United States
Environmental Protection
Agency

Office of Research and
Development
Washington, DC 20460

EPA/625/7-90/008
August 1990

EPA

Guides to Pollution Prevention

The Commercial Printing Industry

EPA/625/7-90/008
August 1990

GUIDES TO POLLUTION PREVENTION: THE COMMERCIAL PRINTING INDUSTRY

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NOTICE

This guide has been subjected to the U.S. Environmental Protection Agency's peer and administrative review and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement of recommendation for use. This document is intended as advisory guidance only to the commercial printing industry in developing approaches for pollution prevention. Compliance with environmental and occupational safety and health laws is the responsibility of each individual business and is not the focus of this document.

Worksheets are provided for conducting waste minimization assessments of commercial printing industry manufacturing facilities. Users are encouraged to duplicate portions of this publication as needed to implement a waste minimization program.

FOREWORD

This guide identifies and analyzes waste minimization methodologies appropriate for commercial printers, who include lithographers, gravure printers, flexographers, and letterpress and screen printers. This information largely addresses the wastes and waste minimization options for offset lithographers.

A variety of wastes are generated during the printing operation. Waste that can be disposed of in trash include some waste paper; film; empty containers; used blankets; and damaged products and other items. These wastes result from image processing, plate making, proof making, printing, and finishing processes. Another form of waste --waste water-- results from image processing, plate making, and printing processes. Equipment cleaning wastes and air emissions are other categories of waste. Much of the waste paper generated can be recycled.

Reducing the generation of these wastes at the source, or recycling the wastes on or off site, will benefit commercial printers by reducing raw material needs, reducing disposal costs, and lowering the liabilities associated with hazardous waste disposal.

ACKNOWLEDGMENTS

This guide is based in part on waste minimization assessments conducted by Jacobs Engineering Group Inc. Pasadena, California for the California Department of Health Services (DHS). Contributors to these assessments include: David Leu, Benjamin Fries, Kim Wilhelm, and Jan Radimsky of the Alternative Technology Section of DHS. Much of the information in this guide that provides a national perspective on the issues of waste generation and minimization for commercial printers was provided originally to the U.S. Environmental Protection Agency by Versar, Inc. and Jacobs Engineering Group Inc. in "Waste Minimization-Issues and Options, Volume II, " report no. PB87-114369 (1986). Jacobs Engineering Group Inc. edited and developed this version of the waste minimization assessment guide, under subcontract to Radian Corporation (USEPA contract 68-02-4286).

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Section 1
INTRODUCTION

This guide was prepared to provide commercial printers with guidelines and options to minimize both hazardous and non-hazardous wastes. It includes worksheets to be used in developing waste minimization options for an individual facility. The worksheets and the list of waste minimization options were developed through assessments of two Los Angeles area firms commissioned by the California Department of Health Services (Calif. DHS 1988). The two firms' operations, manufacturing processes, and waste generation and management practices were surveyed, and their existing and potential waste minimization options were characterized. Economic analyses were performed on selected options.

Inks and paper are the primary raw materials used in printing. Other input materials include photoprocessing and platemaking materials, fountain solutions, cleaning solvents and solutions, and lubricating oils. Solvents and some waste inks represent hazardous materials. Because of the variety of processes and printing substrates used and differences in the final product desired, many different inks are used. Some inks may contain flammable and toxic solvents and/or toxic heavy metals. On the other hand, many inks are claimed to be non-hazardous. The printing industry has made substantial progress toward the use of less hazardous and non-hazardous materials.

Waste minimization is a policy specifically mandated by the U.S. Congress in the 1984 Hazardous and Solid Wastes Amendments to the Resource Conservation and Recovery Act (RCRA). As the federal agency responsible for writing regulations under RCRA, the U.S Environmental Protection Agency (EPA) has an interest in ensuring that new methods and approaches are developed for minimizing hazardous waste and that such information is made available to the industries concerned. This guide is one of the approaches EPA is using to provide industry-specific information about hazardous waste minimization.

EPA has also developed a general manual for waste minimization in industry. The *Waste Minimization Opportunity Assessment Manual* (USEPA 1988) tells how to conduct a waste minimization assessment and develop options for reducing hazardous waste generation at a facility. It explains the management strategies needed to incorporate waste minimization into company policies and structure, how to establish a company-wide waste minimization program, conduct assessments, implement options, and make the program an on-going one. The elements of waste minimization assessment are explained in the Overview, next section.

In the following sections of this manual you will find:

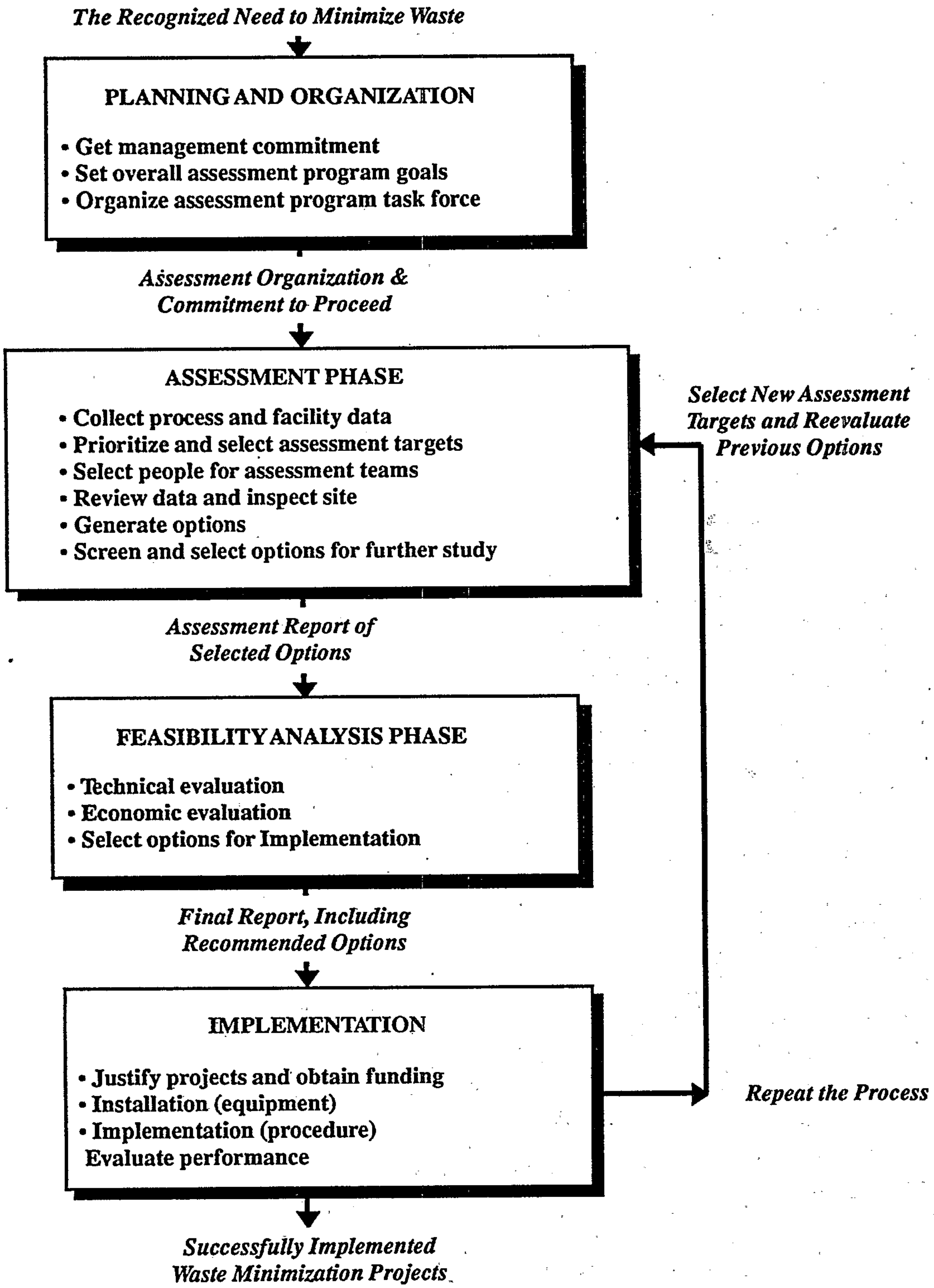
- An overview of the commercial printing industryand the processes used by the industry (Section Two);
- Waste minimization options for commercial printers (Section Three);
- Waste Minimization Assessment Guidelines andWorksheets (Section Four)
- An Appendix, containing:
  - Case studies of waste generation and waste minimization practices of two commercial printers;
  - Where to get help: Sources of useful technical and regulatory information

Overview of Waste Minimization Assessment

In the working definition used by EPA, waste minimization consists of source reduction and recycling. Of the two approaches, source reduction is usually considered preferable to recycling from an environmental perspective. Treatment of hazardous waste is considered an approach to waste minimization by some states but not by others, and thus is not addressed in this guide.

A Waste Minimization Opportunity Assessment (WMOA), sometimes called a waste minimization audit, is a systematic procedure for identifying ways to reduce or eliminate waste. The steps involved in conducting a waste minimization assessment are outlined in Figure 1 and presented in more detail in the next paragraphs. Briefly, the assessment consists of a careful review of a plant's operations and waste streams and the selection of specific areas to assess. After a particular waste stream or area is established as the WMOA focus, a number of options with the potential to minimize waste are developed and screened. The technical and economic feasibility of the selected options are then evaluated. Finally, the most promising options are selected for implementation.

Figure 1. The Waste Minimization Assessment Procedure



To determine whether a WMOA would be useful in your circumstances, you should first read this section describing the aims and essentials of the WMOA process. For more detailed information on conducting a WMOA, consult The *Waste Minimization Opportunity Assessment Manual.*

The four phases of a waste minimization opportunity assessment are:

- Planning and organization
- Assessment phase
- Feasibility analysis phase
- Implementation

PLANNING AND ORGANIZATION

Essential elements of planning and organization for a waste minimization program are getting management commitment for the program; setting waste minimization goals; and organizing an assessment program task force.

ASSESSMENT PHASE

The assessment phase involves a number of steps:

- Collect process and facility data
- Prioritize and select assessment targets
- Select assessment team
- Review data and inspect site
- Generate options
- Screen and select options for feasibility study

Collect process and facility data. The waste streams at a facility should be identified and characterized. Information about waste streams may be available on hazardous waste manifests, National Pollutant Discharge Elimination System (NPDES) reports, routine sampling programs and other sources.

Develop a basic understanding of the processes that generate waste at a facility is essential to the WMOA process. Flow diagrams should be prepared to identify the quantity, types and rates of waste generating processes. Also, preparing material balances for various processes can be useful in tracking various process components and identifying losses or emissions that may have been unaccounted for previously.

Prioritize and select assessment targets. Ideally, all waste streams in a facility should be evaluated for potential waste minimization opportunities. With limited resources, however, a plant manager may need to concentrate waste minimization efforts in a specific area. Such considerations as quantity of waste, hazardous properties of the waste, regulations, safety of employees, economics, and other characteristics need to be evaluated in selecting a target stream.

Select assessment team. The team should include people with direct responsibility and knowledge of the particular waste stream or area of the plant.

Review data and inspect site. The assessment team evaluates process data in advance of the inspection. The inspection should follow the target process from the point where raw materials enter the facility to the points where products and wastes leave. The team should identify the suspected sources of waste. This may include the production process; maintenance operations; and storage areas for raw materials, finished product, and work in progress. The inspection may result in the formation of preliminary conclusions about waste minimization opportunities. Full confirmation of these conclusions may require additional data collection, analysis, and/or site visits.

Generate options. The objective of this step is to generate a comprehensive set of waste minimization options for further consideration. Since technical and economic concerns will be considered in the later feasibility step, no options are ruled out at this time. Information from the site inspection, as well as trade associations, government agencies, technical and trade reports, equipment vendors, consultants, and plant engineers and operators may serve as sources of ideas for waste minimization options.

Both source reduction and recycling options should be considered. Source reduction may be accomplished through:

- Good operating practices
- Technology changes
- Input material changes
- Product changs

Recycling includes:

- Use and reuse of waste
- Reclamation

Screen and select options for further study. This screening process is intended to select the most promising options for full technical and economic feasibility study. Through either an informal review or a quantitative decision-making process, options that appear marginal, impractical or inferior are eliminated from consideration.

FEASIBILITY ANALYSIS

An option must be shown to be technically and economically feasible in order to merit serious consideration for adoption at a facility. A technical evaluation determines whether a proposed option will work in a specific application. Both process and equipment changes need to be assessed for their overall effects on waste quantity and product quality. Also, any new products developed through process and/or raw material changes need to be tested for market acceptance.

An economic evaluation is carried out using standard measures of profitability, such as payback period, return on investment, and net present value. As in any project, the cost elements of a waste minimization project can be broken down into capital costs and economic costs. Savings and changes in revenue also need to be considered.

IMPLEMENTATION

An option that passes both technical and economic feasibility reviews should then be implemented at a facility. It is then up to the WMOA team, with management support, to continue the process of tracking wastes and identifying opportunities for waste minimization, throughout a facility and by way of periodic reassessments. Either such ongoing reassessments or an initial investigation of waste minimization opportunities can be conducted using this manual.

References

Calif. DHS. 1988. *Waste Audit Study: Commercial Printing Industry.* Report prepared by Jacobs Engineering Group Inc., Pasadena, Calif., for the California Department of Health Services, Alternative Technology Section, Toxic Substances Control Division, May 1988.

USEPA. 1988. *The EPA Manual for Waste Minimization Opportunity Assessments.* Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio, EPA/600/2-88-025.

Section 2
COMMERCIAL PRINTING INDUSTRY PROFILE

Industry Description

As defined in the Standard Industrial Classification (SIC) 27 - the printing, publishing, and allied industries include "establishments engaged in printing by one or more of the common processes, such as letterpress, lithography, gravure, or screen; and those establishments which perform services for the printing trade, such as bookbinding, typesetting, engraving, photoengraving, and electrotyping. This major group also includes establishments engaged in publishing newspapers, books, and periodicals, regardless of whether or not they do their own printing." Of the seventeen SIC subgroups under major group 27, about fifteen involve substantial printing operation activities. SIC 275 involves commercial printing operations.

Printing (or graphic arts) establishments are scattered all over the United States, with the largest concentrations in California and New York. These two states share about 12 and 11 percent of the industry, respectively. Illinois, Texas, Florida, New Jersey, Pennsylvania, and Ohio each share about 5 percent of the total. As of 1982, there were approximately 53,500 facilities located in the U.S. (USDC 1985a, 1985b, 1985c).

Printing Processes and Products

The five most common printing processes in order of their market share are lithography, gravure, flexography, letterpress, and screen (see Figures 2 and 3). Presses are also categorized by the form of paper or other substrate used. Web presses, which are used for larger printing runs, print the image onto a continuous roll (web) of paper. After printing, the paper is then slit (cut) and trimmed to the preferred size. Sheet-fed presses print on individual sheets of paper or other substrate. The products associated with each printing process are discussed in the section below.

Lithography is the predominant printing process. Its growth is expected to continue into the 1990s and then stabilize at just under 50% of all printing applications. Sheet-fed lithography is used for printing books, posters, greeting cards, labels, packaging, advertising flyers and brochures, periodicals, and for reproducing artwork. Web offset lithography is used for periodicals, newspapers, advertising, books, catalogs, and business forms. However, sheetfed offset still predominates in numbers of establishments, with 16, 112 nationwide compared with 1,840 heatset web offset printers (Schaeffer, personal communication.) Gravure printing is used for large volume runs and high speed runs for printing high-quality publications, magazines, catalogs, and advertising. It also has large volume applications in the printing of flexible packaging (polyolefin packaging), paperboard boxes, and labels. It can print glossy ink films effectively.

Flexography, a form of letterpress that uses a flexible plastic or rubber plate in a rotary web press, is used primarily for packaging, such as plastic wrappers, corrugated boxes, milk cartons, shower curtains, foil, and paper bags. Flexography works well when printing a large solid surface area and with appropriate substrate can achieve glossy colors. Because of the growth of packaging, the use of flexography has shown a steady increase.

Web letterpress is currently used for printing newspapers and magazines. However, its use is declining with greater use of lithography. Sheet-fed letterpress is used for books, printed stationery, announcements, business cards, and advertising brochures. Because individual changes can be made on a plate without having to redo the entire plate, letterpress is particularly useful for price lists, parts lists, and directories. In this case, however, computerized image making is replacing the practice of having standing typeset plates upon which small changes are made.

Screen printing can print on virtually any substrate, including wood, glass, fabrics, plastics, and metals. It is used for specialty printing, T-shirts, posters and banners, decals, and wallpapers. This type of printing makes up a small but growing segment of the printing industry. Screen printing is also used to print patterns on electronic circuit boards prior to etching.

Raw Materials

The principal raw materials used by the graphic arts industry are inks and substrates. A substrate is any material upon which ink is impressed, such as paper, plastic, wood, or metal. Table 1 shows relative usage of ink and paper by the industry.

Other raw materials used by the industry include gravure cylinders, photographic films, photoprocessing chemicals (developers, fixers, wash baths, reducers, intensifiers), printing plates, plate processing chemicals, fountain solutions, cleaning solvents, and rags. Many of the chemicals employed are discussed under process description.

Process Description

Figure 4 illustrates a typical commercial offset lithographic printing operation. Printing begins with the preparation of artwork or copy, which is photographed to produce an image. A proof is made which will be used to compare with the printed product and make adjustments to the press. The photographic image is transferred to a plate. In the platemaking step, the image areas of the plate are made receptive to the ink. In the printing step, ink is applied to the plate, then transferred to a rubber blanket and then to the substrate.

The substrate accepts the ink, reproducing the image. The substrate is then cut, folded, and bound to produce the final product. Printing can be divided into four separate steps: (1) image processing, (2) platemaking, (3) printing, and (4) finishing. The operations involved in these steps are detailed below.

Table 1. Paper and Printing Ink Used by the Graphic Arts Industry

Material	Annual Volume (short tons)
Paper	
Commercial printers	5,300,000
Magazines and other periodicals (other periodicals include catalogs and directories)	4,000,000
Books	900,000
Printing Ink	
Lithographic and offset	190,150
Gravure	179,750
Letterpress	119,250
Flexographic	91,150

Source: 1984 U.S. Industrial Outlook (USDC 1984); American Paper Institute 1985: Personal communication.

IMAGE PROCESSING

Most printing operations begin with art and copy (or text) preparation. Once the material is properly arranged, it is photographed to produce transparencies. If an image is to be printed as a full color reproduction, then color separations are made to provide a single-color image or record which can then be used to produce the single-color printing plate for lithography or the cylinder for gravure. (Multi-color printing is done by passing the substrate through several single-color printing operations.) Once the film has been developed, checked, and rephotographed (if necessary), it is sent on to the plate- or cylinder-making operation.

The printing industry employs graphic arts photography in the reproduction of both artwork and copy, using materials similar to those in other fields of photography. The materials include a paper, plastic film, or glass base covered with a light-sensitive coating called a photographic emulsion. This emulsion is usually composed of silver halide salts in gelatin. Silver halides include silver chloride, silver bromide and silver iodide. Most photographic films are made of polyester, although some cellulose acetate films are still in use.

A photographic process generally produces a negative in which light parts of the copy that was photographed are represented by heavy deposits of silver, causing them to appear dark. Dark parts of the copy are represented by little or no deposits of silver, causing them to appear light or transparent. Some processes such as letterpress or lithography use the photographic negative to transfer an image to the plate. Gravure, screen printing, and other lithographic processes require positives. These are produced by printing negatives onto paper or film. The resulting images have tone values similar to the object or copy that was photographed.

A photograph or other image made up of a gradation of shades is called continuous tone. Gravure, collotype and screenless lithography produce continuous tone pictures by varying the print density. However, in offset lithography or letterpress continuous tones cannot be reproduced by varying the ink density. These processes print either a solid density of color, or none at all. To approximate the tones of the image, these processes employ a halftone screen, which converts a continuous tone image into a pattern of dots of different sizes. Areas meant to appear dark have larger dots, while light areas use small dots. Due to the limited resolving power of the human eye, the overall effect is very similar to a continuous-tone photograph.

Developing

Oxidation and reduction reactions develop an exposed photographic emulsion. The exposed film or plates is first immersed in a developer. This converts the silver halide in the photographic emulsion to metallic silver, in proportion to the amount of exposure it has received. Developers typically contain benzene derivatives. These include pyrogallol, hydroquinone, catechol, p-phenylene diamine, p-aminophenol, metol (or elon), amidol, and pyramidol. These compounds contain two -OH (hydroxyl) groups, two $-NH_2$ (amino) groups, or one of each. The two most common developing agents are hydroquinone and metol.

In general the developer solution also contains an accelerator, preservative, and restrainer. The accelerator is an alkaline material such as sodium hydroxide, sodium carbonate, or sodium tetraborate (borax), which increases the activity of the developer by neutralizing the acid formed during the development process. The preservative, typically sodium sulfite, reduces oxidation damage to the developing agent. The restrainer, potassium bromide, reduces the formation of "fog" on the images.

An all-purpose developer might contain the two developing agents, such as metol and hydroquinone, a sodium carbonate accelerator, a sodium sulfite preservative and a potassium bromide accelerator. A low-contrast developer frequently employs borax instead of sodium carbonate as the accelerator, and uses no potassium bromide.

The introduction of automatic film processors has resulted in different developer formulas. One type is specifically for rapid-access processing. The developer is a low-contrast type employing a special restrainer to reduce fogging of films at the high developer temperatures. The developer also has a high concentration of sodium sulfite. In rapid-access processing, films develop in 60 to 90 seconds in a developer bath that exceeds 100°F (Hartsuch 1983).

Fixing

The developing action is stopped by immersing the film in a fixing bath of sodium thiosulfate ("hypo"), ammonium thiosulfate, or sodium hyposulfite. These chemicals convert the silver halides from the photographic emulsion to soluble complexes. This prevents them from turning to metallic silver, which would make the image in the emulsion black.

Hypo is typically the major ingredient of a fixing bath. Acetic acid, sodium sulfite, potassium alum, and boric acid are also usually present. Potassium alum, which prevents excess swelling of the photo emulsion gelatin, is not stable in a neutral or alkaline solute; precipitation of aluminum hydroxide will result unless an agent such as acetic acid is added to keep the pH low. The major reason for the low pH is to neutralize the alkalinity of any developing solution remaining on the film and thus stop the developing action.

Hypo will decompose in an acid solution, forming elementary sulfur as a precipitate. Sodium sulfite is added to combine with the sulfur precipitate and form more sodium thiosulfate. Thus, the sodium sulfite stabilizes the fixing solution. Boric acid is added to buffer the fixing solution and limit pH changes. This helps to prevent precipitation of aluminum compounds (aluminum is a constituent of potassium alum).

Each time photographic film or paper is immersed in the fixing bath, a small amount of silver enters the bath from the photographic emulsion. Insoluble compounds that are formed after the silver concentration reaches a certain level cannot be removed from the photographic emulsion. The bath should be recycled before this point is reached. The critical silver concentration for fixing baths is 0.27 ounces per gallon (2 grams/liter), while that for films is 0.8 ounces/gallon (6 gm/l) when hypo is the fixing agent. Use of ammonium thiosulfate doubles the maximum allowable concentrations of silver. The amount of silver present in a fixing bath can be determined with silver test papers available from most graphic arts suppliers.

A fresh fixing bath typically has a pH of 4.1 (Hartsuch 1983). Films and prints immersed in the fixer carry some alkaline developing bath with them. This raises the pH of the fixing bath slightly. When the pH reaches 5.5, the potassium alum is less effective. The bath is then either changed, or the pH is lowered by adding more acetic acid. Sometimes an acid stop bath is used prior to the fixing bath to stop the action of the developing solution. The stop bath prevents most of the pH rise of the fixing bath.

Wash Bath

After a negative or positive is fixed, some of the fixing bath chemicals remain in the gelatin emulsion layer. One of the chemicals present is hypo. If it is not removed from the emulsion, it can react with the silver to form yellowish-brown silver sulfide, which impairs the quality of the image. Complex silver salts will also react with the hypo to form silver sulfide. To prevent sulfide formation, fixing chemicals are washed from the emulsion. Films are washed in a water bath that dissolves the hypo from the emulsion until an equilibrium is reached between the hypo in the water and that in the emulsion, at which point the water is changed, and more hypo is dissolved out of the emulsion. Alternatively, films can be washed in running water. The flow of water into the wash tray is adjusted to typically give a complete water change every five minutes. Washwater at about 80°F increases the efficiency of hypo removal. The pH of most washes is kept above 4.9. This prevents the gelatin of the photographic emulsion from absorbing thiosulfate ions.

Photographic Reducers and Intensifiers

Chemicals are sometimes used to reduce or increase the density of the metallic deposit on the film, in order to change the image contrast. Reducers act by oxidizing some of the metallic silver in the emulsion to a soluble salt. Reducers include ferric ammonium sulfate, sulfuric acid, and potassium ferricyanide. Intensifiers increase the blackness of a silver deposit by adding silver or mercury to the developed silver grains in the emulsion. One common intensifier contains silver nitrate, pyrogallol and citric acid; another contains a mercury salt, metal and citric acid.

PROOF

A proof is produced after the image processing step as part of internal job control, and it may also serve as a communication tool between printer and client. It is used for both single-color and multi-color printing. In the case of color periodicals, the proof step may occur outside the commercial printer's facility, at a color separation house. The proof shows whether all the elements fit, whether the color is right, and how the job will look when it is printed. For multicolor work, both press proofs and off-press (or prepress) proofs are in use. Press proofs are more expensive because they require a press and printing plates or cylinders, however, letter press and gravure generally use press proofs because the platemaking and cylinder-making steps affect tone reproduction. In press proofs, the actual printing inks and paper to be used can be employed, although usually a special (non-production) press is used to print the proof.

Off-press proofs are produced directly, usually photographically, and these serve as a quality control check of camera and scanner separation and corrections (Bruno 1983).

The waste associated with the proof is film and paper. While electronic imaging may in the future make it possible to eliminate the proof, it is currently an indispensable step in commercial printing.

PLATE PROCESSING

The printing process revolves around the intermediate image carrier, a plate or cylinder that accepts ink off a roller and transfers the image to the rubber blanket. The blanket, in turn, transfers it to the paper. Each printing process uses a different type of image carrier. The type of ink and press used, the number of impressions that can be printed, the speed with which they are printed, and the characteristics of the image are all determined by the type of image carrier.

The four different types of image carriers generally used are manual, mechanical, electrostatic, and photomechanical.

Manual image carriers consist of hand-set composition, wood cuts, linoleum blocks, copperplate or steel-die engravings. Manually made images are seldom used now except for commercial use in screen printing.

Mechanical image carriers are produced mainly for relief printing. There are two categories: (1) hot metal machine composition and (2) duplicate printing plates. Intaglio printing also uses mechanically made plates. These include pantograph engravings, used for steel-die engraving, and engravings made with geometric lathes, which produce scrolls for stock and bond certificates and paper currency. Mechanically-made gravure cylinders are also used for printing textiles, wrapping papers, wallpapers, and plastics.

Electrostatic plates are popular in reprography (offset duplicating) where electrophotographic cameras convert original images or pasteups to lithographic plates used on copier/duplicators. Electrostatically produced plates are also used for imaging from pasteups and for laser platemaking used in newspaper printing.

Photomechanical platemaking is the common method of platemaking. These image carriers use light sensitive coatings on which images are produced photographically. Photomechanics is capable of reproducing photographs and other pictorial subjects. This overcomes the limitations of manually and mechanically produced plates.

Production of the Image Carrier

The photomechanical process uses light sensitive coatings whose physical properties change after exposure to light. The exposed coating areas become insoluble in water or other solutions, such as diazo solutions. The unexposed areas dissolve, leaving the exposed portion as an image or as a stencil to form an image.

Natural organic substances such as asphalt, shellac, albumin, and gum arabic have been used as photomechanical coatings. New coatings include polyvinyl alcohol, diazo compounds, and synthetic photopolymer resins. Bichromates, which were used as a sensitizing agent until the diazo coatings were introduced, are now becoming obsolete because of their toxicity. However they are still used in bichromated gelatin for gravure carbon tissue and collotype and in bichromated gum arabic for deep etch and bimetal plates (Bruno 1983).

Two common coatings are diazo and photopolymer. Diazo coatings are used for presensitized wipe-on aluminum lithographic plates. The coatings are thin and are generally used for press runs under 100,000 impressions, although some pre-lacquered plates can run for up to twice as many impressions. Diazo coatings have the advantage of not being affected by changes in temperature and relative humidity. Photopolymer coatings are inert and abrasion resistant, which allows for press runs longer than a diazo-coated plate. The photopolymer coatings also have a low sensitivity to changes in temperature and relative humidity. The polymerization reaction occurs under a UV light.

Lithographic Printing Plates. In lithographic printing, both the image and non-image areas are on the same plane. Lithographic plates have the image areas ink-receptive and non-image areas water-receptive. This is achieved through a chemical change on the coated plate surface, which is typically brought about through a photo-chemical process in the light sensitive coating. Lithographic plates can be either negative or positive working. With the negative the image area reacts and becomes hard, making the area ink receptive. The non-image unexposed area does not react, but remains water receptive and repels ink. Exposure through a positive yields the inverse effect. The majority of the printing industry uses pre-sensitized plates, where the light sensitive coatings have been applied by the manufacturer. There are three types of methods used to make lithographic plates: surface, deep-etch and bi-metal.

- *Surface plates* have a light-sensitive coating which becomes ink receptive when exposed. Most surface plates are made from negatives. The types of surface plates are additive and subtractive. With additive plates the hardened image areas are made ink receptive. This is done by adding an oleophilic resin contained in a one-step emulsion developer. Most coatings for additive-type plates contain a diazo compound. Other organic compounds are used as light sensitive materials. These include azide compounds, hydrazine derivatives, quinone diazides, and quinone esters. The emulsion developer consists of two phases: a solvent phase containing an oleophilic resin and pigment, and a water phase containing gum arabic and acid. When an emulsion between these two phases is formed and spreads on the plate, the emulsion breaks. The resin and pigment are deposited on the hardened image areas while the water phase dissolves the unexposed non-image area.

  Subtractive plates usually have an oleophilic resin incorporated into the coating or applied as a lacquer over the coating. Once the plate is exposed, the coated image areas harden. When the plate is placed in the developer solution, the non-image coated area dissolves. The plate is then gummed and is ready for the press. The waste from surface plate processors is a mildly acidic solution of organic compounds in water.

  Aluminum or anodized aluminum is used extensively for surface lithographic plates. The advantages of aluminum are reasonable cost, availability in uniform thicknesses, and tensile strength. It does not stretch when mounted on the press. Aluminum is also lightweight, weighing 38% as much as zinc. It does not corrode easily, allowing the non-image areas to be water-receptive.

- *Deep-etch plates* are made from positives. When the plate is exposed the coating in the exposed non-image areas hardens. The unexposed image areas are soft. Then the developing solution washes the image area away and the stencil remains. The developing solution is typically calcium, zinc, or magnesium chloride combined with a mild acid. The image area is then plated with copper and/or coated with lacquer, which makes it ink receptive. The lacquer is a combination of polyvinyl chloride, polyvinyl acetate, and a small percent of malic acid. The non-image areas are treated with a desensitizing etch and finally gummed with gum arabic solution. Procedures for making deep-etch plates are long and involved. The wastewater from deep etch plate processing is acidic and contains copper or other heavy metal compounds. This process is quickly becoming obsolete because of cost, heavy metal toxicity, and water pollution problems.

- *Bimetal plates* can be exposed through either a negative or positive. These plates are capable of printing several million impressions. The lifetime of these plates is long because the image and non-image areas are established by two different metals. Therefore, the holding of the image areas is not entirely dependent on a hardened coating or lacquer. The wastewater from bimetal plate processing contains heavy metal compounds. Bimetal plates are also becoming obsolete because of the heavy metal toxicity and water pollution problems.

Gravure Printing Cylinders. Cylinder making begins with a steel cylinder plated with copper. The cylinder is machined and polished so as to remove any imperfections in the copper plating. Next, the surface is either engraved using a diamond stylus or chemically etched using ferric chloride. Use of ferric chloride requires that a resist (in the form of the negative image) be transferred to the cylinder before etching. The resist protects the non-image areas of the cylinder from the etchant. After etching, the resist may be subsequently stripped off. This operation is analagous to the manufacturing of printed circuit boards. Following this operation, the cylinder is proofed or tested, reworked if required, and then chrome plated.

Letterpress and Flexography Relief Plates. Letterpress and flexography both employ plates with raised images; only the raised areas come into contact with the ink rollers. Generally these plates are exposed through a negative. The developing process is similar to that of lithographic plates. However, one extra step is used to etch the non-image areas with an acid solution. Zinc, magnesium, and copper are the metals typically used for relief plates.

Zinc plates have a light-sensitive coating, typically polyvinyl alcohol. This is sensitized with dichromate. It can be developed with water, however chromic acid is used to harden the coating. The plate is then baked at 350°F and etched with a solution of nitric acid. Magnesium plates are usually presensitized with a substance like polyvinyl innamate. After exposure to light, the unexposed part is removed by a trichloroethylene vapor degreaser, and then etched with nitric acid. Copper relief plates use a light sensitive coating of fish glue and egg albumin. This is sensitized with potassium dichromate. The plate can be developed in water and is typically baked at 600°F to harden the image areas.

Baths used for developing these plates eventually build up a high concentration of heavy metals. These solutions cannot be discharged to most sewer systems unless the metals are precipitated out or recovered by ion exchange. Platemaking with etching processes is diminishing because of the hazardous waste problems.

Photosensitive plastic plates are used mostly for commercial magazine printing and newspapers. Some are used in an offset letterpress system called "dry offset or letterset". Plastic plates have an advantage over metal plates because no etching solution is needed. When the plate is exposed the image area and all the plastic underneath the area harden. A typical photosensitizer for these plates is benzophenone, which accelerates the polymerization process carried out under UV light. An alkaline aqueous solution is used to wash the unexposed areas off.

MAKEREADY

Makeready is the procedure in which all the adjustments are made on the press, including proper registration and ink density, to achieve a reproduction equivalent to or comparable to the proof or acceptable to the pressman or customer's representative. This step may be the major source of waste from the printer's point of view. Makeready times can last from a few minutes to many hours. Makeready can be conducted at low speeds or at press production speeds. The printer's objective is to minimize both the time involved in maderead and the number of waste sheets or signatures coming off the press (GATF 1989).

The makeready step is more complex for perfecting web offset presses than for sheetfed offset, because eight press units are involved and must be adjusted properly: there are units on top of and beneath the web, two for each of the four process colors. The major wastes associated with makeready are paper and air emissions.

PRINTING

Once the plates are prepared, the actual printing can begin. The printing operations are generally the same for each of the major processes, with the exception of screen printing. The two common types of presses are sheet-fed presses and web presses. Sheet-fed presses can print up to 3 impressions per second. Web presses typically print at a rate of 1000 to 1600 feet per minute.

Preparation for printing begins by attaching the plate to the plate cylinder of the press. Since litho plates are typically made of thin flat aluminum sheets, they can be wrapped around and attached to the plate cylinder. Virtually all presses print from a plate cylinder, as opposed to a flat plate. Each unit of a printing press prints a single color. To print a full color illustration, four separate units are typically required, one unit each for magenta, cyan, yellow, and black.

In lithographic printing, the plate is mounted to a rotating cylinder. As the cylinder rotates, a water-based dampening solution followed by an oil-based ink is transferred to the plate's image area. The inked image repels the solution and accepts the printing ink, while the non-image area accepts the dampening solution and repels the ink. As the cylinder continues to rotate, the inked image is transferred to a blanket and then onto the substrate. The two major forms of substrates used in lithography are single sheets of paper (sheet-fed lithography) and continuous rolls of paper (web lithography).

In gravure printing, the cylinder is placed in the press and partially immersed in an ink bath or fountain. Solvent is added to the ink to maintain the proper level and viscosity of the bath. As the cylinder is rotated, ink coats the entire surface. Next, a metal wiper(doctor blade) presses against the surface of the cylinder and removes ink from the non-etched (non-image) areas. The substrate is then pressed against the rotating cylinder and the ink is transferred.

After printing, the substrate may pass through a drying operation depending on the type of ink used. Lithography can use heat-set and non-heat-set inks. In heat-set lithography, the substrate is passed through a tunnel or floater dryer which utilizes hot air or direct flame or combination. With non-heat-set lithography, the ink normally dries by absorption. Gravure printing utilizes inks that dry by solvent evaporation.

FINISHING

The term "finishing" refers to final trimming, folding, collating, binding, laminating, and/or embossing operations. A variety of binding methods are used for books, periodicals, and pamphlets. These include stitching (stapling), gluing, and mechanical binding. These finishing operations are frequently accomplished by an outside service organization.

Waste Description

Listed in Table 2 are the principal wastes associated with lithographic printing operations and most other printing activities. Gravure printing operations have been excluded since the major difference between the two processes, from a waste generation viewpoint, is in the plate- and cylinder-making operation. Gravure cylinder making is very similar to other metal processing operations; therefore, the reader is referred to the waste minimization guides for metal fabrication and printed circuit board manufacturers that are part of this EPA series.

Paper is the major wastestream encountered in the lithographic industry. Almost 98 percent of the total waste generated by this segment of the industry is spoiled paper and paper wrap. Waste paper comes from rejected print runs, scraps from the start and end of runs, paper at the end of the web, and overruns. Overruns are the excess number of copies that a printer makes to ensure that he has enough acceptable copies. Other paper includes the paper wrappings, cardboard cores, and scrap from finishing operations. Most paper is recycled, incinerated, or disposed of as trash.

Scrap photographic material and aluminum plates are sold for metal recovery. Empty ink containers are normally scraped clean of ink and discarded. Damaged or worn rubber blankets are also discarded with the trash.

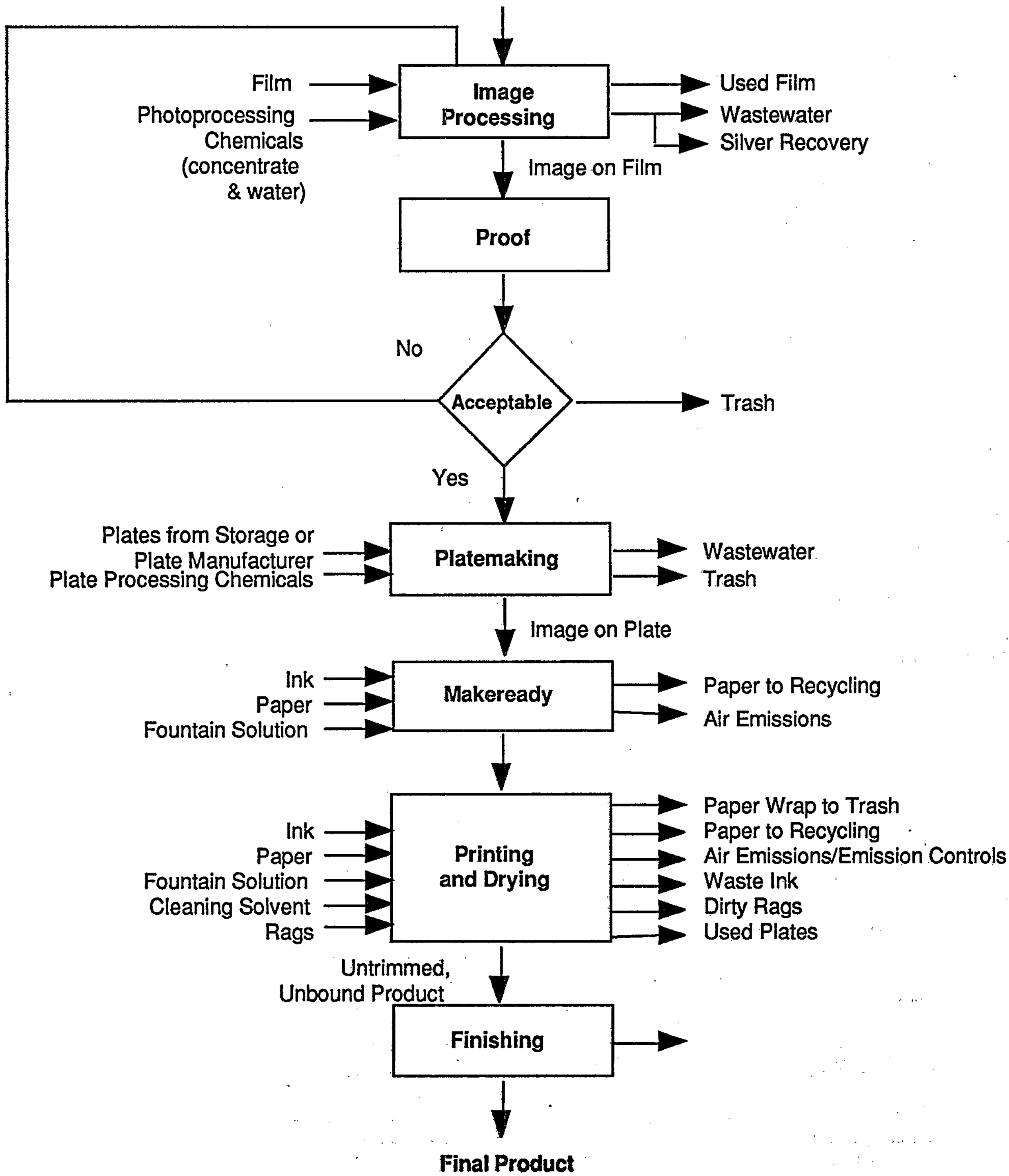
Spent photoprocessing chemicals are generally biodegradable and are discharged into sanitary sewers. Sanitation districts require permits to discharge the chemicals into the sewer. The chemicals have a significant biochemical oxygen demand (BOD). Printing shops that use very large quantities of photographic chemicals may find it necessary to install package biological treatment systems to reduce BOD before disposal into the sewer. Larger printers may find it both necessary and economical to recover the silver from the spent solutions before discharge to the sewer. Solutions that contain hazardous compounds, such as mercury compounds, may require special handling.

Plate-making wastes, such as acids and alkalis used to clean or develop the plates, must be either sent to wastewater treatment or drummed for disposal. For facilities that use pre-sensitized plates, this waste is avoided (although the supplier of the presensitized plates would be producing

Table 2. Offset Lithography Printing Process Wastes

Waste Stream No.	Waste Description	Process Origin	Composition
1.	Trash	Image Processing, Proof	Empty containers, packages, used film, out-dated materials.
		Plate Making	Damaged plates, developed film, out-dated materials.
		Printing	Ink containers (if not recycled), used blankets used plates, unacceptable printings, paper wrappings.
2.	Wastewater	Image Processing	Photographic chemicals, silver (if not recovered).
		Plate Making	Acids, alkali, solvents, plate coatings (may contain dyes, photopolymers, binders, resins, pigments, organic acids), developers (may contain isopropanol, gum arabic, lacquers, caustics), and rinsewater.
		Printing	Spent fountain solutions (may contain chromium).
3.	Recovered Silver	Image Processing, Plate Making	As described.
4.	Empty Ink Containers	Printing	As described. If not recycled, these go to trash.
5.	Paper (recycled)	Makeready	Inked and clean sheets.
		Printing	Inked sheets.
6.	Equipment Cleaning Wastes	Printing, Proof	Lubricating oils, waste ink, clean up solvent (halogenated and non-halogenated), rags.
7.	Air emissions	Makeready, Printing	Solvent from heat-set inks, isopropyl alcohol (fountain solution), and cleaning solvents.

Figure 2. General Flowsheet for Lithographic Printing



this waste). Currently, only large-volume users of plates (i.e. newspapers) still produce their own plates. Photochemical wastes would be handled in the same manner as image processing wastes.

Fountain solutions used in lithography start with a concentrated dilute solution of gum arabic, phosphoric acid, defoamers, and fungicide, which is added to water. To this mixture is added enough isopropyl alcohol (IPA) to bring the concentration of IPA up to a range of 5 to 15%. The IPA is used to reduce the surface tension of the solution. IPA allows the solution to adhere more easily to the non-image area of the plate cylinder. Most of the IPA evaporates along with the water. The other compounds remain on the paper. Virtually none of the fountain solution goes to the sewer as wastewater. Some printing chemical manufacturers now offer fountain solution concentrates that do not use IPA or other volatile compounds. The low-volatility concentrates use soaps or detergents in place of IPA. These are marketed in areas that have stringent air quality controls.

Equipment cleaning wastes consist of spent lubricants, waste inks, clean up solvent, and rags. Waste ink is defined as the ink removed from the ink fountain at the end of a run or following its contamination. Most of the ink used by a printer ends up on the product. Other losses include ink printed on waste paper and spills. Most waste inks are either incinerated (if hazardous) or discarded with the trash.

Volatile organic compounds (air emissions). Depending on the printing process and the substrate, inks may contain solvents (e.g. xylenes, ketones, alcohols, or aliphatics) that are evaporated immediately after printing. This is particularly appropriate for gravure applications in commercial printing. Inks for offset lithography are principally sheetfed inks which dry by oxidative polymerization; heatset inks, which dry by evaporation of the aliphatic ink oils; and nonheatset web inks, which dry by absorption of the ink vehicle in the newsprint substrate. There is no significant VOC emission from the inks when either sheetfed or nonheatset web inks are used. In the case of web offset heatset printing, the printed web passes through a dryer which evaporates the ink oils. The resulting prints frequently have a glossy finish when imprinted on coated papers. The resulting VOC emissions can be controlled by catalytic or thermal incineration, or cooler/condenser systems. In the case of VOC emissions from gravure printing, carbon absorption is the most commonly applied emission control method. In addition to the solvents and ink oils used in the printing inks, common VOCs include isopropyl alcohol (from fountain solutions), toluene, kerosene, methanol and some chlorinated solvents (found in type washes, roller, blanket, and press washes).

Cleaning solvents are used to clean the presses. The rubber blankets are cleaned once or twice per eight-hour shift to reduce or eliminate imperfections resulting from dust, particles, or dried ink. When lower quality paper is used, cleaning is required more frequently. A variety of solvents and cleaning solutions is used in the industry. Solvents include methanol, toluene, naphtha, trichloroethane, methylene chloride, and specially formulated blanket washes.

Most cleanup is done with rags wetted with the solvent or by pouring solvent over the equipment and then wiping it off with a rag. The dirty rags contain solvent, waste ink, oil, dust, dirt, and other contaminants. Clean rags are generally supplied by industrial laundries, which also pick up the dirty rags. The laundries generally dry clean the rags and produce a sludge comprised of the materials that were present on the rags. The sludge may require management as hazardous waste.

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Section 3
WASTE MINIMIZATION OPTIONS FOR COMMERCIAL PRINTERS

Introduction

The list of individual primary lithographic waste streams and their sources along with a list of source reduction methods is presented in Table 3. Recommended waste reduction methods and identified procedures are discussed in the following sections. These methods came from published accounts in the open literature and industry contacts.

In addition to the waste reduction measures that are classified as process changes or material/product substitutions, a variety of waste reducing measures labeled as "good operating practices" has also been included. Good operating practices are defined as procedures or institutional policies that result in a reduction of waste. The following describes the scope of good operating practices:

- Waste stream segregation
- Personnel practices
  - Management initiatives
  - Employee training
- Procedural measures
  - Documentation
  - Material handling and storage
  - Material tracking and inventory control
  - Scheduling
- Loss prevention practices
  - Spill prevention
  - Preventive maintenance
  - Emergency preparedness

Good operating practices apply to all waste streams.

Waste Minimization Options

MATERIAL HANDLING AND STORAGE

Improper storage and handling can result in spoilage and obsolescence of the raw materials. Good operating practices can reduce or eliminate waste resulting from obsolescence and improper storage.

Material Preinspection

Materials should be inspected before being accepted, and unacceptable or damaged materials should be returned to the manufacturer or supplier. This avoids both disposal of a nearly full container of unusable material and printing an unacceptable product.

Proper Storage of Materials

Many photoprocessing and plate developing chemicals are sensitive to temperature and light. Photosensitive film and paper storage areas should be designed for economical and efficient use. Some shops waste up to one-fourth of these materials due to improper storage (Campbell and Glenn 1982). The chemical containers list the recommended storage conditions. Meeting the recommended conditions will increase their shelf life. Even more important to the efficient use of paper is proper handling to avoid damage.

Paper waste can also be reduced through proper handling and storage of rolls or packages of paper. Webs need to be handled so that the outer paper wrapper is not damaged. Paper should be stored in a space having proper temperature and humidity, since it can easily absorb moisture; sheetfed paper should be conditioned to the temperature and humidity of the press room for one day before printing; this requires additional space in the press room.

Restrict Traffic through Storage Area

To prevent raw material contamination, the storage area should be kept clean. Also, the storage area should not be open to through traffic. Through traffic will increase dust and dirt in the storage area, increasing possible contamination. In addition, spills in the storage area will be easier to contain if traffic is restricted.

Inventory Control

Inventories should be kept using the "first-in, first-out" practice. This will reduce the possibility of expired shelf life. This practice may not work for specialty materials that are seldom used. Computerized inventory systems can track the amounts and ages of the raw materials.

Purchase Quantities According to Needs

Raw material order quantities should be matched to usage. Small printers should order ink in smaller containers according to use. This avoids having a large, partly used container of ink going bad in storage because it wasn't properly sealed. Residual ink in sheetfed ink cans should be smoothed and covered in order to prevent loss by skinning. Large printers should order materials in large containers, which may be returnable, thereby eliminating

Table 3. Waste Minimization Methods for the Commercial Printing Industry

Operation	Waste Minimization Methods
Material Handling and Storage	Material pre-inspection
	Proper storage of materials
	Restrict traffic through area
	Inventory control
	Purchase quantities according to needs
	Recycle empty containers
	Recycle photographic film and paper
Image Processing	Electronic imaging and laser platemaking
	Material substitution
	Extend bath life
	Use of squeegees
	Employ countercurrent washing
	Recover silver and recycle chemicals
Plate Processing	Reduce solution loss
	Replace metal etching/plating operations
	Use non-hazardous developers and finishers
Makeready	Implement accurate counting methods
	Automated plate benders, scanners
	Automatic ink key setting system
	Computerized registration
	Ink/water ratio sensor
Printing	Install web break detectors
	Automatic web splicers
	Use automatic ink levelers
	Store ink properly
	Use less hazardous inks
	Standard ink sequence
	Recycle waste ink
	Use alternative fountain solutions
	Use alternative cleaning solvents
	Automatic blanket cleaners
	Reduce the need to clean
	Improve cleaning efficiency
	Collect and reuse solvent
	Recycle lube oils
	Alternative printing techniques
Finishing	Reduce paper use and recycle waste paper

or reducing the need to clean them. It takes less time to scrape out the large single container than several small ones. Ordering materials in returnable tote bins may maximize these advantages. However, the size of container chosen by the printer is determined by economics of volume as well as consideration of waste minimization.

Recycle Empty Containers

Most ink containers are scraped free of ink and discarded in the trash. Since the degree of cleanliness is a function of operator effort, the amount of ink discarded can vary widely. By purchasing ink in recyclable bulk containers, the container can be returned to the ink supplier for refilling instead of being thrown away. In addition, the use of bulk containers also cuts down on the amount of cleaning required since the surface area of the container per unit volume of ink stored is reduced.

Recycle Spoiled Photographic Film and Paper

It is a current practice in the industry to send used and/or spoiled film to professional recyclers for recovery of silver (USEPA 1986). However, this option might not be practical to small scale producers or available to facilities located far away from recyclers.

Test Expired Material for Usefulness

Materials having expired shelf-life should not automatically be thrown out. Instead, this material should be tested for effectiveness. The material may be usable, rather than becoming a waste. A recycling outlet should be found for left over raw material that is no longer wanted.

IMAGE PROCESSING

The major wastestream associated with image processing is wastewater that contains photographic chemicals and silver removed from film. Much work has been done by the printing and photographic industries to abate this waste.

Electronic Imaging and Laser Platemaking

A recent advance in image processing is the use of computerized "electronic pre-press systems" for typesetting and copy preparation. Text, photos, graphics, and layout are fed into the system through an electronic scanner. The copy is edited on a display monitor rather than on paper. This reduces the quantity of film, developing chemicals, and paper used. Only the final edited version is printed out.

Electronic pre-press systems were initially restricted to large printers, such as major newspapers, because of the high initial equipment expenses. As the prices of computer hardware and software drop, smaller printing operations are beginning to use them. Electronic pre-press systems should reduce waste and improve productivity.

Material Substitution

Non-hazardous chemicals and films can be substituted for hazardous ones. This can reduce hazardous waste generation at the image processing step. In particular, the wastes from photoprocessing using silver films are occasionally hazardous due to silver compounds in the wastewater. Some sanitation districts will accept photoprocessing wastewater with silver, if the silver concentration is low enough.

Photographic materials are available that do not contain silver, but these are slower in speed than silver halide films. Diazo and vesicular films have been used for many years. Vesicular films have a honeycomb-like cross-section and are constructed of a polyester base coated with a thermoplastic resin and a light-sensitive diazonium salt. Photopolymer films contain carbon black as a substitute for silver. These films are processed in a weak alkaline solution that is neutralized prior disposal. As such, they produce a non-hazardous waste.

More recently, photopolymer and electrostatic films are being used. Electrostatic films are non-silver films having speeds comparable to silver films and having high resolution as well. An electrostatic charge makes them light sensitive, after which a liquid toner brings out the image.

Some photographic intensifiers and reducers contain hazardous compounds, such as mercury or cyanide salts. Non-hazardous substitutes are available.

Extended Bath Life

Wastes from photographic processing can be reduced by extending the life of fixing baths. Techniques include (1) adding ammonium thiosulfate, which doubles the allowable concentration of silver buildup in the bath; (2) using an acid stop bath prior to the fixing bath; and (3) adding acetic acid to the fixing bath as needed to keep the pH low.

Accurately adding and monitoring chemical replenishment of process baths will cut down chemical wastage. Stored process bath chemicals should be protected from oxidation by reducing exposure to air. Some smaller photo developers store chemicals in closed plastic containers. Glass marbles are added to bring the liquid level to the brim each time liquid is used. In this way, the amount of chemical subject to degradation by exposure to air is reduced, thereby extending the chemical's useful life and the life of the bath.

Squeegees

Squeegees can be used in non-automated processing systems to wipe excess liquid from the film and paper. This can reduce chemical carryover from one process bath to the next by 50 percent (Campbell and Glenn 1982). Minimizing chemical contamination of process baths increases recyclability, enhances the lifetime of the process baths, and reduces the amount of replenisher chemicals required. Most firms, however, use automated processors. Also, using squeegees may damage the film image if it has not fully hardened, so a squeegee should be used after the film image has hardened.

Countercurrent Washing

In photographic processors, countercurrent washing can replace the commonly used parallel tank system. This can reduce the amount of wastewater generated. In a parallel system, fresh water enters each wash tank and effluent leaves each wash tank. In countercurrent rinsing, the water from previous rinsings is used in the initial film-washing stage. Fresh water enters the process only at the final rinse stage, at which point much of the contamination has already been rinsed of the film. However, a countercurrent system requires more space and equipment.

Recovery of Silver and Recycling of Spent Chemicals

Basically, photoprocessing chemicals consist of developer, fixer, and rinse water. Keeping the individual process baths as uncontaminated as possible is a prerequisite to the successful recycling of these chemicals. Silver is a component in most photographic films and paper and is present in the wastewaters produced. Various economical methods of recovering silver are available (e.g. metallic replacement, chemical precipitation, electrolytic recovery), and a number of companies market equipment that will suit the needs of even the smallest printing shop.

The most popular method of silver recovery is electrolytic deposition. In an electrolytic recovery unit, a low voltage direct current is created between a carbon anode and stainless steel cathode. Metallic silver plates onto the cathode. Once the silver is removed, the fixing bath may be able to be reused in the photographic development process by mixing the desilvered solution with fresh solution. Recovered silver is worth about 80% of its commodity price.

Another method of silver recovery is metallic replacement. The spent fixing bath is pumped into a cartridge containing steel wool. An oxidation-reduction reaction occurs and the iron in the wool replaces the silver in solution. The silver settles to the bottom of the cartridge as a sludge.

Some of the companies that buy used film or cartridges containing recovered silver can be located under "Gold and Silver Refiners and Dealers" in a business telephone directory. These firms may pick up directly or may purchase through dealers. To recycle used film, it may be worthwhile to sort the film into "largely black" versus "largely clear" segments, since the rate of payment for mostly black film may be twice that for mostly clear.

Technologies for reuse of developer and fixer are available and include ozone oxidation, electrolysis, and ion exchange.

PLATE PROCESSING

Recent advances in plate processing techniques, some made specifically to reduce the quantity and/or toxicity of hazardous wastes and to improve worker safety, have reduced waste generation. In addition to the methods discussed below, the reader is referred to the companion EPA guides to waste minimization in parts cleaning and metal fabrication. Many of the wastes associated with plate processing are similar to wastes produced by these operations. This is especially true for gravure printing where the cylinders are chrome plated.

Reducing Solution Loss

In gravure printing, metal etching and metal plating operations typically involve chemical compounds that are deemed hazardous. Waste solutions from metal etching or metal plating operations usually require treatment before discharge to the municipal sewer. The same is true for all wastewater used in rinsing operations.

The amount of wastewater generated by rinsing plates can be reduced by using multiple countercurrent rinse tanks. The toxicity of wastewater from plating operations can be reduced by reducing dragout from plating tanks. Examples of dragout reduction techniques include (1) positioning the part on the rack to drain more easily, (2) using drain boards to collect dragout and return it to the plating tank, and (3) raising the temperature to reduce the surface tension of the solution.

Replacement of Metal Etching/Plating Operations

Because of increasing environmental regulations and higher costs of hazardous waste treatment and disposal, the printer should replace metal etching or plating processes wherever possible. Alternative processes include presensitized lithographic, plastic or photopolymer, and hot metal which do not present the hazardous material problems associated with metal etching and plating operations.

The wastes generated by using presensitized lithographic plates are (1) wastewater from developing and finishing baths, (2) used plates, and (3) trash, such as plate wrappers and empty plate processing chemical containers. Chemicals consumption can be reduced by frequently monitoring the bath for pH, temperature, and solution strength. This can extend the bath life, and solution change-outs can be reduced to several times a year. Automatic plate processors can maintain bath conditions. Presensitized plates should be stored at the recommended conditions to maintain effectiveness. The used plates are not a hazardous waste and they should be collected and sold to an aluminum recycler.

Non-Hazardous Developers and Finishers

Non-hazardous developers and finishers are available. For example, one company's developer and finisher are considered non-toxic and have a flash point of 213°F, which is non-flammable by California Title 22 standards (Western Lithotech 1987). Presensitized plates are available that are processed with water only. A company makes plates that are water-resistant until exposed; upon exposure, the coating of the non-image becomes watersoluble. The same company markets a platemaking system that produces offset lithography plates directly from copy or artwork, eliminating the need for photoprocessing. The system is economical for large printing operations (Campbell and Glenn 1982).

MAKEREADY

Paper represents the largest supply item that a printer buys and is probably the most expensive component of his work. The printed paper produced in makeready is frequently the largest waste a printer generates and is nonhazardous. Paper waste at this step is determined by the efficiency of the quality control press adjustments needed to achieve the desired print quality, specifically through proper ink density and accurate registration. This discussion focuses on approaches.to reducing paper waste.

Both in makeready and printing operations, printers need to know how much waste paper is generated relative to the quantity of acceptable pieces. One method that can be used by both sheetfed and offset printers is to weigh discarded paper and discarded product signatures and express the weight of waste as a percent of total paper used. Press counters are available, but under some circumstances, such as when a jam occurs on the press and the counter is not turned off, the count may be inaccurate.

A number of specific devices have been developed to automate press adjustments. With proper use, most of these are promoted by manufacturers as speeding up the makeready step and thus saving paper and ink. However, their direct benefit is to increase quality control. We describe briefly below the use of automated plate benders; automated plate scanners; automatic ink key setting system; computerized registration; and ink/water ratio sensors. More detailed information, including costs, can be obtained by consulting product manufacturers and manufacturers' representations. Also, the Graphic Arts Technical Foundation in Pittsburgh can provide additional information about these products. Each printer must weigh the cost of these items against the potential increases in quality and reduced paper and ink waste that may result.

Automated Plate Benders

Automated plate benders are designed to prevent all or some of the problems that occur in fitting a plate to a cylinder: plate cracking; non-straight plate bending along the length of the bend; curvature of the plate differing from that of the cylinder; and other plate fitting parameters that affect proper registration.

Automated Plate Scanners

Automated plate scanners have been developed for both web and sheetfed offset presses that take advantage of microprocessor technology and high quality optics. Finished plates are scanned to determine the relative density of the printing image across the plate's surface. This information is then used to set the ink fountain keys — in some systems by a press operator in others using remote controlled ink keys (see next) that are automatically pre-set to compensate for variations in image density.

Automatic Ink Key Setting System

Automatic ink key setting is usually accomplished as part of a system that includes scanning densitometry to determine ink density. Information about the ink density is then transmitted to a computer controlled inking system, so that automatic adjustments are made to the ink profile for each ink slide position.

Automated Registration

Optical scanners and microprocessors also form the basis for automated registration systems. One manufacturer's system employs motorized scanners that move laterally in search of registration marks and lock in to the marks for the entire press run. These systems have been developed for gravure, web offset, and other printing processes.

Ink/Water Sensors

Press operators need to know whether ink flow or water flow needs to be adjusted to result in proper ink/water ratio. This ratio must be optimal to produce a sharp dot and strong contrast without the risk of tinting. One manufacturer has developed an ink/water sensor that is part of an automated press control system. An optical system detects light reflected from the ink form roller and measures the surface water and the amount of water emulsified in the ink. Both water feeds and ink keys are linked to the system, so both can be modified and any deviation in the ink/water ratio can be corrected at once.

PRINTING AND FINISHING

The major wastes associated with printing and finishing are scrap paper, waste ink, and cleaning solvents. The clean-up solvent waste stream consists of waste ink, ink solvents, lubricating oil, and solvent. In many printing establishments, excess ink and solvent is collected in a drip pan underneath the press. This waste is typically drummed and hauled away to a landfill area. The following paragraphs describe waste reduction methods.

Standard Ink Sequence

Adopting a standard ink sequence can reduce the amounts of waste ink and waste cleaning solution: if a standard ink sequence is employed, the ink rotation is not changed with the job and you do not have to clean out the fountains in order to change the ink rotation.

Installation of Web Break Detectors

This device detects tears in the web as it passes through a high speed web press. It automatically shuts down the press to prevent damage to the press. Otherwise the broken web begins to wrap around the rollers and forces them out of the bearings. Web break detectors are primarily used to avoid severe damage to the presses. However, they also reduce the waste that would otherwise be generated if a web break damaged a machine.

Electronic systems are available for detecting web breaks in a non-contact fashion that will neither smear ink nor crease the web, thereby reducing waste from these sources. Both McGraw-Hill Publications in New York City and the St. Petersburg Times in St. Petersburg, Florida have installed web break detection systems and have reduced waste.

Automatic Web Splicers

Automatic web splicers have become almost standard on web offset presses. The splice can be made while the paper is running at operating speed (flying web splicer) or while the paper is stationary (zero-speed splicer). Either option can result in significant savings in time and paper waste reduction.

Use of an Automatic Ink Leveller

Ink waste and spoilage is reduced by maintaining the desired ink level in the fountain for optimum inking conditions. Automatic ink levellers are commercially available.

Proper Ink Storage

Ink containers should be resealed after using. Open containers are subject to contamination with paper dust and dirt, as well as forming a "skin" on the surface, loss of solvent, or eventual hardening. It was noted previously that sheetfed offset lithographic inks should be levelled in the can before placing a liner over the ink. Other offset lithographic inks may have low enough viscosity to level themselves. Ink should be scraped from emptied containers with a spatula or knife to get as much of the ink out as practical. This prevents the empty containers from becoming a hazardous waste.

New Ink Systems

Currently-used heatset offset lithographic inks contain: pigments used as colorants; resins; film formers; and 25 percent to 45 percent ink oils. Most of the ink oil is removed during heating while passing through a dryer and is either incinerated, recovered and recycled, or emitted to the air. New types of inks are described below. These were formulated with pollution reduction and energy conservation in mind.

Water-base or water-borne inks are usually composed of pigmented suspensions in water and film formers. These inks find their greatest application in flexographic printing on paper substrates and their use has been recommended for gravure.

One factor stifling the development of water-base inks is that they require more energy to dry than do solvent-borne inks. Another difficulty results from the necessity to shut presses down for short periods of time. When water base ink dries, water is not a solvent for the dried ink; therefore more frequent equipment cleaning is required. Other problems besetting water-borne inks are low gloss and paper curl.

UV inks consist of one or more monomers and a photosynthesizer that selectively absorbs energy. Benefits of using UV inks are that the inks contain no solvent. The paper is not heated above 50°C, and a minimum of moisture is lost in the process. Since the inks do not "cure" until exposed to UV light, and may therefore be allowed to remain in the ink fountains (and plates) for long periods of time, the need for clean-up is reduced. UV inks are particularly recommended for letterpress and lithography. The following have been cited as advantages of using UV inks for sheet-fed lithography (Carpenter and Hilliard 1976):

- Elimination of "set-off", the unintentional transfer of ink to adjacent sheets before the ink has dried up completely.
- Elimination of the use of powders that are applied to protect an ink film that is "set" but not "dry".
- Elimination of the storage of printed sheets for ventilation required in oxidative drying processes.

Disadvantages that should be considered include:

- Cost (75 to 100 percent more expensive than conventional heat-set inks).
- Hazards of UV to operating personnel.
- Formation of ozone by the action of UV light on oxygen.
- Conventional commercial paper recycling procedures will not de-ink papers printed by this process. Therefore, this is a potential source of non-recyclable paper.
- Some of the chemicals in the inks are toxic.

Electron-beam-dried (EB) inks are similar in concept to UV inks, offer the same operational advantages as UV inks, and have no solvents. However, the EB systems require operator protection from X-rays created by the process. Also, the system often degrades the paper.

Automatic Blanket Cleaners

Automatic blanket cleaners, which consist of a control box, a solvent metering box for each press unit, and a cloth handling unit, have increased press efficiency for a number of printers that have installed them. They are available for many types of presses, including both web and sheetfed offset. The increased speed of automated washing compared with manual cleaning results in fewer wasted impressions during the shorter time period needed for washup. One printer noted a difference of 250 - 350 lost impressions using the automated cleaner compared with 1,200 - 3,000 lost using manual washes (Graphic Arts Monthly, May, 1986 pp. 62-68).

There is an added benefit of increased safety. Using the automatic cleaning system eliminates the risk of bodily injury to employees holding a rag against a running blanket; also the amount of solvent used in cleaning is controlled, so the possibility of ignition in the dryer of paper soaked with solvent is less likely.

Recycling of Waste Inks

Most waste inks can be recycled. One recycling technique relies on blending waste inks of different colors together to make black ink. Small amounts of certain colors or black toner may be needed to obtain an acceptable black color. Recycling to get black ink is generally more practical than recycling to get the original color. This reformulated black ink is comparable to some lower quality new black inks, such as newspaper ink. For this reason, much of the black ink for newspaper printing contains recycled ink (Woodhouse 1984). Waste ink recycling equipment is available and advertised in the printing trade magazines.

Off-site ink recycling, either by ink manufacturers or by large printers, may be more economical for smaller printers. The waste ink is reformulated into black ink and sold back to the printer. The small printer can avoid landfill disposal of the ink and the large printer can reduce purchases of new black inks.

Labor time necessary to fill, operate, and empty the ink recycler is about the same as labor required to pack waste ink into drums with vermiculite adsorbent, and to manifest it.

Therefore, the labor savings is not significant. The major operating cost savings are the reductions in raw materials costs and waste disposal costs. (See case study - Plant A, Appendix).

Alternative Fountain Solutions

The fountain solution contains water, isopropyl alcohol (IPA), gum arabic, and phosphoric acid, all of which end up on the paper or evaporate; they do not become hazardous waste. However, the evaporation of the IPA may create an emission problem. In states or regions with stringent air quality limits on VOCs, this may result in a requirement for air pollution control equipment. Alternatively, fountain solution concentrates are available that contain no VOC or very small amounts of VOC.

Alternative Cleaning Solvents

Dangerous chemicals such as benzene, carbon tetrachloride, trichloroethylene, and methanol have been used as components of cleaning solutions. Specially made blanket washes are now available that are less toxic and less flammable. These blanket washes typically contain mixtures of glycol ethers and other heavier hydrocarbons that have a high flash point and low toxicity. Many printers feel that these solvents do not work as well as the solvents mentioned above. However, because of the less hazardous nature of the material, they are gaining in popularity. These blanket washes are typically used for all cleaning operations in the printing step. General cleanup should be done with detergents or soap solutions wherever possible. Solvent cleanup should be used only for cleaning up inks and oils.

Reducing the Need to Clean

Most presses are cleaned by hand with a rag wetted with cleaning solvent. The dirty solvent remains on the rag. A separate waste solvent is not produced. To reduce the amount of solvent and the number of rags used, ink fountains should be cleaned only when a different color ink is used or when the ink might dry out between runs. Aerosol spray materials are available to spray onto ink fountains to prevent overnight drying, so that the ink can be left in the fountain without cleaning at the end of the day. This reduces the amount of waste ink produced and the amount of cleaning solvent and rags used.

For example, a protective film was sprayed over each of four ink fountains on a small offset printing press at the end of each work day. The waste ink was reduced by 5 pounds per day. Based on a disposal cost of 70 cents per pound and 250 operating days per year, the savings in disposal costs are $875 per year. The need for new ink was reduced by 5 pounds per day. At a cost of $2.00 per pound, the savings in raw material costs are $2,500 per year. The total operating cost savings are $3,375 per year. The cost of the spray is relatively low. Also, less labor is needed to spray the fountains than is needed to drain and clean out the fountains and dispose of the waste ink. This labor savings would improve the source reduction economics.

Increasing Cleaning Efficiency

Where cleaning of rollers is accomplished with solvent and roller wash-up blade, several factors affect cleaning efficiency: condition of the rollers; condition of the blade; the blade's angle of attack against the roller; and press speed during washup. Both rollers and blade should be in good condition. The blade's angle of attack should be adjusted so that sufficient pressure is exerted on the roller, but the angle should not be so coarse that the blade can be "grabbed" and "pulled under" the roller. Too slow a press speed means long wash up times, and generally increased solvent use.

Collect and Reuse Solvent

In this practice, solvent is poured over the equipment and then wiped clean with a rag. The solvent is collected in drip pans under the equipment and becomes waste solvent which can be reused. If one container of solvent is used for each color printing unit, the solvents can be reused without cross-contaminating the inks. Used solvent can be reused in cleaning most of the ink from the rollers and blankets, with only a small amount of fresh solvent needed for the final cleanup. Small solvents stills can be used to reclaim the solvent.

In some cases, used solvents having one particular ink color can be used to make up the solvent content of new inks of the same color. This has been done at a company in North Carolina using alcohol/acetate formulations in its flexographic printing process (North Carolina 1987). At Rexham Corporation in Mattews, N.C., toluene is used to clean the ink from the press, and runoff toluene is collected as waste. Rexham has nearly eliminated its toluene waste by segregating used clean-up toluene according to the color and type of ink contaminant and then reusing the collected wastes to thin future batches of the same ink. The procedure has no effect on product quality and has resulted in almost 100% reuse of the toluene solvent (Huisingh et al. 1985). However, solubility characteristics are critical to some types of flexographic printing plates and this approach should be investigated carefully.

Recycle Lube Oils

If the printing presses are lubricated with oil, the used oil should be collected and turned over to a recycler. The recycler can either re-refine the oil into new lubricating oil, create fuel grade oil, or use it for blending into asphalt.

Alternative Printing Techniques

An electrostatic screen printing process, also known as pressureless printing, was developed by the Electrostatic Printing Corporation of America and therefore is called the EPC process (USEPA 1979). A thin, flexible printing element, with a finely screened opening defining the image to be printed, is used. An electric field is established between the image element and the surface to be printed. Finely divided "electroscopic" ink particles, metered through the image openings, are attracted to the printing surface, where they are firmly held by electrostatic forces until they have been fixed by heat or by chemical means.

Reduce Paper Use and Recycle Waste Paper

Because paper is the largest supply item a printer buys and it may be the most expensive component of his work, paper use and the disposition of waste paper is a critical concern. Many printers segregate and recycle paper according to grade: inked paper is one grade and is recycled separately; unprinted white paper is sent separately to recycling; and wrappers for paper, which are a lower grade, are disposed of in trash.

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Section 4
GUIDELINES FOR USING THE WASTE MINIMIZATION ASSESSMENT WORKSHEETS

Waste minimization assessments were conducted at several commercial printers in the Los Angeles area. The assessments were used to develop the waste minimization questionnaire and worksheets that are provided in the following section.

A comprehensive waste minimization assessment includes a planning and organizational step, an assessment step that includes gathering background information and development of waste minimization options, a feasibility study on specific waste minimization options, and an implementation phase.

CONDUCTING YOUR OWN ASSESSMENT

The worksheets provided in this section are intended to assist printers in systematically evaluating waste generating processes and in identifying waste minimization opportunities. These worksheets include only the assessment phase of the procedure described in the *Waste Minimization Opportunity Assessment Manual* (U.S. EPA 1988). For a full description of waste minimization assessment procedures, refer to the EPA Manual.

Table 4 lists the worksheets that are provided in this section.

Table 4. List of Waste Minimization Assessment Worksheets

Number	Title	Description
1.	Waste Sources	Typical wastes generated at commercial printing plants.
2A.	Waste Minimization: Material Handling	Questionnaire on general handling techniques for raw material handling.
2B.	Waste Minimization: Material Handling	Questionnaire on procedures used for handling drums, containers and packages.
3.	Option Generation: Material Handling	Waste minimization options for material handling operations.
4.	Waste Minimization: Material Substitution Image Processing	Questionnaire on material substitution and on image processing operations.
5.	Option Generation: Material Substitution Image Processing	Waste minimization options for material substitution and options for image processing.
6.	Waste Minimization: Plate Processing	Questionnaire on plate processing.
7.	Option Generation: Plate Processing/Makeready	Waste minimization opportunities for plate processing.
8.	Waste Minimization: Printing and Finishing	Questionnaire on printing and finishing.
9.	Option Generation: Printing and Finishing	Printing and finishing waste minimization options.
10.	Waste Minimization: Good Operating Practices	Questionnaire on use of good operating practices.
11.	Option Generation: Good Operating Practices	Waste minimization options for good operating practices.
12.	Waste Minimization: Reuse and Recovery	Questionnaire on opportunities for reuse and recovery of wastes.

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proj. No. ____	Prepared By ____ Checked By ____ Sheet __ of __ Page __ of __

WORKSHEET
1

WASTE SOURCES

Waste Source: Material Handling	Significance at Plant		
	Low	Medium	High
Off-spec materials			
Obsolete raw materials			
Damaged paper			
Spills & leaks (liquids)			
Spills (powders)			
Empty container cleaning			
Container disposal (metal)			
Container disposal (paper)			
Pipeline/tank drainage			
Laboratory wastes			
Evaporative losses			
Trash			
Other			
Waste Source: Process Operations			
Used film			
Image processing baths			
Etching and plating baths			
Wastewater from rinsing			
Damaged/used plates			
Fountain solutions			
Waste ink			
Cleaning solvents			
Cleaning rags			
Lube oils			
Other			

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proj. No. ____	Prepared By ____ Checked By ____ Sheet __ of __ Page __ of __

WORKSHEET
2A

WASTE MINIMIZATION: Material Handling

A. GENERAL HANDLING TECHNIQUES

Are all raw materials tested for quality before being accepted from suppliers? ☐ yes ☐ no
Are expired age-dated materials tested for effectiveness before being disposed of? ☐ yes ☐ no
Is obsolete raw material returned to the supplier? ☐ yes ☐ no
Is paper stored in a humidity and temperature-controlled area?
Describe safeguards to prevent damage to paper in handling and storage: ____

Describe safeguards to prevent the use of materials that may generate off-spec product: ____

Is inventory used in first-in first-out order? ☐ yes ☐ no
Is the inventory system computerized? ☐ yes ☐ no
Does the current inventory control system adequately prevent waste generation? ☐ yes ☐ no

What information does the system track? ____

Is there a formal personnel training program on raw material handling, spill prevention, proper storage techniques, and waste handling procedures? ☐ yes ☐ no
Does the program include information on the safe handling of the types of drums, containers and packages received? ☐ yes ☐ no

How often is training given and by whom? ____

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet __ of __ Page __ of __

WORKSHEET **2B**

WASTE MINIMIZATION: Material Handling

B. DRUMS, CONTAINERS, AND PACKAGES

Are drums, packages, and containers inspected for damage before being accepted?	❑ yes	❑ no
Are employees trained in ways to safely handle the types of drums & packages received?	❑ yes	❑ no
Are stored items protected from damage, contamination, or exposure to rain, snow, sun & heat?	❑ yes	❑ no
Does the layout of the facility result in heavy traffic through the raw material storage area? (Heavy traffic increases the potential for contaminating raw materials with dirt or dust and for causing spilled materials to become dispersed throughout the facility.)	❑ yes	❑ no
Can traffic through the storage area be reduced?	❑ yes	❑ no
Are employees properly trained in handling of spilled raw materials?	❑ yes	❑ no

Describe handling procedures for damaged items: ______

What measures are employed to prevent the spillage of liquids being dispensed? ______

When a spill of liquid occurs in the facility, what cleanup methods are employed (e.g., wet or dry)? Also discuss the way in which the resulting wastes are handled: ______

Would different cleaning methods allow for direct reuse or recycling of the waste? (explain): ______

Do you try to order smaller containers of infrequently used materials to avoid disposing of large quantities of unused obsolete materials?	❑ yes	❑ no
Have you tried to order larger containers of frequently used materials to reduce the number of small containers that must be cleaned and disposed of?	❑ yes	❑ no
Are all empty bags, packages, and containers that contained hazardous materials segregated from those that contained non-hazardous wastes?	❑ yes	❑ no

Describe the method currently used to dispose of this waste: ______

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proc. Unit/Oper. ______ Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
3

OPTION GENERATION: Material Handling

Meeting Format (e.g., brainstorming, nominal group technique) ______
Meeting Coordinator ______
Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. General Handling Techniques		
Quality Control Check		
Test Age-Dated Material (if expired)		
for Effectiveness		
Return Obsolete Material to Supplier		
Minimize Inventory		
Computerize Inventory		
Formal Training		
B. Drums, Containers, and Packages		
Raw Material Inspection		
Proper Storage/Handling		
Reduced Traffic		
Spilled Material Reuse		
Cleanup Methods to Promote Recycling		
Appropriate Purchase Sizes		
Waste Segregation		

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
4

WASTE MINIMIZATION: Material Substitution Image Processing

A. MATERIAL SUBSTITUTION

Do any of the inks or thinners used contain hazardous materials (i.e., chlorinated solvents, lead or chrome pigments, mercury, etc.)? ☐ yes ☐ no

If yes, has material substitution been tried? ☐ yes ☐ no

Discuss the results: ______

B. IMAGE PROCESSING

Are electronic pre-press systems used to prepare copy? ☐ yes ☐ no

If not, has their use been considered? ☐ yes ☐ no

Is silver removed and recovered from photoprocessing waste streams? ☐ yes ☐ no

Is silver recovery done onsite? ☐ yes ☐ no

Has reuse of photoprocessing chemicals been attempted (after silver removal)? ☐ yes ☐ no

Discuss: ______

What other photographic wastes are recycled or recovered in some manner? ______

Are any of the following techniques used to increase the life of the fixing bath?

- Add ammonium thiosulfate ☐ yes ☐ no
- Add acetic acid ☐ yes ☐ no
- Use an acid stop bath ☐ yes ☐ no
- Monitor temperature and pH ☐ yes ☐ no
- Other ☐ yes ☐ no

Discuss: ______

Is countercurrent rinsing used to reduce wastewater volume? ☐ yes ☐ no

Can processing equipment be modified to incorporate these features? ☐ yes ☐ no

Discuss: ______

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proc. Unit/Oper. ____ Proj. No. ____	Prepared By ____ Checked By ____ Sheet __ of __ Page __ of __

WORKSHEET 5

OPTION GENERATION: Material Substitution Image Processing

Meeting Format (e.g., brainstorming, nominal group technique) ____

Meeting Coordinator ____

Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Substitution/Reformulation Options		
Ink Substitution		
Solvent Substitution		
Film Substitution		
Other Raw Material Substitution		
B. Image Processing		
Use Electronic Pre-press System		
Collect and Reclaim Film		
Recover Silver From Baths		
Reuse/Recycle Chemicals		
Increase Fixing Bath Life		
Use Countercurrent Film Rinse		

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet ___ of ___ Page ___ of ___

WORKSHEET
6

WASTE MINIMIZATION: Plate Processing/Makeready

ETCHING/PLATING

Are metal etching/plating operations performed at your plant? ☐ yes ☐ no
(If yes, please see other EPA Waste Minimization Guides for metal parts cleaning, metal fabrication, and printed circuit board manufacturing for additional options.)

Are metals recovered from solution bath dumps or waste streams? ☐ yes ☐ no

If yes, describe the procedure: ______

Describe how etching/plating wastes are handled, treated, and disposed of: ______

PROCESSING

Do you use presensitized plates?	☐ yes	☐ no
Does the plate processor have an automatic replenishment system for developer/finisher?	☐ yes	☐ no
Are plate processor conditions frequently monitored?	☐ yes	☐ no
Are spent plates recycled?	☐ yes	☐ no
Have water-based plate development systems been used or tested?	☐ yes	☐ no
Does the plant use a laser platemaking system?	☐ yes	☐ no

Discuss: ______

MAKEREADY

Which of the following press automation features have you added to reduce makeready times, improve quality control, and reduce paper waste?

- ☐ automated plate bender
- ☐ automated plate scanner
- ☐ automated ink key setting system
- ☐ computerized registration
- ☐ ink/water ratio sensor

Firm ____ Site ____ Date ____	**Waste Minimization Assessment** Proc. Unit/Oper. ____ Proj. No. ____	Prepared By ____ Checked By ____ Sheet ___ of ___ Page ___ of ___

WORKSHEET
7

OPTION GENERATION: Plate Processing

Meeting format (e.g., brainstorming, nominal group technique) ____
Meeting Coordinator ____
Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
Etching/Plating*		
Non-chromate Etchant		
Alternative Plating Baths		
Drag-out Reduction		
Bath-Life Extension		
Metal Recovery		
Store Plates at Recommended Conditions		
Maintain Plate Processing Baths		
Recycle Spent Plates		
Use Water-Based Developers		
Use Laser Platemaking System		
Processing		
Presensitized Plates		
Makeready		
Automated plate bender		
Automated plate scanner		
Automated ink key setting system		
Computerized registration		
Ink/water ratio sensor		

* Additional information useful for minimizing waste in plate processing operations can be found in EPA's waste minimization guides for metal fabricators, metal parts cleaning, and printed circuit board manufacturing operations.

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet __ of __ Page __ of __

WORKSHEET
8

WASTE MINIMIZATION: Printing & Finishing

PRINTING & FINISHING

Are ink containers properly resealed after use?	☐ yes	☐ no
Do any of the inks contain hazardous materials such as solvents or heavy metals?	☐ yes	☐ no
Has the use of less hazardous inks been attempted?	☐ yes	☐ no

Discuss the results: ______

Are ink fountains filled according to expected need as opposed to routine filling?	☐ yes	☐ no
Are automatic ink levelers employed?	☐ yes	☐ no
Are ink fountains cleaned between runs?	☐ yes	☐ no
Is a standard ink sequence used to reduce cleaning?	☐ yes	☐ no
Are measures employed to prevent drying ink or formation of skins inside the fountain?	☐ yes	☐ no
Are waste inks recycled or returned to the manufacturer?	☐ yes	☐ no
Have alternative fountain solutions been tried?	☐ yes	☐ no

Explain any measures employed or problems encountered with these options: ______

Has the use of an automatic blanket cleaner been attempted?	☐ yes	☐ no
Has the use of less hazardous cleaning solvent been attempted?	☐ yes	☐ no
Can the waste solvent be collected and used as thinner?	☐ yes	☐ no
Can the cleaning solvent be recycled?	☐ yes	☐ no
Can soaps and detergents be used for cleaning?	☐ yes	☐ no
Is the roller blade kept in good condition and its angle checked for most effective cleaning?	☐ yes	☐ no

Discuss: ______

Is an automatic web splicer used to save time and paper waste?	☐ yes	☐ no
Do the presses employ web break detectors to prevent damage to the press (tear-down and repair of equipment can produce large quantities of cleaning waste as compared to waste produced during normal operation)?	☐ yes	☐ no
Is waste lube-oil sent to a recycler?	☐ yes	☐ no
Is paper use minimized by proper pre-production planning and lay-out?	☐ yes	☐ no
Is waste paper and trash sent to a recycler?	☐ yes	☐ no

Discuss these options: ______

Firm ______ Site ______ Date ______	Waste Minimization Assessment Proc. Unit/Oper. ______ Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
9

OPTION GENERATION: Printing & Finishing

Meeting format (e.g., brainstorming, nominal group technique) ______
Meeting Coordinator ______
Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
Reseal Containers Properly		
Use Alternative Inks		
Fill Fountains According to Need		
Use Automatic Levelers		
Standard Ink Sequence		
Prevent Ink Drying		
Recycle Waste Ink		
Return Waste Ink to Manufacturer		
Use Alternative Fountain Solutions		
Use Automatic Blanket Cleaner		
Use Alternative Cleaning Solvents		
Collect and Reuse Solvent		
Recycle Waste Solvent		
Use Soap and Detergent		
Check Roller Blade Condition and Angle		
Use Automatic Web Splicer		
Install Web Break Detectors		
Recycle Lube-Oils		
Plan Production/Lay-out		
Recycle Waste Paper/Trash		

Firm __________ Site __________ Date __________	**Waste Minimization Assessment** Proj. No. __________	Prepared By __________ Checked By __________ Sheet __ of __ Page __ of __

WORKSHEET 10

WASTE MINIMIZATION: Good Operating Practices

GOOD OPERATING PRACTICES

Are plant material balances routinely performed?	☐ yes	☐ no
Are they performed for each material of concern (e.g. solvent) separately?	☐ yes	☐ no
Are records kept of individual wastes with their sources of origin and eventual disposal? (This can aid in pinpointing large waste streams and focus reuse efforts.)	☐ yes	☐ no
Are the operators provided with detailed operating manuals or instruction sets?	☐ yes	☐ no
Are all operator job functions well defined?	☐ yes	☐ no
Are regularly scheduled training programs offered to operators?	☐ yes	☐ no
Are there employee incentive programs related to waste minimization?	☐ yes	☐ no
Does the facility have an established waste minimization program in place?	☐ yes	☐ no
If yes, is a specific person assigned to oversee the success of the program?	☐ yes	☐ no

Discuss goals of the program and results: __________

Has a waste minimization assessment been performed at the facility in the past?	☐ yes	☐ no

If yes, discuss: __________

Firm ____ Site ____ Date ____	Waste Minimization Assessment Proc. Unit/Oper. ____ Proj. No. ____	Prepared By ____ Checked By ____ Sheet ___ of ___ Page ___ of ___

WORKSHEET
11

OPTION GENERATION: Good Operating Practices

Meeting format (e.g., brainstorming, nominal group technique) ____
Meeting Coordinator ____
Meeting Participants ____

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
Perform Material Balances		
Keep Records of Waste Sources & Disposition		
Waste/Materials Documentation		
Provide Operating Manuals/Instructions		
Employee Training		
Increased Supervision		
Provide Employee Incentives		
Increase Plant Sanitation		
Establish Waste Minimization Policy		
Set Goals for Source Reduction		
Set Goals for Recycling		
Conduct Annual Assessments		

Firm ____	Waste Minimization Assessment	Prepared By ____
Site ____		Checked By ____
Date ____	Proj. No. ____	Sheet __ of __ Page __ of __

WORKSHEET
12

WASTE MINIMIZATION: Reuse and Recovery

A. SEGREGATION

Segregation of wastes reduces the amount of unknown material in waste and improves prospects for reuse & recovery.

Are spent processing baths segregated from wastewater streams? ☐ yes ☐ no

Are different solvent wastes due to equipment clean-up segregated? ☐ yes ☐ no

Are aqueous wastes from equipment clean-up segregated from solvent wastes? ☐ yes ☐ no

Are different types of paper (colored paper vs. white) segregated to increase their resale value? ☐ yes ☐ no

Are different grades of paper (inked vs. clean, high quality vs. paper wrap) kept segregated for more effective recycling? ☐ yes ☐ no

Is general trash segregated to maximize the amount of recyclable paper, film, aluminum, pallets, etc.? ☐ yes ☐ no

If no, explain: ____

B. CONSOLIDATION/REUSE/RECOVERY

Do you return waste ink to the manufacturer for recycling? ☐ yes ☐ no

Do you recycle the ink onsite? ☐ yes ☐ no

Have you contacted any large printers in your area to see if they want your ink for recycling? ☐ yes ☐ no

Have you contacted waste exchange services or commercial brokerage firms regarding waste ink or other wastes? ☐ yes ☐ no

Are many different solvents used for cleaning? ☐ yes ☐ no

If too many small-volume solvent waste streams are generated to justify on-site distillation, can the solvent used for equipment cleaning be standardized? ☐ yes ☐ no

Is spent cleaning solvent reused as thinner or initial wash? ☐ yes ☐ no

Has on-site distillation of the spent solvent ever been attempted? (On-site recovery of solvents by distillation is economically feasible for as little as 8 gallons of solvent waste per day.) ☐ yes ☐ no

If yes, is distillation still being performed? ☐ yes ☐ no

If no, explain: ____

Discuss other wastes (lube oils, films, paper, etc.) that you are currently recycling and by which means: ____

Appendix A
CASE STUDIES OF COMMERCIAL PRINTING PLANTS

In 1986 the California Department of Health Services commissioned a waste minimization study (DHS 1988) of two commercial printing firms, called Plants A and B in this guide. The results of the two waste assessments were used to prepare waste minimization assessment worksheets to be completed by other commercial printers in a self-audit process.

The companies selected as assessment sites were chosen primarily for their willingness to participate in the study, applicability to the study objectives, and the ability to apply the information to the commercial printing industry as a whole. Plant A was a medium-size commercial printer handling a wide variety of printing products. Plant B was one of several plants owned by a large printer specializing in newspaper advertising inserts and circulars.

The assessments consisted of two visits each to Plants A and B. The initial visits included examination of plant operations, waste handling and disposal, discussion of potential waste minimization techniques, and included a tour of all plant operations. The second visit was used to answer follow-up questions.

This Appendix section presents the results of the assessments of Plants A and B and potentially useful waste minimization options identified through the assessments. Also included are the practices already in use at the plant that have successfully reduced waste generation from past levels.

The waste minimization assessments were conducted according to the description of such assessments found in the "Introduction: Overview of Waste Minimization," in this guide. The steps involved in the assessments were (see also Figure 1 of this guide):

- Planning and organization
- Assessment phase
- Feasibility analysis phase

The fourth phase, implementation, was left to the commercial printers themselves.

WASTE MINIMIZATION ASSESSMENT OF PLANT "A"

Plant A is a medium-sized commercial printer located in the metropolitan Los Angeles area. The company employs about 60 people, of whom 43 are involved in production and the remainder are administrative and staff employees. The company handles a wide range of commercial printing, including advertising inserts, business forms, brochures and pamphlets, and circulars. Corporate sales for the fiscal year ending June 30, 1987 totalled approximately $6 million.

Plant A performs its own photoprocessing. The photoprocessing and plate processing chemicals are received in five gallon containers, referred to as "cubes." Approximately 1-1/2 cubes of developer and 1 cube of fixer are used per month for film processing. For platemaking, presensitized aluminum plates are used. The average monthly usage of plate processing developer and fixer is 2 cubes per month each. All of the developers and fixers are diluted with water at a ratio of 4:1 (water to chemical) before being used. Presensitized aluminum plates and all photoprocessing and plate processing chemicals are manufactured by Kodak. The plant also uses two gallons per month of gum arabic, which is applied to the plates to reduce oxidation.

Automatic processors are used for photoprocessing and plate processing. Fresh developer and fixer are added automatically, and an equivalent volume of solution from the baths is simultaneously removed by overflow to prevent the buildup of impurities in the baths. The spent solution goes to the sewer. Also, the processing baths are dumped and fresh new baths are made up every six to eight weeks. These dumped baths also go to the sewer. Kodak claims that these chemicals are non-hazardous and biodegradable. The local sanitation district accepts the wastewater from Plant A and charges an annual permit fee of $50. Silver recovery from the spent fixing solutions is not felt to be economical and, therefore, is not practiced. The silver concentration in the wastewater is within the acceptable limits set by the sanitation district.

The printing operation at Plant A consists of four web press lines and two sheet-fed units. Three of the web press lines use four color printing units, and the fourth line uses six color printing units. About 95% of Plant A's production is printed using the web presses, and the remaining 5% using the sheet-fed presses.

The plant uses non-heatset inks exclusively. The inks used are manufactured by Inkmakers, Inc., U.S. Printing Ink, and United Printing Ink. Approximately 1500 pounds of ink in 17 different colors are used per month. The inks are ordered in 30-pound kits. Fresh black inks cost from $1.50 to $3.50 per pound; colored inks from $3.50 to $7.50 per pound. Plant A has an arrangement with its ink suppliers in which all of the waste inks are returned to the supplier to be reformulated into black ink. The supplier mixes fresh black ink into the waste ink to obtain an acceptable black color. Typically 50 to 100 pounds of fresh ink is added to each 100 pounds of waste ink. Plant A then buys back the reformulated black ink at a price of $3.00 per pound. Plant A is now looking into purchasing a small ink recycling unit.

Approximately 20 gallons per month of Rosos "Fountain Soup" is used to make fountain solution for the web presses. The Fountain Soup is a concentrate that includes phosphoric acid, gum arabic, a defoamer, and a fungicide. The fountain solution is made up by adding 1 to 4 ounces of concentrate to each gallon of water. This concentrate is formulated for use in areas where there are stringent controls on volatile organic compound (VOC) emissions. (Plant A is located within the jurisdiction of the South Coast Air Quality Management District.) The concentrate contains high-boiling-point surfactants that help to wet the non-image areas of the plate, without the need for isopropyl alcohol.

The Rosos Fountain Soup was found to not work effectively on the sheet-fed units. Therefore, a different fountain solution concentrate (also supplied by Rosos) is used with the sheet-fed units, which requires the addition of sufficient isopropyl alcohol so that the fountain solution contains between 5 to 15% isopropyl alcohol. The average usage of isopropyl alcohol is 10 gallons per month. Since the sheet-fed units only account for 5% of the company's overall business, the VOC emissions from the plant are low enough to be within the prescribed limits.

The fountain solution is never drained from the printing unit reservoirs, but is either applied to the paper or is lost through evaporation. Of the solution that ends up on the paper, most of the water and isopropyl alcohol evaporates, while the other components are absorbed into the paper.

Approximately 230,000 pounds of paper are used per month, on average. Of the sheet-fed paper, approximately 2 to 6% ends up as waste. Of the web-fed paper, approximately 2% of the gross weight of the paper ends up as wrapper slab and core waste, and 6 to 7% as other waste. All waste paper is collected and sold to a paper recycler.

All used and spoiled film is processed by a recycler to reclaim silver and all used aluminum plates are sold to an aluminum recycler. Ink containers are scraped out when empty and then thrown in the trash, along with photoprocessing and plate processing chemical containers. Worn rubber blankets from the presses are also thrown in the trash. An average of 16 blankets are replaced each month on the web presses, and one blanket per month on the sheet-fed units.

Pacific Blanket Wash, manufactured by Shell Chemical, is used for cleaning the presses and for other general cleanup uses. According to the supplier, this wash is formulated to be exempt from California hazardous waste regulations. Cleanup is done with a rag wetted with the blanket wash. Virtually all of the blanket wash ends up on the rags; there is no waste solvent collected. For $40 a week, a local industrial laundry provides about 2000 rags per week, picks up dirty rags and dry cleans them.

Plant A has yet to send out any hazardous wastes under manifest. They have an arrangement with the ink manufacturer who picks up the waste inks and reformulates black ink from it. Under current federal guidelines, offset lithography paste inks are not hazardous.

Ink Recycler Option

Under the current arrangement, the ink manufacturer picks up all of the waste ink from Plant A. This waste ink is blended with enough fresh ink to produce an acceptable black color. Approximately 200 to 300 pounds of waste ink are returned each month to the manufacturer. After blending with fresh ink, Plant A buys back 300 to 500 pounds per month of black ink at a cost or $3.00 per pound.

This price for the reformulated ink is relatively high based on the relatively low quality of the ink. Fresh ink of comparable quality typically costs $1.55 per pound. Plant A can obtain a potentially quick payback on its investment by purchasing an ink recycler.

KMI Marketing, Inc. sells a small recycler which blends 60 pounds of waste ink with 120 pounds of fresh ink to produce a 180-pound batch of reformulated black ink. The complete batch is then filtered and is ready for use. One batch can be processed in one hour.

The following economic comparison is made on a conservative set of assumptions. These assumptions are listed below.

- 200 pounds of waste ink are produced per month.
- Labor and utility costs are negligible.

Case A: Buy a new ink recycler

- The recycler blends in 400 pounds of fresh ink to produce 600 pounds of reformulated ink. The fresh ink costs $1.55 per pound.

- The ink recycler costs $5,900.

Case B: Keep the existing arrangement with the ink manufacturer.

- The ink manufacturer blends in 100 pounds of fresh ink to produce 300 pounds of reformulated ink per month. The cost of this reformulated ink is $3.00 per pound.
- Plant A buys an additional 300 pounds of fresh ink. The cost of this ink is $1.55 per pound. By buying this additional ink, both cases produce a total quantity of black ink of 600 pounds per month.

Table A-1 presents the economic comparison. The payback of just under 8 months makes the on-site recycler look very attractive.

WASTE MINIMIZATION ASSESSMENT OF PLANT "B"

Plant B is a large printing operation in Southern California. The company owns several plants in the state and prints circulars and advertising inserts for many of the major and minor newspapers in Southern California. On occasion, they have printed publications, however, this is not a substantial percentage of this overall business. Plant B includes image processing, plate processing, lithographic printing, and finishing operations. At the time of the audit, the company had been in its current location for about 15 months. The plant operates 7 days per week, 24 hours per day, 360 days per year.

The plant employs modern image processing technology, including computerized pre-press-systems for copy preparation. All photoprocessing is accomplished with automatic processing equipment. Automatic replenishers minimize photoprocessing wastes by adding enough developer or fixer to keep the bath concentrations within a range that allows optimal performance.

Photoprocessing is done with Polychrome "Lith" developer and fixer, and Hunt's Rapid Access developer and fixer. Approximately 55 gallons of developer and 55 gallons of fixer are used per month. The spent photoprocessing solution passes through a two-stage silver recovery system. The first stage consists of a reclaimer that electrolytically deposits the silver onto electrodes. The second stage recovers the remaining silver using steel wool. Approximately three pounds of silver per month are reclaimed this way.

The plant uses approximately 10 gallons per month each of Copykwik photographic developer and fixer manufactured by Olin Hunt in its typesetting operations. The developer is a mixture of hydroquinone, potassium hydroxide, and sodium sulfite. The fixer is a mixture of ammonium thiosulfate and acetic acid.

An Enco color proofing machine is used to check the copy for appearance and accuracy. Naps developer and

TABLE A-1. ECONOMIC COMPARISON OF ON-SITE VERSUS OFF-SITE INK RECYCLING

Case A. (On-site Ink Recycling) Buy an ink recycler to convert all waste ink into reformulated black ink. The capital cost of the ink recycler is $5,900.

Case B. (Off-site Ink Recycling) Continue to return waste ink to the manufacturer, who blends it with fresh ink and sells it back to Plant A.

In both cases, the waste ink is available without cost.

	Case A	Case B
Material Balance, (pounds per month)		
Waste ink	200	200
Fresh ink for blending	400	100
Reformulated ink	600	300
Additional fresh ink	0	300
Total available ink	600	600
Operating Cost, (dollars per month)		
Waste ink	$ 0	$ 0
Fresh ink for blending (@ $1.55/lb)	620	0
Buy back reformulated ink (@ $3.00/lb)	0	900
Buy additional fresh ink (@ $1.55/lb)	0	465
Total Operating Cost to recycle ink	$ 620	$1,365

Savings in operating cost with on-site ink recycler $745/month

Payback periods = $\frac{\$5,900}{\$745/\text{month}}$ = 7.9 months fixer are used in this system. Typically 5 to 6 gallons per month of developer and fixer are used.

The plant uses presensitized aluminum plates. Polychrome chemistry is used for plate processing. In particular, the plate developer is a solution of hydroquinone and sodium formaldehyde bisulfite. Approximately 20 gallons per month of the finisher are used, and about 30 gallons per month of developer are used.

The spent solutions from plate processing and photoprocessing are discharged to the sewer. Plant B is permitted by the local county wastewater treatment district to discharge the waste solutions from image processing and plate processing. Used and spoiled films are collected and sold to a recycler. Used aluminum plates are sold to an aluminum recycler.

The major materials and supplies used in the pressroom are paper, ink, blanket wash, fountain solution, and small quantities of silicone and lubricating oil. Approximately 500 tons of paper are used per month. All excess and waste paper, wrappers, and web cores are segregated into three categories (Kraft paper, clean white paper, and mixed news waste paper) for sale to a recycler.

The plant has four large web printing lines. Three of the lines are open web presses which use non-heatset inks. The fourth line uses heatset inks. All lines print four colors (yellow, blue, red, and black). Table A-2 shows amounts of fresh ink used on an average monthly basis.

Table A-2. Average Ink Usage, Pounds per Month

	Black	Yellow	Blue	Red
Non-heatset	90,000	25,000	10,000	20,000
Heatset	11,000	20,000	11,000	16,000

The heatset inks are manufactured by Waseca, a division of Brown Printing. The non-heatset inks are manufactured by U.S. Printing Ink. Waste ink is recycled onsite into black ink. The recycler was installed at an estimated cost of $15,000 to $20,000. Approximately 3% of the black ink used is recycled from the plant's waste ink. By recycling waste ink, the plant can reduce its purchases of newsprint-quality open web black ink, priced at 34 cents per pound, by about 2,700 pounds per month. The savings in new ink alone results in a payback period of 16 to 22 months (based on the installed cost range of $15,000 to $20,000). If the disposal cost of the waste ink as a hazardous waste were to be considered, the payback would be shorter and even more attractive.

Approximately 600 gallons per month of fountain solution concentrate is used. The brand name of the concentrate is "Super Lo-Rub", manufactured by Quality Control Litho. The concentrate contains phosphoric acid, gum arabic, defoamer, and fungicide. The fountain solution is made up by adding 3 ounces of concentrate to each gallon of water. All of the fountain solution is used up in the printing process, either absorbed into the paper or evaporated.

The heatset printing line is equipped with hoods over the heaters to collect the solvents and other vapors. A catalytic combustor, manufactured by Thermoelectron, incinerates these vapors at a temperature of about 650°F. The use of a catalytic combustor is designated as the best available control technology by the South Coast Air Quality Management District.

A blanket wash, manufactured by Quality Control Litho ("One Step Wash Up"), is used for blanket and roller cleaning on the presses. This solvent is composed of a mixture of aliphatic hydrocarbons (7.5%), aromatic hydrocarbons (6%), chlorinated hydrocarbons (4%), and other compounds (15%). Approximately 300 gallons per month of blanket wash are used. Cleaning is done by wetting a rag with the blanket wash and then wiping the equipment clean. In this way, most of the blanket wash remains on the rag. General cleaning is done using rags and concentrated soap solutions. Rags are supplied by an industrial towel service, which picks up dirty rags (containing blanket wash, ink, soap, dust, and dirt) weekly.

Oil is used for lubricating the presses at Plant B. Used oil is collected at a rate of several drums per year and turned over to a nearby recycler.

During the audit, it was mentioned that the small printing firms in the area do not have ink recyclers and do not have arrangements to return waste ink to the manufacturers. These small printers probably put their waste ink back into containers and throw it into the trash. The representative from Plant B who assisted in the audit suggested that it might be mutually beneficial to both the small printers and Plant B for the plant to accept waste inks from small printers as a feedstock. The plant would use its ink recycler to blend the small printer's waste ink with the plant's waste ink and fresh ink. This would provide a more acceptable means of disposing of waste ink for the small printer, and would slightly reduce Plant B's use of new ink.

Appendix B
WHERE TO GET HELP
FURTHER INFORMATION ON WASTE MINIMIZATION

Additional information on source reduction, reuse and recycling approaches to waste minimization is available in EPA reports listed in this section, and through state programs (listed below) that offer technical and/or financial assistance in the areas of waste minimization and treatment.

In addition, waste exchanges have been established in some areas of the U.S. to put waste generators in contact with potential users of the waste. Four waste exchanges are listed below. Finally, EPA's regional offices are listed.

EPA REPORTS ON WASTE MINIMIZATION

U.S. Environmental Protection Agency. "Waste Minimization Audit Report: Case Studies of Corrosive and Heavy Metal Waste Minimization Audit at a Specialty Steel Manufacturing Complex." Executive Summary.*

U.S. Environmental Protection Agency. "Waste Minimization Audit Report: Case Studies of Minimization of Solvent Waste for Parts Cleaning and from Electronic Capacitor Manufacturing Operation." Executive Summary.*

U.S. Environmental Protection Agency. "Waste Minimization Audit Report: Case Studies of Minimization of Cyanide Wastes from Electroplating Operations." Executive Summary.*

U.S. Environmental Protection Agency. Report to Congress: Waste Minimization, Vols. I and II. EPA/530-SW-86-033 and -034 (Washington, D.C.: U.S. EPA, 1986).**

U.S. Environmental Protection Agency. Waste Minimization - Issues and Options, Vols. I-III EPA/530-SW-86-041 through -043. (Washington, D.C.: U.S. EPA, 1986).**

* Executive Summary available from EPA, WMDDRD, RREL, 26 West Martin Luther King Drive, Cincinnati, OH, 45268; full report available from the National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22161.

** Available from the National Technical Information Service as a five-volume set, NTIS No. PB-87-114-328.

WASTE REDUCTION TECHNICAL/ FINANCIAL ASSISTANCE PROGRAMS

The EPA's Office of Solid Waste and Emergency Response has set up a telephone call-in service to answer questions regarding RCRA and Superfund (CERCLA):

(800) 242-9346 (outside the District of Columbia)

(202) 382-3000 (in the District of Columbia)

The following states have programs that offer technical and/or financial assistance in the areas of waste minimization and treatment.

Alabama
Hazardous Material Management and Resources Recovery Program
University of Alabama
P.O. Box 6373
Tuscaloosa, AL 35487-6373
(205) 348-8401

Alaska
Alaska Health Project
Waste Reduction Assistance Program
431 West Seventh Avenue, Suite 101
Anchorage, AK 99501
(907) 276-2864

Arkansas
Arkansas Industrial Development Commission
One State Capitol Mall
Little Rock, AR 72201
(501) 371-1370

California
Alternative Technology Section
Toxic Substances Control Division
California State Department of Health Service
714/744 P Street
Sacramento, CA 94234-7320
(916) 324-1807

Connecticut
Connecticut Hazardous Waste Management Service
Suite 360
900 Asylum Avenue
Hartford, CT 06105
(203) 244-2007

Connecticut Department of Economic Development
210 Washington Street
Hartford, CT 06106
(203) 566-7196

Georgia

Hazardous Waste Technical Assistance Program
Georgia Institute of Technology
Georgia Technical Research Institute
Environmental Health and Safety Division
O'Keefe Building, Room 027
Atlanta, GA 30332
(404) 894-3806

Environmental Protection Division
Georgia Department of Natural Resources
Floyd Towers East, Suite 1154
205 Butler Street
Atlanta, GA 30334
(404) 656-2833

Illinois

Hazardous Waste Research and Information Center
Illinois Department of Energy of Energy and Natural Resources
1808 Woodfield Drive
Savoy, IL 61874
(217) 333-8940

Illinois Waste Elimination Research Center
Pritzker Department of Environmental Engineering
Alumni Building, Room 102
Illinois Institute of Technology
3200 South Federal Street
Chicago, IL 60616
(313) 567-3535

Indiana

Environmental Management and Education Program
Young Graduate House, Room 120
Purdue University
West Lafayette, IN 47907
(317) 494-5036

Indiana Department of Environmental Management
Office of Technical Assistance
P.O. Box 6015
105 South Meridian Street
Indianapolis, IN 46206-6015
(317) 232-8172

Iowa

Center for Industrial Research and Service
205 Engineering Annex
Iowa State University
Ames, IA 50011
(515) 294-3420

Iowa Department of Natural Resources
Air Quality and Solid Waste Protection Bureau
Wallace State Office Building
900 East Grand Avenue
Des Moines, IA 50319-0034
(515) 281-8690

Kansas

Bureau of Waste Management
Department of Health and Environment
Forbes Field, Building 730
Topeka, KS 66620
(913) 269-1607

Kentucky

Division of Waste Management
Natural Resources and Environmental Protection Cabinet
18 Reilly Road
Frankfort, KY 40601
(502) 564-6716

Louisiana

Department of Environmental Quality
Office of Solid and Hazardous Waste
P.O. Box 44307
Baton Rouge, LA 70804
(504) 342-1354

Maryland

Maryland Hazardous Waste Facilities Siting Board
60 West Street, Suite 200 A
Annapolis, MD 21401
(301) 974-3432

Maryland Environmental Service
2020 Industrial Drive
Annapolis, MD 21401
(301) 269-3291
(800) 492-9188 (in Maryland)

Massachusetts

Office of Safe Waste Management
Department of Environmental Management
100 Cambridge Street, Room 1094
Boston, MA 02202
(617) 727-3260

Source Reduction Program
Massachusetts Department of Environmental Quality Engineering
1 Winter Street
Boston, MA 02108
(617) 292-5982

Michigan
Resource Recovery Section
Department of Natural Resources
P.O. Box 30028
Lansing, MI 48909
(517) 373-0540

Minnesota
Minnesota Pollution Control Agency
Solid and Hazardous Waste Division
520 Lafayette Road
St. Paul, MN 55155
(612) 296-6300

Minnesota Technical Assistance Program
W-140 Boynton Health Service
University of Minnesota
Minneapolis, MN 55455
(612) 625-9677

(800) 247-0015 (in Minnesota)
Minnesota Waste Management Board
123 Thorson Center
7323 Fifty-Eighth Avenue North
Crystal, MN 55428
(612) 536-0816

Missouri
State Environmental Improvement and Energy Resources Agency
P.O. Box 744
Jefferson City, MO 65102
(314) 751-4919

New Jersey
New Jersey Hazardous Waste Facilities Siting Commission
Room 614
28 West State Street
Trenton, NJ 08608
(609) 292-1459
(609) 292-1026

Hazardous Waste Advisement Program
Bureau of Regulation and Classification
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625

Risk Reduction Unit
Office of Science and Research
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625

New York
New York State Environmental Facilities Corporation
50 Wolf Road
Albany, NY 12205
(518) 457-3273

North Carolina
Pollution Prevention Pays Program
Department of Natural Resources and
Community Development
P.O. Box 27687
512 North Salisbury Street
Raleigh, NC 27611
(919) 733-7015

Governor's Waste Management Board
325 North Salisbury Street
Raleigh, NC 27611
(919) 733-9020

Technical Assistance Unit
Solid and Hazardous Waste Management Branch
North Carolina Department of Human Resources
P.O. Box 2091
306 North Wilmington Street
Releigh, NC 27602
(919) 733-2178

Ohio
Division of Solid and Hazardous Waste Management
Ohio Environmental Protection Agency
P.O. Box 1049
1800 WaterMark Drive
Columbus, OH 43266-1049
(614) 481-7200

Ohio Technology Transfer Organization
Suite 200
65 East State Street
Columbus, OH 43266-0330
(614) 466-4286

Oklahoma
Industrial Waste Elimination Program
Oklahoma State Department of Health
P.O. Box 53551
Oklahoma City, OK 73152
(405) 271-7353

Oregon
Oregon Hazardous Waste Reduction Program
Department of Environmental Quality
811 Southwest Sixth Avenue
Portland, OR 97204
(503) 229-5913

Pennsylvania
Pennsylvania Technical Assistance Program
501 F. Orvis Keller Building
University Park, PA 16802
(814) 865-0427

Center of Hazardous Material Research
320 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5320

Bureau of Waste Management
Pennsylvania Department of
Environmental Resources
P.O. Box 2063
Fulton Building
3rd and Locust Streets
Harrisburg, PA 17120
(717) 787-6239

Rhode Island
Ocean State Cleanup and Recycling Program
Rhode Island Department of Environmental Management
9 Hayes Street
Providence, RI 02908-5003
(401) 277-3434
(800) 253-2674 (in Rhode Island)

Center for Environmental Studies
Brown University
P.O. Box 1943
135 Angell Street
Providence, RI 02912
(401) 863-3449

Tennessee
Center for Industrial Services
102 Alumni Hall
University of Tennessee
Knoxville, TN 37996
(615) 974-2456

Virginia
Office of Policy and Planning
Virginia Department of Waste Management
11th Floor, Monroe Building
101 North 14th Street
Richmond, VA 23219
(804) 225-2667

Washington
Hazardous Waste Section
Mail Stop PV-11
Washington Department of Ecology
Olympia, WA 98504-8711
(206) 459-6322

Wisconsin
Bureau of Solid Waste Management
Wisconsin Department of Natural Resources
P.O. Box 7921
101 South Webster Street
Madison, WI 53707
(608) 267-3763

Wyoming
Solid Waste Management Program
Wyoming Department of Environmental Quality
Herchler Building, 4th Floor, West Wing
122 West 25th Street
Cheyenne, WY 82002
(307) 777-7752

WASTE EXCHANGES

Northeast Industrial Exchange
90 Presidential Plaza, Syracuse, NY 13202
(315) 422-6572

Southern Waste Information Exchange
P.O. Box 6487, Tallahassee, FL 32313
(904) 644-5516

California Waste Exchange
Department of Health Services
Toxic Substances Control Division
Alternative Technology & Policy Development Section
714 P Street
Sacramento, CA 95814
(916) 324-1807

U.S. EPA REGIONAL OFFICES

Region 1 (VT, NH, ME, MA, CT, RI)
John F. Kennedy Federal Building
Boston, MA 02203
(617) 565-3715

Region 2 (NY, NJ)
26 Federal Plaza
New York, NY 10278
(212) 264-2525

Region 3 (PA, DE, MD, WV, VA)
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-9800

Region 4 (KY, TN, NC, SC, GA, FL, AL, MS)
345 Courtland Street, NE
Atlanta, GA 30365
(404) 347-4727

Region 5 (WI, MN, MI, IL, IN, OH)
230 South Dearborn Street
Chicago, IL 60604
(312) 353-2000

Region 6 (NM, OK, AR, LA, TX)
1445 Ross Avenue
Dallas, TX 75202
(214) 655-6444

Region 7 (NE, KS, MO, IA)
756 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2800

Region 8 (MT, ND, SD, WY, UT, CO)
999 18th Street
Denver, CO 80202-2405
(303) 293-1603

Region 9 (CA, NV, AZ, HI)
215 Fremont Street
San Francisco, CA 94105
(415) 974-8071

Region 10 (AK, WA, OR, ID)
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-5810

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