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Pollution Prevention Manual for Lithographic Printers

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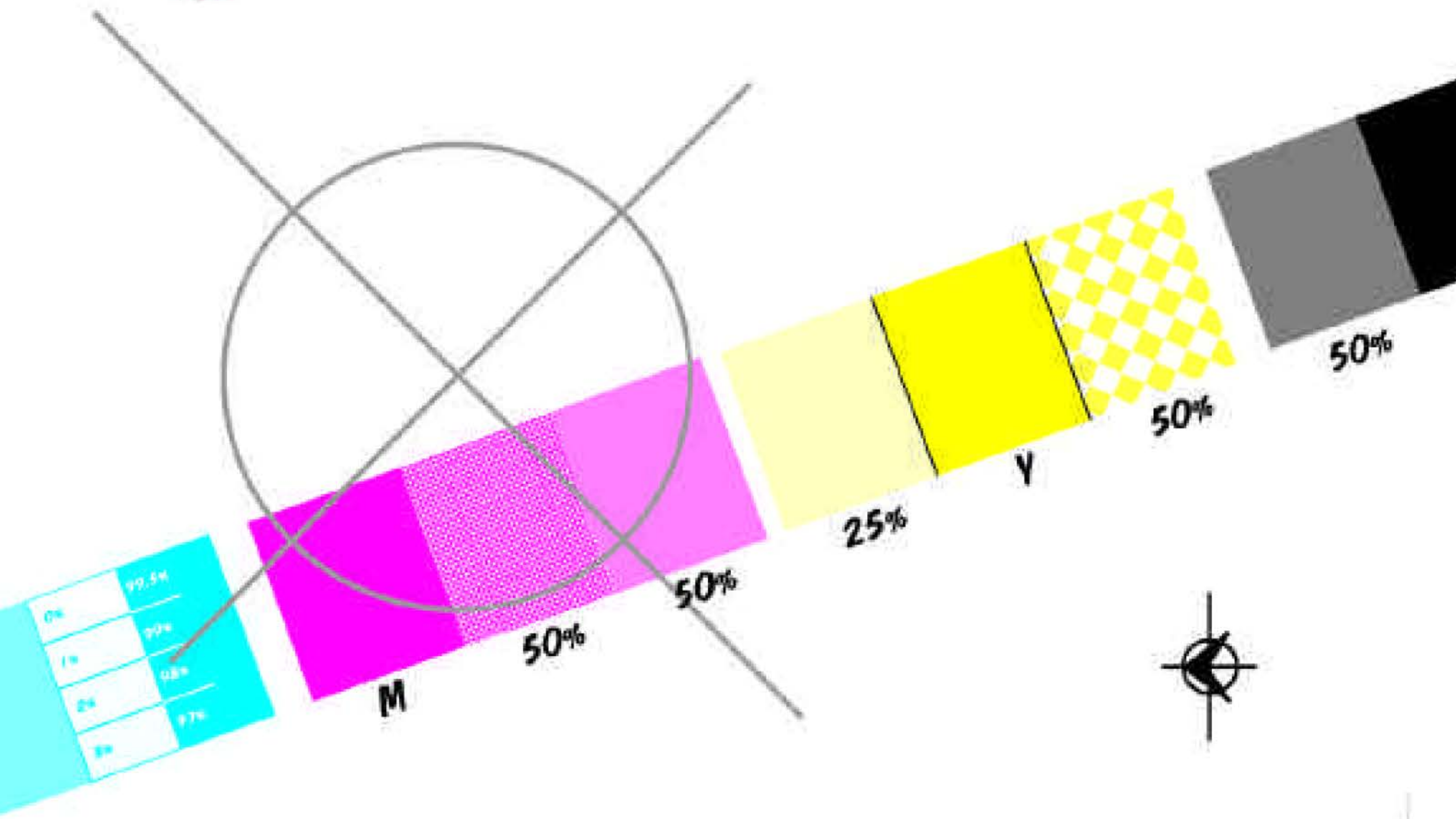

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Printed on Recycled Paper

PRINTED WITH SOY INK

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1.0 Introduction

This manual is for anyone in the graphic arts industry concerned with competitiveness, environmental regulations, waste, and pollution prevention. It is the first product of an on-going project which begins by addressing wastes from the lithographic process. Future publications will address pollution prevention for other areas within the industry. Using this manual and incorporating its concepts into current waste management practices could be among the most important business planning decisions made. Stringent environmental regulations increase demands on the competitive printer to stay one step ahead of costs related to environmental compliance. Pollution prevention techniques can help both small and large printers meet this challenge.

This manual is divided into sections that roughly correspond to the production stages of the lithographic process. Some sections have been expanded to highlight pollution prevention approaches in specific areas such as ink and recycling. Each section provides specific information on implementation and includes testimonial examples of pollution prevention measures. These sections can be used individually to analyze pollution prevention opportunities in specific areas such as makeready or prepress, or the manual can be used as a whole to design a comprehensive pollution prevention program. The first section deals with prepress operations and then moves on to makeready, inks, dampening, and emerging technologies. The manual ends with a look at recycling and its contribution to pollution prevention in the lithographic shop.

1.1 A Perspective on Lithography

The graphic arts industry encompasses a wide variety of industrial endeavors, including "all arts and processes that give information by means of images printed on surfaces (Dennis & Jenkins, 1991)." Printing is one such process, differentiated by the process used to transfer images to the substrate. Direct-to-substrate transfer processes that use raised or recessed image transfer mechanisms include flexography, gravure, letterpress and screen printing. The lithography process uses a blanket cylinder to transfer or "off-set" images from the plate to the substrate, relying on oil / water chemistry to maintain an image in one plane on the image transfer plate. Other related printing sectors include plate-making and bookbinding (Ramus, 1992).

This manual focuses on lithography, the largest sector of the graphic arts industry. Based on the value of shipments in 1990 (see Fig. 1-1), lithography accounts for 47 percent of the U.S. market share (Ramus, 1992). The U.S. printing industry is comprised of nearly 70,000 facilities -- 60,000 of which operate both presses and prepress equipment -- and employs 1.5 million people with an annual payroll of more than $33 billion (Lewis, 1991; Ramus, 1992). Many printing facilities, particularly letterpress and lithographers, are small businesses with fewer than 10 employees. Fewer than 15 percent of lithography plants employ more than 20 people (Lewis, 1991). Even so, the U.S. Bureau of the Census estimated that the total value of all 1991 printing shipments would exceed $161 billion, making the printing industry a significant sector of the United States economy (BOC, 1990).

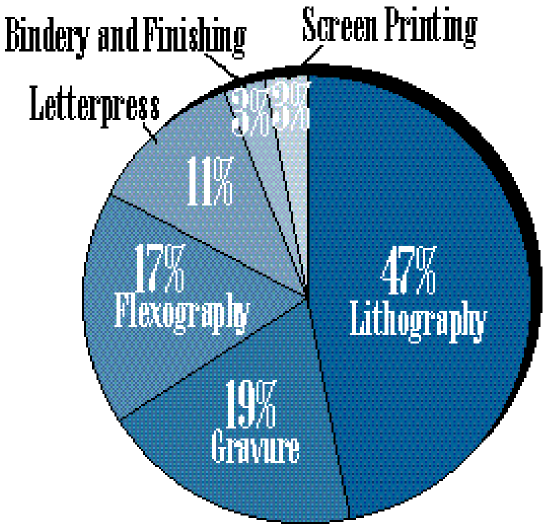

Fig. 1.1: Percentage of Market Share by Printing Type

1.2 Regulation of Lithographic Wastes

The lithographic process can be roughly divided into five steps:

- image processing,
- image transfer to the lithographic plate,
- makeready prior to printing,
- printing,
- drying and finishing of the salable product.

Whether or not all these steps are part of an individual print shop's operation depends on the degree of computerization and the type of lithographic press being used — web or sheet-fed. A wide variety of by-products and wastes are associated with each of these steps (illustrated in Fig. 1-2) from waste paper and empty ink cans to less visible wastes such as vapor emissions from inks and solvents, known as volatile organic compounds (VOCs).

The U.S. Environmental Protection Agency, which compiles the Toxics Release Inventory database designed to track releases of toxics from the industrial sector, places graphic arts in the top ten U.S. industries for amounts of toxic waste released to the air, water, land and disposed of in hazardous waste management facilities. Toxins generated from the printing and allied industries exceeded 56 million pounds in 1990 (US EPA, 1992). Other sources report that the EPA's estimate for the industry may be lower than actual releases because small business are not normally required to report releases. Also, some compounds (such as fountain solutions containing isopropyl alcohol (IPA)), are not reportable (IDEM, 1993).

Volatile organic compounds (xylenes, ketones, alcohols, or aliphatics) are contained in many of the inks, cleaners and fountain solutions. The amount of VOCs in inks depends on the lithographic process and the ink type.

Cleaners (roller, blanket and press washes) are petroleum-based with products containing naphtha, mineral spirits, methanol and toluene. Many cleaners contain almost 100 percent VOCs. (Cleaners that contain highly toxic VOCs, such as methylene chloride are being phased out.) These compounds

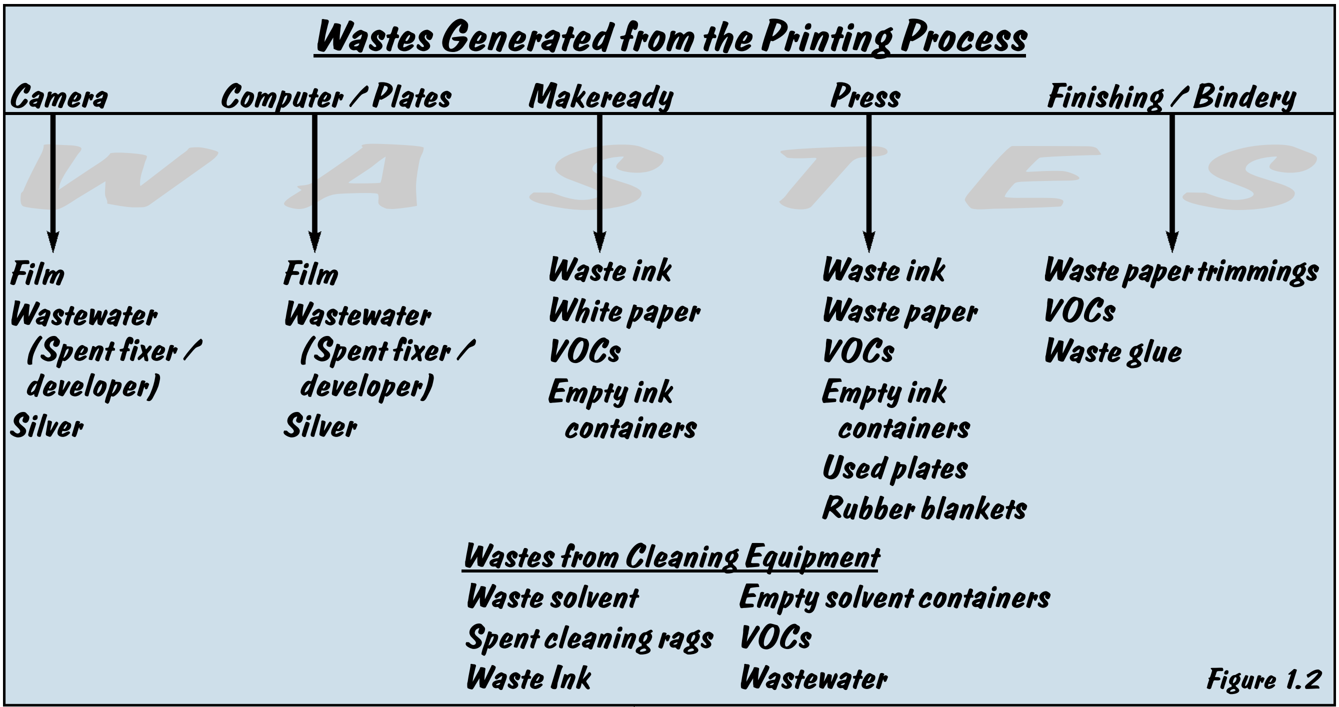

Figure 1.2

readily evaporate at room temperature and have become a major focus of the Clean Air Act Amendments of 1990 because they produce ozone in the lower atmosphere. (Office of Air Quality Planning and Standards, 1993). VOC emissions account for more than 90 percent of the releases from printing facilities, as shown in Fig. 1-3 (Pferdehirt, 1993).

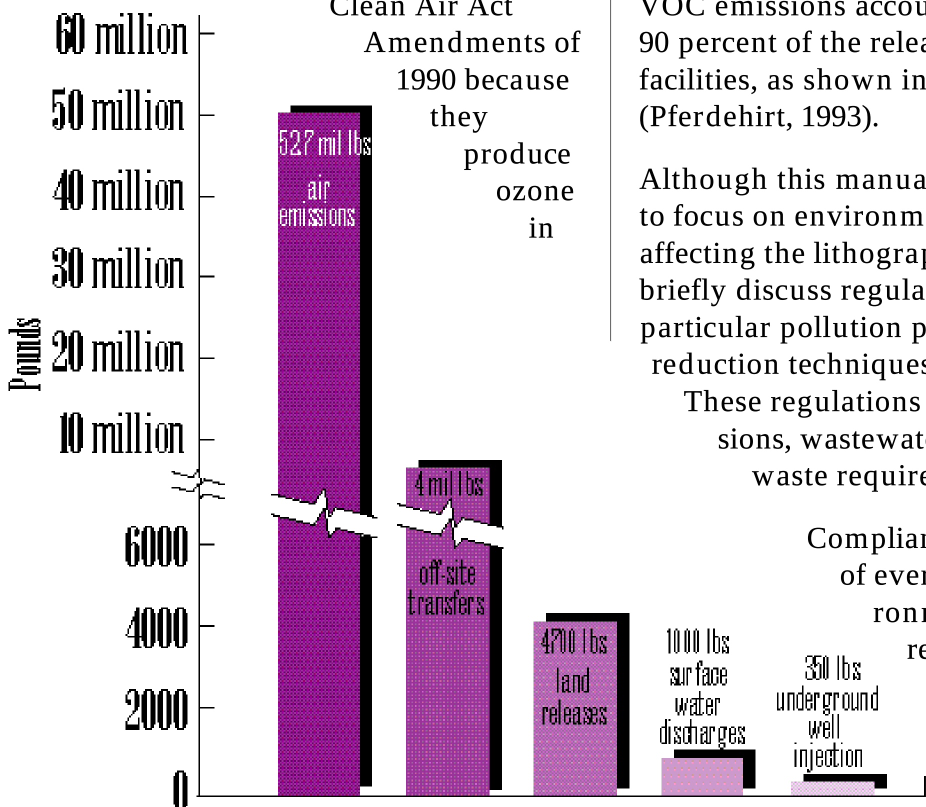

Figure 1.3: Toxic Chemicals Released by Printers

Although this manual is not designed to focus on environmental regulations affecting the lithographic printer, it will briefly discuss regulations that affect particular pollution prevention or waste reduction techniques being described. These regulations include air emissions, wastewater and hazardous waste requirements.

Compliance with the myriad of ever-changing environmental regulations that potentially affect the lithographer can be expensive.

The cost and time required for management oversight, employee training, documentation, and equipment to pretreat waste discharges can be considerable. Effective pollution prevention practices and technologies can help lithographers limit or avoid some of these expenses. In a highly competitive business environment, pollution prevention practices can often provide the extra edge that separate successful printing operations from those beleaguered by excessive environmental compliance costs and potentially crippling state or federal regulatory non-compliance penalties.

1.3 Practicing Pollution Prevention

Pollution prevention focuses on eliminating or reducing waste generation rather than implementing “end of pipe” technology.

The first and most important step in implementing a pollution prevention (P2) program for any facility is making the philosophy of waste prevention and reduction a company priority. To achieve this, a recognized leader at the facility should announce the program to employees, asking for their input when identifying areas where waste can be reduced, and to request their help to carry out pollution prevention projects. Some companies have initiated bonuses or award programs for employees who contribute significantly to P2 programs, while others find that employees get enough satisfaction from involvement in decision-making practices affecting their production activities to maintain momentum for the pollution prevention program (US EPA, 1992; DDNR, 1991).

Once a facility establishes a clear commitment to pollution prevention, it should gather interested, appointed and affected individuals for a brainstorming session. Participants should focus on identifying areas in which waste could be reduced based on information gained from this manual or others listed in the reference section. Other important information sources include records of waste disposal costs, environmental compliance documents, raw materials purchase invoices or an informal inspection of dumpster contents. Press operators and bindery personnel can often accurately identify processes or procedures that generate high volumes of waste and emissions.

After high waste areas have been identified, focus on *one* for the facility's first pollution prevention effort. Concentrate on identifying the most favorable pollution prevention methods for eliminating or reducing that waste stream. This requires consideration of all costs and benefits involved, such as decreases in operating costs, regulatory compliance costs, the likelihood of regulatory violation costs and future regulatory liability (see Fig. 1-4). Improvements in productivity, worker safety, environmental protection and in quality management practices may also result (SHWEC, 1993). For example, a material substitution approach may be chosen to replace a rubber-based ink with a soy/vegetable oil-based ink, or an IPA-containing fountain solution with butyl cellosolve or 2-ethyl-1, 3-hexanediol-based substitute (Fig. 1-5).

Basic Approaches to Pollution Prevention

Changes in Production Processes
- material substitution
- purification of materials
- equipment modification
- equipment automation
- waste segregation
- inventory control
- good material handling practices

Changes in Manufactured Product
- product redesign for less environmental impact
- design for longer life
- pre-design considerations for less environmental impact

Figure 1.4

Regardless of the approach taken, establish a means for measuring the impact of the pollution prevention project (US EPA, 1988). First examine and quantify the costs associated with previous production methods to the greatest extent possible. Then compare this to the costs (including any equipment purchases necessary) to implement the P2 project. Any net savings should be divided by the cost of new equipment, supplies and labor to determine the return on investment.

Potential Benefits of Pollution Prevention Practices

Decreased waste management costs:
Means: Bottom line savings

Decreased environmental compliance costs:
Means: Less time spent assuring compliance

Decreased future environmental liability:
Means: Decreased likelihood of site clean-up
Increased future property values

Increased efficiency and productivity:
Means: On-time delivery and quality work

Increased worker safety:
Means: Decreased workers compensation claims, sick time
Increased productivity

Figure 1.5

While these are important tools for the evaluation and guidance of P2 project decisions, intangible benefits and costs should also be considered. Of what value is an improved business image or a healthier work environment? Intangibles often translate into real costs or real savings and should not be treated lightly (US EPA, 1992).

Keeping a viable pollution prevention program going requires continued support and involvement from management and constant effort from everyone involved in planning and implementation. Obstacles may include concerns about product quality, resistance to change on the part of management or staff or prohibitive state or federal regulations. However, with continued support and enthusiasm from respected persons within the company, the lithographer can implement sound pollution prevention projects. Pollution prevention can become part of quality management practices contributing to the company's bottom line and to environmental quality.

Case Study A

Pollution Prevention in a Small Print Shop

Dan Crotty, production manager at G&R Publishing Company, in Waverly, Iowa, tries to keep on top of new developments in pollution prevention for small business printers and implement as much as possible at G&R.

In addition to recovering waste silver and spent photographic films from its prepress operations, using automatic dampening systems on its presses to reduce make-ready waste, and baling and recycling corrugated cardboard waste, G&R employs several approaches to reduce the amount and toxicity of waste from its press room.

Currently, G&R uses soy inks whenever possible, except for metallic inks, for which suitable soy replacements are not available. Crotty found that switching to soy ink was not extremely difficult and credits this to two things. First, he and his press operators take the time to work with the slower-setting soy ink to avoid set-off problems. Second, at the time of the switchover, G&R began using a computer-controlled mixing program for PMS and specialty colors. To maximize benefits, Crotty decided to order inks without dryers so he could customize the drying characteristics of his inks and prevent skinning for partially-used inks in storage.

When Crotty and his press operators mix PMS and specialty inks, they can custom formulate the drying time for optimal press performance. Crotty is pleased with the amount of inventory reduction achieved with computer-controlled mixing, estimating that excess PMS color stock has decreased by about 40 percent since installing the system.

Crotty cautions that accurate measuring and using inks that do not have dryers already added are necessary to make in-house mixing effective.

In addition to focusing P2 efforts on inks, G&R has reduced volatile organic compound emissions from fountain solutions by replacing isopropyl alcohol with substitutes. It also employs chiller units with filters to keep solutions cool, clean and to avoid evaporation.

When G&R press operators switched to alcohol substitutes, they discovered they needed a water supply with low conductivity. They installed a reverse osmosis unit to eliminate metal salts in make-up water, which, according to Crotty, was immensely helpful in allowing the press operators to run IPA-free without scumming problems. Crotty also makes sure that his alcohol-free Heidelberg MOZ-P has quality rollers in place to guarantee that the technique is successful.

When Crotty started at G&R 14 years ago, he began to search for ways to save money in the press room and helped establish pollution prevention as part of the “cultural ethic” at G&R. By closely following industry publications and researching vendor information, Crotty continually watches for developments in pollution prevention that might benefit G&R's operations.

His advice to other lithographers considering implementing pollution prevention practices: “The less waste you create, the less you throw away, and the more money you save.” But, he cautions, “Don’t wait until the last minute to implement pollution prevention measures,” because you may well be at a competitive disadvantage to other printers who have made changes early on.

2.0 Prepress

Traditionally, images have been made with a camera using film that is exposed and then developed. A printing plate is then made from the photographic negative or positive and that plate acts as the image carrier to the intermediate (blanket) where the image is finally transferred to a substrate.

2.1 Traditional Imaging

Prepress can be divided into two steps: image processing and image transfer.

Image processing is the preparation of art or copy, typesetting, and photoprocessing. Image transfer is the preparation of a plate from a photographic negative or positive. The primary wastes during image processing and image transfer are processing chemicals, silver and wastewater.

Many of the procedures used to prepare and transfer an image are similar, so waste reduction options for image processing and image transfer will be presented together. Although photoprocessing and plate processing steps are similar, their individual waste streams (chemistries) should not be combined. Segregating waste will allow more effective reuse and recycling.

a. Image Processing

The printing industry uses photography to reproduce both art and copy, employing materials similar to those in other fields of photography. These materials include film, which has a paper, plastic or glass base covered with a light-sensitive coating (the photographic emulsion). This emulsion is usually composed of silver halide salts in gelatin. Silver halide salts include silver chloride, silver bromide and silver iodide. Most photographic film bases are polyester.

b. Developing an Image

An image is photographed and processed to produce a photographic positive or negative. Films or plate developing solutions are alkaline and typically contain benzene derivatives like hydroquinone, pyrogallol, catechol, p-phenylene diamine, p-aminophenol, metol, amidol and pyramidol. The most common developing agents are hydroquinone and metol. In general, developing solutions also contain an accelerator, which increases the activity of the developer; a preservative, which reduces oxidation damage to the developer; and a restrainer, which inhibits the formation of "fog" on the image. Developing solutions should be in trays only slightly larger than the materials being processed and solution temperatures should be maintained within 1/4° F of product guidelines (Jacobs Engineering Group Inc., 1988).

c. Fixing an Image

Developing action is stopped by immersing film into a fix bath of sodium thiosulfate (hypo), ammonium thiosulfate or sodium hyposulfite. These chemicals convert metallic silver to soluble complexes. Hypo, the major ingredient of fixing baths, also contains potassium alum, acetic acid and sodium sulfite. Acetic acid is used to keep pH low, which neutralizes the alkalinity of developing solutions and to stop the developing action.

Fresh fixing bath typically has a pH of 4.1, which is slightly acidic (Hartsuch, 1983). Alkaline developer is carried over into the fixer bath on films and prints, which raises the pH slightly. When the pH reaches 5.5, the fogging preventative becomes less effective, requiring the operator to change the fix bath or lower the pH by adding more acetic acid. An acidic stop bath is often used prior to the fixer to stop the action of the developing solutions and prevent fix bath contamination.

After the negative or positive is fixed, some of the fix bath chemicals (hypo) remain in the gelatin emulsion layer. Chemicals remaining in the emulsion can react with the silver to form yellow-brown silver sulfide. To prevent this, fix chemicals are washed from the emulsion in a water bath until the hypo is dissolved. For optimum hypo removal, water pH should be above 4.9 (USEPA, 1990).

Chemicals are used to change image contrast by reducing or increasing the metallic deposits on the film. Reducers oxidize some of the metallic silver in the emulsion to soluble salt, and intensifiers increase silver deposit blackness by adding silver or mercury to the developed silver grains in the emulsion. Small amounts of chemicals and silver rinsed from film can accumulate in the final water bath.

The photographic industry is the largest user of silver in the United States (49 percent) with an estimated 1985 usage of 58 million troy ounces (Cooley, 1988). In addition, American printers generated an estimated 40 million gallons of waste working-strength developer and 30 million gallons of fixer each year (Knapp, 1993). This reveals a need and opportunity for P2 in prepress operations.

Non-hazardous wastes generated during image processing include empty containers, used film packages, film spools and outdated materials. Recycling opportunities are presented in greater detail in section 7.

The primary components of the prepress waste stream are used film, silver dissolved from processing film and wastewater containing photographic chemicals. Photographic chemicals may have significant biological oxygen demand (BOD) that can interfere with the effectiveness of the receiving wastewater treatment facility. Local, state and federal requirements must be met prior to discharging silver-bearing solution to a wastewater treatment system.

A small amount of silver enters the fix bath solution each time film or paper is immersed. Insoluble compounds form after silver concentrations reach a certain level and cannot be removed from the photographic emulsion. Fix baths should be recycled before this point is reached. The critical silver concentration for fix baths is 0.27 ounces per gallon (2 grams/liter).

d. Proofing

After the image processing step, a proof is produced to show whether the color is correct and how the job will look when printed. The two most common proofs are press proofs and off-press proofs such as blue lines, color keys and chromo checks. Press proofs are more expensive, require a press and printing plates and generate more waste. Off-press proofs are produced directly (usually photographically) and serve as a quality control check of camera, scanner separations and corrections. Electronic imaging makes it possible to reduce excess waste from post-film proofing.

Wastes associated with press proofs are film, paper and developing chemistries.

2.2 Image Carriers

The printing process revolves around the intermediate image carrier -- a plate -- that accepts ink from a roller and transfers it to a rubber blanket. There are several types of surface plates used in offset lithographic printing: presensitized, laser imaged, electrostatic, diffusion transfer, photo direct and direct imaged plates.

Wastes associated with image carriers include damaged plates, developed film, acids, alkalis, solvents, plate coatings (dyes, photopolymers, binders, resins, pigment, organic acids), plate developers (isopropanol, gum arabic, lacquers, caustics), dated materials and rinse water.

Developing and finishing presensitized lithographic plates generates small volumes of wastewater. Therefore, the primary P2 effort when using presensitized plates is to reduce photographic chemistry consumption and to recycle the used plate.

2.3 Pollution Prevention Practices for Image Processing

The primary pollution prevention options for image processing are:

- ❖ material handling and storage
- ❖ material substitutions
- ❖ silver recovery
- ❖ photographic chemistry management
- ❖ wastewater reduction
- ❖ electronic technology
- ❖ digital prepress

a. Material Handling and Storage

- ✓ Chemicals sensitive to temperature and light should be stored according to manufacturers' directions.
- ✓ Storage areas should be free of dust or other contaminants that could destroy raw materials.
- ✓ Implement first-in / first-out inventory practices; watch expiration dates closely.
- ✓ Perform small scale tests of outdated materials prior to disposal (expiration dates are estimates.)
- ✓ Avoid overstock--order raw materials according to usage demands.
- ✓ Inspect new materials carefully, return damaged or near expiration supplies.
- ✓ Whenever feasible, purchase often used or high demand raw materials in bulk. Returnable or refillable totes are available from many vendors.

Improper storage and handling of raw materials can cause spoilage and increased inventories of out-dated or expired material. Many photoprocessing and plate developing chemicals are light and temperature sensitive. Chemical container labels list recommended storage conditions and shelf life that should be followed explicitly. Keep inventories using first-in, first-out practices, which will help reduce expired shelf life. Computerized inventory systems are available to track the amounts and ages of in-stock raw materials and may facilitate purchasing decisions. Purchase specialty or rarely used materials in quantities that will allow complete use prior to expiration whenever possible. Expiration dates are estimates and many factors affect their accuracy, so test expired products for effectiveness before disposal.

Large volume printers should purchase raw materials in bulk and make arrangements with their vendors to recycle the containers or return them in exchange for full containers of new product. Inspect all materials upon arrival--unacceptable or damaged product should be returned to the manufacturer or supplier. In addition, inspect materials prior to use to avoid using an unacceptable product.

b. Material Substitution

- ✓ Use dry positive proofs or aqueous developed proofs.
- ✓ Ask vendors for non-hazardous chemical substitutes to replace intensifiers and reducers that contain mercury or cyanide salts.
- ✓ Accept only non-hazardous product samples.
- ✓ Use silverless films such as diazo, vesicular, photopolymer, electrostatic or selenium-based.
- ✓ Use pre-sensitized lithographic plates.
- ✓ Discontinue using etched plates.
- ✓ Use water-developed plates.
- ✓ Ask vendors for non-hazardous developers and finishers.

Non-hazardous proofs such as dry positive proofs that use ultraviolet (UV) light to develop, or aqueous proofs that require only water for development can be substituted for hazardous ones. Vendors are excellent sources of information about substitutes for new or less toxic chemicals. Ask them to provide information about hazardous chemicals on a continuing basis. Use caution when accepting samples; be sure that the product does not contain hazardous components that require costly disposal.

Most spent films will pass the Toxicity Characteristic Leaching Procedure (TCLP) tests and not be a hazardous waste. (See Appendix A) However, photographic films are available that do not contain silver, and their development produces non-hazardous fixer wastes. In the past, these films have been slower speed than silver halide films, but film advances allow silverless films to compete favorably in both quality and speed. Diazo and vesicular films have been used for many years as silverless substitutes, but recently photopolymer and electrostatic films are more commonly used. Vesicular films have a honeycomb-like cross section and are constructed of a polyester base coated with a resin and light-sensitive diazonium salt. Photopolymer films contain carbon black as a substitute for silver. These films are processed in a weak alkaline solution, which is non-hazardous when the pH is adjusted to meet sanitary sewer discharge limits prior to disposal. Electrostatic films are non- silver films with speeds and resolutions almost identical to silver-based films. An electrostatic charge makes them light sensitive.

A new dry process film is being tested that contains selenium encapsulated in the polymer layer, where it remains throughout the life of the film. A combination of charging, exposure to light and heat development during the imaging process causes the selenium molecules to migrate deeper into the polymer layer, resulting in a visible image. Because selenium is a regulated toxic metal, film disposal could pose problems in some parts of the United States if a recycling program for selenium is not implemented by the film's manufacturer.

Again, ask photographic vendors for non-hazardous or less hazardous substitutes. Many commonly used photographic intensifiers and reducers contain hazardous compounds like mercury or cyanide salts. Non-hazardous developers and finishers are available that are reported to be non-toxic and have a flash point over 200^{0}F. Presensitized lithographic plates are an excellent alternative to metal etched plates. Some presensitized plates are processed with water only, further eliminating wastes. Plates can also be produced directly from copy or artwork, eliminating the need for photoprocessing.

2.4 Silver Recovery

- ✓ Install electrolytic deposition for silver recovery from fix solutions.
- ✓ Install metallic replacement canisters to recover silver.
- ✓ For large volumes of wastewater, install an ion exchange unit.
- ✓ Use an automated recirculating silver recovery, water recovery and chemical replenishment system.
- ✓ Recycle spent film and negatives when feasible.

Silver can be removed from fixer and bleach-fix. As much as 80 percent of the total silver processed for black and white positive and almost 100 percent of the silver in processed color work will end up in the fixer or bleach-fix solution. Silver is also present in rinse water following the fix because of carryover. Some facilities use a primary silver recovery unit, which removes the bulk of silver, in combination with a “tailing” unit to treat the relatively low silver concentration effluent from a primary recovery system.

Color developer effluent is not processed through a silver recovery system. Silver content of color developer is very low while its pH is high. If mixed with other silver bearing solutions, it reduces the efficiency of silver recovery and results in ammonia generation. Recovered silver can be sold for as much as 80 percent of its current market value. Desilvered fixer and developer can be reused once the silver has been removed and the correct chemical balance has been restored.

Photoprocessors commonly use three silver recovery methods. The first two, electrolytic (electrowinning) and metallic replacement are used to recover silver from spent fix solutions. The third method, ion exchange, is used to remove silver from rinse water. Ozone oxidation, reverse osmosis and chemical precipitation are less frequently used methods to recover silver.

a. Electrolytic Recovery

Electrolytic silver recovery is the process of passing silver-bearing solution between two electrodes. In an electrolytic recovery unit, a low voltage direct current is created between a carbon anode and a stainless steel cathode. Metallic silver plates onto the cathode. Once the silver is removed, the fixing bath may be reused by mixing the desilvered solutions with fresh fixer.

Many factors can affect the operation and efficiency of electrolytic silver recovery units. Always refer to the equipment manufacturer for specific operating information about the equipment. Common factors include:

Silver concentration--Recovery efficiency is directly related to the silver concentration of the fixer. The higher the silver concentration, the higher the plating efficiency. When silver concentration is below 1 gram / liter (0.12 troy oz. / gal), plating efficiency and plating current decrease rapidly, reducing the recovery rate.

Type of fixer--The type of fixer can greatly affect the electrolytic recovery process and the type of electrolytic cell required. For example, bleach-fix solutions require specially designed equipment. Special “electro” fixers are available with increased concentrations of sulfite. A sufficient amount of sodium sulfite must be present in the fixer for the electrolytic process to work properly because sodium sulfite is consumed during plating.

Line voltage--Another factor that can reduce plating efficiency is line voltage; low voltage will cause reduced plating. High voltage causes improper equipment operation. Optimal line voltage depends on the concentration of silver in the fix solution.

pH--The fixer’s pH has a direct relationship on plating efficiency of a recirculating silver recovery system. With conventional X-ray and graphic arts fixer, a pH of 4.5 to 5.5 is ideal. At a pH above or below manufacturer’s recommendations, recovery efficiency decreases drastically and plating may occur on tubes, photoprocessors and pumps. Specially coated paper kits are available from photo chemistry vendors to estimate the fixer’s silver concentration, sulfite concentration and pH. These inexpensive aids help maximize silver recovery efficiency.

Fixer solution desilvered by electrolytic recovery methods still contains higher than allowable levels of silver for discharge to the sewer. Acceptable levels of silver in wastewater vary widely, so contact a local wastewater treatment professional for information concerning the levels of silver allowable for discharge in your area. Using a follow-up recovery method or tailing method such as a metallic exchange canister to reduce silver to allowable levels is advised. Electrolytic recovery can be used as a batch recovery system, a continuous recovery system or as a recirculating recovery system. In batch recovery, overflow fixer is collected in a tank and stored. When a sufficient volume has accumulated, the waste fixer is pumped to an electrolytic cell for silver removal. The desilvered fixer can be discharged to the sewer (depending on remaining silver concentration), or reused. If reused, sodium thiosulfate is added to replenish its strength. Batch system cells are usually designed to desilver the fixing bath to silver concentrations of about 5,000 mg/l. The effluent typically contains 200-500 mg/l of silver. Tailing units (metallic exchange canisters) are required to further polish the effluent and reduce silver concentration to sewerable levels.

Recovery units operated on a continuous recovery program must be carefully sized to allow the fixer sufficient residence time for optimal silver plating. Some units can sense silver concentrations and will automatically adjust current densities.

Batch treated waste must be included in the monthly hazardous waste generation rate. Waste from both continuous and recirculating units does not need to be included because it is not stored.

Recirculating electrolytic silver recovery systems are installed in-line to remove silver at approximately the same rate that it is added by film processing. A continuous stream of fixer from in-use process tanks is circulated through the unit, silver is removed and the fix is returned to the process tank for reuse. Each photoprocesser requires a separate unit. Different types of electrolytic recovery systems are available for treating all types of non-bleach fix bath equipped with circulation pumps. Fix chemistry requires monitoring and replenishment as needed.

In all applications of electrolytic silver recovery, be sure to control the current density so that “sulfiding” does not occur. Sulfiding is the decomposition of thiosulfate into sulfide at the cathode. This contaminates the deposited silver and reduces recovery efficiencies. Remember this rule of thumb: the higher the silver concentration, the higher the current density can be without sulfiding. Therefore, as silver is plated out of solution, the current density must be reduced.

b. Metallic Replacement

The metallic replacement method for silver recovery is based on the principle that a more active metal (iron, zinc or aluminum) will replace a less active metal (silver) in solution. Spent fixing bath passes through a canister or bucket containing steel wool or a mesh screen. The silver settles to the bottom of the canister as a sludge. The silver-bearing sludge needs to be refined further; therefore, its resale value is considerably lower.

The amount of silver that a recovery system should yield can be calculated by multiplying the silver concentration of the solutions entering the recovery cartridge by the volume of solution being treated. For example: If the average concentration of silver in the solution is 1/2 troy ounce per gallon (as measured using a test strip) and 400 gallons are treated, the potential recovery is 200 troy ounces of silver.

Specially designed silver-estimating test papers impregnated with a chemical substance that changes colors according to the amount of silver present in a solution are used to determine a solution's silver concentration. These test papers should also be used to determine the silver content of effluent from the final cartridge. To test for silver levels of less than 1 gram/liter, soak the test papers in the solution being tested for one hour before comparing to the color indicator.

If a canister fails to collect silver or the silver yield does not meet expectations, any of the following may be the cause:

- Type of film being processed
- Exposure level
- Processing work load
- Replenishment rate
- Solution carry-out
- Obstruction of solution flow
- Channeling
- Flow rate
- Incorrect type of recovery cartridge
- Incorrect installation
- Chemical condition of the fixing solution
- pH of the fixer

A series of canisters is recommended to recover silver. When canisters are used in a series, the first canister removes the bulk of the silver, and the second polishes the effluent of the first and also serves as a safety factor if the first unit is overloaded. When the first canister is exhausted, the second becomes the first, and a fresh unit replaces the second. Change-out is recommended when the silver in the effluent of the first cartridge reaches 25 percent of the influent concentration. For most effective operation, the pH of solutions passing through the metallic replacement canister should be between 5 and 5.5. Below 4, the steel wool dissolves too rapidly; above 6.5, the replacement reaction is so slow that silver removal is incomplete. Proper pH control is critical for high silver recovery (KODAK, 1986).

A series of metallic replacement canisters can recover approximately 85 percent of the recoverable silver in the form of sludge. Fixer that is desilvered using a metallic replacement bucket can not be reused as fix chemistry because of the excessive iron concentration in the effluent (~4,000 mg/l). Metallic replacement buckets may remove silver to levels acceptable for discharge to the sanitary sewer (KODAK, 1986).

c. Ion Exchange

Ion exchange is the reversible exchange of ions between a solid resin and a liquid. The silver-thiosulfate complex has a high affinity for the resin, making silver reclamation and resin regeneration difficult. Resin plugging by suspended matter such as gelatin has been a problem. Ion exchange recovery is used to polish silver-bearing rinse water and can produce effluent with silver concentrations as low as 0.1 ppm, recovering as much as 98 percent of the silver. Typically, ion exchange is used with large volumes of rinse water.

d. Silver Recovery from Scrap Film and Paper

Scrap film and paper contain silver salts or elemental silver. Silver recovery services may agree to recycle scrap film and paper with the silver recovered from spent fix. Another option is the removal of silver from unprocessed scrap film and paper by treating the material with sodium hypochlorite solution to oxidize elemental silver to a silver salt. Once dissolved in the fixer, silver can be recovered using any of the methods previously discussed.

Because scrap film can be messy, processed or unprocessed film can be soaked in an agitated hot sodium hydroxide solution to remove the emulsion. Silver can be separated from this solution by settling, centrifuging or filtering.

2.5 Photographic Chemistry Management

- ✓ Add acetic acid to fix bath.
- ✓ Use an acid stop bath prior to fixing.
- ✓ Closely monitor chemical replenishment.
- ✓ Keep chemical containers closed.
- ✓ Add marbles to bring the level of partially used chemicals up to the top to lessen chemical oxidation.
- ✓ Install floating lids.
- ✓ Use squeegees during hand development or install them on automatic processors.
- ✓ Reuse color developer, adjust as needed.
- ✓ Reuse desilvered fixer, replenish as required.

Process bath life can be extended by adding ammonium thiosulfate, which doubles the allowable concentration of silver buildup in the bath, using an acid stop bath prior to the fix bath and adding acetic acid to the fixing bath to keep the pH low. Contact the chemical vendor and/or manufacturer for product information and suggested methods to extend the bath life.

Using squeegees to wipe excess liquid in a non-automated processing system can reduce chemical contamination in carryover from one process bath to the next by 50 percent (TIP). Minimizing contamination increases recyclability, extends the life of process baths and reduces the quantity of replenisher chemicals required to complete processing. Be cautious when using squeegees; film may be damaged if the image has not hardened completely.

Floating lids can reduce contamination and evaporative losses in bleach and developer tanks. Small scale developers can use glass marbles to raise the liquid level of process chemicals to the brim of the container each time the fluid is used. This procedure extends chemical life by reducing the amount of oxygen to which the liquid is exposed.

2.6 Wastewater Reduction

- ✓ Employ countercurrent rinsing techniques.
- ✓ Recirculate rinse water.
- ✓ Use automatic flow controls for rinse water.
- ✓ Use rinse bath agitators.

Compared to traditional parallel tank wash systems, counter current washing reduces the amount of contamination in processing solutions and conserves water. Rinse water is used in the initial film wash and fresh water is introduced only at the final rinse stage, where most of the contamination has been removed by earlier stage rinsing.

Automatic rinse water flow controls can be installed in place of continuous flow systems that constantly consume water whether film is being processed or not. Set automatic water flow controls to ensure a complete water change-out in the tray once every five minutes. The method by which the water enters and leaves the washing tank also affects the efficiency of the washing process. Best results are achieved when water enters at the bottom of the tray and leaves at the top. Moderately warm wash water (80°F) helps remove the hypo. Automatic water and temperature flow controls, when used in conjunction with mechanical agitation, can decrease hypo removal time by 30 percent (USEPA, 1990).

2.7 Electronic Technology

Recently, prepress has undergone tremendous technological change with the explosion of electronic capabilities and computer chip technology. The goal of electronic prepress is to create a completely digital master copy by using computer systems that electronically combine type, drawings and images. Electronic prepress and imaging may involve preparing text using a personal computer to create disk files, create page layout, graphics and for typesetting. Editing is immediate and design elements are easily manipulated by composition software programs.

Scanners can be used to scan images and send them directly to make plates. and images can now be created electronically with digital cameras. These cameras capture an image, digitize it and either store the image for input at a later time or immediately transport the image to a computer for editing or enhancement.

The obvious advantages of electronic prepress are speed, reduced prepress costs associated with traditional methods, labor savings, editing time and ease, the ability to integrate a number of files on disk and unlimited creative options.

Another major benefit of electronic prepress is the opportunity to reduce or prevent pollution (silver-bearing wastes) typically generated using traditional methods.

Digital prepress also has some disadvantages, including the high initial cost (~$30,000 and up) of acquiring the necessary computer hardware and software, scanners and expansion or add-on technologies such as digital cameras. Technicians may also require training.

Many printers find that a combination of traditional and desktop publishing works well and is cost-effective. Emerging technologies and trends in electronic publishing will be covered in Section 6.0.

Case Study B

Desktop Publishing

Rapid Printing, Des Moines, Iowa, responding to increases in chemical and disposal costs, moved away from traditional typesetting and printing to desktop publishing.

Initially, Rapid Printing purchased a Macintosh and a printer. Kevin Brown, owner, tried to run a hybrid system with one desktop publishing system and four traditional Compugraphic typesetters. The desktop publishing system sat in the box until Brown contacted a consultant to install the software and train his staff. Once the staff became familiar with the Macintosh, it became the system of choice, which made integrating both systems difficult.

The time had come to make a choice: desktop or traditional.

"There really was no choice, my employees loved desktop publishing because it worked great, it saved time, and my old typesetters were about worn out....one Mac simply could not do the work of four typesetters," Brown commented.

Brown secured a $23,000 loan to purchase three more Macs, a second laser printer, and replaced the original Macintosh with a newer, large screen model. With these purchases he had desktop publishing stations capable of matching the demand. The changeover allowed Rapid Printing to expand its font library from 80 to 400. Graphics capability increased dramatically. The software selected included page design, drawing and image manipulation programs. Again, the consultant set up the entire desktop publishing system and trained employees.

The transition was "just painful! Going cold turkey for the first three weeks was a nightmare," said Brown. There were the inevitable bugs to be worked out of the programs, they had trouble downloading fonts correctly so that the computer would read them. Additional sub-programming was needed to hold the large number of fonts now available. They even experienced a total shutdown of the system until the problems were ironed out. The consultant walked them through every step of the process, training the employees how to troubleshoot and solve problems, not just which keys to hit to fix something.

Brown's advice to printers who are contemplating desktop publishing: "Find a good consultant, shop around, do not overlook universities, colleges or community colleges." They have job placement offices and internship programs that provide programmers at a reasonable cost. Established consulting firms also provide assistance but at a much higher cost. "Shop around before you make a decision, but hire the best consultant you can afford."

Brown and his employees have set the stage for future activities focusing on P2 and emerging technologies. Currently, Brown is seeking additional capital to purchase four more computers to expand and update his current desktop capabilities. Ultimately, Brown plans to adopt technologies such as direct-to-plate to eliminate traditional photoprocessing and plate making and the hazardous wastes that are typical of these traditional methods.

2.8 Digital Prepress

Digital technologies eliminate pre-press waste even further than desktop publishing by directly transferring a computer-generated image to the plate.

Although there are many different types of digital technologies, this manual only addresses direct-to-plate, direct-to-press, and digital proofing from the waste reduction aspect. Direct-to-press is addressed in Section 6.2

a. Direct-to-plate

Direct-to-plate technologies enable a printer to image a computer-generated design directly to the plate. Digital plate quality exceeds film-based because there is no image degradation from film contact with the plate.

Other advantages of direct-to-plate technologies are:

- ❖Reduced labor costs from stripping and platemaking as customers supply jobs on computer disks.
- ❖Reduced material costs by eliminating film and processing.
- ❖Significantly reduced solid waste (paper) and potentially hazardous waste (film and processing chemistry).
- ❖Reduced makeready times and reduced waste generation by eliminating defective plates caused by misregistration, dust, contact, and vacuum problems.
- ❖Lower cost for short-run projects.
- ❖Prepress waste eliminated.

Many printers and prepress shops have successfully integrated digital technology to varying degrees. As digital methods are integrated into prepress production, printers need not worry about losing customers who do not use computers because conventional art work can be digitally scanned into the system.

The most common drawbacks of direct-to-plate technology are:

1) plates that develop problems need to be re-imaged
2) desktop file problems, such as improperly set text
3) color management problems on the press can significantly reduce press productivity.

Even with these drawbacks, the advantages of reduced labor, reduced film costs and reduced makeready time on press still make direct-to-plate a viable option for many printers.

"Medium and larger printers should begin exploring the implications of direct-to-plate. The savings promise to be tremendous, and the more files that go desktop, the more sense it will make. Careful planning and exploration of technology options and work flow redesign will lead to a productive solution when the time is right for you," (White, Time 1994).

b. Digital Proofing

Traditional proofs show exactly what will be on the final product because they are made directly from the films that will be used to make the plates. Although film proofs are not perfect in color representation, anyone experienced with reading proofs can judge what is specified in the proof.

Traditional proofs are costly because they are labor intensive to produce and materials are expensive. The largest cost to digital proofing is the capital investment in equipment. Once integrated, digital proofs are easily, quickly and inexpensively generated.

The largest growth area and the most cost-effective for printer and customer is in intermediate or scatter proofs. Even if customers distrust digital for the final proof, it is still cheaper and faster to use digital proofs for approving type, position and color breaks. Additionally, when customers have short runs, they may not be willing to spend a lot of money to proof a color job if the job is to be printed inexpensively on a short-run digital press. "Speed, and especially money, are really underlying the move toward digital proofing. (Hannaford 1994)."

The biggest disadvantages of digital proofing are the capital investment in equipment and a few technical limitations. For instance, currently no standard PostScript interface exists, so files must be in standard high-end CEPS (Color Electronic Prepress Systems) formats. Also, the product is only set for SWOP (Specifications for Web Offset Publications) ink standards. New technology integration will eliminate most of these disadvantages.

Currently, Kodak, 3M, and others have established direct digital color proofing systems. Although the products are different, all systems output proofs that are similar to analog film proofs with color separations laid together and laminated to produce a composite view. These are similar to traditional proofs and a halftone screen can closely approximate the final output, eliminating the need for hard copies. Color copiers and color laser printers are also used to supply color proofs. This saves time and money while reducing proofing waste.

c. Soft Proofing

Proofing can also be done on-screen via computer networks (soft proofing). Images can be digitally transmitted by modem to the client for approval or the client can come in to view the soft proof. The limiting factor to soft proofing is the color accuracy of the monitor. Monitors are available that are color correct. This is a good way to approve layout, text and other parameters.

Once the soft proof is approved, the operator can output a digital hard proof. If that is satisfactory, film can be produced for the final off-press proof. Soft proofing reduces prepress waste and saves time and money.

3.0 Printing Inks

Successful lithographic printing using both traditional water-based processes and waterless technologies requires the press operator to be part skilled craftsperson and part chemist. Lithographic ink, fountain solution, water, substrate and press adjustment all play a role in achieving the proper image. Fine tuning the balance between these elements allows the press operator to produce salable products. Inks are perhaps the most important aspect of the overall process because different ink formulations impart different characteristics to the ink and thus affect its performance in relationship to the other press elements.

a. Ingredients

Lithographic inks are oil-based, allowing them to resist the fountain/water attracting portions of the lithographic plate and maintain the plate image. Traditionally, ink oils have been petroleum-based, but ink manufacturers are continually developing inks that substitute much of the petroleum oil with vegetable-based oils such as soybean oil. The oil base or "vehicle" portion of the ink serves to transport and bind pigments in the ink to the substrate (Eldred, 1992).

Prior to the mid-1970s, pigment relied heavily on inorganic metals to provide ink color (Hutchinson, 1986). These metals were often present in amounts exceeding state and federal regulatory limits, rendering waste ink hazardous. State governments have further restricted the amount of metal pigments allowed in printing inks, particularly for packaging inks (REC, 1992). In response, ink manufacturers have developed organic coloring replacements, many of which are not as heavily regulated as the earlier metal compounds (Hutchinson, 1986). However, some of the new pigments are manufactured from derivatives of benzene, and sometimes still contain metals. A recent study analyzed the presence of the heavy metals (cadmium, arsenic, mercury, antimony, lead, and selenium) in lithographic inks. Although no single metal exceeded 10 parts per million (ppm) in samples, levels for the combined metals often exceeded 30 ppm and ranged as high as 39 ppm (Donvito et al., 1992). Depending on the metal and the amount of waste ink being generated, these levels often exceed regulatory limits, making the waste ink hazardous.

Other ink additives include solvents, varnishes and dryers of various kinds. All of these additives are used to control the ink flow characteristics preventing pigment flocculation and to accelerate drying (Eldred, 1992). Figure 3.1 lists some of the common ingredients in printing inks, highlighting the ones most likely to be regulated by state and federal environmental, health and safety laws. With 1 million new ink formulations released each year, it is impossible to list every ingredient used in every printing ink (Dennis & Jenkins, 1991).

Lithographic Printing Ink Constituents Potentially Found in Paste Inks

Vehicles / Varnishes	Commonly Used Chemical Formulations
Rosin esthers	**Rosin and pentaerythritol**
Long-oil alkyd	Phthalic anhydrite and glycerol
Phenolic resin	Phenol and formaldehyde
Hydrocarbon resin	**Ethylene, butadiene and indine**
Modified resin	Maleic acid and maleic anhydride
Waxes	Natural and synthetic
Mineral oils	Natural and synthetic
Soya / vegetable	Linseed, tall, canola, soybean and safflower oils
Resin / solvent varnishes	**Variety of hydrocarbon solvents**
Drying oils	Alkyd, urethanes and phenolic resins
Urethanes	**Toluene diisocyanate and trimethylol propane**
Other resins	**Nitrocellulose, polyanid, polyurethane resins**
Emulsion from co-polymers	**Polyvinyl chloride and PVC co-polymers Acrylic co-polymers, polystyrene and styrene-based co-polymers**
Pigments	
Organic Pigments:	
Carbon black	Graphite
Organically derived pigments:	**Benzene, Napthalene and Authracene derivatives**
Rhodamines	
AZO pigments	
Organic yellow	**DCB (Dichloro benzene)**
Red	**Barium salts of red AZO pigments**
Cyan blue and green shade cyan	Copper Phthalocyanine
Inorganic Pigments:	
Whites	Calcium carbonates, clays and titanium dioxide
Yellows	**Lead, chromium**
Reds	Iron oxide pigments
Solvents	
Aliphatic hydrocarbons	**Parafins, heptane, hexane**
Alicyclic hydrocarbons	**Cycloparafins, terpenes**
Co-solvent mixtures	**Alcohols and hydrocarbons**
Glycol ethers	**Propylene glycol- monbutyl ethers**
Dryers	
Metal Dryers	Cobalt and nickel containing metal dryers

Constituents listed in this table are included for completeness. These compounds may or may not be present in waste ink. A careful analysis of vendor information is necessary to determine the constituents of a waste ink. **Bolded constituents** may be regulated depending on concentration and overall volume of wastes. Some constituents may be regulated more heavily in one state and not another. Check with your state environmental compliance office of technical assistance center for more information.

* Information for this figure derived from Chemistry For The Graphic Arts, Ellred, 1992 and Environmental Law Index to Chemicals, Government Institutes, Inc., 1993.

Figure 3.1

b. Regulations

Printing inks can contain material that makes them hazardous. The EPA lists some chemicals as hazardous while other chemicals are only considered hazardous if they exceed regulatory levels. In the latter case, laboratory testing is required to determine if the chemical concentrations constitute a hazardous waste.

The need for specific tests can be determined by examining the Material Safety Data Sheets (MSDS) supplied by ink vendors, which list potentially hazardous ingredients. Testing can be arranged through analytical labs to determine if ingredients exceed regulatory limits. Regulatory limits for hazardous components of inks are listed in Appendix A.

Unfortunately, even if waste ink does not test hazardous, state waste authorities and local landfill operators may refuse waste ink shipments because of restrictions on accepting "free liquids" for fear that petroleum-based inks may cause contamination. Thus, inks may have to be disposed of by an EPA-licensed hazardous waste management company. Additionally, depending on the amount of hazardous wastes generated, each facility must meet requirements for obtaining an EPA identification number as a generator of hazardous waste, track the generation and disposal of hazardous waste, monitor the hazardous waste storage area and accomplish these tasks within specific time frames.

The 1990 Clean Air Act Amendments (CAAA) mandate implementation of monitoring and control guidelines for a variety of hazardous air emissions from specific industrial processes, including lithographic printing. Nationwide, lithographers spend over $110 million annually to meet these requirements (ER, 1993). This has focused the printers' and lithographic ink, fountain, and solvent suppliers' attention on the volatile organic compound (VOC) content of their inks, solvents, and fountain solutions. Petroleum-based heat-set inks have higher VOC contents than soy / vegetable oil-based heat-set inks, while electron beam and ultraviolet curable inks produce no VOCs (Tellus, 1993).

The issue of how serious lithographic ink VOC emissions are, from a regulatory standpoint, has been a point of contention in recent years, and the new guidelines are expected to address this (Lustig, 1993). Nevertheless, for printers faced with controlling VOC emissions from their operations, ink choice can contribute to or help reduce emissions.

3.1 Reducing Waste Ink

Color changes, press cleaning and poor ink management such as drying and skinning generate waste ink. Careful attention to good operating practices, process changes and / or product substitutions can decrease the amount of waste ink generated. Reduced disposal costs, monitoring requirements and liability issues related to waste ink generation and disposal will result. A comprehensive list of approaches for each of these three categories is included as Figure 3.2.

Testing, monitoring, assuring proper disposal and completing the paperwork related to waste management activities requires significant employee time and managerial support. This can contribute to overhead costs, which must be considered in addition to the waste ink disposal expense.

Good operating practices (GOPs) are often the most cost-effective way to decrease the amount of waste ink generated. Using careful and consistent GOPs requires building employee commitment and interest in pollution prevention as well as managerial support to encourage employee participation in pollution prevention programs. GOPs include careful inventory control, and careful scheduling and managing of jobs. Most GOP approaches focus on wise raw material management and careful pre-thinking prior to running print jobs, so work is accomplished with a low margin of error, decreasing waste generation. A variety of GOPs

REDUCING INK WASTE - Good Operating Practices

- Keep ink containers sealed and contents leveled; place plastic or waxed paper on top of the ink to prevent oxidation.
- Scrape as much ink from empty cans as possible prior to disposal or recycling of ink tins.
- If the firm is large enough, presses can be dedicated to specific colors or as "hazardous inks" only presses, decreasing the number of cleanings needed for each press.
- Use a standard ink sequence for process colors.
- Schedule runs from lighter to darker colors to decrease the amount of cleaning necessary.
- Recycle light colors into darker and specialty colors.
- Return unused excess ink to the manufacturer.
- Improve accuracy in job estimation.
- Segregate waste ink colors for recycling.
- Carefully monitor inventory to assure that older inks are used in a timely fashion and inks are only ordered if necessary.
- "Prethink" printing jobs and counsel customers about the environmental impacts associated with particular color, paper, or printing method choices. Make sure that print jobs reflect the true cost of doing business and disposing of hazardous wastes.

PROCESS CHANGES

- Install an ink agitator or an ink leveller on the ink tray to prevent premature oxidation of ink.
- Recycle waste inks in shop or through an ink recycling service.
- Use a computer controlled mixing program in conjunction with a digital scale for mixing PMT colors.
- Use an anti-oxidant spray to prevent skinning of ink in the ink fountain.
- Use a digital scale whenever measuring out ink for a job to improve accuracy.

PRODUCT SUBSTITUTION

- Vegetable/soy inks
- Ultraviolet curable inks
- Electron beam curable inks
- Water washable ink systems
- Waterless inks

Figure 3.2

are applicable to ink management. These include:

- Keep ink containers sealed and contents leveled; place plastic or waxed paper on top of the ink to prevent oxidation and spray ink with an anti-skinning agent.
- Scrape as much ink from empty cans as possible prior to disposal or recycling.
- If the company is large enough, presses can be dedicated to specific colors or to hazardous inks only, decreasing the number of cleanings needed for each press.
- Use a standard ink sequence for process colors.
- Schedule runs from lighter to darker colors to decrease the amount of cleaning necessary.
- Recycle light colors into darker and specialty colors.
- Return unused excess ink to the manufacturer.
- Improve accuracy in job estimation.
- Segregate waste ink colors for recycling.
- Carefully monitor inventory to assure that older inks are used in a timely fashion and inks are only ordered if necessary.
- "Prethink" printing jobs and counsel customers about the environmental impacts associated with particular color, paper or printing method choices. Make sure that print jobs reflect the true cost of doing business and disposing of hazardous wastes.

Process changes can be as simple as installing an ink agitator on the ink fountain to prevent skinning or as complicated as implementing an in-house ink recycling system (GATF, 1989). Process changes usually require some equipment purchases and employee training. Process changes include:

- Installing an ink agitator or an ink leveller on the ink tray to prevent premature ink oxidation.
- Recycling waste inks in shop or through an ink recycling service.
- Using a computer controlled mixing program and a digital scale for mixing PMT colors. These programs allow the lithographer to custom mix any ink color from colors already in inventory. This decreases the purchase of new colors and increases the use of existing inventory. A digital scale makes the entire process more accurate and decreases the amount of ink wasted as a result of "guesstimation" errors.

To insure waste reduction benefits, it is important to buy inks without dryers. Dryers should be added by the printer as needed. Case study C describes one printers experience with computer controlled mixing.

Case Study C

Ink Inventory Reduction By In-house Ink Mixing

Woolverton Printing Company, Cedar Falls, Iowa, is a full service lithographic printer offering type and art, prepress, press and bindery services. In a cooperative effort with the Iowa Waste Reduction Center, John Lynch, CEO, and Mitch Weinberg, operations manager, implemented an in-house ink mixing program for specialty colors. Woolverton desired to reduce a high inventory of unused inks and hoped to reduce the costs associated with purchasing new ink colors by mixing its own inks. Lynch and Weinberg also anticipated that increased attention to the amount of ink needed, mixed, and used for specific jobs would improve the press operator's accuracy and decrease ink waste.

With assistance from the IWRC, Woolverton was able to purchase the basics needed to establish an in-house ink mixing program. This included a computer program to describe the exact type and quantity of ink needed to mix a specific specialty color from inventory already on hand, the computer hardware needed to run the program and print the recipes for specialty colors, and a digital scale able to display weights in fractions of ounces or grams. This equipment costs approximately $2,500 to set-up and install.

Once the program was installed, Woolverton employees could mix any color needed for a specialty job from existing inventory. It also allowed employees to mix fractional amounts using the digital scale instead of having to mix whole pounds or ounces of ink.

IWRC staff members and Woolverton employees hoped to decrease inventory, decrease waste ink generated and increase accuracy when mixing inks required for specialty colors. To evaluate the effectiveness of this program, an inventory was generated from a series of 119 jobs without using the in-house ink mixing system. Woolverton employees carefully recorded the amount of ink used and wasted using the digital scale. Press operators then monitored an additional 116 jobs using the in-house ink mixing program and carefully recorded the amount of ink used and waste generated. Employees also watched for a decrease in the inventory generated from the original 119 jobs.

The in-house mixing program reduced inventory 40-50 percent. The press operator was also able to more accurately gauge the amount of ink needed for a particular job and; thanks to the digital scale, measure the exact amount. However, the amount of ink wasted as skins removed from mixing colors increased 17 percent when the in-house ink mixing program was used.

Weinberg attributes the mixed results to a variety of factors. A limited number of jobs were monitored with and without the ink mixing program in place. It was also impossible to control the types of jobs being monitored. The difference in the amount of ink wasted could be a distortion resulting from these uncontrollable variables.

When the ink mixing program was in place, a higher number of church jobs came through requiring reflex blue, which tends to form thick skin faster than other inks. Additionally, all inks in stock at Woolverton already have dryers added to them. Purchasing inks without dryers and adding them when the color is mixed will decrease the amount of waste skins.

Operator experience is also a factor. As press operators become more adept at mixing their own colors and the shop superintendent is able to plan ahead and use as few mixing colors as possible to achieve the desired specialty color, the amount of waste skins will be reduced.

Overall, Weinberg was pleased with the inventory reduction and the ink mixing program's user friendly characteristics.

"Even for the computer illiterate, this program is easy to use," Weinberg said. He believed that in-house mixing is well worth the time and as press operators gained experience with the mixing program and digital scale, they would reduce the amount of waste skins generated. "Overall," states Weinberg, "using the mixing program is a lot easier than the old method of mixing one pound increments of ink or ordering out specialty colors."

- Using an anti-oxidant spray to prevent ink skinning in the fountain. Readily available from ink vendors, these substances act as physical barriers to oxygen, inhibiting the drying reaction. Once the press is running, the anti-oxidant "burns off" on the ink roller, greatly reducing or eliminating its effect. The inks can then dry on the substrate.
- Using a digital scale whenever measuring ink to improve accuracy.

Many lithographers have been successful in reducing the amount of waste ink generated by recycling it on site or by contracting with a recycling service to blend it into darker colors for reuse. Companies such as Semler Industries, Inc., Franklin Park, IL and Resource Recycling and Remediation, Inc., Pittsburgh, PA sell equipment designed to filter and distill waste inks for reuse (Watson, 1988). Research has shown that when a company generates 100-200 gallons of waste ink per week and uses mostly dark colors, on-site filtration, distillation and reuse are cost-effective (Gavaskar et al., 1993). The recycled ink compares favorably to new ink in tests for grind, residue, viscosity, tack, water content, and water pickup.

Some ink recyclers also recycle waste ink on site (Logsdon, 1993). Recyclers provide totes for process color segregation and produce satisfactory final products. Once again, it is important that the generator use sufficient ink quantities for this solution to be viable.

Case Study D discusses one lithographer's experiences with such an ink recycling service.

Case Study D

Ink Recycling to Go

Harry Brinkman, Director of Regulatory Compliance for MetroWeb, in Earlanger, Kentucky, runs two full-web Heidelberg M-300's using about 17,000 pounds of ink per month. Wanting to reduce waste ink, Brinkman considered in-house and outside recycling options without finding a service to fit MetroWeb's needs.

At a trade show, Brinkman discovered Pro-Active Ink Recycling, a Canadian-based ink recycler that brings a mobile ink recycling unit to facilities across the U.S. and recycles ink, mixed or color separated, on site.

MetroWeb tried this service and realized the savings. By recycling on site, MetroWeb can avoid the legal liabilities and paperwork associated with off-site recycling or disposal. Additionally, MetroWeb learned that by working closely with the technician, they could produce recycled process colors very similar to unused inks. Press operators were able to adjust the ink / water balance and produce results comparable to new inks without experiencing trapping problems.

"Pro-Active even helped us find reusable 3,000 pound totes to supply ink to our presses," states Brinkman, "and they supply color-coded storage containers for waste ink." By providing good follow-up with press operators about waste ink segregation practices and the costs associated with ink disposal, MetroWeb achieved good adherence to waste collection and segregation programs, which helps make it cost beneficial.

"My cost per pound for new ink is $1.80 while the recycled ink costs $1.05 per pound for nearly comparable quality," Brinkman said. "And this cost does not include the cost we previously paid for disposal of waste ink. Service is excellent. I can call [Pro-Active] up and they will work me into their schedule in a week or two."

While MetroWeb has had excellent success with its programs, Brinkman has these words of advice for other printers: "Pro-Active has been very good for us, but small quantity ink generators [under 100 gallons a month] should consider shipping waste to a recycler and having it sent back." However, you lose a lot of control over ink quality and processing when it is sent off-site. For larger quantity generators though, "savings can be magnificent provided you can work with someone who will work with you to produce a product that runs [on the presses] well," Brinkman said.

Material substitutions can decrease the amount of waste ink generated. Many lithographers have successfully substituted petroleum-based inks with electron beam curable (EBC), ultraviolet curable (UVC), soy / vegetable, high solids and waterless inks to decrease the toxicity and amount of waste ink. Material substitutions will be presented in-depth but generally include using:

- Vegetable / soy inks
- Ultraviolet curable inks
- Electron beam curable inks
- Water washable ink system
- Waterless inks

3.2 Soy / Vegetable Oil Inks

Soy and vegetable oil-based inks, especially linseed oil-based inks, were once commonly used, but with the advent of high-speed presses were replaced with faster setting petroleum-based inks. The drying time of soy / vegetable-based inks has been one of the major drawbacks to their use (PM, 1991). However, many printers find that customizing dryers and using drying powders helps obtain desirable results. Soy inks are 2-5 percent more expensive than traditional petroleum inks.

Even though vegetable oil inks contain non-petroleum oils, a certain percentage of the oil is still derived from petroleum. Figure 3.2 lists the percentages of soy oil that various categories of ink must contain to be certified by the American Soybean Association (ASA).

Soy inks have considerably lower VOC emissions than petroleum-based inks based on EPA test methodologies, and they are manufactured in part with a renewable resource: soy / vegetable oil. Some printers, especially newspaper printers, have achieved increased coverage and excellent color with most colors of soy ink except black (NSIIC, 1994).

Certified Soy Inks

Ink Types	Required Percent Soy Oil
Heat-set Ink	7% of Total Formulation Weight
Cold-set Ink	30% of TFW
Business Forms Ink	20% of TFW
Black News Ink	40% of TFW
Color News Ink	30% of TFW
Sheet-fed Ink	20% of TFW

Figure 3.3 (NSIIC, 1994)

Further, some sources claim that soy-printed products are more readily deinkable by wastepaper processors and produce a less hazardous sludge, making them more recyclable than petroleum printed products (Rosinski, 1992; NAPIM, 1991). Case study E describes a newspaper lithographer's experience with soy ink.

Case Study E

Switching From Rubber Based Inks to Soy Based Inks

Rapid Printing of Urbandale, Iowa, wanted to improve its workplace air quality and decrease ink rub-off on finished products. Kevin Brown, president and publisher, began working with the Small Business Pollution Prevention Center (SBPPC) at the University of Northern Iowa to implement a change from rubber-based ink to soy-based ink in his printing operations.

Brown hoped to realize improvement in air quality during press runs but also improvements in print quality, decreased rub-off and less failure in Rapid Printing's collator. The collator is an older model machine that jams when rubber-based ink builds up on the rollers.

Pat McMurray, press operator, carefully monitored his A-B Dick 360 and 385 presses during the switch, noting difficulties and / or improvements in ink performance. The average press age was 20 years and both the 385 and the 360 used Grace poly-cell compressible blankets. Impressions per run ranged from 500 up to 1,500.

McMurray discovered that the soy colors were more solid than the rubber based product. Odor during press runs was significantly reduced with the soy based ink, and the purchase cost was lower. Clean-up also required less solvent. Time spent per clean-up job was about the same for the soy and the rubber based inks, and makeready was not significantly different. He also noticed that he was cleaning the collator rollers less when using soy ink.

Problems arose with press runs of over 700 impressions using the soy ink. Quicker drying caused toning on the plate and necessitated more frequent press cleaning in addition to increased fountain consumption. Certain colors, such as reflex blue, seemed to dry more quickly than other colors. Runs of 700 impressions or less, encountered none of these difficulties. McMurray is now investigating having dryers custom blended or mixing in his own dryers to eliminate the toning problem.

Ambient air quality tests indicated that, compared to the rubber based ink, VOCs from the soy ink were greatly decreased. During the longer runs when toning became a problem, VOCs from the fountain were increased. Both Brown and McMurray hope that the toning problem can be overcome by working with the ink supplier.

Overall, Brown was pleased with these initial results and would like to continue working with the soy inks to improve their performance. He felt that the color quality of finished jobs and the low VOC emissions from the inks warrant further work. He was also pleased with customer inquiries about using new soy inks, "We have had customers call because they were intrigued that we were using soy inks," states Brown. "We definitely will consider using only soy ink on our future jobs."

3.3 Ultraviolet and Electron Beam Curable Inks

EBC inks consist of low-molecular-weight polymers able to react with a stream of electrons from a vacuum tube containing a linear cathode which can generate several hundred kilovolts of energy (ESI, 1994). The action of the electrons drives a polymerization reaction which causes polymers to form and the ink to set. A similar process cures UVC inks which react under ultraviolet-spectrum light to complete the polymerization reaction and set the ink (Eldred, 1992).

Both EBC and UVC inks will not cure until exposed to either electron beam or ultraviolet energy. Therefore, they can be left in the fountain overnight without skinning. This decreases both press cleaning time and waste ink generation. Also, EBC and UVC inks do not emit VOCs because they contain no solvents and they eliminate the problem of "off-set" in letterpress printing allowing for high-speed press runs of up to 3,000 ft/min (Eldred, 1992; Nahm, 1991).

Both UVC and EBC inks cost up to two times more than traditional inks. Other drawbacks include high equipment capitalization cost and potential worker exposure to X-ray radiation. A good EBC starter system can cost $1 million, and more elaborate systems cost as much as $5 million (Bartlet, 1994). Although cost-prohibitive for the small printer, the systems work well for moderate to large printing firms (150-200 employees) that can afford the initial capital investment (Bartlet, 1994). Additionally, workers must be protected from the X-ray energy produced by operating equipment (Eldred, 1992; VDEQ, 1991). UVC systems are more affordable, costing about $200,000 for equipment and installation (Bartlet, 1994). Although these systems eliminate VOCs, UV light generates ozone and workers must be shielded from UV radiation. Still, many lithographers using UVC systems are pleased with their performance. Case study F describes the advantages of using UV inks.

Another drawback to using EBC and UVC inks and coatings is finished products that are not easily recycled (Ungurait & Wolfe, 1991). The high-molecular-weight polymers are harder for the traditional repulping systems to break down, making it difficult to obtain a successful ink and fiber separation. Some sources claim that recovered fiber is not as clean as with traditional or vegetable oil-based inks, and as a result is only acceptable for lower grade uses (VDEQ, 1991). Recent evidence, however, indicates that if the deinking facility has more complex, cleaner equipment, a satisfactorily recovered high-grade pulp can be produced (Tebeau, 1993).

Case Study F

The Use of UV Curable Inks

AGI, Inc., Chicago, Illinois, has been using UV inks since the mid- to late 1970's, and CEO Wayne Fox cites environmental benefits, ease of use, and time and effort savings as some of the reasons the company chose UV. In addition, he says the UV inks have excellent resistance to rub-off and set-off and provide the kind of long-lived quality product needed by AGI's customers.

AGI, which runs a Plenatos Multi-Color press, two 55-inch 6-color presses, and two 40-inch 6-color Heidelbergs, produces multi-color covers for major-label compact disc manufacturers. Color requirements and product durability are exacting in AGI's line of work.

Waste in AGI's UV process is minimal if the inks are handled properly, according to Wayne Fox. "Good management practices almost eliminate the waste in our operation. What waste we do have is sent out when a drum is collected for fuel blending. It has a very good BTU value and is used as a fuel for cement kilns," he said. Since the inks do not polymerize until exposed to UV energy sources, they can remain in the ink fountain overnight without skinning.

Clean-up is no harder than with conventional petroleum-based inks, states Simerson, press operator. Other than solvent used in clean-up, the UV process does not release VOCs as the ink cures.

Fox believes that worker safety issues are adequately addressed by today's equipment.

"Early systems left a couple inches gap between the UV source and the substrate," explains Fox. Equipment manufactured today completely shields the curing area, and if any of the shields are raised while the unit is in operation, the UV source immediately shuts itself off. Fox reports he has had no problems with ozone from the curing process, and ozone has not been an issue in obtaining permits for new equipment.

AGI has experienced an added benefit of energy savings by replacing infrared curable inks with UV systems, which use about one-third the energy and achieve the same if not better results, says Fox. Aside from the benefits of faster production times, clear image, and energy savings, Fox said, "I'd recommend UV for its environmental benefits alone, especially if the company wants to produce a durable, color graphic product."

3.4 Waterless Inks

Waterless inks and waterless printing are best discussed as a complete system. The waterless printing process is covered in Section 6.1. Waterless inks are high in solids and are designed to function with a silicon based lithographic plate. They are not necessarily less toxic or hazardous than other ink types, but the waterless printing system as a whole generates considerably less VOC emissions than traditional lithographic processes.

4.0 Dampening System

The dampening system on a lithographic sheetfed press provides fast and complete separation of the image and non-image area of the plate by making the non-image area unreceptive to ink. The principal factors influencing fountain solution selection are inks, plates, press speed, paper, temperature and relative humidity (DeJidas, 1990). Fountain solution is basically composed of water; an acid or base, depending on the ink used; gum or synthetic resin, to desensitize the non-image areas of the plate; corrosion inhibitors; and wetting agents, such as isopropyl alcohol or an alcohol substitute.

4.1 Traditional Dampening Systems

Dampening systems can be contacting or non-contacting systems. Fountain solution is transferred using rollers in conventional contacting systems. Non-contacting systems use brushes or spray bars to transfer the fountain solution from the reservoir to the plate cylinder (Office of Air Quality Planning and Standards, 1993).

4.2 Reducing the Need for Alcohol in Printing

Isopropyl alcohol contributes to atmospheric ozone formation by reacting with nitrogen oxides in sunlight. Using alcohol in fountain solution is popular because it reduces surface tension and leads to easier press control, more even dampening of the form roller, faster evaporation, and reduced ink emulsification. The result: less dampening solution is used and less paper, ink and time are wasted (DeJidas, 1990). Lithographers use alcohol in concentrations up to 35 percent with most presses ranging from 15-20 percent (Office of Air Quality Planning and Standards, 1993). This is much higher than several state and local regulatory agencies will accept. Many restrict alcohol use to 3-8.5 percent, while printers in geographic regions not meeting EPA standards are required to operate alcohol free. Many companies, operating in geographical regions with ambient air quality below EPA standards, are required to remove alcohol from their fountain solutions.

Alcohol substitutes can reduce fugitive VOC emissions because less of the substitute is used and they do not evaporate as readily (DeJidas, Jr., 1992). Substitutes also extend roller life and require less ink.

4.3 Pollution Prevention Opportunities for Dampening Systems

Fountain solution is generally replaced when ink color changes or as part of routine maintenance. Waste fountain solution may contain residual ink and, at some point during the printing process, will release the volatile fraction of the solution.

Pollution prevention opportunities include:

❖ Eliminating alcohol fountain solution.

- Extending fountain solution life by adding filters, chillers and recirculating systems.

a. Eliminating Alcohol from the Dampening System

Different presses use different dampening systems. The main types are: open reservoirs, closed reservoirs that drip onto molleton-covered rollers and central circulation systems that filter and automatically meter fountain solution to the press. Fountain solutions vary with differing systems. Case study G describes the effect the dampening system can have on makeready.

Case Study G

Select Equipment Based on Printing Needs

A recent classroom study showed that makeready can be reduced significantly with an automatic blanket dampener.

For this study, students at the University of Northern Iowa printed four color separations; two colors using the traditional fountain and molleton covered dampening system equipped on a 20-year-old duplicator press , and two colors using an automatic dampening system donated by Varn.

To quantify waste generation, students recorded: makeready sheets, time and fountain solution consumption. Subjective parameters such as print quality and ease of use were assessed by the students.

The first print demonstrated the students' inexperience with the duplicator. Water balance was constantly a problem and paper and time were lost in corrections. Print quality varied as the roller cover dampness varied.

These problems were eliminated with the automatic dampening system.

Dr. Ervin A. Dennis, professor, remarked, "The dampening system definitely creates less waste. Every printed sheet is usable. The consistency of ink coverage, from start to finish, is excellent."

The small lithopress has manual ink key settings and plate adjustment. Burdened without micrometer settings, makeready time and paper waste is directly related to achieving registration and proper ink density.

Given the limitations of the duplicator-press and the context with which it is used, fountain solution consumption is the primary measure of effectiveness.

The molleton-covered dampening rollers used an average of seven ounces each run. The automatic dampener used only two ounces.

The unit also exhibited a surprising 30 percent reduction in paper waste to makeready and a 45 percent reduction in time to the first printed sheet. Some of this was due to increasing press operator experience.

Print quality also improved. When a heavy cover of ink was applied with the molleton system, roller cover dampness was critical in achieving a consistent application of ink across the plate. With the automatic system, adjustments were necessary during the run, but coverage was consistent.

Generally, quality printing can be achieved by using less than 5 percent alcohol or alcohol substitute. When selecting an alcohol substitute, consider the ink, press type and printing constraints. Alcohol substitutes are composed of glycols, such as ethylene glycol, glycol ethers, cellosolve ethers or proprietary compounds. These substitutes reduce the surface tension of the fountain solution but have a more complex chemical structure and higher boiling point than IPA-containing dampeners. To achieve the best print quality without relying on alcohol, several factors must be monitored and adjusted to accommodate the different fountain solution properties.

Before changing the printing process, review how the affected dampening system works. Consult chemical suppliers regarding available options specific to the press model, dampening system, ink roller wash, blanket wash and papers used. Provide a sample of make-up water to the vendor to determine which products (fountain solution, alcohol substitute, anti-foaming agents, etc.) are compatible. Many manufacturers offer samples and technical service to ensure successful printing with their products. Take advantage of their expertise. Discuss changing the fountain solution with the ink supplier as well, to prevent an incompatible selection. Create a press log and record recommendations. Figures 4.1 - 4.3 provide examples of press log entries.

Press Log Entry: Existing Press Conditions

Press: Heidelberg	Dampening System: Alcolor dampening with Royse Refrigeration System.	
Model: 19X25 MOZ 2-color	Roller Hardness	
	Dampening roller:	25
Press Age: 1988	Roller Age:	3 years
Cleaners	Metering Rollers:	25 units
Blanket Wash: XYZ WASH	Roller Age:	3 years
Roller Wash: XYZ WASH	Fountain Solution:	XYZ Litho Etch
Press Wash: XYZ WASH	15% Isopropyl Alcohol	

Figure 4.1

Press Log Entry: Press and Chemistry Manufacturers Recommendations

Chemical Supplier Recommendations:

Water Quality:

Fountain Solution:	Soft Water/RO Unit, XYZ Litho Etch	Alcohol Substitute:	NO-AL
VOC #/gal:	.2	VOC #/gal:	4.83
Hazardous Chemicals:	Phosphoric Acid Diethylene glycol mono-ethyl ether	Hazardous Chemical:	N/A
Flashpoint:	N/A	Flashpoint: > 200°F	
Cleaners:	XYZ WASH	Ink Supplier Comments: NO PROBLEM	
VOC #/gal:	6.78		
Hazardous Chemicals:	Stoddard Solvent, Aromatic Petroleum Distillates, xylenes, cumene, Trimethylbenzene	Paper Supplier Comments: NO PROBLEM	
Flashpoint:	105°F		

Figure 4.2

Adjust the dampening roller pressure setting and plate-to-blanket pressure to accommodate the substitute's different surface tension and viscosity. Check durometer readings for inking and dampening form rollers. The press manufacturer can assist in determining proper settings, though it is recommended that the metering roller durometer be reduced to 18-22.

When first using an alcohol substitute, follow the manufacturer's mixing instructions. Use the smallest amount indicated in the instructions and measure the mixture's pH and conductivity. Record these measurements in the press log. This becomes the reference point. Print with this mixture, recording observations about its performance. Note how the plate rolls up, how the press

Press Log Entry: Optimum Fountain Solution Mix

Recommended Mix Range: 2 oz/gal XYZ LITHO ETCH, 2-3 oz/gal NO-AL

2 oz/gal XYZ LITHO ETCH, 2 oz/gal NO-AL		2 oz/gal XYZ LITHO ETCH, 3 oz/gal NO-AL	
Printability:	Good	Printability:	Good
Conductivity:	1200	Conductivity:	1580
pH:	3.8	pH:	4.0

2 oz/gal XYZ LITHO ETCH, 2.5 oz/gal NO-AL		2 oz/gal XYZ LITHO ETCH, 3.5 oz/gal NO-AL	
Printability:	Good	Printability:	Poor, Foaming occurred
Conductivity:	1450	Conductivity:	1670
pH:	3.9	pH:	4.1

Optimum Conductivity: 1200 - 2500

Optimum pH: 3.8 - 4.2

Figure 4.3

starts after feed trips, if excess fountain solution is used to keep the plate clean, and if the metering roller is picking up ink. The vendor can provide further suggestions and clarification as needed (DeJidas, Jr., 1992). Adjust concentration and print again until the optimum mix is achieved. When optimum performance is achieved, note the concentrations of fountain solution, water and alcohol substitute. Use this information as a reference for standard press operation. Experiment with alcohol substitutes on one press at a time and phase in additional presses when the previous one is running smoothly. Keep the press log current, noting maintenance schedules, problems and solutions.

Conductivity and pH can be used to predict fountain solution quality. Conductivity is the ability to transmit an electrical charge and is proportional to the ionic concentration in the solution. (See Figure 4.4) Measure conductivity of the water and fountain solution mixture, increasing the fountain solution concentration incrementally and graph the values. The graph provides a visual means to estimate fountain solution concentration based on conductivity. Alcohol and alcohol substitutes affect conductivity, so when the optimum mix is determined, measure conductivity again. If using alcohol, remember that during a press run, the alcohol will evaporate. Alcohol substitutes evaporate slower than water; so during a pressrun, water may need to be added.

Conductivity increases during a press run because impurities, such as ink and paper, are picked up by the dampening system. Measure conductivity on a daily basis. When problems with print quality arise, re-measure fountain solution conductivity. This can help predict print problems resulting from fountain solution quality.

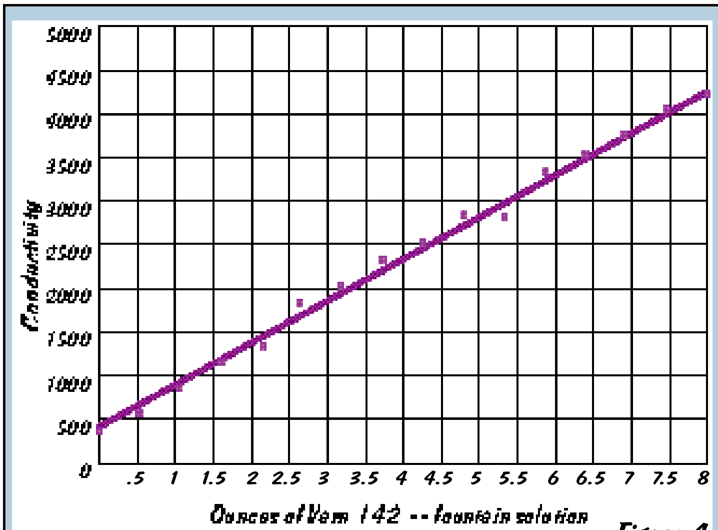

Figure 4.4

The pH of the fountain solution affects print quality. (See Figure 4.5) As the pH becomes more alkaline (7-14), the ability of the gum to desensitize the non-image areas decreases, causing "scumming" where the ink replaces the gum on the plate. When the pH drops, the acid reacts with the dryer, making it useless as a drying stimulator (DeJidas, Jr., 1992).

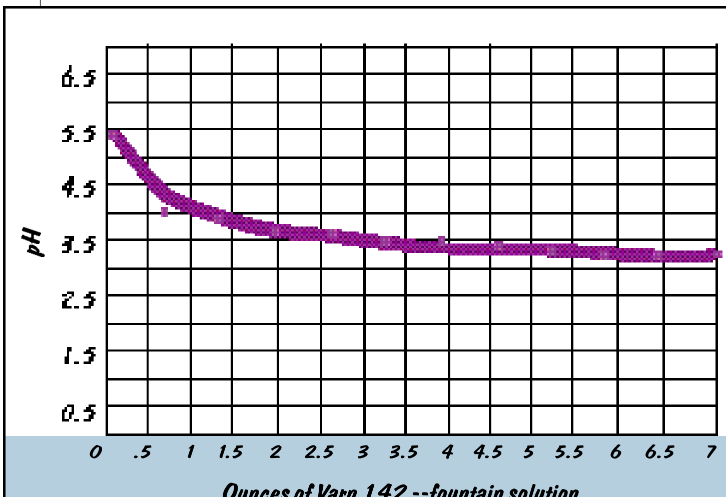

Figure 4.5

Measure the fountain solution pH. Record in the press log and determine the optimum range for printing. Figure 4.6 provides an example of a conductivity and pH press log entry.

Though the pH of the paper should only have a minimal impact on the fountain solution's pH, it's helpful to know the type of paper, alkaline or acid, used for each job in the event of a problem. Alkaline paper is produced using a process that includes calcium carbonate. During printing, the calcium can accumulate in the fountain solution, raising the conductivity without affecting pH. Calcium buildup can create print problems including scumming.

The conductivity of the incoming water affects the performance of alcohol substitutes. In areas with hard water (water with high mineral content), conductivity readings may be as high as 300 micromhos/cm. (A micromho is a measure of electrical conductance). Some water supplies may have widely varying hardness where conductivity readings vary more than 80 micromhos/cm. Water filtration systems are recommended to eliminate problems that alcohol addition formerly masked (MacPhee, 1990).

Water softening systems exchange magnesium and calcium carbonate with sodium carbonate. This form of treatment is effective in eliminating calcium or magnesium salt deposits from spray bar dampening systems or nozzle tips.

Deionizing units remove minerals and salts from the water, reducing conductivity to less than 50 micromhos. This can change pH depending on the deionizing unit used. These are recommended if water supply quality is highly variable.

Reverse osmosis units remove salts, minerals and organic matter from the water. This treatment reduces conductivity to 50 micromhos or less and the pH should be neutral. These units are recommended for water supplies of variable quality as well.

Reverse osmosis units include a water softening unit, carbon filters to remove organic matter, and a micro-membrane to remove sodium carbonate. Reverse osmosis units tend to cost more than deionizing units but have less operating costs.

Water temperature can vary from one side of the fountain tray to the other, affecting viscosity and ability to cover non-image areas of the plate. Low flow may result from clogged lines or

Press Log Entry: Monthly Monitoring of Conductivity and pH

WEEK		MON	TUES	WED	THUR	FRI	SAT	NOTES
1	Cond.	1580	2050	1565	2300	2400	1630	Changed Filters on Recirculating Unit Fri
	pH	3.94	4.30	4.03	3.82	4.46	3.8	
	(+/-)	+	+	+	+	+	+	Print Quality

Figure 4.6

improperly routed lines (MacPhee, 1990). Measure the temperature of the fountain solution across the pan. If it varies more than two degrees (+/-), check the flow rate into the water pan. Case study H describes one printer's experience with reducing and eliminating their use of IPA.

Case Study H

Selecting Alcohol Substitutes

Woolverton Printing Company, Cedar Falls, Iowa, wanted to reduce VOC emissions to improve interior air quality and meet environmental regulations being drafted by the EPA. Mitch Weinberg, operation manager, learned about alcohol free printing. With the assistance of the Iowa Waste Reduction Center, Woolverton began testing low VOC fountain solutions.

Woolverton's three, two-color Heidelberg presses are equipped with chilled and filtered, recirculating fountain reservoirs. Since installation, Woolverton had never discarded fountain solution. Never changing the fountain solution meant Woolverton began adding more alcohol to "fix" print problems, averaging 15 percent alcohol in the fountain solution.

Consistent water quality eases the reliance on alcohol in the fountain solution. As an industry partner, the IWRC installed a reverse osmosis water treatment system. Cedar Falls' water supply has a high concentration of calcium.

With the installation of the water treatment system, Woolverton reduced the alcohol content to 5 percent because calcium carbonate was removed from the water. Calcium carbonate acts as a buffer, requiring more fountain solution concentrate to achieve the desired pH. The reverse osmosis unit also provides water with a consistent conductivity, allowing this measurement, in addition to pH, to predict the quality of the fountain solution.

For this study, Woolverton printed 45 jobs. All used low VOC fountain solutions designed to be used with water with low mineral content. The first 15 used water treated with a water softener; 15 used water treated through reverse osmosis and 5 percent alcohol in the fountain solution; and 15 used water treated through reverse osmosis, alcohol substitute, and fountain solution.

The softened water had a conductivity of 700 micromhos and required a large amount of fountain solution to bring the pH into the recommended range of 3.8-4.2. During this run, the amount of fountain solution necessary to bring the pH into the recommended range suddenly spiked and caused print quality problems.

Traditional trouble shooting focused on cleaning rollers, changing ink and adding alcohol. When reformulating fountain solution, press operators discovered that the water softener exhausted the sodium supply. Once recharged, the water quality stabilized and the print quality improved.

The reverse osmosis unit achieved acceptable print quality using only 5 percent alcohol without any major modifications. Conductivity ranged from 1200 to 3050. Conductivity readings may vary for several reasons including: temperature of the fountain solution when the measurement is read, calibration of the meter, concentration of alcohol and effectiveness of the charcoal filter. As a result of the conductivity variability, Woolverton determined fountain solution quality by measuring both conductivity and pH.

Alcohol free printing requires many changes. Trade associations recommend using softer rollers, tight control of roller settings and water feed rate. Furthermore, when fountain solution is recirculated, printers are encouraged to measure conductivity and pH to predict fountain solution concentration and quality.

Before the 15 runs with the alcohol substitute, Woolverton replaced the water pan metering roller with one of a lower durometer reading. The press manufacturer recommended a durometer reading of 25, slightly higher than published recommendations. Once the press was equipped, Woolverton began testing fountain solution mixtures to find the optimum mix. After much trial and error, they found that a mixture of one gallon of water, two ounces fountain solution concentrate, and two ounces alcohol substitute was determined to give the best print quality.

Woolverton followed the published recommendation to create a conductivity curve of the fountain solution. This is important because both the fountain solution and the alcohol substitute have a vapor pressure lower than water's and will not evaporate like alcohol. Over time, Woolverton should see a general increase in conductivity and will need to add water. The conductivity can be correlated to fountain solution concentration and help predict when water should be added.

Once the optimum mix was determined, the conductivity ranged from 1890 to 2450. The conductivity readings are still influenced by temperature, calibration, and filter performance. When using the conductivity curves to predict fountain solution concentration, a printer must standardize when a measurement is made, check calibration daily, and note filter changes to determine if filter age is a factor.

Even while adjusting the fountain solution / alcohol substitute ratio, Woolverton was printing successfully. The first press run demonstrated the second factor influencing the success of printing without alcohol: roller settings. The press was not achieving proper half-tones. Formerly, the press operator would assume that the screens were not cleaning up properly and adjust the water feed rate. The next run had proper half-tones, but black ink density was too low. The PMT negative was checked to determine the correct half-tone. The operators adjusted the rollers, and achieved good print quality. Monitoring roller settings became part of routine.

Woolverton recognizes the value of flexible press operators willing to try new products. "Before, the press operator would use alcohol to cover up little problems but then spend half a day trouble-shooting a problem when all the little ones added up," said Mitch Weinberg.

Giving the press operators the tools to measure fountain solution conductivity, pH and roller settings based on paper type makes them more involved in the print process. When a problem comes along, like roller settings, minor changes can be made that prevent the loss of valuable time later.

Despite the success Woolverton has had with the alcohol free fountain solution, its testing is not complete. All three Heidelbergs have different dampening systems. Woolverton intends to try other products even though the first alcohol substitute worked.

The following suggestions may help correct problems that can occur when using an alcohol substitute:

1.) Clean presses thoroughly. Carefully select cleaners that are effective for inks and fountain solution used. If rollers are not cleaned sufficiently between uses of different alcohol substitutes, stripping can occur. When this occurs, certain areas of the roller become more sensitive to ink and apply an inconsistent ink thickness. For older presses, copperizing the rollers may eliminate the problem. For newer presses with nylon- or teflon-covered oscillator rollers, flush the ink rollers with warm water after cleaning (DeJidas, Jr., 1992).

Brush dampener systems need the brushes cleaned frequently to prevent increased water feed rate to compensate for dirt. Keep brush guards in place and use white rollers so soiling is visible (MacPhee, 1990).

2.) Control the water feed carefully. Excessive water feed causes emulsification and poor performance. Some presses will flood the inking system if the dampening system is left on when the paper feed stops. Reducing the nip between the chrome roller and form roller to run alcohol substitutes compounds this problem.

3.) Check the pressure settings of all rollers. Check both the dampening roller pressure setting and the plate to blanket pressure settings. Include the optimum settings in the press log for reference.

4.) Inspect the chrome roller for pitting or ink sensitivity. Pitting can cause an uneven water feed rate across the press and pitted chrome rollers should be replaced (MacPhee, 1990).

5.) Check the metering roller for ink sensitivity or salt deposits. Alcohol substitutes can affect water receptivity of the chrome and metering rollers. When this happens, etch the chrome roller with a solution of 1 ounce phosphoric acid to 32 ounces gum. Water receptivity of the metering roller is maintained by applying gum (DeJidas, Jr., 1992).

Some fountain solutions encourage salt deposits on the metering roller. When this happens, back the metering roller away from the chrome roller and clean it. A water softener could eliminate this problem if the mineral content of the water is above 300 micromhos.

6.) Check the hardness of the metering rollers. Banding or grind marks (comb-like or corduroy-like marks on the substrate in the direction of paper flow) can occur if the metering rollers are too hard or if the fountain solution is not mixed correctly. Softer rollers or rollers with a slightly grained surface can prevent this problem. Consult the press manufacturer and fountain solution vendor for optimum roller hardness. Continue monitoring roller hardness. When the durometer reading varies by 10 points beyond the recommended range, replace or recondition the roller (MacPhee, 1990).

Rollers harden over time and a combination of age and glazing can render the rollers ineffective. Deglazing rollers should reduce the roller hardness by five durometer points (Schneider, Jr., 1989).

Efforts to track the condition of press hardware can also be recorded in the press log as shown in Figure 4.7.

Press Log Entry: Inspection Items

Roller Settings	Inspection Checklist
Dampening Roller Pressure:	Chrome roller:
Coated Paper: 3 -3.5	pitting, ink sensitivity
Uncoated Paper: 6 - 6.5	Metering roller:
Blanket Pressure:	ink sensitivity, salt deposits
no adjustments to date	Roller hardness check:
	value, date

Figure 4.7

b. Extending the Useful Life of Fountain Solution

Filters can be installed on recirculating units serving one fountain pan or as large central units supplying fountain solution to multiple presses. Filter media can be as simple as a charcoal or polypropylene filter, or involve a mixed media, free flow design. Depending on individual needs, select filters to remove gross contamination (including paper-dust and lint). The filter media should remove ink residue as well, extending the life of the solution.

A refrigeration unit will reduce evaporative losses, even when using alcohol. Optimum fountain solution temperature is 50-55°F (DeJidas, Jr., 1992). The EPA estimates that reducing the temperature of fountain solution from 80°F to 60°F can reduce alcohol consumption by 44 percent (Office of Air Quality Planning and Standards, 1993). If an alcohol substitute is used, it will increase viscosity. Be careful not to overcool the fountain solution because ink will become tacky and cause picking or piling problems. Clean condenser coils regularly.

An automatic mixing system can accurately mix fountain solution to the proper concentration and eliminates monitoring conductivity, although, it is impossible to determine the actual concentration of the alcohol substitute in a fountain solution.

Some geographical regions have problems with organic growth in recirculating systems and require stringent cleaning. Ultraviolet light reduces algae, waterborne fungi and bacterial growth. The traditional method of preventing organic growth in the recirculating unit is to clean it with a 10 percent bleach wash followed by numerous rinses.

Foam-free recirculating systems are available. These systems, if compatible with the press, eliminate foaming without anti-foam agents. Contact press equipment manufacturers, fountain solution vendors or graphic arts associations for recommendations. This is a specific concern when using alcohol substitutes.

5.0 Press Cleaning

A press in good repair is essential to meeting pollution prevention goals. In addition to preventative maintenance, regular cleaning is also necessary to keep the many moving parts operating. While it is easy to collect and recycle the used press oil for re-refining or energy recovery, minimizing solvents from press cleaning presents more of a challenge.

5.1 The Role and Composition of Press Cleaners

Cleaning solutions are predominantly petroleum based, are often mixed with detergents and water, contain up to 100 percent VOCs and can be used as a multipurpose presswash or for cleaning just one part. One general cleaner is not always effective for cleaning rollers, blankets and the outside of the press.

Blanket cleaning consumes approximately two-thirds of cleaners used on a press and is performed once or twice a shift, between jobs and as needed to improve print quality. These cleaners must remove excess ink and dry quickly without leaving any oil residue. Remaining cleaner is used for cleaning press rollers (Office of Air Quality Planning and Standards, 1993).

Cleaners used on chain and ink rollers should be less volatile so solvent moves over all rollers before evaporating. For metal press parts, slower working solvents are as effective as a general press wash. Stronger solvents are needed for intermittent cleaning of hardened ink, or for specific purposes such as etching the chrome roller.

Define cleaning needs to select the best alternative cleaners and cleaning methods to reduce VOC emissions.

5.2 Cleaning Wastes and Alternatives

Cleaning the press generates several wastes:

- ❖ Waste cleaner with residual ink
- ❖ Waste ink from the ink fountain
- ❖ Rags containing cleaner and ink
- ❖ VOC emissions from cleaners

Manage petroleum-based solvents and inks as hazardous waste. Some inks may not be hazardous when discarded but are unacceptable for landfilled disposal because they are viscous. Most states require that a waste be tested to verify that it is non-hazardous and also solid for landfill acceptance.

Disposable rags may be landfilled if laboratory testing demonstrates that they are non-hazardous. Launderable rags are not subject to hazardous and solid waste regulations because they are reused after cleaning.

Press cleaning releases VOCs. Intentionally evaporating used solvent is illegal disposal of a hazardous waste and subject to penalty. Additionally, it exposes employees to hazardous working conditions.

Chemical manufacturers are developing low VOC cleaners. Just as there are many different presses, there are many different cleaners. Most low VOC cleaners still contain naphtha and average 3.5 pounds per gallon of VOCs and have a flashpoint greater than 200°F. "Quick drying" cleaners may have slightly higher VOC content and usually have a flashpoint below 140°F, making them hazardous waste. Some substitutes present a two step approach, using a cleaning solution with a higher VOC content as step one to be immediately rinsed with a low VOC cleaner as a second step. Consult proposed and enacted regulations regarding low VOC cleaners to ensure compliance.

Low VOC products continue to clean more effectively, but because the first cleaners performed poorly, the industry has not readily accepted them. EPA research has demonstrated successful substitution of low VOC cleaners using an integrated approach. Cleaning equipment, targeted product substitution and changing operator practices can reduce VOC from cleaning.

5.3 Reducing VOC Emissions from Cleaners

Almost 50 percent (by volume) of high VOC cleaners evaporate before cleaning (US EPA, 1993). Substitute cleaners, containing no more than 30 percent VOC by weight have lower vapor pressure and higher flash point than traditional cleaners but may not effectively clean all areas of the press (Office of Air Quality Planning and Standards, 1993).

The EPA estimates that it will cost the printing industry $110 million annually to implement VOC control guidelines for lithographers (Environmental Reporter, 1993). Many control technologies require equipment to capture and destroy emissions. If a company can reduce emissions using product substitution or process change, the expense of the air pollution control equipment may be eliminated.

Allocating time for employees to experiment with substitute cleaners and creating press procedures that use low VOC cleaners is an investment in cutting control technology costs to meet air emission standards. Feedback from employees and constructive suggestions will create an effective pollution prevention program.

a. Equipment to Reduce Cleaning Needs

Automatic cleaning systems reduce cleaner consumption by removing excess ink. These systems prevent ink buildup which requires stronger cleaning solutions. When used properly, they also reduce wasted time and lost impressions. One report cites that lost impressions were reduced from 1,200-3,000 to 250-350 (Hanna, 1990).

An automatic blanket cleaner is comprised of a control box, a solvent metering box for each press unit and a cloth handling or brush unit. Many larger presses are equipped with automatic blanket cleaners and older presses can be retrofitted. One company manufactures a unit that uses a rotary oscillating spray and brush device with solvent recovery. It is an enclosed system designed to reduce overspray and eliminate wipe-up towels.

Roller wash-up blades and ink blades remove residual ink from specific rollers, reducing the amount of cleaner needed. The roller and wash-up blades' condition influence how well both stay clean. The blade's angle against the roller should be adjusted to apply sufficient pressure without being grabbed or pulled under the roller. Press speeds should be just slow enough to allow for thorough cleaning. Slower press speeds require more cleaner (Hanna, 1990).

To respond to special needs, presses can be equipped with specialized form rollers (such as oscillating or hickey-picking) instead of standard form rollers (Schneider, Jr., 1989). Specialized rollers reduces press operator dependency on squirt bottles of cleaner.

Automated press control systems improve productivity and reduce make-ready as well as cleaning needs. Systems that adjust ink / water ratio, ink density and image density on the plate eliminate the repeated cleanings between press operator adjustments.

High quality optics and computer control systems allow automatic plate scanners to determine the relative density of the printing image across the plate's surface. This data can be transferred to an automatic ink key setting system, adjusting the ink profile for each ink slide position. Automatic registration uses optical scanners to locate the registration marks and set this position for the duration of the press run.

One manufacturer has developed an optical system that detects the ink / water ratio. Because both water feed and ink keys are part of the system, any deviation of the ratio is detected and can be corrected. The system correlates the refraction of light from the ink form roller with the amount of water emulsified in the ink (Jacobs Engineering, 1989). This system could also help encourage the transition to successful alcohol-free printing.

b. Product Substitution

Low VOC blanket and roller washes generally contain naphtha, inorganic phosphates and proprietary compounds. Many formulations are totally proprietary and their ingredients are not listed. Contact manufacturers to discuss your cleaning needs. Consider ink, paper, fountain solution and the type of press. Request samples. Many manufacturers provide technical assistance to ensure successful product use.

Do not judge low VOC cleaners by the performance of one product. Try a variety of different formulations. Follow the manufacturer’s recommendations. Most formulations require less cleaner than naphtha based cleaner. Excess amounts will cause color problems on the press.

Target cleaners for a specific purpose. A low VOC cleaner effective on ink trays and metal parts may not be an effective blanket wash.

When selecting a new product, determine your specific pollution prevention goals you wish to attain. Review the product's material safety data sheet for hazardous constituents (i.e. naphtha; 1,2,4, trimethylbenzene), the flashpoint (if less than 140°F the material becomes an ignitable hazardous waste when discarded) and the VOC content, either expressed as a percent (preferably less than 30) or in pounds of VOC per gallon of solution.

The volume of low VOC cleaner should not be compared to the amount of traditional cleaner used to do the same job. Even if it takes more low VOC cleaner to effectively clean the press, the actual VOC emissions will be less because it has a lower vapor pressure as well as less VOC content and does not readily evaporate. Most manufacturers caution that less cleaner is required when used properly.

Follow manufacturer's cleaning directions for new products. If the products are not used as intended, more will be needed to clean the press. Low VOC cleaners tend to be water-soluble or water-miscible and often require a water rinse following cleaner application. Although this may take more time than traditional cleaners, the rinse also removes paper-dust and lint.

Be careful when cleaning directions recommend "immediately rinse"or "let product work into ink." Immediate rinsing may be necessary to prevent a blanket wash from leaving a film on the blanket. Low VOC roller cleaners may need time to loosen excess ink to effectively clean. Warm water is usually more effective for rinsing cleaners. If minerals build up, examine the rinse-water quality before blaming the cleaner.

c. Procedural Changes Reduce Cleaning Wastes

Clean presses as needed, not on a schedule. Immediate cleaning and using automatic systems will minimize cleaner consumption and prevent buildup of ink, paper-dust or lint that will affect print quality. When ink builds up, stronger cleaners become necessary.

Use the smallest amount of cleaner possible. Apply the cleaner to the rag instead of pouring it over the part which wastes cleaner.

If cleaners must be poured over rollers or press parts, use a catch pan beneath the part (like roller trays) and empty the used cleaner into a closed container as soon as the rollers are wiped. Store used cleaner by color for future blanket and roller cleaning.

Store all volatile cleaners in closed containers. Make low VOC cleaners readily available at each press. Store high VOC cleaners in another area and tell the press operator to use it only for specific purposes such as color change.

Do not leave an open funnel in the waste drum. Open funnels allow the container to continuously emit VOCs. This is also considered an open container under hazardous waste regulations. Remove funnel and close drum when through.

Collect used rags in a self-sealing, flame-resistant can. Use launderable rags instead of disposables. As long as the rags are wet, not soaked, laundries will accept them for cleaning. Remember, laundering the rags does not eliminate the waste, but transfers it to the laundry's waste stream.

Schedule jobs by color. Clean the ink tray only when changing colors.

Sequence colors from lightest to darkest: yellow, magenta, cyan, black. Sequencing reduces cleaning and prevents a darker color from bleeding through the lighter color. Sequencing also reduces fountain solution changes if the press does not have a filtration unit. Case study I describes a recent innovation in easy to clean ink / solvent systems.

Case Study I

Engineering A Solution

Deluxe Corporation, a check printing company with 55 facilities throughout the country, responded to stricter environmental regulation and employee health and safety concerns by designing water soluble inks and cleaners that eliminate fugitive volatile organic compound (VOC) emissions. Deluxe, a large company with the resources to perform research and development, evaluated the relationship of lithographic ink and press wash. It developed and patented a pantone-licensed line of water soluble inks and solvent-free, non-VOC containing roller wash.

Most companies do not have the resources or expertise to research and develop their own custom chemistries. They can, however, benefit from the work of larger companies. Deluxe Corporation's approach is one that can be emulated in even the smallest print shop using commercially available products.

Deluxe Corporation set an environmental goal to meet the EPA's proposed Control Technique Guidelines (CTG) mandated by the Clean Air Act of 1990. The draft CTG calls for blanket and roller wash to be formulated with less than 30 percent by weight of VOCs. As part of its search for a solution, Deluxe Corporation experimented with commercially available cleaners.

Petroleum based press washes were most effective, but also contained the highest percent by weight of VOCs. Deluxe tested available low VOC washes and discovered the cleaners were not always compatible with the inks or presses. At that point, Deluxe reviewed its entire lithographic process and performance criteria for cleaners. Instead of just substituting cleaners, Deluxe reviewed the relationship between the inks and cleaners then developed the idea of an ink that changes solubility in water.

Deluxe Corporation's inks use standard pigments that include copper and barium. The carrier is 100 percent vegetable oil. Waste ink and rinse water from cleaning the press or ink trays is collected at each of the Deluxe facilities. Because the solubility of the oil phase of the ink is reversible, it can be filtered to remove the pigmented vegetable oil portion from the aqueous phase. This aqueous portion should be acceptable for sewer disposal. The remaining ink residue may not be a hazardous waste but is not recommended for landfill disposal.

Deluxe is currently evaluating the impact of these water-soluble and water-washable inks and cleaners on a selected commercial laundry's effluent. If the effluent meets discharge limits established by the wastewater treatment plant in accordance with the Clean Water Act, then Deluxe Corporation can conclude that the inks and cleaners are less toxic and will meet future revisions to environmental regulations.

Deluxe has realized other benefits from the new ink and cleaning system, including dramatic reduction in worker exposure to VOCs. Using a mass balance approach recommended by the EPA, Deluxe has measured a 50-70 percent reduction in VOCs. Expected benefits from removing the solvents in the inks include reduced wear and plasticizer removal of the rollers. Water rinse which removes paper-dust prior to press runs, may be eliminated because the inks and cleaners are themselves water based.

Deluxe Corporation met the challenge of complying with environmental regulations and accepted the responsibility to re-evaluate its waste management in light of the new wastes generated. Changing to comply with environmental regulations demands the commitment, patience, and flexibility displayed by Deluxe when it experimented with alternatives. One result of its commitment is a water-soluble and water-washable ink and cleaning system that may offer environmental benefits to other businesses.

5.4 On-Site Cleaner Recycling

Some printers use a solvent sink to wash ink trays. These sinks circulate a solvent (generally naphtha-based) for quick, complete removal of residual ink. These sinks are usually serviced by a hazardous waste management company that replaces the used solvent with new solvent according to a set time schedule. The hazardous waste management company may recycle the solvent through distillation, reclaiming the purified solvent and disposing of the hazardous still bottoms.

Distillation involves heating the dirty solvent to its specific boiling point, converting it into a gas, leaving behind the impurities (ink, paper-dust, lint) that were dissolved in the solvent. The gas is then cooled, condensed into a liquid and collected in a separate container. This solvent is ready for reuse on the press or in an ink tray solvent sink.

Companies can purchase small distillation units that reclaim 3-5 gallons within eight hours or large units that process more than 100 gallons per hour. Companies that use 10 gallons or more of solvent per week could significantly reduce raw material purchases and hazardous waste disposal with a distillation unit (Iowa Waste Reduction Center, 1992).

On-site solvent distillation can also save waste solvent from launderable rag waste streams. One company reduced the amount of solvent in its rags by using an explosion-proof centrifuge to remove excess solvent from the rags. This company recovered 2-4 gallons of spent solvent from 220 rags (US EPA, 1993). Over time, this adds up to a substantial amount of solvent. Coupled with a distillation unit, the recovered solvent can be refined on site and used as a primary press wash or parts wash solvent suitable for cleaning ink trays.

An explosion-proof centrifuge and distillation equipment can be a substantial investment. The payback period for a small distillation unit can be one to two years, but the centrifuge is much more expensive. Investigate purchasing equipment through a trade association and sharing the equipment among members. The equipment can be transferred from business to business for on-site use of the centrifuge and distillation unit. Hazardous wastes must remain on site and be managed accordingly. Scheduling must be responsive to hazardous waste storage time limits to maintain compliance with the hazardous waste regulations while allowing small printers to remove excess solvent from rags for reclamation and reuse.

For more details regarding solvent waste reduction and distillation contact the Iowa Waste Reduction Center at 800/422-3109 or 319/273-2079.

6.0 Emerging Technologies

New technologies are significantly changing the printing industry. What was once done by artists and typographers is now almost all computer-generated. Developments in waterless printing have eliminated the dampening system and some new digital presses no longer require plate processing.

As these new high-tech methods work their way to the common market place, they will not only provide a high-quality product, but eliminate much printing waste, furthering their cost effectiveness.

6.1 Waterless Printing

a. Background

The concept of dryography, or waterless printing, is not a new one. It was introduced in the late 1960s by 3M with little success. Problems were encountered with plate durability and performance was inconsistent with inks available at that time. In 1972, the technology was sold to Toray Industries of Japan who perfected the waterless plate and re-introduced the technology to the American market in 1985.

The new waterless technology is completely different from its predecessor. Waterless inks are now consistent and readily available from suppliers. The major manufacturers are conducting ongoing research to continually develop waterless products, and printers can retrofit original equipment with temperature control systems or purchase new, fully equipped waterless presses.

b. The Plates

The plate remains the most important factor in the waterless system. Plates are made of unanodized straight-grain aluminum coated with a light-sensitive photopolymer layer followed by a thin silicon rubber layer. (The rubber repels ink from the nonimage area of the plate). The protective top layer of the plate is a thin transparent cover film that does not need to be removed during exposure because it does not cause dot gain or undercut.

The plates are exposed with UV light in a standard vacuum frame. Exposure time is comparable to presensitized conventional plates; but vacuum time may increase 10 to 15 percent because the plate's smooth surface does not allow for air evacuation like a grained aluminum plate. UV exposure activates the photopolymer, breaking its bond with the silicon layer. This reaction is extremely precise, creating resolutions as fine as six microlines that support a dot range from 0.5 to 99.5 percent at a screen ruling of 175 lines per inch (“Introducing,” 1992).

Dot gain is normally reduced by about 30 - 50 percent compared with conventional lithographic processes (“The Benefits,” 1993). This is attributed to the plate's intaglio-type surface. Supporting walls around each portion of the image area enable the screened film image to be transferred with low dot gain. Ink densities are higher on the finished product because the recessed plate area allows a greater ink charge.

Once exposed, the protective cover film is removed and the plates must be processed in a special processor or by hand. Waterless plate processors use two specialized chemicals and tap water as the developer. (A waterless plate processor costs about $30,000.) Total processing time for a 40-inch plate is about 2.5 minutes.

"In the finishing stage, where the mechanics are identical to the developing station, a strong blue dye solution is applied to the plate. The dye is important -- it provides a visual contrast between image and nonimage areas; adds a slight etch to the photopolymer image area (thus making it more ink receptive) and hardens the nonimage areas of the plate, (Cross, Plate 1993)." As for process chemistry, 5 gallons of pretreatment solution can process 1,000 to 1,200 40-inch plates. This small amount of spent chemistry may be considered hazardous waste. Printers must be aware of federal, state and local regulations prior to discharging. The dye, used only on the surface of the plate, is never discharged.

The silicone / photopolymer combination allows the plate to print without water, etches or alcohol. The silicone repels the ink while the photopolymer attracts it. The silicone surface makes the plate susceptible to scratches and requires careful handling. In storage, the plate should be protected with a paper slipsheet. The negative plate does not require any gums, sealers or preservatives.

On-cylinder etching must be minimal. Simple additions and minor image modifications can be made by scratching or scribing the silicone surface to expose the ink receptive photopolymer layer. Liquid silicone solution can be applied for deletions.

During operation, it is important to keep the press room dust free. Because there is no water or rinsing agent on the plate surface, waterless printing is susceptible to contamination from airborne particulates. Any dust on the plate will cause hickeys.

Currently, the only producer of waterless plates is Toray of Japan. More companies will likely begin to manufacture waterless plates when Toray's patents expire.

Toray rates its negative-working plate at 150,000 impressions and its positive-working plate at 300,000 impressions. Plates cost approximately 30 to 50 percent more than conventional plates (Cross, Watershed 1993).

c. Inks and Temperature Systems

Waterless printing most often requires special inks that are designed to maintain viscosity in a narrow temperature range. The silicone non-image area of the plate repels ink as long as the ink's viscosity gives it a greater affinity for itself than the silicone. For this reason, waterless inks tend to have higher viscosities and stiffer bodies. Their pigments, waxes and oils are similar (if not identical) to conventional inks. The difference is the resins or vehicles. Resins used in waterless inks offer higher viscosity than those in conventional inks.

The waterless press replaces ink / water balance with ink / temperature balance. In waterless printing, temperature balance is critical because it directly affects ink viscosity, which enables the non-image area to repel ink. If the roller temperature gets too high, the ink thins and is no longer repelled by the silicone.

Conventional inks may sometimes be used in waterless printing, but this does not work for all applications. It works best in short runs, depending upon the percentage of solvent in the ink. "Eventually the solvent in conventional ink will loosen the bonds between the silicone and photopolymer on the plate, creating, in effect, image areas as the silicone is picked off," (Cross, Ink 1993).

Waterless printing runs hotter than conventional because the dampening system is removed. Waterless inks generate more friction because of higher viscosity which also causes higher roller temperatures. Because this process relies on ink viscosity, temperature balance is critical. If the rollers are too warm, ink viscosity decreases. If it decreases too much, the non-image area of the plate will no longer resist the ink and cause dry scumming or toning on the printed sheet. (Ink adheres to the non-image area of the sheet.) If ink temperature is too low and ink viscosity increases too much, ink flow will be suppressed. The result is a mottling effect in solid areas on the printed sheet, picking of the paper and hickies.

To maintain temperature balance, chilled water or a water and ethylene glycol mixture is piped through the vibrator rollers to dissipate heat generated from friction. (This is similar to chill-roll technology on web presses.) When rollers get too cold, the system circulates warm water to increase the temperature. Temperature control systems can be installed on existing presses or purchased preinstalled on new presses.

The temperature control system has three basic parts: a refrigeration unit to chill water; piping to carry the water inside selected press rollers; and sensors and controls to maintain constant temperature. Every tower on new multicolor waterless presses is equipped with this temperature control system, known as a "multizone temperature control system."

In new systems, infrared pyrometer sensors continuously monitor the temperature of each printing unit. These systems read either the temperature of the plate or the form roller. While authorities acknowledge the importance of measuring from the same place, they disagree on which part should be measured. The temperature reading serves solely as a reference point for the press operator; the actual value is not as important as understanding how the temperature affects the process.

Currently, the press operator inputs the desired temperature for each press unit to the control unit. If the temperature begins to rise or fall, the sensor signals a mixing value to adjust the temperature. The system maintains a consistent temperature, allowing only a 3-4°F variance.

Once installed, the temperature control system is not limited to waterless printing. Retrofitted presses can still print conventionally and actually print a higher quality product because the temperature control stabilizes operating variables. Water balance is better controlled and density variation is minimized on a conventional press operating with a temperature control system.

d. Conversion Costs

Three types of costs are associated with converting to waterless printing: capital investment, time investment and raw product cost differences. The capital costs associated with converting a conventional 6-unit 40-inch press to waterless with a multizone system where all units are controlled individually is approximately $100,000 to $120,000. (Cylinder width is the main factor in determining retrofitting costs.) The conversion takes four to six hours of down time to measure rollers and check engineering diagrams. When new equipment arrives 8 to 10 weeks later, installation requires about six days (“Waterless,” 1993).

Raw material costs tend to be higher than those of conventional dampening systems. Ink costs range from competitive with conventional inks to much more expensive, depending on the supplier. Waterless plates typically cost 25 percent more than conventional plates.

However, higher material costs can be overcome in a reasonable amount of time through the efficiencies of the waterless process. One cost study revealed an 18 month payback on an initial investment of $150,000. The study was based on operating waterless 65 percent of the time. Most of the savings were realized from reduced makeready time, paper savings and decreased dampening system costs (Cross, Watershed 1993).

e. Current Uses

Currently, the most common and cost-effective use of waterless printing is in high quality sheet fed projects as illustrated in Figure 6.1.

Waterless Printing Applications	
High Quality Projects	50%
Packaging	30%
Specialty Plastics	10%
Fine Arts Reproduction	10%

"Waterless," 1993

Figure 6.1

Most waterless printing is sheetfed. Waterless technology in web printing has experienced some technical difficulties but is developing. Inks are being redefined and paper compatibility problems are being overcome.

f. Benefits

The most obvious advantage to waterless printing is the high quality end product. It produces “brighter, snappier color...” (“Waterless,” 1993). And, because the inks are run in a much greater film thickness, the color is vibrant and the product is more rub and scratch resistant. This is the result of the ink laying on top of the paper, rather that being absorbed by it, like conventional printing.

Other advantages of removing the dampening system are:

1. It is more compatible with recycled paper because recycled paper fibers are shorter and less stable than virgin paper. Adding moisture in conventional printing further decreases the paper's stability. Waterless printing lays the ink onto the paper and keeps it from absorbing water.

2. Inks have a higher gloss because they do not emulsify and are not absorbed into the paper. This makes waterless a better way to print on non-absorbent materials such as plastics, metals, synthetics and recycled paper.

3. Registration is better because paper stretch (caused by introducing water) is eliminated.

4. Wastewater is eliminated and VOC emissions are reduced by 50 percent or more.

Once a press operator is properly trained and practiced, waterless printing becomes:

- more efficient,
- more productive,
- less labor intensive,
- delivers consistent colors
- and reduces spoilage.

Once the press is ready to print, the color does not change from the first to last sheet. Proper temperature control must be maintained, but ink and fountain solution jiggling is eliminated.

Makeready can also be significantly reduced (by up to 40 percent over conventional) and requires only two operators. Salable product can be attained in just 20 sheets (“Waterless,” 1993).

Also, “It (waterless printing) is a much more environmentally sound way to print. You don't have the alcohol or VOC problems, you don't have the problems with alcohol substitutes. The product that you use to develop the plates is very good. It's not very toxic and the inks aren't any more dangerous than normal. I think you get a better looking product on recycled substrate (“Waterless,” 1993).”

In summary, the advantages of the waterless plate are:

- higher screen rulings,
- minimal dot gain,
- higher density from less ink,
- and reduced air emissions and hazardous waste generation.

One downfall of waterless is that the plate's silicone rubber surface scratches easily and requires careful handling. However, cautious handling is a small price for the quality and environmental advantages of waterless technology. Case study J describes the use of waterless technology for four-color printing.

Case Study J

Waterless Printing

When the Brandt Company, Davenport, Iowa, expanded its business into four-color printing, owner Don Brandt wanted to produce a high quality product that offered an alternative to the traditional four-color work on the market. In January 1993, he invested in a six-color press that can operate both waterless and conventionally.

Brandt said that the waterless press has been beneficial but waterless jobs are a small percentage of his business because they are more expensive to produce. Waterless plates and their processing are more expensive than the traditional plates and that cost must be passed on to the customer. Small demand and a market unwilling to pay the higher cost are other factors.

Waterless plates are not as durable as conventional and must be handled carefully, but The Brandt Company has found that careful handling is enough to prevent scratching. No additional treatment is necessary. Plates can be stored the same way as conventional. Brandt also indicated that waterless is most cost effective on long runs and is rather expensive for short runs because of the time involved with setting up the press. By running both conventional and waterless, more set-up time is required and currently, makeready is equal to or longer on waterless than conventional. However, makeready time and waste should decrease with experience of the press operators.

Brandt projects that with practice, waterless makeready could be cut by 30-40 percent.

Temperature control is the most important press factor of waterless printing and requires skill on the part of the press operator. Roller temperature must be carefully monitored and adjusted to ensure a high quality product.

The Brandt Company uses conventional inks for waterless printing and clean-up time and wastes are comparable.

Brandt believes that waterless printing has been beneficial to The Brandt Company, however, he notes that new prepress technologies can produce similar results.

6.2 Digital Direct-to-Press

Direct-to-press technologies are developing quickly and could possibly change the cost-effectiveness of short run color while offering fast turnaround time.

Several digital presses are on the market. All operate differently but apply the same principles. These presses digitally image a plate on the press with an electrostatic charge. Some of the new digital presses use dry toner while others use liquid toner. The plates are reusable and presses are both sheet fed and web.

Images can be customized "on-the-fly" because presses are designed to produce a new image with every rotation of the press cylinder. This eliminates much down time, all prepress paper, film negative, processing wastes and even conventional proofing. Because registration and color balance is electronically controlled, there is virtually no makeready. Pages are imaged on both sides as they pass through the press and documents are printed one page at a time rather than running all of one page then repassing all for the next color. Most of these presses operate waterless and alcohol-free, reducing the printer's hazardous waste generation and air emissions.

Direct-to-press is most cost-effective--for the printer and customer--on full color short runs and on-demand printing. With traditional printing, full color short runs and print-on-demand orders are not cost effective. For this reason, direct-to-press technology should be lucrative if properly marketed.

All product quality advantages have economic benefit. However, when considering investing in new technologies, all expenses, such as equipment costs and employee training, must be evaluated. If considering a digital press, be ready to make a 100 percent commitment. In addition to hardware, software and plate processing equipment, a digital proofer is needed because there is no film from which to make a conventional proof.

"Although it is probably too early in the game to compare benefits to prices, it would appear that at least some of the digital printing solutions about to enter the market will be priced considerably less than traditional offset presses (Roth, 1994)."

Several companies are now marketing these new presses in the United States.

7.0 Recycling in the Graphic Arts Industry

Recycling addresses waste streams that pollution prevention approaches have not been able to address. Although preventing the waste is always the best option, recycling programs are still an important element of any pollution prevention / waste minimization program.

7.1 Potential Recyclables

Lithographic facilities generate a wide variety of potentially recyclable items, listed in Figure 7.1. Trimmings, waste signatures, web breakage and web ends are some examples of waste papers most printers recover (Tebeau, 1993). These waste papers are used to manufacture strong, high-quality recycled-content papers. Figure 7.1 lists potential recyclables from printing facilities. Another item recovered at printing facilities is silver from prepress operations. The market for silver is usually good despite price fluctuation. To avoid violating federal speculative accumulation laws, 75 percent of the silver flake obtained from an electrolytic cell must be recycled within one year.

Additional recyclables include corrugated cardboard, office paper waste, aluminum printing plates, beverage cans and glass. Containers made from plastics can be rinsed and recycled. Fiber core tubes from web rolls and steel ink cans are examples of materials that can be difficult to recycle. The former because of the tube's short fiber length and heavy glue content and the latter because of ink contamination concerns. Case Study K describes how one lithographer worked through the difficulties associated with marketing empty steel ink cans and established a successful recycling program for this waste.

Potential Recyclables and Ease of Recycling

Wastes	Market	Origin
Waste signatures, millbroke, etc.	Usually steady demand	Press floor and bindery
Corrugated cardboard	Market usually steady	Supply room and bindery
Precious metal / spent negatives	Market usually steady	Pre-press
Office paper	Market variable	Administrative, support offices
Aluminum	Market currently variable	Pre-press, supply room
Plastic 1 and 2	Market variable	Pre-press, supply room
Glass	Market variable	Administrative, support offices
Fiber core tubes	Market difficult	Press floor
Steel ink tins	Market difficult	Press floor
Wooden pallets	Market variable	Supply room, shipping and receiving

Figure 7.1

Case Study K

Recycling at Bankers Systems

Because Bankers Systems, Inc., of St. Cloud, Minnesota, encourages waste minimization, Chuck Rau, graphics director, and Gary Mrozek, production systems engineer, developed and implemented a recycling program for empty plastic and steel ink containers.

These containers are traditionally not recycled because of the environmental liabilities associated with their handling.

This required Rau and Mrozek to implement meticulous cleaning procedures for the empty containers, establish a chain of custody that would satisfy all applicable environmental laws and work with regulators to obtain approval for the program.

The cleaning procedure for empty tins involves using an ink knife to remove as much of the leftover ink as possible, and a rubber spatula to remove any remaining ink. This ink is added to waste ink for disposal by a hazardous waste management company.

The rubber spatula, following the cleaning step, is washed in a parts wash bath. The empty containers are crushed and placed in a 55-gallon drum prior to pick-up by the recycler. This is an effective procedure because after cleaning, ink containers weigh only 2/100ths of a pound more than ink cans that never contained ink.

Employees are carefully trained to prepare empty containers for recycling.

Mrozek and Rau documented the steps involved in transporting, processing, and recycling the empty containers by requesting detailed letters from the hauler, processor and recycler to explain their procedures following pick-up.

These letters were sent to the Minnesota Pollution Control Agency (MPCA) with a detailed explanation of Bankers' in-house container cleaning procedures. As a result, MPCA approved this program, reassuring all parties involved.

The program allows Bankers to divert approximately 1,000 pounds every ten weeks from area landfills.

7.2 Designing and Maintaining a Recycling Program

The steps to a successful waste minimizing recycling program are similar to those involved with pollution prevention programs. In fact, most printers include recycling programs as part of P2 programs. The most important thing is knowing the kinds and

amounts of potential recyclables being generated. Next, based on a preliminary investigation of surrounding markets and the facility's storage capacity, decide which recyclables should be collected.

Once this has been established, P2 teams can plan canister placement, collection times and locations within the plant, and the type of employee information program to best suit the culture and needs of the particular facility.

7.3 Marketing Recyclables

Recycling program success depends on finding reliable markets while organizing the collection program. Too often recycling programs are instituted at facilities without clear ideas of where the recyclables will be used once they are collected. Reliable markets will help ensure that the collection program is viable in the long run.

Marketing requires persistence and follow-up. Several potential avenues for information include:

- The yellow pages directory under recyclers, metal collectors, precious metal collectors, wooden pallet rebuilders, glass recyclers, solid waste brokers, etc.
- Other businesses may be willing to share their markets. Sometimes markets are guarded to protect prices, but friends or business acquaintances are often willing to share market information.
- Many state solid waste agencies publish recycling directories that list a variety of markets and collectors.
- Your solid waste hauler is often familiar with area recyclers.
- Regional and national waste exchange services list materials available for recycling or exchange, often free of charge. Additionally, some waste exchanges have field representatives who will assist with marketing. These services may publish lists of markets for industrial by-products and wastes. Appendix B contains a listing of North American Waste Exchanges.

Regardless of where market information is obtained, marketing recyclables is an on-going process. As the market for recyclables is prone to fluctuation, follow-up is necessary to ensure top price and quality service (Powelson & Powelson, 1992). Case Study L describes a comprehensive program for recycling at The Printer Ink, of Des Moines, Ia., and offers some advice on recycling markets.

Case Study L

Comprehensive Recycling Programs

The Printer, Inc., of Des Moines, Iowa, incorporates recycling and new automated presses in its waste reduction plan. Paper waste, plastic, silver effluent, waste negatives, and printing plates are recycled and other pressroom wastes, such as waste ink, are sent for fuel blending. Press room rags are laundered, presses are run with alcohol substitutes, and clean-up is accomplished with solvents having flash-points above the 140°F limit for a characteristically ignitable hazardous waste.

Press operator Bill Murphy has long been involved with pollution prevention and recycling programs and contends there are two important aspects to implementing and maintaining a good program: a company commitment to the principles of recycling / pollution prevention and persistence in finding reliable vendors to help you deal with individual waste streams.

The Printer, Inc. committed to the Demming Management Concept - each department in the plant is focused on not wasting money. This means eliminating process mistakes and unnecessary waste.

At the end of the year, a bonus is paid to each employee based on the company's profit.

“Waste goes to the bottom line; the smaller your waste, the smaller the amount of money subtracted from the bottom line and the larger the bonus,” notes Murphy. Thus, a firm commitment by company management to practices that increase the overall profitability and involve employees helps support P2 and recycling initiatives.

Employee incentives assure that recyclables are properly segregated and rinsed if necessary. Plastic recycling is a good example of the excellent follow through at The Printer, Inc. Plastics #1 and #2 are collected from both the pre-press and press area and are rinsed and stored in the loading dock prior to recycling without significant problems. “We have a saying,” relates Murphy, “everybody has to realize it is someone's job [to segregate, rinse, and recycle].”

Finding reliable markets is the second part of a successful recycling / pollution prevention plan. Murphy suggests that businesses interested in starting or expanding their recycling plans network with other businesses willing to share their markets. This will help to establish the personal contacts that can make the recycling program successful. If these do not work out, referring to the local yellow pages can often turn up local recyclers / collectors that can themselves lead to other potential markets.

It is important to start programs with more readily recyclable items such as waste paper and silver / spent negative recover. “Recycling ink tins can be a much greater challenge, and you need some successes to begin with. It is also important to make sure your recyclers do what they say they will — make them stick to pick-up schedules,” advises Murphy.

7.4 Obstacles to Recycling

The variety of forces that might inhibit the recycling process include:

- technical constraints
- physical constraints
- economic constraints
- regulatory constraints

Technically, mechanical infrastructure and efficient methodologies to deal effectively with some waste streams are lacking. Printers who use UVC or EBC inks may find it difficult to locate a processor with the equipment needed to repulp these types of paper. Printers wanting to recycle plastic-laminated papers may find it nearly impossible to locate a market that can effectively process these materials (Tebeau, 1993). Physical constraints also make it difficult to recycle some wastes. For example: plastic wastes that consist of more than one type of plastic must often be separated by hand prior to recycling, making the recovery process labor-intensive and cost prohibitive. Sufficient physical storage space at the production facility to hold recyclables until enough volume is gathered to successfully market the recovered materials can also be an obstacle.

Economic constraints — such as low market demand, distance between facility and recycler and insufficient quantities — limit what can be recovered. Although no regulations prevent recycling, potential liability may limit a printer's willingness to try recycling certain items and may also inhibit the end market's desire. Case Study M is a good example of a company that worked through regulatory issues to recover waste steel and plastic ink containers after a great deal of planning and commitment above and beyond the scope of many beginning recycling programs.

7.5 Pollution Prevention for Lithography

Recycling obstacles can effectively preclude recovery of certain materials, yet creative solutions exist for a variety of recycling problems. These include prethinking to avoid future problems and community actions, such as collective marketing of recyclables.

When making decisions about purchasing raw materials, consider potential recyclability. For example, some types of colored stock are more easily recycled than others. Letting customers know the potential recyclability of ink and paper combinations prior to specification can contribute to the final product's recyclability. This is true for adhesives used in adhesive binding as well since some adhesives such as alkali-soluble hot melt adhesives and EVA, Polyurethane Reactive (PUR) and animal glue hot melts are more recyclable than other hot melts (Tebeau, 1992).

Better yet, eliminate any need to recycle items. Choose vendors that take back excess chemicals, inks, containers and other waste products for refill rather than disposing of or recycling them. Some printers also use returnable ink totes for their process colors which completely avoids recycling empty ink containers.

Companies that encounter economic and physical barriers to recycling might consider collective marketing or recycling cooperatives. Several small printshops with similar recycling problems can cooperate and pool their recyclables. This puts printers in a better position when looking for markets and helps stabilize their markets since larger quantities are usually more attractive to potential buyers (BioCycle, 1990). Similar agreements might be worked out to assure that adequate storage space is available for recycled items prior to pick-up. To make this approach successful excellent diplomacy, cooperation and teamwork skills are necessary. Furthermore, each party involved should practice good source separation to assure that collected recyclables are high quality.

Finally, strong markets depend on purchasing materials made from recycled products. A wide variety of printing materials can now be purchased that contain recycled content (KCSWD, 1991). All federal government printing jobs and federal government contractors are required by Executive Order 12873, to use a minimum of 50 percent recycled content with 20 percent of this fiber from post-consumer waste. By 1999, the post-consumer fiber content will be 30 percent (Blessing, 1994; Abramic, 1994).

Of the 50 U.S. paper mills, 30 manufacture recycled papers. The recycled content market has grown at three times the rate of the non-recycled content paper market (API, 1994; Franklin, 1990). Increased demand for these papers has also led to increased attention to producing quality recycled papers with stronger fiber and improved pulp characteristics (Abramic, 1994). This does not alleviate working with the press and paper to achieve high-quality results. Some approaches to successfully working with recycled papers are listed in Figure 7.2.

Whatever combination of approaches is taken to recycle and prevent pollution, a carefully planned P2 program supported by management and faithfully carried out by production staff can help meet environmental regulations, avoid future regulatory liability, and pass on a healthful environment to subsequent generations. Pollution prevention is an investment in the bottom line as well as the future.

Case study M ends this manual with a description of one medium-sized printer who designed their new facility with the future--and pollution prevention in mind.

Tips for Printing on Recycled Stock

Prepress

- *Pinch back dots in the shadow and midtone areas after the correct color is obtained to limit dot gain*
- *For halftones and separations use a 133-line dot screen*
- *When printing on colored stock, better separation results can be achieved by using gray component replacement (GCR) and unsharp masking (USM)*

During the Press Run

- *Always inspect paper stocks upon delivery for correct weight, color, consistency, etc.*
- *Paper lifts should be wiped down with glycerine to eliminate excess paper-dust*
- *Pass sheets through press without water or ink to dust them, eliminating loose paper particles*
- *Slow press runs slightly to eliminate picking or linting*
- *Reduce the ink tack slightly*
- *Print two "hits" of a solid to reduce picking*
- *Allow more drying time and use smaller stacks of paper*
- *Run sheet grain parallel to press cylinders to avoid sheet spread*
- *Run slightly more water or alcohol on uncoated sheets but be careful to avoid too wet a run which can lead to ghosting*

Figure 7.2
**Excerpted from "Helpful Hints for Printing on Recycled Uncoated Papers," 1993. Cross Pointe Paper Corporation, St. Paul, Mn.*

Case Study M

Prethinking Pollution Prevention

Richmond Newspaper, Inc. (RNI), in Richmond, Virginia, did more than just implement pollution prevention practices at its new web-offset plant; it "prethought" all of its renovation plans and capital purchases to include P2 techniques and technologies whenever possible.

Robert Rogers, Vice President of Operations for RNI, explains that prior to upgrading and rebuilding its 200-employee production plant, management sat down with environmental lawyers to discuss a 40-50 year environmental contingency plan.

"The biggest issue in the future is not OSHA, it's EPA. We wanted to make sure we were as pro-active in regard to EPA regulations as possible," states Rogers.

This included careful planning during the preconstruction phase to minimize impact to the natural landscape. To capture stormwater run-off, 100-year flood retention ponds were constructed and seeded with aquatic plants. To this day the area attracts a wide variety of wildlife such as blue herring, several duck species, deer, and "on a cloudy day," says Rogers, "you can count the wild turkeys in the field [outside the plant]."

A state-of-the-art water treatment system separates domestic and process waste streams by treating both separately. More advanced ultrafiltration and neutralization treats the process water stream before it merges with domestic waste effluent and returns to the public sewer system. Currently, engineering studies are underway at RNI to evaluate the possibility of implementing a $300,000 gray-water project that would divert 125,000 gallons of waste water from entering the public sewer system. This water can instead be used to water the grounds and save costly potable water for human consumption and make-up water.

But RNI did not stop with building renovations and advanced waste effluent treatment. It replaced outdated wasteful equipment with the latest Mitsubishi web lithopress, OSHA-acceptable guided automatic delivery vehicles, and two robots for splice separation.

Upgrading the equipment reduced down time and improved makeready time. This was coupled with Baldwin dry blanket wash systems, which decrease the number of complete wash-ups required. RNI also uses soy inks for all process colors except black, and Rogers is still looking for an acceptable black soy ink that runs well on his presses.

To recover ink on site, RNI installed an STI ink recycling system that filters impurities from waste ink and mixes it with unused ink at a 4:6 ratio.

Other forward-thinking pollution prevention measures at Richmond Newspapers include silver recovery from used photographic fixer by electrolytic recovery, followed by a metal exchange canister to polish the effluent prior to discharge; recycling spent photographic negatives; recycling aluminum lithographic plates; the latest in vapor recovery systems for RNI's fleet pump house; and double-walled, cathode-protected fuel storage vaults.

Rogers admits RNI “may not have an immediate payback,” but “we have a great chairman of the board,” and “in our capitalization plans, environment often stands on its own merits.” This pro-active approach to environmental issues has not gone unnoticed by Virginia's state environmental agencies.

In fact, Richmond Newspapers was invited to serve on the Governor's Task Force for Pollution Prevention, a citizen's advisory committee, earning RNI a say in the development and implementation of future environmental regulations.

Rogers has this advice for small businesses not currently implementing good pollution prevention planning: “watch your discharges of metals, acids, and photochemicals — water is going to continue to be a very important issue. Second, if you haven't weaned yourself from kerosene, varsal and naphtha, you had best hurry up and do that.” Environmental regulations aren't going to go away anytime soon, cautions Rogers, and the best approach to profitably deal with these requirements is “being as pro-active as possible.”

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Toxicity Characteristic Leaching Procedure (TCLP)

Parameter	Regulatory Level	EPA Hazardous Waste Number
Arsenic	5.0 mg/l	D004
Barium	100.0 mg/l	D005
Benzene	0.5 mg/l	D018
Cadmium	1.0 mg/l	D006
Carbon tetrachloride	0.5 mg/l	D019
Chlordane	0.03 mg/l	D020
Chlorobenzene	100.0 mg/l	D021
Chloroform	6.0 mg/l	D022
Chromium	5.0 mg/l	D007
m-Cresol	200.0 mg/l	D024
o-Cresol	200.0 mg/l	D023
p-Cresol	200.0 mg/l	D025
Cresols (total)	200.0 mg/l	D026
1,4-Dichlorobenzene	7.5 mg/l	D027
1,2-Dichloroethane	0.5 mg/l	D028
1,1-Dichloroethylene	0.7 mg/l	D029
2,4-Dinitrotoluene	0.13 mg/l	D030
Endrin	0.02 mg/l	D012
Heptachlor	0.008 mg/l	D031
Hexachlorobenzene	0.13 mg/l	D032
Hexachloro-1,3-butadiene	0.5 mg/l	D033
Hexachloroethane	3.0 mg/l	D034
Lead	5.0 mg/l	D008
Lindane	0.4 mg/l	D013
Mercury	0.2 mg/l	D009
Methoxychlor	10.0 mg/l	D014
Methyl ethyl ketone	200.0 mg/l	D035
Nitrobenzene	2.0 mg/l	D036
Pentachlorophenol	100.0 mg/l	D037
Pyridine	5.0 mg/l	D038
Selenium	1.0 mg/l	D010
Silver	5.0 mg/l	D011
Tetrachloroethylene	0.7 mg/l	D039
Toxaphene	0.5 mg/l	D015
Trichloroethylene	0.5 mg/l	D040
Vinyl chloride	0.2 mg/l	D043
2,4-D	10.0 mg/l	D016
2,4,5-TP	1.0 mg/l	D017
2,4,5-Trichlorophenol	400.0 mg/l	D041
2,4,6-Trichlorophenol	2.0 mg/l	D042

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