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EPA Office of Compliance Sector Notebook Project

Profile of the Printing and Publishing Industry

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EPA/310-R-95-004.	Inorganic Chemical Industry	Walter DeRieux	564-7067
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EPA/310-R-95-006.	Lumber and Wood Products Industry	Seth Heminway	564-7017
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EPA/310-R-95-008.	Metal Mining Industry	Keith Brown	564-7124
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EPA/310-R-95-017.	Stone, Clay, Glass and Concrete Ind.	Scott Throwe	564-7013
EPA/310-R-95-018.	Transportation Equip. Cleaning Ind.	Virginia Lathrop	564-7057

Printing Industry Sector Notebook Contents

Exhibits Index

List of Acronyms

AFS - AIRS Facility Subsystem (CAA database)
AIRS - Aerometric Information Retrieval System (CAA database)
BIFs - Boilers and Industrial Furnaces (RCRA)
BOD - Biochemical Oxygen Demand
CAA - Clean Air Act
CAAA - Clean Air Act Amendments of 1990
CERCLA - Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS - CERCLA Information System
CFCs - Chlorofluorocarbons
CO - Carbon Monoxide
COD - Chemical Oxygen Demand
CSI - Common Sense Initiative
CWA - Clean Water Act
D&B - Dun and Bradstreet Marketing Index
ELP - Environmental Leadership Program
EPA - United States Environmental Protection Agency
EPCRA - Emergency Planning and Community Right-to-Know Act
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FINDS - Facility Indexing System
HAPs - Hazardous Air Pollutants (CAA)
HSDB - Hazardous Substances Data Bank
IDEA - Integrated Data for Enforcement Analysis
LDR - Land Disposal Restrictions (RCRA)
LEPCs - Local Emergency Planning Committees
MACT - Maximum Achievable Control Technology (CAA)
MCLGs - Maximum Contaminant Level Goals
MCLs - Maximum Contaminant Levels
MEK - Methyl Ethyl Ketone
MSDSs - Material Safety Data Sheets
NAAQS - National Ambient Air Quality Standards (CAA)
NAFTA - North American Free Trade Agreement
NCDB - National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NEIC - National Enforcement Investigation Center
NESHAP - National Emission Standards for Hazardous Air Pollutants
NO_2 - Nitrogen Dioxide
NOV - Notice of Violation
NO_X - Nitrogen Oxide

NPDES - National Pollution Discharge Elimination System (CWA)
NPL - National Priorities List
NRC - National Response Center
NSPS - New Source Performance Standards (CAA)
OAR - Office of Air and Radiation
OECA - Office of Enforcement and Compliance Assurance
OPA - Oil Pollution Act
OPPTS - Office of Prevention, Pesticides, and Toxic Substances
OSHA - Occupational Safety and Health Administration
OSW - Office of Solid Waste
OSWER - Office of Solid Waste and Emergency Response
OW - Office of Water
P2 - Pollution Prevention
PCS - Permit Compliance System (CWA Database)
POTW - Publicly Owned Treatments Works
RCRA - Resource Conservation and Recovery Act
RCRIS - RCRA Information System
SARA - Superfund Amendments and Reauthorization Act
SDWA - Safe Drinking Water Act
SEPs - Supplementary Environmental Projects
SERCs - State Emergency Response Commissions
SIC - Standard Industrial Classification
SO_2 - Sulfur Dioxide
SO_X - Sulfur Oxides
TOC - Total Organic Carbon
TRI - Toxic Release Inventory
TRIS - Toxic Release Inventory System
TCRIS - Toxic Chemical Release Inventory System
TSCA - Toxic Substances Control Act
TSS - Total Suspended Solids
UIC - Underground Injection Control (SDWA)
UST - Underground Storage Tanks (RCRA)
VOCs - Volatile Organic Compounds

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water and land pollution (such as economic sector, and community-based approaches) are becoming an important supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, compliance assurance, education/outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. The desire to move forward with this "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, states, the regulated community, and the public became interested in this project, the Office of Compliance expanded the scope of the original project. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community and the public.

For any given industry, each topic described above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is desired. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further

explored based upon the citations and references listed at the end of this profile. As a check on the information included, each notebook went through an external document review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate and up-to-date summaries.

I.B. Additional Information

Providing Comments

The Office of Compliance plans to periodically review and update notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviroene Bulletin Board or the Enviroene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing these data systems. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the existing notebooks reflect an approximation of the relative national occurrence of facility types that occur within each sector. In many instances, industries within specific geographic regions or states may have unique characteristics that are not fully captured in these profiles. For this reason, the Office of Compliance encourages state and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested states may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with state and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume.

If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE PRINTING AND PUBLISHING INDUSTRY

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the printing and publishing industry. The type of facilities described within the document are also described in terms of their Standard Industrial Classification (SIC) codes. Additionally, this section contains a list of the largest companies in terms of sales.

II.A. Introduction, Background, and Scope of the Notebook

The printing and publishing industry, defined most broadly, includes firms whose business is dominated by printing operations, firms performing operations commonly associated with printing, such as platemaking or bookbinding, and publishers, whether or not they actually print their own material. This categorization corresponds to the Standard Industrial Classification (SIC) code 27 used by the Bureau of the Census to track the flow of goods and services within the economy. The Census identifies 58,000 firms and 62,000 facilities within SIC code 27.[1,a]

From the printing industry's perspective, the industry is organized by the type of printing process used: lithography, (roto)gravure, flexography, screen, and letterpress. Trade associations, technical foundations, suppliers, and supporting academic institutions are organized along process lines (See Section VIII.C). For example, the Screen Printing Technical Foundation supports the screen printing process and the Graphic Arts Technical Foundation supports lithographers. The Rochester Institute of Technology specifically supports gravure and flexographic printers. Facilities tend to employ one type of printing process exclusively, although some of the larger facilities may use two or more types. Based on the estimated value of shipments from the U.S. printing industry in 1990, lithography dominates the market with a 47 percent market share; gravure, 19 percent, flexography, 17 percent; letterpress, 11 percent; and screen printing, 3 percent.[2]

[a] Variation in facility counts occur across data sources due to many factors including, reporting and definitional differences. This notebook does not attempt to reconcile these differences, but rather reports the data as they ar e maintained by each source.

II.B. Characterization of the Printing and Publishing Industry

According to 1987 Census data, the printing and publishing industry was comprised of 58,000 firms operating 62,000 facilities. This figure does not capture the large number of "in-plant" printing operations located throughout the manufacturing sectors. The total number of printing and publishing operations, therefore, could well exceed 100,000. The printing industry has a high ratio of small operations, with nearly one-half of printing facilities employing fewer than five employees. Printing operations are most often located adjacent to population and business centers and therefore their distribution closely parallels the distribution of the U.S. population.

II.B.1. Industry Size and Geographic Distribution

While the precise number of printing and publishing facilities is difficult to determine, 1987 Census data identified approximately 58,000 firms operating 62,000 facilities.[3] Other estimates of industry size are higher, in the range of 70,000, 86 percent of which are thought to have press operations, with the remainder performing printing-related operations such as publishing or platemaking.[4] It is important to note that because printing itself is a process used to transfer images or material to a substrate, "in-plant" printing operations are present in facilities throughout the manufacturing sectors. For example, one of the largest screen printing operations is within Boeing Corporation. Other examples include firms that print textiles, product manufacturers that print their label, and manufacturers of printed circuit boards. The number of printing and publishing operations, therefore, could well exceed 100,000.

The Bureau of the Census estimates that in 1987, 1.5 million people were employed in printing and publishing.[5] The value of shipments (revenue associated with product sales) generated by printing and publishing facilities totaled $135 billion.[6] This value of shipments figure omits up to $100 million associated with in-plant and quick printers (operating xerographic copiers or small lithographic presses).[7] Sales within the printing industry are expected to grow by 3.5 to 5.3 percent annually between 1990 and the year 2000.[8]

One of the most significant characteristics of the printing industry is the large proportion of very small firms. Almost one-half of all printing facilities have fewer than five employees; approximately 84 percent employ fewer than 20.[9] Flexographic and gravure printers, however, tend to be larger operations and to have more employees.

Exhibit 1: Printing Facilities by Number of Employees		
Employees per Facility	**Number of Facilities**	**Percentage of Facilities**
1-4	**32,158**	**46%**
5-9	**17,068**	**24%**
10-19	**9,800**	**14%**
20-99	**8,652**	**13%**
100+	**2,036**	**3%**
Total	**69,714**	**100%**

Source: U.S. Department of Commerce, Bureau of the Census. 1987 Census of Manufacturers.

Printing facilities typically serve regional or local markets although some firms, such as those producing books and periodicals, serve national and international markets. Consequently, the geographic distribution of printing facilities closely parallels the distribution of the U.S. population. Facilities are most frequently located in light industrial areas in or adjacent to population and business centers, although smaller operations are somewhat more likely to be located in residential settings. Across the U.S., sixty percent of printing facilities are located in just ten states: California (13%), New York (8%), Illinois (7%), Texas (6%), Florida (5%), Pennsylvania (5%), Ohio (4%), New Jersey (4%), Michigan (4%), and Massachusetts (3%).[10]

Source: U.S. EPA, Toxics Release Inventory Database, 1993.

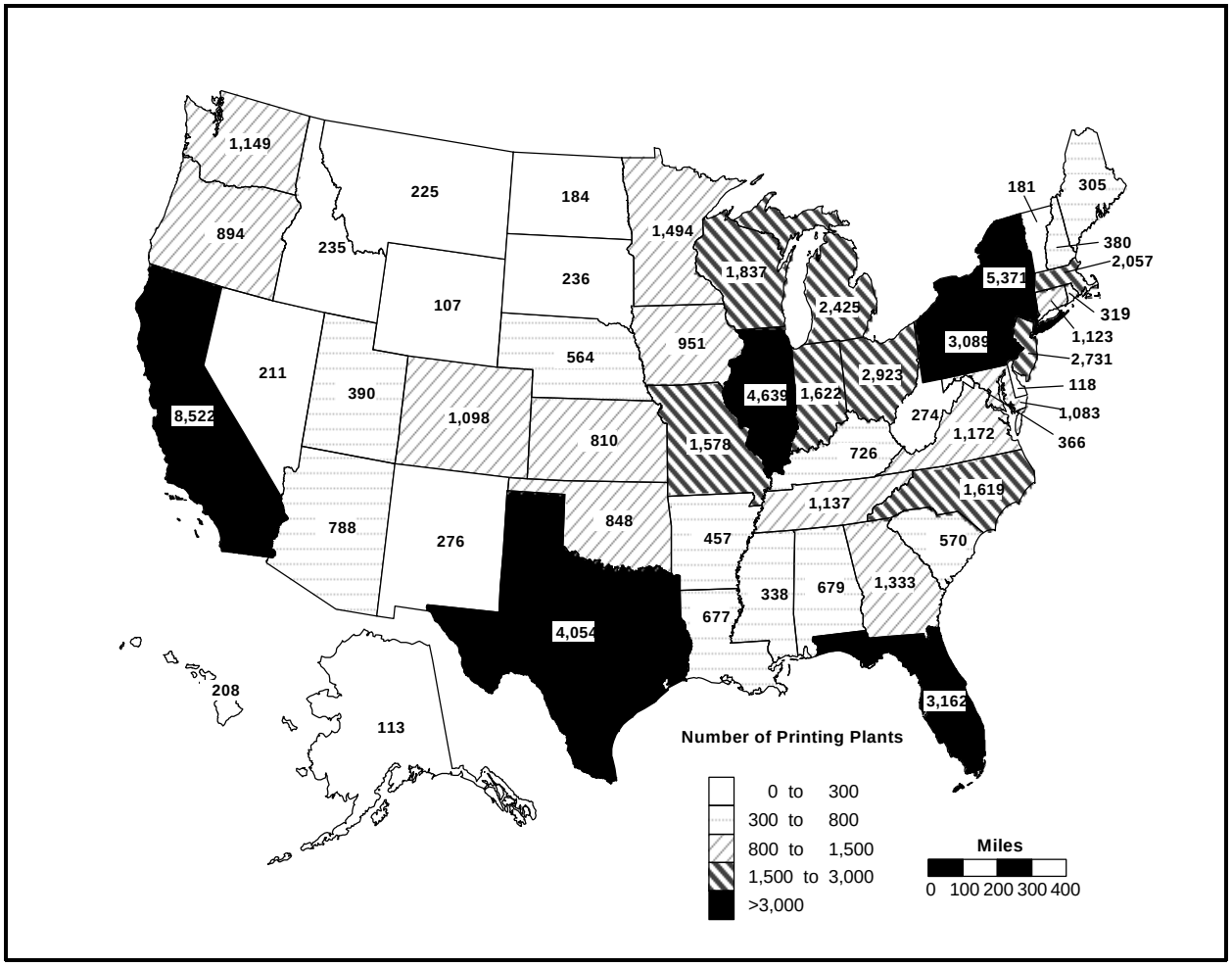


Exhibit 2: Printing Facilities

Ward's Business Directory of U.S. Private and Public Companies, produced by Gale Research Inc., compiles financial data on U.S. companies including those operating within the printing industry. Ward's ranks U.S. companies, whether they are a parent company, subsidiary or division, by sales volume within the 4-digit SIC codes that they have been assigned as their primary activity. Readers should note that: 1) companies are assigned a 4-digit SIC that most closely resembles their principal industry; and 2) sales figures include total company sales, including subsidiaries and operations not related to printing. Additional sources of company specific financial information include Standard & Poor's Stock

Report Services, Dun & Bradstreet's Million Dollar Directory, Moody's Manuals, and annual reports.

Exhibit 3: Top U.S. Companies with Printing Operations

Rank[a]	Company[b]	1993 Sales (millions of dollars)
1	R.R. Donnelley & Sons Company - Chicago, IL	3,915
2	Times Mirror Company - Los Angeles, CA	3,624
3	Gannett Company, Inc. - Arlington, VA	3,382
4	Hallmark Cards, Inc. - Kansas City, MO	2,800
5	Reader's Digest Association, Inc. - Pleasantville, NY	2,345
6	Cox Enterprises, Inc. - Atlanta, GA	2,300
7	Knight-Ridder, Inc. - Miami, FL	2,237
8	Tribune Company - Chicago, IL	2,035
9	McGraw-Hill, Inc. - New York, NY	1,943
10	Dow Jones and Company, Inc.	1,725

Note: [a] When Ward's Business Directory lists both a parent and subsidiary in the top ten, only the parent company is presented above to avoid double counting. Not all sales can be attributed to the companies printing operations.
[b] Companies shown listed SIC 2711, 2721, 2731, 2732, 2741, 2752, 2754, 2759, 2761, 2771, 2782, 2789, 2791, 2796 as primary activity.

Source: Ward's Business Directory of U.S. Private and Public Companies - 1993.

II.B.2. Product Characterization

The printing and publishing industry produces a wide array of printed products as well as materials used in the printing process. Some of the products produced within the industry include: newspapers, books, greeting cards, checks, annual reports, magazines, and packaging. Products vary in print quality from newsprint to *National Geographic Magazine*. Also, firms performing operations commonly associated with printing, such as platemaking or bookbinding, and publishers, whether or not they actually print their own material, are included within the industry.

The SIC codes, developed by the Office of Management and Budget, divide the printing and publishing industry according to the product manufactured, such as books, newspapers, and greeting cards. Most facilities identified as printers by SIC code have few, if any, business lines other than those that fall within printing and publishing. However, there are tens of thousands of in-plant printing operations at facilities whose predominant lines of business are not printing. Only if data are collected for multiple SIC codes would it be evident that such facilities engaged in printing. The following list presents the three-digit SIC codes with the associated product they represent, as well as the printing process used in the product's manufacture.

SIC 271 - Newspapers | *Processes used: lithography, flexography and letterpress*
SIC 272 - Periodicals | *Processes used: lithography, flexography and letterpress*
SIC 273 - Books | *Processes used: lithography, gravure and letterpress*
SIC 274 - Miscellaneous Publishing | *Processes used: lithography, gravure, and letterpress*
SIC 275 - Commercial Printing | *Processes used: lithography, gravure, flexography, screen and letterpress*
SIC 276 - Manifold Business Forms | *Processes used: lithography and plateless*
SIC 277 - Greeting Cards | *Processes used: gravure and screen*
SIC 278 - Blankbooks, Looseleaf Binders and Bookbinding | *Primarily nonprinting*
SIC 279 - Service Industries for the Printing Trade | *Primarily nonprinting*

Newspapers (SIC 271) and commercial printing (SIC 275) account for 57 percent of the total value of shipments for the printing and publishing industry. Newspapers (SIC 271) include establishments primarily engaged in publishing newspapers, or in publishing and printing newspapers. Newspaper printers that are not engaged in publishing are classified under Commercial Printing (SIC 275). Commercial printing products include but are not limited to the following: maps, periodicals, coupons, menus, postcards, stationary, envelopes, magazines, and custom products. Other three-digit categories comprised of firms involved primarily in printing accounted for an additional 22 percent of the value of shipments. Other SIC categories include: textile screen printing (SIC 2346) and nameplates (SIC 3993). Firms that may not be involved in printing, such as publishing of blankbooks, bookbinding and printing trade services (e.g., platemaking and typesetting), accounted for the remaining 21 percent of the value of shipments.[11]

II.B.3. Economic Trends

The following discussion has been summarized from the *U.S. Industrial Outlook*, published by the Department of Commerce, which tracks and forecasts the economic performance of most major sectors of the U.S. economy. The U.S. is the world's largest market for printed products. In aggregate, the printing and publishing industry accounts for a significant portion of the nation's goods and services; the 1991 value of shipments totaled $161 billion with an estimated payroll of $39 billion for 1.5 million workers. Printing and publishing is the largest conglomeration of small businesses in the domestic manufacturing sector. While the industry is large in number, many individual facilities, particularly small letterpress operations are marginally profitable. Industry growth is affected by several factors including: business formations and transactions (which drive advertising expenditures), population growth, and trends in certain characteristics of the population, such as leisure time availability and individuals' consumption patterns.[12]

Competitive pressures come from non-print media, such as CD-ROM, other electronic means of transferring information as well as the movement of book printing to offshore facilities where production costs are lower. In 1992, the U.S. imported $2.1 billion worth of printed products, principally from Canada, the United Kingdom, Hong Kong, and Germany. During the same period, the U.S. exported $3.8 billion worth of printed material. The major export markets for U.S. printed material are Canada, the United Kingdom, Japan, and Mexico.[13]

Once the U.S. economy emerges fully from the recession of 1990/1991, printing and publishing sales are expected to grow by 3.8 to 5.3 percent per year through the year 2000. The next five years are expected to offer printers several opportunities for business expansion due to the North American Free Trade Agreement (NAFTA) and the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) which will reduce trade barriers to U.S. exports and strengthen protection of international copyrights.[14]

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the materials and equipment used, and the processes employed within the printing and publishing industry. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for of a list of reference documents that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (via air, water, and soil pathways) of these waste products.

III.A. Industrial Processes in the Printing and Publishing Industry

The diversity of technologies and products in the printing industry makes it difficult to characterize the processes and the environmental issues facing the industry as a whole. These process differences can lead to distinct environmental concerns and are critical when developing compliance assistance programs. It is estimated that 97 percent of all printing activities can be categorized within five different printing processes: lithography, gravure, flexography, letterpress, and screen printing.[15] The equipment, applications, and chemicals for each of these processes differ; however, they all print an image on a substrate following the same basic sequence. The fundamental steps in printing are referred to as imaging, pre-press, printing, and post-press operations. The type of printing technology that is used depends on a variety of factors, including the substrate used (e.g., paper, plastic, metal, ceramic, etc.), the length and speed of the print run, the required print image quality, and the end product produced.

The first step in the printing process, imaging, produces an image of the material to be printed. Traditionally, this image is produced photographically, but with increasing frequency the image is produced electronically. The production of a photographic image involves a variety of chemicals similar to those used in other fields of photography. The image on the film is transferred to the image carrier or plate. In pre-press

operations, an image carrier is produced that can transfer the ink in the image area and can repel the ink in non-image areas. In printing, ink is applied to the plate and the image is transferred to the substrate. In the post-press step, the printed material may receive any one of numerous finishing operations, depending on the desired form of the final product.

Each of the five predominant printing technologies differ significantly in how the image is transferred from the image carrier to the substrate in the printing step. In general, the imaging and post-press operations are fairly similar for all printing technologies. Therefore, imaging and post-press procedures are discussed for all printing technologies, and the platemaking and press operations are discussed separately for each technology.

III.A.1. Imaging Operations

Imaging operations begin with composition and typesetting, and are followed by the production of a photographic negative or positive. Composition involves the arrangement of art and text into the desired format. This composition task was performed manually. Today, however, computer systems are commonly used to accomplish the task. Computers can be equipped with both optical character recognition and photographic image scanners and digitizers so that pre-typed material and images can be incorporated into the document being composed.[16]

Once the desired format and images are assembled, they are photographed to produce transparencies. The printing industry photographic process uses input materials very similar to those used in other fields of photography. The purpose of this step is to produce a photographic negative (for lithography and letterpress) or a positive (for gravure, screen printing, and other lithographic processes). Input materials for the process include paper, plastic film, or a glass base covered with a light-sensitive coating called a photographic emulsion. This emulsion is usually composed of silver halide salts and gelatin. The desired image is projected onto the film to produce a film negative or a film positive. When the exposed photographic emulsion is developed, the silver halide in the emulsion is converted to metallic silver, in proportion to the amount of exposure it has received. The developing action is stopped by immersing the film in a fixing bath, which is mainly composed of sodium thiosulfate ("hypo"). The fixed photographic emulsion is then rinsed. If an image is to be printed as a color reproduction, transparencies are made for each of the colors to be used on the press. Multi-color printing is done by passing the same substrate through several single-color printing operations.[17] Three or four basic colors are combined on the final product to yield any color desired.

III.A.2. Platemaking and Printing

From photographic negative or positive, a plate is produced that is used in each printing process to carry or transfer ink in the form of the image to the substrate. The plate must pick up ink only in the areas where ink is to be applied to the final image on the substrate. The five basic printing technologies employ five different types of plates. The platemaking step and the printing operations summaries are described below for each technology.

Lithography

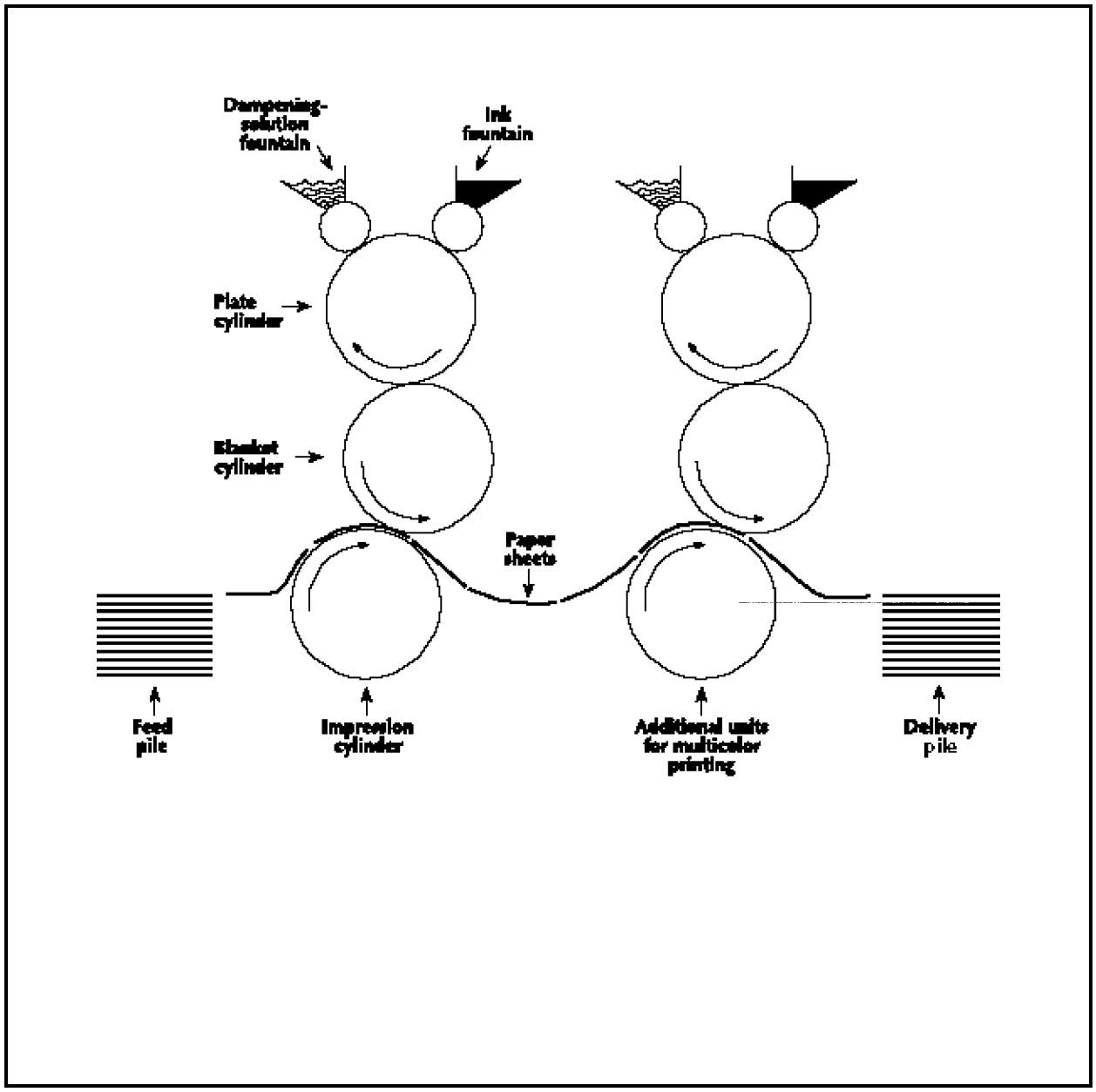
In lithography, a planographic plate is used where the image areas and the non-image areas are on the same plane (they are neither raised nor depressed) and are defined by differences in their physiochemical properties. There are several types of lithographic printing, but they all use a planographic plate and they all rely on the fundamental property that oil and water do not mix. As a result, lithographic inks are oil-based and traditionally the ink oils are petroleum based. A metal or paper or plastic printing plate is coated with a light-sensitive chemical which becomes ink receptive when exposed to light. Through the photographic negative, the coating is exposed to light chemically changing the exposed areas, making the image areas ink-receptive. The non-image areas remain water-receptive. Water-based mixtures, referred to as fountain solution, are applied to enhance the non-image area's ability to repel ink. Fountain solutions may contain five to 10 percent isopropyl alcohol or they may contain alcohol substitutes that meet the same needs but with a lower VOC content. Through the use of inking rollers, ink is applied to the plate, adhering only to the image areas. The image is transferred or offset from the plate to a rubber roller (the blanket), which then transfers the image to the substrate being printed. To accelerate drying and control ink flow characteristics, lithographic inks contain solvents. There are lithographic inks that are curable using ultraviolet energy or electron beam, and do not contain solvents.[18]

Depending on the type of substrate or the products printed, the lithographic process is further divided into subprocesses: sheet-fed, heatset web, and non-heatset web. In lithography, as in most printing technologies, presses are available as sheet-fed or as web-fed. On a sheet-fed press, the substrate is fed into the press one sheet at a time. A web-fed press prints on a continuous roll of substrate, known as a web, which is later cut to size. "Offset" lithography refers to the use of a rubber blanket to transfer the image from the plate to the substrate. Within the category of web offset lithography, there is heatset web offset and non-heatset web offset. In the

heatset process, the ink is dried by evaporating the ink oil with indirect hot air dryers. This process is potentially the most significant source of VOC emissions in lithography.[19]

Sheet-fed offset lithography is typically used for printing books, posters, brochures, and artwork. Web-fed offset lithography is commonly used for high speed production of magazines, catalogs, and other periodicals, newspapers, magazines and catalogs.

Exhibit 4: Simplified Lithographic Press Layout



Source: EPA 1994

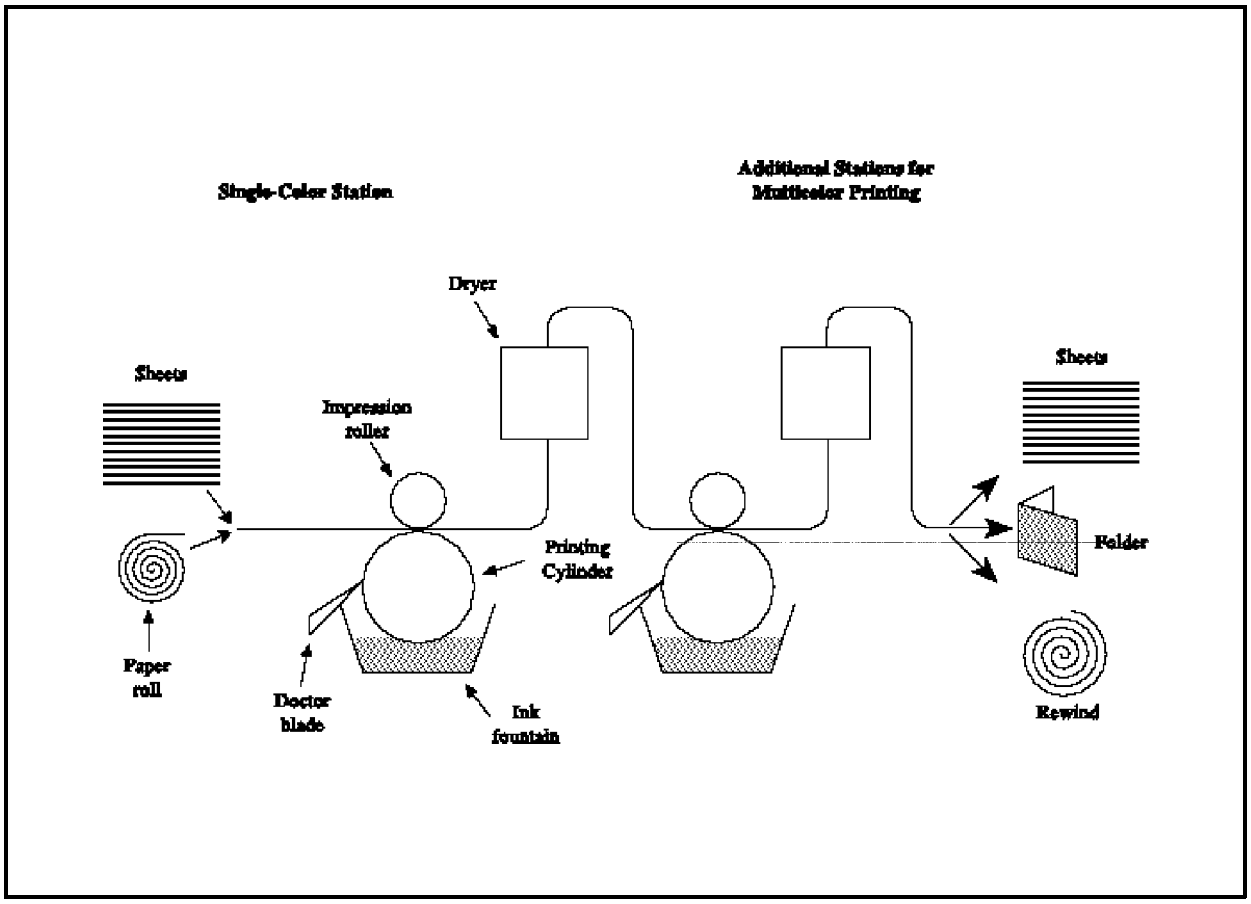
Gravure

Gravure printing uses almost exclusively electro-mechanically engraved copper image carriers to separate the image area from the non-image area. Typically, the gravure image carrier is a cylinder. It consists of a steel or plastic base which is plated with copper or a special alloy. The electro-mechanical engraving is accomplished by the electronic impulses driving the diamond stylus which engraves minute cells at the rate of over 3,000 per second. Today, most of the gravure cylinders are engraved directly from digital files. Chemical etching, which is a dominant technology for the gravure cylinder imaging in the past, represents a very small percentage of the total engravings done today. It is used for special applications only. Gravure was the first printing process capable of direct imaging from electronic data.

In gravure printing, ink is applied to the engraved cylinder, then wiped from the surface by the doctor blade, leaving ink only on the engraved image area. The printing substrate is brought into contact with the cylinder with sufficient pressure so that it picks up the ink left in the depressions on the cylinder. (Exhibit 5) Low viscosity inks are required for gravure printing in order to fill the tiny depressions on the plate. To dry the ink and drive off the solvents, drying ovens are placed in the paper path. The solvent-laden air can be passed through carbon beds to trap and condense the solvent. Most of the ink solvents are recaptured using this process, and can either be reused or destroyed by incineration.[20] Also, low VOC inks can be used making carbon beds unnecessary.

The cost of a gravure cylinder is still considered higher compared to other types of printing plates; however, today gravure is the most mature process in "digital data/direct to plate" technology. Also, gravure cylinders have a very long useful life. Several million impressions can be printed before a cylinder needs to be replaced. Gravure printing is capable of producing high-quality, continuous tone images on a variety of substrates. It is most commonly used for large circulation catalogs, magazines, Sunday supplements, and advertising inserts. Also, gravure printing is used for a variety of packaging materials, postage stamps, greeting cards, currency, resilient floor coverings, and wall paper. As in lithography, the two basic types of gravure presses are sheet-fed and web. In the US, almost all commercial gravure printing is done on web fed rotogravure presses.

Exhibit 5: Rotogravure Press



Source: EPA 1994

Flexography

Flexographic and letterpress plates are made using the same basic technologies. Both technologies employ plates with raised images and only the raised images come in contact with the substrate during printing.

The traditional method of making these plates begins with the exposure of a metal plate through a negative and processing of the exposed plate using an acid bath. The resulting metal engraving may be used directly for letterpress (flatbed), or alternatively used to mold a master using a bakelite board. The board, under pressure and heat, fills the engraving and, when cooled, becomes a master for molding a rubber plate with a raised area that will transfer the graphics. The second method of making plates employs photopolymers in either a solid or liquid state. The photopolymer sheet (consisting of monomers) is exposed to light through a negative and the unexposed areas washed out by means of a solvent or water wash. The result is the relief plate.

Typically, flexographic plates are made of plastic, rubber, or some other flexible material, which is attached to a roller or cylinder for ink application. Ink is applied to the raised image on the plate, which transfers the image to the substrate. There are three basic configurations of flexographic press -- stack, central impression and in-line. (Presses can be configured to print both sides of the web. (Exhibit 6 illustrates a three-roller webfed rotary press.)[b] In the typical flexographic printing sequence, the substrate is fed into the press from a roll. The image is printed as the substrate travels through a series of stations with each station printing a single color. Each station is made up of four rollers where the first roller transfers the ink from an ink pan to the second roller, the meter roller. The meter roller (also known as an Anilox Roll) meters the ink to a uniform thickness onto the third roller, the plate cylinder. The substrate moves between the plate cylinder and fourth roller. The plate is attached to the third roller (the plate cylinder) and the fourth roller (the impression cylinder) applies pressure to the plate cylinder, thereby forming the image on the substrate. The printed web proceeds through an overhead dryer section to dry the ink before the next station. Upon completion of the printing of the last color, the web may then move through an overhead tunnel dryer to remove all residual solvents. The finished product is rewound onto a roll. The width of flexography presses ranges from 4.5 inches up to 115 inches. The ink tray used on larger flexographic presses is very long, allowing for significant evaporation of ink (which may have

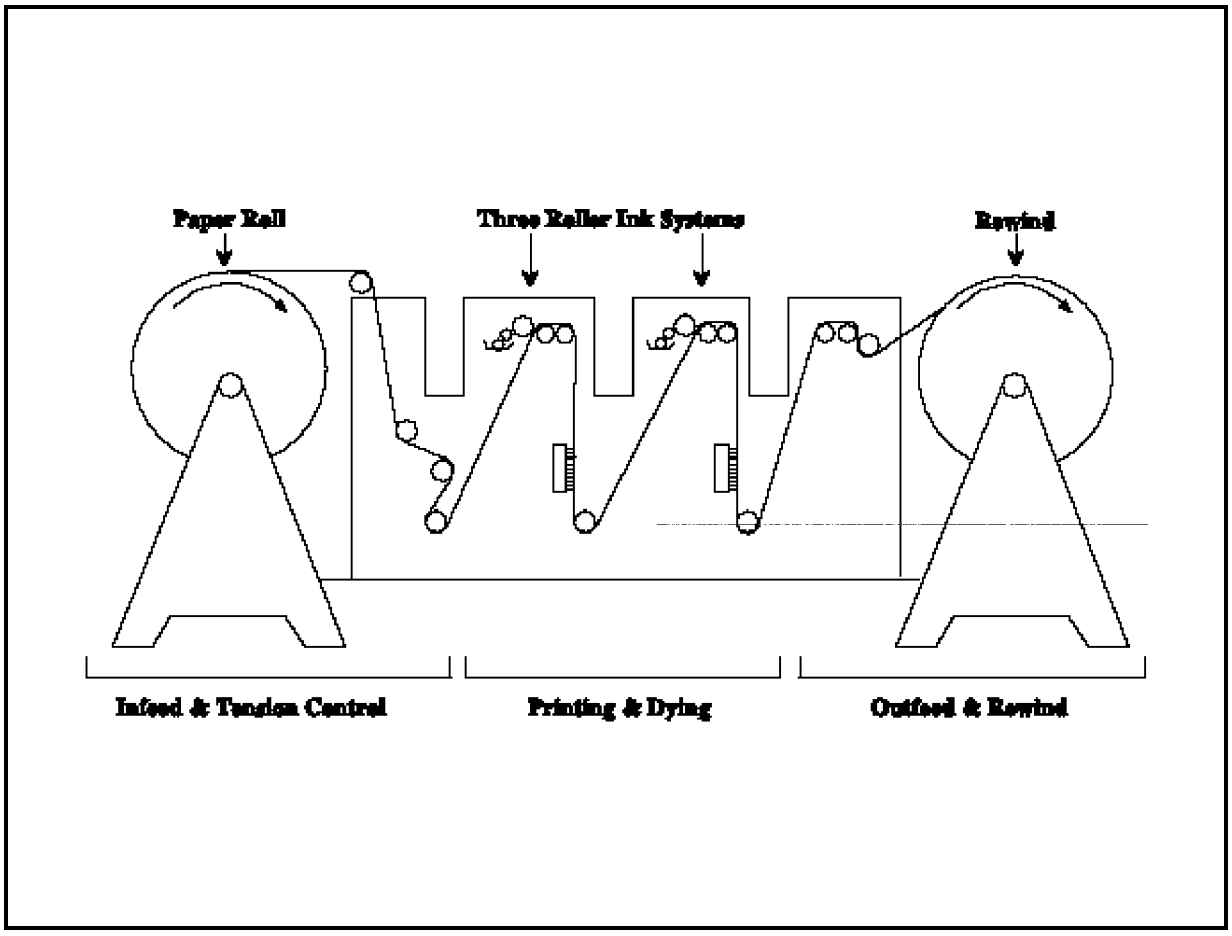
[b] Information on other flexographic printing configurations, such as, the wide web common impression press and the wide web stack type press is available from the Flexographic Technical Association (Section IX).

a high alcohol content). Modern presses are now equipped with enclosed doctor blade systems which eliminate the fountain roller and fountain, thereby reducing evaporation losses. Printers with the more narrow presses (for tags, labels and tapes) generally use water based inks and UV coatings. Using UV inks reduces the volatility of the ink.

As in gravure, fast-drying, low-viscosity inks are used. These inks lie on the surface of nonabsorbent substrates and solidify when solvents are removed, making flexography ideal for printing on impervious materials such as polyethylene, cellophane and other plastics and metallized surfaces. The soft plates allow quality printing on compressible surfaces such as cardboard packaging.

With low cost plates and a relatively simple two roller press, flexography is one of the least expensive and fastest growing printing processes. According to the Flexographic Technical Association, 85 percent of packaging is printed with flexography.[21] It is used primarily for packaging, such as plastic wrappers, corrugated boxes, milk cartons, labels, and foil and paper bags.

Exhibit 6: Webfed Rotary Flexographic Press



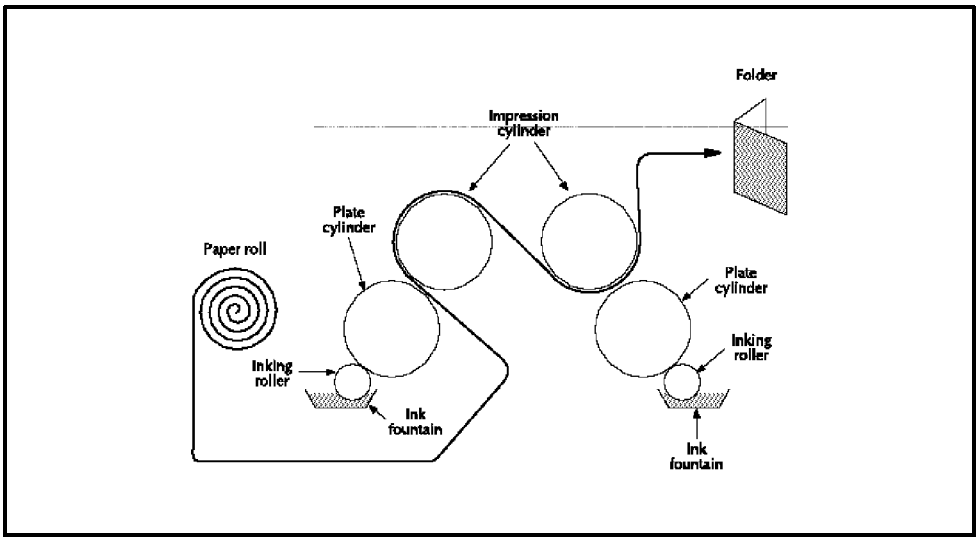
Source: EPA 1994

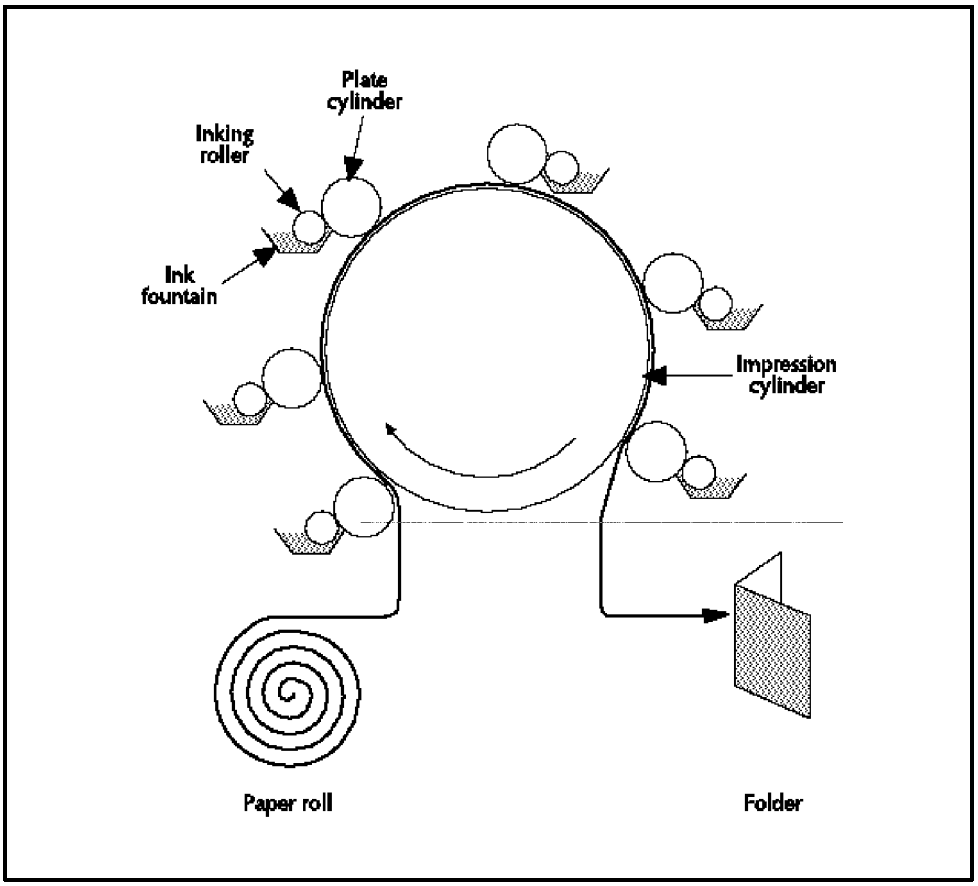
Letterpress

Like flexography, letterpress uses a plate with a raised image on a metal or plastic plate. The three types of letterpresses in use today are the platen, flat-bed, and rotary presses. On the platen press, the raised plate is locked on a flat surface. The substrate is placed on another flat surface and pressed against the inked plate. The flat-bed cylinder press prints as the substrate passes around an impression cylinder on its way from the feed stack to the delivery stack. These presses are often very slow relative to lithographic, flexographic or gravure presses. The most popular letterpress is the web-fed rotary letterpress. Designed to print both sides of the web simultaneously, these presses are used primarily for printing newspapers.

Letterpress was once the predominant printing method, but its prevalence has declined dramatically. It now accounts for an estimated 11 percent of the total value of the U.S. printing industry. Lithographic printing, gravure, and flexography have all begun to replace letterpress. Web letterpress, traditionally used to print newspapers, is being replaced by lithography and flexography. Gravure has largely replaced letterpress for printing long-run magazines and catalogs, while flexography is replacing it for printing paperbacks, labels, and business forms. Today, letterpress is primarily used for printing books, business cards, and advertising brochures.

Exhibit 7: Rotary Letterpress Press





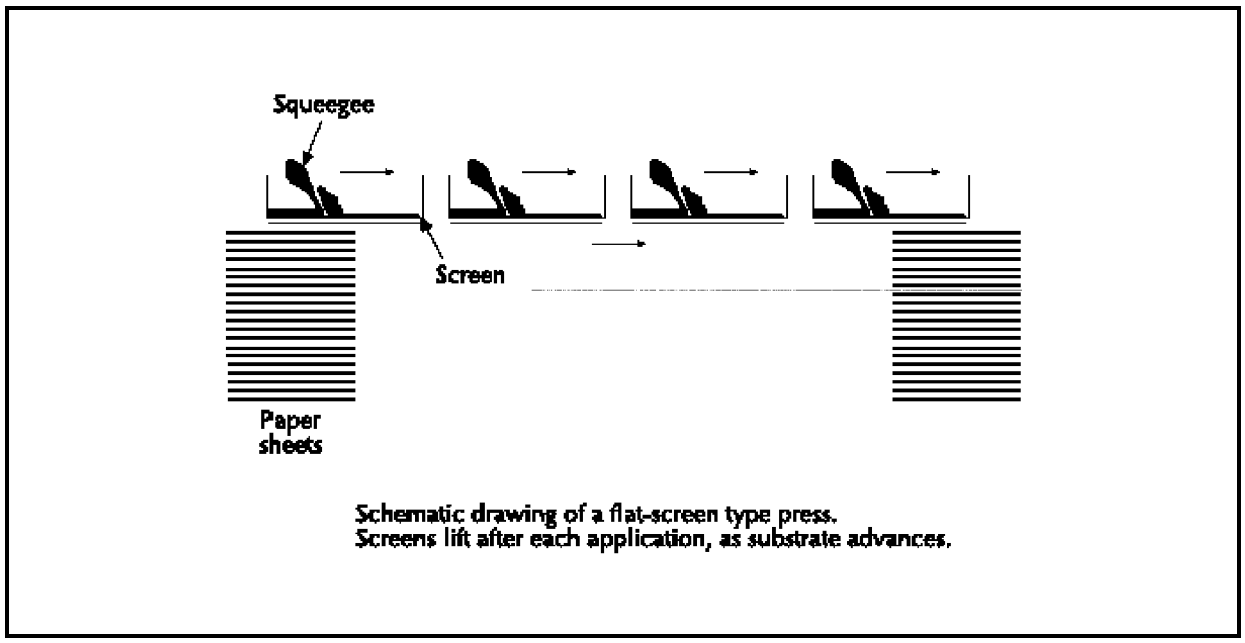
Source: EPA 1994

Screen Printing

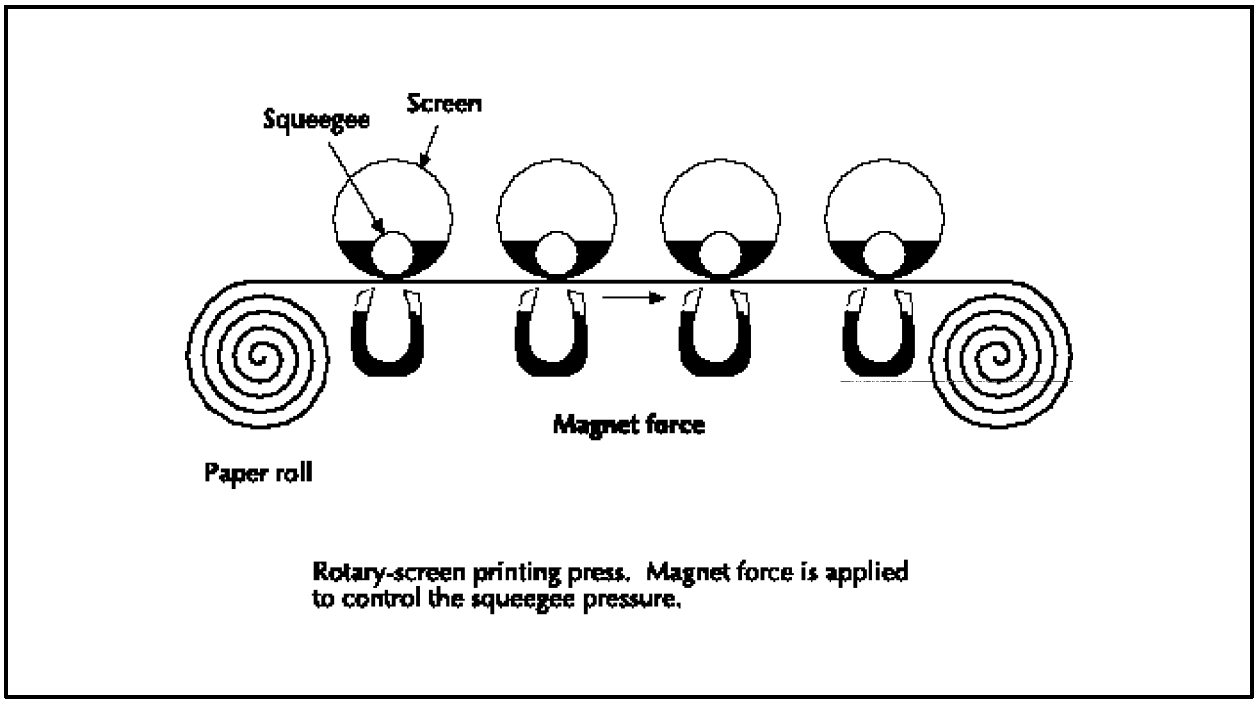
Unlike the impervious plates used in the other four printing processes, the screen printing process uses a porous polyester mesh. The mesh is stretched tightly over a frame, and a stencil, which defines the image to be printed, is applied to the mesh. The squeegee applies pressure to the ink thereby forcing the ink through the open areas of the screen. The thread count and diameter determine the amount of ink deposited onto the substrate below.

The major chemicals used in screen printing process include organic solvents, adhesives and inks. The chemical composition of the ink used varies depending on the substrate printed and the end product produced. There are five main categories of inks used within the screen printing process: UV-curable, solvent-based, and water-based for graphic applications, plastisols for textile applications, and water-based for textile applications. Screen printing is an extremely versatile printing process, and can be used to print on a wide variety of substrates including paper, plastics, glass, metals, nylon and cotton to produce a wide variety of products including, but not limited to, posters, labels, fleet decals, signage, all types of textile garments and membrane circuits.[22]

Exhibit 8: Two Methods of Screen Printing



Schematic drawing of a flat-screen type press.
Screens lift after each application, as substrate advances.



Rotary-screen printing press. Magnet force is applied to control the squeegee pressure.

Source: EPA 1994

Plateless Technologies

Plateless technologies include electrostatic and laser printing, and other printing methods which do not rely upon the use of a separately developed or prepared plate or screen. Although currently used primarily for low-volume applications, these methods are likely to see increased use as the technologies continue to develop.

III.A.3. Post-press Operations

Post-press processes include cutting, folding, collating, binding, perforating, drilling, and many others. From an environmental impact viewpoint, binding is the most significant of the post-press operations. Liquid glue used for binding is typically a water-based latex that becomes impervious to water when it dries.[23]

III.B. Raw Material Inputs and Pollution Outputs in the Production Line

Printing operations use materials that may adversely affect air, water, and land: certain chemicals involved in printing volatilize, which contributes to air emissions from the facility and to smog formation; other chemicals may be discharged to drains and impact freshwater or marine ecosystems; and solid wastes contribute to the existing local and regional disposal problems. The five printing processes outlined in the previous section have many common wastes; however, they also each have outputs that are process specific. Thus, it is important to note that wastes do differ from process to process and the solutions identified to reduce waste in one printing process do not necessarily apply to other printing processes. The following charts outline potential outputs for each of the five printing processes.

Exhibit 9: Lithography Process: Inputs, and Outputs		
Process	**Inputs**	**Outputs**
Imaging	Film	Used film and out-of-date film.
	Paper	Scrap paper.
	Developer	May be volatile and contribute to air emissions. Spent developer (sent to POTW).
	Fixer	May be volatile and contribute to air emissions. Silver from film is often electrolytically recovered from the fixer prior to discharge of spent fixer to POTW.
	Wash Water	Used rinse water.
	Cleaning Solutions	Rags containing solvents (sent to laundry service or disposed of as hazardous waste).
	Chemical Storage Containers	Empty containers (disposed of or returned to suppliers).
Platemaking	Plates	Used plates.
	Water	Used rinse water (discharged to POTW).
	Developer	Spent developer (may contain alcohol; contributes to air emissions).
Printing	Fountain Solution	May contain VOCs and contribute to air emissions.
	Ink	Waste oil based ink disposed of as hazardous waste. Solvent-based inks contribute to air emissions.
	Paper	Waste paper from bringing press up to required print quality and from rejected prints.
	Cleaning Solutions	Solvents used to clean press and remove excess ink contribute to air emissions.
	Rags	Ink and solvent-laden rags (sent to laundry service, disposed of as hazardous waste, or treated to recover solvents).
Finishing	Paper	Reject prints and edges from trimming.
	Adhesives	Possible losses to the air.
	Shipping boxes	Waste issue.

Exhibit 10: Gravure Process: Inputs, and Outputs		
Process	**Inputs**	**Outputs**
Imaging	Digital Data	Film or engraved image carrier (cylinder)
	Film	Used film and out-of-date film.
	Paper	Scrap paper.
	Photographic processing solution	May be volatile and contribute to air emissions. Waste solution.
	Wash Water	Used rinse water.
	Cleaning Solutions	Rags containing solvents (sent to laundry service, disposed of as hazardous waste, or treated to recover solvents).
	Chemical Storage Containers	Empty containers (disposed of or returned to suppliers).
Cylinder Making	Copper-clad Cylinder	Used cylinders.
	Acid etching solution	Waste solution.
Printing	Ink	Solvent-based inks (toluene-based for mass-circulation printing and alcohol-based for packaging) maintain the required low viscosity and contribute to air emissions. Waste ink disposed of as hazardous waste.
	Heat	Ovens are used to drive off the solvents to dry the ink. Ink solvents are recaptured through chillers and other equipment.
	Paper	Waste paper from bringing press up to required print quality and from rejected prints.
	Cleaning Solutions	Solvents used to remove excess ink contribute to air emissions.
Finishing	Paper	Reject prints and edges from trimming.
	Adhesives	Possible losses to the air.
	Shipping boxes	Waste issue.

Exhibit 11: Flexography Process: Inputs, and Outputs		
Process	**Inputs**	**Outputs**
Imaging	Film	Used film and out-of-date film.
	Paper	Scrap paper.
	Developer	May be volatile and contribute to air emissions. Spent developer (to POTW).
	Fixer	May be volatile and contribute to air emissions. Silver from film is often electrolytically recovered from the fixer prior to disposal of spent fixer to POTW).
	Wash Water	Used rinse water.
	Cleaning Solutions	Rags containing solvents (sent to laundry service, disposed of as hazardous waste, or treated to recover solvents).
	Chemical Storage Containers	Empty containers (disposed of or returned to suppliers).
Platemaking	Plate mold	Used molds, engravings and washes.
	Rubber plate	Used plates, defective plates and photopolymer.
	Etching and wash-out solutions	Waste solution and spent solvents.
Printing	Ink	Waste ink disposed of as hazardous waste. Solvent-based inks contribute to air emissions.
	Paper/film	Waste paper and film from bringing press up to required print quality and from rejected prints.
	Heat	Exhaust heat and odor. High alcohol content of some inks contribute to air emissions as ink dries. Water-based inks are used for paper and some films.
	Cleaning Solutions	Solvents used to remove excess ink contribute to air emissions and hazardous wastes.
Finishing	Paper/film	Reject prints, edges from trimming, box and bag-making wastes.
	Adhesives	Possible losses to the air.
	Shipping boxes	Waste issue.

Exhibit 12: Letterpress Process: Inputs, and Outputs		
Process	**Inputs**	**Outputs**
Imaging	Film	Used film and out-of-date film.
	Paper	Scrap paper.
	Developer	May be volatile and contribute to air emissions. Spent developer to POTW.
	Fixer	May be volatile and contribute to air emissions. Spent fixer (silver from film is often electrolytically recovered from the fixer prior to disposal of spent fixer to POTW).
	Wash Water	Used rinse water.
	Cleaning Solutions	Rags containing cleaning solvents (sent to laundry service, disposed of as hazardous waste, or treated to recover solvents).
	Chemical Storage Containers	Empty containers (disposed of or returned to suppliers).
Platemaking	Plate mold	Used molds.
	Plate	Used plates.
	Plate developer solution	Waste solution.
Printing	Ink	Waste ink disposed of as hazardous wastewater. Solvent-based inks contribute to air emissions.
	Paper	Waste paper from bringing press up to required print quality and from rejected prints.
	Cleaning Solutions	Solvents used to remove excess ink contribute to air emissions.
Finishing	Paper	Reject prints and edges from trimming.
	Adhesives	Possible losses to the air.
	Shipping boxes	Waste issue.

Exhibit 13: Screen Printing Process: Inputs, and Outputs		
Process	**Inputs**	**Outputs**
Imaging and Screen Making	Emulsion	Waste emulsion and out-of-date product.
	Photosensitization solution (needed for unsensitized films only)	Waste solution.
	Screen (polyester, nylon or wire mesh)	Excess screen trimmings; used screens.
	Frame	Reused.
	Developer	Spent developer (sent to POTW).
	Fixer	Spent fixer.
	Chemical Storage Containers	Empty containers.
Printing	Ink	Waste ink usually disposed of as hazardous waste. Solvent-based inks contribute to air emissions.
	Paper or other printing substrate	Waste paper from bringing press up to required print quality and from rejected prints.
	Blockout	Removed during screen reclamation and disposed with screen reclaim chemicals.
	Screen Reclamation Chemicals	Screen reclamation chemicals and ink are disposed of in rags and in clean-up wastewater.
	Water	Water used for screen reclamation is discharged to POTW; sometimes it is filtered prior to discharge.
Finishing	Paper or other printing substrate	Reject prints and edges from trimming.
	Adhesives	Possible losses to the air.
	Shipping boxes	Waste issue.