental News of the American Bakers Association, 1991; Carawan, 1991).

The use of solvents for cleanup would only increase costs of materials and waste treatment. Additionally, the risks of using potentially toxic substances must be considered in a food manufacturing environment. Thus, more emphasis is placed on reducing effluent volume and the biological oxygen demand loads exerted on the waste treatment plant than is placed on solvent usage (Environmental News of the American Bakers Association, 1991; Carawan, 1991).

4.2.2 Nonprocess Solvent Usage

Federal regulations control the use of solvents in the presence of food. To illustrate, the fluid used for hydraulics and as a heat transfer medium in bakery equipment is often food-grade, white mineral oil. The Food and Drug Administration or United States Department of Agriculture mandates use of an aqueous chlorine cleaning solution (15 to 30 percent strength) in particular circumstances. All contacts stated that solvents are not used for routine cleaning. Solvents are used during equipment repair, overhaul, and preventive maintenance (A. Giesecke, American Bakers Association, personal communications, July 28, September 25, and October 28, 1992).

A solvent is used to remove old lubricants, dirt, flour, grease, and other contaminants from equipment parts during maintenance/repair. This occurs during both regularly scheduled preventive maintenance and upon occasional equipment failure. Due to the perishable nature of the raw materials and products, equipment downtime is minimized by preventive maintenance of the conveyor systems. Ovens, having few moving parts, require much less maintenance (W. Sanford, Research Triangle Institute, personal communication, November 10, 1992). The solvent is similar to that used in other industries for maintenance. Typically, a product based on stoddard solvent, derived from a particular cut in the distillation of naphtha,

is used (B. Pursley, American Institute of Baking, personal communication, July 31, 1992, and A. Giesecke, American Bakers Association, personal communications, July 28, September 25, and October 28, 1992). Naphtha, an intermediate mixture in the petroleum feedstock, contains paraffins, isoparaffins, naphthenes, and aromatics. The boiling point of such a solvent ranges from 320 to 390 °F. Stoddard solvent has a flash point of 110 °F.

Water-based cleaners are commercially available and have been evaluated by a large wholesale baker. A spokesperson for the facility stated that based on their experience, these products are not adequate replacements for the cleaners currently used. The water-based products tested at this bakery did not effectively dissolve or disperse the oils and greases that must be removed from the equipment as part of the maintenance and repair process (P. Fischer, Campbell Taggard, personal communication, July 31, 1992).

Although packaging for baked goods is printed off-site, some bakeries print manufacturing/expiration date codes on the package. A spokesperson for another large, wholesale bakery stated that the facility uses two date coding systems. The VIDEOJET system uses technology similar to computer ink-jet printers. One bakery, perhaps the largest in the United States, used 187 gallons of ink in 1991. This system permits quick changes of products or dates on the packaging line (C. Gjersvik, Continental Baking, personal communication, November 10, 1992). These solvent-based inks contain methanol, methyl ethyl ketone (MEK), and 1-methoxy-2-propanol. VOC content ranges from 75 to 98 percent by weight (VIDEOJET Systems International, Inc., 1987). The equipment is cleaned with a product based on the aforementioned solvents and contains 100 percent VOCs (VIDEOJET Systems International, Inc., 1985).

The second date encoding apparatus uses heat to transfer and emboss ink from a ribbon. Although no information was obtained on VOC content, it is expected that VOC emissions are low (C. Gjersvik, Continental Baking, personal communication, November 10, 1992).

Other contacts mentioned additional ways of including manufacturing/expiration codes. Some twist-ties are color coded. Dates may be printed on plastic clips that are used to close the package (P. Fischer, Campbell Taggard, personal communication, July 31, 1992).

To prevent sticking of the baked goods, oil is applied to the baking trays. Some facilities use compressed-air spray guns to apply the oil. Others may grease trays by manually applying solid shortening or using an oil-soaked cloth. An aerosol-dispensed product is used in the industry with less frequency. No information on propellant composition was obtained (W. Sanford, Research Triangle Institute, personal communication, November 10, 1992). A wholesale baker stated that aerosol products are too expensive to use. This contact speculated that even small, retail bakeries would realize savings by using an alternative application technique (P. Fischer, Campbell Taggard, personal communication, July 31, 1992).

Periodically, baking trays must be reglazed. The service is performed by an outside facility. Once the solvent-based coating cures, VOC emissions are negligible. Conversations with bakeries and trade associations have not identified any members of the baking industry that reglaze baking pans in-house (W. Sanford, Research Triangle Institute, personal communication, November 10, 1992).

A contact from a large, wholesale bakery noted difficulties encountered during general plant painting with solvent-based paints. Because of the necessary cleaning and subsequent solvent disposal, this site will soon use disposable rollers and brushes (P. Fischer, Campbell Taggard, personal communication, July 31, 1992).

The ABA noted that the use of 1,1,1-TCA-based glues for packaging is no longer necessary because alternative products are available. A spokesperson stated that solvents are used in the adjacent delivery truck garages for vehicle maintenance or repair. The products are similar to those used for bakery equipment maintenance or any other vehicle repair process (A. Giesecke, American Bakers Association, personal communications, July 28, September 25, and October 28, 1992).

4.3 BUILDING RENOVATION

4.3.1 Introduction

Building renovations are performed by establishments classified under several different SIC code numbers. The majority of construction businesses, 66 percent, are classified as general contractors (GCs) for single-family housing and listed under SIC code 1521. In addition to new construction, their operations include additions, alterations, remodeling, and repair. The 1987 census lists 90,378 facilities which employ 396,291 individuals as construction workers and support staff. Separate data were not available for construction workers only. The net value of the construction is approximately $27 billion. Net value is defined as the total value of construction less the value of subcontracted work. Approximately 67 percent of the total value of construction is attributed to new construction. Additions, alterations, or reconstruction accounts for 27 percent of the total. The remainder is from maintenance and repair (Census of Construction Industries, 1987; *Standard Industrial Classification Manual,* 1987).

SIC code 1522 corresponds to GCs of residential construction, other than single family. With 8,143 facilities, it includes less than 6 percent of the total number of establishments in the trade. Like the previous segment, construction also includes additions, alterations, remodeling, and repair. The net value that the 61,245 construction workers produced is approximately $6 billion (Census of Construction Industries, 1987; *Standard Industrial Classification Manual,* 1987).

GCs engaged in the construction of industrial buildings and warehouses are classified under SIC code 1541. Construction includes additions, alterations, remodeling, and repair. The 7,014 businesses account for just over 5 percent of the total number in the trade, employing 110,785 construction workers. The net value of construction is approximately $11 billion (Census of Construction Industries, 1987; *Standard Industrial Classification Manual,* 1987).

The net construction value from the 31,337 facilities classified under SIC code 1542 is approximately $40 billion. GCs associated with nonresidential building, other than industrial buildings and warehouses, produce nearly 47 percent of the net value of the SIC code. The segment employs 366,871 construction workers. As with the rest of the industry, facilities engaged in the previously mentioned renovation tasks are included (Census of Construction Industries, 1987; *Standard Industrial Classification Manual,* 1987).

The typical contractor has four employees. In the past, a GC would perform most of the tasks associated with the construction. Now, because of the increasingly complex building techniques, materials, and designs, more of the work is subcontracted. Approximately 25 percent of the payment a GC receives is paid to subcontractors (Exceltech, 1990).

Just as no SIC code directly pertains to building renovation, no information specific to this aspect of construction was acquired. However, many of the processes employed in new construction are identical to those used during building renovation. Exceptions include, among others, removal or stripping of paints, wallcoverings, and floor finishes. A significant amount of data exist on both alternative building materials and the effects of building materials on indoor air quality. By comparison, little information is available concerning nonprocess solvent use in the building renovation industry.

4.3.2 Nonprocess Solvent Usage

Although little information is available on nonprocess solvent usage, the use of petroleum distillates-containing solvents for paint thinning and cleanup was repeatedly mentioned (D. Whyte, Associated Builders and Contractors, personal communication, August 3, 1992; Ashland Chemical Company, 1986). One study concluded that, for new construction, the painting trade generates more hazardous waste than other construction trades. Renovation often involves removing old surface coatings from wood, concrete, and metal. These varnishes, paints, sealers, or finishes are usually removed with a $MeCl_2$-based stripper (Exceltech, 1990). Several companies manufacture strippers that contain acetone, toluene, methanol, and methylene chloride. Some formulations are available that do not contain $MeCl_2$. These products are based on various mixtures of acetone, methanol, toluene, isopropyl alcohol (IPA), ethyl-3-ethoxy propionate, methyl isobutyl ketone (MIBK), hexane, dimethyl adipate, and dimethyl glutarate (Hollar, 1992a). These products are expected to be slower to act than the traditional formulations.

Lacquer thinner is often used to remove excess adhesive when applying laminates to surfaces, such as countertops. Electrical contacts are cleaned with solvents. Spackling putty, which contains 0.03 lb/gal of VOC, is used when installing or patching interior walls (Hollar, 1992b). Prior to the installation of marble, the substrate is cleaned with a solvent. Caulks that contain solvents are used to waterproof joints and seams around windows, bathrooms, and electrical boxes. Before the caulk is applied, it may be necessary to remove dirt and oils from the surfaces with solvents (Exceltech, 1990). Several products are manufactured for use in the installation of ceramic tile. A finish that is said to seal and brighten tile and grout contains glycol ether. Ceramic tile mastic contains petroleum distillates (Hollar, 1992b).

Solvent-based adhesives are used to glue vinyl baseboards to walls, carpet tiles or vinyl composition tiles to floors, and insulation to pipes or ducts. Fittings and joints for polyvinyl chloride (PVC) piping are fastened with an adhesive that contains MEK, tetrahydrofuran, cyclohexanone, and acetone (N. Pendergraft, Research Triangle Institute, personal communication, October 13, 1992; and Hollar, 1992b).

There are many products and materials commercially available that have been reformulated to contain little or no VOC, for example, an exterior paint that contains no VOC is a powder and is mixed with water at the construction site. Drawbacks include poor coverage and thin consistency that results in drips and runs (D. Gottfried, Siegal Environmental, personal communication, August 13, 1992). One major paint manufacturer recently introduced a zero-VOC, nonpetroleum-based paint for interiors. It is available, premixed, and in four shades of white. Tinted colors are not offered. Water-based adhesives for carpet tiles and vinyl baseboards provide an alternative to solvent-based products. Opportunities for solvent reduction exist in the manufacturing of adhesives for laminates, wall coverings, and carpets. As these products are improved and gain acceptance, they are likely to reduce the need for solvent-based cleaners (D. Gottfried, Siegal Environmental, personal communication, August 13, 1992). The acceptance of water-based cleaners and strippers has been hindered because, although they may be effective, they are often slower to act or require more physical treatment than a solvent-based cleaner.

4.4 CHEMICAL MANUFACTURING

4.4.1 Introduction

Companies in the synthetic organic chemicals industry are classified under SIC codes 2865 and 2869. SIC code 2865 is described as "establishments primarily engaged in manufacturing cyclic organic crudes and intermediates, and organic dyes and pigments." Establishments listed under this code produce (*Standard Industrial Classification Manual*, 1987):

- aromatic chemicals,

- synthetic organic dyes, and
- synthetic organic pigments.

SIC code 2869 is described as "establishments primarily engaged in manufacturing industrial organic chemicals, not elsewhere classified." Facilities registered under this code manufacture a variety of synthetic organic chemicals including (*Standard Industrial Classification Manual,* 1987):

- aliphatic and other acyclic chemicals;
- solvents;
- polyhydric alcohols;
- synthetic perfume and flavoring materials;
- rubber processing chemicals;
- plasticizers;
- synthetic tanning agents;
- chemical warfare gases; and
- esters, amines, etc., of polyhydric alcohols and fatty and other acids.

The 1987 census lists 186 facilities under SIC code 2865. These establishments employed 22,800 people and shipped products that were valued at $8,859.4 million. The same census statistics cite 699 facilities under SIC code 2869 employing 100,300 people and shipping $42,189.1 million in products (Census of Manufactures, 1987).

4.4.2 Nonprocess Solvent Usage

Representatives of various trade and professional associations, including the American Chemical Society and the Chemical Manufacturers Association, were unable to supply any information on the use or emission of nonprocess solvents (D. Artemis, Chemical Manufacturing Association, personal communication, September 2, 1992; H. Saxe, American Chemical Society, personal communication, September 3, 1992; A. Krisher, Materials Technology Institute of the Chemical Process Industries, personal communication, September 8, 1992).

A literature search of solvent usage in this industry showed that although there is much information on process solvents, specific information on nonprocess solvent usage directly associated with chemical manufacturing facilities is not readily available.

Generally, chemical manufacturing facilities are large operations composed of many smaller units. Nonprocess solvents are likely to be used extensively for both internal and external equipment cleaning in batch and continuous operations, for routine equipment maintenance, and for floor cleaning. In addition to units directly associated with manufacturing chemicals, smaller units using nonprocess solvents include electrical repair, machine shops, office facilities, paint shops, vehicle maintenance, and janitorial operations. Based on information obtained from other industrial/commercial business categories,

nonprocess solvent usage in chemical manufacturing facilities would include the same general types of products and use procedures discussed in other sections of this report.

4.5 ELECTRICAL EQUIPMENT MAINTENANCE AND REPAIR

4.5.1 Introduction

For purposes of this report, all electrical repair businesses were considered except refrigeration and air conditioning repair shops, and those companies primarily engaged in the repair of electronic computers and computer peripheral equipment.

Electrical repair shops are listed under SIC codes 7622, radio and television shops; and 7629, electrical and electronic repair shops, not elsewhere classified. SIC code 7622 is described as "establishments primarily engaged in repairing radios, televisions, phonographs, stereo equipment, and tape recorders," as well as those involved in installing and repairing radio transmitting and receiving equipment or television, amateur, and citizens band antennas. SIC code 7629 is characterized as "establishments primarily engaged in the repair of electrical and electronic equipment, not elsewhere classified, such as electrical household appliances and electrical and electronic industrial equipment" (*Standard Industrial Classification Manual,* 1987).

The 1987 census listed 15,167 establishments under these two SIC codes. In 1987, these facilities employed 86,866 people and had receipts of $5,076 million. The census statistics also indicate that a majority of the businesses in this industry are very small. Specifically, 58 percent of these businesses employ fewer than five people, and 12 percent do not operate during the entire year (Census of Service Industries, 1987).

4.5.2 Nonprocess Solvent Usage

A number of solvent cleaners may be used in electrical repair work. Before soldering, connections need to be cleaned so that resin and flux from previous soldering work are completely removed. Electrical components may also be contaminated with dirt, grease, or residue left from an accidental spilling of liquid on the appliance. If this occurs, the repair person may, instead of replacing the component, try to clean it. In all cases, aerosol cleaners or degreasers are used. The repair person sprays relatively small amounts of the cleaners onto cotton swabs or pieces of cloth, then wipes clean the connection or component (W. Welch, Circuit City Service, personal communication, August 27, 1992).

These aerosol cleaners are manufactured primarily by specialty chemical manufacturers. According to a Chemical Specialties Manufacturers Association representative, specialty degreasers contain one of four types of chemicals:

- halogenated solvents,

- a mixture of aromatics,
- a mixture of aliphatics, or
- oxygenated organics.

Although any of these types of cleaners may be used in the electrical repair industry, halogenated solvents are preferred because of their high solvency and lack of residue (D. Fratz, Chemical Specialties Manufacturers Association, personal communication, September 8, 1992). For this reason, many aerosol cleaners used in the electrical repair industry contain chlorofluorocarbons (CFCs). The material safety data sheets (MSDSs) of some solvent degreasers, flux cleaners, and tuner degreasers confirm this fact and show that some also contain other solvents, such as methyl alcohol, $MeCl_2$, 1,1,1-TCA, and/or mineral oil (Chemtronics, 1991a-d and 1992).

Many organizations are conducting research into alternative cleaning solvents. Currently, National Center for Manufacturing Science (NCMS) is conducting three experiments to find alternative cleaners that can be used in the electrical manufacturing industry. According to an NCMS representative, the results of these experiments will be applicable to the electrical repair industry because this industry uses the same type of solvents (C. Vinton, National Center for Manufacturing Science, personal communication, September 10, 1992).

The first NCMS experiment is a materials compatibility study in which different materials used in electrical components are exposed to various cleaners including aqueous, semi-aqueous, alcohol, and hydrocarbon solvents. In this study, changes in the initial and long-term properties (e.g., weight and volume) of the material are measured. In the second experiment, electrical components are exposed to the cleaners. The performance of these components is tested throughout the exposure. The third experiment is designed to determine "how clean is clean." In this test, the performance of electrical components is tested after they are exposed to known contaminants. Through this analytical study, the researchers hope to quantify the performance degradation caused by specific contaminants (C. Vinton, National Center for Manufacturing Science, personal communication, September 10, 1992).

The first two parts of the NCMS study have been completed but results of the tests have not been released as of the publication date of this report. The third experiment is continuing and results are expected in 1995 (C. Vinton, National Center for Manufacturing Science, personal communication, September 10, 1992).

In general, lubricants are not used in this industry. Occasionally, aerosol adhesives are used to reattach the coverings of some appliances that may accidently detach during repair work (W. Welch, Circuit City Service, personal communication, August 27, 1992). In some cases, final repair work may require the use of paint for entire components or touchup. Emissions associated with paint use in electrical equipment maintenance and repair shops are anticipated to be small.

4.6 FLORISTS

4.6.1 Introduction

Retail florists listed under SIC code 5992 are "establishments primarily engaged in the retail sale of cut flowers and growing plants" (*Standard Industrial Classification Manual,* 1987). The 1987 census cites 26,683 establishments as employing 125,048 people and having annual sales of $4,810.4 million (Census of Retail Trade, 1987).

4.6.2 Nonprocess Solvent Usage

Most florists do not use VOC-containing products. Nevertheless, florists were initially considered in this study for two reasons: (1) information about the possible solvent content of the preservatives and other products, such as floral adhesives and colorants, used by the industry was not readily available, and (2) the amount and type of household cleaners being used by the industry was unknown. Some household cleaners contain either nonaerosol solvents or aerosol propellants and/or solvents. Therefore, the use of significant amounts of these products could have possibly indicated large VOC emissions.

Florists use preservatives that are water-based solutions containing only sugars, buffering salts, and biocides such as chlorine.

Several products are used to clean florist shops and display areas. Florists tend to avoid the use of chemicals that may have an adverse effect on plants and flowers. Therefore, many florists prefer to use water-based cleaning solutions for their general shop cleaning. Although specific consumer cleaning products, such as floor cleaners or wall cleaners, may be used, the most common cleaning products used are bleach and ammonia solutions. The use of consumer glass cleaners is also commonplace but, according to an industry representative, the use of these cleaners is not excessive when compared to their use in other retail businesses (S. Daigler, Society of American Florists, personal communication, July 8, 1992).

4.7 FURNITURE REPAIR/RESTORATION

4.7.1 Introduction

The 1987 Census of Service Industries enumerates 6,144 facilities in SIC group 764. Establishments primarily engaged in furniture repair and reupholstery are in this group. Additional descriptors include furniture and antique refinishing, redecorating, remodeling, and restoration. The census lists an additional 1,002 establishments that were not in business for the entire year. Receipts for the industry were approximately $882 million. Just over 22,000 individuals were employed (Census of Service Industries--Subject Series, 1987; *Standard Industrial Classification Manual,* 1987). Most of the businesses are small. Over 50 percent

of the facilities employ fewer than three people. Only 6 percent of the establishments have 10 or more employees.

4.7.2 Nonprocess Solvent Usage

A particular subgroup of the industry includes the reconditioners of metal office furniture. Prior to repainting, the old paint is stripped. Solvents were used in the past, but a spokesman from the National Office Products Association stated that alternative methods are now employed where paint is removed by sandblasting or by using plastic beadblasting (D. Scott, National Office Products Association, personal communication, July 27, 1992).

When office furniture is reconditioned, the upholstery may be cleaned instead of replaced. One company uses spot cleaners for highly soiled or stained areas. The cleaners used in "spotting" contain up to 85 percent solvent. The company uses two systems for general upholstery cleaning: an all aqueous solution or a mixture containing less than 7 percent solvent. The solvent blends used for general cleaning and spotting contain propylene glycol and a "mineral spirits-type" solvent (B. Bary, CFR Corporation, personal communication, September 24, 1992).

When wood furniture is refurbished, one of two approaches is taken. The traditional approach begins by removing the old finish. Typically, this involves a solvent strip. Products available to the consumer at hardware stores often contain $MeCl_2$. A furniture refinisher claimed that strippers based on this solvent are used only as a last resort. The contact stated that because he is not able to recycle spent solvent from this type of strip, expensive disposal costs are incurred. Typically, the refinisher uses a product consisting of toluene, acetone, methanol, and a small percentage of MEK. Often spent lacquer thinner (a mixture of isobutyl isobutyrate, MEK, MIBK, methanol, naphtha, and toluene) is added to the mixture (M. Yarbrough, Y & J Furniture Company, personal communication, August 5, 1992). Other resources indicate that blends may contain toluene, xylene, acetone, ethanol, butanol, IPA, naphtha, MEK, and esters (Kohl et al., 1984).

A furniture refinisher who was contacted uses a recirculating spray system for stripping. The solvent is pumped from a 5-gallon reservoir and is sprayed onto the furniture. A trough catches the solvent and returns it to the tank. The solvent is reused until the cleaning efficiency diminishes; then it is sent to a recycler (M. Yarbrough, Y & J Furniture Company, personal communication, August 5, 1992).

An older technique for stripping includes placing the piece of furniture in a covered 4- x 8-foot tank that holds 300 to 400 gallons of stripping solution. This solution may contain any of the aforementioned solvents. One facility that owns dipping tanks no longer dips furniture due to the excessive amount of solvent required, workplace exposure to chemicals, and the fire hazard. Additionally, dipping often adversely affects glued wood joints. Now the facility keeps 3 to 5 gallons of lacquer thinner in the bottom of the tank. The facility places the furniture into the vessel where the solvent is brushed onto it. Then the

old finish is scraped off. Occasionally, approximately 10 percent of $MeCl_2$ is added to remove stubborn finishes (H. Regmi, Triangle Furniture Stripping, personal communication, November 2, 1992).

After initial cleaning or stripping of furniture, several layers of stains, sealers, and top coats are applied with spray guns. Base coatings, such as stains, may be applied by wiping or brushing. The upper layers are almost always sprayed to obtain a smooth finish (M. Yarbrough, Y & J Furniture Company, personal communication, August 5, 1992). An unsatisfactory finish could be the result of operator error; spray equipment malfunction; or poor quality, contaminated, or old finishes. Periodically, the spray equipment is flushed with solvents. Also, the opportunity for overspray exists at each application. Solvents are used to remove the accumulated overspray from the spray booths. When flaws in the finish are detected, the piece may be stripped and refinished (Kohl et al., 1984).

The furniture conservator, instead of stripping the finish, begins by applying a mild aqueous soap solution to remove waxes, oils, and dirt. Stubborn contamination is removed by wiping with mineral spirits (T. Neely, Conservation Technician, personal communication, August 5, 1992). When it is necessary to remove coatings that are applied over the original finish, solvents are carefully selected and sparingly used to remove only the top coatings. A particular solvent or blend of solvents is chosen with a high specificity for the coating that is to be removed. The conservator selects from a wide range of solvents based on workplace safety and finish specificity. Instead of applying new coatings to hide scratches, the conservator may resolvate and redistribute the old finish (D. Williams, Smithsonian Institution, personal communication, August 6, 1992). It is sometimes necessary to coat the reconditioned furniture with a light application of wax to restore the original shine (T. Neely, Conservation Technician, personal communication, August 5, 1992).

Alternative water-based finishes are commercially available. The use of these materials would likely reduce the need for some solvents during stripping and finishing. However, several problems with these products have slowed their acceptance. When wood is in contact with water, the grain rises. Without additional sanding, the resulting finished surface is rough. Some objections arise because of increased drying times and reduced clarity of finish. Because of the corrosive nature of water-based products, stainless steel equipment must be used. Stainless steel spray guns are more expensive and, because of their spark-generating potential, this equipment should not be used with traditional, highly flammable, solvent finishes. Therefore, a company using both water- and solvent-based finishes would require both types of spray guns. An additional limitation that many contacts have noted is that water-based finishes cannot be successfully applied onto traditional solvent stains and top coats. One refinisher stated that the furniture manufacturing industry must first adopt water-based finishes; otherwise, subsequent applications of water-based finishes are not recommended (M. Yarbrough, Y & J Furniture Company, personal communication, August 5, 1992).

Alternative cleaning products are being introduced. One particular product is a terpene derived from orange peel extracts. Applications include the cleaning of hands and lacquer overspray. Although it is not effective at stripping all finishes, the product can be used for preliminary cleaning (T. Vieyra, Furniture Medic, personal communication, July 29, 1992).

4.8 HEATING, VENTILATION, AND AIR CONDITIONING SERVICES

4.8.1 Introduction

For the purposes of this report, HVAC service companies are considered to be contractors who repair commercial heating, air conditioning, and refrigeration units. In many instances, these companies are the same contractors who install these units (B. Axelrod, Air Conditioning Contractors of America, personal communication, September 3, 1992). Companies that operate and service large industrial refrigeration and central air conditioning plants are not evaluated in this report.

HVAC repair companies are listed under SIC codes 1711 and 7623. SIC code 1711 is described as "special trade contractors primarily engaged in plumbing, heating, air conditioning, and similar work." SIC code 7623 is characterized as "establishments primarily engaged in servicing and repairing household and commercial electrical refrigerators and air conditioning and refrigeration equipment" (*Standard Industrial Classification Manual,* 1987).

The 1987 census listed 69,566 facilities under SIC code 1711. These facilities employed 617,333 people and produced a net value of $44,517.7 million (Census of Construction Industries, 1987). The same census statistics cite 3,565 establishments under SIC code 7623. These businesses employed 20,512 people and had receipts of $1,521.1 million. The census reports that 55 percent of the companies in the latter SIC code employ less than five people, and 11 percent do not operate during the entire year (Census of Service Industries, 1987).

Residential refrigeration and air conditioning units are hermetically sealed. Although some parts of these machines are accessible, very little repair work can be done on these units. If a specific part, such as a condenser coil or an electrical component is not working, it will not be repaired. Instead it will be replaced with another part. For extensive repairs, the unit must be sent back to the manufacturer. Larger units are semihermetically sealed and may be taken completely apart by the repair person for service work (E. Mastin, Refrigeration Service Engineers Society, personal communication, August 25, 1992).

Electrical repair work is not done by the majority of these shops. In general, electrical connections and electrical components, such as motors, starters, control boards, etc., are simply replaced when they are not working (W. Harris, Refrigeration Service Engineers Society, personal communication, August 21, 1992).

4.8.2 Nonprocess Solvent Usage

A number of different cleaning products may be used during maintenance and repair of heaters, air conditioners, and refrigerators. One type of cleaner removes accumulated grease and dirt from external machinery parts. Because these cleaners are used primarily to clean evaporator and condenser coils, they are often referred to as coil cleaners. Some coil cleaners may also be used to clean other mechanical parts (Stewart Hall, 1991a).

Coil cleaners are available in either aerosol or liquid form. The aerosols are simply sprayed onto the coils or other machine part, and the liquid products are applied with a high-pressure washer. Scrubbing may be required, depending on the specific cleaner used; but after a few minutes, the cleaner is washed off with water (E. Lovette, Research Triangle Institute, personal communication, September 8, 1992). Some liquid coil cleaners are sold as concentrates and must be diluted with water. The manufacturer of two liquid concentrates suggests that they be diluted with 3 to 10 parts water, depending on their intended use (Stewart Hall, 1991b).

Although the contents of coil cleaners vary, they in general contain either organic solvents or a caustic or corrosive solution. The contents of six different coil cleaners are listed in Table 2.

Repair persons may use other cleaning solvents that are not sold as coil cleaners. One repair person that was contacted uses an aerosol cleaner that is designed to clean the outside surface of engines. This cleaner, which contains petroleum distillates, can also be used to clean the exterior of any mechanical part (B. Rives, Research Triangle Institute, personal communication, September 23, 1992). Cleaning solvents may also be used to clean parts that have been removed from a unit. An MSDS for one cleaning solvent used for this purpose shows that it contains aliphatic solvent naphtha, 1,1,1-TCA, perchloroethylene (perc), and $MeCl_2$. This solvent has a VOC content of 3.91 lb/gal (Virginia KMP, 1991).

Lubricants often are used in the repair of heating, air conditioning, and refrigeration units. An MSDS obtained for one common aerosol lubricant stated that it contains 50 percent aliphatic petroleum distillates, 25 percent hydrocarbon propellants, greater than 15 percent petroleum-based oil, and less than 20 percent of proprietary mixtures of corrosion inhibitors, wetting agent, and fragrance (WD-40 Company, 1989). Another aerosol lubricant contains 70 to 85 percent hexane, 10 to 25 percent propane, and 10 to 25 percent isobutane according to the MSDS (Valvoline, Inc., 1992). Although these types of aerosols are commonplace, light machine grease may also be used as a lubricant (B. Axelrod, Air Conditioning Contractors of America, personal communication, September 3, 1992).

Repair persons may install piping through walls, floors, and/or ceilings. After this is done, sealants are used to prevent water or air leakage from around the pipe. Expanding foam sealants are commonly used to accomplish this (B. Axelrod, Air Conditioning Contractors of America, personal communication, September 3, 1992). An MSDS for one of

TABLE 2

CONTENTS OF COIL CLEANERS

Product Form	Contents
Aerosol	Alkaline Solution[1]
Aerosol	62% petroleum distillate, 17% xylene, 8% isobutane, 7% propane, 6% detergent[2]
Liquid	Alkaline Solution[3]
Liquid	67.5% 1,1,1-trichloroethane, 24% perchloroethane, 5% mineral spirits[4]
Liquid Concentrate	Acidic Solution with 1.4% glycol butyl ether[5]
Liquid Concentrate	Alkaline Solution with 2.2% glycol butyl ether and 1.9% alcohol[6]

[1]Stewart Hall Chemical Corporation. 1992c. Material Safety Data Sheet for Renewz Aerosol. Mount Vernon, NY. July 8.

[2]Siloo. 1985. Material Safety Data Sheet for Engine Shampoo 35A. Warminster, PA. November.

[3]Nu-Calgon Wholesales, Inc. 1991. Material Safety Data Sheet for Calclean. Maryland Heights, MO. April 11.

[4]ERC Enterprises. 1989. Material Safety Data Sheet for Blast Off. Cincinnati, OH. January 1.

[5]Stewart Hall Chemical Corporation. 1992b. Material Safety Data Sheet for Con-Coil. Mount Vernon, NY. August 13.

[6]Stewart Hall Chemical Corporation. 1992a. Material Safety Data Sheet for Coil-Rite. Mount Vernon, NY. January 1.

these products indicates that its contents are less than 30 percent hydrofluoroalkanes, less than 14 percent 4,4-diphenylmethane diisocyanate (MDI), and less than 14 percent higher oligomers of MDI (Fomo Products, 1992). Aerosol coatings are also used as sealants (B. Rives, Research Triangle Institute, personal communication, September 23, 1992). An MSDS for one coating used as a sealant shows that it contains solvents including toluene, hexane, 1,1,1-TCA, isobutane, propane, varnish makers' and painters' (VM&P) naphtha, and petroleum hydrocarbon oil (Drummond American Corporation, 1990).

Cements are often used by repair persons to connect pieces of PVC pipe. This cement, applied with a small fiber swab, dissolves some of the piping and then evaporates to fuse the two pieces of pipe (B. Axelrod, Air Conditioning Contractors of America, personal communication, September 3, 1992). An MSDS for a PVC cement shows that it contains 55 percent MEK, 23 percent tetrahydrofuran, and 10 percent cyclohexanone (La-Co Industries, Inc., 1990).

Sealants and adhesives may also be used if HVAC ductwork is repaired. Various types of caulks may be used as joint sealants when constructing the ductwork. In addition, many HVAC ducts are lined with insulation that is attached to the duct with an adhesive. In depth, evaluation of these two products was excluded from the scope of this report since companies that service HVAC units do not commonly repair or replace ductwork.

Penetrants are often sprayed on rusted bolts and screws to loosen them. Although aerosol lubricants are sometimes used to accomplish this, specific products are marketed as penetrants (E. Lovette, Research Triangle Institute, personal communication, September 8, 1992). An MSDS for one penetrant shows that it contains greater than 90 percent aliphatic petroleum naphtha (Radiator Specialty Company, 1985).

Various aerosol coatings are used by repair persons to touch up the paint on the external casings of many units (E. Lovette, Research Triangle Institute, personal communication, September 8, 1992). An MSDS for three different spray paints shows that these aerosol coatings may contain various combinations of propane, 2-methylpropane, hexane, light aliphatic hydrocarbon, VM&P naphtha, mineral spirits, toluene, xylene, and isopropyl acetate (Martin-Senour Company, 1992).

Certain refrigerants have been commonly used in the past for cleaning parts, as well as for cleaning the internal system after a motor burnout. The refrigerant most often used for cleaning, CFC R-11, is no longer generally used due to a current phaseout in production and because the 1990 CAAA prohibits the intentional release of CFC refrigerants (E. Hill, Research Triangle Institute, personal communication, September 24, 1992; Gardner and Baker, 1992). Nevertheless, CFC R-11 is not out of circulation completely, and a representative of the Air Conditioning Contractors of America suspects that it is still being used by a small number of repair persons (B. Axelrod, Air Conditioning Contractors of America, personal communication, September 3, 1992).

4.9 MACHINE SHOPS

4.9.1 Introduction

A variety of traditional mechanical machining operations are performed in most machine shops. These operations include turning, milling, drilling, grinding, and polishing. In addition, some shops perform electrical, chemical, and/or thermal machining operations (Metcut Research Associates, 1972).

According to a representative from the National Tooling and Machining Association (NTMA), machine shops are listed under SIC codes 3544 and 3599. The majority of these businesses are registered under SIC code 3544, which is described as "establishments commonly known as contract tool and die shops and primarily engaged in manufacturing, on a job or order basis, special tools and fixtures for use with machine tools, hammers, die-casting machines, and presses." SIC code 3599 is identified as "establishments primarily engaged in manufacturing machinery and equipment and parts, not elsewhere classified," as well as those primarily engaged in "repairing machinery and equipment parts, not elsewhere classified, on a job or order basis for others" (O. Henderson, National Tooling and Machining Association, personal communication, September 9, 1992; *Standard Industrial Classification Manual,* 1987).

The machining industry has a large number of small companies. Approximately 68 percent of NTMA's membership, which totals over 3,100 companies, are businesses with fewer than 50 employees (O. Henderson, National Tooling and Machining Association, personal communication, September 9, 1992). In addition, many machining companies, especially smaller ones, serve customers within very small niche markets (B. Ruxton, National Tooling and Machining Association, personal communication, September 2, 1992).

The 1987 census lists 7,317 facilities under SIC code 3544. These businesses employed 114,400 people and had product shipments valued at $7,550.1 million. Of these establishments, only 1,517 had 20 or more employees and only 411 had 50 or more employees. The same census lists 21,545 facilities under SIC code 3599. These facilities employed 228,400 people and had shipments valued at $13,692 million. In this SIC code, only 2,985 facilities had 20 or more employees (Census of Manufactures, 1987).

4.9.2 Nonprocess Solvent Usage

Machine shops commonly use solvents to clean parts for inspection, grinding, and prior to shipping. These solvents are used primarily to remove scale (i.e., oxides) and grease. Rust is usually mechanically removed from the parts through sandblasting or bead-blasting or through the machining operations themselves. Two solvents that are used routinely for cleaning purposes are 1,1,1-TCA and perc (O. Henderson, National Tooling and Machining Association, September 9, 1992; B. Ruxton, National Tooling and Machining Association, September 2, 1992; D. Tichenor, Durham Technical Community College, personal

communication, September 9, 1992; Taylor, 1989). These two solvents are applied to the machine parts by hand wiping, by dipping, or through the use of a vapor degreaser. The use of degreasers is common in machine shops with 25 employees or more (O. Henderson, National Tooling and Machining Association, personal communication, September 9, 1992; Taylor, 1989).

For general parts cleaning, many machine shops use mineral spirits that are provided by solvent supply and recycling companies. Parts washers are used that are similar to those described in Section 4.1.2. These solvents, which are used to remove grease and dirt from parts, are monitored by the supply company for contamination and replaced at regular time intervals (O. Henderson, National Tooling and Machining Association, personal communication, September 9, 1992).

Solvents may be found in cutting fluids and coolants. The specific type of cutting fluid used depends on many variables including the type of machining being done, the machining tool, and the type of material being machined. There are four basic types of cutting fluids and coolants (University of Northern Iowa, 1990):

- straight oils,
- soluble oils,
- synthetics, and
- semisynthetics.

Some straight oils contain 100 percent petroleum oils. These oils are appropriate for the easiest machining task. For more severe applications, straight oils containing up to 20 percent additives (e.g., fatty oils, sulfur, chlorine, and/or phosphorus) are used. For extreme conditions, additives may exceed 20 percent. Straight oils provide very good lubricity but they are not very effective coolants. Because of this, they are usually limited to low-speed operations (University of Northern Iowa, 1990).

Soluble oils are made up of 60 to 90 percent petroleum oil and contain an emulsifier which makes them soluble in water. These oils are suitable for most machining operations. They do not equal the lubricity of straight oils but they do have better cooling properties. Because of their water content, they are formulated with additives to prevent rust formation and rancidity. The characteristics of these oils are relatively expensive to maintain; therefore, in most operations, they have been replaced with chemical synthetics (University of Northern Iowa, 1990).

Synthetic cutting fluids contain no petroleum fluid and may be diluted with water. They are easy to maintain and provide relatively good lubricity, high cooling capacity, and corrosion prevention. They are preferred when clarity is important, for purposes of observing the machining operation, and when less lubrication is needed (University of Northern Iowa, 1990).

Semisynthetics contain 2 to 30 percent petroleum oil, with the oil being dispersed in the water-soluble fluid. These fluids are used in applications that require good lubricity, especially at high temperatures (University of Northern Iowa, 1990).

4.10 MOLD RELEASE AGENTS

4.10.1 Introduction

External mold release agents may be used in the production of plastics, metals, glass, and rubber. For the purposes of this report, only mold release agents that are used in plastic and plastic-foam molding were considered. Plastic molding operations include:

- reaction injection molding,
- compression molding, and
- blown foam processes.

In each of these processes, the release agent coats the mold so that the molded product can easily be removed in one piece. Currently, 50 American companies are registered with The Society of the Plastics Industry, Inc. (SPI), as manufacturers of mold release agents (SPI, 1992). Data concerning the quantity of mold release agents produced is not available from SPI. This information is also not listed in the 1987 census statistics.

4.10.2 Nonprocess Solvent Usage

External mold release agents traditionally contain a solvent-based carrier agent. These carriers are often the CFCs R-11 or R-12, but other halogenated compounds, such as $MeCl_2$, are also used. Anticipating the eventual phaseout of CFCs, the plastics industry is investigating several alternatives to these chemicals, and alternative products are currently available in many cases.

In general, the alternatives to halogenated organic carriers can be classified into five categories:

- petroleum-based carriers,
- water-based carriers,
- semipermanent release agents,
- internal release agents, and
- atomized mold release agents.

Mold release agents that contain petroleum- or water-based carriers are marketed by a number of companies. One company sells both types of mold release agents for use in polyurethane foam molding, and their water-based products contain no VOC. Although these release agents can be used in nearly every type of polyurethane foam molding operation, many of

their customers prefer the solvent-based line of products since these release agents are less expensive and flash off faster, thereby decreasing the required process time (K. Murphy, Air Products & Chemicals, Inc., personal communication, October 10, 1992).

Silicone- or teflon-based coatings are semipermanent mold release agents. While traditional mold release agents must be repeatedly sprayed onto the mold (e.g., before each molding operation), semipermanent release agents are designed to be applied once and used several times before needing to be reapplied. Nevertheless, these types of products still contain a carrier agent (G. Walmsley, Hickory Springs Manufacturing Company, personal communication, October 8, 1992). The MSDSs from one manufacturer show that three of their silicone release agents contain 97 percent halogenated hydrocarbons and ether (George Mann & Company, Inc., 1990a-c).

Internal mold release agents are contained in the plastic foam itself and, therefore, no external release agent is needed. Based on limited investigation, no current application of this technology was found but these types of release agents are being investigated by some manufacturers in the industry (G. Walmsley, Hickory Springs Manufacturing Company, personal communication, October 8, 1992).

One company has developed atomized mold release agents. In their system, low pressure nozzles are used to atomize a mold release agent within a spray chamber. Molds are passed through the chamber where they are coated with a layer of the release agent. This system, which has only been used in the manufacturing of in-line skate wheels, does not require the use of solvents. Another company is currently trying to apply this technology to other molding operations (Gardner and Baker, 1992).

Cleaning solvents may be required in molding operations. The spray guns used to apply most mold release agents must be cleaned periodically. At the very least, these guns are flushed out with solvent at the end of each work day. In addition, cleaning of the mold itself is required if the plastic being molded does not separate completely from the mold or, in the case of semipermanent molds, if the silicone coating has been scratched (G. Walmsley, Hickory Springs Manufacturing Company, personal communication, October 8, 1992).

4.11 OFFICE PRODUCTS

4.11.1 Introduction

Office products are used in nearly all industries and, irrespective of the type of business, most companies tend to use the same types of office products. In 1987, the value of shipped office products in SIC codes 3951 (pens and mechanical pencils) and 3955 (carbon paper and inked ribbons) was $1,627 million (Census of Manufactures, 1987). Items that could potentially contain solvents include:

- inks from pens, markers, stamp pads, and typewriter and printer ribbons;
- correction fluids;
- rubber cement and other glues;
- thinners for correction fluids and rubber cement;
- specific office cleaners, such as white-board cleaner; and
- carbon paper.

Other products not normally considered to be office supplies may also be used in an office environment. Specifically, graphic arts supplies, such as adhesive spray mounts and acrylic spray coatings, are common.

4.11.2 Nonprocess Solvent Usage

A wide variety of inks are available for pens and markers. Information concerning the contents of some of these inks, obtained from various MSDSs, is shown in Table 3. Although the MSDS for ballpoint pen ink does not list the type of solvent used, it most likely contains an organic solvent because it is suggested that ink spills be cleaned up by first flushing with "thinner" (Pilot Corporation of America, 1991). Water-based inks, such as those used in felt tip pens, rolling ball pens, overhead markers, and highlighters, all contain organic solvents. These solvents, which are most often ether alcohols, diols, and/or triols, are soluble in both water and alcohol and are used to give the inks their required flow characteristics.

An MSDS for an ink used in printer ribbons shows that it contains unspecified amounts of high, molecular-weight hydrocarbons that presumably have very low volatility (International Rotex, Inc., 1990). An MSDS for a stamp pad ink did not list any of the components (Dennison Stationery Products Company, 1992b).

Correction fluids and correction fluid thinners are made by a variety of companies. Liquid Paper Correction Fluid is produced by The Gillette Company (Gillette). Correction fluid is commonly available in either small (approximately one ounce) containers that include a brush applicator or in the form of a pen-type dispenser. Prior to October 1, 1992, this correction fluid and thinner both contained 1,1,1-TCA and had VOC contents, as defined by Gillette, of 50 and 100 percent, by weight, respectively. Gillette is no longer producing these products. Instead they have permanently discontinued thinner production and are manufacturing a reformulated version of correction fluid. The new correction fluid contains no 1,1,1-TCA and has a VOC content of 40 percent, by weight. Gillette defines a VOC as a compound containing at least one carbon atom and having a vapor pressure greater than 1mm mercury at 20° C (0.01934 psia at 68° F) (J. Thompson, The Gillette Company, personal communication, August 25, 1992; Wernick, 1992). The manufacturer of another correction fluid discloses that the product has 0.224 pounds of VOC per gallon and contains unspecified amounts of 1,1,1-TCA and mineral spirits (International Rotex, Inc., 1991). No information was obtained on the contents of correction fluids that are dispensed from pens.

TABLE 3
CONTENTS OF PENS AND MARKERS

Product		Ink Content
Pens	Ballpoint	4.5% complex dyestuff[1]
	Felt Tip	water, diethylene glycol[2]
	Felt Tip	18-19% diethylene glycol, glycerine, and polyethylene glycol; 6% dyestuffs; 75-76% water, etc.[3]
	Rolling ball	14-17% diethylene glycol, glycerine, and 2-pyrrolidone; 6.5% dyestuffs; 76.3-79.5% water[4]
Markers	Permanent	50-70% 2-methoxyethanol, 0-35% ethyl alcohol, 0-14% 2-methoxyethyl acetate, and 0-10% r-butyrolacetone[5]
	White-board	methyl isobutyl ketone, n-butyl acetate[6]
	White-board	50% ethyl alcohol, 30% isopropyl alcohol, 4% pigments.[7]
	Overhead	water, propylene glycol.[8]
	Highlighter	10-30% glycerine, diethylene glycol, 2-pyrrolidone, and triethanolamine; 1.5% dyestuffs; 68-88.5% water[9]

[1]Pilot Corporation of America. 1991. Material Data Sheet for Better Retractable. Trumbull, CT. January 14.

[2]Sanford Corporation. 1988. Material Safety Data Sheet for Expresso® Polymer Point Pens Extra Fine Point. Bellwood, IL. June 10.

[3]Pilot Corporation of America. 1990a. Material Safety Data Sheet for Fineliner, Razor Point, Razor Point II. Trumbull, CT. June.

[4]Pilot Corporation of America. 1990b. Material Safety Data Sheet for Precise Rolling Ball Ink. Trumbull, CT. June.

[5]Pilot Corporation of America. 1990c. Material Safety Data Sheet for SC-UF. Trumbull, CT. December 12.

[6]Sanford Corporation. 1987. Material Safety Data Sheet for Expo® Dry Erase Markers Broad Tip. Bellwood, IL. April 28.

[7]Pilot Corporation of America. 1990e. Material Safety Data Sheet for Whytebord Marker. Trumbull, CT. June.

[8]Sanford Corporation. 1989. Material Safety Data Sheet for Vis-A-Vis® Overhead Projector Pen Waterbase Fine Point. Bellwood, IL. April 19.

[9] Pilot Corporation of America. 1990d. Material Safety Data Sheet for Spotliter Ink. Trumbull, CT. June.

An MSDS for a rubber cement and thinner show that both products contain naphtha, n-hexane, IPA, and paraffins (Dennison Stationery Products Company, 1991 and 1992a).

A whiteboard cleaner sold by one manufacturer contains unspecified amounts of IPA and ethylene glycol monobutyl ether (Sanford Corporation, 1990b). Other aerosol products may also contain VOCs. One spray adhesive contains 1,1,1-TCA, isobutane, and 1,4-dioxane while a spray coating contains toluene, xylene, ethyl benzene, acetone, isobutane, and propane (Krylon-Hardware Program, 1992). A photo-mount product is formulated with propane, n-hexane, acetone, and naphthol spirits and contains 5.0 lbs/gal of VOC (3M, 1992).

Computer disk drive cleaning kits include a cleaning solution that contains 99 percent IPA (Verbatim, 1987). A typewriter platen cleaner is manufactured that contains 1,1,1-TCA, glycol methylene either, and sec butanol (Sanford Corporation, 1990a).

4.12 QUICK PRINT SHOPS

4.12.1 Introduction

Quick print facilities, in general, offer three services:

- photocopying,
- offset lithographic printing, and
- digital duplicating.

Photocopying is done primarily with dry-process machines but some shops use wet-process photocopiers. Offset lithography uses small sheet-fed presses that have one to four colors. Digital duplicating is accomplished using equipment that is somewhat similar to a mimeograph machine. Although not in widespread use, the digital duplicator is being used by an increasing number of quick printers. This machine prints using a stencil that is wrapped around an ink-soaked print cylinder but, unlike a mimeograph machine, it has an automatic stencil-making process and the ability to print at high speeds (D. Witty, National Association of Quick Printers, personal communication, August 25, 1992; A. Adelson, Riso, Inc., personal communication, August 26, 1992).

Many quick printers offer more elaborate services that are similar to those provided by reprographers. Reprography shops, traditionally termed blueprint shops, offer services that include: production of white prints, large document copying, plotting, color copying, microfilm and slide production, and offset printing. Machines that produce blueprints or white prints use either aqueous or anhydrous ammonia. VOCs are not used in this type of equipment. Most reprographers feel that they provide unique services to clients who are more technically oriented than the customers seen by quick printers. Their clients are often engineering, designing, graphic arts, and legal firms. Nevertheless, a precise distinction between quick printers and reprographers does not exist since quick printers are, in general,

updating their services and starting to compete with reprographers for the same potential clients (M. J. Sager, International Reprographics Association, personal communication, August 27, 1992; P. Nowers, Association of Reproduction Materials Manufacturers, personal communication, August 21, 1992).

Quick print facilities are listed under the SIC codes 2752 and 7334. SIC code 2752, lithographic commercial printing, is described as "establishments primarily engaged in printing by the lithographic process" while SIC code 7334, photocopying and duplicating services, is identified as "establishments primarily engaged in reproducing text, drawings, plans, maps, or other copy by blueprinting, photocopying, mimeographing, or other methods of duplication other than printing or microfilming" (*Standard Industrial Classification Manual,* 1987). Quick print facilities that contain offset presses may list themselves under SIC code 2752 but this is not true in all cases. In fact, the National Association of Quick Printers (NAQP) advises all of its members to list their facilities under SIC code 7334 regardless of whether or not they have offset presses (V. Lustgarten, National Association of Quick Printers, personal communication, September 10, 1992). Reprography shops are most commonly listed under SIC code 7334 but some reprography shops may also be listed under SIC codes 8711 and 8712, which are described as "engineering services" and "architectural services," respectively (M.J. Sager, International Reprographics Association, personal communication, August 27, 1992).

The 1987 census cites 982 quick print facilities under SIC code 2752 as having receipts of $100,000 or more. In 1982, only 320 facilities had receipts of this amount. All quick print facilities under SIC code 2752 had combined receipts of $430.5 million (Census of Manufactures, 1987). The census statistics list 4,474 establishments under SIC code 7334 in 1987. These establishments, which include reprography shops, employed 37,785 workers and had receipts of $1,978.4 million (Census of Service Industries, 1987).

4.12.2 Nonprocess Solvent Usage

Solvents may potentially be used in both the operation and routine maintenance of dry- and wet-process photocopiers. For either type of machine, maintenance and repair are rarely performed by the quick printer. Instead, these operations are done by a manufacturer, dealer, or third-party service company (D. Witty, National Association of Quick Printers, personal communication, August 25, 1992).

Although dry-process photocopiers use dry toner in their operations, small amounts of emitted organic vapors have been detected in at least one study of these machines. In this study, it was speculated that the vapors are monomers from the resin in the toner powder, and that they are more likely to be emitted as the toner powder is fixed to the paper with heat-rolls. The study further theorized that these vapors may react with emitted ozone and result in reaction products, such as oxygenated hydrocarbons (e.g., lower aldehydes, ketones, and carbolic acids) (Hannsen and Andersen, 1986).

Routine maintenance of dry-process photocopiers, usually done every four months, primarily involves vacuuming accumulated toner from the machine. Methyl alcohol and consumer glass cleaner may be used to clean external parts of the machine. Small amounts of light machine grease, synthetic aerosol lubricant, and/or light machine oil may be used to lubricate the internal parts of the photocopier. A belt cleaner that contains solvent may also be used on a regular basis (B. Hecker, Copy Pro, personal communication, August 26, 1992).

Wet-process photocopiers use liquid toner and dispersant. Although these photocopiers may be more suitable for high-volume copying operations since they, in general, last longer and require less maintenance than dry-process machines, they are not used extensively in quick print facilities (D. Witty, National Association of Quick Printers, personal communication, August 25, 1992, and B. Hecker, Copy Pro, personal communications, August 26, 1992). In fact, only one American distributor of wet-process photocopiers was found. This distributor sells its product line of wet-process photocopiers to quick print facilities, as well as to offices and schools (K. Costigan, Savin Corporation, personal communication, August 25, 1992).

The liquid toner used in these machines contain 75 percent, by weight, of hydrotreated heavy naphtha (Ricoh Corporation, 1990a). The dispersant is composed of greater than 99 percent hydrotreated heavy naphtha (Ricoh Corporation, 1990b). Both the toner and dispersant for these machines are supplied in canisters and replaced by the user, as needed.

Various studies examining emissions from wet-process photocopiers have been conducted. Two of these studies indicate that VOC exhaust from these photocopiers is predominantly a mixture of C_{10} and C_{11} branched alkanes, although other VOCs are present including xylene, phthalates, isocyanates, nitropyrene, and 2,2,4-trimethyoctane (Hodgson and Daisey, 1989; Cutter Information Corporation, 1992). Another study examined the total VOC emissions from a wet-process photocopier and found emissions ranging from 0.222 to 0.253 grams per copied page (Kerr and Sauer, 1990). Emissions from wet-process photocopiers can be estimated by arbitrarily assuming that 5 percent of the 5,456 facilities use this type of equpment. Assuming each facility produces 1,500 copies per day for 250 days per year, annual VOC emissions would range from 36.5 to 41.6 tons.

Regular maintenance of wet-process photocopiers, also normally done every four months, involves removing the toner and dispersant mixture (called the working solution) from the tank assembly. The working solution is disposed of by the service company. The tank assembly and development assembly are then wiped clean using cleaning dispersant. The same lubricants that are used in dry-process machines are used in these photocopiers and, likewise, methyl alcohol and consumer glass cleaner may be used to clean the external parts (B. Hecker, Copy Pro, personal communication, August 26, 1992).

The small offset presses used in quick print facilities use non-heatset inks. One manufacturer's line of rubber-based inks contain 10 to 30 percent hydrotreated petroleum hydrocarbons and 15 to 30 percent vegetable oil. The black ink has a VOC content of 1.32

lb/gal, while the color inks have a VOC content of 1.10 to 1.60 lbs/gal (Van Son Holland Ink Corporation of America, 1991a and b).

The fountain solutions used in these presses are often mixtures of water, IPA, and a commercially available concentrate. At one quick print facility, the fountain solution is mixed by combining approximately 2 fluid ounces of concentrate with 8 ounces of IPA and 10 to 15 ounces of water, depending upon the specific concentrate used (V. Snipes, Research Triangle Institute, personal communication, September 17, 1992). One concentrate used at this facility contains no VOC, while another contains 1 to 2 percent ethylene glycol, 1 to 2 percent glycerol, 15 to 20 percent ethylene glycol monobutyl ether, and 5 to 10 percent IPA (A.B. Dick Company, 1989a and b).

Although there are a wide variety of lithographic plate-making procedures, most quick print facilities use one of three types of offset plates:

- metal surface plates,
- photopaper plates, or
- electrostatic plates.

Surface plates are either additive or subtractive, depending upon whether an ink-receptive lacquer is added to the plate or removed from the plate. Additive plates are treated with an emulsion developer, consisting of a lacquer and gum-etch in acid solution. Subtractive plates are treated with a solvent which, according to one MSDS, contains 3 to 4 percent benzyl alcohol (A.B. Dick Company, 1990). Photopaper plates are processed with developer, fixer, and a stop bath. It is unlikely that any of these processing chemicals contain significant amounts of organic solvent, since they were described by a NAQP representative as being similar to those chemicals used to develop photographic paper. Electrostatic plates are based on the principles of photocopiers and may use either a dry or liquid toner (D. Witty, National Association of Quick Printers, personal communication, August 25, 1992; and Bruno, 1989).

The press blankets and the ink blades, which act as ink reservoirs, are cleaned when a change in ink color is required and at the end of each day. Various cleaning solvents, often termed blanket cleaners, are used. At one facility, the press operator squirts cleaning solvent on cleanup mats that have been wrapped around the blankets. The press is then operated so that each solvent-soaked mat rotates with the blanket and removes all residual ink in the printing area. The ink blades are manually wiped clean using the same solvent. At this facility, 2 to 3 fluid ounces of cleaning solvent are used each time a color station is cleaned (V. Snipes, Research Triangle Institute, personal communication, September 17, 1992). The VOC content of blanket cleaners can vary greatly. For example, one blanket cleaner has a VOC content of 6.13 lb/gal, while that of another is only 2.60 lb/gal (Anchor Lithkemko, 1992; Van Son Holland Ink Corporation of America, 1991c).

Digital duplicators use a water-based ink which, according to an MSDS supplied by one company, contains 17 percent mineral oil as well as an undisclosed percentage of glycerol

(A. Adelson, Riso, Inc., personal communication, August 26, 1992; Riso Kagaku Corporation, 1991). A request has been made for details on how these machines are cleaned but this information has not yet been received.

4.13 ROAD PAVING

4.13.1 Introduction

The United States Census reports that 10,986 establishments classified under SIC code 1611 were in business during 1987. This SIC code includes facilities engaged in the construction of roads, streets, alleys, sidewalks, parkways, and airports. The census data obtained also include companies that construct guardrails, perform highway grading, and install highway signs. The industry employed 284,380 individuals, approximately 84 percent of whom were directly involved in construction. The net value of construction work is approximately $28 billion (Census of Construction--Industry Series, 1987; *Standard Industrial Classification Manual*, 1987).

Generally, roads are constructed of either bituminous asphalt concrete (asphalt) or portland cement concrete (concrete). Asphalt is blended at a facility that may be located several hours from the job site (K. Ours, Research Triangle Institute, personal communication, September 17, 1992). The hot asphalt mixture (hot mix) is blended and maintained at approximately 300° F prior to being laid and compacted. The major constituent of asphalt is aggregate, a mixture of sand and gravel. Asphalt cement (AC), a derivative of the bottom cut in the distillation of crude oil, serves as the binder for the aggregate. A variation is formulated by preparing an emulsion of AC and water. Cutback asphalt is based on a mixture of AC and kerosene or naphtha (F. Waller, Asphalt Institute, personal communication, September 25 and November 2, 1992). Previously, cutback asphalt was considered to be a major source of VOC emissions. In recent years, the increased use of water-emulsified products has resulted in decreased organic emissions (Kersteter et al., 1992).

It is estimated that between 460 and 500 million tons of hot mix was prepared in 1991. This estimate does not include hot mix prepared from cutback or emulsion asphalt. Approximately 5.5 percent of the hot mix is AC (C. Campbell, National Asphalt Pavement Association, personal communication, September 25, 1992). A different source estimates that 22.2 million tons of AC was used for paving in 1991. That same year, approximately 926,000 and 2.4 million tons of cutback and emulsion asphalt, respectively, were produced (B. McGinnis, Asphalt Institute, personal communication, September 25, 1992).

Concrete is an inorganic mixture of portland cement, aggregate, and water. The aggregate is a precisely controlled mixture of fine, medium, and coarse materials. This includes sand and gravel of various sizes. Cement, a reaction product of lime and gypsum, reacts with the water to form a medium that binds the aggregate. The mixture is prepared away from the job site. Water is added either immediately or at the site, depending on the

required mixing time. It is poured into molds, and the concrete hardens as it dries (K. Ours, Research Triangle Institute, personal communication, September 17, 1992).

4.13.2 Nonprocess Solvent Usage

AC contains low concentrations of VOC when properly prepared. The North Carolina Department of Transportation evaluates AC by a "loss on heating test." When heated, if more than 0.5 percent by weight volatilizes, the AC is rejected. Realistically, VOC concentrations in AC are on the order of 0.0025 percent (F. Waller, Asphalt Institute, personal communications, September 25 and November 2, 1992).

Emulsion-based asphalt is prepared in a colloidal mill where the AC is dispersed into 1 to 10 micron-sized particles. Approximately 30 to 33 percent of the mix is water. An emulsifying agent is added. The typical 5 to 5.5 percent ratio is maintained when adding emulsified AC to aggregate. When this product cures, the water evaporates, leaving AC, residual emulsifying agent, and aggregate (F. Waller, Asphalt Institute, personal communications, September 25 and November 2, 1992).

When formulating cutback asphalt, approximately 20 to 45 percent by weight of naphtha or kerosene is added to AC. Aggregate is added so the final product contains the typical 5 to 5.5 percent solvent and AC. The solvent evaporates as the asphalt cures (B. McGinnis, Asphalt Institute, personal communication, September 25, 1992). The impact of the limited use of cutback asphalt is demonstrated in the following calculations. As stated earlier, between 460 and 500 million tons of hot mix was prepared in 1991. From 5.0 to 5.5 percent of the hot mix is AC. Thus, between 23 and 27.5 million tons of AC was used in the hot mix. Another source estimated the usage at 22.2 million tons. A simple average of the three numbers yields 24.2 million tons of AC. An estimation of potential VOC emissions is obtained by multiplying the tonnage of AC in hot mix by a VOC content of 0.0025 percent. This calculation yields 605 tons of VOC in 1991. An estimation of the maximum quantity of VOC emissions can be obtained by assuming the VOC content is 0.5 percent. Similar arithmetic indicates 121,000 tons of potential emissions.

The same calculations can be performed for cutback asphalt. A source estimated the 1991 use of cutback asphalt to be approximately 926,000 tons. Assuming 33 percent of the cutback formulation is kerosene or naphtha (containing 100 percent VOC), VOC emissions would total nearly 306,000 tons of VOC. Although the production of cutback asphalt is less than 4 percent of the straight AC production, emissions from cutback asphalt far exceed those from straight AC.

Both asphalt and concrete paving rely on heavy equipment, which requires periodic maintenance and repair. The process often involves removing oils and greases from parts. For this purpose, it is necessary to use solvents that are commonly used in equipment maintenance shops. These include the varsol- or mineral spirits-based products that are used

to clean and degrease parts (K. Starwalt, American Road and Transportation Builders Association, personal communication, July 30, 1992).

In the asphalt industry, regular equipment cleaning is performed with high-pressure water sprays, although this may not have always been the practice. In some states, remediation work is required at the locations where repeated equipment cleaning resulted in ground contamination (A. Steiner, American Association of State Highway and Transportation, personal communication, July 29, 1992).

Some construction groups coat the truck and hopper beds with diesel fuel to prevent sticking. The asphalt absorbs any excess liquid. Diesel fuel is also used to clean hand-held tools, such as shovels and rakes. One facility keeps the diesel fuel in a covered bucket and reuses it for cleaning purposes until the cleaning ability is exhausted. An outside contractor removes the spent solvent annually (J. Benda, Illinois Tollway, personal communication, August 4, 1992).

Fresh concrete is usually removed from clothing and work equipment with water. There is no need to use solvents for cleaning (B. Risser, American Concrete Paving Association, personal communication, August 4, 1992).

4.14 ROOFING

4.14.1 Introduction

In 1987, the census tallied 25,673 establishments with 231,137 employees in business under SIC code 1761. These establishments are engaged in roofing, siding, and sheet metal work. The census places the value of the work performed at $14 billion. The census does not provide information that is specific to the roofing industry (Census of Manufactures--Industry Series, 1987; *Standard Industrial Classification Manual,* 1987).

Roof coverings vary in materials and construction. A few of the materials used include: asphalt-type shingles, rubber, tar and gravel, plastic, metal, and foam. Tar and gravel roofs are installed by heating coal tar or petroleum-derived asphalt and pumping it onto the roof. The liquid is spread evenly with mops. Just before the tar cools and solidifies (after about 30 minutes), gravel is spread over the surface (J. Short, Research Triangle Institute, personal communications, August 4 and September 15, 1992). The main purpose of the roofing aggregate is to provide protection from the evaporative and oxidative effects of the sun, heat, air, and water (The Roofing Industry Educational Institute, 1987).

Rubber roofs are installed by rolling the covering onto the roof and trimming it to fit. An adhesive affixes the roof to the building and joins adjacent pieces (J. Short, Research Triangle Institute, personal communications, August 4 and September 15, 1992).

4.14.2 Nonprocess Solvent Usage

The asphalt used in roofing is similar to the AC used to pave roads. AC is derived from the bottom cut in the distillation of crude oil. When properly distilled, the asphalt contains very small amounts of VOC. Material specifications are more stringent for roofing than for paving asphalts. For roofing, a higher viscosity AC is prepared. Two grades are available, "dead level" and "steep." The lower viscosity AC, dead level, has a higher viscosity than paving AC. The semisolid material is heated to 400° F and pumped to the roof. No sand or aggregate is added until the surface cools (B. Woodring, GAF, personal communication, September 29, 1992; and F. Waller, Asphalt Institute, personal communications, September 25 and November 2, 1992).

Estimates have placed the amount of AC used for roofing at 3.7 million tons (B. McGinnis, Asphalt Institute, personal communication, September 25, 1992). Assuming VOC concentrations of 0.0025 and 0.5 percent (as stated in Section 4.13.2), potential emissions of VOC from straight AC are 94 and 18,739 tons, respectively.

Naphtha or kerosene is used in a cutback asphalt formulation. Cutback asphalt represents a small portion of the industry. These products are used in detail work such as flashing. Also, water-based asphalt emulsions are used in specialty applications where the coating is exposed, unprotected by gravel or sand. Although coal tar dominated the market 50 years ago, it is rarely used today (B. Woodring, GAF, personal communication, September 29, 1992).

For tar and gravel roof applications, nonprocess solvents are used to clean tools and clothing. An industry-affiliated member of the Residential Roofing Committee of the Roof Coatings Manufacturers Association (RCMA) stated that kerosene and mineral spirits are often used. When necessary, roofing tars are thinned with mineral spirits (D. Shaw, Georgia Pacific, personal communication, July 30, 1992). Mineral spirits is a solvent derived from a cut in the distillation of naphtha. Boiling points range from 300 to 415 °F. Flashpoints range from 100 to 140 °F (Budavari, 1989).

A roofing contractor was contacted by the National Roofing Foundation because the association had limited information on cleaning solvent use within the industry. According to the contractor, asphalt is removed from tools and building surfaces with mineral spirits. Waterless hand cleaners are used for personal cleaning (T. Shanahan, National Roofing Foundation, personal communication, July 30, 1992). A spokesperson from the RTI facility maintenance department stated that tools are cleaned with varsol. The inexpensive mops are not cleaned but are discarded (J. Short, Research Triangle Institute, personal communications, August 4 and September 15, 1992).

The contact from the facility maintenance department continued by stating that when rubber roofs are repaired, the area around the patch must first be cleaned to assure proper adherence. The product used is called Black Splice Cleaner (J. Short, Research Triangle

Institute, personal communications, August 4 and September 15, 1992). According to the label, the product contains carbon black, heptane, IPA, and toluene. Silicon caulk is used as an adhesive (B. Woodring, GAF, personal communication, September 29, 1992).

The spokesperson affiliated with the RCMA added that cements and coatings are being reformulated as water-based emulsions. The contact expects the need for cleaning with solvents to be reduced as the products are modified (D. Shaw, Georgia Pacific, personal communication, July 30, 1992).

4.15 TEXTILE MANUFACTURING

4.15.1 Introduction

The SIC manual classifies facilities primarily engaged in the manufacture of textile mill products in major group 22. For this document, research efforts centered on all industry groups with the exception of group 229, miscellaneous textile goods. Examples of facilities within group 229 and, therefore, outside the scope of study, include establishments engaged in the manufacture of tire cord and fabrics, nonwoven fabrics, cordage and twine, nonrubberized coated fabrics, and those not elsewhere classified. Future references to the textile industry are pertinent to all facilities in major group 22 with the exception of industry group 229 (*Standard Industrial Classification Manual*, 1987).

The textile industry employs approximately 534,500 individuals in 2,010 facilities. The net value added for the industry is nearly $23 billion (Census of Manufactures--Industry, 1987). Industry groups 221 and 222 correspond to cotton broadwoven fabric mills and manmade fiber and silk broadwoven fabric mills, respectively. Facilities engaged in the weaving or braiding of narrow fabrics from cotton, wool, silk, and manmade fibers are classified as industry group 224. Industry group 223, wool broadwoven fabric mills, includes dyeing and finishing, unlike groups 221, 222, and 224. Group 226 is for facilities engaged in the dyeing and finishing of textiles, exclusive of broadwoven wool fabrics and knit goods (*Standard Industrial Classification Manual*, 1987).

Knit goods manufacturers, dyers, and finishers are included in group 225. This group is the largest in this industry, containing approximately 43 percent of the facilities and 33 percent of the employees in the industry. Establishments engaged in the manufacture of carpets and rugs are classified under industry group 227. SIC group 228 includes yarn and thread mills (*Standard Industrial Classification Manual*, 1987; Census of Manufactures--Industry, 1987).

4.15.2 Nonprocess Solvent Usage

Estimates have been made that nonprocess applications are responsible for 30 to 60 percent of solvent use in textile facilities (B. Smith, North Carolina State University, personal

communication, June 29, 1992). Because textile facilities generally are large plants composed of different types of manufacturing and support operations, nonprocess solvents are used in many ways. Several of the support operations, such as HVAC repair, electrical repair, and machine shops, are discussed elsewhere in this report. Additionally, such facilities require routine janitorial cleaning of the plant and associated office space. As discussed in Section 4.11, common office products also contribute to the total amount of nonprocess solvent use at a facility. One use of solvents that is unique to the textile industry is the process of spot cleaning fabric as it is being inspected.

Spot cleaning is a process that uses solvents to remove oil and other soils from fabric as it passes across the inspection tables. Solvents typically used include trichloroethylene, perc, and 1,1,1-TCA. Solvent is applied by the following methods: direct pour from the container, contact with a solvent-soaked pad, and/or use of an electric spray gun (Textile Research Council, 1980). Some facilities anticipate converting to a mineral spirits-based solvent for spotting. However, its relatively slow evaporation rate poses some problems (J. Conner, Textured Yarn Association of America, personal communication, August 3, 1992). One facility explained an option for reducing the amount of solvent used in spotting. Soap can be added to the spot when fabric that is soiled requires further wet processing, such as dyeing. Then the initial baths of the subsequent process will remove most stains. The facility stated that this technique was partially responsible for reducing the quantities of solvents used. As a result, emissions are below the reporting limit for the Toxic Release Inventory (J. Roberts, West Point Pepperell, personal communication, August 3, 1992).

"Ringing" occurs when the solvent migrates radially from the stain; carrying the soil and other previously hidden residues with it. It soon evaporates, leaving a ring around the old stain area. The area must be spot cleaned again until the residue is no longer visible. Ringing is sometimes minimized by blowing the fabric with compressed air after the solvent is applied (Textile Research Council, 1980).

Because productivity in a textile facility depends on efficient equipment operation, preventive maintenance schedules are in place to reduce machinery downtime. Equipment maintenance and repair operations include the removal and replacement of lubricants. Solvents are used to clean and degrease equipment parts (J. Tew, American Association of Textile Chemists and Colorists, August 3, personal communication, 1992).

Unlike nearly every other operation in a plant, there is a lack of standard written procedures for cleaning. This deficiency often results in inappropriate or excess use of solvents (B. Smith, North Carolina State University, personal communication, June 29, 1992). Varsol-type solvents have nearly replaced the 1,1,1-TCA that was previously used for cleaning equipment parts. Special solvent blends are available from vendors with a flashpoint over 140 °F. Thus, wastes resulting from cleaning with these solvents are not classified as ignitable (J. Roberts, West Point Pepperell, personal communication, August 3, 1992). Arrangements are sometimes made with outside services for the removal and recycle of spent solvent.

To date, investigation by one facility into alternative parts cleaners has been unsuccessful. A particular aqueous-based product that demonstrated promise for cleaning applications was found to initiate equipment rust (J. Conner, Textured Yarn Association of America, personal communication, August 3, 1992). In addition, most water-based products that were evaluated by this facility did not cut the oils and greases as effectively as organic solvents. Therefore, based on the level of cleanliness that is desired (or required), water-based products are often not the first choice for companies unless there are other considerations (e.g., regulations or environmental ethics).

SECTION 5

ANALYSIS OF SOURCE CATEGORIES AND RANKING CRITERIA

Literature searches provided little specific information on nonprocess solvent use. Contacts with trade associations and industrial representatives proved to be the best source of information. Even so, most individuals contacted had not previously considered nonprocess solvent usage. Therefore, specific information on types of solvents and quantitative data on use within the selected industrial/commercial business categories were not readily available.

5.1 RANKING CRITERIA

The information that has been presented in the preceding section can be used along with information that has been gathered as part of other EPA efforts to select three to six industrial/commercial business categories for further evaluation. It will be through this further, detailed evaluation that specific data will be obtained on quantities and types of nonprocess solvent used.

Six criteria within four levels of consideration will be used to select categories for further evaluation. These criteria are summarized in Table 4. The first criterion to be considered is other research efforts being pursued by EPA. Because of the potential for overlap and duplication of efforts between projects, evaluation of this criterion is considered most important. Information about other EPA research projects will be gathered primarily through contacts with EPA personnel.

The second most important criterion to be evaluated will be the potential cooperation of the industrial/commercial category being investigated. Helpful and knowledgeable trade associations will provide invaluable assistance in gathering information and planning a pollution prevention demonstration. This criteria also is critically important since any demonstration that is undertaken will require the full cooperation of a host facility.

While the first two levels of consideration are important and include issues that must be addressed prior to conducting further research, the three criteria included within the thrid level of consideration are also of significant importance. These three criteria are: (1) evaluation of the potential impact on VOC emissions, (2) opportunities for pollution prevention research, and (3) applicability of the research to other business categories will help to determine the overall usefulness of conducting research within the category.

The proximity of facilities within each category will be the last, and least important, criterion evaluated. Gathering information through site visits and conducting demonstration projects will be easier and more efficient if there are facilities located near the Research Triangle Park.

TABLE 4
CRITERIA USED TO DETERMINE CATEGORIES FOR FURTHER EVALUATION

Level of Consideration	Criteria	Issues
1	Other Research Efforts	Is the category being investigated by other EPA researchers? Will this research include an assessment of nonprocess solvents? Can EPA dovetail its efforts?
2	Industrial Cooperation	Based on contacts to date, does it appear that facilities will participate in the site assessments and demonstrations? Have trade associations been cooperative?
3	Potential Impact on VOC Emissions	Is the category a large user of nonprocess solvents? Do nonprocess solvents account for a significant portion of overall VOC emissions within the category?
	Opportunities for Pollution Prevention Research	From efforts to date, does it appear that there are significant opportunities for conducting successful pollution prevention research demonstrations that show how emissions from nonprocess solvents may be reduced or eliminated?
	Applicability of Research	Does the category use nonprocess solvents in a way that is applicable to many other industry groups? Does the category use nonprocess solvents in a way that is specific to its SIC code but generally applicable to most facilities within that code?
4	Proximity of Facilities	Are there facilities in the category that are within a 100-mile radius of the Research Triangle Park? Are there facilities located in North Carolina?

Table 5 lists a brief summary of the selection criteria and information gathering efforts that pertain to each of the 15 industrial/commercial business categories. Because significant efforts were made in the early stages of the project to avoid redundancy of research while addressing topics of collective interest, the issue of "Other Research Efforts" has already been addressed within this report (see Section 2). As a result, "Other Research Efforts" is not included on Table 5.

TABLE 5

SELECTION CRITERIA FOR INDUSTRIAL/COMMERCIAL BUSINESS CATEGORIES

Industry	VOC Emission Impact	Pollution Prevention Opportunities	Relevance to Other Industries	Industry Cooperation	Proximity of Facilities
Automobile Repair	Approximately 55,000 facilities in United States.	Nonaerosol product formulations. Alternative cleaners.	Industrial fleet maintenance. Parts cleaning.	Independent Garage Owners of NC helpful.	Many local facilities.
Bakeries	Many small facilities that do not use organic solvents. Larger facilities have few uses of solvents unique to bakeries.	Water-based cleaners, paints, and thinners. Alternative methods for date code printing.	Equipment/vehicle repair and maintenance. Facility painting. Printing industry.	Industry and trade associations helpful.	174 retail baking and selling facilities in NC. 81 NC facilities in SIC Codes 2051, 2052, and 2053 report to TRI.
Building Renovation	Variety of practices by many contractors.	Low- or no-VOC paints, coatings, adhesives, strippers, and cleaners.	Relevant to consumer do-it-yourself and new construction.	Segmentation and specialization of industry is a hindrance. Trade associations not helpful.	High growth in Triangle area supports construction and renovation.
Chemical Manufacturing	Potentially large.	Products and procedures for cleaning, maintenance, and general industrial operations.	Relevant to other large industrial facilities.	Trade associations somewhat helpful but have little available information.	20 NC facilities in SIC Codes 2865 and 2869 report to TRI.
Electrical Equipment Maintenance & Repair	Approximately 15,000 facilities in United States.	"No-clean" options. Alternative product forms and formulations. Current work practice already limits usage.	Limited.	No trade association for all facilities. Must contact individual facilities.	Both small and large facilities are nearby.
Florists	Very small.	Limited to changes in work practice.	General shop cleaners are used in other retail businesses.	Society of American Florists helpful.	Commonplace.
Furniture Repair & Restoration	Small facilities with little access to control techniques. Current practices rely on solvent-based technology.	Water-based strippers, cleaners, and finishes. Alternative stripper and coating formulations. Methods used by furniture conservators.	Relevant to furniture manufacturers. Equipment cleanup issues applicable to other industries.	Furniture conservators helpful. Refinishers acknowledge increased attention on solvent use.	Local facilities.

(continued)

TABLE 5

SELECTION CRITERIA FOR INDUSTRIAL/COMMERCIAL BUSINESS CATEGORIES
(Cont'd)

Industry	VOC Emission Impact	Pollution Prevention Opportunities	Relevance to Other Industries	Industry Cooperation	Proximity of Facilities
Heating, Ventilation, & AC Service	Use variety of solvents.	Low-VOC products are available. Alternative product forms.	Required in other industries.	Two helpful trade associations.	Many small and large facilities are nearby.
Machine Shops	Cleaning solvents are a large source of VOC emissions.	Alternative use procedures. Low-VOC cutting fluids and cleaners.	Metalworking industry.	National Tooling & Machining Association helpful.	Many small and large facilities are nearby.
Mold Release Agents	50 manufacturers in the United States.	Alternative product formulations.	Very limited.	Manufacturers and users of mold release agents helpful.	Only one manufacturer of mold release agents is located in NC.
Office Products	Large users of solvents.	Low-VOC adhesives, cleaners, coatings, and inks. Alternative product forms.	Nearly every industry.	Some product suppliers helpful.	Few local manufacturers but many users.
Quick Print Shops	Large users of solvents.	Maintenance and cleanup. Low-VOC fountain solutions.	Office environments and printing industry.	National Association of Quick Printers helpful.	Many local facilities.
Road Paving	From 310 to 450 K tons VOC in 1991.	Replace cutback with emulsion. Minimize tool contamination. Water-based cleaners. Alternative coating for hopper and truck beds.	Relevant to roofing trades.	Trade associations interested in alternative cleaners.	State Department of Transportation in Raleigh, NC.
Roofing	From 93 to 18,500 tons VOC in 1991.	Alternative roofing materials. Minimize tool contamination. Water-based cleaners.	Techniques and products similar to road paving.	Industry was helpful.	Many local opportunities.
Textile Manufacturing	Nonprocess solvents account for 30% to 60% of solvent use.	Alternative products for spotting, adhesives, cleaning, and equipment maintenance.	Equipment maintenance and repair is common to other industries.	NCSU's College of Textiles, Trade Associations, and Industry are helpful	176 textile facilities in NC report to TRI.

SECTION 6

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APPENDIX 1

KEY WORDS USED IN LITERATURE SEARCH

solvent	pollute
waste	emission
VOC	clean
prevent	minimize
organic	baking, baker, bake
build	construct
renovate	roof
furniture	textile
Xerox	photocopy
print	office
machine	florist
asphalt	road
HVAC	heat
repair	service
maintenance	chemical
manufacturing	electric
paving	

APPENDIX 2

SIC CODES USED FOR PTS PROMPT SEARCH

Code	Descriptor
1521	Construction: General Contractors--Single-Family Houses
1522	Construction: General Contractors--Residential Buildings, Other than Single-Family
1541	Construction: General Contractors--Industrial Buildings and Warehouses
1542	Construction: General Contractors--Nonresidential Buildings, Other Than Industrial Buildings and Warehouses
1611	Construction: Highway and Street Construction, Except Elevated Highways
1761	Construction: Roofing, Siding, and Sheet Metal Work
2051	Manufacturing: Bread and Other Bakery Products, Except Cookies and Crackers
2052	Manufacturing: Cookies and Crackers
22	Manufacturing: Textile Mill Products
2511	Manufacturing: Household Furniture--Wood Household Furniture, Except Upholstered
2512	Manufacturing: Household Furniture--Wood Household Furniture, Upholstered
2865	Manufacturing: Industrial Organic Chemicals--Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments
2869	Manufacturing: Industrial Organic Chemicals--Industrial Organic Chemicals, Not Elsewhere Classified
2952	Manufacturing: Petroleum Refining--Asphalt Felts and Coatings
3295	Manufacturing: Abrasive, Asbestos, and Miscellaneous Nonmetallic Mineral Products--Minerals and Earths, Ground or Otherwise Treated
3861	Manufacturing: Photographic Equipment and Supplies
7334	Services: Mailing, Reproduction, Commercial Art and Photography, and Stenographic Services--Photocopying and Duplicating Services
7623	Services: Electrical Repair Shops--Refrigeration and Air-Conditioning Service and Repair Shops
7629	Services: Electrical Repair Shops--Electrical and Electronic Repair Shops, Not Elsewhere Classified
7641	Services: Reupholstery and Furniture Repair
7692	Services: Miscellaneous Repair Shops and Related Services--Welding Repair
7699	Services: Miscellaneous Repair Shops and Related Services--Repair Shops and Related Services, Not Elsewhere Classified

APPENDIX 3

TRIP REPORTS - AUTOMOTIVE REPAIR

MEMORANDUM November 30, 1992

To: Coleen Northeim

From: Larry Hollar

Subject: Visit to [redacted]

I. General

[redacted] Service Center is a family-owned business located at [redacted] in [redacted] North Carolina. [redacted] and his son, [redacted] own the 6-bay facility. Seven individuals are employed full time. The original business, a service station, was across the street. Now it is vacant because of soil contamination from leaking underground storage tanks. The new facility was built less than four years ago and is still surprisingly clean. The owners estimate they service approximately 80 cars per week. Both Japanese and Domestic cars are repaired. Facility spokesmen claim to perform all forms of maintenance and repair except body work.

II. Parts Washing

Several parts washing techniques are employed by the facility. General parts washing is performed in one of two facility-owned solvent sinks. Sparkle, a waste contractor, removes and replenishes both sinks with solvent every 28 days. The cleaner is based on mineral spirits. The older model consists of an open tray that holds several gallons of solvent. A pump with an unfiltered intake is in the bottom of the tray. A rack holds the part above the solvent where it is washed. In the newer model, the solvent and pump are located in a drum that supports and is covered by the sink. The pump intake is filtered. A brush mounted on the nozzle facilitates cleaning. The dirtiest parts are washed in the old sink first, then in the new sink.

Carburetors and other parts that are more difficult to clean are soaked in one of two solvents. The product of choice, Hydro-Seal II by Gunk, is based on 2-butoxy-1-ethanol and n-methyl-pyrolidine. Facility representatives stated that it is an effective cleaner. In addition, the cleaner does not burn the skin or have an offensive odor. When a part is cleaned, rubber O-rings may be left in place because the product will not swell or destroy them. Hydro-Seal

II is purchased, stored, and used in covered 5-gallon buckets. The two buckets in use are the only ones purchased since the relocation.

If Hydro-Seal II does not adequately clean the surface, a chlorinated solvent-based product is used. The cleaner is kept and used in a closed 55-gallon drum. The contacts stated that an aqueous layer on top of the solvent is used to rinse the parts and reduce solvent evaporation. The business has purchased 36 gallons since its relocation four years ago. There has yet to be a need for disposal.

III. Prepackaged Solvent-Containing Products

This facility uses a variety of prepackaged, solvent-containing products. Purchase rates for the most commonly used products are included in Attachment 1. Assuming all products are 100 percent VOC, emissions from these products total 1,228 pounds per year. This calculation neglects the effect of combustion when the product is added to the engine fuel or air intake. Therefore, actual VOC emissions are expected to be lower. Products that are used in this manner include: carburetor cleaner, fuel injector cleaner, and fuel additive.

IV. Waste Stream Disposal

A 55-gallon drum is used to store waste antifreeze. A contractor removes the spent coolant and recycles it. The contractor will remove the antifreeze for no fee if the shop, in turn, agrees to purchase the recycled antifreeze. The facility refuses to use recycled antifreeze as long as the "Big Three" automakers do not approve of the product.

An underground tank is used to store waste gasoline, diesel fuel, and oil. A contractor removes the waste for recovery as fuel. Thus, care is taken to keep water and coolant wastes from entering this stream. A "sock" surrounds the tank so local authorities can monitor for potential leaks.

A second 55-gallon drum is used for mixed wastes. Disposal costs are high for this stream. For this reason, the facility strives to segregate material.

V. Spill Control/Shop Hygiene

Drip trays are always used. Oil-fill funnels are kept in a 5-gallon bucket that is periodically drained into the waste oil receptacle. Once each week, the facility hoses down the floors. Water flows into a center trough leading to two settling basins piped in series. The overflow of the second basin discharges to the publicly owned treatment works. It has not been necessary to remove the sludge from either basin.

Small gasoline spills are absorbed by cloths and stored in an open receptacle that is provided by Safety-Kleen. Periodically, Safety-Kleen removes the used cloths.

VI. New Techniques/Approaches

The facility is licensed to operate, and has purchased, equipment that recovers and recycles freon. The contacts have not investigated in-house engine coolant recycling equipment because the resulting product has not yet been approved for use in automobiles manufactured by the "Big Three."

Attachment 1
Product Usage Rates

Product	Case/Month	lbs VOC/year
Carburetor Cleaner	4	576
Penetrating Lubricant	2	288
Fuel Injector Cleaner	0.3	32.4
Brake Cleaner	2	288
Fuel Additive	0.3	43.2

Sample Calculation

- 4 cases/month carburetor cleaner
- 16 ounce/can
- 12 can/case

(16 oz/can)*(12 can/case)*(4 case/month)*(12 month/yr)*(1 lb/16 oz) = 576 lbs/year

MEMORANDUM November 30, 1992

To: Coleen Northeim

From: Larry Hollar

Subject: Visit to [redacted] Service Station

I. General

[redacted] is the owner of the facility located on [redacted] in [redacted] North Carolina. [redacted] stated that he services approximately 250 cars per week. The facility has four lifts, one of which is outside. The service station has 13 full-and five part-time employees. Systems repaired and serviced include: brake, cooling system, air conditioning, and electrical. Minor drivetrain, carburetor, and fuel injection repair and service is performed. Vehicle maintenance procedures, such as fluid and filter changes, are commonplace. Examples of work that is not performed include the rebuilding of carburetors and transmissions. Because of the difficulty and expense of waste disposal, cooling system flushes are not performed. Instead, the facility only drains and refills radiators.

II. Parts Washing

[redacted] owns a parts washer and does not contract an outside agency for solvent replenishment or removal. On the day of the visit, several boxes were piled on top of the closed sink. [redacted] stated that the sink is used an average of twice a day. Varsol is purchased and added to the sink as needed. The contact did not explain disposal procedures.

III. Prepackaged Solvent-Containing Products

This facility uses a variety of prepackaged, solvent-containing products. Purchase rates of the most commonly used products are included in Attachment 1. Assuming all products are 100 percent VOC, emissions from these products are 1,329 pounds per year. This calculation neglects the combustion of products that are added to the engine fuel or air intake. These products include: fuel injection tune-up, fuel injector cleaner, and starting fluid. Thus, actual emissions are expected to be lower.

IV. Typical Product Contents

The facility maintains a file of MSDSs. Not all products with MSDSs on file are used or sold. Nevertheless, for future reference, the information obtained is listed in Attachment 2.

V. Waste Stream Disposal

[redacted] contracts Safety-Kleen to remove waste oil from the facility at a cost of 50 cents per gallon. The facility will accept, at no charge, up to one gallon from an individual. Receptacles inside the building are hard piped to a locked and protected collection vessel on the outside. Safety-Kleen periodically removes the used motor oil. Care is taken so that only motor oil is added to the tank.

A 55-gallon drum is used to store spent antifreeze. An outside contractor removes the waste for recycling. Care must be taken to avoid contamination of the material.

Metal-containing parts are saved for scrap dealers who, in turn, sell to metal recovery facilities. Batteries are removed from the facility to be recycled. Other components like fuel and water pumps, alternators, and starters are sold to rebuilders.

VI. Spill Control/Shop Hygiene

[redacted] stated that drips and spills on the shop floor are prevented by the use of collection pans. The floor is rarely mopped. Holes that lead to the storm sewer have been plugged. The contact did not explain the disposal of mop water. Oil Dry is used to absorb small amounts of oil or grease. Polypropylene towels [redacted] are placed on small gasoline spills. These are kept in an uncovered receptacle for disposal by Safety-Kleen.

VII. New Techniques/Approaches

Units are commercially available that are said to collect spent antifreeze and regenerate or recycle the liquid for reuse. Some machines purify or reconcentrate the ethylene glycol (removing the water diluent) by distillation. Some equipment models add components that are not reclaimed during the recycling. [redacted] is suspicious of the protection and effectiveness afforded by regenerated coolant. For this reason, the facility has not investigated the purchase of such a unit.

[redacted] purchases motor oil in bulk containers. He sells oil in 1-quart containers. Used containers (collected from the trash receptacle) are refilled with bulk motor oil of the appropriate grade. The facility sells 300 gallons per month in 1-quart containers. This practice prevents nearly 14,400 containers from going to the landfill each year. If the economic incentive is reduced by higher priced bulk oil, the contact stated that he may discontinue the practice.

A freon recycling apparatus is on order. The facility has obtained proper certification and licensing. [redacted] expects that using the machine will be inconvenient and expensive because it remains on the car for one hour, rendering a service bay idle.

To recover costs associated with the responsible management of waste, surcharges are implemented on certain procedures. Examples include $1 per battery and 50 cents per oil change surcharges. Individuals at the Independent Garage Owners of North Carolina support such a policy. They believe it reinforces to their customers that wastes are managed responsibly.

VIII. Challenges/Problems

Occasionally, customers pump gasoline into a diesel tank or vice versa. Also, for a variety of reasons, fuel in auto tanks is contaminated and must be removed and disposed.

Attachment 1
Product Usage Rates

Product	Case/Month	lbs VOC/year
Fuel Injection Tune Up	1	144
Gumout	1	144
Fuel Injector Cleaner	1	144
Gum Cutter	1	144
Brake Cleaner	4	576
Brake Anti Squeal	1	144
Starting Fluid	0.3	33

Sample Calculation:

- 1 case/month fuel injection tune-up
- 16 ounce/can
- 12 can/case

(16 oz/can)*(12 can/case)*(1 case/month)*(12 month/yr)*(1 lb/16 oz) = 144 lbs/year

Attachment 2
Product Contents

Product	Components	%
Atlas Penetrating Lubricant	1,1,1-TCA Oxygenated Hydrocarbon Naphtha Phenol Graphite CO_2	45 to 66 5 to 15 5 to 15 5 to 15 1 to 5 1 to 5
Rubber Cement	1,1,1-TCA	90
Atlas Brake Cleaner	Perchloroethylene Methylene Chloride Heptane CO_2	38.7 48.4 9.7 3.2
Atlas Brake Part/CV Boot Cleaner	1,1,1-TCA Xylene CO_2	87.3 9.2 3.5
Atlas Carburetor Intake Cleaner	Butyl Cellosolve Naphtha Mineral Oil Hydrocarbon Propane Isobutane	
Concrete Cleaner	Sodium Silicate 2-Butoxyethanol	
Atlas Cooling System Cleaner	o-dichlorobenzene Borax Inorganic Salts	
Cooling System Sealer	Isopropanol	
Carburetor Cleaner	Petroleum Distillates Acetone Toluene o-dichlorobenzene	20 10 66 4
Gas Line Antifreeze	Methanol	
Gasoline Additive	Stoddard Solvent	
Glass Kleen Concentrate	Methanol	56
Ice Remover	Methanol Diethyleneglycol CO_2	89.8 3.8 5.4
Atlas Lubricating Compound	1,1,1-TCA Propylene Glycol Castor Oil CO_2 SiO_2	60 to 85 5 to 15 5 to 15 1 to 5 1 to5

APPENDIX 4

CONVERSION FACTORS

To Convert		To	Multiply by
LENGTH			
feet	(ft)	meters	0.3048
meters	(m)	feet	3.281
MASS OR WEIGHT			
ounces	(oz)	kilograms	0.02835
pounds	(lb)	kilograms	0.4536
pounds	(lb)	tons	0.0005
tons		pounds	2,000
tons		kilograms	907.2
kilograms	(kg)	pounds	2.205
kilograms	(kg)	tons	0.001102
VOLUME			
gallons	(gal)	liters	3.785
gallons	(gal)	inches^3	231
gallons	(gal)	fluid ounces	128
milliliters	(ml)	fluid ounces	0.03381
liters	(l)	gallons	0.2642
inches^3	(in^3)	gallons	0.004329
fluid ounces	(oz)	gallons	0.007813
fluid ounces	(oz)	milliliters	29.57
CONCENTRATION			
pounds/gallon	(lb/gal)	grams/liter	119.8
grams/liter	(g/l)	pounds/gallon	0.008345
DENSITY			
pounds/gallon	(lb/gal)	grams/milliliter	0.1198
grams/milliliter	(g/ml)	pounds/gallon	8.345
PRESSURE			
pounds/inch^2	(psia)	mm Hg or torr	51.71
pounds/inch^2	(psia)	atmospheres	0.0680
millimeters of mercury or torr	(mm Hg)	pounds/inch^2	0.1934
TEMPERATURE			
Fahrenheit	(° F)	Celsius	subtract 32, then multiply by 0.5556
Celsius	(° C)	Fahrenheit	multiply by 1.8, then add 32

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/R-94-019		

4. TITLE AND SUBTITLE	5. REPORT DATE
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	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO
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15. SUPPLEMENTARY NOTES AEERL project officer is Michael Kosusko, Mail Drop 61, 919/541-2734.

16. ABSTRACT The report gives results of a project to gather and evaluate existing data on nonprocess solvents; i.e., products not directly incorporated into specific industrial processes. This information is to be incorporated into an overall inventory project assessing consumer product use and emissions. An additional objective of this project is to identify pollution prevention approaches and technology demonstration opportunities to enhance regulatory development efforts. The report presents the data and information gathered for nonprocess solvent use in 15 industrial/commercial business categories: automotive repair; bakeries; building renovation; chemical manufacturing; electrical equipment maintenance and repair; florists; furniture repair/restoration; heating, ventilation, and air-conditioning services; machine shops; mold release agents; office products; quick print shops; road paving; roofing; and textile manufacturing. Literature searches provided little specific information on nonprocess solvent use. Contacts with trade associations and industry representatives proved to be the best source of information. The information obtained tends to be qualitative and may include subjective extrapolations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Prevention	13B
Organic Compounds	Stationary Sources	07C
Volatility	Volatile Organic Compounds (VOCs)	20M
Emission		14G
Solvents	Nonprocess Solvents	11K
Paints		11C, 13C
Coatings		

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