Pollution Prevention for the Printing Industry

A Manual for Pollution Prevention Technical Assistance Providers

February 1997

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1 Keys to Using This Guide

Look around your office and count the number of items that have some type of printing on them. There are five principal types of printing processes that produce the images you see. They are lithography, gravure, flexography, screen printing, and letterpress. Each printing process includes three basic steps: preparing an image carrier; transferring the image, either directly or indirectly onto the substrate to be printed; and finishing. The finishing steps will differ depending upon the printing process. For example, lithographic printed materials may be folded, trimmed, collated, bound, laminated, die cut, or embossed, depending on the function of the final product (Pferdehirt, 1993).

The packet you hold in your hands will give technical assistance providers, both those experienced in working with printers and those just starting, a basic reference on a variety of pollution prevention (P2) and waste minimization suggestions. The packet includes a statistical overview of the industry, general pollution prevention options based on the process flow of typical printing operations, chapters on each specific printing type highlighted by case studies and a annotated bibliography.

The annotated bibliography of each section provides a basic overview of what the compilers of this document believed to be some of the more informative references pertaining to each printing type. As there are hundreds, if not thousands, of articles, factsheets, and so forth pertaining to printing, the annotated bibliography should not be considered to be all inclusive of the printing information currently available.

The four appendices cover federal regulations (up to Spring 1996), human resources, electronic resources, and a glossary of printing terms.

In putting together this packet, we have made several assumptions. First, that those reading this are already familiar with P2 concepts and the steps needed to implement a P2 program. If not, we refer you to "Pollution Prevention: A Guide to Program Implementation," distributed by the Illinois Waste Management and Research Center. Second, that any technique or technology presented here as a possible method to reduce waste will be more thoroughly investigated by the technical assistance provider as to the applicability to the facility they are assisting.

The pollution prevention options section of this packet was extracted from the myriad of factsheets, brochures, booklets and other publications developed for printers by governmental agencies-both state and federal. Of note is the fact that many, many of these materials did not present actual data such as, "technology or technique A reduced waste ink by 25 percent, from X to X, for a capital cost of $10,000. Thus the company saved $100 in disposal costs for the year." Therefore, the material presented here, outside of the case studies, has not been verified in the production of this packet. The technical reviewers of this packet helped in pointing out things that were off base, but technical assistance providers should be judicious in the pollution prevention choices they recommend to their clients. Knowing how the client runs their printing business, how the process flow of materials and machinery to produce the product, will help the assistance person in choosing the applicable P2 technique or technology from those presented in this packet.

Each printing section provides information on how the basic process works, inputs/outputs from each step in the printing process, any specific pollution prevention options for that type of process and case studies highlighting pollution prevention options in use.

Appendix A is a shortened version of the US EPA Office of Pollution Prevention and Toxic's publication, *Federal Environmental Regulations Potentially Affecting the Commercial Printing*

Industry, EPA [illegible], March 1994. It is included as a basic outline of federal regulatory issues that pertain to printers. As each state differs in their regulations, and they usually change fairly often, no attempt was made to present this material. Both regulatory and non-regulatory agency contact information are provided in the human resources appendix (Appendix B) for further information. Local and national trade associations can also provide specifics on regulations affecting their particular printing industry.

With literally dozens of private, governmental and trade associations focusing on developing pollution prevention and regulatory compliance materials for printers, new information will be accessible. The fastest growing information resource is the Internet and World Wide Web. The electronic resource list (Appendix C) provides the Internet addresses of use to technical assistance providers and printers alike (as of Summer 1996). Listservs, electronic mailing lists centered on specific topics such as printing regulations, are also available via e-mail.

Appendix D contains a glossary with often used terms in the printing industry. Appendix E contains quick reference sheets to the major types of printing, their uses, substrates, and inks. An index to the document is also provided.

PRINTING TIDBITS

In 1985, the average cost of a magazine was $2.10. By 1994, the cost had risen to $3.10, an increase of 47.6 percent over nine years.

More than 200 magazines are now available online.

There were 1,552 daily newspapers in 1993, down from 1,763 in 1960.

More than 30 newspapers have created a home page on the World Wide Web.

Commercial printing occurs at about 34,000 establishments; it employs more than double the number employed by the steel industry.

In 1995, there were over 40,000 screen printing facilities in the U.S. Approximately 50 percent of these screen printing facilities are involved in the printing of all types of textiles.

The U.S. Postal Service reports that third-class mail, the category used for bulk-mail printed material, increased by 400,000 tons in 1994.

In 1974, there were 20,000-25,000 quick printers in the U.S. By 1994, that number had risen to 38,000-42,000.

In 1995, there were more than 6,000 plants with web offset presses in the U.S.

Nearly 60 million newspapers were sold every day in 1994. During the same year, 58 percent of all newspapers were recycled.

Sixty-seven new sports magazines came onto the nation's newsstands in 1994.

Excerpts from "Alive and Kicking-Rumors of the death of paper-based printing are greatly exaggerated," in Adobe Magazine, January/February 1996, pg. 100.

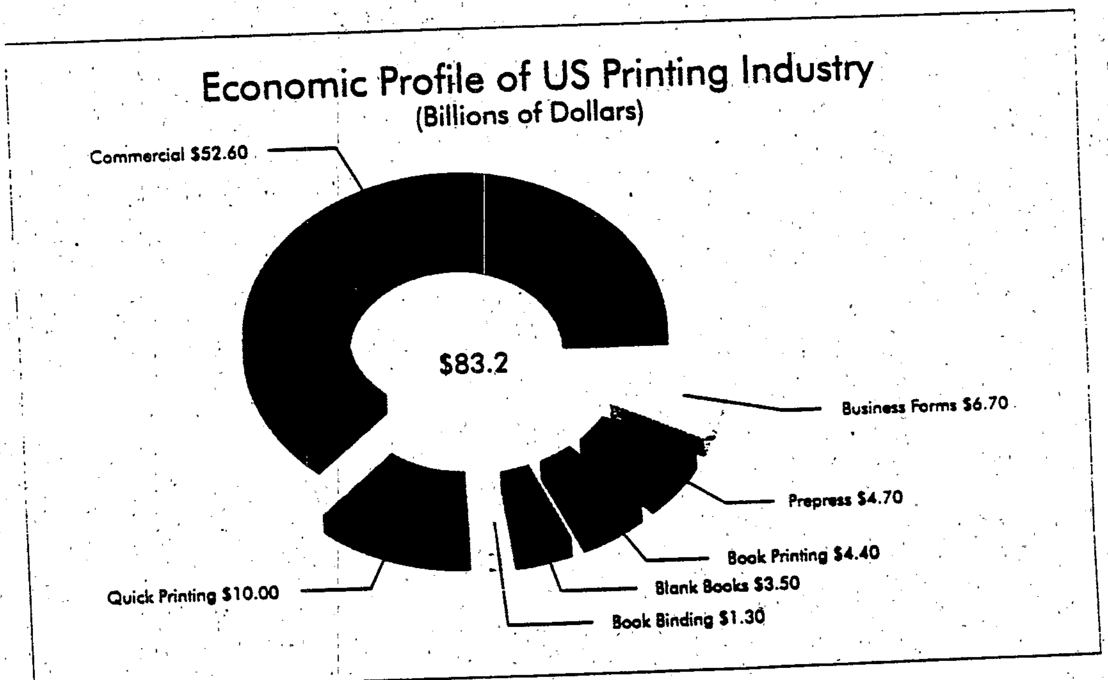
2 The U.S. Domestic Printing Industry

Overview

Who is the bigger employer in the United States, the printing or the automotive industry? If you guessed printing, take a bow—an $83+ billion bow. Yes, believe it or not, in the US, printing isn't just big business, it's the biggest. Printers employ nearly 1 million people across the country, placing the meager 780,000 in the auto industry a distant second. Sounds pretty outrageous until you stop to think about it. In a society that's constantly in search of access to information and literally obsessed with record-keeping, it stands to reason that printing is ubiquitous. From new car manuals to tabloid newspapers to t-shirts to those little tags on mattresses, nearly every product calls on the printing industry somewhere along the line. Put in that light, the numbers don't seem quite so far-fetched. So the big question is, if it's such a big industry, how come we've never noticed?

The relative invisibility of the industry is due primarily to the nature of the business and the way it has evolved. To understand how the industry works and how to effectively target printing facilities for pollution prevention programs, we need to understand who they are, what they do, and perhaps most importantly, where is everybody?

According to the 6th Annual Report to Congress by the Printing Industry of America (PIA), printers are defined as: "Those firms engaged primarily in commercial printing, business forms, book printing, prepress services, quick printing and blank books and binders." This definition does not include firms mainly involved in publishing. Figure 1 (PIA, 1994)



From: *6th Annual Report to Congress: Printing Industry.* Printing Industries of America, Inc. 1994.

Figure 1.

illustrates the economic breakdown of the industry into these seven major areas. Before the screaming begins, according to USEPA data, letterpress really did account for 11 percent of the economic market and screen only 3 percent. However, of all the major printing processes, screen printers are the most undocumented. So, in this case, 3 percent is the number that can be physically established.

For the purposes of this report, printers are defined by the Bureau of Census' Standard Industrial Classification (SIC) 27. A word of warning about SIC codes might be in order at this time. Anyone who has attempted to use them has no doubt found them to be vague at best and just downright obsolete at worst. SIC 27, Printing, Publishing, and Allied Industries, is unfortunately no exception. While this definition of the printing industry is similar to the PIA's, it doesn't necessarily include firms engaged in fabric and textile printing (largely a screen process), manufacturers of products containing incidental printing or circuit board printers. But, it could. Broad headings and subjective interpretation of various industries leaves the SIC codes open to a great deal of confusion when it comes to actual statistics. It's often difficult to determine what counts under SIC 27 and what doesn't.

There is some good news on the horizon. Even as this manual is heading towards publication, efforts are underway to clarify and to expand SIC 27. In particular, screen printing will be given two separate listings. So, hopefully, two or three years down the road will see a new, improved SIC 27 that will make it much easier to get a numerical handle on printing in the United States. However, for the moment, and for this overview, the current SIC 27, confusing as it may be, is it.

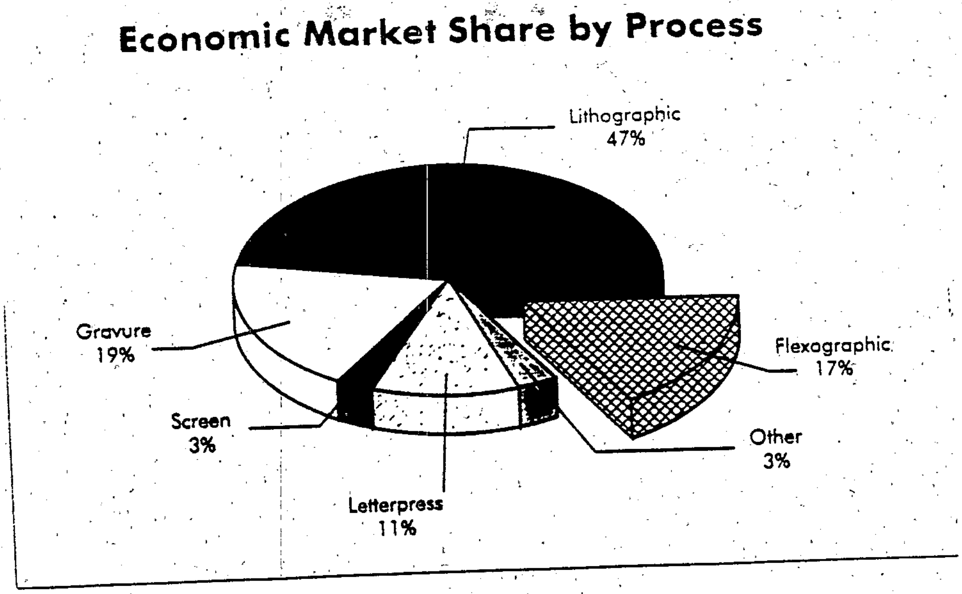
This sort of uncertainty about the codes leads to some large statistical ranging, depending on the source consulted, and what the authors chose to classify under which SIC. But it should be kept in mind that these numbers, while not necessarily deadly accurate, still serve to illustrate the magnitude and the diverse nature of the industry. Also, it's good to note that, if anything, the numbers quoted here underestimate reality. So, while the 1994 SIC 27 may leave out a potentially sizable number of printing operations, it still provides plenty to keep everyone busy for some time to come.

SIC 27 is made up of firms printing by the five most common processes (lithography, screen, flexography, letterpress, and gravure) as well as newspaper, book and periodical publishers (whether or not they do their own printing). The primary focus of this manual is on the five processes mentioned above. They account for about 97 percent of the economic output in the domestic printing industry (US EPA, 1994), and by necessity, are the first step to anything else in SIC 27. (Bookbinders may have their own pollutants, but they can't do much until someone has printed their books.) Figure 2 shows the financial breakdown of the industry by process-type.

At the moment, a number of alternative printing processes and technologies are in use and being further refined and developed. These include various electronic, thermographic ion-deposition, ink-jet and Mead Cycolor printing processes. While these newer methods currently account for about 3 percent of the market, their share is expected to be nearer 20 percent by 2025 (US EPA, 1994). Also afoot are numerous "paperless" publishing and recording technologies. It's not inconceivable, given the increasing popularity of the "information superhighway" and new computer imaging and transmitting equipment, that a net-reduction in printed materials could eventually impact the industry. However, that appears to be a few years down the road, at the very least, and until that comes to pass, there is every indication that old-fashioned printing will remain a very growing concern.

Companies, Presses and Employees

Various estimates place the number of printing establishments in the US somewhere between 60,000 - 70,000. However, these estimates are thought to exclude most-to-all of the 40,000+ plants with screen presses, placing the total nearer to 100,000 facilities.(US EPA, 1994). Apparently, screen printers are even

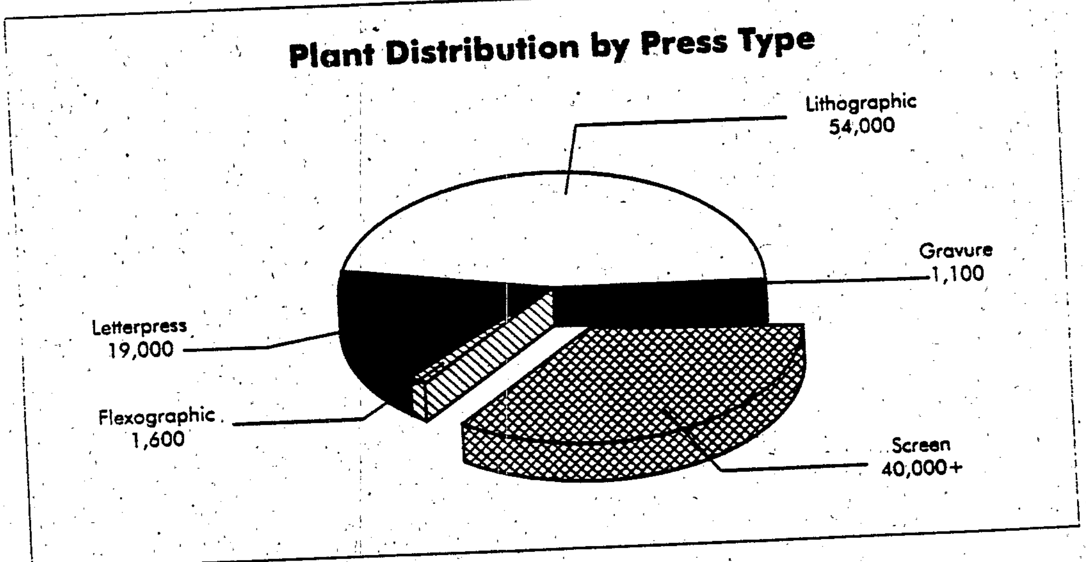


From: US EPA Printing Industry Cluster Profile, 1994, p. 5

Figure 2.

more difficult to put a finger on than are the others. So, with that in mind, be warned that many of the numbers in this chapter should be considered suspect in terms of the impact of screen printers. Figure 3 illustrates plant distribution by press/process-type.

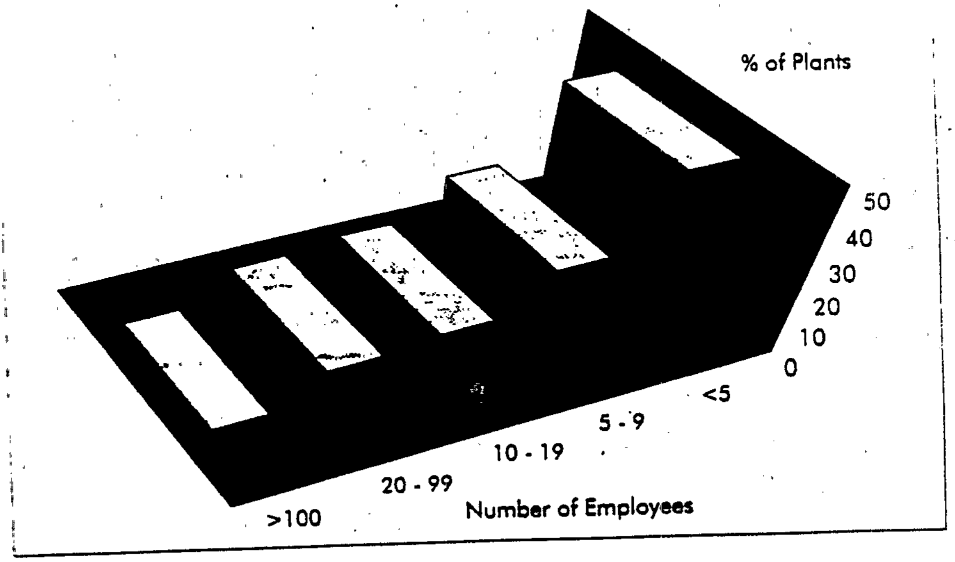
Interestingly, while the industry does account for a significant share of the nation's total volume and goods, services and employment, at the same time, it is the ultimate small business. Nearly 80 percent of the printers in the US employ fewer than 20 people. While there are some printers dealing in national and international scope, most serve local or regional markets. This is an industry largely populated by small, neighborhood shops, rather than sprawling multi-acre industrial complexes. You just don't



From: US EPA Printing Industry Cluster Profile, 1994, p. 15

Figure 3.

Distribution by Number of Employees



From: US EPA Printing Industry Cluster Profile, 1994, p. 18.

Figure 4.

find that many printing plants employing 20,000 people.

Of the operating plants in the US, about 46 percent have fewer than five employees, 24.5 percent have between five and nine, and 14.1 percent have between ten and nineteen. Roughly 12 percent employ between 20 and 99, leaving less than 3 percent of all printers in the country employing more than 100 people. Figure 4 shows the distribution of plants by number of employees. This distribution of employment size matches fairly closely with the type of presses in operation. Gravure and flexographic plants tend to be the larger operations. Over half of the flexographic and about one-quarter of the gravure shops employ more than 20. The majority of the shops utilizing letterpress, lithographic and screen presses fall in the under-20 category (US EPA, 1994).

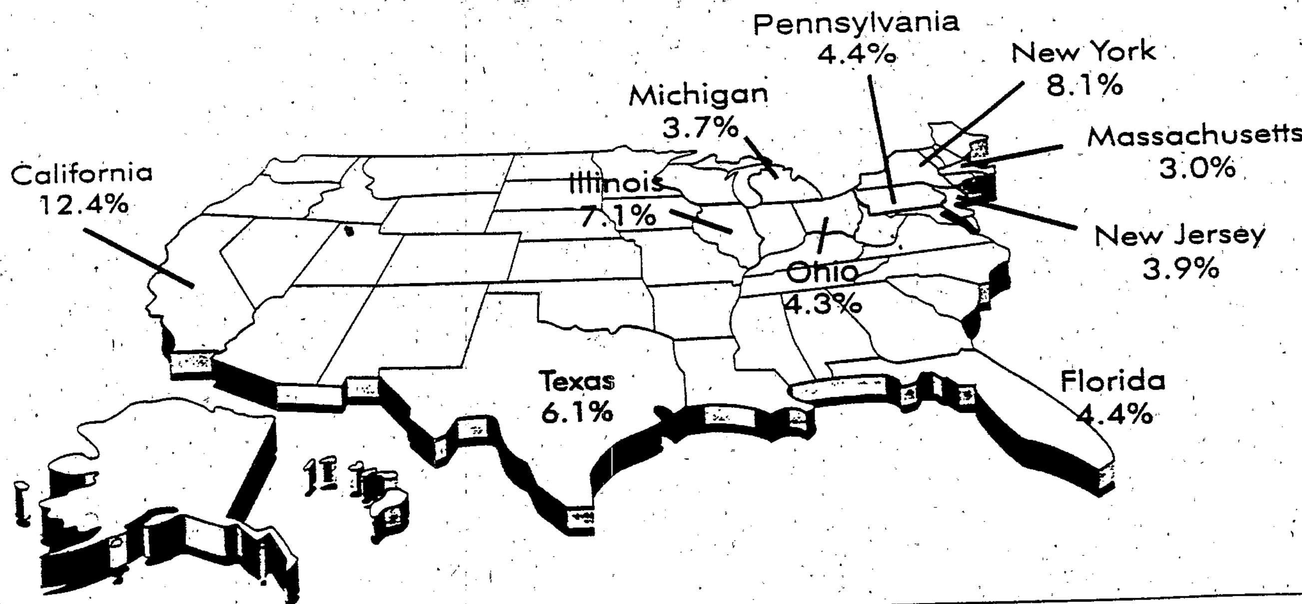
The conclusions, with regard to pollution prevention efforts, drawn from this section should be pretty clear. The majority of the shops that need assistance aren't going to be multi-national conglomerates with the corresponding resources. Odds are, the average printer is running a lithographic or screen press, employing less than 20, and quite probably, working on a thin profit-margin, without vast pools of cash available for major capital improvements or process reengineering. Knowing the profile of the individual operation will help identify the psychological approach that will be most effective, as well as the technical considerations.

Geographic Distribution

At this point, we have a good idea of who constitutes the US printing industry and we know that there are thousands of printers out there. However, we still don't know where they are hiding. With the majority being so small, they could turn up just about anywhere. And, in fact, that's almost exactly the case. From Alaska to Wyoming, you will not find a shortage of printers. In fact, every single state has at least one plant employing over 100 and hundreds of smaller plants. But, if you want to play Pin-the-Tail-on-the-Printer at a party, ten states stand out above the rest.

California, New York, Illinois, Texas, Florida, Pennsylvania, Ohio, New Jersey,

Plant Distribution in 10 Leading States



From: US EPA Printing Industry Cluster Profile, 1994, p. 10.

Figure 5.

Michigan, and Massachusetts by themselves account for more than 60 percent of the entire industry. The top three alone are home to over 1/3 of all the plants. Figure 5 shows the ten states by their percentage of the total.

Conclusion

The US domestic printing industry is an entity unlike almost any other. It's the largest employer-one of the largest in terms of economic output-and, if you were to judge by the response of the average person on the street, the printing industry maintains a profile so low that it just about disappears from sight. Instead of a rampaging giant of economic clout, it's a diverse, dispersed swarm of small businesses. The average printing facility is small (<20 employees), probably runs a lithographic or screen press, and has a better than average chance of finding itself in one of ten particular states. But, it could also be 120 people running gravure presses in Nome, Alaska. Probably more so than any other industry of comparable size today, printing is a quickly shifting, unpredictable business.

The US printing industry is nothing else, if not proof of strength in numbers. They don't take up lots of real estate. They aren't generally the major employers in a given area. Individually, they are usually not a major environmental concern. But, when you examine the industry as a whole, you face an entirely different animal. Comprised of thousands of small, independent units, the printing industry employs nearly 1 million in some 60,000-100,000 plants and accounts for somewhere in the neighborhood of 100 billion dollars in business every single year, while at the same time, contributing to toxic air emissions and solid and chemical waste problems on an ever-growing scale. It's too big to be ignored on all fronts, economic, social and environmental.

Looking at each plant individually, it might not seem like the average printer is responsible for all that much pollution. However, whether that assumption is grounded or not. 100,000 individual sources of VOC emissions, petroleum ink wastes, and various types of waste chemicals can add up to a very considerable problem in a very short time.

Unfortunately, the diversity and wide-spread dispersion of the printing industry contributes to its economic survival and viability, and creates a number of sticky logistical problems in bringing wholesale pollution prevention and waste management to the entire industry. With some 100,000 shops operating in nearly every corner of the country, there is, at present, no "short-cut" access to the industry as a whole. Simply reaching these plants presents an enormous challenge, to say nothing of the other factors, such as size, financial situation and location that will also have considerable influence on any pollution prevention strategies that might be suggested.

Facing that and knowing that the printing industry is projected to grow by 3.8-5.3 percent annually during this decade (US EPA, 1994), the environmental problems created by the printing industry aren't going to disappear on their own and without action, will simply become that much more unmanageable each year.

Regulatory and legislative actions m[illegible] come about, but the size and distribution of the [illegible]ustry again will insulate it from much of this. It's simply not possible to effectively regulate and monitor this many institutions. Printers are going to have to decide on their own that pollution prevention and waste management can be an environmentally and economically productive innovation. Like any other industry, the most effective policing method isn't a regulatory agency, but the bottom line. Nothing motivates like the prospect of increased profits. Skilled technical assistance with a feel for the requirements and conditions of the printing industry is one of the most promising routes to this re-education process.

This is still no quick fix. There is no such thing, at least not to be found under SIC 27. Faced with such overwhelming numbers, even directed technical assistance efforts targeting the industry will initially be a shotgun approach. But, with personnel armed with a little background about the printing industry and some practical knowledge of the various major processes, odds are good that some successes will be achieved. This should lead to a snowball effect. The successful shops that implement new and more efficient techniques will lead others in the right direction.

It's not possible to overstate the value of understanding the printing industry as a whole--what are each individual printers' characteristics, how do they do business and what are their limitations. Going into a technical assistance visit with only an understanding of how the press works, you can make suggestions that will be quite effective in theory, *but only by understanding how the printer works, can you make suggestions that are going to be practiced.*

Annotated Bibliography

PIA, "6th Annual Report to the Congress of the United States: Printing Industry." 1994. Printing Industries of America, Inc.

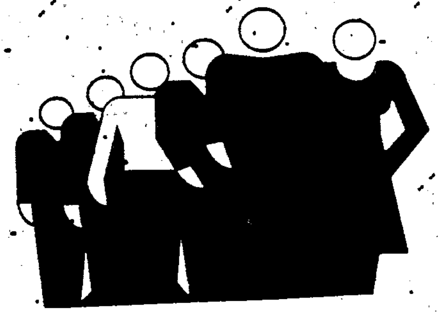
The PIA report to Congress provides a very brief overview of the US printing industry, including statistics on wages, composition, and employment. It also offers a cursory discussion of future trends in the industry and a short glossary of new technological terms.

US EPA "Printing Industry and Use Cluster Profile." 1994. Regulatory Impacts Branch, Economics, Exposure and Technology Division, Office of Pollution Prevention and Toxics, US EPA, Washington, DC.

The US EPA cluster profile offers a little bit of everything, although its main purpose is a thorough statistical examination of the US printing industry. From explanations of the major technologies and new technologies and a look at upcoming industry trends to lists of chemicals used, this book is a good introduction to the technical side of printing. In terms of statistics, from values of exports, to payroll by state, to the number of actual presses of any given type, this book is hard to beat. Unfortunately, the value of these numbers is tempered by their age. Much of the data presented is from the mid-to-late 1980s and is possibly dated by this time.

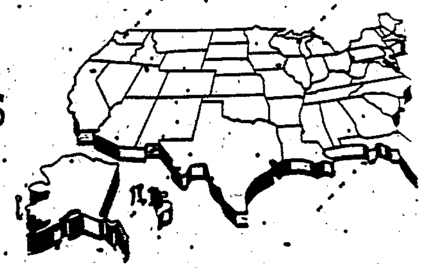
US Printing Industry

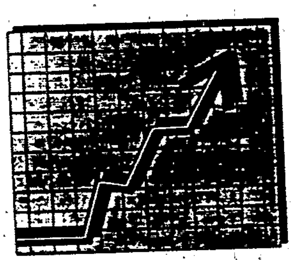
- Employed over 1.5 million people
- ~85% of plants employ <20 people
- Largest group of small businesses in manufacturing sector



- Accounted for shipments of over $136 billion
- Annual payroll estimated in excess of $33 billion
- Lithography, letterpress, gravure, screen, and flexographic account for 97% of market

- Between 70-100,000 printing operations in US
- Nearly 60% located in just 10 states





- Projected growth at 4-5%/year in 1990
- Alternative technologies and processe expected to grow from 3% to 20% ov next 20 years

Source: USEPA

3 Emerging Technologies

Computers and other quickly changing technologies are having a huge impact on the printing industry both at the prepress and actual printing stages. The computer-to-plate (CTP) advances currently are being adopted primarily by lithographic printers.

Prepress operations will continue to change with the development of computer-based front-end platforms that allow creation of entire documents as digital data. Before the advent of desktop publishing, customers would provide printers with a "camera-ready" document that consisted of the actual text and line-art pasted to a special kind of paper ("paste-ups"). With the availability of computer desktop publishing programs such as PageMaker and Quark Express, this mechanical layout is now done electronically and all the customer hands a printer is a computer diskette. Photographs, graphic art, and line art can either be scanned into the document by the customer or printer.

With the ability to electronically image plates, some poteníially large waste generating steps will be eliminated since photoprocessing will be greatly reduced if not eliminated completely.

Press operations continue to change with additional automated features being added to presses. Waterless lithography also continues to be an option for printers adding new press operations. Material substitution for VOC containing fountain solutions, press cleaners, and inks provides the printer with available options to increase the facility environmental "friendliness." Screen printing facilities are adopting and using electrostatic and ink jet technologies. The SGIA is undertaking a study to determine the environmental impacts from the use of these two technologies. It is uncertain, without these studies, to see if these technologies reduce the environmental burden of the process.

Benefits of CTP

- improved print quality, as a result of using first-generation digital data to "expose" the plate
- a reduction in prepress costs, by eliminating film from the production process
- faster publisher closing schedules, allowing advertisers and the editorial staff more time to prepare reproduction materials
- environmental concerns, to some extent, because of the elimination of film and chemicals from the process (Sasso, 1994)
- competitive advantages with opportunities to attract new customers
- business survival (Cross, 1996a)

Drawbacks of CTP

- cost of purchasing new and expensive equipment
- gaining cooperation from the advertising community and vendors to supply materials in digital form to a common set of guidelines and specifications
- changing the mindset of workers

Postpress trends include further automation of all finishing operations as well as the addition of in-line finishing in lithographic facilities. Water-based adhesives have been developed to substitute for some of the currently used solvent-based products.

Annotated Bibliography

Cross, Lisa. 1996a. "Computer-to-Plate: Long Wait, Hot Issue." Graphic Arts Monthly, February 1996, pp 36-42.

A good article describing the current state of CTP technologies and processes. Early adopters of this technology provide their experiences with CTP. A table provides a complete listing of manufacturers of CTP products and descriptions of their systems.

Cross, Lisa. 1996b. "Early Adopters Report Experiences with CTP," Graphic Arts Monthly, May 1996, pp. 65-75.

An informative article with example financial project models used by Dupont Printing and Publishing to calculate return on investment performance for CTP. Also anectodal account by printers currently using CTP.

Cross, Lisa. 1996c. "Dry-Processible Films Recover from Setback," Graphic Arts Monthly, June 1996, pp. 46-48.

This article highlights the current product statistics in the dry-processible film marketplace. It gives first hand accounts of companies who have been using this process and the results they have achieved.

Gibbs, Ron. 1995. "Printing Benefits from New Technologies," Laser Focus World, Nov. 1995, pp 77-82.

A fairly technical article about laser technologies and systems used in the printing industry.

Jendrucko, R.J., Coleman, T.N., and T.M. Thomas. 1994. **Waste Reduction Manual for Lithographic and Screen Printers**, University of Tennessee.

A good introduction to lithography and screen printing with explanations of the primary methods of pollution prevention for these two types of printing facilities.

Sasso, Richard. 1994. "Computer to Plate: Why Wait?" Publishing and Production Executive, December 1994.

This article chronicles the conversion of the magazine *Scientific American* to computer-to-plate technology. All the problems, challenges are presented as well as anticipated benefits to using this new technology.

Shuster, Robert. "The Future Meets the Press," Adobe Magazine, January/February 1996, 42-47.

An informative overview article on what digital presses are and how they're changing the way things are printed. Provides examples of three different types of digital presses, how they differ from one another, and how they are currently used in the printing industry.

Toth, Debora. "CTP Vendors Ask: Which Plate Choice?" Graphic Arts Monthly, February 1996, pp. 61-66.

This article describes the current state of CTP plate materials available to printers and providing information on the current trends in this technology.

Wilken, Earl. "Computer-to-Plate: Framing the Issues," Graphic Arts Monthly, February 1994.

A discussion of the issues that commercial printers who are considering exploring or adding computer-to-plate capabilities to their operations must consider.

4 Common Pollution Prevention Practices in Printing

The composition of wastes from each printing type varies, but overall, source reduction of these wastes will benefit printers by reducing raw material needs and disposal costs, and by lowering the long term liabilities associated with waste disposal. The pressures from government and local citizens to reduce wastes and the emission of pollutants has led to changes in the operation of many printing facilities. Traditionally, pollution control focused on end of pipe controls. Changing this focus to process improvement will help to prevent pollution and promote profits.

Major Wastestreams

The three major types of wastes in the printing industry include:

1. Solid Wastes - In a general printing environment solid waste could consist of the following: empty containers, used film packages, outdated materials, damaged plates, developed film, dated materials, test production, bad printing or spoilage, damaged products, and scrap paper.

2. Wastewater - Wastewaters from printing operations may contain lubricating oils, waste ink, cleanup solvents, photographic chemicals, acids, alkalis, and plate coatings, as well as metals such as silver, iron, chromium, copper and barium.

3. Air Emissions - Printing operations produce volatile organic compound (VOC) emissions from the use of cleaning solvents and inks, as well as alcohols and other wetting agents (used in lithographic printing). Larger plants can be the source of NO_x and SO_2 emissions.

Hazardous wastes, defined and regulated by federal, state, or local governments, can be a subset of any of the three major wastestreams.

This section will provide a general overview of pollution prevention options applicable to any type of printing facility.

How to Reduce Waste

Start at the Beginning-Graphic Design

Waste can be reduced most efficiently from the inception of the printing project through graphic design choices. Preparing layouts that use the most efficient image size to the press sheet size reduces paper waste at the later stages of cutting and binding. Designers should also be made aware of inks containing heavy metal or other hazardous pigments and provided with information on non-toxic alternatives. Other graphic design options to consider include decreasing the amount of ink coverage of the layout and using non-coated, non-bleached paper, and recycled papers.

Job Planning

Thorough planning of the overall job load will reduce wastes. Planning allows for scheduling of the daily runs to reduce color changes and to run inks from lighter to darker. Both techniques reduce heavy cleaning steps. Planning also allows the press operator to prepare only the amount of ink needed for the day's jobs. Using a computer controlled mixing program equipped with a digital scale for weighing inks can help reduce waste. These programs allow the printer to custom mix any ink color from colors already on hand thus decreasing the purchase of new colors and increasing the use of existing inventory. A digital scale makes the entire process more accurate and decreases the amount of ink wasted as a result of "guesstimation" errors. Increased attention to the amount of ink mixed for specific jobs improves material use efficiency.

Best management practices (BMPs) are the most cost-effective way to decrease the amount of waste generated. BMPs require building employee commitment and interest in pollution prevention, as well as managerial support, to encourage participation in pollution prevention programs. This includes careful control of raw materials, practical scheduling, and job management. For example, a good housekeeping and maintenace program helps to ensure that all machinery and processes are working well with no leaking valves, tanks, etc. Wise planning of a print job through the entire process accomplishes the task with a low margin of error, consequently decreasing waste generation.

With any substrate, **consistency is key.** Inconsistent quality of substrates is a major factor in problematic quality of finished product. Once a process is set with the correct inks, paper and machine conditions, changes in the substrate affect all parts of the process. Many ancillary resources are wasted due to inferior and inconsistent substrates. All printing companies need to be vigilant in the identification of quality and consistency of incoming raw materials.

Vendor certification programs on all raw material sources should be strongly evaluated as a tool to help reduce waste. Each supplier needs to know how their products are used in the printing process and the expectations of [illegible] printer so they can recommend process improvements. Developing partnerships with vendors can allow the printer to have access to the technical assistance and experience of each supplier.

Material Handling and Storage

As with best management practices, wise material handling and storage can contribute to less waste generation. These procedures can virtually eliminate wastes from spoilage and improper storage.

By limiting purchasing authority to a specified individual, a company may be able to avoid duplicate purchasing. In addition, a printer could have an environmental manager provide an approved list of materials to the purchasing agent. To avoid unwanted materials that will eventually have to be disposed, the printer can adopt a policy of not accepting any material samples without authorization.

A prime location for waste reduction is in the receiving area. The acceptance of unusable or damaged materials results in unnecessary wastes. All materials should be inspected and the unacceptable goods returned to the manufacturer or supplier. The savings here are twofold, the expense of the damaged goods and their subsequent disposal. Use a first-in, first-out (FIFO) inventory system, check expiration dates and heed storage specifications particularly for photosensitive film and paper.

Proper storage of chemicals should, at a minimum, meet the label specifications. By meeting the required conditions, the shelf life of a chemical can be guaranteed and the likelihood of spoilage decreased. With paper, proper storage will avoid damage from temperature, humidity, and spills as well as physical damage. It may also be necessary to restrict access to the storage area. By reducing traffic flow, damage from dust, dirt, and spills is avoided. All storage areas should be clearly labeled as to content.

Once solvent-based cleaners have been opened, they should be stored safely. Attention must be paid to flammability and flash point. As a guideline, consult OSHA regulations on flammable storage (29CFR1910.106). Clearly written guidelines should be made available for workers on correst usage and storage. Safety precautions such as grounding containers and bonding wires should be considered. These guidelines should be included in all training programs and posted near equipment. All volatile solvents should be stored in closed, airtight containers. If a drum is being used for waste solvent, it is important to cover any funnels or openings. Open waste solvent containers that contain hazardous materials can result in a violation of the open container rules under federal hazardous waste regulations as well as increased VOC emissions (Price 1994, Cross 1989).

Waste Segregation, Recycling, and Reuse

Recycling plays an important role in any printer's waste management program. Materials reported in the literature as being recycled by printers include paper, solvents, ink containers, reusable plate or cylinder boxes, pallets, and sometimes ink. Using returnable/refillable items or large totes, when available, can also cut down on packaging waste. Vendors or suppliers can be requested to provide returnable/refillable containers as part of their contract with the printer.

Cloth cleaning rags/wipes (also called shop towels) covered in ink and solvent can be reused by sending them to an industrial laundry service. It is advisable to remove the majority of liquids by a gravity drain, a wringer, or a centrifugal extractor prior to shipping. Many states now require this step. Use caution in doing this, as the solvents used may be ignitable or flammable. The extractor must be explosion proof. This recovered solvent can be used initially for parts washing, recaptured, then distilled for reuse or sent out for fuel blending. The wipes should be stored in an air-tight, self-closing, flame resistant container marked for recycling.

Contaminated wipes may be regulated as hazardous waste and can be a source of regulatory problems. Also, significant VOC emissions and personnel exposure are associated with press cleaning operations. If the shop towels are laundered, make certain that the towels are being handled properly. Dry cleaning may also be an option for used shop towels. An annual visit to the laundry facility should be part of the waste management program in order to review the handling procedure for your wipes. The printer may need guidance from a technical assistance person on what to ask and how to interpret the answers. Check with the local POTW (publicly owned treatment works) that services the laundry to determine if the laundry is complying with sewerage discharge limits. A written description of how the printer's towels are handled should be requested from the laundry and kept on file. Note that the regulations about shop towels have been changing in recent years. Check with the proper regulatory authorities for the latest statutes.

Solvent recycling can also be done in plants of all sizes. The most common method is to install clearly marked drums on the plant floor. Always make sure that the solvent is actually spent before it is exchanged for new solvent. Do not commit to a scheduled solvent replacement program unless it is proven through in-plant trials that solvent is completely spent after a specifically measured amount of time.

The solvents collected from the cleaning operations and recovered from the rags can be recycled on-site or sent to a professional recycler. Many large firms keep solvent storage baths for each process ink color, thereby allowing multiple reuse prior to recycling. In the cases where on-site recycling is done, companies generally use distillation. Distillation is the boiling off of waste solvent to leave behind a sludge of ink, paper dust, and lint. The vaporized solvent condenses within the still and collected for reuse. It should be noted that all equipment in this process must be explosion proof. A variety of different sized stills are now on the market making this technology applicable to the majority of printers. Some states may require a permit, so check with the appropriate regulatory agency. Each printer will have to crunch numbers to determine if a particular still system is an economically sound option for them.

Alternative Materials

Looking for alternative materials that generate less waste and/or are less toxic in terms of human health, can provide a printer with economic as well as environmental benefits. Searching for alternative materials, however, can be a long-term and often frustrating process requiring continued initiative on the part of the printer. Trials may be required of new chemicals or processes and additional personnel training may be necessary. Working closely with vendors and pollution prevention technical assistance providers, within the constraints identified by the printing client, can lead to useable alternative materials or processes.

Solvents

New solvent alternatives for cleaning are continually entering the marketplace. These materials are made of glycol ethers and other heavier hydrocarbons. The hazard rating of these solvents are low due to their high flashpoints (usually above 140 °F) and low toxicity. The alternative solvents can be used for cleaning all equipment contaminated with ink, while detergent and water can be used for non-ink cleaning. Problems associated with the new low hazard solvents include longer drying times, more difficulty in cleaning, residual film on carriers, and an extremely strong odor. Alternative solvents may have a low VOC content but that does not always guarantee they will have an overall lower human toxicity or REL. Always check the MSDS for this information. However, the most recent releases in alternatives have overcome these problems but workers are slow to accept the products due to the past performance of their predecessors and the uncertainty of changing an accepted practice.

For a successful substitution, unlike with solvent based cleaners, it is important to select cleaners specific to the purpose, the cleanliness goal, or in some cases the type of printing done or equipment owned. The technical assistance provider will have to work closely with the printing facility, especially the press operators, to find the right alternatives for their situation. While environmentally sound, the use of alternative solvents is the most difficult pollution prevention technique to implement from a worker standpoint.

Prepress

Chemical process vendors should contacted when attempting to alter pre-press chemistries. Some alterations in pre-press chemistries that are "home-grown" will result in invalidation of any pre-existing service or guarantee should the in-house chemistry change not work. Often the vendor can suggest ways to help extend the life of their products and will work with the shop as they "experiment" with the best approaches.

Photochemistry

Processes that employ photography in the reproduction of artwork and/or copy can employ a number of techniques to reduce waste generation. Materials used in photo reproduction include paper, plastic film, or an emulsion which is covered with a light sensitive coating. Emulsions are usually composed of silver halide salts including silver chloride, silver bromide, and silver iodide.

After an emulsion (film) has been exposed to light it must be developed. Developing solutions usually contain benzene derivatives, along with accelerating agents (to increase the speed of the developing process), a preservative to control oxidation damage to the developer, and a restrainer which prevents the image from fogging.

The developing action must be stopped in a fixing bath to prevent over exposure. Small amounts of silver enter the bath from the emulsion each time a photographic film is immersed in a fixing bath. To prevent insoluble compounds from forming, fixer must be diluted before the silver concentration reaches the maximum among the fixer can work on. After exceeding this level, these compounds cannot be removed from the emulsion, leaving an often unusable image.

Once the image has been properly fixed to the emulsion, it must be washed to prevent residual chemicals from reacting and damaging the image. In some photoprocessing emulsions, the image contrast must be reduced or increased by additional chemical steps, in order to touch-up the image. Reducers oxidize some of the silver, while intensifiers add silver or mercury to the developed grains of silver in the emulsion.

A variety of techniques can be used to reduce photoprocessing waste generation. For example, in hand-processing, squeegees can be used to wipe off excess liquid to prevent chemical carry-over from one process bath to the next; in color processing, iron-EDTA can be substituted for ferrocyanide bleaches as iron-EDTA is less toxic and eliminates costs associated with the treatment or disposal of toxic bleaches. The photoprocessing department can also reuse rinsewater as long as possible, use fog nozzles and sprays, use still rinsing, use rinse bath agitators, use automatic flow controls, and remove sludge frequently.

Typical wastes generated from the photoprocessing stage include: developed films, acids, alkalis, solvents, spent fixer, silver, waste paper, outdated material, contaminated rinse water, spent developer, and sludge.

Silver Recovery

The most concentrated silver-containing waste in film and image processing is spent or excess fixer bath solution. In film developing, fixer solution is replenished continuously to maintain solution strength. The overflow has varying concentrations of silver, but frequently exceeds 5.0 mg/L. Because of this high silver concentration, silver recovery from the fixer solution is cost effective (Department of Defense, 1995).

When the film is moved from the fixer to the rinse it carries small amounts of silver usually as silver thiosulfate complexes that are very stable. Environmental regulations prohibit discharge of untreated rinse water if the silver concentration exceeds regulatory or POTW limits. Silver recovery technologies include precipitation, ion exchange, metallic replacement, reductive exchange, electrolytic recovery, reverse osmosis, and electrodialysis.

Hydroxide precipitation is commonly used to recover metal-laden solids from wastewaters. Silver is frequently precipitated from metal wastewater as silver chloride. Sulfide is also widely used to precipitate silver, both free silver and silver sulfide, but the chemical costs, the need for supplemental heat input, and labor costs make it a relatively costly technique.

Electrolytic silver recovery applies controlled current in an anode-cathode array to remove silver from the wastewater solution. Silver is removed in nearly pure form, but capital costs and lower treatment efficiency (effluents have 100-200 ppm silver) must be considered. Electrolytic and metallic replacement systems are sometimes used in series to reduce the silver concentration in the effluent.

Metallic replacement involves using iron steel wool to react with silver thiosulfate in the wastewaters, whereby the iron replaces the silver in solution and the silver settles out as a solid. The silver is recovered as a sludge of silver salt compounds, which is more difficult to recover than electrolytically reduced silver flake, the chemical recovery cartridges cannot be reused, and the effluent contains high iron concentrations. The advantages to this method are relative low cost and availability, and that no special energy or plumbing connections are needed. Metallic replacement is usually used in conjunction with electrolytic recovery as a polishing step.

Silver removal by ion exchange is accomplished by passing the wastewater through a mixture of anionic exchange resins, or by using a strong base gel anion resin to selectively remove the silver. Automated ion exchange units are usually only practical for larger processing facilities due to their high cost. It is also essential that the correct resin be chosen for efficient operations. The printer, technical assistance provider, and vendor will need to work together to determine the best resin to be used.

Reverse osmosis uses high pressure to force liquid solutions through a semipermeable membrane, separating larger molecular substances from smaller molecular substances. Up to 90 percent of the silver thiosulfate complexes can be removed from wastewaters using this method. Also, reverse osmosis is effective in removing most other chemicals in solution, including color couplers and ferrocyanide, rendering the water suitable for reuse in final rinses. The disadvantage of this method is the high capital investment required.

Silver recovery technologies can result in a net positive economic return because of the metals recovered and the reduced waste disposal costs. Large firms will sometimes make a capital investment to purchase an automated recirculating system which includes silver recovery, waste recovery, and chemical replenishment. These will remove large percentages of silver as they will be able to treat the low concentration rinse waters as well as the higher concentration process waters.

Alternative Prepress Technologies

Electronic imaging and laser platemaking allow text and photos to be edited on a video terminal and color separations to be prepared electronically. This eliminates the need to photograph, edit, re-shoot, and photoprocess several times (Price 1994). Vesicular films that contain silver and diazo films have been used traditionally, but photopolymer films that are now available use carbon black as a substitute for silver, which eliminates the need to send the waste film to a metal reclaimer. Electrostatic films are also silver-free and have resolution and speeds comparable to silver films. However, these silver-free films are not being widely used. Reducing wastewater generation can be accomplished with counter-current washing, or reusing rinse water in the initial film-washing stage, rather than using fresh water at each stage (Price, 1994).

Press

Mechanical Modifications

Improvements and/or modifications to existing printing equipment may be a suitable choice in a pollution prevention and waste reduction program. Changes to press equipment such as automatic registration systems, ink viscosity measuring systems, revised ink pans, revised ink pumping systems, new doctor blade technology in gravure and flexo printing and vapor recovery systems can go a long way in improving the manufacturing processes.

Ink viscosity measuring systems cannot only control the viscosity of the inks to ensure quality printing but can prevent excessive use of solvent thereby reducing the potential pollution. Changing the design of ink pans to a shallower depth on a lithographic press can reduce the amount of ink needed in each printing station and reduce waste ink as a pollutant.

Web break detectors can reduce waste by informing the operator of breaks without creasing or smearing the web. These non-contact electric systems detect web breaks and inform operators to stop production or automatically shut down the presses without damage to the equipment. Installing an ink agitator or an ink leveller on the ink tray or sump to prevent premature oxidation can reduce ink waste and spoilage. UV light can reduce algae, water borne fungi and bacterial growth in fountain solutions, further reducing waste solutions.

Automatic registration systems are available in several different types and styles. Registration is the precise fitting together of two or more printing images on the same paper in direct alignment with one another. These systems allow the press crew to check and maintain quality registration and high press speeds resulting in less waste and improved process output. With the ability to bring jobs into register quicker and keep them in quality register longer, less inks, solvent and substrate are consumed or wasted. For web-fed presses the consideration of automatic splicing may be evaluated. Using this process improvement will reduce the waste of inks, solvent and paper as well as avoid slowing down press speed.

Installing automatic lubrication systems on the critical rollers, bearings and gears will reduce waste and conserve resources. Self contained lubrication systems which are properly maintained can prevent contamination of the lubricant and extend its useful life.

Other methods to reduce waste involve careful attention to operating parameters and instrumentation: installing automated plate benders, optical scanners to lock onto registration marks, automatic key settings, and ink/water ratio sensors. Another technique for sheetfed printing is to use both sides of the make-ready paper, slipping in clean sheets periodically in order to check registration and print quality.

Quicker make-readies and changeovers can reduce the amount of raw materials that are consumed in getting to the press ready stage. Efficient and effective scheduling plays a major role in how printing companies can reduce waste and practice sound pollution prevention. Constant scheduling changes will adversely affect the best of programs.

The newest printing technology is "computer-to-press," currently available for lithographic sheetfed print. This technology eliminates all wastes associated with prepress photoprocessing wastes. This and other equipment is available from local equipment vendors and increasing numbers of manufacturers are entering the marketplace.

During cleaning operations, equipment can be introduced which will reduce wipe and solvent usage. The least technical of these is the employment of squeegees to remove excess liquids from equipment. This in turn will reduce the quantity of wipes required. Automated cleaning systems can further reduce residual liquids and in turn reduce cleaner consumption. Some examples of these systems are an automated blanket cleaner, roller wash-up blades, and ink blades. The choice of equipment is dependant upon the type of printing operation. Any new equipment will require training of plant personnel as well as their cooperation in changing their working methods.

Inks

Alcohol- and petroleum-based ink systems use various solvents that are major contributors to pollution. However, these alcohol and oil-based systems allow for faster press speeds then some of the alternatives currently available, longer cylinder wear and (occasionally) better ink transfer to various substrates. Effective solvent recovery systems are needed to develop, implement and maintain sound pollution prevention programs when using alcohol and oil-based systems. Solvent recovery systems can be internal or external. On-site batch distillation systems can be used when justified by volume. Off-site professional solvent recyclers can be an alternative to reclaim solvents.

Recycling Inks

Inks have traditionally consisted of colored pigments and a vehicle or carrier for printing fluidity during application and subsequent pigment binding. Inks are perhaps the most important aspect of the overall process because different ink formulations bestow distinct characteristics to the product and thus affect its performance in relationship to the other press elements. Prior to the mid 1970's most colors in inks were produced by using metals. These metals were often present in amounts that exceeded state and federal regulatory limits, thus rendering the waste ink hazardous. In recent years, ink manufacturers have developed organic color replacements which are not as heavily regulated as their inorganic counterparts. Unfortunately, even if waste ink does not test hazardous, it may require disposal by a licensed hazardous waste management company. Individual states and their industrial waste requirements differ as to whether these petroleum-based materials require special handling.

Some waste ink can be recycled through an ink recycling service or in-shop. Blending colors usually requires some additives such as toner to fine tune the color quality. Recycling allows blending several colors together into darker colors for reuse. Equipment is currently on the market with a wide range of capabilities to filter and distill waste inks. The recycled ink compares favorably to new ink in tests for grind, residue, viscosity, tack, water content, and water pickup. On site recycling has been found to produce satisfactory final products. For large quantity generators there are recyclers who bring mobile recycling units on site to recycle ink, mixed or color separated. By recycling on site, the legal liabilities and regulatory paperwork associated with off-site recycling and disposal can be avoided. Colors can be produced very similar to new inks. Press operators can adjust the ink/water balance and produce results comparable to new inks without experiencing trapping problems. Trapping is the ability to print a wet ink film over previously printed ink. Ink recovery machines currently on the market in a wide range of capacities make on-site reclaiming a viable option for larger printers.

Alternative Inks

The correct selection of alternative carriers can reduce the amount of waste ink generated without compromising product quality. Ink choice is dependent upon the print process, the substrate, and the ultimate end use of the product. In lithography, for example, petroleum-based inks can be substituted, depending on the application, with EBC (electron beam curable), ultraviolet curable, soy/vegetable, water-based, and/or waterless inks.

Ultraviolet (UV)

Ultraviolet systems consist of a photo-polymerization process that uses mercury vapor lamps for UV photoinitiated monomer inks. This method has high initial costs, high ink/coating costs, low energy costs, and has no hydrocarbon emissions. The driving force to use UV systems is low VOCs. High quality radiation and optimum spectral distribution are the keys in perfecting the use of these systems. There is a wide range of UV-ink "chemistry" available for adhesion to popular substrates in flexographic and screen printing. UV in flexographic printing offers good resistive properties and economical curing or drying. (Rudolph, 1991)

UV-curable inks are widely used in the printing industry for printing primarily on plastic, vinyl, metal and paper substrate. These inks contain low VOCs. Instead, curing is by ultraviolet light-induced polymerization. These inks will not dry on a press or in ink fountains so cleaning requirements may also be reduced. Some reported advantages of UV curables include:

- decreased or eliminated VOC emissions
- less frequent press cleaning and associated solvent use
- reduction in required floor space (eliminates need for drying ovens or racks)
- increased throughput
- elimination of ventilated storage of sheets during oxidative drying
- can be used on web and sheetfed presses.

On the negative side, the following barriers have been reported by screen printers using UV curables:

- performance is not always as good (insufficient opacity and color matching)
- substrates with deeply textured surfaces are not currently suitable for UV-curables
- outdoor durability may be a problem
- UV curables are brittle and finishing operations like die cutting and molding present problems
- a significant capital investment is needed for conversion to UV systems
- small printers may not experience the increased production speed and ink cost/coverage benefits due to shorter average runs (Jendrucko et al, 1994)
- ink costs are often higher
- recycling problems may be encountered with substrate printed with UV inks.

Electron Beam Curable (EBC)

EBC inks consist of low-molecular weight polymers that react with a stream of electrons from a vacuum tube. These inks contain no solvents, and do not cure until exposed to light and may therefore remain in ink fountains for long periods of time, reducing clean-up needs. The electrons drive the reaction, forming polymers and setting the ink. Problems reported with EBC inks include paper degradation and worker exposure to X-ray.

Electron beam dryers use polymerization by electron bombardment to dry liquid and powdered coatings. These dryers have high initial costs and low to moderate operating costs. They are sometimes used for higher gloss coatings and metal decorating applications.

Vegetable Oil-Based Inks

Vegetable oil-based inks are used only in the lithographic industry. Soybean oil inks can replace 20 to 40 percent of petroleum based oils in ink. The soybean oil replacement is said to reduce volatile organic compound content by as much as 80 percent. This advantage is somewhat limited due to the continued use of solvents for cleaning. The soybean oil inks are more expensive than petroleum inks and require somewhat longer drying times in non-heatset applications. The drying times can be shortened by the installation of custom dryers or power sprayers.

Benefits of soy oil-based inks are: VOC emissions into the atmosphere can be reduced on heatset presses because the VOC content of soy oil-based ink is potentially lower than traditional petroleum based inks (based on the percentage of soy oil in the ink); press washes for soy oil-based inks can be water/detergent types, thus reducing or eliminating the need for high VOC solvent formulations; less paper waste from quicker start-ups, as water and ink balance is reached more easily; and spoilage during runs from color or variation in tracking is minimized; quicker and more even ink coverage to the press blanket is achieved. Soy oil-based inks have exceptional transfer properties, minimizing plate scumming. Brighter colors and darker blacks are produced, because soy oil-based inks have greater color retention than do traditional petroleum-based inks. The disadvantages are: longer drying time, ink sitting up on the paper, cost, and substituting other chemicals for the petroleum-based ink processes requires operator adjustment and training.

Water-Based Inks

Water-based inks, while more environmentally sound in that there is little need for petroleum-based solvents in the printing process, have several problems associated with in-plant usage. The most noticeable of these is the significant increase in chemical additives required. It will necessitate the training of workers in basic chemistry and during this period the likelihood of costly mistakes is high. If incorrect chemicals or solvents of any kinds are mixed into a waterbased system, the ink will curdle. Surface tension of the water-based ink is high and therefore reduces the transfer efficiency of the ink to substrate. Water-based ink also tends to foam when pumps are running. Another problem with the water-based system is a somewhat limited color choice. Water-based inks require increased energy for drying and there are occasional difficulties in ink spread. Paper curl and shutting down of presses for short periods of time for more frequent cleaning all contribute to the difficulties in using these inks. Another disadvantage is that dried ink on the press and rollers can be very difficult to remove.

Water-based inks, however, do have several advantages. They are 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.

The best applications for water-based inks are in flexographic printing, gravure printing, as well as textile screen operations. Both low solvent and 100 percent water-based inks are available. Non-VOC containing cleaners can also be used. Inks may still contain heavy metal pigments that may be required to be disposed of as a hazardous waste, however substitutes for these inks are available and should be used. Testing of the ink waste should be done to determine whether it needs to be classified as hazardous or not. De-inking of material printed with water-based inks may be difficult.

Process changes will occur when using a water-based system compared to alcohol- and solvent-based ink systems. There are manufacturing tradeoffs that need to be evaluated when using water-based systems in comparison to the cost of solvent recovery systems.

Water-based ink systems may not allow the same press speeds to be maintained due to the need for extra drying capacity. Because there are no solvents that evaporate and help dry the inks, the water-based inks must be heat-set and dried in various types of ovens. Generally water-based ink systems are run through ovens that are 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. Sometimes the press ovens can be changed and lengthened between the printing units to provide a longer drying time in the printing process. When the total length of a press is critical, ovens may be extended by going upwards over each printing unit. Gas ovens that cannot be lengthened to allow the substrate to stay in the drying area longer may be modified. One method would be to add infrared dryers to the oven to help in the drying process. Another method might be to change the oven configuration and baffle design to produce the maximum drying capabilities of each oven.

Water-based inks are capable of receiving various additives that assist ink drying, ink holdout, ink laydown and printability on various substrates. These additives are used by the press crew in different ratios and formulas depending on the desired finished product. Complete water-based ink systems do not have the vapor recovery concerns that the alcohol and solvent-based ink systems have. This might be a strong consideration to evaluate water-based ink systems. Press speeds should be evaluated in the complete cost of each type of ink system.

Waterless Inks

Special lithographic presses or re-fitted presses are needed to run waterless inks and special plates. exposure methods, and plate handling techniqes need to be employed when waterless inks are used.

Waterless inks are high viscosity inks with characteristics similar to petroleum based inks. The major difference in these ink systems is a resin which produces high viscosity, but requires exact temperature controls. The temperature must be controlled with a three stage refrigeration unit. A waterless system requires a high initial capital investment and careful monitoring during operations.

If the printer has an experienced press operator willing to learn about proper mixing of ink with dryers, ink could be purchased without incorporated dryers: Dryers can then be added by the printer only as needed. Purchasing inks without dryers and adding them when the color is mixed will reduce the amount of waste skins.

Operator experience can also be a factor in the success of waste reduction. An inexperienced press operator will often mix more colors than necessary to achieve the desired specialty color. For a new employee, using a digital scale whenever measuring ink will improve accuracy. Planning ahead and using the fewest mixing colors will reduce the amount of waste skins needing disposal.

Once the ink has been mixed, the use of an anti-oxidant spray will prevent ink skinning in the fountain. These substances are physical barriers to oxygen, and inhibit the drying reaction. Once the press is running, the anti-oxidant "burns off" on the ink roller, greatly reducing or eliminating its effect. The inks can then dry on the substrate. A potential drawback is the same ink in the fountain may be wasted during start-up because it doesn't perform as well a non-treated ink.

Cleanup

Care should be taken to not use more solvent than is necessary—only the bare minimum needed to do the job should be used. Reuse the solvent if possible. The reuse of inks and solvents not only prevent pollution through effective use of resources and materials, but can reduce costs. Depending on the job, if solvents are needed to clean press parts, consider using recovered solvents. Solvent tanks and containers should be kept closed to prevent evaporation and emissions.

Changing from high VOC content cleaning compounds to compounds with low or no VOCs will reduce air emissions. For short print runs, more VOCs are usually released from evaporating press cleaners than from the inks themselves. Segregating and reusing solvent will extend the life of these materials. Installing an on-site solvent distillation unit for solvent recovery can stretch the useful life of the solvent even further. Such a unit may need appropriate permits as well as trained personnel and a capial investment. It is also recommended that aerosol products be replaced with manual pump bottles, especially if the product can be bought in bulk and small containers refilled.

Several simple procedures can reduce the quantity of solvent used for press-side cleaning and the associated VOC emissions:

- Minimize the solvent applied to a rag by using plunger cans or squeeze bottles.
- Use press wipes as long as possible before discarding. Use soiled wipes for the initial pass and clean ones for the last.
- Store used solvent-contaminated rags in sealed, fireproof containers labeled "contaminated shop towels" to avoid solvent evaporation and a safety hazard.

Another alternative may be the use of low vapor pressure solvents. While they may have a high VOC content, they evaporate at such a low rate that less solvent is used.

Parts Washers

If parts washers are used to perform maintenance on press parts, use solvents not characterized as hazardous (ignitability: flash point < 140 F) or that are not listed wastes when spent. Install a filtering mechanism in the parts washer to extend the life of the solvent. A solvent still may be an option to reduce the waste and recover/reuse the solvent for the parts washer.

Postpress

Finishing operations may include final trimming, die cutting, folding, collating, binding, laminating, embossing, and assembling operations. Binding methods including stitching (stapling), gluing, and mechanical binding. The primary wastes are binding and laminating chemicals, and scrap paper (Price, 1994).

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Campbell, M.E. and W.M. Glenn. 1982. "Printing" in *Profit from Pollution Prevention: A guide to Industrial Waste Reduction and Recycling*. Pp. 201-217.

This chapter, which is part of a larger document, gives an overview of the printing industry and the processes involved in the printing. Pollution prevention opportunities discussed include general housekeeping and process control, conserving photosensitive materials, platemaking, inks (types, wastes, and curing), and dirty rag recycling. Brief case studies are included for many of the pollution prevention opportunities discussed.

Legnetti, P. 1992. Sucess stories in ink, paint and plastics applications. First annual Conference for Southern States on Hazardous Waste Minimization and Environmental Regulations, Sept. 22-24, 1992.

This article discusses the progress that has been made in developing environmentally acceptable pigments. Replacements for lead chromate, barium, and cadmium are listed.

Lewis, B. 1994. The Absence of Waste and Beyond. FLEXO p.19-22

This article focuses on the advances in the printing industry and how business and manufacturing principles such as just-in-time and total quality management are being adopted into the industry.

Alternatives to Petroleum- and Solvent-Based Inks. 1994. Fact Sheet 6. Massachusetts Toxics Use Reduction Institute.

This fact sheet covers all the substitute inks available for lithographic, flexographic and gravure printing, including radiation-curable, vegetable oil, and water-based inks. It includes a very comprehensive table that gives the applications, benefits, operational advantages and disadvantages, cost, product quality, and limitations for each alternative.

Moore, T. 1994. Electrotechnologies Cures Inks and Coatings in a New Light. EPRI Journal Dec 1994, p. 24-29.

This article covers applications for ultraviolet and electron beam curing for specially formulated inks and coatings, and focuses on replacing gas-fired convection drying ovens with these electrotechnologies to achieve gains in productivity, environmental compliance, and save energy.

Price, R.L. 1994. Printing & publishing industry pollution prevention and recycling. Center for Hazardous Material Research (CHMR) 530-4296-000.

Student manual prepared for the Illinois Environmental Protection Agency. This manual gives the history of the printing industry, and statistics about Illinois printing establishments. Each of the printing processes are explained and diagramed. The common pollution prevention and waste reduction opportunities are explained.

Rudolph, A.C. 1991. UV-Flexo et al. TAPPI Proceedings Polymers, Laminations & Coatings Conference 1991.

Advances in inks, and curing and printing processes have facilitated the break through of UV-curing technologies. The process of UV-curing, along with its advantages and constraints are discussed.

Stowe, Richard W. 1991. Ultraviolet curing and recent advances. Polymers, Laminations & Coatings Conference. TAPPI Proceedings 1991: 9-15.

The basics of UV curing are presented, along with recent advances in the development of UV materials in flexographic printing and silicone release coatings cured with UV lamps.

US EPA. 1990. Printing and Allied Industries. EPA/530-SW-90-027. 4 pgs.

This is a short document that lists materials used, including the chemical components, and hazardous wastes that are potentially generated for each of the processes part of the typical printing operation. Readers are referred to the RCRA/Superfund Hotline for further information.

US EPA. 1990. Guide to Pollution Prevention: The Commercial Printing Industry. Office of Research and Development. EPA/625/7-90/008.

This document gives an overview of the commercial printing industry and waste minimization assessment procedures and methods. Waste minimization assessment worksheets are given, along with case studies, and a listing of organizations/agencies that can provied further help. This document is identical to the Guide to Waste Minimization in the Commercial Printing Industry by USEPA RREL and California Dept. of Health Services and Toxic Substances Control Division (also reprinted by the Hazardous Waste Research and Information Center, Champaign, IL).

Virginia Department of Waste Management. 1991. Virginia Waste Minimization Program. Opportunities to Reduce Waste Generation: Printing Industry. Report 27-1, March 1991.

This document was developed as a component of outreach services to Virginia waste generators and includes the results of a survey of 14 printing companies to ascertain the waste reduction potential of Virginia printers. The document includes industry profile, current VOC regulations and hazardous waste codes, waste summaries for Virginia generators, waste minimization techniques, operational costs to consider, and potential barriers to implementation. Case studies in source reduction and recycling are given. Information about the companies surveyed is included.

Places to Look for Waste Reduction in the Printing Industry

Good Housekeeping

- keep hazardous wastes segregated from nonhazardous wastes and nonhazardous from each other to increase opportunities for recycling
- do not allow personal caches of hazardous materials (e.g., cleanup solvents) and establish satellite accumulation points for hazardous waste
- check for and repair all leaks and spills from equipment
- keep shop clean and orderly to prevent accidents and spills
- use spigots or pumps when dispensing new materials and funnels when transferring wastes to storage containers to reduce spills, keep lids, bunges, and cans closed
- maintain spill kits and instruct all personnel on their location and proper use
- consider secondary containment where appropriate

Waste Accounting

- collect accurate data on waste and emissions generation from each source/press
- establish accountability for waste generation and provide incentives for reduction
- provide feedback on waste reduction performance to employees

Inventory

- order and manage materials to minimize products going out of date and becoming a waste
- use "first in, first out" inventory policy
- centralize responsibility for storing and distributing solvents
- use returnable containers and returnable plastic or wood pallets and buck totes
- require that all potentially hazardous product samples be pre-approved and require vendor to take unused portion back
- materials with expired shelf life should be tested for effectiveness before discarding
- materials should be inspected when received and off-specification or damaged materials returned immediately to the manufacturer or supplier
- store inks according to manufacturer directions to prevent skinning and drying and in locations that will preserve shelf life
- order materials in bulk containers that are returned to the supplier for refilling, if practical
- keep lids on containers to reduce evaporation or spillage and to prevent contamination with water, dirt or other materials

Photochemicals

- install floating lids to exclude air and reduce evaporation and contamination. This can double the life of the solution.
- to reduce the amount of oxidation of developer solution add glass marbles to bring the liquid level up to the brim each time the liquid is used. This will extend the chemical's useful life and the life of the bath.
- extend lives of photo and film developing baths by adding replenishers and regenerators (detailed description in Jendrucko, 1994)
- reclaim and recycle silver from wastewater
- keep sensitive process baths covered to prolong potency
- squeegee chemicals from films or plates to minimize cross contamination
- use squeegees to wipe off excess liquid from film and paper in non-automated or tray developing operations
- increase use of electronic imaging when practical
- recycle used photographic film and paper
- always follow the recommended storage conditions for photoprocessing chemicals and film to increase shelf life
- use countercurrent rinsing to reduce process solution contamination and water usage (i.e. using dirty solvent for initial cleaning and clean solvent for final cleaning) also in photoprocessing

Platemaking

- use presensitized plates that are processed with water or bimetallic plates if chemistry is recycled
- use laser plate-making with an electronic imaging system
- eliminate once-through cooling water for compressors by reuse/recycling
- reduce drag-in of contaminants, reduce drag-out of solutions by adding dripboards and extending drip time
- use nonhazardous developers and finishers
- increase use of direct-to-plate technologies that allow preparation of plates from computer images without intermediate steps, i.e., replace the current image-making operation with a "computerized electronic prepress system" for type-setting and copy preparation
- sell used and damaged plates to an aluminum recycler

Alternative Materials

- use inks that reduce VOC emissions: e.g., vegetable-based; water-based; ultraviolet; and electron beam drying where applicable

- switch to ink with pigments that do not contain hazardous heavy metals.
- eliminate or reduce alcohol in fountain solutions
- consider using waterless offset printing, if possible for the particular printing process
- use non-hazardous, low- or no-VOC solutions to clean equipment
- use alternative fountain solutions in lithographic printing (low or no-IPA)

Printing

- use standard sequence on process colors to minimize color changes on presses, i.e., schedule production of the lightest color batch first so that cleaning rinses can be used for subsequent batches
- run similar jobs back to back to reduce waste generation between cleanup and start of the next run
- fill ink fountains only enough for a particular run or shift. Return all unemulsified inks to their containers. Install automatic ink levelers to keep ink fountains at their optimal level for good print quality in large web presses.
- dedicate one press for inks with hazardous pigments or solvents
- dedicate presses for specific ink colors, if feasible
- improve quality control to reduce rejects
- improve accuracy of counting methods, reducing excess quantities printed to accomodate inaccuracy
- use web break detectors and automatic splicers
- use refrigerative cooling to reduce evaporative losses of fountain solution
- reuse waste paper or collect for recycling (if sheetfed, print on other side)
- clean ink fountains only when changing colors or when the ink might dry out between runs to reduce waste ink generation. Fountains can be left with ink overnight if sprayed with special non-drying anti-skinning materials.
- use solvent hoods to recapture solvent losses from presses
- recover solvents with an on-site distillation unit

Cleanup

- segregate and recover spent solvent according to color and type of ink. Reuse to thin future batches of the same ink
- use dry and non-solvent cleaning procedures when feasible
- use automatic blanket washes
- use high-pressure washing equipment to reduce amount of waste water generated in screen printing

- improve operating practices for efficient press clean-up
- use cloth towels which can be cleaned and reused
- reduce clean up waste by cleaning ink fountains only after a color change, if you are running color sequencing (light to dark) you shouldn't have to clean the fountain
- wring or centrifuge used cloths to recover solvent before laundering and reuse solvent in parts washers or for additional press cleaning
- squeeze excess solvent out of used towels. Collect and reuse the liquid for initial cleanup with dirty rags, followed by clean solvent on clean rags for final cleanup
- avoid soaking cloths in solvent; use plunger or squeeze bottle to dampen cloth with only what is necessary to complete the task
- utilize parts washing equipment with recirculating solvent as an alternative to towels for cleaning the trays that collect the solvent and inks below each press roller.
- a stream of solvent can be used to wash ink waste to one end of the tray where a hole fitted with a hose allows solvent to drain into a container, which can then easily be transferred to the storage drum.
- use cleanup solution with lower VOC content and lower vapor pressure
- provide marked, accessible containers for segregated collection of used solvents, if feasible
- use an on-site distillation unit for solvent recovery
- use less toxic cleaning solvents or detergent solutions instead of solvents
- avoid cross-contamination of cleaners
- set up an in-house dirty rag cleaning operation if quantity of rags warrants, or send out to approved industrial laundries, if available
- squeegee excess ink off equipment before cleaning
- use squeegees to wipe off excess liquid in a non-automated film processing system and to minimize process bath contamination. This prolongs bath life, reduces the amount of replenisher chemicals required, and makes the bath more easily recycled.
- increase cleaning efficiency by maintaining press clean-up equipment
- save old inks and consider reusing as house colors

Waste Inks

- carefully label and store special-order colors for future reuse
- mix to make black ink for internal or external use
- recycle after processing
- donate for reuse by printing schools or others
- control inventory and buy only as much ink as needed for the near future
- scrape or drain ink and mixing containers before disposal
- remove ink from stir sticks, adhesive tape and screen using a scraper or spatula instead of

using solvent and shop towels. Return excess ink to the original or waste container. Use reusable stainless steel, plastic vs. wooden stir sticks. Wooden stir sticks can absorb additives and solvents and degrade ink quality if left sitting in cans of ink.

- return excess ink to supplier whenever possible

Finishing

- use water-based adhesives rather than solvent-based, if appropriate
- minimize coatings and adhesives that hinder recycling
- reduce paper use by selecting properly sized paper and recycle waste paper and cardboard
- use mechanical binding methods instead of glues or adhesives, if appropriate

List other ideas below for future reference

5 Lithography

Overview

Lithography dominates the U.S. printing industry, accounting for as much as 50 percent of all conventionally printed materials. Approximately 85 percent of these printers employ fewer than 20 people. There are two types of lithographic printing: sheetfed and web. Sheetfed presses run individual sheets of paper through the press, while web presses feed paper continuously from a large roll and can use either heatset or nonheatset inks. Once the image is printed onto the substrate, the paper is either fed back onto a roll or cut and/or trimmed into specific shapes and sizes. Web lithography is designed to print large jobs and is used for newspapers, books, catalogs, periodicals, advertising and business forms. Sheetfed lithography is used mostly for short runs of books, periodicals, posters, advertising flyers, brochures, greeting cards, packaging and fine art reproduction.

Preventing pollution at the source may be achievable at each production step used in lithographic printing. To begin evaluating and implementing pollution prevention opportunities within the printing process, principal input materials and processes need to be outlined. The principal materials used in lithographic printing are inks and paper substrates (Figure 6). Additional input materials are photographic films, photoprocessing chemicals (developers, fixers, wash baths, reducers and intensifiers), printing plates, plate processing chemicals, fountain solutions, cleaning solvents, correction fluids, rags and water.

The lithographic process can be divided into four major steps: prepress, makeready, press, and post press. Prepress operations involve a series of steps for which artwork or design for the printed image is converted onto an image carrier--the printing plate. During this step raw materials such as photoprocessing chemicals and solutions are used. This process continues to change as digital prepress, with computer transfer of digitized images, replaces much of the photographic process and related wastes.

Makeready are the steps taken to prepare the press to print. This involves attaching printing plates to the press; adding ink and fountain solutions to each print unit; testing the press to make sure the image is aligned properly (registration); and, printing according to customer specifications. While essential, paper, inks and solvents used during makeready are basically all waste. Anything done to reduce makeready saves time, money and reduces waste.

The press step is the actual printing operation in which inks, cleaning solvents and substrates are used (Figure 7).

Postpress involves any finishing work performed to the printed product. This includes any cutting, trimming, binding by gluing or stitching, and final packaging. This step may use large amounts of binding and/or tape and adhesives when producing books, directories, and pads. A specific look at each step in lithographic printing process follows.

Prepress

Prepress includes all the steps involved in getting the printing plates ready to be mounted on the press. In the image processing step, the material to be printed, whether a "camera-ready" paper copy or an electronic version, is converted to film images. Pollution prevention for this step involves techniques and technologies used in photo processing operations. Wastes generated from image processing include empty containers, used film packages, used film, outdated materials and chemicals, spent fixer solution containing silver, spent developer solution, and waste rinse waters. Color separations for the four primary colors (yellow, magenta, cyan and black) are also done in the prepress stage.

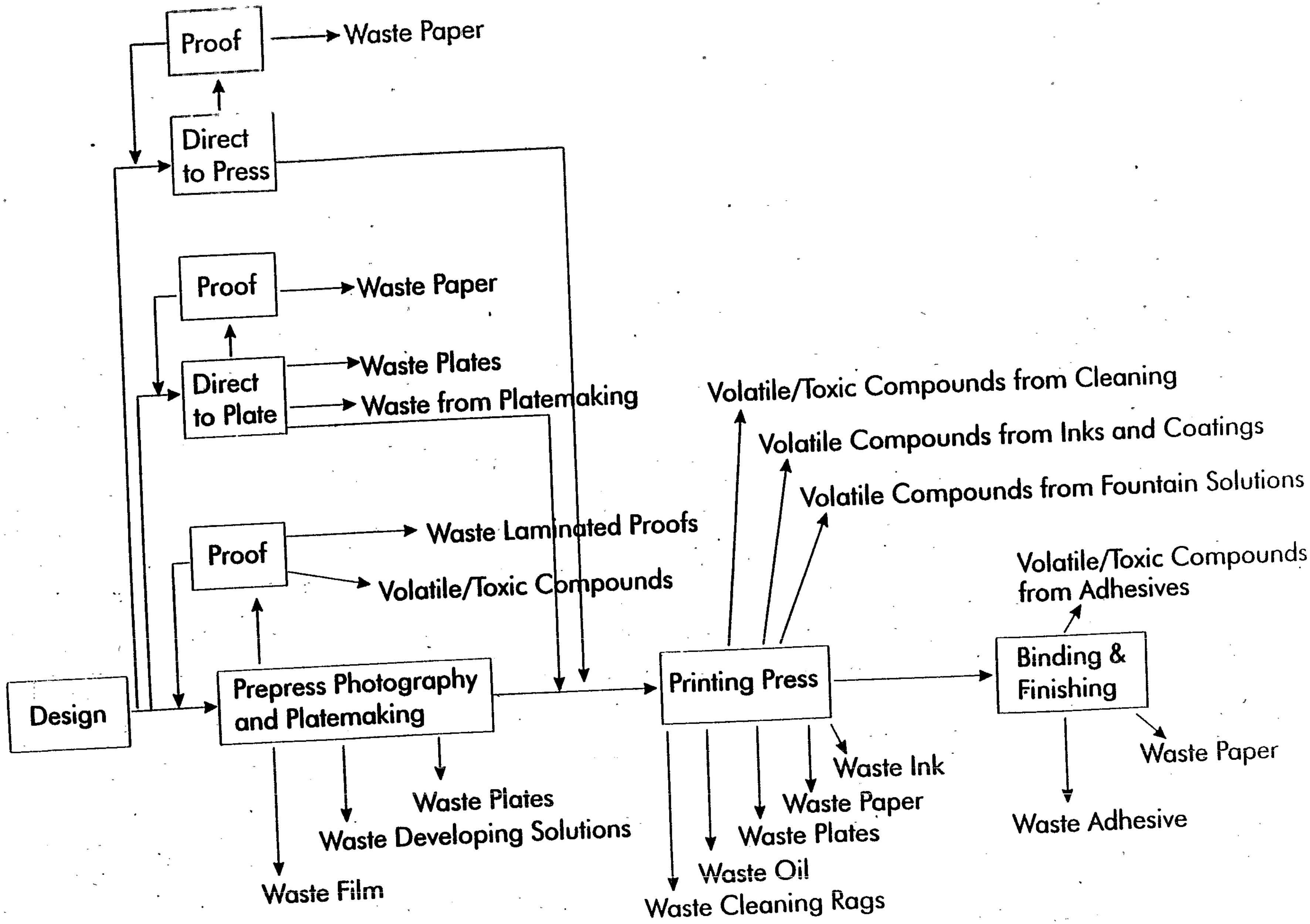

Figure 6. Typical Lithographic Printing Process and Principal Releases to the Environment
from: Anderson, C.L. and Epstein, L.N. "The Great Printers Project," Pollution Prevention Review, Summer 1996, p. 47.

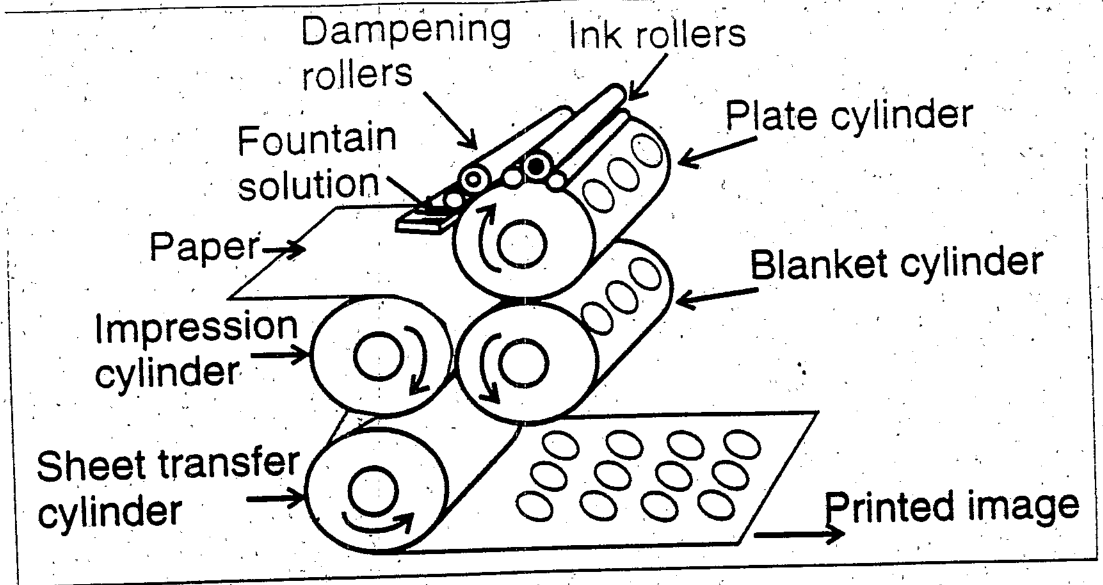

Figure 7. Principle of Offset Lithography

Most printing operations begin with artwork and/or text. The "camera-ready" is the final copy of the materials from which the printer will make the film used to image the printing plates. Prior to the use of electronic desktop publishing, these camera-readies involved gluing or waxing the back of the art and text to another sheet of paper. This board was then photographed. If any errors were detected after this step, the board would be corrected and re-shot. This process is still in use, but is being replaced by electronic imaging.

Electronic imaging allows text to be edited and digitally manipulated on a computer screen to also reduce waste generation in the prepress stage. The image is scanned or created with digital cameras. The cameras digitize the image and then send it to a computer for editing. After correction, the master copy is saved to a disk file. Color separations can also be prepared electronically. This reduces or eliminates the need to photograph, edit, re-shoot, and repeat photo processing. The advantage is the elimination of a labor intensive and time intensive process involved in the manual layout and color separation for the film. Once the film has been developed and proofed (checked for accuracy) it is sent to the plate making operation.

Photo Processing

As previously noted, lithographic printing employs photography for the reproduction of artwork and/or copy. The materials used include paper, plastic film or emulsion. Emulsions are usually composed of silver halide salts, including silver chloride, silver bromide, and silver iodide.

One of the major areas for waste reduction in the printing process focuses on photographic chemistry management. The three separate processes of photo processing include developing, fixing, and washing. Many methods exist to better manage the raw materials used, reclaim valuable raw materials from the process such as silver, and to extend the life of the chemical baths. Additional help for assisting printers in reducing waste in their photo processing labs can be obtained from vendors. New prepress processes are regularly being brought to the market. Some printers are installing automated recirculating silver recovery (fixer), water recovery and chemical replenishment systems.

Proofs

Proofs are made from the film produced in the initial photo processing step described above, to compare the press image to the customer approved artwork and act as a final check prior to making the printing plates. The proof will show whether all images are in line (registered), whether the color is right, and how the final printed image will appear. Most proofing is now done electronically. All major prepress manufacturers produce proofing systems that come in solvent and the newer aqueous-based models. Proofs are made because the platemaking step will affect tone reproduction. Proofs are also used to check camera and scanner separations and correction in color printing.

Plates

There are a number of different type plates used in lithographic printing: photomechanical, electrostatic, bimetallic, relief, paper, and polymer plates. Photomechanical surface plates are most common. They are made from thin anodized or grained aluminum coated with a light-sensitive material. The most common plate coatings are diazo compounds and photopolymer resins, although asphalt, shellac, gum arabic, and polyvinyl alcohol are also used. An image transparency is placed over the sensitized plate. Then a framed glass sheet is placed over the transparency and a vacuum is applied to pull them tightly together. The plate is exposed to ultraviolet light, which passes through the transparency and hardens the coating on the plate to make it insoluble to water or other solvents (Jendrucko, 1995).

The next step in the platemaking process is developing. Plates can be additive or subtractive. Additive plates are developed using a one step emulsion developer that contains an oleophilic resin. This is used to make the hardened image areas receptive to ink. Subtractive plates usually have an oleophilic resin included in the coating or applied over the coating as a lacquer. When the plate is placed in the developer solution, the non-coated image area dissolves. The image carrying plates accept ink from a roller and transfer this image to a rubber blanket. The blanket, in turn, transfers the image to the substrate-thus, offset printing.

Electrostatic plates are non-metallic paper plates and are made using the same process as making office copies. The plate is coated with a photoconductor, which is ionized by an electro-photographic camera. The charged paper is exposed to the reflection of light from the image or copy to be reproduced. The white areas of the image reflect light to the plate, which causes a dissipation of the charge on the image areas. The dark areas of the image absorb light, which causes the electrostatic charge to remain on these areas of the plate. Toner, which is attracted to the charged areas, is applied to the plates and forms a visible image. During press operation, the toner attracts ink and the white areas are water receptive (Jendrucko, 1995).

Photomechanical plate making is the most common method used in lithography. The plates are coated with a photosensitive emulsion that changes chemical properties after being exposed to light. The exposed area hardens, becoming hydrophobic repelling the water-based fountain solution and being receptive to ink.

After the photographic emulsion has been exposed it must be developed. In developing the plate, the unexposed areas are hydrophilic (attracts water in the fountain solution) and become water receptive but repel the oil-based ink.

Printers should work closely with chemical vendors and ask them to supply nonhazardous materials and inform them about any new products that are less toxic to replace currently used materials.

One of the recent technologies used in lithographic printing includes moving away from solvent-based plate developing systems. Switching to aqueous developed plates causes little disruption to the plate processing system or printing operations (Kasper, date unknown). Optimum performance is achieved by keeping the liquid volumes up to the recommended level and closely monitoring the developer. The price these systems are similar to other high-quality plates, and chemistry costs are less because there is only one developing chemistry and no replenisher. Glass marbles can be used to bring liquid levels of process chemicals to the brim each time the liquid is used, which extends the chemical's life by minimizing contact with oxygen (Price, 1994). This technique can also be used for film developing chemicals.

Plastic or photopolymer and electrostatic plates are all alternative plate types. Information on alternative plate materials can be obtained from printing trade associations as well as vendors. Changing to a computer-to-press print environment may eliminate the need for plate chemistry totally, but this technology is currently expensive and may not be applicable to all types of printing.

Press

During makeready, printing plates are attached to the cylinder. Printing occurs when the plate rotates so that the non-image areas can be treated with an ink-repelling fountain/ dampening solution. The plate is then coated with the ink, which adheres to areas of the plate that contain the image. As the cylinder rotates, the image is transferred to the substrate via the impression or blanket cylinder. The press is then fine-tuned to ensure registration and ink density are accurate and identical on all copies coming off the press. A final check for acceptability usually occurs, then the press run begins. Although an essential step, everything generated in makeready is waste. Finding ways to reduce makeready yields multiple benefits by saving waste paper, chemicals and time which in turn results in less waste disposal costs and money saved.

A strict quality control program will help eliminate waste by correcting problems as they arise. It is helpful to include in this program a process where periodic "press checks" are performed by an unbiased party to verify the quality of the product during a press run. The majority of the techniques available to printers to reduce waste at the press can be classified as good housekeeping and material substitution. Figure 6 shows a typical lithographic press roller arrangement.

The printing process itself produces scrap paper, waste ink, cleaning solvents which result in VOC emissions as does the ink drying process. According to one study on VOC emissions, the average VOC emission at three offset printing shops was 2 tons per year. In lithography, a majority of the VOCs from the ink stays with the product. With non-heat set inks, approximately 95 percent of the VOCs from the ink stays with the product, while in heat set inks approximately 60 percent remains.

Materials Substitution

Inks

Ink substitutions for the standard petroleum-based inks are now available in the form of ultraviolet-curable or electron beam inks, and vegetable-based inks, including soy oil-based inks. Customer requirements can dictate the type of ink used.

Fountain Solution

Isopropyl alcohol (IPA), added to the fountain solution at a rate of 2 to 15 percent, has been the most common additive used in fountain solutions and holds the distinction of being one of the main contributors to VOC emissions from lithographic printing facilities. Refrigeration of the fountain solution is usually used to reduce the evaporation of the IPA. Switching to an alternative fountain solution with lower or no VOCs is a good pollution prevention option. Typically low or no VOC fountain solutions cost more based on volume because the cost to produce these products is significantly greater compared to IPA. Due to stringent federal air quality standards the use of these alternative products is beginning to increase. Additionally, due to permitting and recordkeeping requirements, no VOC fountains solution may prove to be more cost effective in the long-term.

In lithographic printing, alcohol substitutes, such as glycol ethers, can be used in some dampening systems. These substitutes reduce the surface tension of the fountain solution but have a more complex chemical structure and higher boiling point than the alcohol dampeners. To determine if a substitute is applicable it is important to consider the ink, press type, paper, type of dampening system, and printing constraints. This is one of the easiest ways to minimize emissions.

Of concern with determining the substitutes compatibility and performance with the fountain solutions are the temperature, pH, and conductivity. The conductivity of the incoming water affects the performance of the alcohol substitute. An automatic mixing system will accurately mix fountain solution to the proper concentration and can somewhat reduce risks of problems from varying conductivity. Hard water causes calcium deposits and requires an additional water softening system. This problem was formerly masked when using an alcohol fountain solution. Some large operations have chosen deionizing units or reverse osmosis to remove salts, minerals and organic matter which would affect the performance of the alcohol substitute. Water temperature will now affect the viscosity of the substitute and therefore the ink transferability.

Alcohol substitutes also have a foaming problem. This problem can be eliminated by use of a foam free recirculating system which mechanically eliminates foam rather than chemical anti-foaming agents. Adding filters to the recirculating units will remove contamination and ink residue, effectively extending the life of the solution. Evaporation of the mixture can be reduced by the installation of a refrigeration unit. However, ink viscosity could be increased with a cooled sump, which may effect the printing performance. Any changes implemented will have to go through a "shake-down" period of trial and error until the best working conditions are determined. The roller condition and durometer (hard/soft) will become much more important.

Cleaning Solutions

Cleaning of the press occurs most often during make-ready as adjustments are made to the press and plates, during the actual press run, between press runs, and at the end of the day (shut down). The frequency of press washes depends on many factors including paper dust and dried ink accumulation, the quality of the paper, and the habits of the particular press operator. Ink rollers and plates are typically cleaned in place with a solvent. Residual ink is dissolved in the solvent and scraped from the roller with a blade. The resulting solvent/ink waste is collected in a tray. Blankets are cleaned during and following a run or after a color change. Most blanket cleaning is done with solvent wetted rags. Common cleaning solvents include methanol, toluene, and trichloroethane, while naptha, methylene chloride, and a variety of specially formulated solvent blends may be used (Jendrucko, 1995).

For larger presses, installing automatic blanket washers can increase press efficiency and safety. The blankets can be cleaned during a press run rather than stopping the press and using manual cleaning methods. Due to speed of cleaning there are fewer wasted impressions (paper) and less cleaning solution used. Worker safety is improved through less exposure to moving equipment, air emissions, and harsh cleaning compounds.

Parts Washing

Any parts washer at the printing facility may have the ability to be retrofitted or replaced with units containing filters to extend the life of the solvent. One type of parts washer now on the market utilizes a cyclone type filter that removes the solids and then recirculates the solvent. Alternative cleaning solvents are available as well. Many products such as d-limonine based compounds will work just as well as petroleum-based solvents. They are less harmful to workers, emit less VOCs into the air and can be disposed of as non-hazardous waste. However, they emit a citrus smell to which workers will need to become accustomed. When leasing parts washing units ask the supplier about how the solvent is treated/recovered and what options are available.

Post Press

Wastes generated from the finishing process include waste paper and VOC emissions, contaminated or spilled materials such as glue and laminates. Waste paper is created from trimming, off spec product and printing overruns.

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"Compliance Plus Guide—Environmental Compliance and Pollution Prevention for Illinois Lithographic Printers," 1996, Printing Industry Publishing Corporation.

A good general reference for all lithographic printers, even thought the document targets Illinois-specific regulations. Has worksheets to follow for determing compliance status.

"Pollution Prevention Assessment of the Office of State Printing," California Environmental Protection Agency, Department of Toxic Substances Control, Doc. No. 519, 44p.

A good report of an assessment on California lithographic operation and the pollution prevention suggestions to be examined for further consideration and implementation.

"Waste Audit Study-Commericial Printing Industry" by Jacobs Engineering Group Inc., Hazardous and Toxic Materials Division for California Pollution Prevention and Technology Development, Department of Toxic Substances Control. Doc. No. 303.

A good overall report with descriptions of various waste minimization techniques; also presents a number of case studies of California printers.

"Guide to Pollution Prevention in the Commercial Printing Industry," U.S. EPA Risk Reduction Engineering Laboratory and Center for Environmental Research Information, 1990, 45 p.

This report covers basics of all printing wastes and pollution prevention efforts; includes worksheets for conducting an assessment of a printing facility.

"Control of Volatile Organic Compound Emissions from Offset Lithographic Printing" Guideline Series Draft. US EPA Office of Air Quality Planning and Standards, September 1993.

Lengthy report on methods and techniques used to control VOC emissions at lithographic printing facilities; includes a variety of control strategies, costs associated with these techniques, impact analysis and selection of reasonably

available control technologies, and factors to consider in implementing a control technology

"A Guide for Lithographic Printers" Washington State Department of Ecology, Environmental Management and Pollution Prevention, Report No. 94-139, September 1994.

A good primary resource for the lithographic printer. Has good checklists of Do's and Dont's for each major wastestream.

"Pollution Prevention Manual for Lithographic Printers," Iowa State Waste Reduction Center, 1995.

An excellent resource with current information. Geared toward printing plant personnel, rather that technical assistance providers. Covers every step in the lithographic printing process and provides alternatives to current waste-generating practices, provides real life examples with case studies.

"Pollution Prevention: Strategies for the Printing Industry," Center for Hazardous Materials Research Factsheet, n.d.

Has very general information on pollution prevention and list options for paper, waste lubricating fluids for machinery, waste chemicals, equipment cleaning wastes, and process wastewaters.

"Water, Water Everywhere...But Not a Drop in the Ink," Graphic Arts Monthly, November 1991.

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Cross, Lisa "Ink Waste Disposal." Graphic Arts Monthly, vol. 61, May 1989.

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Cross, Lisa "Litho Plates Get Eco Friendly," Graphic Arts Monthly, May 1993.

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Johns, David R. "Environmentally Safe Fountain Solutions for the Printing Industries" in *Innovative Clean Technologies Case Studies Secondy Year Project Report*. US EPA, Office of Research and Development. EPA/600/R-94/169, p. 202-214.

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Technical paper on methods used to test the concentration of VOCs in indoor air of 3 different size printing facilities.

Watkins, L.A. "A Multi-Disciplinary Approach to Ink Recycling," 1992 Proceedings of the Technical Association of the Graphic Arts, pgs. 604-615.

Easy to read and understand article on ink recycling. Provides examples of processes and equipment used to reclaim ink, and case studies with numerical data.

Case Study 1

Aetna's In-house Printing Plant Leads the Way Pollution Prevention: Environmental Management's Next Goal

Michael Feldman

GAFTWORLD Vol. 5, Issue 6, 1993

Aetna's printing plant employs 130 people and does approximately $15 million worth of commercial offset printing, primarily sheetfed, yearly. They run a six color, 2 two-color, and a four color press. The pollution prevention program undertaken at Aetna consists of a number of different projects.

They eliminated alcohol from the dampening solution which caused some problems with the ink and water balance. The problems were solved by: 1) changing the electronics of the press to cut off the dampening system sooner to eliminate water in the ink; 2) reformulating inks with vendor assistance; 3) switching to a different chemistry in the dampening solutions; 4) reconfiguring all the rollers and switching from crown to parallel rollers and experimenting to find the optimum settings; and, 5) switching to lesser grained plates. The results from this changeover included a decrease in liquid hazardous waste from 11,000 gal./year to 5,000 gal./year with a savings of $42,000 annually in disposal costs.

Dampening solution disposal was another project undertaken by the facility. The used solvent was dumped at a designated sink location, pumped through two activated charcoal canisters, and then discharged directly into the municipal sewer system. Contamination problems from other materials dumped into the sink led the company to develop a "pump mobile." This is a cart with a 55 gal. drum and pumps that moves from press to press. The used dampening solution is pumped into the drum, then the cart is moved to the cleaning station where drum contents are pumped into the activated charcoal system. This project costs $2,000 annually to recharge the activated carbon and saves $48,000 in disposal costs.

Ink reclamation saves the company $200,000 in ink disposal costs alone and $90,000 on reduced new ink purchases each year. Previously, premixed inks were ordered on a job by job basis resulting in 7,500 lbs. of ink in inventory. Much of this ink was special ordered and if the print job changed or was cancelled, the ink was unusable. Computer software was ordered to allow better planning and estimates as well as to provide the ability to mix new Pantone colors from existing mixed Pantone colors. This helped to eliminate the unused ink in inventory. Also, waste and excess ink returned from the presses has been used to make black ink. The company is also starting to use vegetable-oil based inks with lower VOC content.

Other efforts undertaken in Aetna's pollution prevention program include: switching from a chlorinated to nonchlorinated wash-up solution; instituting a parts washing system that allows reuse of parts cleaning solvents; recycling all wastepaper; trying to reduce the number and variety of chemicals used in the printing operation; and, making sure vendor facilities comply with environmental regulations.

Case Study 2

Pollution Prevention Works for Iowa: Case Summaries

Moore Business Forms & Systems Division
May 1994

Moore prints custom business forms for a wide range of customers. The company wanted to find ways to use the paper waste not amenable to recycling such as carbon-backed, coated, mixed and "dirty papers". In partnership with a number of different groups, Moore developed a refuse-derived fuel cubing program in 1992. The process shreds waste materials, adds moisture for proper mixing and compaction, removes tramp ferrous metals with magnets and extrudes material into fuel pellets. The product is sold to coal fired power plants that mix the cubes with coal at approximately a 10 percent ratio of total fuel. The company in now able to divert essentially all unrecyclable paper waste to fuel. Through diverting 912 tons/year from the landfill, Moore saved $10,032/year in landfill fees. When transportation savings are included the savings total $11,832/year.

Case Study 3

Toxics Use Reduction Case Study
Alcohol Free Fountain Solution at Americraft Carton, Inc.

Office of Technical Assistance, Massachusetts
September 1993

Americraft Carton, Inc. is a $30 million a year folding carton manufacturer and printer. Until August 1991, Americraft mixed fountain solution for its presses in the traditional manner. A solution of 15-25 percent isopropyl alcohol (IPA), tap water, and etch material was measured by hand into a drum and stirred with a wooden paddle. Americraft received bulk deliveries of IPA every two to three weeks. Up to six 55 gallon drums of waste solution were generated monthly by the company's four sheetfed offset presses.

There are significant economic, health and safety, and environmental drawbacks to this method of producing and using fountain solution. Inconsistency in the solution can cause press downtime. It also involves increased labor and material costs, and it can require disposal of inadequate, unused, or waste solution at a cost of more than $2 per gallon. Inhalation of alcohol-laden vapors present health and safety concerns for employees. IPA is an ozone producing volatile organic compound (VOC), thereby increasing the cost and complexity of air emission permitting and reporting.

The company purchased and installed the new no-IPA system at a cost of $108,000. The system is a closed loop recycling system connected to all the presses, which can release solution at up to 15 gallons per minute. Recharging of the solution (made up of water obtained by reverse osmosis, IPA substitute (Prisco Q-11), and used fountain solution) is computer-controlled to ensure that pH, temperature, and conductivity are all precisely maintained. From the press, the solution goes to a return tank where it is chilled and filtered to 25 microns (contaminants are ink, paper, dust, and paperboard stock). The solution is then returned to the main system for filtering to 10 microns and for further chilling as well as solution recharging. The chiller is a holding tank with a 250 gallon capacity to ensure adequate quantities at all times.

The new system has resulted in: the end of losses and costs associated with hand mixed solution; the cost and disposal cost of unacceptable solution that also sometimes caused press downtime; reduced costs for waste removal by internal recycling of the solution and from converting from weekly solution disposal and pan maintenance to an annual schedule; and, significantly reduced use of VOCs and VOC emissions through the replacement of IPA. The $108,000 equipment investment had an expected payback resulting solely from the reduced cost for materials of about 30 months after introduction of the new system. There are substantial additional savings from increased press efficiency, reduced wastes, and reduced and eliminated permit costs. Americraft has also found that alcohol substitutes increase the rate of roller replacement and maintenance, but also require lower durometer settings meaning they may last longer.

Case Study 4

Case Histories of Cost Saving Through Waste Reduction by Small Industries in Tennessee

TVA 8: Magazine Printing

Tennessee Valley Authority

A magazine printer substituted well water for all process cooling water and lawn sprinkling to reduce potable water use and associated sewer charges. The change resulted in a $10,000 savings in sewer charges annually. The company also used water-based detergent for cleaning most surfaces and used a petroleum naptha cleaner for washing metal press parts. A parts-cleaning station containing 25 gallons of the cleaner was rented for each printing press. During each change-out, approximately 15 gallons of cleaner vaporized into the work areas. The company reduced the number of stations from 43 to 4 and cleanout frequency went from every two weeks to three weeks, saving $5,000 annually. An ink mill was installed to salvage waste ink and formulate an acceptable blend of recycled and new ink to reduce costs of purchasing new ink and disposing of waste ink. The mill salvaged 90 percent of waste ink, saving an estimated $200,000 to $250,000 annually.

Case Study 5

Managing Solvents and Wipes

Design for the Environment Printing Project Case Study

US EPA, 1994

The John Roberts Company in Minneapolis employs 240 people and prints annual reports, brochures, catalogs, forms, limited edition fine art prints, and direct mail pieces using sheet-fed and web offset processes. The company studied their solvent use practices because the industrial laundry that cleaned their leased towels was having problems meeting the regulations for discharging to the sanitary sewer.

The company thoroughly investigated the reasons they were using the solvents, the properties that the solvent required for their needs, and how the solvents were applied by the press personnel. The goal was to find a substitute solvent that was better matched to the task that did not substantially affect work procedure or productivity.

The raising of awareness in the effort to find a substitute resulted in a reduction in the misuse of the all-purpose cleaning solvent. Usage of the solvent, which was a mixture of acetone, toluene, MEK, and isopropyl alcohol, was reduced from 152 fifty-five gallon drums to 5 in the first year. A new replacement solvent, an ultra-fast blanket wash, was blended especially for the company and performed well with respect to speed and lack of an oily film.

Only 38 fifty-five gallon drums of this new blanket wash were purchased in the first year. Even after including the purchase of the replacement solvents, the company saved more than $18,000 in the first year by changing solvents and using them more prudently. In addition, the contribution of the company to the laundry's effluent no longer exceeded limits.

An additional effort undertaken was the purchase of a centrifuge to remove solvent from the wipers prior to sending them to the laundry. This technique saved the company $34,000 in the first year alone, resulting in a quick payback of less than one year on the $15,000 centrifuge price.

The company continued making improvements on the solvent alternative, and replaced it with a reformulated and less volatile press wash that eliminated the 1,1,1 trichloroethane present in the former solvent. With less volatilizing to the air, the company has found that it purchases 4 fewer drums of solvent each month.

Case Study 6

Pollution Prevention Efforts at the Journal Press, Inc.

Vermont Agency of Natural Resources, Pollution Prevention Division
in *Pollution Prevention Successes: A Compendium of Case Studies From the Northeast States*, NEWMOA
December 1993

The Journal Press, Inc., is a small commercial offset lithographic printing business. Production activities at the company include photo processing, plate making, printing and book binding.

The fixer from photo processing operations is run through an ion exchange unit to recover the silver. The Journal Press receives payment for the silver recovered from this process. The company sells the used plates and film to a scrap metal dealer for resale.

The Journal Press has located low toxicity substitutes for a majority of the hazardous chemicals used in the printing process. Isopropyl alcohol has been eliminated in 99.9 percent of printing jobs through chemical substitution with a mixture of butyl cellosolve and glycol ether. The new fountain solution requires press operators to take more time during the make ready process to ensure that all press adjustments are exact. Once the press is adjusted, the new solution does not have an adverse effect on the speed of the printing operation. However, it has been observed that after operating a press continuously for three to four months with the new fountain solution some printing problems may occur. These problems may be corrected by adding a very small amount of IPA to the system.

Waste ink is the only waste stream shipped off-site for disposal. Good housekeeping, such as using just enough ink to do the job, keeping all ink containers closed except when ink is being removed from or added to the containers, and keeping ink used during production in small containers, reduces the amount of waste ink generated. The company is also actively seeking a recycling outlet for its waste ink.

Case Study 7

Waste Water Reduction at the Stinehour Press, Inc.

Vermont Agency of Natural Resources, Pollution Prevention Division
in *Pollution Prevention Successes: A Compendium of Case Studies From the Northeast States*, NEWMOA
December 1993

The Stinehour Press has had significant success in reducing the volume of waste water generated from their printing and photo processing activities. Many printing companies discharge waste waters from these processes to POTWs or discharge the waste to surface waters under the auspices of a NPDES permit. No POTW was available to the Stinehour Press and discharge to the Connecticut River was considered to be technically difficult and economically infeasible. In the late 1980's the company began collecting its waste waters and managing them as hazardous waste. Costs related to management and disposal of the waste mounted and concerns related to potential long-term liability heightened. These two issues, cost and liability, became the driving forces behind waste water and toxic use reduction at the facility.

The volume of waste water managed by Stinehour Press has been reduced through a combination of closed-loop recycling and evaporation. Prior to implementing these methods, up to 10,000 gallons of water were used daily to operate the film processors and up to 5456 gallons of waste water from other sources, some of which were deemed hazardous, were generated annually. Presently, the company has reduced film processor waste waters to 100 gallons per week through recycling and has reduced hazardous waste water streams to 77 gallons per month.

Film Processor Wastes

The film processors at the facility use 12 gallons of rinse water for each sheet of film processed. During peak operation, this could be as much as 10,000 gallons per day. These rinse waters contain low concentrations of silver (.02-.05 ppm). Although these waste waters were not considered to be hazardous waste, concerns were raised as to whether the material would continue to meet strict groundwater discharge requirements. Additionally, concerns were raised regarding the stress to the environment related to continued removal of such large quantities of water from the company's well system.

On-site discharge of film processor waste water has been eliminated and water consumption has been drastically reduced. This has been achieved in part through the installation of four small ion exchange units. These units are hard-piped to individual film processors. Rinse water from the film processors flows into a reservoir on the recycling unit. A small pump then forces the rinse water through the ion exchange column. Silver ions within the rinse water are exchanged with ions from the resin column. De-silvered water leaving the resin column is further filtered to remove any resin particles which may have been dislodged during the recycling process. The recycled water is then pumped back into film processors.

The plumbing within the ion exchange systems is equipped with valves which allow the operator to back flush the system. This is considered to be an important feature because it allows the operator to "fluff" the resin within the non-exchange column. "Fluffing the resin" reduces the effect of channeling within the ion exchange column and helps to maintain the efficiency of the system.

Company personnel collect 25 gallons ofspent rinse water from the ion exchange units on a weekly basis. The water is evaporated on site under the terms of a state permit. The ion exchange columns within the recycling systems are removed every three months. The spent ion exchange columns are returned to the manufacturer for silver recovery and regeneration. After regeneration the ion exchange columns are returned to the Stinehour Press for reuse.

Spent Fixer

The company uses a batch type electrolytic silver recovery unit equipped with a tailing system to remove silver from spent fixer. During the electrolytic process an electrical current is applied to two electrodes which are immersed in the fixer. Silver from the solution collects on the cathode. Silver flake is removed from the silver recovery unit periodically and sold.

An ion exchange tailing system is used to further remove silver from the spent fixer. This second silver recovery step ensures that spent fixer is not a hazardous waste based on its silver content. The tailing cartridge is also sent off-site for silver recovery and regeneration. The de-silvered fixer is stored on-site until it can be evaporated.

Evaporation

Film processor water, spent developer, de-silvered fixer, fountain solution, and press bucket water are collected on-site and evaporated to reduce the volume of water in these waste streams. None of these waste streams are considered to be hazardous waste under the provisions of the Vermont Hazardous Waste Management Regulations. However, the waste streams do contain low concentrations of solvent and silver and are not considered suitable for on-site discharge.

Initially silver, chrome, and formaldehyde levels were of concern to the Vermont Agency of Natural Resources. The concerns about the silver levels were addressed by adding the tailing system to the electrolytic silver recovery unit. The presence of chrome was due to the use of a film processor cleaning solution which contained sodium dichromate. A non-chrome containing replacement for this solution was found.

A cost analysis outlining the expenses and savings associated with the project appear below:

Gross Annual Savings	$45,042
Operating & Disposal Costs	$18,105
Net Annual Savings	$26,937
Gross Equipment Costs	$38,247
Amount of State Grant	$15,020
Stinehour Investment	$23,227

Payback period on Gross Cost	1.6 years
Payback period on Stinehour Investment	0.9 years
Percentage of Waste Reduced	92.5 percent

This analysis does not include figures relating to the reduction in the volume of film processor rinse water used prior to recycling. The amount of rinse water required by this process has been reduced by more than 99 percent.

Case Study 8

Case Study: McNaughton & Gunn, Inc., Saline, MI

Michigan Department of Environmental Quality, Environmental Assistance Division
November 1995, #9509

McNaughton & Gunn prints books and as a company strives to prevent or minimize the waste they generate. Source reduction strategies such as substituting raw materials, working with suppliers to reduce input packaging, and office management changes have become key components of the company's approach to eliminating hazardous and solid waste.

Through the efforts of a volunteer employee committee, dubbed the "Recycling Fanatics," the company has achieved source reduction in the following ways:

- Purchased two new ink pumping systems

The first system pumps vegetable based black ink from 55 gallon refillable drums through pipes in the ceiling to four sheet fed presses. The second system pumps black ink from 3,000 pound totes to two web presses. The totes are returned to the ink manufacturer for refilling. The 55 gallon drums and the 3,000 pound totes replaced five and ten pound cans that came in boxes with cardboard separators.

- Modified beverage vending machine to eliminate disposable cups

The company provides each of it's 250 employees with a ceramic mug to use in place of polystyrene cups.

- Modified purchasing policies

Janitorial supplies are now purchased in bulk and aerosol cans have been eliminated.

- Modified all three film processors so they are on a complete chemistry recycling system

The developer has a rejuvenator added to it to prolong its life. The fixer goes through a silver recovery unit and is then returned to the processor. This is a closed loop system and the only replenishment needed is to compensate for oxidation.

- Purchased an office copier capable of two-sided copying

This resulted in a major reduction in paper use and a savings in paper purchase costs.

- Purchased a new projection system that requires less film and fewer chemicals for developing
- Implemented an electronic communications system that eliminated the need for most memos

All Requests for Quotes and purchase orders are also done electronically, thereby reducing paper use.

In 1995 McNaughton & Gunn generated an income of $280,000 from recycling film plate and paper. New recycling programs, along with source reduction strategies, allowed the company to reduce solid wastes by half. The company is recycling in the following ways:

- Vegetable based colored ink is still received in five pound cans due to the small quantities ordered. The cans and lids are all recycled and the cardboard boxes and separators are picked up by the ink manufacturer for reuse.
- A large Cyclone Scrap Removal System was installed on the roof of the facility. The system creates vacuum points and picks up paper waste and trimmings that are generated by machines in the plant. The waste is transported through ceiling pipes to a paper baler where it is compacted and tied with wire into 1,500 pound bales. The bales are then loaded on semi-trailers and transported to a paper mill for recycling.
- Film scraps are sent off-site and processed to reclaim their silver content.
- Over 125,000 pounds of aluminum printing plates are recycled each year.
- Each workstation has a recycling basket to collect office paper for recycling.
- Batteries used in the plant and in the employees' homes are recycled.
- Wood waste from broken pallets is shredded (by an outside vendor) into wood chips.

Other steps the company has taken to contribute to preserving the environment include:

Changed to an environmentally friendly chemistry system for plate developing.

- Now use vegetable based ink on all sheetfed presses.
- Totally eliminated isopropyl alcohol form the dampening systems of all presses.
- Now use low VOC solvents for blanket and roller washes.

Case Study 9

Technology Creates Really "Green" Ink, New Process Enables 100 Percent Recovery from Hazardous Sludge

The P2 Alert, Tennessee Div. of Pollution Prevention & Environmental Awareness
Autumn 1995

Thanks to the ingenuity of Knoxville inventor Frank Prasil, printing ink residue at lithographic print shops can be completely eliminated from the waste stream and used to formulate quality ink.

Prasil has discovered how to change ink sludge from lithographic printers, a gooey hazardous waste, into high grade ink. In addition to being economical and environmentally positive, the recycled ink is rich in pigment. Even compared to ink manufactured from virgin raw materials, recycled ink generated by this process has superior printing qualities, generates less process waste, and prints better on recycled paper.

The process, known as Lithographic Ink-Waste Recovery Technology (LIRT), recovers 100 percent of the waste sludge, composed of oil, oxide pigments, solvents and acid wash waters. Lithographic printers currently incinerate more than 60 million pounds of this ink sludge.

Recovery of usable components occurs with no solid, liquid or gaseous emissions to the environment.

The waste ink which once represented a disposal and reporting liability for printers is now a $2000 per barrel asset. In addition to the money savings this process represents, it also conserves natural resources. Prasil estimates that his ink recovery system can save an equivalent of 560 million cubic feet of natural gas and 660,000 barrels of crude oil, and can reduce air pollution by 3,780,000 tons. The ink recovery also uses 98.5 percent less energy than manufacturing ink from virgin raw materials. European countries, which lack the richness of raw material resources of the United States, could prove an eager market for LIRT ink.

The inventor is currently working to secure patent rights and submitted a National Industrial Competitiveness through Energy, Environment, and Economics grant proposal to the Department of Energy, in cooperation with the University of Tennessee Center for Industrial Services (UT-CIS) and the Tennessee Department of Environment and Conservation. This grant was awarded and the project in underway.

If you have an interest in trying the LIRT ink or learning more about the ink recycling process, contact the UT Center for Industrial Services in Nashville, 615/847-8007.

Update From: Tennessee Materials Exchange Bulletin, Summer 1996, Bulletin No. 3

The black ink is produced from ink wastes that would normally be disposed of, e.g. wash-up solutions from cleaning lithographic presses and residues from air-exposed ink fountains that feed presses. Let's be clear--this is not "reused" ink from half-filled containers. This is "recycled" ink and the Department of Energy has awarded Prasil a grant for commercial product development. While commercial quantities of inks should be available by the end of the year, small quantities of "recycled black" are available now, and various earth tones will be developed in the near future.

Case Study 10

Running "Green," An Environmental Case Study

Stu McMichael
Business Management, Printing Industries of America, Inc.
1993

Custom Print runs a full service printing company in Virginia. The company began their own environmental consciousness raising by experimenting with various alternative chemicals to isopropyl anhydrous alcohol. During a five year period, the company went through seven different products, each better than the last. As they worked on improving their pressroom environment, they realized that they needed to do a full-scale environmental review of every department, from camera and stripping to platemaking to bindery to shipping to front office. Each department head reviewed all the chemicals used and was asked to come up with better alternatives whenever possible.

Using OSHA and EPA standards as benchmarks, the company took steps to go beyond existing requirements. Some examples:

- Completely changed the way they made plates, switching to an aqueous plate processing system, drastically cutting polymer waste.

- Converted to soy inks, now using them exclusively with excellent results.

- Use water from four dehumidifiers controling moisture buildup in their paper in press water fountains.

- Recycle all paper, including office paper waste.

- Print the great majority of their jobs on recycled paper and educate customers on what's available.

- Retrieve film from camera and stripping departments and recycle it. Silver from the film and developing fluid is extracted, collected, then sent to a mint and pressed into one-troy-ounce coins of pure silver. These coins are given to the people working at the press for Christmas presents.

The transition to environmentally friendly materials has been expensive due to the need to experiment with different chemicals, plates and papers. On the bottom line, for this press it does cost more to produce their products. But the marketing edge in their environmentally conscious community is a benefit that far outweighs the downside.

Case Study 11

Cleaner Technologies Substitutes Assessment for Lithographic Blanket Washes

Design for the Environment, US EPA
EPA-744-R-95-008
August 1996

The first major publication of the DfE Lithograpy Project, the draft Cleaner Technologies Substitutes Assessment for Lithographic Blanket Washes (CTSA), is now available. The DfE Lithography project partners have evaluated the trade-offs associated with using 37 different lithographic blanket washes. They examined costs, performance, environmental hazards, and human health risks of each blanket wash. The Lithographic CTSA presents the results of these extensive studies. It contains detailed technical information, including:

- Results of the blanket wash performance demonstrations and a cost analysis for each product;

- Descriptions of the individual chemicals used in the 37 blanket washes and of the human health and environmental hazards associated with these chemicals;

- Discussions of the environmental and occupational risks inherent to each blanket wash solution as a whole, including VOC content and flammability;

- Discussions of relevant international trade issues, energy and natural resource issues, and Federal regulations; and,

- Descriptions of pollution prevention opportunities, emphasizing simple changes that can be made to everyday work practices.

The CTSA is valuable resource for anyone intersted in the lithographic printing industry. For example:

Suppliers can use the CTSA for a variety of purposes. They may use the comparative risk, performance, and cost analyses to identify which blanket wash chemicals and formulations are best suited for the current market. Suppliers interested in manufacturing new blanket washes can use the environmental and human health data presented for individual chemical components as a building block for designing more environmentally friendly formulations.

Technical assistance programs can use the CTSA as a source of background information on lithography, blanket washes, and the DfE Lithography Project. They will find the comparative risk, performance, and cost analysis useful when working with printers to reduce VOC emissions and hazardous wastes.

Printers will be interested in the in-depth information on blanket washes and their chemical components. The performance methodology used to evaluate blanket washed may also be helpful. Printers can use this methodology to conduct their own performance evaluations of blanket washes or of other alternative products or processes.

A free copy of the Draft CTSA may be obtained by contacting EPA's Pollution Prevention Information Clearinghouse (PPIC) at: US EPA, 401 M St. SW (3404), Washington, DC 20460. It can also be downloaded from the DfE Web page at http://es.inel.gov/dfe *(was not yet up on the Web as of Aug. 23, 1996).*

6 Screen Printing

Overview

There are about 40,000 graphic art screen printing and textile printing shops in the United States. These mostly small- and medium-sized businesses perform diverse functions ranging from the printing of billboard advertisements, greeting cards, art books, clothing and posters to printing onto electronic equipment (US EPA, 1995a).

Screen printing is probably the most versatile of the printing techniques, as it can place relatively heavy deposits of ink onto practically any type of surface with few limitations on the size and shape of the object being printed. The ability to print variable thicknesses of ink with a high quantity of pigment allows for brilliant colors, back lighting effects, and durable products which are able to withstand harsh outdoor weather conditions or laundering. Unlike many other printing methods, substrates for screen printing can include all types of plastics, fabrics, metals, papers, as well as exotic substrates such as leather, masonite, glass, ceramics, wood, and electronic circuit boards. While screen printing does compete with other printing techniques for some products (especially for small paper substrate products), it has a specialized market niche for many graphic art materials and textile printing applications. Comparatively low equipment investment costs allow for low-cost short production runs (US EPA, 1994a).

Screen printing uses a porous mesh screen with an ink-resistant image on its surface as a template to transfer ink to substrates. The type of material used to make a screen depends on the substrate being used as well as the desired appearance of the product. Screen preparation begins by tightly stretching and securing the material in a rigid frame so that it is level and smooth. Non-image areas of the screen must be blocked and image areas open to allow ink to pass through to the substrate (Figure 8).

The image can be transferred to the screen manually, but it is more common to use a direct coating photomechanical stencil, which consists of an emulsion of bichromated gelatin or bichromated polyvinyl alcohol (PVA) applied to the screen's surface. The emulsion is spread and leveled either manually with a squeegee or automatically. When the coating has hardened, a stencil is applied and the screen is exposed to UV light, that causes a photochemical reaction and makes the emulsion insoluble. The unreacted emulsion, which is still water soluble, is rinsed

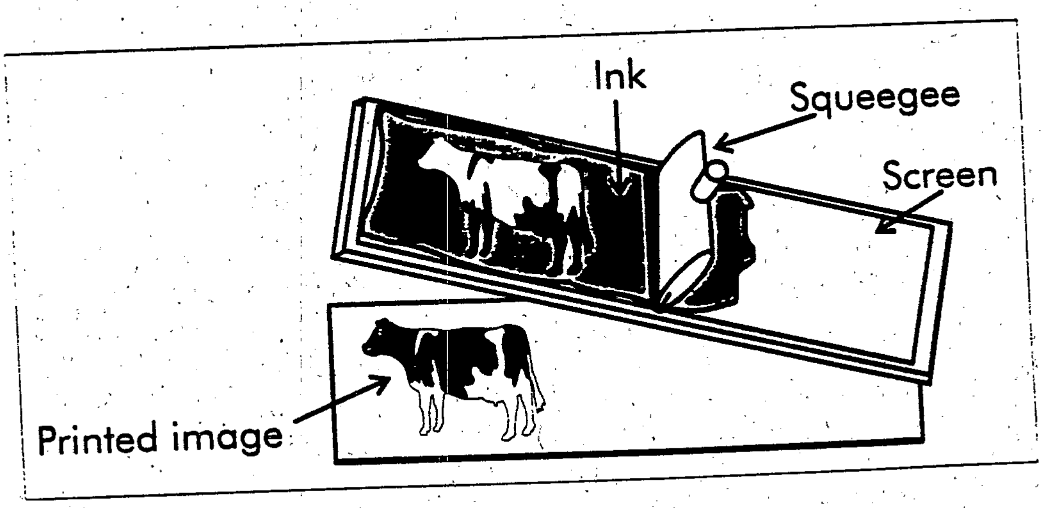

Figure 8. Principle of Screen Printing

off. A rubber-type blade (squeegee) is swept across the screen surface, pressing ink through the uncovered mesh to print the image defined by the stencil. Many screen printing facilities reclaim their screens for reuse because the screen material is valuable and costly to replace (US EPA, 1994a).

Screen reclamation has three steps. First, any residual ink must be removed with a solvent, usually sprayed directly on the screen. Some common ink removal solvents are d-limonene-based products, glycol ether and dibasic ester blends, mineral spirits, methyl ethyl ketone, acetone, butyl celusol, cyclohexane, toluene, and methyl isobutyl ketone (Jendrucko, 1994). If the image on the screen is not going to be reused, the emulsion that blocks the non-image area needs to be removed. Emulsion remover is generally sprayed onto the screen then brushed into its pores. Typical emulsion removers contain sodium metaperiodate or salts of periodic acid. After the ink and emulsion have been removed, there is often a ghost image that remains on the screen. A haze remover, which usually contains potassium hydroxide and aliphatic ether alcohols, is applied to the affected areas to remove the ghost. The use of these screen reclamation products, however, can pose potential risks to the people who work with them and to the environment (US EPA, 1995a).

The number of workers exposed to screen reclamation products in the graphics section of the screen printing industry is estimated to be as low as 20,000 or as high as 60,000 depending on how many workers at each facility spend part of their time reclaiming screens (US EPA, 1994a). A Workplace Practices Survey for screen printers, conducted by the Screenprinting and Graphic Imaging Association International (SGIA), reported that almost 36 percent of the respondents had implemented changes in workplace practices to reduce their use of ink removal/reclamation products (US EPA, 1994b).

Prepress

Stencils and Screen Preparation

Several types of emulsions or stencils, such as indirect or direct photo stencils, are used in transferring an image to a screen. Most direct stencils are water-soluble, and thus incompatible with water-based inks. However, chemical curing of water-soluble stencils can improve their resistance to water. A water-resistant stencil must accompany a solvent-based ink, and a solvent-resistant stencil must accompany a water-based ink. Solvent and UV curable inks are typically coupled with water-resistant emulsions. Thus, a commercial facility using 90 percent solvent-based inks and 10 percent UV curable inks can use the same water resistant emulsion systems for both inks. If, however, the screen printing facility wants to replace some of its solvent-based inks with water-based inks, a new type of solvent resistant emulsion will have to be used to complement the water-based inks. Using solvent-resistant emulsion with water-based inks will cause the emulsion to erode quickly and pinholes will show up in the stencil.

Press

A simple way to reduce waste is to keep the various waste segregated. Do not mix various waste streams in an effort to conserve space. This will cause problems and cost money in the disposal or recovery of reusable materials from the wastes.

Ink

Ink categories include traditional solvent-based inks (which include enamels), ultraviolet (UV)-curable inks, water-based inks, and plastisols (for textile printing).

The most common screen printing inks are solvent-based. They dry through solvent evaporation, which produces VOC emissions. Depending on the quantity of ink used, VOC emissions can create regulatory problems for printers, especially those located in nonattainment areas as designated under the Clean Air Act Amendments (CAAA) of 1990 (Jendrucko, 1994).

Water-based inks include water, emulsion resins, other resins, pigments, and additives. Many printers observe that these water-based inks have more vibrant colors and print more crisply than their solvent-based counterparts. The sharper definition possible with water-based inks allows printers to use finer dot patterns in screened process printing. Water-based inks do not require organic solvents when cleaning the presses and, if free of heavy metals, do not produce hazardous wastes. They are usually less expensive than solvent-based inks and are similar in quality, gloss, and adhesion. However, water-based inks require a longer drying time than solvent-based inks (Alaska Health Project, 1987).

Excess ink used in the screen printing process is currently recaptured. The ink left on the screen is squeegeed back into the can prior to washing the screen. This not only reduces the amount of ink used but also decreases the amount of cleaning emulsions needed to wash the screen (Alaska Health Project, 1987).

Postpress

Screen Reclamation

While screen reclamation techniques may vary significantly from one screen printer to another, two basic functions must be performed in order to restore a used screen prior to reuse: removal of ink and removal of emulsion (stencil). A third step, removing any remaining "ghost image" or haze, may be required depending upon the type of ink used, effectiveness of ink removal and/or emulsion remover products, and the length of time that ink and stencil have been on the screen (US EPA, 1994a).

Screen reclamation activities generate solvent waste and wastewater. VOC emissions may also be associated with the solvent used to remove inks (Jendrucko, 1994).

Ink removal (also called screen washing or screen cleaning) precedes stencil removal so that excess ink does not interfere with removal of the stencil. Ink is also removed at other times prior to screen reclamation (for example, when dust gets into the ink and clogs the screen mesh, or at lunch break, to avoid ink drying on the screen). This "process cleaning" usually occurs at press side, in a separate ink removal area of the shop, or in an area where emulsion and haze are removed.

Most emulsion removers are packaged in a water solution or as a powder to be dissolved in water; the water acts as a carrier for the actual reclaiming chemical. The predominant chemical in an emulsion remover is often sodium metaperiodate. Because periodate needs water as a carrier to reach certain chemical groups in the emulsion, it is more difficult to reclaim a water-resistant emulsion than one which is only solvent-resistant. Most commercially available emulsion removers are able to remove either water resistant or solvent resistant emulsions. High pressure water spray can also facilitate emulsion removal and may lower the quantity of emulsion remover required. The rinse water should be evaluated for recycling possibilities since the major contaminant would be suspended solids. Special care must be taken to ensure that the emulsion remover does not dry on the screen, as the screen will become almost impossible to clean even with repeated applications of the remover, thus adding to regulated waste quantities (US EPA, 1994a).

A haze or ghost image is sometimes visible after the emulsion has been removed. This results from ink or stencil being caught in the knuckle (the area between the overlap of the screen threads) or dried/stained into the threads of the screen. Staining of the mesh frequently occurs when petroleum-based solvents are used in the ink removal process. The solvent dissolves the ink, leaving behind traces of the pigment and resin in the screen. The residual pigment and resin bonds to the screen after the solvent evaporates, leading to haze accumulation. Ghost images are especially common when dark inks (blue, black, purple and green) are used, or if an excessively long time period elapsed prior to ink removal from the screen. A ghost image is particularly likely when using solvent-based ink systems, as opposed to other ink systems. If the ghost image is dark or will interfere with later reimaging or printing, a haze remover product can be applied until the image disappears or fades. The level of cleanliness required at the end of the process varies depending on the kind of printing job that the screen will be used for after reclamation. Some printers can use screens with light ghost haze, others cannot. Haze remover can potentially damage the screen mesh, particularly caustic haze removers that are traditionally used in the industry. The excessive use of these products, such as applying the chemical and leaving it on the screen too long, can weaken the mesh (US EPA, 1994a).

The major health impact on the general population for screen reclamation products is probably their release of VOCs that may be detrimental to the worker's health and contribute to the formation of smog in the air. The traditional products, because of their volatility, are likely to have a much greater impact than the alternative products on ambient air quality. The major benefit identified for switching from traditional screen reclamation methods to alternative methods is a significant reduction in inhalation risks to workers (US EPA, 1994a).

Issues which are important in the selection of chemical alternatives are: risk, performance, disposal, quantity used (is more required to do the same job), cost, employee acceptance (perceived benefit), effectiveness (cleaning time), effect on substrate (detrimental effects to the screen), and effect on print quality.

Equipment Modification

Several types of equipment can be used in screen reclamation to prevent pollution. Many of these systems can save money as well as reduce regulatory requirements, facilitate compliance and reduce the amount of chemicals used in screen reclamation. Each printer needs to examine his or her particular process to determine the applicability of any or all of these equipment modifications. In addition, printers should consult their operating permit and applicable water and waste disposal regulations to ensure compliance before making equipment changes (US EPA, 1994a).

The current practice of screen printers is the use of hand held pump bottles to apply screen reclamation chemicals to the used screen which can help reduce emissions and potential exposures with more effective application (US EPA, 1994a). By allowing the screen reclaimer to control the amount and direction of ink remover, emulsion remover, and/or haze remover, pump bottles effectively minimize the amount of solution used and reduce chemical waste at the source. Other sprayer/application systems are also on the market, but the printer will be the one to best determine what will work for their shop.

To further minimize chemical throughput, the more complex systems frequently combine solvent recirculation systems with a spray applicator system. For the smaller printer who spends minimal time in reclamation, the relatively inexpensive spray bottle might be the most cost effective. However, companies that spend a substantial amount of time and effort in reclamation might find the more extensive spray systems a viable option. While the initial costs may be substantially higher, some or all of the cost may be recovered through decreased solvent use. Further, these systems may decrease labor costs because they tend to be quicker and easier methods for cleaning screens. In addition to surveying product literature, a printer may wish to check with several suppliers as well as other printers to determine feasability for their situation (US EPA, 1994a).

A washout booth can also minimize exposures and waste by containing the reclamation process in a confined area and collecting spent chemicals for proper reuse or disposal (US EPA, 1994a). The premise of the washout booth is that concentrating the ink and/or emulsion remover within a specific area will minimize the quantity of solvent necessary for reclamation, while maximizing the cleaning potential of the quantity used. Consequently, these booths are built to focus the cleaning solution in a small semi-contained area (usually box shaped). Although some booths consist of multiple cleaning areas to separate the ink and emulsion removal functions, single unit booths are equipped to remove both ink and emulsion. Waste solution is usually funneled into a drain where it may be recycled or disposed of in several ways.

A booth can be made to specifications; however, the price increases according to size and level of complexity. For the small printer that reclaims very few screens, such an apparatus may not be a prudent or feasible investment. However, for printers with a sizeable reclamation operation, a washout booth may be a positive addition. Printers should consider their individual situations as well as other sources of product information to make a choice that remains consistent with good business practices (US EPA, 1994a).

Filtration systems can be used to remove specific substances from the waste stream, facilitating compliance and allowing reuse of some chemicals (US EPA, 1994a). They work by several different processes. Used independently, these products may not provide unique pollution prevention opportunities; however, when used in conjunction with a recirculator/recycler, the filtration of solvent may allow for substantial decreases in the quantity of solvent used. A filtration system's function within the solvent recirculation process is to filter out particulates (filters), heavy metals (nanofiltration, reverse osmosis), hydrocarbons (ultrafiltration), and other waste products. This process of treating the effluent makes it possible for conditioned solution to recirculate back for reuse in subsequent reclamation.

By screening the effluent resulting from the reclamation process, filtering systems also facilitate compliance with effluent guidelines. The cost of these systems should be carefully considered by a printing facility. Printers should also consider potential savings generated by reducing the use of chemicals and by avoiding fines that could result from noncompliance with federal, state, and local environmental regulations (US EPA, 1994a).

A recirculation system, through a combination of several technologies, allows a printer to minimize solvent usage, and consequently, minimizes pollution at the source. Its purpose is to filter contaminants from the cleaning solution so that the filtered solution can be reapplied to future screens. Generally, a recirculation system consists of an applicator/sprayer system, a filtration unit, and a recirculating mechanism.

A recirculation system can take on a variety of different forms. From a simple ink remover recirculator, to a system that involves complete reclamation, these systems can be made to fit almost any operation. If a printer decides that this is an appropriate method of pollution prevention, he/she should carefully consider the vast array of options in order to properly match the system to their facility. Further, printers should keep in mind that recirculation systems are not closed systems. Printers should consult applicable water and wastewater disposal regulations to ensure compliance (US EPA, 1994a).

Distillation devices that can be used to reclaim used solvent represent another alternative for addressing screen reclamation waste issues. These devices separate the contaminants from screen reclamation effluent and provide an effective way to recycle and reuse spent solvent. Thus, like a filtration and recirculation system, these solvent distillers provide an opportunity to reduce solvent use, raw materials purchased, and operating costs.

Distillation units can provide a cost-effective method to reclaim solvent used in screen reclamation, and this may result in other benefits as well (lower cost, compliance benefits). Differential distillers can vary in size (two to three gallon capacity up to 250 gallons) as well as in cost. The relatively high cost may prohibit many small printers from utilizing this technology. When purchasing these units, printers should consider cost, relevant environmental regulations, and changes in the Uniform Fire Code affecting the availability and use of distillers (US EPA, 1994a).

Use of an automatic screen washer for ink removal may significantly reduce air emissions of certain volatile ink remover components, although the amount of reduction depends on the chemical components of the formulation (US EPA, 1994a).

Totally enclosed systems are commercially available for ink, emulsion, and haze removal or ink only removal. These systems can reduce the quantity of chemicals necessary for screen cleaning and reduce air emissions. Labor involved with screen cleaning will also be reduced. These systems are currently expensive and may be cost prohibitive for small printers (Jendrucko, 1994).

Many printers have found that by making simple process modifications they can reduce solvent use, waste disposal costs and employee exposure to harmful chemicals.

Whenever possible, avoid delays in cleaning and reclaiming the screen. The quantity of chemicals needed to remove ink, emulsion, and haze can be reduced if screens are cleaned promptly (US EPA, 1994b).

A printer in Minnesota reported that he had identified chemical overspray not directed at the screen during emulsion and haze removal as one of the biggest sources of chemical loss. Employees built a simple "catching frame" to place around the screen during the chemical application steps. The catching frame is used to capture the overspray, which is then recycled or reused (US EPA, 1994a).

A printer in New York said his facility keeps chemicals in safety cans or other sealed containers to minimize solvent loss from evaporation. They used to use a pump and spray unit to apply ink degradant and emulsion remover, followed by a high-pressure water wash. They only use haze remover if it is absolutely necessary. This facility has now gone to manual, spot application of the ink degradant and manual application of the emulsion remover, followed by a low-pressure rinse. A final high-pressure water blast follows this rinse step. Results of industrial hygiene monitoring at the facility indicate that this new method of applying chemicals results in no overspray of chemicals and reduced worker exposure, since the high-pressure water blaster no longer disperses the chemicals as a mist in the air. They have also reduced the accidental discharges from crimped or cracked discharge lines in the pump system. This printer estimates that the new methods of applying chemicals to the screen have resulted in a 15 percent reduction in material use (US EPA, 1994a).

An alternative technique for ink removal is to use a high-pressure water blast. The high velocity fluid impacting the screen loosens the emulsion and increases the removal efficiency. Pressures up to 4,000 psi have been used without damaging screens. The combination of this and previous measures could potentially reduce emulsion remover use by as much as 75 percent (Jendrucko, 1994). Precautions will have to be taken to protect the employees from the noise generated by the high pressure jet.

Using haze remover can cause screens to become brittle and tear more easily. It also contributes chemicals to the wastewater stream. Therefore, it is beneficial to minimize its use. Several simple techniques can be used to accomplish this reduction:

◆ Apply haze remover only to the affected area instead of over the entire screen

◆ Avoid allowing used screens to sit for a long period of time before reclamation because the longer ink and emulsion remain on the screen the more likely "ghost" images will form

◆ Apply an ink degradant to the screen before reclamation to prevent "ghost" image formation (Jendrucko, 1994).

Screen Disposal

Many screen printing facilities reclaim their screens for reuse because the screen material is valuable and costly to replace. Screen fabric can be one of the most expensive supplies that a screen printer uses and can have a large impact on cost of operations. For example, the most commonly used fabric, polyester, costs $10 to $40 per square yard. A shop that wastes $100 - $200 per week in fabric costs from ruining screens or failing to reclaim them, increases its production costs by as much as $5,000 to $10,000. The average monthly expense for fabric is $360. In addition, reclaiming screens has the advantage of saving labor time needed for stretching mesh across the frame and adjusting it to the correct tension. Some printers believe that using retensionable frames when stretching the mesh "work hardens" the fabric, improving the printability and longevity of the screen. Other printers note that reusing screens for other jobs, instead of storing them in an imaged screen inventory, saves both screen fabric costs and storage space often needed for presses (US EPA, 1994a).

Some screen printers with long production runs and extremely small screens, such as those used to print on medicine bottles, simply cut the screen mesh out of the frame after completion of the production run. By simply disposing of the screens, printers could eliminate the high cost of reclamation chemicals and labor time associated with screen reclamation, as well as reduce the risk associated with occupational and population exposure to these chemicals. However, printers have to dispose of more screens, some of which may be designated as hazardous waste due to the chemicals applied to them during imaging and printing. Due to the different types of source reduction involved in these two options, they are difficult to directly compare in terms of pollution prevention. Based on Design for the Environment (DfE) analysis, it is clear that screen disposal is not a cost-effective option for a majority of screen printing facilities. However, printers should not view this cost estimate as a final analysis, because the operations of any one facility can be different from the assumptions used in generating this analysis. Screen disposal would be more cost-effective in circumstances where production runs approach the useful life of a screen and where the size of the screen is relatively small (US EPA, 1994a).

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Annotated Bibliography

"Chemical Alternatives for Screen Reclamation-Case Study 5: Screen Printing." Design for the Environment Printing Project Factsheet. US EPA. 1994. 4 p.

Factsheet compares chemical alternatives for screen reclamation to traditional systems (includes only chemical composition of alternative, not product name). Tests were conducted at two facilities--includes performance, risk and cost data.

"Designing Solutions for Screen Printers." Design for the Environment Printing Project Factsheet. US EPA. 1995. 2p.

Factsheet gives overview of DfE project, gives no information about results of study.

"Reducing the Use of Reclamation Chemicals in Screen Printing: Screen Printing" Design for the Environment Printing Project Factsheet. US EPA. 1993. 4 p.

Very good factsheet. Case study of Romo Incorporated gives lots of good basic ideas, some easy and inexpensive to apply--includes cost and waste reduction data.

"Technology Alternatives for Screen Reclamation-Case Study 2: Screen Printing." Design for the Environment Printing Project Factsheet. US EPA. 1994. 4 p.

Factsheet discusses three alternative technologies for screen reclamation--compares risk, performance and cost to traditional methods.

US EPA. 1994a. "Cleaner Technologies Substitutes Assessment: Industry: Screen Printing Use Cluster: Screen Reclamation (Draft)" Washington, DC: United States Environmental Protection Agency, 1994.

Massive technical document including lots of data. Compares alternative and traditional screen reclamation products, technologies, and processes in terms of environmental and human health exposure and risk, performance and cost. Includes general screen printing information and good overall pollution prevention opportunities. An executive summary is available.

US EPA. 1994b. "Work Practice Alternatives for Screen Reclamation-Case Study 4: Screen Printing." Design for the Environment Printing Project Factsheet. US EPA. 1994. 4 p.
Very good factsheet lists general pollution prevention opportunities including process improvements and materials management/ inventory control.

"A Guide for Screen Printers." Washington State Department of Ecology, Environmental Management and Pollution Prevention, 94-137, September 1994.
A good primary resource for the screen printer. Has good checklists of Do's and Don'ts for each major wastestream.

Pollution Prevention for Printers and Photoprocessors, Metro-Dade County Department of Environmental Resources Management, October 1995.
A good booklet on general pollution prevention practices applicable to all types of printing broken down by process.

Factsheets

"Removing solvent and ink from printer shop towels and disposable wipes" MnTAP 1991, 6 p.
Presents options for removing solvent from shop towels and management of disposable wipes, includes some vendors.

Office of Waste Reduction Fact Sheet, Washington State Department of Ecology Nov 1988, Printing Shops, 4 p.
A listing of general pollution prevention opportunities for all types of printers.

Center for Hazardous Materials Research "Pollution Prevention: Strategies for the Printing Industry," 4 p.
Reasons to practice pollution prevention and general tips for all types of printers.

"Waste Reduction for the Commercial Printing Industry" California Department of Health Sevices Toxic Substances Control Division Alternative Technology Division, Aug 1989, 6 p.
Waste reduction incentives, requirements and alternatives including inks and solvents.

"Waste Reduction Checklist" Office of Waste Reduction Services, State of Michigan, Departments of Commerce and Natural Resources, Dec 1989, 6 p.
Checklist of general pollution prevention opportunities for all types of printers.

"Management of Solvents and Wipes in the Printing Industry" SHWEC Waste Education Series, May 1994, 4 p.
Proper management of cleanup wipes and methods of reducing solvent waste.

"Hazardous Waste Reduction Facts: General Commercial Printers" City of Santa Monica Department of General Services, 2 p.
General pollution prevention tips for all types of printers.

"Pollution Prevention Opportunities in Printing" USEPA Region 3, Oct 1990
General pollution prevention tips for all types of printers.

"Lithographic Ink Wastes: How to Reduce, Reuse, and Recyle Ink Waste" SHWEC Waste Education Series, Aug 1995, 6 p.
Discusses ink management techniques including 2 case studies and some ink recycling services providers.

"Waste Reduction Opportunities for Printers" SHWEC Waste Education Series, Aug 1994, 4 p.
Lists potential sources and types of printers' waste and to waste and emission reduction opportunities for printers.

Case Study 1
"Reducing the Use of Reclamation Chemicals in Screen Printing"

Design for the Environment Printing Project Case Study 1
US EPA, 1995, 4 p.

Romo Incorporated of De Pere, Wisconsin is a commercial screen printer that produces a wide variety of products including decals, banners, point-of-purchase displays, and original equipment manufacture. About 60 percent of the company's printing uses traditional solvent-based inks and 40 percent uses ultraviolet (UV) curable inks.

Romo began looking for pollution prevention opportunities in the screen reclamation process. Since screen reclamation is crucial to screen durability and the quality of printing, but also requires a number of expensive and harsh chemical products, the process seemed to provide a large potential to prevent pollution and save money. They concentrated on all three parts of screen reclamation: ink removal (screen cleaning), emulsion removal, and haze or "ghost image" removal. The company searched for ways to reduce chemical risk and prevent pollution through three strategies:

- reducing the volume of all products used
- testing alternative application techniques
- experimenting with alternative formulations of traditional products.

In-process recycling

Romo was using between 20 to 40 gallons of solvent per day. Used screen cleaning product drained through a trough into an open tank, then was lightly filtered and hosed back onto the screen. Unfortunately, the open tank allowed large quantities of solvent to evaporate, and an inefficient filtering system left the recovered solvent dirty and ineffective. Romo reduced their use of solvent to 55 gallons every three or four weeks by installing an in-process recycling still for a one-time cost of $2,900. This investment was recovered within seven weeks through reduced solvent costs. The new still is a closed system that uses a heating and filtering system to remove pigment before pumping the solvent back for reuse. The 5-gallon still is cleaned once or twice a week. The same 55-gallong solvent container lasts for 3 to 4 weeks. When the solvent becomes too dirty to clean effectively, Romo disposes of the ink-contaminated solvent as hazardous waste. This saves the company $83 per day or $20,750 per year in solvent procurement costs alone.

Alternative application techniques

For years the screen cleaning solvent was applied by hosing the solvent onto the screen. Romo added an adjustable spray nozzle in order to provide more direct and efficient application of the product. The nozzle, paired with better use of brushes to loosen the ink, was able to reduce the amount of solvent needed for each screen. Further reductions in solvent use were made by creating a pressure control device for the spray nozzle. The device was simply a small piece of wood secured under the handle of the nozzle by a locking band. Since the wood prevented the screen reclaimers from pushing the nozzle past a certain release point, the amount of solvent being sprayed was controlled.

By making the switch to a new press-side screen cleaning product. Romo was able to reduce its use of toluene and methyl isobutyl ketone by approximately 70 percent. Although the new product was expensive ($13 per gallon versus $3 per gallon for the old solvent) it performed well, and Romo decided to use this less hazardous product for press-side cleaning. Savings generated by using less reclaiming solvent with the new spray nozzle were used to fund the increased cost of the new press-side cleaning product.

New emulsion remover approach

Romo tested and then bought an extremely high-pressure water blaster (290 pounds psi) for $2,450 that harnessed the physical power of water pressure to reduce the amount of chemical emulsion remover product used on each screen. Romo was concerned that the increased pressure might disturb screen tensioning or deteriorate the mesh. After five years of use, they were confident enough that the equipment did not deteriorate the mesh that they bought another even higher pressure (1,500 psi to 4,000 psi) blaster for $4,900. Another way Romo reduced the amount of emulsion remover needed was by diluting it with water before applying it to the screen and creating a new applicator for emulsion remover. Formerly, employees dipped a scrub brush into the sliced-open top of an emulsion remover containers before bringing the brush to the screen. Now, the 15-gallon drum has been modified by adding a spray nozzle to evenly mist the emulsion remover onto the screen.

The plant engineer estimates that the combination of the change in emulsion remover application technique, dilution of the emulsion remover, and use of the high-pressure water blaster has resulted in a 75 percent reduction in emulsion remover use. This reduction saves the company almost $3,800 per year.

Haze remover use change

Romo has taken several steps to reduce the use of haze remover. First, the screen reclaimer applies haze remover precisely to the part of the screen that is stained. Second, employees try to remove ink and emulsion as quickly as possible. Third, Romo is looking for alternative chemicals that will eliminate the ghost images and the need for haze remover. The company is also testing a method that the Screen Printing Technical Foundation believes can eliminate the need for a haze remover. The techniques requires that the operator degrease and apply ink degradant to the screen before applying emulsion remover.

Modification	Advantages	Disadvantages
Sprayer/applicator systems	Minimize cleaning solution used, reduce chemical waste at the source, may decrease labor costs because screen cleaning will be faster and easier	Cost of sprayer system
Washout booths Filtration systems	Minimize exposures and waste Minimize cleaning solution used, recycle solutions	Expense of systems Disposal of filter and/or concentrate
Recirculation systems Distillation units	Reclaim solvent for reuse	Expensive and prohibitive for small printers. Disposal of sludge
Automatic screen washers	Reduces air emissions, reduce quantity of chemicals used, labor will be reduced	Expensive and prohibitive for small printers

Case Study 2

"Infrared Ink Curing Boosts Productivity for Indianapolis Apparel Decorator"

EPRI Journal, October/November 1994

In collaboration with Indianapolis Power & Light Company (IP&L), EPRI's Center for Materials Fabrication recently evaluated the energy savings potential of on-line infrared ink-curing ovens at Logo 7, Inc., a major Indianapolis apparel decorator. Four IR panels, each rated at 4.8 kW, were installed on a 12-stage silk-screening machine and were evaluated through a series of tests. The tests demonstrated that inks could be fully cured while still on the machine, eliminating the need for a convection oven. Energy consumption was reduced 23 percent compared with convection oven curing--a reduction that translates to annual energy cost savings of nearly $900 per silk-screening machine.

Case Study 3

"Conversion to Low VOC Technologies" Pollution Prevention for the Printing Industry

Screenprinting and Graphic Imaging Association, Intl., US EPA, Printing Industries of New England and Massachusetts Office of Technical Assistance
September 1993

A screen printing facility switched to inks with low amounts of volatile organic compounds (VOC) from inks with high VOC levels. This change allowed the company to continue to operate and expand its operations in an area of ever increasing air pollution control programs.

Traditionally, the screen printing facility primarily printed with solvent based ink systems. The facility is printing a wide variety of point-of-purchase products, banners for indoor and short term outdoor use, and all types of window decals. Due to the regulatory environment that was forcing reductions in the amount of volatiles emitted, the facility began the transition to low VOC technologies.

Ninety-five percent of the inks used by the facility are low VOC. The facility uses both UV curable and water based ink systems depending on the printing requirements. Employee training in the use of both ink systems was required. Originally, the facility moved into UV technology and then into the use of water based technology.

The facility phased in the use of water based technology over a period of nine to twelve months. They began by doing parts of a print run with water based inks. Working with these low VOC ink systems has required this facility to become more sophisticated in its approach to the screen printing process.

The following are SGAI's recommendations and work practice modifications for effective use of water-based technology.

- Ensure that films are clear of scratches, splices, and improperly developed areas. Any of these problems tend to cause a weak stencil.

- When haze removers were used to remove dried on water-based ink, screens were flushed completely with a strong water wash and degreaser before new stencil application. Caustic based cleaners, if not thoroughly removed, tend to re-wet the screen and break down the stencil.

- Screen stencils needed to be completely and thoroughly dried before exposure. Maintain a low humidity (below 60 percent RH) and warm air (up to but not exceeding 100 degrees F) to assure thorough drying. Drying cabinets, under these conditions, will complete the drying in less than two hours, regardless of screen size. The facility has found that screens for water-based inks should not be coated as thick (one-third less) as ones used for solvent based inks.

- To assure thorough and complete exposure of the stencil, an exposure unit rich in actinic light (correct spectral intensity in UV) was used. The wattage output was not the concern here, duration of spectral intensity expressed in real time, minutes or seconds, was. The facility is now using a 7500 watt lamp.

- Stencils used for long runs are chemically hardened.

- After developing the stencil a sufficient amount of drying needs to occur. Using warm air and low humidity conditions, the drying times were less than two hours.

- If pinholing the stencil after exposure is necessary, the same photo emulsion used to coat the screen must be used again and re-exposed. Caution must be exercised not to use an excessive amount, regardless of technique, of brush or flat applicator.

- Press operators must have spray bottles of water to mist on flooded screens to replace water that evaporates.

- Pre-lubricate the squeegee with a very oily safety solvent to double or triple the number of impressions obtained prior to resharpening the squeegee.

- Water-based inks may be very difficult to remove from the stencil, and the use of haze removers may be necessary.

A major concern with the use of water based inks is the weather, or the ability of the air to draw the water out of the ink. The facility has found that as shop conditions change throughout the day, printing conditions may change as well. For example, the print run in the morning may only thin with water, and as temperatures increase, more solvent based retarders may be used. However, in both hot and cool humid conditions, care must be taken to use water as a thinner since water based inks loaded with too much retarder are difficult to dry.

The following are SPAI's recommendations and work practice modifications for effective use of UV technology.

- 360 and up mesh counts are used.

- The durometer of the squeegee changes. A harder squeegee is used to print UV inks.

- Prior to running the actual job, a radiometer is used to measure the intensity of the lamp. In addition, an ink cure analyzer is used to test the degree of cure that is achieved.

The facility has found that employee training is crucial to the effective use of low VOC technologies in a production setting. By reducing the amount of solvent based inks used by 95 percent, the facility realized a 70 percent emission reduction from ink emissions alone.

The use of UV technology does require the purchase of new equipment. A typical cure unit, depending on belt width, costs $12,000 to $24,000. However, UV curing equipment is more compact and can reduce the amount of space required for a facility's print area.

While the cost of UV ink is higher than traditional solvent based ink, the UV ink provides a larger amount of coverage. 2,700 square feet from a gallon of UV ink, as opposed to 1,500 from a gallon of solvent based ink.

Water-based inks behave more like solvent based ink, and no new equipment was required to introduce this ink system into the facility. The costs of water based ink are similar to the solvent based ink, so there was no appreciable difference in overhead.

The facility did not find that water-based ink systems require more energy to dry as compared to similarly used solvent based ink systems. Overall, the facility is pleased with the change to water based products. They are easy to work with, there is very little odor associated with the system, but they are difficult to dry.

Case Study 4

"Screen Printing Case Study-Waste Water Issues" Pollution Prevention for the Printing Industry

Screenprinting and Graphic Imaging Association, Intl., US EPA, Printing Industries of New England and Massachusetts Office of Technical Assistance
September 1993

The screen printing facility produces a wide variety of products with both solvent and UV curable ink systems. Upon relocation to a new facility, the screen printing operation was required to install and institute new programs for all operations producing a waste water stream to comply with state and federal regulations.

Prior to the move, the facility was using a solvent based material to clean and reclaim screens. Today, the facility is using a water soluble product for both ink removal and reclaiming.

A silver recovery/wash water recirculating system was installed in the darkroom. This unit reduces the amount of silver contained in the waste stream to acceptable levels, and reduces the amount of waste water that must be disposed in a hazardous waste treatment facility.

A system was designed that allows for the recycling of the waste water from screen cleaning activities. This minimizes the use of water as well as disposal costs. After the water is spent, it is placed in holding tanks and transported to a legal disposal facility. To install this waste water recirculating systems, the facility spent $35,000 and will incur an annual operating cost of $8,000.

By making a switch from solvent based to water soluble screen cleaning/reclamation products, the facility realized a savings of $7,000 per year.

Due to the installation of the silver recovery/wash water recirculating system, the facility has seen a 60 percent to 80 percent decrease in the amount of waste that must be properly disposed.

The filter recirculating system installed in the screen reclamation area has reduced the amount of waste by 75 percent. With the addition of both recirculating/filtration systems, disposal costs for this facility are approximately $9,000 per year.

Case Study 5

Pollution Prevention Opportunities in Screen Printing Operations: A Case Study

presented by Lisa F. Wilk
Screenprinting and Graphic Imaging Association, Intl., US EPA, Printing Industries of New England and Massachusetts Office of Technical Assistance
September 1993

A screen printer in New England was faced with increasing costs for disposal of solvent wastestreams generated by cleaning of fine mesh screens.

Input chemical substitution--screen cleaning operations formerly utilized organic solvents (toluene, mineral spirits). Through a product literature search, an alternative aqueous cleaning chemistry was identified. Pilot testing of the alternative cleaner indicated that satisfactory cleaning could be obtained with the aqueous chemistry.

Rinse process modification--spray nozzles were installed to control flow, which improved cleaning and minimized excess wastewater generation from rinsing operations.

Cleaning process modification--a countercurrent cleaning system was installed to achieve more efficient use of cleaners. This is an idea borrowed from the electronics and metal finishing industries, which involves passing the component (e.g., the screen) requiring cleaning (or rinsing) through two or ideally three baths of cleaner (or rinse). Fresh solvent (or rinsewater) is only added to the last bath. The solvent (or rinse) is periodically (or continuously in the case of rinsewaters) transferred from the last container to the previous bath (and from the second bath to the first bath in the case of triple countercurrent systems). Thus, the screen is rinsed in the cleanest bath last. Computer modelling has shown triple countercurrent rinsing to be the most effective in terms of cleaning quality as well as reduction in cleaning solvent (or rinse) required. Adding four or more baths to the system does not achieve measurable improvement over the triple countercurrent system.

Process equipment modification/upgrade--automated cleaning systems were investigated. Due to capital equipment investment requirements, it was decided to postpone this option for further review in the future.

Through a cooperative team effort, a New England Screen Printer was able to identify and implement pollution prevention techniques in its screen cleaning operations. The printer achieved a significant cost savings in cleaning chemistry purchase costs, water and sewer costs, and waste stream disposal costs. In addition, the printer helped contribute to an improved environment by reducing its use of toxic chemistries and its generation of hazardous waste streams. Encouraged by its success with implementation of pollution prevention techniques in screen cleaning operations, the company is now investigating potential techniques for reducing ink usage and waste generation.

Case Study 6

Technology Alternatives for Screen Reclamation Design for the Environment Printing Project

US EPA
October 1994
(also available to download from EnviroSense http://es.inel.gov/)

This is one of a series of case studies focusing on the screen printing industry that EPA has developed to illustrate how the DfE concepts can be incorporated into screen printing operations. This case study focuses on different technologies that can be utilized in screen reclamation. Three screen reclamation technologies that may enable the printer to change both the types and amounts of chemicals used are: high pressure screen washers, automatic screen washers, and sodium bicarbonate (baking soda) spray.

This case study presents:

1) Descriptions of two commercially available technologies that can reduce a facility's usage of traditional solvent-based ink removers.

2) Description of a technology now under development that could further reduce the costs and potential health risks of screen reclamation.

3) Comparative cost, performance and risk information for three reclamation technologies.

The costs and risks for each of the three substitute technologies are compared to the costs and risks of a traditional screen reclamation system. The traditional system used in the comparison consists of lacquer thinner as the ink remover, a sodium periodate solution as the emulsion remover, and a xylene/acetone/mineral spirits/cyclohexane blend as the haze remover. These chemicals were selected because screen printers indicated they were commonly used in screen reclamation. In both the cost and risk comparison, it was assumed that these chemicals were applied manually to 6 screens per day, each 2,127 in^2 (approximately 15 ft^2) in size.

High Pressure Screen Washers

Two high pressure screen reclamation systems were reviewed. In addition, the performance of one system was evaluated in a print shop as part of the DfE Screen Printing Project. High pressure washers typically work as follows. Excess ink is carded off the screen prior to cleaning. No ink remover is applied to the screen. An emulsion softener or remover is applied and allowed to work, typically for anywhere from ten seconds to less than one minute. The ink and stencil are then removed by a high pressure water blaster sprayed on both sides of the screen at a pressure of up to 3,000 pounds per square inch (psi). If necessary, a haze remover is then applied and allowed to work. Again, the high pressure water blaster is used to rinse off the haze and the haze remover. Cleaning usually takes place in a washout booth where the rinse water can be collected.

While this technology may require significant water use, most emulsion and haze removal products are formulated to allow discharge to sewers. Where ink residues in the rinse water exceed wastewater permit concentration limits, such as for suspended solids, manufacturers also supply a variety of filters. Some improved filtration systems allow rinse water to be reused. Filter wastes are typically disposed of as hazardous waste.

In general, the benefits of high pressure washes are that they reduced both chemical use (eliminating ink removers) and worker exposure (less scrubbing required). The DfE Screen Printing Project found that the occupational risks of this system were notably lower than the risks associated with the traditional solvent-based reclamation chemicals, particularly with organic solvents, were significant. For the high pressure screen reclamation system, health concerns were related to unprotected skin contact with the reclamation chemicals. Dermal exposures could be reduced dramatically, however, by wearing gloves. Ecological risks from discharges to the water were not a concern for either the traditional system or the high pressure blaster system. General population risks from air releases also were not a concern for either system.

Performance

Performance of a high pressure water blaster were evaluated by DfE staff at a volunteer printing facility where the technology was in place. During the demonstration, the technology's performance was very good. On screens with solvent- and water-based inks, the stencil dissolved easily, leaving no emulsion residue on the screen. Ink stains on these screens were completely removed by the haze remover even before the waiting period or pressure wash. Reclamation results were fairly similar for UV-curable ink as well.

Cost

The DfE Screen Printing Project also estimated the cost of equipment, labor, and chemicals for the high pressure wash. Assuming that 6 screens are reclaimed daily and each screen is 2,127 in² in size, the cost estimate for the high pressure washer totaled $4.53 per screen. This estimate was compared to that of traditional screen reclamation system. Using the same assumptions, the estimated reclamation cost using the traditional system is $6.27 per screen: 30 percent more that the high pressure wash, with the greatest savings coming from the reduced labor costs for the high pressure washer. Equipment costs, estimated at $5,300 (installed) account for just 12 percent of the per screen costs. This estimate does not include filtration units, which range in price from $1,300 to $12,000, although maintenance and operating costs vary widely.

Automatic Screen Washers

There are several different types of automatic screen washers, and although most are used for ink removal only, automatic systems for emulsion and haze removal are also available. The major benefits of automatic screen washers are reduced solvent losses, reduced labor costs, and reduced worker exposure. The DfE Screen Printing Project identified a wide variety of automatic screen washers on the market and found significant differences in the chemicals used and costs. Costs vary based on the level of automation (such as conveyors), system capacity, and complexity of the equipment.

The basic component of the automatic screen washers is the wash unit, and enclosed box that can house a variety of screen sizes (up to 60 in. by 70 in.). After a screen is clamped inside the wash unit and the top closed, the cleaning process begins. A mobile mechanical arm sprays solvent onto the screen through pressurized nozzles (30 to 150 psi) for any preset number of cleaning cycles. Since the systems are enclosed to reduce solvent losses, volatile solvents, such as mineral spirits, are often recommended because of the efficacy. There are, however, a number of alternative formulations offered by equipment manufacturers. Used solvent drains off the screen and is directed to filtration system to removed particulates (inks and emulsion). Following the filtration step(s), reclaimed solvent is typically reused. Some systems have separate wash, rinse, and air dry cycles or separate tanks for washing and rinsing. Solvent reservoirs must be replenished intermittently and changed once or twice a year. Filter wastes are typically disposed of as hazardous waste.

Risk

Compared to manual application of the traditional screen reclamation chemicals, the DfE risk evaluation of automatic screen washers found that worker inhalation exposures to the volatile organics used in solvents (mineral spirits and lacquer thinner) were reduced by as much as 70 percent. Although the health risks associated with skin contact of the chemicals remained high, these risks could be reduced dramatically if gloves are worn while handling the screens. Since the automatic screen washer is used for ink removal only, the risks associated with emulsion and haze removal remained the same as the traditional system's risks for these steps.

Performance

As described above, there are several types of automatic screen washers, and for each type there are several manufacturers. Because of the resources required to do a full demonstration of the equipment commercially available, performance demonstrations of automatic screen washers were not conducted as part of this project.

Cost

The DfE Screen Printing Project estimated costs for two automatic screen washers, assuming that the washers were used for ink removal only and that 6 screens (as above) were reclaimed per day. Screen reclamation costs using an automatic screen washer ranged from a low of $4.13 to $10.14 compared to $6.27 for traditional reclamation. The largest cost component, and the cause of the variability in costs, is typically equipment cost. Additionally, the savings of switching to this technology would be greater if this costing accounted for the labor savings of workers moving on to other tasks once the screen is loaded in the washer. It is important to note that the cost per screen of the more automated, higher cost washer would be much lower if it operated nearer to its capacity of over 100 screens per day.

Sodium Bicarbonate Spray

A sodium bicarbonate (baking soda) spray technology was evaluated by the DfE Screen Printing Project to determine if it is potentially adaptable as an alternative screen reclamation technology. This technology is currently used for removing coating, such as paint, grease, or teflon from metal parts. In these applications, the technology has been successful in replacing hazardous cleaning chemicals. Based on the technology's success in other applications, it appears to be a promising substitute for chemical screen reclamation systems. Because the sodium bicarbonate spray technology had never been tested for screen reclamation, DfE staff conducted a one-day site visit to the equipment manufacturer's facility. Three imaged screens were inked with three types of ink. An inked screen was placed inside an enclosed cleaning booth, and the screen was passed, back and forth, under the sodium bicarbonate spray. No chemicals other than the sodium bicarbonate spray were used during the reclamation.

Risk

The DfE project did not undertake a risk assessment of this spray technology for a number of reasons. Sodium bicarbonate has been shown to be a fairly innocuous chemical and it is not a skin irritant. In addition, it is a common ingredient in baked goods, toothpaste and detergents. If this technology proves to be a viable alternative for screen reclamation in the future, a detailed assessment of the human health and environmental risk should be conducted.

Performance

The performance demonstration showed that cleaning the screen with a pressurized sodium bicarbonate spray alone, without water, resulted in excessive damage to the screen. Performance clearly improved when the sodium bicarbonate spray was combined with a pressurized water spray for screens with solvent-based ink and water-based ink. Typically, the emulsion came off in stringy rolls, and ink flaked off rather than dissolved. A 100 in^2 area took approximately 15 minutes to clean. Following this cleaning, there were either significant haze or ink residue sops. Slightly greater spray pressures or slightly longer times resulted in visual screen damage or a ripped screen. Cleaning of UV-curable inks was ineffective. No evaluation of subsequent use of these screens was made.

Based on these limited demonstrations, initial results indicate that with further testing and research, this may be a promising new screen reclamation technology. Some modifications are needed to clean the screens faster and with less possibility of screen damage. For example, the physical support behind the screen greatly reduced the stress on the mesh. Use of hot water was suggested as a means of improving emulsion removal. Other modifications may include decreasing the sodium bicarbonate particle size, or modifying the delivery rate and pressure of the sodium bicarbonate and water sprays. Further testing is needed before a definitive evaluation of performance can be given.

Cost

Since the available equipment was not designed specifically for screen reclamation, it was assumed that the cost of equipment modified for screen reclamation would be similar to the cost of the equipment used in the performance demonstration. The available equipment ranges from $32,000 to $52,000, including a filtration system. The sodium bicarbonate itself costs between $0.65 to $0.75 per pound, based on amount purchased, and approximately 1 pound is sprayed per minute. If this technology proves to be a feasible alternative for screen reclamation after further developments, a more detailed cost analysis can be conducted.

This case study described three distinct screen reclamation technologies that could offer a screen printer the means to reduce employee exposures to chemicals. These technologies may also reduce the total cost of screen reclamation (which included equipment, labor, reclamation products, and waste disposal costs). One of the technologies under development (sodium bicarbonate spray) offers the benefit of using relatively benign chemicals.

Case Study 7

Chemical Alternatives for Screen Printing
Design for the Environment Screen Printing Project

Case Studies #5 (EPA 742-F-95-004) and #10 (downloaded from EnviroSense at http://es.inel.gov/)
US EPA 1995

Printers, EPA, product manufacturers, and the screen printing trade association are all concerned with minimizing the environmental and health hazards of screen-reclamation chemicals currently used in printing shops. In response to these concerns, the DfE Screen Printing project worked with printers and selected the screen reclamation process as one of the foci.

Through DfE, these groups worked together to evaluate alternative screen reclamation products. A total of eleven alternative chemical "systems" were evaluated. Most "systems" included an ink remover, an emulsion remover, and a haze remover.

This case study is geared toward getting information to small- or medium-sized printers. It is a compilation of the data presented in DfE Screen Printing Case Studies #5 and #10. Included are: performance evaluations of the alternative system from laboratory tests and from two printing facilities; the health and environmental risks of the alternative system compared to a traditional screen reclamation system; and the cost of the alternative system compared to the cost of a traditional system.

Background

Initiated by industry, this project was entirely voluntary and involved almost all sectors of the screen printing industry. All product systems were evaluated using the same methods. The consistency of the evaluations allows the printer to determine which of the alternatives may be a substitute for their current reclamation products.

This case study highlights two alternative systems, referred to as Chi and Epsilon. These systems, as with all systems demonstrated in the project, is a real, commercially available screen reclamation system; however, the names of the products are masked. The actual trade name for these alternative system is not used in this case study or in the final project report. Trade names were masked for several reasons: 1) DfE hopes to encourage printers to discuss the characteristics of the products they use, or are considering using, with their suppliers; 2) since every screen printing shop is different, manufacturers recognize that their product's performance may vary greatly depending on both the operating conditions and the varying options of the different printers using the products. In order to get their full cooperation before the results were available, some manufacturers asked that the product name be masked.

To compare the cost and risk of the alternative systems to a known system, a baseline was established using a traditional solvent-based screen reclamation system. The traditional system used in the comparison consists of lacquer thinner as the ink remover, a sodium periodate solution as the emulsion remover, and a xylene/acetone/mineral spirits/cyclohexanone blend as the haze remover. These chemicals were selected because screen printers indicated they were commonly used in screen reclamation. In both the cost and risk comparisons, it was assumed that these chemicals were applied manually to 6 screens per day, each 2,127 in^2 in size.

Promising Performance

Performance was evaluated in two phases: 1) performance demonstrations at Screen Printing Technical Foundation's laboratory evaluated the products under controlled conditions; and 2) field demonstrations at volunteer printers' facilities provided performance information under the variable conditions of production. Each product system was demonstrated in two or three facilities for one month to get a more complete evaluation of performance under a variety of operating conditions.

Laboratory Testing

During laboratory testing, three imaged screens were reclaimed using each alternative system: one that had been inked with solvent-based ink, the second with an ultraviolet-curable (UV) ink, and the third with a water-based ink. Following the ink application, screens were allowed to dry for 15 minutes to simulate a shop situation. After drying, the ink remover was applied according to the manufacturer's instructions. Again the screen was allowed to sit, this time for 24 hours, before applying the emulsion and haze removers.

System Chi

Two applications of the Chi ink remover were required to remove the solvent-based ink. The ink dissolved more easily on the other two screens (UV-curable and water-based ink), however, an ink residue or haze remained on all of the screens after applying the ink remover. On two of the screens, the stencil started to deteriorate during the ink removal process, indicating that this product may not be applicable for in-process ink removal. The emulsion remover easily dissolved the stencil with only light scrubbing, leaving no emulsion residue behind. When additional ink remover was applied (used as a haze remover in this product system), it removed the ink residue and lightened the stains on all three screens.

System Epsilon

The Epsilon ink remover dissolved the ink quickly, was easy to use, and rinsed clean of reside on the screens with solvent-based inks and UV-curable ink. In both cases, a light to moderate ink stain remained on the screen. When the ink remover was used on the water-based ink, more time and effort were needed, but the ink was removed except for a light stain. On all three screens, the emulsion remover dissolved the stencil and there was no emulsion residue on any of the screens after pressure rinsing. In the final step, the haze remover lightened the ink stains of all three screens.

On-Site Demonstrations

Four printing facilities evaluated these alternative systems. Facility A and B used Epsilon for one month. Facility C and D used Chi for one month. Their experience with these systems follows.

Ink Remover Performance

System Chi

At Facility C, the alternative ink remover worked well, although some of the workers who used it thought that it acted more slowly than their standard product (a solvent blend). Facility D found the alternative ink remover worked well, especially on metallic inks.

System Epsilon

At Facility A, the ink remover worked well, although some of the workers who used it thought that it acted more slowly and required more effort on catalyzed inks than on other solvent-based inks. At Facility B, the product removed both UV-curable and solvent-based inks efficiently, but the UV-curable inks was slightly easier to clean than the solvent-based ink. In addition, Facility B found they used significantly less alternative ink remover per screen than their standard product, which was lacquer thinner.

Emulsion Remover Performance

Both emulsion removers worked well at all facilities, dissolving the stencil quickly and easily.

Haze Remover Performance

System Chi

This system did not include a haze remover; instead the manufacturer recommended applying the ink remover again to remove any remaining haze. Facility D found their screens were clean after the emulsion remover and a haze remover was not needed. At Facility C, the haze remover lightened the haze, however, a ghost image remained on the screen that continued to build over time. For light haze, the haze remover was acceptable, but in most cases, this facility needed to dehaze the screen again with another product.

System Epsilon

Both facilities evaluated the haze remover performance as "acceptable," and similar in efficacy to their standard haze removers.

Overall Evaluation

System Chi

At both facilities, the performance of Chi was comparable to the performance of the facilities' standard screen reclamation products. The consistent performance of the product at SPTF and in two print shops demonstrates that this system can work under a variety of operating conditions. When compared to the traditional system described in this case study, a switch to Chi significantly reduced risks and costs while maintaining the screen reclamation performance printers expect from their products. Although the alternative system described, may prove to be a good alternative in many printing shops, it may not be the solution for all types of screen printing operations.

System Epsilon

The performance of Epsilon was similar at both facilities, according to the printers' evaluations. Because the two facilities have very different operations, the fact that Epsilon performed well at both plants demonstrates that this system can work well under a variety of operating conditions. Facility A prints banners and point-of-purchase displays on plastic using a variety of solvent-based inks, a dual cure emulsion, and mesh counts of 83-280 threads/inch. Facility B prints vinyl and mylar labels using both solvent-based and UV-curable inks. They use a direct photo stencil and screens with a mesh count of 355 threads/inch. Even with these differences, Epsilon was successful in reclaiming screens at both facilities. The final proof for the participating printers was that all the reclaimed screens could be reused for future print jobs.

Reduced Risk

The risks associated with inhaling the chemicals in Epsilon are much lower, in Chi were found to be negligible, while there is a clear concern for chemical inhalation risk with the traditional system. Gloves should be worn with both alternative systems as well as with the traditional system.

Cost Savings

The performance demonstrations showed that all of the participating print shops could reduce their costs for screen reclamation by switching to an alternative system. Costs of the alternate systems were compared to costs of using the traditional system. Assumptions included 6 screens reclaimed daily (approx. 15 sq. ft.) in size for both the traditional and alternative systems. The cost estimate for each reclamation system included labor time spent to reclaim the screen, the cost of an average quantity of reclamation products, and the cost of hazardous waste disposal for RCRA-listed waste or RCRA characteristic waste; the RCRA-listing applies to the traditional system ink remover only.

System [illegible]

For Facility C. their reclamation cost per screen would drop from $6.27 to $3.89/screen. This would lead to annual savings of $3,560. At Facility D. the reclamation of $6.27 would decrease to $3.25 screen. Over a year, the savings would amount to $4,520. The difference in costs between the facilities is due to differences in the quantity of product used and the labor time required per screen as recorded by employees.

System Epsilon

For Facility A. their reclamation cost per screen would drop from $6.27 to $3.08/screen. This would lead to annual savings of $4,775. At Facility B the cost per screen with the alternate system would be $5.29. Over a year, the savings would amount to $1,469. The difference in costs between the facilities is due to differences in the quantity of product used and the labor time required per screen as recorded by employees.

7 Flexography

Overview

Flexographic printing uses a printing plate made of rubber, plastic, or some other flexible material. Ink is applied to a raised image on the plate, which transfers the image to the printing substrate. The fast-drying inks used in flexography make it ideal for printing on materials like plastics and foils. This makes flexography the predominant method used for printing flexible bags, wrappers, and similar forms of packaging. The soft rubber plates are also well-suited to printing on thick, compressible surfaces such as cardboard packaging. Inks used in flexography are usually either water-based or solvent-based (Pferdehirt, 1993).

The print area or image consists of a raised surface, known as relief printing, that can be inked and pressed onto the substrate. Non-image areas are below the printing surface and do not reproduce (Price, 1994). Both sheet-fed presses and web presses are used in flexographic printing. A diagram for flexographic printing is shown in Figure 9.

All original text, pictures, and illustrations are photographed to convert them into the proper positive or negative films to make the plate which reproduces the image on the substrate. This step includes the use of photographic chemicals, paper, and film. The plates are made photomechanically, using a flexible material such as plastic or rubber, and coated with solutions to make certain areas insoluble in water. Wastewater from this process may contain acids, alkalis, solvents, plate coatings, and developers. If using metal plates, non-image areas are etched with an acid solution that result in high concentrations of heavy metals in the waste water. If using rubber or plastic plates, no metals are introduced into the waste water. Ink is applied to the image on the plate. From the plate, ink is transferred directly to the substrate. Wastes associated with this process are waste paper, waste ink, and cleaning solvents. Air emissions containing VOCs from inks and cleaning solvents are important waste streams (Price, 1994).

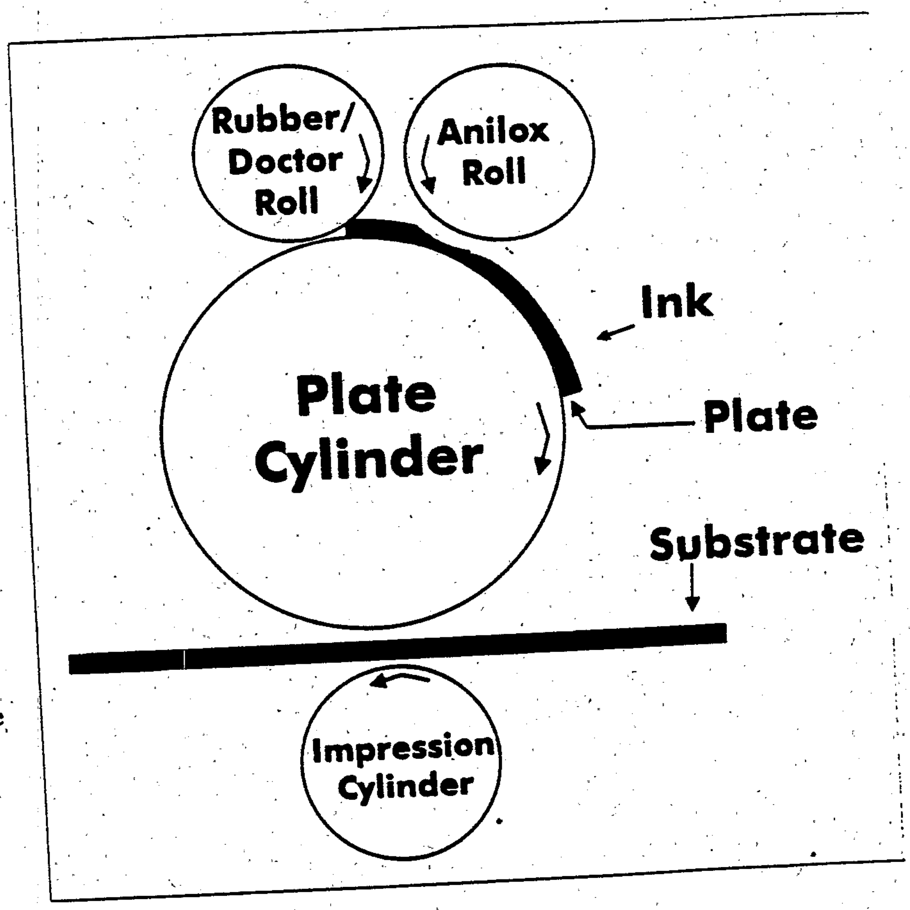

Figure 9. Principle of Flexography

Flexographic printing has considerable impact on the environment based on the use of rubber and photopolymer plates, solvent-based inks, and hydrocarbon solvents, as well as a broad range of substrates. Printers select and mix chemicals for a variety of prepress and pressroom applications. Darkroom chemistry, platemaking, inks and solvents, and maintenance all use chemicals to achieve the ultimate goal of transferring a quality image to a substrate (Shapiro, 1993a).

The traditional flexographic operation has many large, open containers for inks and solvents which are used in the printing process. These evaporate rapidly into the plant and are emitted through the exhaust stacks. Process waters are discharged from darkrooms, cleaning tanks and cooling systems. Water-based inks may result in cleanup wastes going to sewers or septic tanks. Adhesives used in converting may also find their way into the water discharges. These wastes may still be considered to be hazardous in some states depending upon their composition. The state regulatory agency will be able to provide guidance on this issue. The manufacture of engravings for rubber plates and photoploymer plate processing introduce sources of air, water and hazardous wastes (Shapiro, 1993a).

Prepress

Plate Preparation

Citrus-based solvents and other more acceptable solvents have replaced the traditional chlorinated solvents available to plate shops and printers who make photopolymer plates. Water-washable photopolymer platemaking systems are now on the market. These are usually classified as nontoxic, noncarcinogenic, and noncorrosive (Thompson, 1994).

Photopolymer masters have been introduced for making rubber plates. The hard photopolymer replaces the metal engraving. Laser-engraved rubber plates have also been introduced and provide a chemical-free means of platemaking. Future improvements might be in the area of reuse and recycling of photopolymer plates, trim scrap and polyester cover sheets, and further packaging reduction/reuse (Thompson, 1994).

In-line platemaking systems are fully enclosed and have microprocessor-controlled exposure with processor and dryer/light finisher units. Light finishing via UV sources with advanced automation and computerized controls ensures accurate platemaking and reduced operator handling. These systems work well with a solvent-reclamation unit (Thompson, 1994).

Press

Inks

Water-based inks have been used most broadly among flexographic printers, especially when printing on paper substrates such as corrugated containers. The first large-scale testing of water inks on film and foil substrates occurred in late 1979 and continued throughout 1980. In general, flexographic printers made the switch before it was required. Trials began with white ink, which represents the largest ink usage for the majority of flexographic printers. Early problems included poor adhesion, poor wet rub properties, low gloss, and reduced press speeds (Morris, 1986). The poor adhesion has been particularly troublesome with frozen food packaging.

Water-based ink technology has improved to the point where it is in the mainstream of film printing. The colors produced are more vibrant and crisp than their oil counterparts (Price, 1994). Films need further development to tailor them for the wetting-out and adhesion of water-based inks. Inking and drying systems need modifications to achieve more effective transfer and drying of water-based inks. In addition, there is a need for cleaning systems that will facilitate the removal of all ink components and extend the life of anilox rolls and doctor blade systems (Shapiro, 1993b).

With water-based inks, the surface tension causes beading (ink that will not "lay down") that produces sharp process dots with less tendency to bridge. Printers capitalize on that by using ceramic anilox cylinders and plates that release the ink more readily to the substrate. Good ink trapping insures good process printing. To accomplish good dry trapping one must increase the negative pressure on the in-between driers to accommodate the increased expansion of water compared to alcohol, i.e., increase warm air movement. Enclosed ink systems and ink temperature control can reduce amine loss and retain the color strength at the original viscosity. Water-based inks dry in a 3-step process; water evaporates from the ink, amines must leave the ink for the ink to have water resistance, and the polymer emulsion particles must join to create a film or network in the dried ink film. Water inks are more stable in high humidity conditions and do not suffer solvent loss and the resulting changes in viscosity that solvent inks do. To maintain good process printing with water-based inks, it is necessary to prevent excessive mechanical agitation, maintain suitable pH, keep temperatures below 110 °F, refingerprint press using water inks, and change to ceramic anilox cylinders (Matthiesen, 1993).

A new class of water-dispersible polyester resins is finding application in water-borne flexographic printing inks and overprint lacquers. Unlike other aqueous ink systems that rely on relatively high acid resins for water dispersibility, the new polyesters require no neutralizing agents, such as ammonia or amines, to maintain water dispersibility. The need to balance ink pH on the press is thus unnecessary, and odor problems associated with volatile amines are avoided. These polyester systems dry faster on the substrate, allowing faster press speeds or lower oven temperatures, and they exhibit rewettability on the press (cylinders, plates, anilox rolls). This is all made possible because the linear aromatic polyesters contain sodiosulfo groups (Barton, 1991).

Achievements in doctor blade technology have resulted in high quality flexographic printing and pollution prevention through controlled ink transfer from the ink container to the substrate. The average two-roll system with its ink fountain, fountain roller and anilox roll is a veritable open reservoir, exposing large quantities of solvents that are readily evaporated. The chambered doctor blade halts this evaporation. Ink enters the chamber from the reservoir or ink sump by a pump. The ink is held in the manifold area, with a small area exposed to the anilox roll. A doctor blade is positioned to shear off the excess ink as the anilox turns, returning any extra ink to the chamber. A second plastic or metal blade retains the ink within the chamber. The chamber is sealed off completely so that no ink goes beyond the width of the unit. Anilox roll technology has advanced to accommodate the wear of the doctor blade. When cleaning anilox rolls, use automated systems with ultrasonic or high-pressure, and liquid cleaning (versus mechanical) to reduce damage to rolls or cells.

Chrome-plated rolls have been replaced by laser-engraved ceramic surfaces. The blades now wear instead of the roller (Shapiro, 1993b).

By using the chambered doctor blade system and other related improvements, the fountain and the ensuing solvent exposure and evaporation have been reduced. The only ink solvents evaporating are those carried by the anilox roll to the printing plates and then to the substrate. No matter what the press speed, the ink amount deposited using doctor blades will be consistent. Laser-engraved ceramic rollers wear better with the doctor blade in place. An innovative chamber blade system with automatic washing system (automatic blanket cleaners and ink levelers) built into the unit solves problems of ink remnants and reduces the amount of water previously used to clean the printing system (Price, 1994.) Some continuing problems with the blade systems include end-seal leaks, inks spitting-up from seals on impression drums, set up and cleaning time on chamber systems, and part corrosion with water-based inks (Shapiro, 1993b).

Several new and innovative drying and curing technologies have been developed that reduce energy costs and work well with new ink formulations (Wold, 1991). Infrared drying uses electromagnetic radiation and high energy concentration. It requires moderate capital cost, and has high operating costs; it is often used in conjunction with convection air dryers to provide the sensible heating load to the coated web. Radio frequency uses high frequency electrical energy to dry water and solvent based coatings using high energy concentration. There are high capital costs and moderate operating costs.

Supplemental convection air dryers are sometimes used in conjunction with radio frequency.

Post Press

Refer to the general pollution prevention section.

Letterpress

Like flexography, letterpress uses a plate with a raised image on a metal or plastic plate. Once the predominant printing method, today it is used primarily for printing books, business cards, and advertising brochures. The use of letterpress continues to decline dramatically with lithographic, gravure and flexography replacing what was once done by this technique.

The three types of letterpresses in use today are the platen, flat-bed, and rotary presses. On the platen press, the raised plate is locked on a flat surface. The substrate is placed on another flat surface and pressed against the inked plate. The flat-bed cylinder press prints as the substrate passes around an impression cylinder on its way from the feed stack to the delivery stack. These presses are often very slow relative to lithographic, flexographic or gravure presses. The most popular letterpress is the web-fed rotary letterpress (US EPA, 1995).

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This is a report of an assessment at a plant manufacturing ~ 1.8 million lbs. of printed plastic bags for snack foods annually. The lamination process waste could be handled with an automatic adhesive/solvent mixing system.

Matthiesen, D. 1993. Water Based Inks: Techniques in process printing. TAPPI Second Annual Converting Short Course. May 1993.

This paper provides a thorough overview of the physical properties of water-based inks and how those properties affect print quality. Numerous recommendations are made on how to maintain and improve print quality.

Parsons, R., B. Donovan, and M. Hayward. Ultrafiltration for the treatment of ink and starch wastewater in the corrugated container industry.

This technical paper describes the use of ultrafiltration in treating flexographic ink wash water and dilute starch adhesive waste.

Pferdehirt, W.P. 1993. Case Study: Roll the presses but hold the wastes: P2 and the printing industry. Pollution Prevention Review, Autumn 1993.

A review of the printing industry, including a description of the basic printing processes, is given. Waste reduction opportunities are explained, along with a review of progress that has been made in pollution prevention in the printing industry.

Price, R.L. 1994. Printing & publishing industry pollution prevention and recycling. Center for Hazardous Material Research (CHMR) 530-4296-000.

Student manual prepared for the Illinois Environmental Protection Agency. This manual gives the history of the printing industry, and statistics about Illinois printing establishments. Each of the printing processes are explained and diagramed. The common pollution prevention and waste reduction opportunities are explained.

Shapiro, F. 1993. High-quality flexo can be environmentally responsible. FLEXO 18(8):68-71. The effects of environmental legislation and resulting compliance on the printing industry is discussed.

Shapiro, F. Impact of hazardous waste on the package printer/converter. FLEXO

Wastes generated at each step of the printing process are described, along with ways to minimize those wastes.

Shapiro, F. 1993. Pollution Prevention. Boxboard Containers. May 1993.

Pollution prevention and waste reduction in the boxboard industry are discussed in relation to compliance with regulations and quality manufacturing.

Shields, G.N. 1994. New method to clean anilox rools. FLEXO 19(4):36-40.

Automated cleaning systems with multiple-nozzle spray bars, and liquid-through-liquid spray cleaning are discussed.

Strutt, D.B. 1991. Photopolymers achieve new quality levels in flexographic printing. Polymers, Laminations & Coatings 1991: 337-338.

The use of photopolymer printing plates and their impact on quality and printing speed are discussed.

Thompson, D.F. 1994. Green flexo: Converter can create competitive edge. Paper, Film & Foil Converter April 1994: 68-70.

A brief overview of P2 and waste reduction opportunities in flexographic printing.

Wold, J.L. 1991. Maintaining productivity with convection air dryers when switching from solvent based to water based applications includ-

[illegible] flexo presses. Polymers. Laminations & Coatings 1991. 305-313.

Drying curing technologies are reviewed. The technical aspects of drying, including heat transfer and evaporation rates, are presented along with actual data from test drying stations.

Related industries

Hang, M. 1994. Alternative Plate Processing. FLEXO 19(1): 50-52.

This article compares closed-loop solvent plate systems with water-washable plate systems as alternatives to perchloroethylene washout solutions.

Mounsey, G. 1994. Alternative Washout Solutions. FLEXO 19(4): 31.

The hazards of perc/butyl washout solutions and the benefits of alternative washout solutions are discussed.

Case Studies

Case Study 1

Replacement of Hazardous Material in Wide Web Flexographic Printing Process

Kranz, P.B., T.R. Williamson, and P.M. Randall

USEPA RREL Project Summary. EPA/600/SR-93/149. 1993.

A wide web flexographic printing firm substituted water-based inks for solvent-based inks when manufacturing flexible packaging using plastic sheet substrates (e.g., plastic bags for bread). The project objectives were to evaluate the technical feasibility, economic effect, and resulting change in VOC emissions achieved by the substitution. The technical evaluation was to quantify the reduction in both volatile and liquid-phase solid hazardous wastes. Reduction of VOC emissions by switching from the use of solvent-based inks to water-based inks required several equipment modifications and a feedstock substitution, including dryer capacity enhancement, press roller modification, ink handling equipment upgrade and installation of an in-line corona treatment system. Water-based inks containing 72.5 percent less VOC were used in place of, and combined with, traditional solvent-based inks.

For each percent increase in water-based ink use, VOC emissions were reduced 14 lb. This was based on usage of ~2250 lb. of solvent-based ink per week, resulting in VOC emissions of about 1570 lb. Typically the substitution did not adversely affect product quality or non-hazardous scrap waste generation. An average reduction of 95 percent of liquid F003 waste from waste ink and cleaning solvents resulted from operational practice changes and employee training.

The economic evaluation was completed by calculating the costs of press modifications, ancillary equipment, waste disposal, inks, and solvent. The project had a positive net present value of $39,165 and a payback period of 2.5 yr, based on 21 percent utilization of water-based ink; 100 percent utilization of water-based inks would yield a payback period of 0.54 yr.

Additional benefits from reduced VOC emissions and liquid hazardous waste have been improvements in the workplace resulting from the switch to water-based inks include reduced indoor air pollutants, reduced handling of hazardous solvents, and the appreciation by company employees of the need to make a conscious effort to further reduce waste generation.

Case Study 2

Achievements in Source Reduction and Recycling for Ten Industries in the United States

J. W. Tillman
USEPA RREL Report. EPA/600/2-91/051. 1991

Amko Plastics, Inc., in Cincinnati, Ohio is a decorative printer for packaging of consumer products, retail store packaging and industrial packaging employing approximately 280 people. By switching from solvent-based inks to water-based inks, they have minimized their volatile emissions by an estimated 88 percent. The reduction of alcohol solvent vapors has improved the ambient air quality of the press room.

The following process changes and modifications were evaluated and implemented:

- control of pH of the ink to maintain viscosity and print quality
- modification of dryer heads between successive color print stations to direct heated air onto the printed film (increased drying capability for water-based inks)
- redesign of ink metering systems for handling a higher strength ink and thinner application
- replace metal anilox rolls, which were having their wear-life drastically reduced, with more expensive ceramic rolls
- switch the fountain roll surface material to a harder durometer rubber to improve wear-life with ceramic anilox rolls
- develop systems and equipment to inversely vary the percentage of resin 'slip additive' blended into the resin as the film was being extruded to allow high speed printing
- installation of larger corona treating systems for electrostatic treatment of the film surface at the higher surface tension required for water-based inks
- switch to foam cushion 'sticky-back' from conventional 'sticky-back' to compensate for the additional pressure needed with water-based inks to achieve impression

The major costs incurred by Amko from 1984 to 1987 (exceeding $2 million) have today resulted in the ability to print with quality and productivity at the same level as U.S. solvent-based printers.

Case Study 3

Solvent Recovery from Flexographic Printing Inks

D.C. Crump
Pollution Prevention: Proceedings for the Conference "Waste Reduction - Pollution Prevention Progress and Prospects within North Carolina. Ed. Gray, et.al.

Rexham Corporation installed a two-stage distilling process at their flexographic printing plant in Greensboro to recycle used solvent. A special room was built to house the stills and all appropriate safety features were incorporated. They have found that uncut ink cannot be distilled due to charring. This onsite distillation has reduced the amount of hazardous waste to a level that changed the status of the generator to small generator.

Case Study 4

Venture Packaging, Charlotte NC.

Case Summaries of Waste Reduction by Industries in the Southeast
Waste Reduction Resource Center for the Southeast, Raleigh, NC, 1989

Venture Packaging undertook a project to replace solvent-based inks, coatings and adhesives with water-based materials to reduce emissions and the volume of ignitable waste generated. Since implementing this program in 1980, emissions have been reduced by approximately 55 percent. An additional 15 to 20 percent reduction appears possible with further application of water-based materials. The greatest success has been achieved in adhesives. Water-based adhesives are now being used for almost all production. Ink development has been more difficult and has varied with the substrate to be printed. Laminating inks have been more successful than surface-print inks.

Capital expenditures have been minimal, but experimental costs have been incurred. The alternative, the addition of incineration equipment, would be very costly.

Case Study 5

Water and Ink Waste Reduction at F.C. Meyer Company

Toxics Use Reduction Case Study
Massachusetts Office of Technical Assistance -C101-2, 8/93

F.C. Meyer Company, a Lawrence, Massachusetts cardboard box manufacturer and printer, employs 200 people operating eight printing presses over three shifts/day, five days/wk. In 1989, F.C. Meyer switched from solvent-based inks to water-based inks, and reduced its VOC emissions from 280 tons per year to less than 1,000 lbs.. per year. Performance quality was unchanged and the regulatory workload was reduced substantially. In 1992 they began to seek further waste reduction opportunities in the area of press cleaning procedures. Through employee training, and improved washing practices, the company was able to reduce wastes from 10 drums of hazardous waste to 2 drums of nonhazardous waste per week. This reduction was achieved by draining and scraping as much ink as possible before washing, and minimizing the amount of water used.

In addition to reducing the volume of wash water used, the company asked its supplier to deliver black ink with 10 percent reduced water content. Waste water was added to the black ink with no apparent effect on the color quality of the ink. The waste water can also be added to other colors, such as gray, in smaller amounts than when added to black ink.

Reductions achieved

Solids in spent wash water were reduced from more than 30 percent to 13 percent. The volume of water used decreased by 35 percent; about one pint of water is now used each time a press is washed. By reusing most of the wash water, waste disposal has decreased from 10 to 2 55-gallon drums per week. The 55-gallon drums of waste cost ~$100 each to dispose. Implementing the reuse of ink waste water has reduced the yearly cost of waste disposal from $52,000 to $5,200.

Case Study 6

VOC Reduction at Hampden Papers, Inc.

Toxics Use Reduction Case Study, C201-1, 8/93
Massachusetts Office of Technical Assistance

Hampden Papers Inc. of Holyoke, MA, reduced emissions of VOCs by 97 percent over a ten year period by using new aqueous based acrylics developed by I.C.I. Resins US of Wilmington, MA. Hampden is a 180-worker specialty manufacturer of converted paper, film, foils, and boards with 64 production lines in a 300,000 ft^2 facility. In the 1970s they elected to pursue reduction at the source rather than emission control. The company implemented a new coating system using non- and low-VOC inks and coatings and now uses gas oven drying and electron beam curing where necessary. They have not had to purchase VOC collection and control equipment.

Hampden found that I.C.I. acrylic copolymer resin inks and coatings have fast drying characteristics. Thermally sensitive films and coatings are cured in one of the first Energy Sciences electron beam units ever installed. Infrared technology is also used to improve drying. The aqueous products have demonstrated excellent clarity and resolubility on the press.

Over a 10-year period, Hampden has reduced annual VOC emissions at its facility by 97 percent, from over 420 tons to less than 20 tons. VOCs emitted per unit of product dropped from 8.15 pounds to 0.22 pounds. Hampden increased total production by 21 percent in the same period and has realized significant savings in fire insurance premiums. The reduction of VOCs has resulted in lower compliance costs, savings on insurance premiums, and a safer work environment.

Case Study 7

A (UV) Cure That's Eco-Friendly

Graphic Arts Monthly, November 1991:S6

James River is a marketer and manufacturer of consumer products, food and consumer packaging, and consumer-related communications papers. Their product lines include brands such as Northern bathroom tissue, Brawney paper towels, Dixie cups and plates, Monterey magazine paper, and the Quilt-Rap sandwich wrap. Sales for 1990 were $5.4 billion.

In 1975 James River began using UV-cured inks, and by the mid-1980s a significant process expansion was undertaken. UV-cured inks are used in the converting process. They create the opportunity to combine multiple steps into an in-line process. These inks dry instantly and are more energy efficient, but generally cost more than conventional inks.

Case Study 8

Tubed Products, Inc. Use Reduction Case Study

Office of Technical Assistance, Commonwealth of Massachusetts
Case Study No. 31. Nov. 1995

Tubed Products, Inc., of Easthampton, MA is a manufacturer of plastic squeeze tubes and caps for the cosmetic, personal care, pharmaceutical, and household chemical market. About 40 percent of their production is decoration of tubes with specific logos and information specified by customers.

Tubed Products made the switch to ultraviolet inks and coatings over a period of 20 years. Trials with their first UV decorating line in the early 1970s showed that UV systems had significantly reduced emissions, required less energy and floor space, reduced waste ink (since UV inks do not dry on the press), and allowed them to blend base inks to achieve custom colors. In 1979, after working with coating manufacturers to develop and evaluate UV-curable tube coatings, they purchased their first production line that used UV curing for both inks and coatings. Later, 'on-mandrel' UV curing equipment was designed and manufactured that allowed tubes to be printed, coated, and capped while mounted on the same mandrel, thereby eliminating the need for tube transfer mechanisms.

Conversion to UV-cured inks and coatings required new procedures for color matching, measurement of surface friction, permeation, flexibility, and non-yellowing properties. The addition of high speed presses and UV lamp systems required additional training.

The benefits of switching to UV curing have been space and energy savings; each line occupies about one-third the floor space of a comparable thermal line and about one-fifth the energy (12,000 watts per hour). Thermal lines need about 40 minutes to produce a tube, while the high-speed on-mandrel lines take only 5 minutes. UV inks and coatings contain no solvents, reducing worker exposure and environmental concerns significantly. Although the firm has not calculated the exact cost savings, they believe that switching to UV systems has been an important factor contributing to its growth in the industry, helping it to become a low-cost producer and the largest US supplier of plastic squeeze tubes.

Case Study 9

How We Anticipated and Corrected Problems When Converting to Water

F. Lamar Jones, Label America, Inc.
Flexo, July 1990

In the beginning, all press operators were very experienced, but only with solvent-based inks. During the transition from solvent- to water-based inks, customers were demanding better color matches, more consistency from run to run, and much improved light-fastness. Suppliers were not providing inks that were base color consistent, and service was poor. Other flexo converters were beginning to switch to water inks, so we looked for a supplier that would commit to us, providing both service and quality, and made the switch.

We chose one press and one pressman to experiment with the water-based inks. That minimizes disruption in the pressroom, and allowed us to "work off" the inventory of solvent-base inks. We had to make adjustments in press speed, wash-up sink, substrates, tools, and ink additives.

Press speed: We routinely run water-based inks at 400-500 feet per minute, on both gloss and uncoated stocks. We have found that movement of air is as important, if not more important, than heat, in the drying of water-based inks.

Wash-up: Water-based inks require a mild soap solution for wash-up. In order to avoid contamination of the inks with this solution, a custom wash-up sink was built. It is centrally located in the pressroom and large enough to accommodate the ink pan, bucket and pump. At the end of the job, ink is drained back into the ink container. Residual ink in the pan, bucket, and pump go to the sink where the wash solution circulates through until they are clean (about 3 minutes). Disposable pans are available, which would also reduce wash-up time.

Substrates - paper vs. film: Label America, Inc. specializes in EDP labels, both pinfed and sheetfed, so the bulk of the printing is on uncoated paper, which may be rough. Ink coverage can be improved with ink additives. Our experience has been that with proper primer and specially formulated inks, we can effectively print on films and foils with excellent results.

Tools: With the switch to water-based inks, we had to make more use of Zahn cups and pH meters to maintain the ink quality.

Ink maintenance: Replenishment is added as needed, and the pH meter is used often.

Ink additives: Slow, medium, and fast dry reducer, print cleaning additive, glycol, ammonia, extender and color boosters are all being used to improve print quality

Computerized ink mixing: This is among the most significant changes for Label America, Inc. It has paid for itself several times over within a year. It has reduced raw material purchases by allowing the company to purchase only base colors. It allows for effective mixing of even very small batches, reduces mixing time to about 3-4 minutes, and allows us to keep much better record of ink inventory.

Water-based inks are better environmentally and for human health - (fire hazard, solvent fumes, ease of disposal.) Inventory has been reduced by over half and sales have doubled. Insurance costs have decreased. Color consistency and colorfast characteristics have improved.

Case Study 10

The Spirit of Innovation

Martha Ortmann

Boxboard Containers, pg. 32-33

Lawrence Paper decided to retrofit its printing stations with a new, more efficient doctor blade system. The original open system was too costly in terms of ink consumption and contamination. Printco is a company that does retrofittings on printing presses. The retrofit involved many weeks working with the intricacies of the press, and engineering and redesigning the plate system. The new system saves ink and improves print quality. The blades are changed more often, and blade pressure is determined and adjusted automatically. Laser engraved anilox rolls are used as opposed to mechanically engraved ones.

Advantages of the new system: the old system used 30 to 40 lbs. of ink per ink change whereas the new system requires only 8 lbs. which reduces ink usage and volume of ink contaminated; blades can now be changed in 20 minutes versus an hour with the old system; the new system is detachable, making repairs easier.

Lawrence Paper recycles 100 percent of the water used in the printing process.

Case Study 11

Waste Minimization Assessment for a Manufacturer of Product Carriers and Printed Labels

Waste Minimization and Recycling Report, 1994
Government Institutes, Inc.

A plant manufacturing printed polystyrene packaging labels and high density polyethylene (HDPE) product carriers with over 400 employees produces 8 billion labels and over 500 million product carriers each year.

Wastes produced include volatile emissions (from the polystyrene extrusion process from the blowing agent Freon-22TM and impurities in the polystyrene); photoprocessing wastes; plate washing wastes (butanol/perchloroethylene solvent mixture), both liquid and volatile emissions; damaged or obsolete plates; solvent inks; press washing solvents (liquid and volatile emissions); defective product; wastes from the thermoforming and cutting process.

Solvents are recovered with two large distillation units and reused in the plant; all extrusion wastes that have not been inked are reground and reworked onsite; off-spec inks and surplus inks are reworked; ink runs are scheduled to allow light-to-dark transitions in the printing trays; wash-up solvent is recovered onsite for reuse.

The economic savings from the waste minimization opportunities implemented result from the need for less raw material and from reduced waste treatment and disposal. Additional waste minimization opportunities are listed in the case study.

Case Study 12

Thinking Positive about Compliance Pollution Prevention through Process Improvement

Fred Shapiro
Polymers, Laminations & Coatings Conference: 315-320
1991

A flexographic printer of stationery items and coating paperboard with overall solid colors was concerned with disposing of wastewater. Corporate engineers estimated the volume at 50 gallons per day, but further inspection revealed that one press operation alone was generating about 1,000 gallons per week. Examination of the printing process also revealed poor scheduling, untrained personnel, unsound practices in sequencing of colors, inadequate accessory equipment to facilitate efficient changes of color, and using free running water to clean parts during changes. A wastewater treatment unit was installed at a cost of $40,000 - $50,000.

Added ink pans and ink pumps helped make color changes more efficient. A cleaning tank was purchased so parts could be cleaned while the press was running, reducing the length of time it took to change colors and the amount of water used. Improved scheduling of colors eliminated some of the cleanup as well. Savings in downtime alone amounted to over $100,000 per year.

Gravure

Overview

Gravure printing process is used for long runs of multi-colored, high quality jobs at high press speeds. Examples of gravure printed products include art books, greeting cards, advertising, currency, stamps, wall paper, wrapping paper, magazines, wood laminates and some packaging. Gravure printing is a direct printing process that uses a type of image carrier called intaglio. Intaglio means the printing plate, in cylinder form, is recessed and consists of cell wells that are etched or engraved to differing depths and/or sizes. These cylinders are usually made of steel and plated with copper and a light-sensitive coating. After being machined to remove imperfections in the copper, most cylinders are now laser engraved. In the past, they were either engraved using a diamond stylus or chemically etched using ferric chloride which creates pollution. If the cylinder was chemically etched, a resist (in the form of a negative image) was transferred to the cylinder before etching. The resist protects the non-image areas of the cylinder from the etchant. After etching, the resist was stripped off. The operation is analogous to the manufacture of printed circuit boards. Following engraving, the cylinder is proofed and tested, reworked if necessary, and then chrome plated (US EPA, 1990). Often corrections and touch-ups are still done using the old process.

In direct image carriers such as gravure cylinders the ink is applied directly to the cylinder and from the cylinder it is transferred to the substrate. Modern gravure presses have the cylinders rotate in an ink bath where each cell of the design is flooded with ink. A system called a "doctor blade" is angled against the cylinder to wipe away the excess ink, leaving ink only in the cell wells. The doctor blade is normally positioned as close as possible to the nip point of the substrate meeting the cylinder. This is done so

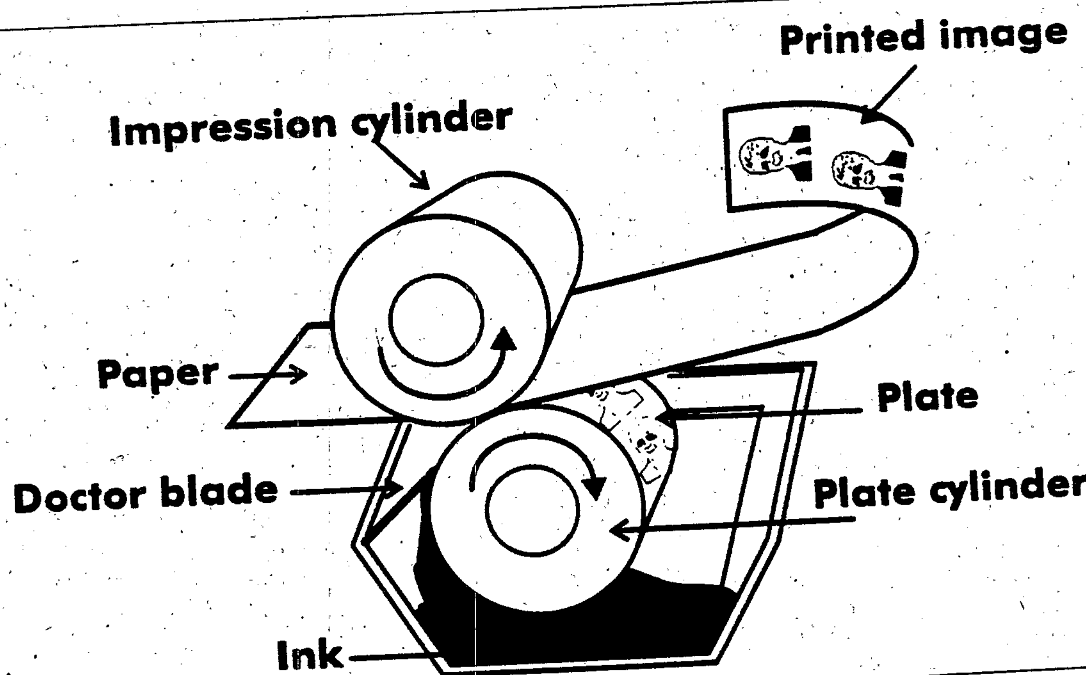

Figure 10: Principle of Gravure Printing

[illegible] dry out before it meets the substrate [illegible] the impression rollers. The capillary action [illegible] the substrate and the pressure from impression rollers draw/force the ink out of the cell cavity and transfer it to the substrate (Figure 10).

Gravure printers usually use solvent-based inks, although use of water-based is increasing due to regulatory issues. Processes that continue to use solvent inks can run considerably faster than processes that have changed to water-based inks. The nature of solvent evaporation allows the inks to dry much quicker and allows for faster press runs. This is especially true on multi-color jobs where the basic process color scheme, CMYK (cyan-magenta-yellow-black [or key]) is used to produce many different hues, shades, and colors. This is commonly called process color printing.

Rotogravure presses use the gravure process to print continuously on long rolls rather than sheets of paper. Unlike lithography and flexography, gravure printing does not break solid, colored areas into minute dots (half tones) to print the areas, which makes it ideal for reproducing high-quality continuous tone pictures, especially when using glossy inks. Many state-of-the-art printing presses are now able to run 8 to 10-color jobs at high speeds.

The basic raw materials used in most gravure printing techniques are those of a substrate, either in sheet or web(roll) form; a direct transfer or mechanically engraved etched cylinder; impression cylinders; ink systems; ink viscosity control; solvent recovery system; drying ovens; in-line cutting and stripping to remove excess margin waste; quality control systems or procedures to control the quality of the product, and a finished product that ends in sheet form or roll form.

Substrates have an impact on several parts of the printing process. Substrates can affect how the ink is transferred to the surface, how the ink lies on the surface, how well the ink dries and is absorbed by the surface, and how well the press operator can control the register of the finished product. Common substrates include coated and non-coated papers, coated and non-coated board, release papers for the food industry, foils, and metallized papers. Less common substrates are cellophane, polyurethanes and tissues. Coated papers and board probably make up the bulk of the more common printing substrates. One of the more popular coatings used is a clay coating. This coating is generally applied when the paper or board is manufactured. There are single, double, one-sided, and two-sided coated papers. The end use is generally decided by end product/customer specification and the manufacturing process.

Engraved cylinders are stored by the printer until the job is scheduled on the press. Cylinders (only one if a single color) are then mounted on the press and matched with the correct size and hardness of impression rollers. When all of the cylinders have been mounted in the press, each printing unit is set with the correct inks and rollers. A proof is then pulled by the press crew (sometimes on a proof-press). Press proofs can be done on non-virgin substrates or obsolete paper and end rolls to reduce waste and pollution. Color adjustments and registration corrections are made. Once customer approval is obtained, the press run begins. When the press run is completed the cylinders are removed from the press, cleaned, wrapped and placed in protective boxes (normally constructed of aluminum or heavy pine) and then moved to a designated storage area. Cylinders are stored for future press runs or placed back into the process to be dechromed, copper plated, and re-etched with new designs.

PrePress

Cylinder Preparation

Gravure cylinders are made by engraving or etching a design on a steel/copper and aluminum/copper base that is chromed after the design is proofed. The chromed cylinder surface is hard enough to resist image breakdown on long press runs, which would occur with softer material. Solvent-based ink cylinders vary in the depth and style of engraving or etching compared to water-based ink cylinders. Generally, the engraving or etching has a shallower cell micron depth for water-based inks. In each process a design is mechanically or laser engraved into the surface [illegible]. The circumference of the cylinder depends on the type of press and the repeat of the design, if any.

Depending on the press, cylinders can be made of copper-plated steel or aluminum. In preparation for plating, cylinders are heated in warm water and then put into a muriatic acid bath that strips the chrome plating and rust from the cylinder. They are then rinsed clean. Steel cylinders are nickel-plated to promote the bonding of the copper, and the aluminum cylinders are zinc-plated for the same reason. Aluminum cylinders are also treated with cyanide prior to copper plating. The final process after engraving is to chrome plate each cylinder and ready it for proofing (EPA/600/S-93/009). If the printer does not make its own cylinders, they are proofed at the manufacturer before shipment to the printing company. During proofing, design, engraving and color separation approvals are given.

Press

Process Modification

There are several methods available to address pollution prevention and waste reduction in gravure printing environments. Each method should be evaluated for its practical application, both in cost and resource consumption. Caution should be used to ensure that a prevention program or waste reduction program is not discarded based solely on cost.

In conjunction with shallower ink pans, improved doctor blade technology results in reduced ink usage. Vapor recovery systems can be one of the largest contributors to reducing pollution in solvent-based operations. These systems need to be matched to the specific environment and have been successfully carried out in many printing companies. In addition, alternative chemical solutions can significantly reduce pollution. Test runs and trial projects should be considered when searching for safe alternatives.

Printers need to develop partnerships with each of their major raw material suppliers. Within these partnerships there needs to be a clear understanding of the printers needs matched with materials so a quality finished product is achieved. Suppliers have technical assistance available to their customers so an acceptable product can be manufactured with as little pollution and waste as possible. Development of partnerships with ink vendors is essential so that use of the technical assistance that the ink and solvent suppliers can provide is used. Partnerships with ink vendors allows printers to take advantage of an ink technician's assistance with "ink kitchens" that automatically mix inks to the correct color and quantity thereby reducing the opportunity for waste and pollution.

Post Press

Equipment Modifications

There are many types of equipment modifications that printers can use to help reduce pollution. The type and degree of modification depends upon the company goals, financial health, commitment to improvement, and availability of new technology. Printing press makers have taken advantage of new technology and installed several types of process improvement controls on their equipment. After market items that improve the printing process are also available to modify existing equipment. High temperature ovens, solvent and vapor recovery systems (afterburner) can be improved or modified to reduce pollution. In many cases the improvements used to reduce pollution result in increased manufacturing output that justifies the capital expenditure for these projects. Any reduction in wasted resources will improve the overall pollution prevention program.

Process Modification

The degree to which vegetable oils can replace petroleum oils in inks to reduce VOCs depends on several things, including the type of press, the type of substrate, and the type and color of the inks. Gravure presses generally use heatset inks, which are inks that are set by going through an oven or dryer. These inks generate the most VOCs because they tolerate only the smallest amount of vegetable oil content. The drying temperature needed to set vegetable oil inks will normally scorch the substrate and ruin the product. Vegetable inks dry slower than conventional inks - especially on coated papers.

[illegible] substrate will determine the amount of vegetable oil content that can be used in the ink. Absorbent papers hold the ink in the substrate so less VOCs are released as compared to coated papers which normally need heat to dry the inks - thereby releasing VOCs. Soy and vegetable based inks provide beneficial printing properties - but dry slower than petroleum based inks.

Water-based inks, while environmentally friendly, pose their own special kinds of concerns in gravure printing. As a rule, water-based inks dry slower than solvent-based inks resulting in initial obstacles when making a switch to water-based. They are more abrasive and cause increased cylinder wear and they require somewhat different engraving and etching processes. Water-based inks tend to have surface adhesion and lay-down problems that solvent-based inks do not have. Printing process adjustments are needed to maintain the quality of finished product.

Some of the more common solvents used in solvent-based gravure printing are toluene, xylene, methyl ethyl ketone (MEK), methyl isobutyl ketone, acetone, methylene chloride, isopropyl and normal-propyl alcohol. All pose risks that are inherent in a solvent-based system. Alternative materials with less risk associated to their use should be considered.

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This paper presents technical information on the use of foamed aqueous inks, which can lower VOC emissions significantly in rotogravure operations. Good basic information on this technique, author works for Foamink Company, Inc.

Pferdehirt, W.P. 1993. Case Study: Roll the presses but hold the wastes: P2 and the printing industry. Pollution Prevention Review. Autumn 1993.

A review of the printing industry, including a description of the basic printing processes, is given. Waste reduction opportunities are explained, along with a review of progress that has been made in pollution prevention in the printing industry.

Rosen, D.R. and M.R. Wool, 1986. "Microprocessor Control of Rotogravure Airflow," Office of Research and Development, US EPA. EPA/600/2-85/068.

The report discusses the technical and economic viability of using microprocessor-based control technology to collect volatile organic compound emissions from a paper coating operation. The microprocessor-based control system monitors and controls both the airflow rate and vapor concentration level within the rotogravure printing press dryers. It incinerates the VOC emissions in the plant's existing steam boiler and also saves energy by reducing the amount of dryer and room air that must be heated.

"[illegible] Pollution Prevention in the Commercial Printing Industry." U.S. EPA Risk Reduction Engineering Laboratory and Center for Environmental Research Information, 1990. 45 p.

This report covers basics of all printing wastes and pollution prevention efforts; includes worksheets for conducting an assessment of a printing facility.

Related Processes

Jendrucko, Richard J., Thomas N. Coleman, and Gwen P. Looby "Waste Minimization Assessment for Manufacturer of Gravure-Coated Metalized Paper and Metalized Film" Environmental Research Brief, US EPA Risk Reduction Engineering Laboratory, Sept. 1994, EPA/600/S-94/008

A waste minimization assessment was performed for a plant that manufactures gravure-coated metalized paper and film. The team's report, detailing findings and recommendations, indicated that a large quantity of unused coating mixture is wasted. The greatest cost savings can be achieved by the plant through the installation of an automated system for mixing and diluting coating mixtures.

Fleischman, Marvin; Kirsch, F. William and Gwen P. Looby, 1993, "Waste Minimization Assessment for a Manufacturer of Rotogravure Printing Cylinders," US EPA Risk Reduction Laboratory,EPA/600/S-93/009.

Documentation of a waste minimization assessment with good information on the various plating processes used to manufacture rotogravure cylinders. Provides various minimization options suggested to this facility with associated savings in terms of estimated waste reduction, waste management cost savings, raw material cost savings, operating cost, total cost savings, implementation costs and simple payback.

Case Studies

Case Study 1

Waste Minimization Assessment for a Manufacturer of Printed Labels

F. William Kirsch and J. Clifford Maginn
Environmental Research Brief, Risk Reduction Engineering Laboratory
EPA/600/M-91/047

A waste minimization assessment was carried out at a plant producing approximately 14 billion printed labels/yr. Steel printing cylinders are nickel and copper plated, etched with the label patterns to be printed, chromium plated, and then used with ink applied to print the labels. About 75 percent of the cylinders are chemically etched, and the remainder are mechanically etched. Solvents used with ink concentrate and for cleaning press parts are recovered and sold to reclaimers. Spent reagents, filters, cleaning rags, and sludge are shipped offsite for disposal. Process wastewater and rinse water are treated by ion exchange and distillation. The team's report detailing findings and recommendations, indicated that most waste other than water and paper consists of spent solvents, and that the greatest savings could be obtained by using recovered solvent instead of virgin solvents for cleaning at press side.

The recommendations for waste minimization included:

- using recovered solvent instead of virgin solvent for cleaning press parts; net annual savings of $284,292.
- using recovered solvent instead of safety solvent for cleaning; net annual savings $59,443
- automating mixing of ink, extender, and solvent to reduce overmixing and evaporative loss; net annual savings $47,085; implementation costs $288,800; payback years 6.1

- [illegible] tank [illegible] to reduce solvent evaporation loss, net annual savings $9 [illegible] implementation cost $500, payback years 0.1
- [illegible] spent ink filters with solvent and reuse; net annual savings $5,016

Case Study 2

R.R. Donnelley & Sons-Mattoon

in Pollution Prevention: Illinois Industry Case Studies
Hazardous Waste Research and Information Center, TN94-039, 1994

R.R. Donnelley operates large printing facilities. In 1990, their Mattoon facility generated 31,700 gallons of waste gravure ink and 17,800 gallons of waste cleaning solvent. By modifying their process, some of the ink and solvent were gradually fed back into the ink supplies for the printing press. This reuse resulted in a total waste volume reduction of 16,900 gallons per year, or 34 percent.

Case Study 3

Case Study: A Gravure Printer

Cannard, Herve, et al.
Spring 1995, Pollution Prevention Review

Constant Services, Inc. (CSI), a gravure printer, worked with the New Jersey Technical Assistance Program, to develop and implement alternatives for TRI-listed solvents and to decrease solvent usage. The company found that substituting alternative solvents for the listed solvents enabled them to eliminate emissions from the room where the company's strike-off press is located as well as reduce fugitive emissions of hazardous air pollutants previously associated with the formulation of their ink pigments. Moreover, by using dry rags instead of solvent-dampened rags to wipe down the presses, CSI not only further reduced solvent use and fugitive emissions, but also realized a substantial cost savings.

The company prints and laminates vinyl webs that are sold primarily as wallpaper. They have five production lines and a room containing a strike-off press which is a slow gravure press used to make proofs. CSI uses an ink that is formulated in-house. The ink binder, a PVC resin, is purchased from a vendor as "dry chips" that are mixed with methyl ethyl ketone (MEK) and methyl isobutyl ketone (MIBK) to form the vehicle. During formulation, the vehicle is added to surplus inks left from previous runs, and to fresh and spent solvent (dirty, spent press wash that is collected after press wash-ups). CSI has the mixing process well organized and uses all spent press wash and almost all surplus inks in new ink blends. Pigments made on-site are added to adjust the color shades. The pigments were previously stored as MIBK solutions. Those applied to the vinyl contains 70-80 percent solvents.

It was believed that partial substitution for TRI-listed solvents would reduce the overall toxicity of the fugitive emissions into the strike-press room.

Changing the Press Wash Procedure

Under the old process, ink trays and doctor blades were "washed down" between production runs in a 1:1 mixture of MEK and MIBK, which was captured in pails for later reuse in ink. The equipment was then cleaned with rags that were soaked with the MEK/MIBK mix.

At the suggestion of an employee, CSI introduced a new cleaning procedure that reduced solvent use and solvent emissions by avoiding the wash down altogether and using dry rags to wipe down the press parts. This new process relies solely on the solvent content of the ink residue to clean the parts. As a result, solvents are now used only to wash the rubber rollers. Roughly, 1,100 pounds of solvents are now being saved by eliminating wash down resulting in a cost savings of $440 per year.

Calculations showed that nearly 60 solvent-laden rags, holding 5.5 ounces of solvent per rag, were thrown away daily. By adopting the use of dry rags, the company not only reduced solvent emissions by 3,600 pounds per year, but also realized cost savings of $1,440.

Cleaning with dry rags instead of washing the press thoroughly also reduced the overall cycle time. Shutdowns which previously lasted 90 minutes have now been reduced to 10-20 minutes. Yearly labor savings of 2,300 hours predicts a cost savings of $23,575.

Switching from TRI-listed to Nonlisted Solvents

Concern about employee health led CSI to change the solvents used to make ink for the strike-off press. The introduction of two non-TRI listed substitutes for the cyclohexanone and MIBK previously used enabled the company to eliminate emissions from the room where the strike-off press is located. In addition, the substitutes have replaced MEK and MIBK in the pigment formulation of the ink used in production processes.

An initial search for substitutes led to the introduction of PMA, a glycol ether acetate. Later, a solvent which is a combination of N-methyl 2-pyrrolidone and dipropylene glycol methyl ether (Printsolve®), was added to the ink formulation and used for press cleaning. The company eventually replaced the PMA with DBE, a dibasic ester mixture, also an unlisted solvent. By making these substitutions, CSI has eliminated approximately 2,000 pounds per year in TRI-listed solvents. However, because Printsolve® is more expensive, the additional solvent purchase cost is approximately $3,370 per year.

MIBK solutions used in the formulation of pigments were replaced with the Printsolve®/DBE blend. This reduced the total amount of hazardous air pollutants used in the plant, and the associated fugitive emissions.

In addition, it is estimated that approximately 10,000 pounds per year of MIBK have been replaced with the Printsolve®/DBE blend, at an additional solvent purchase cost of $12,770 per year.

Other P2 Activities

All the spent inks that are too dirty to be reused, as well as the dirty wash solvents, are recovered in an on-site distillation unit. The distillate is reused in the formulation of inks. The dry residue is a nonhazardous waste and is disposed of accordingly.

Ink and solvent containers, which previously remained open to the air, have been covered with hinged lids. As a result, solvent emissions, especially in the ink formulation room, have been drastically reduced

Ink pans are covered with any available material (often cardboard) to reduce emissions from open ink surfaces.

A policy statement regarding pollution prevention has been distributed to all employees. In addition, the company now posts information on matters such as weekly usage of solvents during production, production totals, job break-downs, and color changes.

Case Study 4

Hampden Papers Reduces Wastewater by 80 Percent, Ends Excessive Zinc Discharge

Toxics Use Reduction Case Study
Massachusetts Office of Technical Assistance

Despite earlier reductions, waste water discharges from Hampden papers specialty operations continued to contain zinc and copper levels above the discharge limits set by the local wastewater treatment authority. Continued excessive discharges could have forced the POTW to mandate installation of a very costly treatment technology.

The waste waters are generated from the printing machines (6 gravure presses and 3 air knife coaters), the coating mixing area, and kettle washup. Discharges from the coating mixing area came from spill cleanup; improved spill prevention was the appropriate action to reduce wastes there. Zinc ammonium carbonate (ZAC), present as a crosslinker which allows aqueous based ink and coating constituents to become waterproof, is a component in 60 percent of Hampden's throughput and is used almost exclusively on the gravure presses. Copper, a pigment in blue and green ink dyes, is only used in about 3 percent of Hampden's production

Cleanup of the gravure presses includes ink being manually reclaimed and presses cleaned with water. Four of the presses require less than 5 gallons per cleanup, the other two require 30 and 45 gallons of water respectively per cleanup. Analysis showed that the two high volume machines generated concentrations that would affect effluent concentrations.

Zinc

There are two possible alternatives to ZAC, as well as an emerging production method that would use dispersion, rather than solution, technology. One of the alternatives was a carcinogen, and therefore ruled out. The other chemical, ammonium zirconium carbonate (AZC), is more expensive than AZC. Trials showed that discharge limits could be met, but print quality standards could not. The dispersion system, though only applicable to certain coatings, was compatible with 85 percent of Hampden's total coating needs. The system was installed for 20 percent of the production, and Hampden plans to increase this to 70 percent.

Copper

Unrestricted hoses used to clean the ink wells on the air knife coaters had a flow of 7.5 gallons/min. for 60 to 90 minutes per cleaning. The ink mixing kettles required 20 to 50 gallons [illegible] cleanup. Because the kettles are used to mix custom colors, they [illegible] be cleaned a dozen times per day. Copper concentrations from these cleanups were below detection level only because of the dilution. Colors and carriers were tested for zinc and copper content. Since no substitute could be found for the copper pigment, segregated waste water treatment was a possible temporary solution.

Water Conservation

All leaking hoses and faucets were fixed, automatic shutoffs were installed on all toilets, sinks and hoses. All air conditioning and machinery cooling lines and non contact cooling water discharges were diverted from the sewer line to a nearby river. The cumulative effect of these efforts reduced average daily discharge on production days to 12,000 gallons (from highs of 130,000 gallons); nonproduction days had a flow of zero. The POTW removed Hampden from the significant industrial user list, provided the company continued to seek substitute chemicals and implement improved cleanup practices. Water discharge is now less than 20 percent of 1993 average daily flow. By 1995, zinc will be reduced to 20 percent of previous levels.

Appendix A
General Printing Regulations

Overview

This section is a short summary of *Federal Regulations Potentially Affecting the Commercial Printing Industry, Office of Pollution Prevention and Toxics, Design for the Environment Program (EPA774B-94-001)*. This document includes only the appropriate federal regulations. Even when federal regulations apply, there may be additional requirements based on state laws. In some instances, there may be state or local legislation without corresponding federal regulations.

Clean Air Act (CAA)

Under the requirements of the Clean Air Act, the Environmental Protection Agency has the responsibility of identifying air pollutants that are potentially hazardous to the public health, safety and welfare; establishing the National Air Quality Standards for setting the permissible levels of these pollutants; and, working in cooperation with state and local governments to enforce the terms of the act.

Title 1 Provisions for Attainment & Maintenance of National Ambient Air Quality Standards

This section of the CAA establishes levels of air quality that are applied throughout the regions of the United States. It also designates "nonattainment" areas where additional air control measures will be required. The National Ambient Air Quality Standards were established for the following six pollutants:

Pollutant	Primary Standards (protective of health)
Ozone	0.120ppm (235 ìg/m^3) (1-hour average)
Carbon Monoxide	9ppm (10mg/m^3) (8-hour average)
	35ppm (40 mg/m^3) (1-hour average)
Particulate Matter (PM-10)	150 ìg/m^3 (24-hour average)
	50 ìg/m^3 (annual arithmetic mean)
Sulfur Dioxide	0.140 ppm (365 ìg/m^3) (24-hour average)
	0.03 ppm (80 ìg/m^3) (annual arithmetic mean)
Nitrogen Dioxide	0.053 ppm (annual arithmetic mean)
Lead	1.5 ìg/m^3 (arithmetic mean averaged quarterly)

In the printing industry, the standards of concern will be ozone, NO_x and particulate matter. While printers are not commonly producers of ozone, they are major sources for emissions of volatile organic compounds (VOCs) which are considered the precursors of ozone. Therefore, in printing facilities, the monitoring data for ozone are instead measured for VOCs. It is necessary for all [illegible] determine whether their facility is located in an ozone non-attainment area. The classification of ozone areas is based on the fourth highest parts per million (ppm) reading taken over any 24-hour period for that region. Sources within these regions are then classified as to whether they are major. A major source is defined based on the both the size of the facility-wide emissions and the category of the nonattainment area. Additionally, if any firm has the potential to emit (PTE) more than 100 tons per year of ozone, it is considered a major source, where potential to emit is the maximum capacity of a stationary source at design capacity. Individual states will set their own guidelines for reducing the ambient ozone concentrations.

Title II Provisions Relating to Mobile Sources

Not specifically related to the commercial printing industry.

Title III Hazardous Air Pollutants

Section 112 of Title III lists the air pollutants which are considered to have a significant or widespread effect on the wildlife, aquatic life, or other natural resources, including impacts on populations of endangered or threatened species or degradation of environmental quality over a large area. The USEPA will provide a guide to the maximum achievable control standards for any source emitting at least one of the chemicals listed in section 112.

Chemicals Used in Printing Listed as Hazardous Air Pollutants

Benzene	Formaldehyde	Perchloroethylene
Cadmium compounds	Glycol ethers	Polycyclic organic matter
Carbon tetrachloride	Hexane	Propylene oxide
Chromium compounds	Hydrochloric acid	Toluene
Cobalt compounds	Isophorone	2,4 Toluene diisocyanate
Cumene	Lead compounds	1,1,2 Trichloroethylene
Dibutylphthalate	Methanol	Trichloroethylene
Diethanolamine	Methyl ethyl ketone	Vinyl Chloride
Ethyl benzene	Methyl isobutyl ketone	Xylenes
Ethyl glycol	Methylene chloride	

If a source is able to reduce emissions of hazardous air pollutants by 90 percent or particulate emissions by 95 percent prior to the state's issuance of maximum attainable control standards, the source will receive a six year extension in the compliance date. The only requirement being the demonstration of emissions reduction prior to the proposed standard effective date. It is up to the operator to contact the state EPA to obtain guidance on the specifications of said demonstration.

Title IV Acid Deposition Control

Does not directly relate to the commercial printing industry.

Title V Permits

This section of the CAA requires states to have a federally enforceable air pollution permit system and that the permitting program be paid for by emission fees from permit holders. The permit [illegible] current regulatory requirements, as well as any anticipated requirements during the permit length. Maximum permit term is five years. The permit must fully detail all emission sources, establish emission limits, and specify a method to demonstrate compliance. In other words, the operator is required to tell the state which regulations apply at their facility and then demonstrate compliance with record keeping and monitoring.

The emissions regulated under Title V are the potential to emit rather than the actual emissions. The potential to emit is calculated as the emissions from a source as if it were operated at full design capacity year round. A permit is required if the potential is a) at or above 10 tons per year of any single hazardous air pollutant, b) twenty-five tons per year of any combination of hazardous air pollutants, or c) 100 tons per year of any other regulated air pollutant. Should a facility be located with an ozone nonattainment area, permits are required for lower emission levels.

A Title V permit is required to be submitted to the state EPA within one calendar year of the approval of the state's Title V program by the USEPA. It will be necessary to contact individual states to determine the timeframe necessary for each facility. Once a permit has been submitted, operations may continue until the permit is issued. The issued permit will include all air requirements for the facility, compliance schedules, emission monitoring programs, emergency provisions, self-reporting responsibilities, and emission limits. Permit conditions will be applicable to the source category rather than on the individual facility.

Title VI Stratospheric Ozone Protection

This section of the CAA sets up the procedure for the phase-out of the production and usage of chlorofluorocarbons (CFCs) and other stratospheric ozone depleting chemicals. The chemicals are divided into two categories, Class I and Class II chemicals, which are interim substitutes for Class I chemicals. Section 604 of Title VI calls for the complete phase-out of Class I chemicals by January 1, 2000 (with the exception of methyl chloroform for January 1, 2002). The Class I chemicals commonly used in the printing industry are Carbon tetrachloride and Methyl chloroform. The complete phase-out of the Class II substances is currently scheduled for January 1, 2030. However, the USEPA is proposing the phase-out begin in 2002. Production of carbon tetrachloride, hydrobromofluorcarbons, and methyl chloroform ceased on January 1, 1996.

Clean Water Act (CWA)

The primary goal of the CWA is to protect, restore, and maintain the chemical, physical and biological integrity of the waters of the United States. One interim goal of the act is to return the nation's water to conditions deemed "fishable and swimmable". All discharges into the waters of the United States, publicly owned treatment works, storm water discharges, and storm sewers are covered under this act. Direct discharge to any surface water requires a National Pollutant Discharge Elimination System (NPDES) permit.

Discharge to a publicly owned treatment work (POTW) does not require a NPDES permit, but will require an industrial user permit which is issued by the local water treatment operator. At this time, no categorical pretreatment standards exist for the commercial printing industry. All printing facilities are required to meet the general pretreatment standards for discharge of process wastewater. The general pretreatment requirements prohibit the following: 1) pollutants that create a fire hazard in the POTW; 2) pollutants that will cause corrosive damage to the POTW; 3) pollutants (solid or viscous) in amounts that will obstruct flow in the POTW; 4) any pollutant released at a flow rate or concentration that interferes with the POTW operations (this includes oxygen demanding pollutants); 5) effluents at a temperature that will inhibit biological activity in the POTW; 6) petroleum oils, non-biodegradable cutting fluid, or mineral oil products which will pass through the POTW or interfere [illegible] in the POTW, [illegible] pollutants that result in toxic fumes within the POTW, and [illegible] any trucked or hauled pollutants. Facilities are also required to notify the POTW within 24-hours of any violation of the pretreatment requirements occur. Often state or local governments have additional reporting requirements which should be addressed prior to discharge.

Often, an NPDES permit is required even if no wastewater is produced onsite. If any storm water comes into contact with industrial activity or construction activity a permit will be necessary. This contact includes any handling equipment or activities, raw materials, intermediate products, final products, or industrial machinery exposed to storm water that drains to a storm sewer system or directly to receiving waters. Note that a storm water permit is not required for municipal systems which have combined wastewater and storm water systems, but the POTW should be informed that industrial storm water will be entering the sewers.

Reportable Quantities of Hazardous Substances used in the Printing Industry

Hazardous Substance	Reportable Quantity (lbs.)
Benzene	10
Carbon tetrachloride	10
Chloroform	10
Cyclohexane	1000
Ethylbenzene	1000
Formaldehyde	100
Hydrochloric acid	5000
Propylene oxide	100
Styrene	1000
Toluene	1000
Xylene (mixed)	1000

Occupational Health and Safety Act

Under OSHA, employers regardless of size are required to meet several standards which will maintain a safe and healthful workplace. The "general duty clause" of OSHA states that "employee employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm" must be provided to the employee. Section 1910.1200 of OSHA is the hazard communication standard and requires employers to inventory, classify, and label all chemical substances onsite that are considered to be "hazardous" to health or have physical properties which are hazardous. All employers must have a written program available to employees which includes inspection, inventory, labeling, availability of material safety data sheets, employee training, agency reporting, and recordkeeping systems. Employers of less than ten people may be exempt from the recordkeeping systems only. Several states have their own OSHA regulations, it will therefore be necessary for facilities to contact their state agency to find their requirements.

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act designated the difference between hazardous waste and nonhazardous waste. RCRA also includes a system for regulating underground storage tanks containing petroleum or other hazardous substance.

Subtitle A of RCRA defined solid waste as "any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility, or other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural activities." It went on to define disposal as "the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any water, including groundwater."

Subtitle C established what is commonly known as the Cradle-to-Grave tracking of hazardous waste. It defined hazardous waste as a waste or any combination of wastes which due to its quantity, concentration, or chemical, physical, or infectious characteristics, may (1) cause or contribute to any increase in the mortality or increase the serious irreversible or incapacitating reversible, illness; or (2) pose a present or future hazard to human health or the environment when improperly treated, stored, transported, disposed of, or managed. The EPA set the standards for a waste to be classified as hazardous due to its ignitability, corrosivity, reactivity, or toxic characteristics. In addition, RCRA document 40 CFR Part 261 lists wastes which are considered hazardous without testing. It is required that the waste generator determine if the waste is hazardous and what classifications apply. Wastes are classified as being either type F (non-specific wastes that occur in several industries), type K (specific waste sources), or types P and U which are wastes that are intended to be discarded and are acutely hazardous or hazardous, respectively. In 1980, the EPA adopted rules stating that any mixture of hazardous and nonhazardous waste is to be considered hazardous ("mixture rule"). Wastes that are acquired through the use of listed hazardous wastes are considered hazardous despite any changes which affect their properties ("derived from rule").

Contaminants Found in the Printing Industry

Barium	Silver
Chromium	Tricholoroethylene
Carbon tetrachloride	Vinyl Chloride
Methyl ethyl ketone	

Spent solvents (solvents with a FP<140 F (mineral spirits)

toluene, alcohol, xylene

Listed Wastes Common in the Printing Industry

F001 Spent halogenated solvents used in degreasing operations, including tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1 trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons. Also any mixture that includes a total of ten percent or more by volume of any of the above solvents.

[illegible] Spent [illegible] solvents including tetrachloroethylene, methylene chloride, [illegible] ethylene, [illegible] ethane, chlorobenzene, 1,1,2 trichloro-1,2,2, trifluoroethane, orthodichlorobenzene, trichlorofluoromethane, and 1,1,2 trichloroethane. This also includes any mixture [illegible] containing more than ten percent of any of the above solvents.

F003 Spent non-halogenated solvents including xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol. Also any mixture or blend that before use contained ten percent or more of the above solvents.

F005 Spent non-halogenated solvents including toluene, methyl ethyl ketone, carbon disulfide, isobutanol, pyridine, benzene, 2 ethoxyethanol, and 2 nitropropane. This also includes any mixture that before use contained ten percent or more of any of the above solvents.

U002 Acetone
U019 Benzene
U211 Carbon tetrachloride
U055 Cumene
U056 Cyclohexane
U069 Dibutyl phthalate
U112 Ethyl acetate
U359 E'hanol, 2-ethoxy
U359 Ethylene glycol monoethyl ether
U122 Formaldehyde
U154 Methanol
U226 Methyl chloroform
U080 Methylene chloride
U159 Methyl ethyl ketone (MEK)
U161 Methyl isobutyl ketone
U210 Tetrachloroethylene (perchloroethylene)
U220 Toluene
U223 Toluene diisocyanate
U228 Trichloroethylene
U043 Vinyl chloride
U239 Xylene

Chemicals under Investigation for Listing Used in the Printing Industry

Solvents III - Proposal April 1994, Final June 1995: Cumene, phenol, isophorone, acetonitrile, furfural, epichlorohydrin, methyl chloride, ethylene dibromide, benzyl chloride, p-dichlorobenzene

Solvents II - Proposal September 1997, Final September 1998: 2-methoxyethanol, 2 methoxyethanol acetate, 2 ethoxyethanol acetate, cyclohexanol

Solvent Study - Report September 1996: Diethylamine, aniline, ethylene oxide, allyl chloride, 1,4 dioxane, 1,1, dichloroethylene bromoform

Any RCRA regulated wastes are then to be disposed of based upon the status of the waste generator. Generators are divided into three categories: large, small and conditionally exempt. A large quantity generator is a facility that generates at least 1000 kg (approximately 2200 lbs.) of hazardous waste per month or greater than 1 kg (2.2 lbs.) of acutely hazardous waste per month. A small quantity generator is a facility that generates greater than 100 kg (220 lbs.) but less than 1000 kg (220 lbs.) per month of hazardous waste, or up to but not exceeding 1 kg (2.2 lbs.) per month of acutely hazardous waste. Conditionally exempt generators are facilities that generate no more than 100 kg (220 lbs.) per month of hazardous wastes and up to but not exceeding 1 kg (2.2 lbs.) per month of acutely hazardous waste. The main difference in the status is in the length of time wastes may be stored on-site. Small quantity generators may accumulate up to 6000 kg (13,200 lbs.) of [illegible] waste for up to 180 days or for up to 270 days if the waste must be [illegible] 200 miles. Large quantity generators must ship wastes off within 90 days.

All generators, regardless of status, are required to meet certain rules regarding the storage of wastes. All wastes must be stored in a separate area labeled for hazardous waste in sealed containers that are also labeled in accordance with EPA and Department of Transportation requirements. A generator may accumulate as much as 55 gallons of hazardous waste at the point of generation prior to removal to the hazardous waste storage area (satellite storage). If any wastes are disposed of on-site, for any reason including operator error, the site will be reclassified as a treatment, storage and disposal facility and require the necessary permit.

Also included under Section C of RCRA is the concept commonly known as the "Cradle to Grave" rule. Under this rule, the generator is required to obtain an EPA identification number in order to allow the agency to monitor and track all hazardous waste produced. Prior to shipping, a Uniform Hazardous Waste Manifest must be obtained from the state environmental agency. The manifest will have enough copies to provide one each to the state environmental agency, the generator, transporter, and operator of the treatment, storage and disposal (TSD) facility. An additional copy is signed by the TSD facility and returned to the generator and the state environmental agency to verify receipt and handling of the materials. This copy must be maintained, along with the original copy for a minimum of three years, but it is recommended that they be retained forever.

In the future, the printing industry may be faced with additional RCRA requirements as a decision is upcoming as to the status of industrial wipes and shop towels. At this time, a wiper is only considered a hazardous waste if it contains or is mixed with a listed waste. It is essential that printers contact the state EPA to verify if there are variations in this definition.

Superfund (Comprehensive Environmental Response, Compensation, and Liability Act) and Superfund Amendments and Reauthorization Act (SARA)

Under the original Superfund, the EPA was authorized to undertake any measures necessary to address any hazard to human health and the environment triggered by burning, leaking, or explosion of hazardous substances, contamination of food chains, or drinking water contamination. Relevant to the printing industry is the requirement to report all releases of all CERCLA (Superfund) hazardous substances to the National Emergency Response Center within 24 hours. The need for reporting is based on the chemical specific reportable quantity (RQ) number assigned by the EPA.

CERCLA Reportable Quantities for Chemicals Used in the Commercial Printing Industry

Chemical	Reportable Quantity (lbs.)
Acetone	5000
Ammonia	100
Benzene	10
Cadmium and compounds	1
Carbon tetrachloride	10
Chloroform	10
Chromium and compounds	1
Cumene	5000
Cyclohexane	1000
Dibutyl phthalate	10
Ethanol, 2 ethoxy	1000
Ethyl acetate	5000
Ethylbenzene	1000
Formaldehyde	100
Hydrochloric Acid	5000
Isophorone	5000
Lead and compounds	1
Methyl chloroform	1000
Methylene chloride	1000
Methanol	5000
Methyl ethyl ketone	5000
Methyl isobutyl ketone	5000
Perchloroethylene	100
Phosphoric acid	5000
Propylene oxide	100
Sulfuric acid	1000
Toluene	1000
Toluene diisocyanate	100
1,1,1 Trichloroethane	1000
1,1,2 Trichloroethane	100
Trichloroethylene	100
Vinyl chloride	1
Xylene (mixed)	1000

The reauthorization of the Superfund act by SARA is significant to printers because of Title III. known as the Emergency Planning and Community Right-to-Know Act (EPCRA). This created the emergency planning guidelines and included the right of local governments and the public to obtain information on hazards posed by potential toxic substance releases for the facility. The levels for reporting the presence of hazardous chemicals are the presence of 10,000 lbs. of hazardous chemicals, and 500 lbs. of the threshold planning quantity of extremely hazardous chemicals. In addition, any facility that is required by OSHA's Hazard Communication Standard (29 CFR 1910.1200) to have Material Safety Data Sheets (MSDSs) for chemicals onsite, must also provide copies of said MSDSs to the State emergency response commission, the local emergency planning commission, and the local fire department. Facilities must also provide to these three organizations an annual report called a "Tier I" indicating the amount of chemicals above the threshold quantities onsite. If any agency that receives a Tier I report requests additional information, a Tier II report containing a summary of all chemicals in any quantity must be supplied within 30 days. The level of the threshold quantities can be more stringently determined by the individual states and is available from the local environmental agency.

Threshold Quantities for Extremely Hazardous Chemicals in the Printing Industry
(Federal levels)

Chemical Name	Reportable Quantity (lbs.)	Threshold Planning (lbs.)
Ammonia	100	500
Formaldehyde	100	500
Hydroquinone	1	500/10,000*
Propylene oxide	100	10,000
Sulfuric acid	1000	1000
Toluene 2,4 Diisocyanate	100	500

*Revised threshold planning quantity based on new or re-evaluated toxicity data

Any printing facility employing more than 10 persons that uses or manufactures more than 10,000 or 25,000 pounds per year of a listed chemical must also file a toxic chemical release inventory (TRI). The difference in the quantity for reporting is dependant on the use of said chemical and should be obtained from the state environmental agency.

Chemicals Listed in the Toxic Release Inventory used in the Printing Industry

	Hydrochloric acid,
Ammonia	Hyrdroquinone
Barium	Lead
Cadmium	Methanol
Chromium	Methyl ethyl ketone
Copper *	Methyl isobutyl ketone
Cumene	Phosphoric acid
Cyclohexane	Silver
Methylene chloride	Sulfuric acid
Ethylbenzene	Tetrachloroethylene
Ethylene glycol	Toluene
Ethylene oxide	Trichloroethylene
Formaldehyde	1,1,1 Trichloroethane
Freon 113	Xylene

*Copper phthalocyanine pigments were delisted in May 1991

Toxic Substances Control Act (TSCA)

Under TSCA, the EPA is given the authority to limit or prohibit the manufacture, processing, distribution or disposal of a chemical substance which they have determined poses a risk to human health or the environment. EPA will also gather information on all risks associated with toxicity to all new and existing chemicals. Of importance to the printing industry are sections 4, 5, 6, and 8.

Section 4 is the authorization for the EPA to require testing of chemical substances or mixtures they determine could be a risk to human health or the environment. Section 5 grants the EPA the right to test all new chemical substances to determine their toxicity and subsequent risk 90 days before manufacturing, processing or importing said chemical. Section 6 is the official notification that the EPA may regulate the manufacture, processing, distribution in commerce, and the use and disposal of any chemical substance determined to be toxic. Section 8 is the requirement for all users and manufacturers to keep records and submit reports to the EPA. Printers using processed film developers or replenishers should contact the local environmental agency to determine reporting requirements. Printers who import inks are also subject to all TSCA reporting requirements.

Appendix B
Human Resources

Connecticut

Connecticut Department of Environmental Protection, Office of Pollution Prevention
79 Elm Street, 4th Floor
Hartford, CT 06106-5127
Phone: 860-424-3297
Fax: 860-424-4060

Connecticut Technical Assistance Program (ConnTAP)
50 Columbus Blvd., 4th Floor
Hartford, CT 06106
Phone: 203-241-0777
Fax: 203-241-2017

Illinois

Illinois Waste Management and Research Center
One East Hazelwood Drive
Champaign, IL 61820
Phone: 217-333-8940
Fax: 217/333-8944

Illinois Environmental Protection Agency
Office of Pollution Prevention
P.O. Box 19276
2200 Churchill Rd.
Springfield, IL 62794-9276
Phone: 217-782-8700
Fax: 217-782-9142

Indiana

Indiana Department of Environmental Management
Office of Pollution Prevention and Technical Assistance
100 N. Senate St.
P.O. Box 6015
Indianapolis, IN 46206-6015
Phone: 317-233-5626
Fax: 317-233-5627

Indiana Pollution Prevention and Safe Materials Institute
1291 Cumberland Avenue, Suite C
West Lafayette, IN 47906
Phone: 317-494-6450
Fax: 317-494-6422

Iowa

Iowa Department of Natural Resources
Waste Management Assistance Division
Wallace State Office Building
Des Moines, IA 50319-0034
Phone: 515-281-8941
Fax: 515-281-8895

Iowa Waste Reduction Center
University of Northern Iowa
Cedar Falls, IA 50614-0815
Phone: 319-273-2079
Fax: 319-273-2926

Maine

Maine Department of Environmental Protection
Office of Pollution Prevention
State House Station #17
Augusta, ME 04333
Phone: 207-287-2811
Fax: 207-287-2814

Massachusetts

Massachusetts Executive Office of Environmental Affairs
Office of Technical Assistance
100 Cambridge Street, Suite 2109
Boston, MA 02202
Phone: 617-727-3260
Fax: 617-727-3827

Toxics Use Reduction Institute
University of Massachusetts Lowell

[illegible] University [illegible]
Lowell, MA
Phone 508-934-3275
Fax 508-934-3050

Michigan

Great Lakes and Mid-Atlantic Hazardous Substance Research Center
Michigan State University Office
A124 Research Complex-Engineering
East Lansing, MI 48824-1326
Phone: 517-353-9718
Fax: 517-355-0250

Michigan Department of Environmental Quality
Environmental Assistance Division
P.O. Box 30457
Lansing, MI 48909-7957
Phone: 517-335-7310
Fax: 517-335-4729

Grand Valley State University
Waste Reduction and Management Program
1 Campus Drive
Allendale, MI 49401
Phone: 616-895-3048
Fax: 616-895-3864

Spill Control Association of America
1000 Town Center, 22nd Floor
Detroit, MI 48243
Phone: 313-358-4400
Fax: 313-358-3351

Minnesota

Minnesota Technical Assistance Program (MnTAP)
1313 S Fifth Street SE, #207
Minneapolis, MN 55414
Phone: 612-627-1910
Fax: 612-627-4769

Minnesota Office of Environmental Assistance
520 Lafayette Rd., Second Flor
St. Paul, MN 55155
Phone: 612-215-0242
Fax: 612-215-0246

Minnesota Pollution Control Agency
Pollution Prevention Program
520 Lafayette Rd.
St. Paul, MN 55155
Phone: 612-296-8643
Fax: 612-297-8676

Western Lake Superior Sanitary District
2626 Courtland Street
Duluth, MN 55806-1894
Phone: 218-722-3336 ext. 324
Fax: 218-727-7471

New Hampshire

New Hampshire Department of Environmental Services, Pollution Prevention Program
6 Hazen Drive
Concord, NH 03301-6509
Phone: 603-271-2902
Fax: 603-271-2456

New Hampshire Department of Environmental Services, Small Business Technical and Environmental Compliance Assistance Program
64 North Main Street, 2nd Floor
Concord, NH 03302-2033
Phone: 603-271-1370
Fax: 603-271-1381

New Jersey

New Jersey Department of Environmental Protection
Office of Pollution Prevention
CN423
401 East State Street
Trenton, NJ 08625
Phone: 609-777-0518
Fax: 609-777-1330

New Jersey Technical Assistance Program (NJTAP)
New Jersey Institute of Technology
323 MLK Jr. Drive
ATC Building
Newark, NJ 07102
Phone: 201-596-5864
Fax: 201-596-6367

New York

Cornell Waste Management Institute
Cornell University
466 Hollister Hall
Ithaca, NY 14853-3501
Phone: 607-255-1187
Fax: 607-255-0238

[illegible] of Pollution Prevention
[illegible] Franklin Street, Room 10[illegible]
Buffalo, NY 14202
Phone: 716-858-6370
Fax: 716-858-7713

New York State Department of Environmental Conservation
Pollution Prevention Unit
50 Wolf Road
Albany, NY 12233-8010
Phone: 518-457-7276
Fax: 518-457-2570

New York State Energy Research and Development Authority
2 Empire State Plaza
Albany, NY 12223
Phone: 518-465-6251, ext. 261
Fax: 518-432-4630

New York Manufacturing Extension Partnership
385 Jordan Rd.
Troy, NY 12180
Phone: 518-283-1010
Fax: 518-283-1212

Ohio

Cleveland Advanced Manufacturing Program (CAMP)
4600 Prospect Ave.
Cleveland, OH 44103-4314
Phone: 216-432-5300
Fax: 216-361-2900

Institute of Advanced Manufacturing Sciences
Center for Applied Environmental Technologies
1111 Edison Drive
Cincinnati, OH 45216-2265
Phone: 513-948-2000
Fax: 513-948-2109

Ohio Environmental Protection Agency
Office of Pollution Prevention
P.O. Box 1049, 1800 Watermark Drive
Columbus, OH 43266-0149
Phone: 614-644-3469
Fax: 614-644-2329

Canada (Ontario)

Environment Canada
Pollution Prevention and Abatement
25 St. Clair Ave. East, 7th Floor
Toronto, Ontario M4T1M2

Automotive Parts Manufacturers Association
195 The West Mall, 25 Adelaide St. E., Suite 516
Toronto, Ontario M5C1Y7
Phone: 416-620-4220
Fax: 416-620-9730

Great Lakes Pollution Prevention Centre
265 N. Front Street, Suite 112
Sarnia, Ontario N7T1 7X1
Phone: 519-337-3423
Fax: 519-337-3486

Ontario Waste Exchange (ORTECH)
2395 Speakman Drive
Mississauga, Ontario L5K1B3
Phone: 905-822-4111 ext. 358
Fax: 905-823-1446

Pennsylvania

Institute for Cooperation in Environmental Management
437 Chestnut Street, Suite 715
Philadelphia, PA 19106
Phone: 215-829-9470
Fax: 215-829-9471

Pennsylvania Technical Assistance Program
Penn State University
117 Tech Center
University Park, PA 16802
Phone: 814-865-0427
Fax: 814-865-5909

Pennsylvania Department of Environmental Resources
Pollution Prevention Program
P.O. Box 8472
Harrisburg, PA 17105
Phone: 717-787-9647
Fax: 717-783-3278

University of Pittsburgh
Applied Research Center
Center for Hazardous Materials Research

[illegible]
Pittsburgh, PA [illegible]
Phone 412-826-53[illegible]
Fax 412-826-5552

Canada (Quebec)

Environment Canada Library
P.O. Box 10100
Saint-Foy, Quebec G1U4H5
Phone: 418-649-6545
Fax: 418-648-3859

Environment Canada
National Office of Pollution Prevention
351 St. Joseph Blvd.
Hull, Quebec K1A0H3
Phone: 819-994-6593
Fax: 819-953-7970

Rhode Island

Rhode Island Department of Environmental Management, Pollution Prevention Program
83 Park Street
Providence, RI 02903-1037
Phone: 401-277-3434
Fax: 401-277-2591

University of Rhode Island
Rhode Island Center for Pollution Prevention
Crawford Hall
Chemical Engineering Department
Providence, RI 02908
Phone: 401-792-2443
Fax: 401-782-1180

Vermont

Vermont Department of Environmental Conservation, Pollution Prevention Program
103 South Main Street
Waterbury, VT 05671-0404
Phone: 802-241-3629
Fax: 802-241-3296

Wisconsion

Solid and Hazardous Waste Education Center
University of Wisconsin-Extension
610 Langdon Street, Rm. 529
Madison, WI 53707
Phone: 608-262-0385
Fax 608-262-6250

Wisconsin Department of Natural Resources
Hazardous Waste Minimization Program
P.O. Box 7921 (SW/3)
Madison, WI 53707-7921
Phone: 608-267-3763
Fax: 608-267-2768

Wisconsin Department of Natural Resources
Pollution Prevention Program
P.O. Box 7921 (TS/6)
Madison, WI 53707
Phone: 608-267-9700
Fax: 608-267-5231

National and Regional Groups

National Pollution Prevention Roundtable
2000 P Street, NW, Suite 708
Washington, DC 20036
Phone: 202-466-P2T2
Fax: 202-466-7964

National Pollution Prevention Center for Higher Education
430 E. University, Dana Bldg.
Ann Arbor, MI 48109-1115
Phone: 313-764-1412
Fax: 313-936-2195

Great Lakes Regional Pollution Prevention Roundtable
1 East Hazelwood Drive
Champaign, IL 61820
Phone: 217-333-8946
Fax: 217-333-8944

Northeast Waste Management Officials' Association (NEWMOA)
129 Portland Street, 6th Floor
Boston, MA 02114
Phone: 617-367-8558
Fax: 617-367-0449

Printing Associations

Lithography

Printing Industries of America
100 Daingerfield Rd.
Alexandria, VA 22314

Phone: [illegible]
Fax: [illegible]

Printing Industry of Illinois and Indiana Association
70 East Lake Street
Chicago, IL 60601
Phone: 312-704-5000
Fax: 312-704-5025

Printing Industry of Ohio
P.O. Box 819
Westerville, OH 43086-0819
Phone: 614-794-2300
Fax: 614-794-2049

Printing Industries of Virginia
1108 East Main St., Suite 300
Richmond, VA 23219
Phone: 804-643-1800

Printing Industries of Metropolitan Washington
7 West Tower
1333 H St., NW
Washington, DC 20005
Phone: 202-682-3001

Printing Industries of New England
10 Tech Circle
Natick, MA 01760
Phone: 508-655-8700
Fax: 508-655-2586

Graphic Arts Technical Foundation
4615 Forbes Ave.
Pittsburgh, PA 15213-3796
Phone: 412-621-6941
Fax: 412-621-3049

National Association of Printers and Lithographers
7 West Tower
1333 H Street, NW
Washington, DC
Phone: 202-682-3001

National Association of Printers and Lithographers
780 Palisades Avenue
Teaneck, NJ 07666
Phone: 300-642-6275
Fax: 201-342-0700

Gravure

Gravure Association of America
1200-A Scottsville Rd.
Rochester, NY 14624
Phone: 716-436-2150
Fax: 716-436-7689

Flexography

Flexographic Technical Association
900 Marconi Ave.
Ronkonkoma, NY 11779
Phone: 516-737-6020

Flexographic Technical Association
210 Stephen Street
Levittown, NY 11756
Phone: 516-935-7241
Fax: 516-935-1460

Screen Printing

Screenprinting and Graphic Imaging Association International (SGIA)
10015 Main Street
Fairfax, VA 22031
Phone: 703-385-1335
Fax: 703-273-0456
http://www.sgia.org/

Other Associations

In-Plant Management Association
1205 W. College Ave.
Liberty, MO 64068
Phone: 816-781-1111

National Association of Quick Printers
401 N. Michigan Ave.
Chicago, IL 60611
Phone: 312-644-6610

Environmental Conservation Board of the Graphic Communications Industries
1899 Preston White Drive
Reston, VA 22091-4367
Phone: 703-648-3218

National Assoc. of Printing Ink Manufacturers

[illegible] Halstead A[illegible]
Harrison, NY [illegible]52[illegible]
Phone: [illegible]14-835-[illegible]

National Association of Printing Ink Manufacturers
777 Terrace Ave.
Hasbrouck Heights, NJ 07604-3110
Phone: 201-288-9454

American Institute of Graphic Arts
1059 Third Avenue
New York, NY 10021
Phone: 212-752-0813

American Newspaper Publishers Association
The Newspaper Center
11600 Sunrise Valley Drive
Reston, VA 22091
Phone: 703-620-9500

National Association of Photographic Manufacturers
550 Mamaroneck Avenue, Suite 307
Harrison, NY 10528-1612
Phone: 914-698-7603

International Digital Imaging Association (IDIA)
5601 Roanne Way, Suite 608
Greensboro, NC 27409
Phone: 910-854-5697
Fax: 910-854-5956

International Association of Printing House Craftsmen
Phone: 612-560-1620

Waterless Printing Association
P.O. Box 59800
Chicago, IL 60645
Phone: 312-743-5677

Graphic Arts Education and Research Foundation
1899 Preston White Drive
Reston, VA 22091
Phone: 703-264-7200

Appendix C
Electronic Resources

Printing Web Sites

EnviroSenSe
Printing Industry Content Guide or Envirosense: Printing P2
http://www.seattle.battelle.org/es-guide/print/print.htm
This home page contains case studies, P2 practices, regulations and vendor information of interest to printers. From this page you can also link into the US EPA web site (http://www.epa.gov).

Printers' National Environmental Assistance Center
http://denr1.igis.uiuc.edu/pneac/pneac.html
The PNEAC is jointly sponsored by WMRC, SHWEC, the Graphic Arts Technical Foundation, and Printing Industries of America. The goal of the center is to provide information about the environmental impacts of printing and effective means to achieve compliance with environmental regulations.

GATF Home Page
http://www.gatf.lm.com/
The Graphics Arts Technical Foundation home page provides information about GATF membership, workshops, products, servcies, NSTF scholarships, etc.

PIA Home Page
http://www.printing.org
The Printing Industries of America home page provides information about PIA membership and a search features to locate local PIA members.

NAPL Home Page
http://www.napl.org/napl/home.html
The National Association of Printers and Lithographers home page describes NAPL, lists NAPL resources, equipment vendors and manufacturers, etc.

SGIA Button Page
http://www.sgia.com/button/html
Screenprinting and Graphic Imaging Association International home page contains information about SGIA membership, suppliers, employment opportunities, etc.

U.S. Screen Printing Institute
http://www.usscreen.com
A commercial site for screen printers with information on trade shows, industry resources, the US Screen Printing Institute products, and access to an available interactive chat session with other screen printers. Appears to be a site primarily targeting the apparel sector of the screen printers.

Flexographic Technical Association Home Page
http://www.fta-[illegible]
The FTA Home Page has information on membership, hot news items, an environmental corner, an announcements of training and upcoming meetings.

Gravure Association of America
http://www.gaa.org
The Gravure Home page has information on membership, publications, available services, a calendar, and information on the Gravure Education Foundation.

Craftnet Web Site
http://craftnet.eas.asu.edu/welcome.html
The International Association of Printing House Craftsmen home page describes the Craftsmen's clubs, seminars, etc.

Listservs

Listservs are basically electronic bulletin boards where the subscribers "post" questions and answers pertaining to a specific topic via e-mail.

PRINTECH focuses on technical aspects of environmental compliance issues faced by printers. Special attention is given to providing practical information on materials, practices and technologies that can prevent wastes and emissions at the source.

P2TECH is dedicated to the free discussion of technical strategies for implementing pollution prevention. This is not specific to the printing industry.

Subscription requests or questions should be e-mailed to <listman@wmrc.hazard.uiuc.edu>

Videos

"Printers Win Through Pollution Prevention"
Waste Reduction Assistance Program
P.O. Box 10009
Richmond, VA 23240-0009
(804) 371-8716

"Saving Money and Reducing Waste"
US EPA Design for the Environment Screen Printers Video
Pollution Prevention Information Clearinghouse (PPIC)
US EPA
401 M Street, SW (3404)
Washington, DC 20460
(202) 260-1023

"Controlling Waste in Web Offset Printing"
Graphic Arts Technical Foundation
4615 Forbes Ave.
Pittsburgh, PA 15213-3796
(412) 621-6941

[illegible] Printing
S[illegible] Waste Education Center
610 Langdon Street, Rm. 529
Madison, WI 53707
(608) 262-0385

Other

Sourcebook '96-Official Phone Book of the Printing Industry-with instant phone and fax access to more than 1,200 sources of equipment and supplies, plus an exclusive list of dealers by state
Graphic Arts Monthly
249 W. 17th St.
New York, NY 10011
Sales office: 212-463-6828

Appendix D
Glossary

anilox roll—a roller that supplies a predetermined and uniform ink volume to the surface of a printing plate.

basis weight—the weight in pounds of a ream (500 sheets) of paper cut to a given standard size for that grade: 25 x 38 for book papers, 20 x 26 for cover papers, 22 1/2 x 38 for bristols, 25 1/2 x 30 1/2 for index. E.g., 500 sheets 25 x 38 of 80-lb coated weighs eighty pounds.

bimetal plate—**in lithography**, a plate used for long runs in which the printing image base is copper or brass and the non-printing area is aluminum, stainless steel, or chromium.

blanket—**in offset printing (lithography)**, a rubber-surfaced fabric which is clamped around a cylinder, to which the image is transferred from the plate, and from which it is transferred to the paper.

burn—**in platemaking**, common term used for plate exposure

catching up—**in lithography**, a term which indicates that the non-image areas of a press plate are starting to take ink or scum.

chalking—**in printing**, a term which refers to improper drying of ink. Pigment dusts off because the vehicle has been absorbed too rapidly into the paper.

coated paper—paper having a surface coating which produces a smooth finish. Surfaces vary from eggshell to glossy.

color separation—**in photography (pre-press)**, the process of separating color originals into the primary printing color components in negative or positive form. **In lithographic platemaking**, the manual separation of colors by handwork performed directly on the printing surface. An artist can pre-separate by using separate overlays for each color.

contact screen—a photographically-made halftone screen on film having a dot structure of graded density, used in vacuum contact with the photographic film to produce halftones.

continuous tone—a photographic image which contains gradient tones from black to white.

crossline screen—**in halftone photography**, a grid pattern with opaque lines crossing each other at right angles, thus forming transparent squares or "screen apertures."

curl—**in paper**, the distortion of a sheet due to differences in structure or coatings from one side to the other, or to absorption of moisture on an offset press.

cyan—one of the subractive primaries the hue of which is used for one of the 4-color process inks. It reflects blue and green light and absorbs red light.

dampeners—**in lithography**, cloth-covered, parchment paper or rubber (bare back) rollers that distribute the dampening solution to the press plate or ink roller.

dampening system—**in lithography**, the mechanism on a press for transferring dampening solution to the plate during printing.

distributing rollers—**in printing presses**, rubber covered rollers which convey ink from the fountain onto the ink drum.

doctor blade—**in gravure**, a knife-edge blade pressed against the engraved printing cylinder [illegible] excess ink from the non-printing areas

electrostatic plates—plates for high-speed laser printing using zinc oxide, organic photoconductor or cadmium sulphide coatings.

fountain solution—**in lithography**, a solution of water, gum arabic and other chemicals used to dampen the plate and keep non-printing areas from accepting ink.

halftone—the reproduction of continuous-tone artwork, such as a photograph, through a crossline or contact screen, which converts the image into dots of various sizes.

hickeys—**in lithography**, spots or imperfections in the printing due to such things as dirt on the press, dried ink skin, paper particles, etc.

impression—**in printing**, the pressure of type, plate or blanket as it comes in contact with the paper.

impression cylinder—**in printing**, the cylinder on a printing press against which the paper picks up the impression from the inked plate in direct printing, or the blanket in offset printing.

ink fountain—**in printing presses**, the device which stores and supplies ink to the inking rollers.

laser platemaking—the use of lasers for scanning pasteups and/or exposing plates in the same or remote locations.

makeready—**in printing presses**, all work done prior to running, i.e., adjusting the feeder, grippers, side guide, putting ink in the fountain, etc. Also, **in letterpress**, the building up of the press form, so that the heavy and light areas print with the correct impression.

magenta—one of the subtractive primaries the hue of which is used for one of the 4-color process inks. If reflects blue and red light and absorbs green light.

moire—**in color process printing**, the undesirable screen pattern caused by incorrect screen angles of overprinting halftones.

offset—**in printing**, the process of using an intermediate blanket cylinder to transfer an image from the image carrier to the substrate. Short for offset lithography.

plate cylinder—the cylinder on a press on which the plate is mounted.

process printing—the printing from a series of two or more half-tone plates to produce intermediate colors and shades. In four-color process: yellow, magenta, cyan, and black.

register—**in printing**, fitting two or more printing images on the same paper in exact alignment with each other.

screen angles—**in color reproduction**, angles at which the half-tone screens are placed with relation to one another, to avoid undesirable moire patterns.

trapping—the ability to print a wet ink film over previously printed ink. **Dry trapping** is printing wet ink over dry ink. **Wet trapping** is printing wet ink over previously printed wet ink.

-up—**in printing**, two-up, three-up, etc., refers to imposition of material to be printed on a larger size sheet to take advantage of full press capacity.

work and tumble—to print one side of a sheet of paper, then turn the sheet over from gripper to back using the same side guide and plate to print the second side.

work and turn—to print one side of a sheet of paper, then turn the sheet over from left to right and print the second side. The same gripper and plate are used for printing both sides.

yellow—one of the subtractive primaries the hue of which is used for one of the 4-color process inks. It reflects red and green light and absorbs blue light.

Reader Response Survey

Pollution Prevention for the Printing Industry Manual - Reader Response Survey

This manual has been published as a pilot project to develop a comprehensive pollution prevention manual for technical assistance programs for the printing industry sector. In order to determine the utility and make improvements in future editions, we would like to hear from you. Your comments will enable us to increase the value of this document. Please take a few moments to answer some questions. When completed, simply fold in half, staple and mail the survey back. We appreciate your comments and suggestions.

Where did you learn about this report?

- WMRC newsletter
- EPA Pollution Prevention Information Clearinghouse (PPIC)
- Colleague
- E-mail announcement
- Internet site (please name)________________
- Other ________________

For the following questions, please circle the number that best describes your level of agreement with each statement.

1. The overall quality (organization, content) of the manual was high?

   5 4 3 2 1

2. The manual provided a comprehensive overview of pollution prevention techniques for metal finishing.

   5 4 3 2 1

   If you felt the manual was not comprehensive what information was lacking:

   ____

   ____

   Was there any information that was unnecessary or inaccurate?

   ____

   ____

3. Information was easily located in the Manual.

   5 4 3 2 1

4. Additional comments regarding the Manual.

   ____

   ____

   ____

[illegible]

Federal/State/Local pollution prevention assistance program

Federal/State/Local environmental regulatory program

Other government (federal, state, or local) assistance program

Environmental consultant

Printing facility

University-affiliated researcher

Privately-employed researcher

Environmental organization

Student

Other ______________________________

6. Would you like to receive updated/revised copies of the printing manual?

Yes No

7. If you would like receive WMRC's quarterly newsletter, please complete the information below.

Name: ______________________________

Title: ______________________________

Company: ______________________________

Address: ______________________________

City: ______________ State: _____ Zip: __________

Telephone: ______________ Fax: ______________

E-mail: ______________________________

FOLD HERE, TAPE AND MAIL TO THE ADDRESS BELOW. THANK YOU!

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