Environmental Management in Lithographic Printing

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A Research Monograph of the Printing Industry Center at RIT
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R·I·T Printing Industry Center
An Alfred P. Sloan Foundation Center

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Abstract

With approximately 62,355 firms and sales of $210 billion annually[1], the printing industry is a significant contributor to the overall U.S. economy. The printing industry is also an important environmental actor in several major areas, such as use of paper (about 8 percent of all the wood cut down worldwide is used for paper production, much of which is used in printing), use of hazardous materials in printing inks, and production of volatile organic compound (VOC) emissions from cleaning solvents used in the printing process. Regulatory standards and social pressures are requiring printing firms to reduce their use of resources and emissions of hazardous and other substances. Doing this can be costly. In 1994, for example, the printing and publishing industry reported spending over $57 million on pollution control equipment alone (United States Census Bureau).

Many in industry and government agree that preventing pollution tends to be more efficient, from an economic and environmental perspective, than controlling it after the fact. Pollution prevention is accomplished through changes in production, operation, and raw materials use, in contrast to pollution control, which is accomplished by the adoption of emissions-abatement or waste treatment technologies. Indeed, many lithographic printing firms have achieved significant reductions in emissions and regulatory costs through the implementation of pollution prevention. Adoption of alcohol-free fountain solutions, solvent recovery and reuse, non- or low-VOC inks, and non- or low-VOC blanket and roller washes are but a few examples of the kinds of process changes implemented by this industry that have led to significant environmental improvements.

While many lithographic printers, and their suppliers, have done a great deal to reduce the environmental impact of their operations, the call for further reductions has not dissipated. Printing firms continue to face the challenge of meeting or exceeding environmental requirements while staying competitive. The overall objective of this research effort is to provide insight into these challenges, the ways in which firms have succeeded in meeting them, and impediments that have caused some firms to be less successful.

This monograph reviews several key aspects of environmental management in the lithographic printing industry and forms the foundation for future research. After a very brief description of the lithographic printing industry, the monograph presents a summary of the major environmental issues facing the industry today. Second, it presents a synopsis of relevant environmental regulations. Third, the paper focuses on the pollution prevention techniques that have been employed by the industry to reduce the emission of VOCs. VOC reduction has been a prime regulatory target for this industry and has been the focus of much pollution prevention activity. The paper reviews both general information on techniques for reducing VOCs — through process change — as well as a tabularized summary of 15 case studies of printing firms that were successful in reducing their environmental loadings through pollution prevention. Fourth, the monograph contains a review of a number of technical assistance and regulatory reform programs aimed at facilitating pollution prevention in the printing industry. The concluding section summarizes our proposed research agenda for the coming year.

Introduction

A BRIEF OVERVIEW OF LITHOGRAPHY

Approximately 97 percent of all printing activities can be categorized within the five most important printing processes: lithography, gravure, flexography, letterpress, and screen-printing (*Profile*). The use of any of these technologies depends on the substrate used, the required image quality, the end use of the product (e.g., food packaging, pharmaceutical packaging, and toys) and the speed and size of the print run. While most of the printing technologies use the same set of fundamental steps — imaging, prepress, printing, and post-press operations — each uses different equipment, chemicals, and raw materials.

The commercial lithographic printing sector is one of the most important and dynamic sectors in the printing industry, with a growth rate higher than that prevailing in the printing industry at large. As of 1994, the economic market share of lithography was 47 percent, and in 2000 lithographers employed the majority of employees in the printing industry. Lithographic printing technology has succeeded because of its ability to produce high-quality text and illustrations in an efficient manner for high-, medium-, and short-volume production orders (*CTSA*). Because of this success, the relative magnitude of its environmental impact is significant.

The primary raw materials used in the printing industry include inks, substrates, photographic films, photo-processing chemicals, gravure cylinders, printing plates, plate-processing chemicals, fountain solutions, cleaning solvents, and rags (*Pollution Prevention and Best Management*). The lithographic printing process is classified in two different subprocesses, depending on how the paper is fed and if the paper is heated:

1. **Sheet-fed offset lithographic:** Images are printed on individual sheets of paper and the ink dries in an oxidative polymerization process. The technology is normally used for short-run orders. 92 percent of the printing facilities that run lithographic presses have sheet-fed offset lithographic presses (*CTSA*). The most common products that use this technology are fine-art reproduction, books, posters, periodicals, advertising flyers, greeting cards, brochures, and packaging.

2. **Web offset lithographic (heatset and nonheatset):** In web offset lithographic, images are printed on top of a continuous roll (web) of paper, and during the post-press operations the roll of paper is cut into individual sheets. Web offset lithographic printers are used for longer runs. The most common products that use this technology are business forms, newspapers, periodicals, catalogs, advertising, and books. Only 11 percent of lithographers use the web offset process (*CTSA*). The heatset process uses a recirculating hot air system to dry the ink, while the nonheatset process uses a type of ink that does not require assisted drying.

ENVIRONMENTAL REGULATION

The printing industry is regulated by federal, state, and local environmental and health and safety agencies. The U.S. Environmental Protection Agency (EPA) has the responsibility of promulgating and enforcing federal regulations that are intended to protect public health and the environment. States and local regulations may be more stringent than federal regulations.

Federal Environmental Legislation Overview

This section contains a brief overview of federal environmental legislation and its relevance to the printing industry.

Clean Air Act (CAA)

The CAA focuses on preserving and improving the quality of the air. The act contains six titles, or sections. Of these, Titles I, III, and V are the ones that most affect lithographic printing companies.

Title I

This title establishes the provisions for attainment and maintenance of the National Ambient Air Quality Standards (NAAQS). Primarily, NAAQS have been established for six "criteria" air pollutants: ozone, carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide, and lead (*Pollution Prevention and Best Management*). The air pollutant of primary concern to the printing industry is ozone. Although printing facilities do not emit ozone directly, they emit VOCs, which are precursors of ozone. Regulations governing existing and new sources of VOC emissions affect the operations of industry.

Within the NAAQS section on Existing Sources of Emission, regions of the country are classified as either attainment or nonattainment areas for each criteria air pollutant. A region is considered a nonattainment area if specific levels of the six criteria air pollutants are exceeded for specific lengths of time. Next, each nonattainment area is graded as marginal, moderate, serious, severe, or extreme, depending on the level of pollution (in parts per million). For each category, a deadline to attain the NAAQS standards has been established.

The regions that have been deemed nonattainment areas for ozone have to implement a State Implementation Plan (SIP) to reduce ambient ozone concentrations. These plans directly affect the printing industry. Any printing facility that is classified as a major source of VOCs must install Reasonably Available Control Technology (RACT). A printing facility can be classified as a major source if it exceeds any of the following thresholds (United States Environmental Protection Agency): 10 ten tons per year of VOC or NO_x in an extreme nonattainment area, 25 tons per year of VOC or NO_x in a severe nonattainment area, 50 tons per year of VOC or NO_x in a serious nonattainment area, and 100 tons per year of VOC or NO_x in a moderate and marginal nonattainment area. Alternatively, a printing facility may be classified as a major source of VOC if the facility has the potential to emit more than 100 tons per year. Potential to emit is defined as "the greatest amount of emissions that could be released from a piece of equipment based on its maximum design capacity or maximum production (assuming the equipment will run 24 hours per day 365 days per year or 8,760 hours per year)." (*Pollution Prevention and Best Management*)

With regard to the NAAQS rules on New Sources of Emission, fewer controls are applied. Basically, any company that plans to construct a major stationary source of air pollution or make major modifications is required to obtain an air pollution permit before starting the construction (United States Environmental Protection Agency).

Title III

This title establishes Maximum Achievable Control Technology (MACT) standards for a list of 189 hazardous air pollutants (HAPs). The pollutants that are on the list and are used in the printing industry are (United States Environmental Protection Agency): benzene, cadmium compounds, carbon tetrachloride, chromium compounds, cobalt compounds, cumene, dibutylphthalate, diethanolamine, ethyl benzene, ethylene glycol, formaldehyde, glycol ethers, hexane, hydrochloric acid, isophorone, lead compounds, methanol, methyl ethyl ketone (MEK), methyl isobutyl ketone, methylene chloride, perchloroethylene, polycyclic organic matter, propylene oxide, toluene, 2,4-toluene diisocyanate, 1,1,2-trichloroethane, trichloroethylene, vinyl chloride, and xylenes.

The EPA has the right to establish MACT standards for source categories that release at least one of the pollutants on the list. The source will receive a six-year extension of the compliance date for a MACT standard if it achieves a 90 percent reduction in its HAP emissions prior to the date on which the MACT standard is proposed for its industry category (United States Environmental Protection Agency).

Over the past ten years, the EPA has issued 45 air toxics MACT standards under Section 112 of the 1990 Clean Air Act Amendments. Compliance is required within three years unless otherwise specified in the rule. In 1996, the EPA published its final MACT standard for the printing and publishing industries, covering two distinct segments: Publication rotogravure printers, which produce paper products such as catalogues, magazines, newspaper inserts, telephone directories, and package-product rotogravure, and wide-web flexographic facilities, which print on paper, plastic film, metal foil, and vinyl for use in products such as flexible packaging, labels, and gift wrap. These standards target chemicals such as toluene, xylene, methanol, and hexane. The EPA's rule incorporates flexible compliance options into its emissions control requirements. Facilities may use pollution prevention methods (which allow printers to eliminate the use of toxic chemicals or to substitute nontoxic chemicals for toxic ones), traditional emissions capture and control equipment, or a combination of the two.

At the time of promulgation, the rule was expected to affect an estimated 27 publication rotogravure facilities and 100 package-product rotogravure and wide-web flexographic facilities. It was expected, at the time of promulgation, to reduce air toxics emissions from publication rotogravure printers by about 5,200 tons per year, and those from package-product rotogravure and wide-web flexographic printers by about 2,100 tons per year (based on 1999 emissions). The cost of implementation was expected to be approximately $40 million (Office of the Federal Register).

Title V

This title establishes a permit process for all "major sources" (and certain other sources) regulated under the CAA. The permit applies to VOCs and Hazardous Air Pollutants (HAP) emissions. Title V describes the minimum standards and procedures required for these federally enforceable, state or locally issued, operating permits (United States Environmental Protection Agency). These standards and procedures include emission limitations, compliance schedules, emission monitoring, self-reporting responsibilities, and emergency provisions.

Clean Water Act (CWA)

The CWA is a federal law that protects the nation's waters, including coastal areas, aquifers, lakes, and rivers. The CWA has two objectives: to eliminate the discharge of pollutants into the nation's waters and to achieve water quality levels that are fishable and swimmable (*Clean*). Lithographic operations generate waste water (containing acids, alkali, and solvents), rinse water contaminated with photochemicals (especially silver) and plate-making chemicals (containing chromium and cyanides), and lubricating waste oil (*Pollution Prevention and Best Management*). The following is a summary of some requirements under the CWA for lithographic companies:

- **Discharges to the Public-Owned Treatment Works (POTW):** Notifying the POTW of discharges that could cause problems at the POTW, monitoring and record-keeping as established by the POTW, and a one-time notice of the discharge of hazardous waste, specifically, if more than 33 pounds per month (*Profile of the Printing*).

- **Direct Discharges:** Regulated facilities have the responsibility to notify the federal government when discharging hazardous substances that meet or exceed the reportable quantity.

- **The Storm Water Rule:** Regulated facilities that fall within any of 11 categories defined in 40 CFR 122.26 are subjected to storm water permit application regulations (*Profile of the Printing*).

- Disposal or discharge of used oil in the sanitary sewer, septic tank, on the ground or in water body is prohibited (*Pollution Prevention and Best Management*).

Resource Conservation and Recovery Act (RCRA)

RCRA gives the EPA the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste (*Resource*). Any waste is classified as a hazardous waste if it is listed in 40 CFR 261 in RCRA or if it exhibits any of the following characteristics: ignitability, corrosiveness, reactivity, TCLP toxicity (the waste is tested and found to contain high concentrations of heavy metals) (*Pollution Prevention and Best Management*). Specific requirements deal with issues such as waste containers, hazardous waste shipments, land disposal restrictions, training, release or threat of release reporting, biennial reporting, and record keeping. Possible hazardous wastes generated by lithographic printing processes are the following (*Pollution Prevention and Best Management*):

- **RCRA-listed wastes:** Acetone, benzene, formaldehyde, methanol, methyl chloroform, methylene chloride, MEK, perchloroethylene, toluene, xylene.
- **Ignitable wastes:** Blanket and roller washes, cleanup solvents, isopropyl alcohol (IPA), inks, contaminated shop towels.
- **Corrosive wastes:** Film and plate-processing chemicals, etching chemicals, acids, alkaline cleaners.
- **Reactive wastes:** Bleaches and other oxidizers.
- **TCLP toxic wastes:** fixer, plate-processing chemicals, cleanup solvents.

Emergency Planning and Community Right-to-Know Act (EPCRA)

EPCRA has two basic objectives: first, to increase public knowledge of and access to information on the presence of toxic chemicals in communities, releases of toxic chemicals into the environment, and waste management activities involving toxic chemicals; second, to encourage and support planning for responding to environmental emergencies (*Emergency*). In order to achieve its objectives, EPCRA created the Toxics Release Inventory (TRI) and hazardous chemical inventory. Both programs impact lithographic printers by alerting the community, state, and federal agencies of the level of toxics released by a printing company (*Pollution Prevention and Best Management*).

In the year 2000, only 202 firms in SIC 27 reported their emissions of listed toxic chemicals under EPCRA. Changes made to EPCRA in 1998 may have important implications for the printing industry. In particular, the EPA has lowered the reporting threshold for a subset of chemicals, called PBT chemicals (i.e., persistent, bioaccumulative, and toxic chemicals), which may require more printers to report toxic emissions as part of the TRI.[2]

Methods

Information presented here was obtained from numerous sources, principally trade association and government publications dealing with lithographic printing technology, environmental regulation, and process changes that reduce VOC emissions. Key sources include the Institute of Advance Manufacturing Sciences; Graphic Arts Technical Foundation; and U.S. Environmental Protection Agency, Design for Environment Program.

In addition to a more general literature search, a targeted search was made for existing case studies on environmental improvement in the printing industry. Many of these cases were found through industry association or regulatory agency web sites. Fifteen of the cases collected dealt with VOC reduction in the area of lithography. These cases were coded according to a number of categories and are summarized in Appendix IV. The goal was to identify any patterns among plants that achieved successful VOC reductions.

Information was also gathered through interviews with a number of employees in several small- to medium-sized printers. Environmental regulators and industry association representatives also were interviewed. Interviews were either taped and then transcribed or were written up as soon after the interview as possible to maintain accuracy.

Lastly, information on environmental performance also was gathered from several government sources. Information on toxic releases was gathered through the EPA TRI program. At the time that data was being gathered, data was available only up to 1999. Since then, 2000 data was added to the EPA database and will be added to our analysis. Industry-level information was also gathered from the United States Census Bureau. Because many of the firms in the printing industry are private and/or small, this type of information was extremely limited and was used to plot overall trends. More detailed, facility-level, economic census data is available, but only up to 1992, which we felt was too outdated for this study.

ENVIRONMENTAL ISSUES

Volatile Organic Compounds (VOCs)

Principal among environmental issues in the printing industry is the release of VOCs. VOCs are defined as any organic compound that reacts with nitrogen oxides (NO_x), in the presence of sunlight, to form ozone (Jacobson). Ozone in the lower atmosphere acts as a lung irritant. VOCs can come from many points in the lithographic printing process, the type and amount released depending upon the production volume, type of raw materials, technology used, and VOC control procedures in place. VOC emissions tend to be concentrated in three particular stages of the printing process: prepress proof, printing press, and finishing. Most VOCs stem from the printing process, specifically from the use of petroleum-based ink, IPA for damping systems, and cleaning solvents such as trichloroethane, methanol, and toluene - all VOCs and all chemicals that evaporate as they are used in the printing process (*Pollution Prevention in the Printing Industry*).

Less than 1 percent of VOC emissions come from ink. The main sources of VOCs are the damping system and cleaning solvents (Clement and Kramer). In fact, eliminating the damping solution by, for example, switching to waterless printing, may reduce VOC emissions by 50 percent or more (Clement and Kramer). Press washes are another important source of VOCs. Through judicious use of solvents or by switching to low-vapor-pressure alternatives, VOC emissions from this part of the process can be reduced. Appendix I presents an illustration of the points in the lithographic printing process at which VOCs are emitted.

Waste Generation

Printers generate an array of both hazardous and nonhazardous waste. The types of waste in the lithographic printing process can be classified as follows (*Pollution Prevention and Best Management*):

- **Hazardous waste**
    - Photographic wastes: Photo developer, fixer, intensifiers, reducers, cleaner, and scrap film.
    - Spent solvents: Acetone, carbon tetrachloride, ethanol, ethyl benzene, isopropanol, methanol, methylene chloride, mineral spirits, toluene, and xylene.
    - Spent fountain solutions with hazardous components (alcohols, ethylene glycol, etc.).
    - Waste inks with solvents and heavy metals: Ink sludge containing chromium, lead, or cadmium.
    - Strong alkaline wastes: Ammonium hydroxide and sodium hydroxide.
    - Strong acid wastes: Chromic, hydrochloric, nitric, phosphoric, and sulfuric acids.
    - Cleaning rags contaminated with solvents and inks containing heavy metals.
    - Containers with hazardous residues of solvents, inks, or adhesives if not legally empty.

- **VOCs**
  - Inks: Alcohols, aliphatics, ketones, xylenes.
  - Fountain solutions: IPA.
  - Adhesives: Ammonia, isopropanol, toluene.
  - Cleaning solvents: Acetone, chlorinated solvents, kerosene, methanol, naphtha, and toluene.
- **Contaminated waste water**
  - Rinse from photo processing.
  - Any liquid hazardous waste dumped down the drain.
- **Nonhazardous solid waste**
  - Waste substrates: Paper, plastic, foil, etc. from trimmings, rejects, and excess quantities.
  - Nonhazardous waste inks: Water-based inks without heavy metals.
  - Legally empty containers (no more than one inch of residue for a 55 gallon drum or 3% of the total capacity).
  - Empty cartons, wrappers, and roll cores.

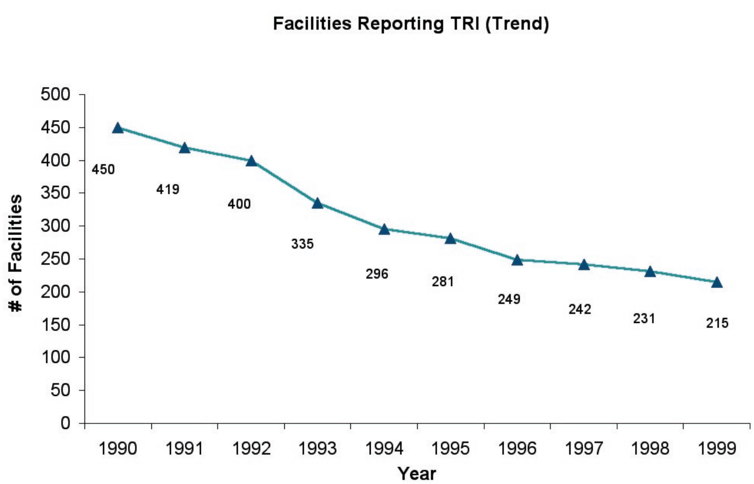


Figure 1: Number of Facilities Reporting TRI Emissions, 1995 to 1999.

Appendix II presents a listing of common chemicals used, wastes generated and disposal practices employed by lithographic printers.

Toxic Chemical Releases

In 1999, according to the TRI (Toxics Release Inventory), 215 printing firms that reported to the EPA (i.e., firms reporting under SIC 27) released almost 21 million pounds of toxic chemicals to the air. This amount represented only 0.3% of the total air releases by all manufacturers (SIC 20-39) that reported under the TRI that year (*TRI Explorer*). The total quantity of toxic chemical waste reported by printing firms was 318 million pounds. This includes chemicals recycled on and off site, chemicals burned for energy recovery on and off site, chemicals treated on and off site, and chemicals released directly to air, water, and land, either on or off site.

As can be seen in Figure 1, the number of reporting facilities has decreased over time, perhaps because of facility closures or possibly because facilities no longer exceeded the reporting threshold quantity of TRI chemicals manufactured, processed, or otherwise used. The number of firms that reported is small compared to the total number of printing facilities in the U.S. As mentioned before, one characteristic of the printing industry is that the majority of facilities are small. As a result, many are not required to report under the Toxics Release Inventory.

As seen in Figure 2, there has been a downward trend, over time, in reported TRI air emissions for the printing industry. Looking at data for the period 1995 to 1999, reported TRI air emissions have dropped from 31 million pounds in 1995 to 21 million pounds in 1999. Over that time period, however, the number of facilities reporting also declined from 281 to 215. Once again, the exact cause of the decline is not apparent from the data, although it is probably closely linked to the lower number of facilities reporting.

In terms of what plants were doing with their captured toxic chemical wastes during this period, the results are more interesting While the majority of this waste was recycled (on average 65 percent), this percentage steadily decreased over time (Figure 3). Meanwhile, the percentage of waste being treated increased. Also somewhat surprising is the small degree to which these chemicals were used for energy generation. This suggests that facilities are actually moving away from value-added disposal practices and that there may be potential cost savings opportunities for many plants through greater recycling and energy recovery.

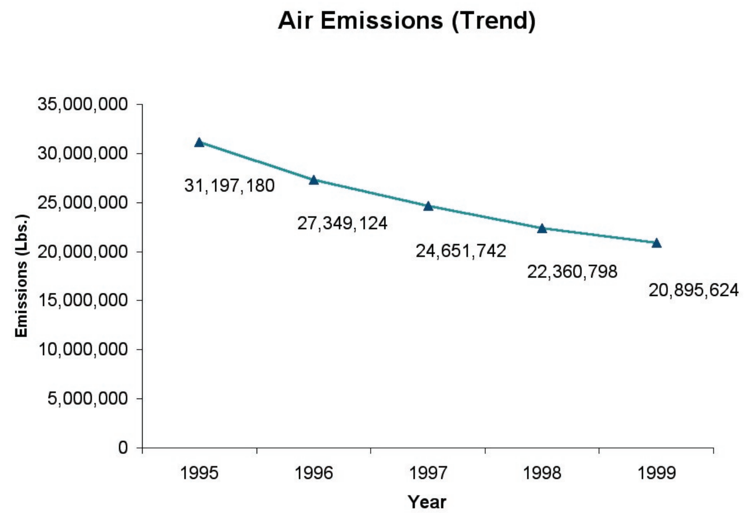


Figure 2: TRI Emissions from 1995 to 1999.

WASTE REDUCTION

Many printers have begun to see the connection between reducing waste and cutting cost. Since the cost of properly managing and disposing of hazardous waste is so high, reductions in the generation of these wastes in particular can represent significant cost savings. Table 1 lists the commercial lithography industry's expenditures on a variety of material inputs for the year 1997. Many firms are working to increase material efficiency in order to reduce their costs for materials and waste disposal.

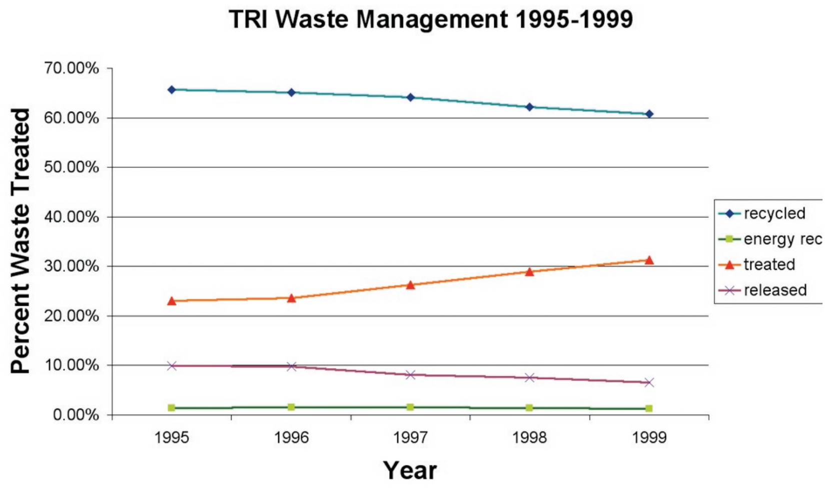


Figure 3: TRI Waste Management Practices from 1995 to 1999.

A great deal of attention within the industry is being paid to energy use. The Graphic Arts Information Network (GAIN) found that, although energy costs usually make up only 2 percent of the total costs for the industry, they are having an impact on firm behavior (Davis and Kodey). Energy and other utility costs increased by an average of 16 percent for all North American printers in the year 2000, with particularly steep increases for printers in the western part of the country. Of those that answered the GAIN questionnaire, one sixth of the respondents reported that energy price increases had a "significant negative impact on the bottom line." Moreover, nine percent of the respondents reported that energy/utility costs were a "significant" issue for their firm. Overall, printers are paying greater attention to material and energy efficiency as a way to reduce costs and improve environmental performance. This puts them in line with a growing movement among industry, termed "eco-efficiency," which is the efficient use of resources. Companies that adhere to the philosophy of eco-efficiency see it as both smart business and environmental management strategy.

VOC REDUCTION IN LITHOGRAPHY THROUGH PROCESS CHANGE

There are two general means by which firms can reduce VOC emissions. The first path is through the use of abatement equipment, which in essence “burns” the emissions as they leave the plant. This approach, although effective, is also costly. In 1994, for example, the printing and publishing industry (firms over 20 employees) reported spending $45.3 million on air abatement capital equipment (United States Census Bureau, *Current Industrial Reports*). The majority of these costs were borne by the commercial lithography industry — over $39.9 million.

Table 1: Materials Consumed by Commercial Lithographers 1997
(United States Census Bureau, *1997 Economic Census*)

Resource	Delivered Cost ($1,000)
Newsprint	1,218,520
Uncoated paper in sheets	1,142,820
Uncoated paper in rolls	2,075,071
Coated paper in sheets	1,867,288
Coated paper in rolls	2,247,303
Pressure-sensitive base stock, self-adhesive, including paper, film, foil, etc.	173,999
Cloth and nonwoven fabrics for hardbound book covers	32,135
Glues and adhesives	40,567
Printing ink	1,004,209
Light-sensitive films and papers	226,323
Unexposed photosensitive printing plates	154,106
Printing plates, prepared for printing	187,253
Engraved printing cylinders for gravure printing	2,241
Paperboard containers, boxes, and corrugated paper-board	151,982
Purchased envelopes	213,641
All other materials and components, parts, containers, and supplies	1,136,750
Materials, ingredients, containers, and supplies, n.s.k.	4,786,970

Typically, a more cost-effective and efficient way to reduce VOCs is through preventing pollution. Pollution prevention (P2) is defined as "the elimination or reduction in volume or toxicity of waste prior to generation or prior to recycling, treatment or release to the environment" (New York State Department of Environmental Conservation). Other choices to reduce pollution such as recycling, treatment, or recovery of waste are considered less optimal from an environmental standpoint, because they do not eliminate adverse impacts associated with manufacturing of the chemicals and with handling and treatment.

The following sections summarize a number of pollution-prevention process changes in the press stage of the printing process that can reduce emissions of VOCs. Essentially, all the alternatives can be classified into one of the following categories: raw material changes, technology changes, or improved operating practices. It is acknowledged that printing is a complex process of many interacting elements. Therefore, a change in one element usually requires adjustment to others. In other words, a change in raw material might require a change of technology and vice versa. We acknowledge that these "effects" are not adequately addressed here.

Ink

Ink is an indispensable part of the printing process. However, ink can be problematic from an environmental standpoint for two reasons. First, printing inks might contain hazardous materials such as metals used for coloring and solvents used to accelerate the drying process. Second, since many inks are alcohol- or petroleum-based, they emit VOCs (MacFadden and Vogel). Petroleum-based inks typically contain 30 to 35 percent VOCs (Carstensen and Morris). To counteract these effects, ink manufacturers have introduced low-VOC inks and other inks that are less taxing on the environment. A summary of ink options is contained in Appendix III. Examples include:

- **Ultraviolet (UV) curable ink**
  Solvent-based inks dry through evaporation of solvents in the ink. In contrast, UV curable inks dry by curing through ultraviolet light-induced polymerization (*Pollution Prevention in the Printing Industry*). Some of the benefits of these inks are: a decrease in or elimination of VOC emissions, improvement in productivity through shorter drying time, and a reduction of the amount of cleaning solvents used, since UV curable ink does not dry on the press and in the ink fountains. There are disadvantages as well: a high capital investment is required to change to ultraviolet curable ink, ink cannot be used on all substrates, and ink costs can be twice that of conventional inks (Clement and Kramer).

- **Electron-beam curable ink (EBC)**
  Essentially, this ink is similar in nature to UV curable ink, however, rather than ultraviolet light, electron beams are used for drying. The benefits are almost the same, but initial costs are higher. The capital investment for an EBC system is within a range of one to five million dollars. The advantages are similar to those of UV curable inks.

- **Vegetable-oil-based ink**
  This type of ink is well known to lithographic commercial printers. It can be used in either heatset or nonheatset web presses and also in sheet-fed presses. The use of vegetable-oil-based ink generally does not require equipment changes (Massachusetts Toxics Use Reduction Institute). The most commonly used vegetable-oil-based ink is soybean-based ink. This ink can have as much as 80 percent less VOC content than petroleum-based inks (*Pollution Prevention in the Printing Industry*). Another advantage is that water/detergent type press washes can be used and, as a result, the use of high-VOC solvent-based cleaners can be reduced. Nevertheless, there are some issues that limit the adoption of soybean oil ink. First, its price is higher than that of conventional ink. Second, its drying time is longer than that of conventional petroleum-based inks. Third, operator re-training is required to achieve the same quality standards.

- **Water-based ink**
  Water-based ink is typically composed of pigmented suspensions in water along with film-forming chemicals (Massachusetts Toxics Use Reduction Institute). The best application for water-based ink is flexographic, gravure printing, and textile screen operations. The main advantages of this ink are that it is often classified as nonhazardous, and no special air pollution control equipment is required for emissions. Disposal costs are often reduced, and these inks are less toxic to employees. Nevertheless, the ink has some technical limitations, such as limited color choice, less transfer efficiency of ink to the substrate, and longer drying time, which results in a press speed reduction. Because there are no solvents that evaporate to help dry the inks, water-based inks must be heatset and dried in various types of ovens. Generally, water-based ink systems are run through gas-fired re-circulating air ovens. When presses have limited space available for expansion or modification, the ability to dry the inks has a definite bearing on the press output. Furthermore, the use of the ink demands basic chemistry training for operators.

- **Waterless inks**
  Waterless inks are high-viscosity inks that require high initial capital investment and strict monitoring during the printing process. To implement waterless ink, special lithographic presses, plates, exposure methods, and plate-handling techniques are needed (*Pollution Prevention in the Printing Industry*). From an environmental standpoint, the significant advantage of waterless ink technology is that the damping system is eliminated, which eliminates the use of isopropyl alcohol (IPA) (Clement and Kramer).

Other alternative processes that reduce VOC emissions from inks are the result of improved process operations or technology changes, rather than raw-material changes. They include:

- Avoiding ink evaporation by keeping ink containers closed.

- Scheduling printing jobs using a standard ink sequence from light to dark.

- Reducing ink vaporization by using diaphragm pumps, which heat ink less than mechanical vane pumps (*Pollution Prevention and Best Management*).

- Using ink-viscosity measuring systems to prevent excessive use of solvent (*Pollution Prevention in the Printing Industry*).

- Using automatic registration systems to reduce the time needed to approve the start of a production run, thereby reducing ink consumption.

Fountain Solutions or Damping Systems

On lithographic presses, the damping system applies a water-based dampening solution to the printing plate before it is inked (MacFadden and Vogel). The objective is to prevent ink from adhering to the non-image areas of the plate. One of the most commonly used fountain solutions is IPA. Though IPA is very efficient in lithographic presses, it negatively affects the environment and worker health. First, IPA is a VOC that has prompted many environmental regulations. Second, IPA vapors are a respiratory irritant. Finally, the low flash point (53° F) makes IPA a flammable chemical that has to be handled and stored with tremendous caution (DeJidas). As a result of all these drawbacks, at least 15 states and local air pollution control agencies have established regulatory limits on the concentration of IPA in fountain solutions. For example, the limit is 3 percent by weight for new sheet-fed presses in Los Angeles and 8.5 percent by weight for presses in Maryland (DeJidas).

VOC emissions from the damping system can be reduced or eliminated either by reducing the isopropyl concentration or eliminating the use of IPA in the fountain solution with alcohol substitutes. Substitutes can reduce VOC emissions by 90 percent (Clement and Kramer). However, any change in the fountain solution might require changes in the printing press, depending on the interaction of the alcohol substitute with the specific press, the ink roller, the substrate, the damping system, and the blanket wash and ink (Colorado Department of Public Health & Environment). Alcohol substitutes on the market consist of glycols, glycol-ethers, and additives. The alternatives are classified as either one- or two-step processes. One-step fountain solutions concentrate an alcohol substitute in water. Two-step fountain solutions combine the damping solution concentrate with a separate alcohol substitute, water, and wetting agents.

Another alternative to reduce VOC emissions from the damping system is to refrigerate the fountain solution to retard the evaporation process. Isopropyl consumption can be reduced by up to 44 percent using this method. Refrigeration of fountain solutions requires the installation of a reservoir and a recirculation system. In addition to reducing VOC emissions, refrigerating fountain solutions may also improve overall print quality. Fluctuating fountain solution temperatures directly affects the solution's viscosity. Variations in viscosity vary the amount of water delivered to the plate, which alters the press ink/water balance (Clement and Kramer).

Cleaning Solvents

Cleaning solvents are used to clean printing equipment and the blankets that transfer the ink-filled image to the substrate. Many of the cleaning solvents used are petroleum-based and include toluene, xylene, methanol, MEK, glycol ethers, and 1,1,1-trichloroethane (TCA). These chemicals have high VOC content (60%) and high vapor pressure (Carstensen and Morris). Without doubt, they are effective cleaning agents.

Alternatives to these traditional cleaning solvents are available and include:

- **Water-miscible cleaning solvents**
  Water-miscible solvents contain water as a partial substitute for solvents. These solvents can reduce VOC emissions from this process by 20 to 50 percent (Clement and Kramer).

- **Vegetable-oil-based blanket washes**
  These washes do not contain petrochemical solvents and have an average of 5 percent VOCs (*CTSA*). Though using vegetable-oil-based washes reduces the amount of VOC, three performance issues limit their positive impact. First, compared to petroleum-based washes, extra effort is required to achieve the same level of cleanliness. Second, vegetable-oil-based washes leave an oily film that has to be removed (Carstensen and Morris). Third, they take more time to dry, resulting in longer downtimes when switching jobs.

- **Terpene cleaners**
  Wood and citrus products are used to produce terpene cleaners. In a comparative study of blanket washes, printers found that terpene cleaners cut the ink well but left an oily residue that required more prints to return to print quality. The thick consistency prevented the wash from adequately soaking into towels, resulting in greater effort to clean the blankets (*CTSA*).

Another approach to reducing emissions from the blanket-washing process is to switch from manual to automatic blanket washers. Automatic blanket washers clean the rubber blankets while the printing press is running, with little or no participation from operators. Though the technology is becoming a standard feature for large printers, the technology change requires a high initial capital investment, and operators have to be trained to operate the new equipment. Automatic blanket washers use one of the following three methods: cloth, spray, or brush. The price for an automatic blanket wash system using the spray method ranges from $3,000 to $11,000 (Clement and Kramer). The cloth- or brush-based systems cost between $7,000 and $22,000 (*CTSA*). Automatic systems require less cleaning solvent overall, and some systems can be used with low-VOC solvents. The use of this technology reduces operator exposure to potentially harmful solvents and moving press cylinders.

VOC emissions from cleaning can also be reduced by changing operating practices. Some examples are cited below:

- Train operators to use only the amount of cleaning solvent required for the task at hand. Develop a cleaning procedure or chart that recommends a certain quantity of cleaning solvent to be used based on characteristics of the production run (time, colors, substrate, etc.).

- Utilize proper solvent dispensers or squeeze bottles to prevent overuse of solvents. Discourage the common practice of completely submerging a shop towel in cleaning solvent (Clement and Kramer).

- All receptacles containing cleaning solvents should be closed properly to reduce the chance of evaporation.

- If possible, schedule sequential runs from light to dark ink, and dedicate presses to specific colors to reduce the frequency of cleaning operations and the use of cleaning solvents.

REGULATORY REFORM AND TECHNICAL ASSISTANCE EFFORTS

There are a number of government and industry programs intended to help printers reduce their environmental impact in the most efficient and effective way possible. Descriptions of these programs follow.

EPA Common Sense Initiative (CSI)

The CSI was an approach to environmental protection developed by the EPA to look at environmental issues from the industry perspective rather than from the more traditional single medium (i.e., water, air, land) perspective. The printing section of the CSI started in January 1995. The project works through a number of subcommittees.

One outcome of the CSI is a project called PrintSTEP (Printers' Simplified Total Environmental Partnership), which is geared toward developing flexible permitting systems that lead to reduced emissions. The program incorporates multi-media oversight, emphasis on pollution prevention, increased public involvement, simpler language, and a streamlined permitting process. Three states are currently involved in implementing pilot PrintSTEP programs: Minnesota, New Hampshire, and Missouri. These programs will be evaluated by the EPA to assess their effectiveness.

At its final meeting in 1998, participants of the CSI reflected on the experience. Improved working relationships among stakeholders, many of whom had interacted only as adversaries in the past, was consistently noted as one of the CSI's most important achievements. Though the EPA did provide technical assistance to those stakeholders who needed support, many groups felt that more sharing of technical information and expertise would have improved participants' understanding of key issues and facilitated progress.[3]

EPA Design for Environment (DfE) Program

The DfE Lithography Project, initiated in 1992, is a voluntary cooperative effort between the lithographic printing industry and the U.S. EPA that evaluates and provides information to industry and the public about environmentally sound technologies (*Fact Sheet*). For the project entitled "Cleaner Technologies Substitutes Assessment (CTSA): Lithographic Blanket Washes," project participants conducted tests on 38 low- or non-VOC blanket-wash substitutes, both in laboratories and at 18 printing shops. Environmental performance and cost data for these alternatives were analyzed and reported in a number of technical reports and case studies. All printed materials are available on the EPA's web site (http://www.epa.gov/dfe/projects/litho/index.htm).

Graphic Arts Technical Foundation (GATF)

The Graphic Arts Technical Foundation is a member-supported, nonprofit, technical, and education organization serving the international graphic communications industries. Its mission statement is "to serve the graphic communications community as the leading resource for technical information and services through research and education."[4] Started in 1924 as the Lithographic Technical Foundation, it is the oldest continuous organization of its kind in graphic communications.

GATF has five principal areas of service to the industry: research, training, consulting, process controls, and publications.

In conjunction with the Printing Industries of America (PIA)[5], GATF offers printers assistance with environmental, safety, and health affairs through research, training, and compliance reviews. GATF is considered an important source of technical support for the industry in the areas of environmental, health, and safety compliance; their involvement in these issues dates back to the late 1960s when they performed research on solvent use in the printing industry. The foundation has been active in negotiating industry-wide compliance requirements at the federal, state, and local levels, and conducting research on the effects of various printing processes on the environment and employees. GATF participated as a partner in the EPA's DfE Lithography Project and in the EPA's printing sector CSI effort. Each year, GATF staff responds to more than 1,300 technical inquiries from its EPA and OSHA hotline on a variety of topics including safety and health concerns.

Great Printers Project

The lithographic printing industry in the Great Lakes States accounts for 340,000 jobs and $35 billion in sales each year. It is a key contributor to the region's economy and comprises one-third of the nation's lithographic printing industry.[6] In 1993, the Council of Great Lakes Governors, the Environmental Defense Fund and the Printing Industries of America formed a team, along with Great Lakes regulatory agencies, state and federal technical assistance providers, printers, suppliers, customers, and members of labor and environmental groups. This team reviewed regulations and permit and reporting requirements for all environmental media to identify barriers and possible incentives to pollution prevention and general environmental protection in the printing industry. They made recommendations for needed technical, financial, and regulatory assistance and how best to provide it. The team released a report in July 1994 titled, "The Great Printers Project Recommendations to Make Pollution Prevention a Standard Practice in the Printing Industry."

In 1994, the initial 37-member project team signed a commitment to making pollution prevention the primary choice of the Great Lakes states' lithographic printing industry in meeting and exceeding its environmental and human health protection responsibilities and to recasting the current approach to environmental policy. They recommended the following specific actions [7]:

- "Printers should voluntarily adopt the Great Printing Principles which include: complying with applicable environmental, health, and safety laws; going beyond compliance; and seeking continuous environmental improvement.
- "Print buyers should work with printers to reduce the environmental and worker health impacts of their printing requests.
- "Print suppliers/distributors should work with printers to identify and sell environmentally superior chemicals and equipment that can produce high-quality jobs.
- "Regulators should create a pollution prevention friendly regulatory framework that better communicates environmental and worker health goals and consolidates all requirements into an easy-to-use information and reporting system.
- "Technical and financial assistance programs should provide printers with easy access to industry-specific technical and financial assistance."

To date, the project has launched four state pilot partnerships of printers, environmental groups, state regulatory agencies and technical assistance providers in Illinois, Michigan, Minnesota, and Wisconsin. They have created enrollment programs to educate printers about the project and to acknowledge and support printers who commit to adopt the Great Printing Principles. They developed a model simplified reporting system that helps printers easily understand their compliance status and how to prevent pollution. Lastly, they established the Printers National Environmental Assistance Center, described below.

Printers National Environmental Assistance Program (PNEAC)

PNEAC is a partnership of the GATF, Waste Management and Research Center, PIA, Solid and Hazardous Waste Education Center, and the EPA. PNEAC is a major source of information on developments in environmental regulation, environmental compliance, pollution prevention, and new technologies. PNEAC's Web site offers updates on legislative and regulatory issues, highlights of environmentally successful companies, case studies on pollution prevention, and information on emerging technologies. The organization also manages two list-serves. PRINTECH is focused on the technical aspects of environmental compliance issues faced by printers. PRINTREG is focused on the development, application, and interpretation of environmental regulations affecting printers.

NEWMOAs Pollution Prevention Information Dissemination Printing Project (P2Print)

Funded under the EPA's STAR program from 1995 to 2000, the P2Print project explored the use of electronic media to disseminate pollution prevention information for printers in the Northeast.[8] Three products came from this project, a CD-ROM system that enabled lithographic printers to ask questions and locate pollution prevention and regulatory information; an e-mail forum for printing companies, technical experts, and others; and a source of pollution prevention information that technical assistance programs could use to help printers. The CD-ROM was distributed through trade associations. Interestingly, the list-serve was not successful, because many printers did not have access to or regularly use e-mail. Therefore, the list-serve was discontinued in 1999.

CASE STUDIES

A total of 15 cases focusing on reducing VOCs in lithography were reviewed in order to better understand the issues and trends in VOC reduction. A summary of the cases can be found in Appendix IV. The majority of the cases involved a change in technology (eight instances), raw materials (five instances), or both (nine instances). Only one of the improvements related to operational efficiency.

There were a number of motivations for implementing environmentally superior technologies and processes. As can be seen in Figure 4, while a commitment to environmental performance was a motivation for a few of the plants, the most common motivators were health and safety concerns and government regulation (this included meeting new standards and adjusting to current standards as production increased). Other, less frequent, motivations included environmental concern expressed by customers, public recognition or improvement of their business image, and reduction in wastes and their associated costs. Many of the projects achieved lower VOC emissions and an improved work environment. Often, however, there were other positive side effects, such as improved product quality, reduced costs, increased productivity, development of new markets, reduced materials use, and recognition through environmental excellence awards. In a minority of the cases, companies were able to obtain a patent on the new technology or raw material.

The cases also illustrate the importance of access to technical information for improving environmental performance. At any given time, printing companies rarely were aware of all the environmental solutions that existed in the market. Therefore, companies relied to a great degree on a variety of partners to discover, test, and implement new technologies. Often, it was the supplier that had developed a new technology or material. In fact, 31 percent of these printers recognized the approach and active participation of vendors or suppliers. Sometimes, both suppliers and printing companies worked together to develop the solution. Although many of the cases were written by government-supported assistance programs, only one company recognized the role of government assistance or technical guidance for implementing a VOC reduction solution.

A number of obstacles to implementation factored across several cases. One of the most prevalent challenges was to prove that changes in technology or raw materials provide the same quality. In some cases, quality issues such as customer complaints and poor ink adhesion to primary substrates delayed the final implementation of a project. In addition, new solutions were rarely free of environmental concern. New materials often required plants to consider compliance issues under other environmental regulations, as they transferred contamination to other media or raised different environmental concerns. Of course, cost was always a factor. Experimenting with new technologies meant lost production time, there were often new training requirements, and the cost of the new materials themselves could be higher.

Two major factors seemed to help plants overcome these obstacles and assist in the adoption of new technologies and materials. First, employee participation in planning and implementing the program, as well as employee education, led to a smoother and quicker implementation period. Second, it was important that plants had outside help in rapidly identifying new technologies, such as close relationships with suppliers and vendors.

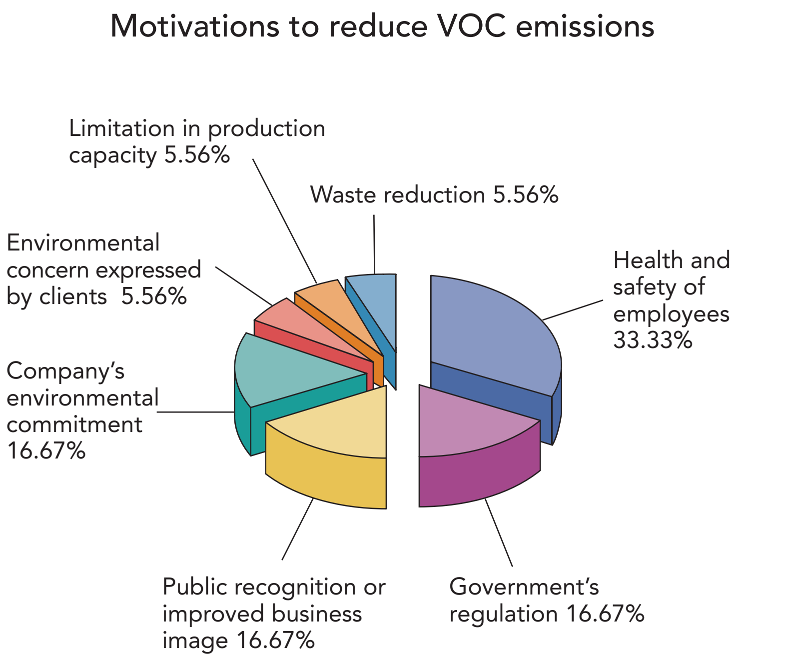


Figure 4: Motivations to Reduce VOC Emissions in Case Studies

Conclusion

Clearly, lithographic printers are operating in an environment of numerous, ever-changing, and sometimes confusing regulations that impact many aspects of their operations. In particular, rules that govern emissions of VOCs remain a constant challenge. Traditionally, the industry has addressed VOCs and other emissions by means of waste treatment and pollution control. Industry-wide expenditures of tens of millions of dollars annually in pollution control equipment are a testament to the economic cost of complying with these requirements. More recently, however, alternative process technologies have become available that eliminate these pollutants at the source and obviate the need for pollution control.

The case studies presented here provide evidence of the commercial viability of these alternative process technologies for VOC reduction and lessons learned by those companies that have implemented them. Much can be learned from these and other case studies about the promises and pitfalls of these methods. In principle, the firms highlighted in the case studies could serve as mentors to those companies that are just beginning to go down the same path, or they could serve as showcases for technical assistance programs or technology suppliers.

The cases also highlight the fact that technology changes for environmental improvement are often not as “clean” as would be hoped. Sometimes, for example, a switch from a VOC-emitting material leads to the use of a chemical that has adverse health impacts. By reducing one type of impact, another may be created. Furthermore, reducing one regulatory burden may cause another to arise. Firms need to carefully negotiate these trade-offs.

Fortunately, the last decade marks an era of increasing opportunity for regulatory and technical assistance for the industry. There has been a proliferation of programs sponsored by industry/government partnerships that provide a range of services, often free of charge. Regulatory agencies have begun to seek ways to streamline the regulatory process, which, in theory, should reduce the regulatory burden on firms and clear the way for more economically efficient means of achieving emissions reductions. While anecdotal evidence of the success of these programs exists, there has yet to be systematic research on their effectiveness, especially in light of other managerial and technological forces that are continually shaping the industry.

Works Cited

Carstensen, Michelle, and David Morris. *Biochemicals for the Printing Industry*. Minneapolis: Institute for Local Self-Reliance, The Carbohydrate Economy, 1997.

Clean Water Act: A Brief History. United States Environmental Protection Agency. 20 Apr. 2002 <http://www.epa.gov>.

Clement, Sally, and Larry Kramer. *Final Report: Pollution Prevention Technology Transfer for the Printing Industry: Improve Efficiency and Reduce Waste through Process Control in the Lithographic Printing Industry*. Cincinnati: Institute of Advanced Manufacturing Sciences Inc., Printing Industries Association of Southern Ohio & US EPA, [c. 1998].

Colorado Department of Public Health & Environment. *Pollution Prevention Ideas for the Printing and Allied Industry Sectors*. Colorado: November 2001.

CTSA: Lithographic Blanket Washes - Contents. EPA 744-R-97-006. Sept. 1997. U.S. Environmental Protection Agency, Design for the Environment Program. 12 Sept. 2002 <http://www.epa.gov/dfe/pubs/lithography/ctsa/contents.html>.

Davis, Ron and Steve Kodey. "First Quarter Survey: Print Markets Slowdown." *Graphic Arts Information Network: Quarterly Market Surveys Archive* (2001). 12 Sept. 2002 <http://www.gain.org/ECON/Q12001.pdf>.

DeJidas, Lloyd P. "Alcohol-Free Printing." *GATFWorld: SecondSight*. 1999: SS Number 74.

Emergency Planning and Community Right-to-Know Act. Aug. 2002. United States Environmental Protection Agency, Region 8 – Toxics and Pesticides. 12 Sept. 2002 <http://www.epa.gov/Region08/toxics_pesticides/epcra/epcra.html>.

Fact Sheet: Blanket Wash Solutions for Small Printers. EPA 744-F-95-008. Jul. 1995. United States Environmental Protection Agency, Design for the Environment Program. 12 Sept. 2002 <http://www.epa.gov/dfe/pubs/lithography/factsheet/index.htm>.

Jacobson, Debra. *What Are VOCs and Do Printing-Related Materials Contain Them?* 2001. Printer's National Environmental Assistance Center. 10 Feb. 2002 <http://www.pneac.org/Sheets/all/vocs.html>.

MacFadden, Todd and Michael P. Vogel. *Fountain Solution Solutions*. June 1996. Printer's National Environmental Assistance Center. 12 Sept. 2002 <http://www.pneac.org/Sheets/litho/fountain.html>.

Massachusetts Toxics Use Reduction Institute. *Technical Fact Sheet 6: Alternatives to Petroleum and Solvent-Based Inks*. Lowell, MA: TURI, 1994.

New York State Department of Environmental Conservation Pollution Prevention Unit. *Environmental Compliance and Pollution Prevention Guide for Lithographic Printers*. Albany, NY: NYS Dept. of Environmental Conservation Pollution Prevention Unit, 1997.

Office of the Federal Register. “Rules and Regulations.” *Federal Register.* 61.105 (30 May 1996): 27131-27159.

Pollution Prevention and Best Management Practices for Lithographic Printers Operating in Broward County. Broward County (Florida) Department of Planning and Environmental Protection, Pollution Prevention and Remediation Division. 12 Sept. 2002 <http://www.co.broward.fl.us/ppi02700.htm>.

Pollution Prevention in the Printing Industry - A Manual for Pollution Prevention Technical Assistance Providers. North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention and Environmental Assistance. 12 Sept. 2002 <http://www.p2pays.org/ref/03/02453/index.htm>.

Profile of the Printing and Publishing Industry. EPA 30-R-95-014. Aug. 1995. United States Environmental Protection Agency, Office of Compliance and Enforcement, Sector Notebook Project. 7 Dec. 2002 <http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/printing.html>.

Resource Conservation and Recovery Act of 1976. United States Environmental Protection Agency. 20 Apr. 2002 <http://www.epa.gov/region5defs/html/rcra.html>.

TRI Explorer. United States Environmental Protection Agency. 12 Sept. 2002 <http://www.epa.gov/triexplorer/chemical.htm>.

United States Census Bureau. *1997 Economic Census*. Washington: GPO, 2001.

---. *Current Industrial Reports: Pollution Abatement Costs and Expenditures: 1994*. Report MA200(94)-1. Washington: GPO, May 1996.

United States Environmental Protection Agency, Office of Pollution Prevention and Toxics. *Federal Environmental Regulations Potentially Affecting the Commercial Printing Industry*. EPA 744B-94-001. Washington: GPO, Mar. 1994.

Endnotes

[1] 1997 estimates. U.S. Census Bureau, http://www.census.gov.

[2] The Printers' National Environmental Assistance Center (PNEAC) has prepared a helpful summary of the implications of the changes to the TRI for printers. See "Persistent, Bioaccumulative, and Toxic Chemicals, A Printer's Roadmap," at http://www.pneac.org/sheets/all/PBTprintersroadmap.pdf.

[3] http://www.epa.gov/ooaujeag/csi/CSInews.html

[4] http://www.gain.org/servlet/gateway/PIA_GATF/about_join/aboutgatf.html

[5] Printing Industries of America, Inc. (PIA), is a graphic arts trade association representing more than 13,000 member companies through its core functions of government affairs; management information, education, and research; and workforce development and career awareness.

[6] http://www.cbemw.org/wisc/Printers.html#intro

[7] http://www.cglg.org/projects/printers/

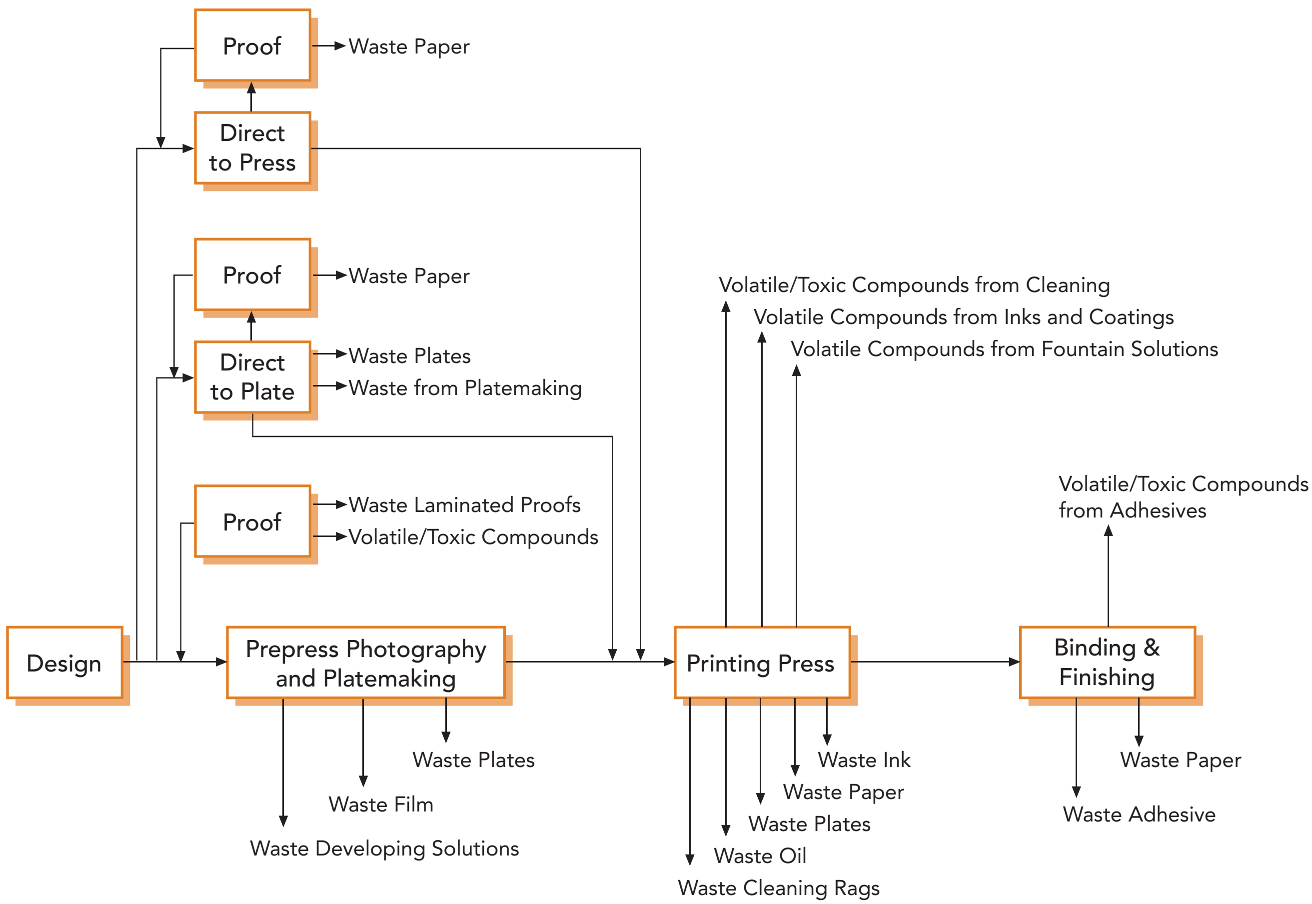
[8] United States EPA, Final Report: Pollution Prevention Information Dissemination Printing Project, http://es.epa.gov/neer/final/grants/95/incentive/goldberg.html

[9] Source: Alternatives to Petroleum- and Solvent-Based Inks, TURI Fact Sheet 6. "Printing Inks" 0.92 P*NEAC: Fact Sheets and Case Studies: Lithographic Printing: Printing Inks.* http://www.pneac.org/Sheets/litho/inks.html.

[10] Source: *Pollution Prevention and Best Management Practices for Lithographic Printers Operating in Broward County.* http://www.co.broward.fl.us/ppi02700.htm.

[11] Source: North Carolina Department of Environment and Natural Resources. "Pollution Prevention in the Printing Industry - A Manual for Pollution Prevention Technical Assistance Providers" http://www.p2pays.org/

Appendix I: Typical Lithographic Printing Process and Principal Releases to the Environment



Source: North Carolina Department of Environment and Natural Resources. "Pollution Prevention in the Printing Industry - A Manual for Pollution Prevention Technical Assistance Providers" http://www.p2pays.org/

Appendix II: Common Chemicals Used, Waste Generated And Disposal Practices Lithographic Printers [1]

IMAGE PROCESSING:

PRODUCT	COMMON CHEMICAL USED	WASTE GENERATED	DISPOSAL PRACTICES*
- Film/glass cleaner	- Acetone, hexane, ethanol, propanol, 2-butoxy ethanol, perchoroethylene.	- VOCs.	- Atmospheric emissions. May require Air permit
- Equipment cleaner	- Isopropanol, hexane, acetone.	- Waste solvents.	- Hazardous waste licensed haulers.
- Film developer solution with accelerator, restainer, preservative	- Hydroquinone, pyrogallol, methol, sodium sulfite, butyl-diethanolamine, potassium hydroxide, borax, potassium bromide.	- Empty photoprocessing chemical containers.	- Recycled or discarded with municipal waste if empty.
- Film fixing solution buffer	- Ammonium thiosulfate, aluminum sulfate, sodium acetate, acetic boric acid	- Waste water containing developers, fixers with silver, intensifiers, reducers, rinse water. - Out-dated materials.	- Discharged to sewer with POTW approval. May require pretreatment prior to discharge. Never discharge to septic tank. Fixer solutions may be recycled on/off site (silver recovery). - Licensed hauler or return to vendors.
Proofing		Waste film and paper	- Discarded with municipal waste. Film may be recycled for its silver content.

[1] Source: *Pollution Prevention and Best Management Practices for Lithographic Printers Operating in Broward County.* (http://www.co.broward.fl.us/ppi02700.htm).

PLATE MAKING:

PRODUCT	COMMON CHEMICAL USED	WASTE GENERATED	DISPOSAL PRACTICES*
- Plate developer	- Benzyl alcohol, dietanolamine, polyvinyl alcohol, ethylene glycol, acetic acid.	- VOCs.	- Atmospheric emissions. May require control.
- Plate finisher/replenisher	- Dextrin, mineral spirit, sodium hydroxide N-methylpyrrolidone, sodium sulfite.	- Waste acids and alkali.	- Hazardous waste licensed haulers.
- Image preserver	- Stoddard solvent, phosphoric acid.	- Empty plate chemicals containers.	- Recycled or discarded with municipal waste if legally empty.
- Color proofing	- N-propanol.	- Wastewater containing acids, alkali, developer, finisher, rinse water with chromium and cyanides.	- Discharged to sewer with POTW approval. May require pretreatment and/or silver recovery prior to discharge.
- Bleaches	- Sodium dichromate, sodium ferricyanide, sodium ferrocyanide.	- Out-dated materials.	- Hazardous licensed hauler or return to vendors.
- Etching solutions	- Organic solvents, metal salts, acids.	- Damaged plates.	- Discarded with municipal waste. Aluminum plates may be recycled.

MAKE READY AND PRINTING:

PRODUCT	COMMON CHEMICAL USED	WASTE GENERATED	DISPOSAL PRACTICES*
- Ink, varnish	- Petroleum distillates, resins, pigments (lead, cadmium, cobalt, chromium, copper)	- VOCs from inks and fountain solutions. - Waste ink. May contain heavy metals.	- Atmospheric emissions. May require control (destruction or capture before release). - Discarded with municipal waste after drying. May require disposal as hazardous waste.
- Fountain solution	- Isopropanol, 2-butoxy ethanol, gum arabic, ethylene glycol, phosphoric acid, defoamers, fungicides.	- Spent fountain solution. May contain chromium. - Empty ink containers. - Used blankets, used plates, damaged plates. - Waste paper (overruns, unacceptable prints, etc.). - Lubricating oils.	- Discharged to sewer with POTW approval. May require pretreatment prior to discharge. - Recycled, refilled by the supplier or discarded with municipal waste if legally empty. - Discarded with municipal waste. Aluminum plates may be recycled. - Recycled or discarded with municipal waste. - Waste oil licensed haulers for recycling.

PRESS CLEANING:

PRODUCT	COMMON CHEMICAL USED	WASTE GENERATED	DISPOSAL PRACTICES*
- Wash solvent/plate cleaner	- Aliphatic and aromatic hydrocarbons, ethanol, mineral spirits, acetone, xylene, toluene, ethyl benzene methylene chloride.	- VOCs.	- Atmospheric emissions. May require control.
- Glaze remover	- Toluene, methanol, acetone.	- Soiled cloth-cleaning rags contaminated with ink pigments, solvents. - Spent solvent recovered from cleaning rags.	- Laundered off-site by industrial laundries. Disposable rags used to absorb inks containing hazardous components and/or solvents require disposal as hazardous waste. - Recycled on- or off-site, reused or disposed as hazardous waste through a licensed hauler.

FINISHING:

PRODUCT	COMMON CHEMICAL USED	WASTE GENERATED	DISPOSAL PRACTICES*
- Glue, adhesive	- Paraffin wax, isopropanol, toluene, ammonia, amines.	- Scrap paper.	- Recycled or discarded with municipal waste.
- Bronzing powder	- Copper, zinc, stearic acid.	- Waste glue, adhesives and lacquer.	- Recycled on- or off-site. May be shipped off- site for use in a fuel program.

*These methods may or may not be in compliance with regulations applicable to your facility. You are responsible for evaluating your waste streams to determine their regulatory status

Appendix III: Summary of Product Substitution Alternatives to Solvent-Based Inks[1]

Alternative	Applications	P2 Benefits	Operational Advantages	Disadvantages	Cost	Product Quality	Limitations
Vegetable-Oil Heatset Inks	Lithographic web presses	Reduced VOC emissions and worker exposure to petroleum oils	Less ink build-up; greater stability; increased flexibility	Slower drying time; poor drying can result in set-off, marking, and poor rub resistance	No capital cost; ink cost can be 5% to 8% higher	Similar quality	Heatset requirements limit replacement of petroleum oils; ink dryer contributes to VOC emissions; ink waste may still be hazardous
Vegetable-Oil Nonheatset Inks	Lithographic nonheatset web and sheet-fed presses	Reduced VOC emissions and worker exposure to petroleum oils	Can provide better print quality, brighter colors, better pickup and transfer	Slower drying time	No capital cost; ink cost slightly higher	Similar quality; brighter colors and improved clarity	Usually some petroleum oils; ink waste may still be hazardous
Vegetable-Oil Newspaper Inks	Lithographic web presses	Reduced VOC emissions and worker exposure to petroleum oils; 100% replacement of petroleum oils possible	Better color reproduction; and control; less rub-off; less tendency to build up or skin over; greater stability; smoother flow; better coverage; greater ink-water balance permits greater flexibility	Usually slower drying time	No capital cost; higher ink cost may be offset by reduced newsprint spoilage	Higher-quality color printing; similar-quality black printing	May contain some petroleum oils; ink waste may still be hazardous
Vegetable-Oil Form Inks	Lithographic nonheatset web presses	Reduced VOC emissions and worker exposure to petroleum oils	Smoother flow; better coverage	Slower drying time	Slightly higher ink cost	Higher-quality color printing	May contain petroleum oils; ink waste may still be hazardous
UV Curable Inks	Lithographic web and sheet-fed presses	No ink-derived VOC emissions or worker exposure to petroleum oil; reduced process waste	No ink drying on press reduces frequency of press cleaning; rapid curing; no set-off; no need for ventilation of printed sheets		Capital equipment cost; high ink cost; lower energy use than thermal drying; increased productivity	Good gloss and durability; print quality may be less clear; possible adhesion problems on some materials (aluminum, steel, some plastic)	Workers must be protected from UV light; some toxic chemicals in inks; may cause skin sensitivity; ventilation needed to reduce ozone buildup; paper difficult to recycle
EBC Inks	Lithographic web and sheet-fed presses	No ink-derived VOC emissions or worker exposure to petroleum oil; reduced process waste	No ink drying on press reduces frequency of press cleaning; rapid curing; no set-off; no need for ventilation of printed sheets		Capital cost; considerably higher ink cost	Print quality less clear	Workers must be protected from EB light; some toxic chemicals in inks; may cause skin sensitivity; often degrade paper; paper difficult to recycle
Water-Based Inks	Flexographic and gravure presses	Few or no ink-derived VOC emissions or worker exposure to alcohol; replacement of solvent-based cleaners and solutions with safer substitutes	Hold color and viscosity longer during press runs; more coverage per pound of ink; reduces the need for make-up solvent during printing	More frequent equipment cleaning; less forgiving of equipment imperfections, may cause paper curl	May require new capital equipment; greater energy use; reduced hazardous waste disposal and liability costs	Similar quality with new equipment; low ink gloss on porous substrates	May contain low level of solvent; ink waste may still be hazardous; greater energy use for drying

1 Source: Alternatives to Petroleum- and Solvent-Based Inks, TURI Fact Sheet 6. "Printing Inks" 0.92 PNEAC: Fact Sheets and Case Studies: Lithographic Printing: Printing Inks. http://www.pneac.org/Sheets/litho/inks.html

Appendix IV: Case Study Summaries

AMERICRAFT CARTONS, INC., MASSACHUSETTS

Case Study Title	Alcohol Free Fountain Solutions at Americraft Cartons, Inc.
Case Study Source	Commonwealth of Massachusetts, Executive Office of Environmental Affairs. Office of Technical Assistance, 1996 http://www.state.ma.us/ota/cases/americraft.htm
Company Description	A folding carton manufacturer and printer
Company Size	$30 million of sales a year Facility has plants in 7 states
Source of VOC	Isopropyl alcohol (IPA) Petroleum-based ink
Challenges	Prove that high quality printing is possible without isopropyl alcohol
Motivation	Concern for the health and safety of its employees and the environmental concerns expressed by clients (health and beauty products, children's toys and games, and food products)
Solution	Purchased Prisco Aquamix Central System ($108,000) to reduce inconsistency and waste from fountain solution mixing process Implemented a reverse osmosis system to ensure high quality and uniform water supply (pH and conductivity). This enabled switch to fountain solution without IPA. Initially replaced isopropyl alcohol-based fountain solution with a new formulation with 20% monoglycol ether, a VOC. This reduced VOC but required reporting un SARA Title III, Section 313 (Form R, TRI) and Mass. TURA. A new substitute was chosen that nearly eliminated VOC and does not contain glycol ethers. This formulation is used in a computer controlled, chilled, closed loop recycling system connected to all presses. Switched from petroleum to soy-based ink
Results	88% of reduction in VOC emissions from the printing operation Elimination of VOC from the air in the plant Reduction of flammability (new solution has lower flashpoint) Savings: Total materials purchase savings of $222,896 over six years. The end of losses and costs associated with non-uniform hand mixed solutions and press downtime Reduced costs for waste removal through internal recycling of the solution

DELUXE CORPORATION, MASSACHUSETTS

Case Study Title	Deluxe's Solvent-Free Printing System
Case Study Source	Commonwealth of Massachusetts, Executive Office of Environmental Affairs. Office of Technical Assistance, 1994, http://www.state.ma.us/ota/cases/deluxe.htm
Company Description	Headquartered in Minnesota, Deluxe is the largest check printer in the U.S. Prints checks and other products. Implementation conducted in Boston and Springfield, Mass. plants.
Company Size	Fortune 500 company with annual sales of $1.6 billion Employs more than 17,000 people corporate wide.
Source of VOC	Petroleum-based cleaning solvents Petroleum-based ink
Challenges	N/A
Motivation	Response to increasingly strict U.S. EPA-proposed emission standards under the Clean Air Act VOCs present employee health and safety concerns
Solution	Development of a water-washable ink system that eliminates the use of petroleum-based solvents Focus on printing as a system, that is, the company began to look at lithographic ink and press wash as interdependent, not independent, elements
Results	Reduction in solvent emissions from approx. 2 million lb/yr to 1 million lb/yr Alleviation of employee health and safety concerns related to solvent use and reduction of hazardous waste New ink meets or exceeds the performance of conventional lithographic inks Deluxe began selling the system in 1994

KELLER CRESCENT COMPANY, INDIANA

Case Study Title	Keller Crescent Company's Solvent Recovery Solution: A Success Story
Case Study Source	PNEAC, 1996, http://www.pneac.org/Sheets/litho/litho.html
Company Description	A full-service advertising agency and commercial printer. Conducts web flexographic and sheet-fed offset printing.
Company Size	Employs more than 500 individuals. Clients range from pharmaceutical to automotive companies.
Source of VOC	Shop towels and blanket wash
Challenges	Improve performance of solvent recovery system for print towels. Prior to 1996, Keller used a combination of centrifuge and distillation to recover solvent from print towels with a recovery rate of 50%. Wanted to increase recovery, reduce labor costs of recovery system and waste disposal cost for disposal of distillate bottoms.
Motivation	A strong focus on environmental stewardship, which has led Keller Crescent's management to conduct progressive waste reduction efforts. A corporate commitment to pollution prevention made by Keller Crescent in the 1990s to stay ahead of regulation.
Solution	Microwave-based solvent recovery system. The system is a one-step process that can handle print towels and blanket wash. After the microwave system, the print towels can be laundered by a commercial laundry. The wastewater fraction can typically be discharged to a local sewer authority.
Results	Elimination of all hazardous waste costs associated with print towels and recovered blanket wash. Solvent recovery rate was almost 98% of amount present before processing. Each 55-gallon barrel of print towels returns an average of five gallons of solvent. The 55-gallon barrels of blanket wash return an average of 25 gallons of solvent each. Keller avoided becoming a large quantity generator and significantly reduced their solvent purchases.

WINCUP, INC., ILLINOIS

Case Study Title	Emission Reduction in Waterless Printing Operations
Case Study Source	PNEAC, 2002, http://www.pneac.org/Sheets/litho/wincup.html
Company Description	WinCup, Inc. is a foam cup and food container manufacturing company with manufacturing plants located throughout the U.S. Their manufacturing process includes printing logos and other graphics onto pre-formed Styrofoam cups and other food containers through a waterless offset printing process (other wise known as "dry offset").
Company Size	The second largest producer of polystyrene foam cups in the world
Source of VOC	IPA press cleaning chemistry
Challenges	WinCup had been using isopropyl alcohol (IPA) to clean ink and related soil off their printing equipment after a job was run. Isopropyl alcohol is considered a VOC emission source by EPA and is a flammable substance with a flash point of 54 F. Flammable materials are subject to stringent storage and handling rules, additionally the user may be limited to the amount they can store on site at any one time.
Motivation	Due to increasing air emission regulatory limitations, and concerns about worker safety due to the use of a flammable cleaning product, WinCup wanted to identify an alternative cleaning product that worked just as well as the IPA at removing ink and other residues from the printing presses and related parts, yet met their VOC emissions reduction goals. Company was faced with a regulatory limit on their production and cleaning activities while IPA was used.
Solution	By working closely with their supplier, the company identified a low vapor pressure cleaning product – Wash-Up Evap A (100% VOC, but 8.3 mm Hg vapor pressure, equiv. to 30% VOC by weight). Though cost was significantly higher than IPA, company expected to use less and save money.
Results	Company reduced VOC emissions from press cleaning activities by 66% (from 4.32 to 2.85 tons/yr) and was able to increase production without exceeding air permit limits. 7 drums of Wash-Up Evap A were used in place of 24 drums of IPA.

NEENAH PRINTING DIVISION OF MENASHA CORPORATION, WISCONSIN

Case Study Title	The Neenah Printing Division of Menasha Corporation
Case Study Source	PNEAC, 1999, http://www.pneac.org/sheets/flexo/neenah.PDF
Company Description	Lithographic web and sheetfed printing, and wide web flexographic printing.
Company Size	Employs 350 people at four Neenah, Wisconsin, facilities
Source of VOC	Petroleum and solvent-based inks Alcohol-based fountain solutions
Challenges	N/A
Motivation	A firm commitment to sound environmental management as an outgrowth of the corporate philosophy The company's Environmental Mission Statement
Solution	Since 1997, 80% of all sheet-fed offset inks have been soy-based. All presses run on non-alcohol fountain solutions. 97% of all wide-web flexographic inks used are water-based. Concurrent implementation of a waste reduction program.
Results	Less chemical exposure for employees Steady decline in VOC emissions, from 89.7 tons in 1987 to 42.6 tons in 1993 Awards for Neenah Printing's efforts: 1994 Wisconsin Business Friend of the Environment: Environmental Stewardship Award 1996 Associated Recyclers of Wisconsin (AROW) Award for Business Recycling 1998 Wisconsin Governor's Award for Excellence in Hazardous Waste Reduction

MCNAUGHTON & GUNN, MICHIGAN

Case Study Title	McNaughton & Gunn, Inc., Saline Michigan, Book Printer Reduces Waste at the Source
Case Study Source	Michigan Department of Environmental Quality and Environmental Assistance Division, 1996, http://www.deq.state.mi.us/documents/deq-ead-p2-migpp-mcnaugun.pdf
Company Description	Book printing and binding
Company Size	The company has 250 employees and processes over two million pounds of paper each month into books
Source of VOC	Ink and solvents
Challenges	Finding high-quality, low-VOC black ink for its web presses to replace petroleum-based inks
Motivation	Source reduction is driven by a desire to reduce adverse impacts to the environment and reduce disposal costs
Solution	Implementation of a wide variety of projects to reduce environmental impacts, including the use of vegetable-based ink on all sheet-fed presses, eliminating IPA from the dampening systems of all presses, using low VOC solvents for blanket and roller washes. Key aspects of their overall environmental program includes: Employee participation in planning and implementing source reduction programs Employee education Identification of new technologies Working with suppliers
Results	Environmental awards: 1996-2002 Michigan Great Printer 1998-2002 Waste Knot Award from the Washtenaw County Public Works Division 1999-2002 Certificate of Partnership in the Community Partners for Clean Streams Program 1999 Washtenaw County Environmental Excellence Award (source: http://www.bookprinters.com/marketing/environ.html)

BURTON & MAYER, INC., WISCONSIN

Case Study Title	4.7.1 Printing: Lithographic Printing Case Study #3, 1997
Case Study Source	U.S. EPA, EnviroSource database http://es.epa.gov/new/business/sbdc/sbdc116.htm
Company Description	A commercial and advertising printer of labels, booklets, and brochures
Company Size	70 employees
Source of VOC	IPA and petroleum-based inks An alcohol fountain solution was used, most of which evaporated, emitting VOCs
Challenges	Waterless printing requires rollers to be chilled and involves a special, more expensive plate-developing process. Conversion of ten presses took three years. Each press needed individual testing to maintain printing quality.
Motivation	Process VOCs produce air emissions and create health hazards.
Solution	Convert to alcohol substitutes and vegetable-oil-based inks The company uses soy-based inks, which are easier to de-ink when recycled Printing processes are run alcohol-free by converting several presses and buying two new presses that run waterless systems
Results	Totally eliminated alcohol use in presses, down from 1,815 gallons per year in 1991 to 825 gallons per year in 1992 After converting to vegetable-oil-based inks, reduced petroleum oil based ink usage by 85%, reduced VOC levels below 10% Worker safety was greatly improved by eliminating IPA from the printing process

COLT REPRODUCTION, COLORADO

Case Study Title	Colt Reproduction, 2525 Frontier Road, Boulder, CO 80301, a commercial printing company
Case Study Source	Colorado Pollution Prevention Case Studies for the Printing Industry, 1995
Company Description	Commercial printing
Company Size	28 employees
Source of VOC	Blanket and roller wash
Challenges	New solvent explored dries more slowly. However, the cleaning process takes less time overall because the new solvent cleans more thoroughly.
Motivation	Improve worker health and safety, public recognition by City of Boulder
Solution	Varn "Airo-clean WM", low-VOC, water-miscible blanket and roller wash for use on the same presses. Contains only 4.1 lb/gal VOCs, and is mixed with 50% water, which reduces the solvent usage by 50% and solvent VOC emissions by 60%. Management support for pollution prevention and employee involvement were key to the success of these efforts.
Results	Cost savings of $1,050 per year Lower VOCs from cleaning solvents by 370 pounds per year or 60% Improved quality: water-miscible solvents remove gum and paper glaze simultaneously with ink Longer roller and blanket life Improved public image through recognition as a "Business Partner for a Clean Environment" by the City/County of Boulder Improved worker health and safety Time for implementation: two years

D&K PRINTING, COLORADO

Case Study Title	D&K Printing, 2930 Pearl Street, Boulder, CO 80301, a commercial printing company
Case Study Source	Colorado Pollution Prevention Case Studies for the Printing Industry, 1995
Company Description	Commercial printing
Company Size	28 employees
Source of VOC	Prisco Powerklene UK Blanket and Roller Wash for use with Heidelberg Speed-Master 4-colorY 40-inch and 5-colorY 28-inch presses. Powerklene has a VOC content of 6.67 pounds per gallon.
Challenges	Alternatives take slightly longer to dry
Motivation	To improve worker health and safety and reduce VOC emissions To be recognized as a "Business Partner" by the City/County of Boulder.
Solution	Prisco Environmental Series (PES) VOC Reduction Program for reducing the VOCs in blanket and roller washes used with the Heidelberg Speed-Master presses (Technology) Step 1 of the technology reduces the VOC content of the current blanket and roller wash by 20% (PES 153 contains 5.3 pounds per gallon VOCs)
Results	Prisco Environmental Series (PES) 153 reduces VOC emissions from blanket and roller washes by 20% Improved business image through recognition as a "Business Partner for a Clean Environment" by the City/County of Boulder Improved worker health and safety, liability reduction Time to implement changes was six months

JOHNSON PRINTING, COLORADO

Case Study Title	Johnson Printing, 1880 South 57th Court, Boulder, CO 80301, commercial printing
Case Study Source	Colorado Pollution Prevention Case Studies for the Printing Industry, 1996
Company Description	Commercial printing
Company Size	122 employees
Source of VOC	Fountain solution with 20% IPA for sheet-fed and nonheatset web lithographic printing VOC content of IPA is 6.5 pounds per gallon
Challenges	Find a formulation to work with metallic inks Lost production time and labor required to experiment with new fountain solutions and operating conditions
Motivation	Reduce VOC emissions Improve business image
Solution	Alcohol-free fountain solution is used for sheet-fed and nonheatset web lithographic printing 10% Rycoline 9-289 Alcohol Replacement is used in combination with 187-A Fountain Solution Etch (Technology) This formulation results in a 60% reduction in VOCs from the fountain solution
Results	VOC emissions from fountain solutions are reduced by 60% (8,000 pounds per year) Improved business image with customers and the community Improved worker health and safety, liability reduction, company and employee satisfaction The new formulation evaluated does not work as well with metallic inks; more difficult jobs may require the use of IPA Time to implement changes was four years

XYZ COMPANY, NORTH CAROLINA

Case Study Title	Elimination of Toxic Chemicals from Blanket Wash by a Lithographic Printer, 1995
Case Study Source	N.C. Division of Pollution Prevention and Environmental Assistance http://www.p2pays.org/ref/06/05647.htm
Company Description	N/A
Company Size	N/A
Source of VOC	Blanket wash solvent
Challenges	Finding a drop-in replacement blanket wash.
Motivation	Eliminating a TRI chemical and the requirement to report under SARA Title III, EPCRA (TRI Form R's)
Solution	Traditional blanket wash, with a VOC content of approximately 6.5 pounds per gallon, was replaced with a blanket wash containing 5.2 pounds per gallon (raw material)
Results	In 1993, the printer generated in excess of 9,000 pounds of TRI-listed chemicals from use and disposal of the blanket wash. By substituting an alternative blanket wash blend, the TRI waste generation from blanket wash dropped to less than 1,000 pounds in 1994, and reached zero in 1995. Benefits include reduced environmental reporting, fire hazard, VOC emissions, and worker exposure to toxic chemicals. Drying and cleaning rates are slower than the traditional blanket wash, which contained trimethylbenzene. Machine operators had to become accustomed to using the new blanket wash without compromising print quality or increasing press clean-up time. The cost of the new solution is approximately 25% more per gallon than the traditional blanket wash. More waste liquid must be disposed due to a lower evaporation rate Time to implement changes was 1.5 years

JOURNAL PRESS, INC., VERMONT

Case Study Title	Pollution Prevention Efforts at the Journal Press, Inc.
Case Study Source	Vermont Agency of Natural Resources, Pollution Prevention Division in Pollution Prevention Successes: A Compendium of Case Studies from the Northeast States, NEWMOA 1993, http://www.p2pays.org/
Company Description	Small commercial offset lithographic printing business. Production activities at the company include photo processing, plate making, printing and book binding.
Company Size	N/A
Source of VOC	IPA fountain solution
Challenges	N/A
Motivation	N/A
Solution	Low toxicity substitutes for a majority of the hazardous chemicals used in the printing process IPA has been eliminated in 99.9% of printing jobs through chemical substitution with a mixture of butyl cellosolve and glycol ether
Results	The new fountain solution requires press operators to take more time during the make-ready process to ensure that all press adjustments are exact

QUAD/GRAPHICS, INC., WISCONSIN

Case Study Title	4.7.1 Printing: Lithographic Printing Case Study #4
Case Study Source	U.S. Environmental Protection Agency, EnviroSense Database, 1997, http://es.epa.gov/new/business/sbdc/sbdc117.htm
Company Description	Printer of magazines, catalogs, and commercial products
Company Size	N/A
Source of VOC	Cleaning solvent Petroleum-based ink
Challenges	N/A
Motivation	Air emissions from VOC inks and cleaning solvents threatened worker health Environmental regulations
Solution	A new press cylinder prewash cuts use of cleaning solvent in half The company patented a vegetable-oil-based ink that replaces petroleum-based inks, using a mixture of corn, linseed, and soy oils A closed-loop ink system captures up to 90% of MEK vapor and condenses it for reuse
Results	Solvent use reduced from 1,100 gallons per year to 550 gallons per year MEK use reduced 6,900 gallons per year Ink VOCs reduced 10% to 15% percent through use of vegetable-oil-based inks Worker safety was greatly improved by reducing use of VOC materials. MEK is a strong eye and skin irritant, affects the peripheral and central nervous systems, and is a highly flammable liquid Environmental awards: Industrial beautification award, Climate Wise Partner Achievement Awards, Recycling at Work Award, National Air Filtration Association (NAFA) Clean Air Award, 1995 Business Friend of the Environment Award, 1993 Wisconsin Governor’s Waste Reduction & Recycling Award

G&R PUBLISHING COMPANY, IOWA

Case Study Title	Pollution Prevention in a Small Print Shop at G&R Publishing Company
Case Study Source	Pollution Prevention Curriculum for Lithographic Printers, 2001, http://www.p2pays.org/ref1716242.htm
Company Description	N/A
Company Size	Small
Source of VOC	Fountain solutions (IPA)
Challenges	In order to facilitate the switch to IPA substitutes, realized that they needed a water supply with low conductivity
Motivation	Saving money in the press room
Solution	Installed a reverse-osmosis unit to eliminate metal salts in make-up water, which was immensely helpful in allowing the press operators to run alcohol-free without scumming problems Use of soy inks whenever possible Replacing IPA with substitutes Use of chiller units with filters to keep solutions cool and clean and to avoid evaporation
Results	G&R has reduced VOC emissions

QUAD/GRAPHICS, INC., WISCONSIN

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Company Description	Printer of magazines, catalogs, and commercial products
Company Size	N/A
Source of VOC	Cleaning solvent Petroleum-based ink
Challenges	N/A
Motivation	Air emissions from VOC inks and cleaning solvents threatened worker health Environmental regulations
Solution	A new press cylinder prewash cuts use of cleaning solvent in half The company patented a vegetable-oil-based ink that replaces petroleum-based inks, using a mixture of corn, linseed, and soy oils A closed-loop ink system captures up to 90% of MEK vapor and condenses it for reuse
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