United States Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park NC 27711
EPA-453/R-95-002a
February 1995

Air

EPA

National Emission Standards for Hazardous Air Pollutants: Printing and Publishing Industry Background Information for Proposed Standards

NESHAP

EPA-453/R-95-002a

National Emission Standards for Hazardous Air Pollutants:

Printing and Publishing Industry Background Information for Proposed Standards

Emission Standards Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711
February 1995

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

1.1 OVERVIEW

Section 112 of the Clean Air Act (Act) requires that the U. S. Environmental Protection Agency (EPA) establish emission standards for all categories of sources of hazardous air pollutants (HAP). These national emission standards for hazardous air pollutants (NESHAP) must represent the maximum achievable control technology (MACT) for all major sources. The Act defines a major source as:

> ...any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants.

In July 1992, the Documentation for Developing the Initial Source Category List[1] was published. "Printing/Publishing (Surface Coating)" was included as a source category. The Printing and Publishing Industry NESHAP project will establish standards for major sources in this source category.

The purpose of this document is to summarize the background information gathered during the development of the printing and publishing industry NESHAP.

1.2 PROJECT HISTORY

1.2.1 Background

The printing industry can be divided by technology, substrate or type of product. Further divisions and industry segments can be identified in each of the major industry divisions. Many manufacturing processes include printing operations as one step in the production process. It is estimated that more than 60,000 establishments in the U. S. operate printing presses[2]. This estimate excludes plateless printing establishments.

The printing industry can be divided by technology into six different segments: gravure, flexographic, lithographic, letterpress, screen, and plateless (xerographic, electrostatic, magnetic, thermal, ink-jet, etc). The technology (i. e. the type of press equipment) dictates the types of inks and coatings which can be used. This defines to a large extent the type of HAP involved, the emissions and the control techniques which are applicable.

The printing industry can also be divided by the type of substrate that is printed. Among the flexible substrates, paper, foil and films are printed. Paper can be further classified in many ways, including coated vs. uncoated. Films include polyethylene and a number of other polymers. Rigid substrates include cardboard and vinyl. A given substrate may be printed using different technologies depending on factors such as the end use, quality requirements, quantity, cost and environmental considerations. Textiles are specifically excluded from the printing source category.

The printing industry can be additionally divided by the type of product. In general, the end use falls into the broad categories of publication, packaging or product. Publication printing includes newspapers, magazines, books and advertising. Packaging includes paper, plastic and foil bags and wrappers, and cardboard cartons. Products include wall and floor covering, greeting cards and paper towels. Various technologies can be used to print specific items within the broad categories.

In 1978, a control technique guidelines (CTG) document was established for the control of VOC from rotogravure and flexographic printing operations[3]. New source performance standards (NSPS) for VOC emissions from publication rotogravure[4] were proposed October 28, 1980 (45 FR 71538) and promulgated November 8, 1982 (47 FR 50644). NSPS for VOC emissions from rotogravure printing and coating of flexible vinyl[5] were proposed January 18, 1983 (48 FR 2276) and promulgated June 29, 1984 (49 FR 26885). In 1993, a draft CTG document was published for the control of VOC emissions from offset lithographic printing[6]. None of these efforts were specifically directed towards HAP, however, many HAP of concern in the printing and publishing industry are VOC and the same control devices used to limit VOC emissions are also applicable to control of HAP.

HAP are present in some of the inks, coatings, primers and adhesives applied on printing presses, and are also present in some of the materials used for cleaning press parts. Aromatic (e. g. toluene), aliphatic and oxygenated hydrocarbons make up the majority of the HAP used in the printing industry. HAP use associated with various printing technologies and industry segments is discussed in Chapter 2.

1.2.2 Data Gathering

In 1993, a questionnaire was developed by EPA and the Gravure Association of America (GAA), to determine HAP use and control in the publication rotogravure segment. Responses to this questionnaire were voluntarily provided to EPA by all publication rotogravure facilities operating in the U. S.

Two additional questionnaires were developed by EPA, GAA, and the Flexible Packaging Association (FPA), to determine HAP use and control by product and packaging rotogravure facilities and flexographic printing facilities. These questionnaires were included with information collection requests (ICR) sent out under the authority of section 114 of the Act. Most of the recipients opted to complete the questionnaires in lieu of the ICR. Questionnaires were sent to approximately 90 companies thought to operate product or packaging rotogravure presses, and approximately 370 companies thought to operate wide-web flexographic presses.

In addition to information obtained from these questionnaires, several site visits were made to printing facilities. Also, the EPA has met with multiple trade organizations and industry representatives over the past several years.

1.2.3 Emissions and Control Data

The available emissions and control information for the printing and publishing industry has been summarized in Chapter 3. Most of the information collected is based on calendar year 1992, and is representative of current practices. In some segments of the industry, there has been a shift away from HAP to non-HAP VOC and waterborne materials. Control efficiency data are relevant to current conditions for the purpose of MACT determination.

1.3 REFERENCES

1. U. S. Environmental Protection Agency. Documentation for Developing the Initial Source Category List: Final Report. Publication No. EPA-450/3-91-030. Research Triangle Park, NC July 1992.

2. U. S. Environmental Protection Agency. Use Cluster Analysis of the Printing Industry--Draft Final report. Washington, DC. May 26, 1992. 182 pp.

3. U. S. Environmental Protection Agency. Control of Volatile Organic Compound Emissions from Existing Stationary Sources-Volume VIII: Graphic Arts-Rotogravure and Flexography. Publication No. EPA-450/2-78-033. Research Triangle Park, NC. December, 1978. 52 pp.

4. U. S. Environmental Protection Agency. Publication Rotogravure Printing-Background Information for Proposed Standards. Publication No. EPA-450/3-80-031a. Research Triangle Park, NC. October, 1980.

5. U. S. Environmental Protection Agency. Standards of Performance for New Stationary Sources; Flexible Vinyl Coating and Printing Operations. 48 FR 12. January 18, 1983. p.2276 et. seq.

6. U. S. Environmental Protection Agency. Draft-Control of Volatile Organic Compound Emissions from Offset Lithographic Printing. Research Triangle Park, NC. September, 1993. 234 pp.

2.0 THE PRINTING AND PUBLISHING INDUSTRY

2.1 INTRODUCTION

The printing industry can be divided by technology, substrate or type of product. Further divisions and industry segments can be identified in each of the major industry divisions. Many manufacturing processes include printing operations as one step in the production process. It is estimated that more than 60,000 establishments in the U. S. operate printing presses[1]. This estimate excludes plateless printing establishments.

The printing industry can be divided by technology into six different segments: gravure, flexographic, lithographic, letterpress, screen, and plateless (xerographic, electrostatic, magnetic, thermal, ink-jet, etc). The technology (i. e. the type of press equipment) dictates the types of inks and coatings which can be used. This defines to a large extent the type of HAP involved, the emissions and the control techniques which are applicable.

The printing industry can also be divided by the type of substrate that is printed. Among the flexible substrates, paper, foil and films are printed. Paper can be further classified in many ways, including coated vs. uncoated. Films include polyethylene and a number of other polymers. Rigid substrates include cardboard and vinyl. A given substrate may be printed using different technologies depending on factors such as the end use, quality requirements, quantity, cost and environmental considerations. Textiles are specifically excluded from the printing source category.

The printing industry can be additionally divided by the type of product. In general, the end use falls into the broad categories of publication, packaging or product. Publication printing includes newspapers, magazines, books and advertising. Packaging includes paper, plastic and foil bags and wrappers, and cardboard cartons. Products include wall and floor covering, greeting cards and paper towels. Various technologies can be used to print specific items within the broad categories.

Because inks and other HAP containing materials are customized for particular printing technologies in terms of viscosity (e. g. gravure and flexographic inks are relatively fluid, lithographic, letterpress and screen inks are relatively viscous) and chemical compatibility (e. g. flexographic plates are incompatible with aromatic solvents) HAP emissions will be discussed in terms of printing technology. It should be recognized that in many cases the same product can be produced by more than one technology (e. g. newspapers are produced by lithography, letterpress, and flexography).

2.2 GRAVURE PRINTING

Nearly all gravure printing is done by rotogravure. Gravure printing is a printing process in which an image (type and art) is etched or engraved below the surface of a plate or cylinder. On a gravure plate or cylinder, the printing image consists of millions of minute cells.[2] Gravure requires very fluid inks which will flow from the cells to the substrate at high press speeds. In addition to inks, other materials including adhesives, primers, coatings and varnishes may be applied with gravure cylinders. These materials dry by evaporation as the substrate passes through hot air dryers. Solvent borne or waterborne ink systems can be used but these ink systems are not interchangeable. Both the printing cylinders and the drying systems are specific to the solvent system in use. The evaporated components of the ink and other materials may contain HAP to varying extents. Additional HAP may be present in solvents used to clean presses and press components. Rotogravure can be divided into the publication and product/packaging segments. Because of the expense and complexity of rotogravure cylinder engraving, it is particularly suited to long run printing jobs.

2.2.1 Publication Rotogravure

Publication rotogravure printing focuses on magazine, catalog and advertising insert printing. In 1993, there were 27 publication rotogravure plants in the U. S. These plants were operated by six corporations. These plants all use toluene/xylene based ink systems, and operate solvent recovery systems based on carbon adsorption with steam regeneration. Recovered solvent is sold back to the ink manufacturers. Press capture systems vary depending on the age of the press. Press and cylinder technologies, products, inks and control systems are discussed in the Background Information Document for New Source Performance Standards for Publication Rotogravure Printing[3]. Capture technologies and capture efficiency testing are discussed in The Measurement Solution: Using a Temporary Total Enclosure for Capture Efficiency Testing[4].

2.2.1.1 Process Description. On a gravure cylinder, the printing image consists of millions of minute cells which are engraved into the surface of the cylinder[5]. Different colored inks are applied in succession as the web passes from station to station. A separate cylinder, ink supply and dryer are required for each station. After the ink is applied at each station, the web is dried before being printed by the next station. Typically, four stations are required to print each side of the web. Publication gravure presses in operation in the U. S. have up to 16 stations. Gravure requires very fluid inks which will flow from the cells to the web at high press speeds. The ink dries by evaporation as the substrate passes through hot air dryers.

Publication gravure presses in the United States use solvent borne ink systems exclusively. Because of the expense and complexity of rotogravure cylinder engraving, it is particularly suited to long run printing jobs. It is generally believed in the industry that publication gravure equipment is capable of higher quality printing than competing processes.

2.2.1.2 Profile of the Publication Rotogravure Segment. There are 27 publication gravure plants in the United States. These plants are owned by six companies, none of which are small businesses. All 27 plants are major sources for hazardous air pollutants. Some of these companies operate additional printing processes using technologies other than rotogravure. In some cases, these other processes are conducted at separate locations. All of the plants voluntarily provided responses to a list of questions developed by the EPA and the Gravure Association of America.

The information in this section is based on these responses. Seventeen of the responses are in the public docket; the remaining ten responses contain some confidential business information. A list of plant locations and owners is given in Table 2-1.

2.2.1.3 HAP Use and Emissions. All of the U. S. publication gravure plants use solvent based ink systems. The primary solvent is toluene, a HAP. At some plants xylenes and ethyl benzene, also HAP, are present in the solvent blend and are used, emitted, recovered and handled in the same manner as toluene. The plants purchase ink containing solvent and add additional solvent to obtain the desired viscosity. Ink is applied to the web which then passes through a dryer, where the solvent is evaporated into heated air. The web then travels to the next press station where the process is repeated with a different color. Most of the evaporated solvent is recovered using activated carbon solvent recovery systems. The recovered solvent is reused; excess solvent is sold back to the ink manufacturers. Additional solvent (of the same composition as the solvent in the ink) is used for cleaning gravure cylinders and other press components.

Table 2-1. Publication Gravure Plants

Company Name	City	State
Brown Printing Company	Franklin	KY
R. R. Donnelley Printing Company	Casa Grande	AZ
R. R. Donnelley Printing Company	Lynchburg	VA
R. R. Donnelley Printing Company	Newton	NC
R. R. Donnelley Printing Company,	Des Moines	IA
R. R. Donnelley & Sons Company	Mattoon	IL
R. R. Donnelley & Sons Company	Reno	NV
R. R. Donnelley & Sons Company	Warsaw	IN
R. R. Donnelley & Sons Company	Spartanburg	SC
R. R. Donnelley & Sons Company	Lancaster	PA
R. R. Donnelley & Sons Company	Chicago	IL
R. R. Donnelley & Sons Company	Gallatin	TN
Quad/Graphics	Lomira	WI
Quebecor Printing Atglen Inc.	Atglen	PA
Quebecor Printing Buffalo Inc.	Depew	NY
Quebecor Printing Dallas Inc.	Dallas	TX
Quebecor Printing Dickson Inc.	Dickson	TN
Quebecor Printing Memphis Inc.	Baltimore	MD
Quebecor Printing Memphis Inc.	Memphis	TN
Quebecor Printing Mt. Morris Inc.	Mt. Morris	IL
Quebecor Printing Providence Inc.	Providence	RI
Quebecor Printing Richmond Inc.	Richmond	VA
Quebecor Printing San Jose Inc.	San Jose	CA
Ringier America Inc.	Corinth	MS
Ringier America, Inc.	Evans	GA
World Color Press, Inc.	Salem	IL
World Color Press, Inc.	Dyersburg	TN

All of the U. S. publication gravure plants account for solvent on the basis of liquid-liquid mass balances. Emissions are calculated taking into account ink purchases, solvent purchases and sales, and changes in inventory over a suitable time frame. All solvent losses are counted as emissions whether they result from pressroom capture losses, control device losses, retention in the finished publications or evaporation from uncontrolled equipment (including proof presses).

HAP emissions result from incomplete recovery of captured HAP, and from incomplete capture. Activated carbon solvent recovery systems are suitable for control of toluene and similar aromatic solvents. High control efficiencies can be achieved, however some solvent is unavoidably emitted as a result of thermodynamic limitations (the toluene-carbon/toluene-air equilibrium) and flow irregularities (e. g. channelling through the carbon bed). Some HAP is not captured in the dryer exhaust. This includes HAP which evaporates from the ink fountains into the pressroom, HAP which is evaporated from the web in the dryers but is then swept out of the dryer as the web travels towards the succeeding press station, HAP which remains in the web after the last drier which evaporates during additional processing (slitting, folding, stitching, etc.) and HAP which leaves the plant trapped in the magazine, catalog or advertising insert.

Additional HAP is emitted from proof presses, which in some plants are uncontrolled, gravure cylinder cleaning, other parts cleaning, storage tank evaporation and breathing losses and ink mixing operations. These sources are relatively minor by comparison, however, they are reflected in the overall efficiencies determined from liquid-liquid mass balances.

2.2.1.4. Baseline Emissions. There are 27 publication gravure plants in the United States. All of the plants voluntarily provided responses to a list of questions developed by the EPA and the Gravure Association of America. The information in this section is based on these responses. Seventeen of the responses are in the public docket; the remaining ten responses contain confidential business information. A total of 38,400,000 pounds (19,200 tons) of HAP was emitted in 1992. The HAP is primarily toluene; some plants report using a mixture containing mixed xylenes and ethyl benzene.

2.2.2 Packaging and Product Gravure

The gravure printing operation is, in many cases, a relatively small part of the total package or product production process. This section briefly describes the various types of packages and products that include gravure printing in their manufacture, and notes what production steps are required in addition to the gravure printing step.

Folding Cartons. Folding carton packages are used for a wide variety of products including wet and dry foods, beverages, bakery items, and candy. They are also used for nonfood products such as detergents, hardware, paper goods, cosmetics, medical products, tobacco products, and sporting goods.

The folding carton is made from one of several grades of paperboard. It may be printed, laminated or coated, or may be shipped unprinted to be used with another label or wrapper. Besides printing, operations in the manufacture of folding cartons include creasing, trimming, die-cutting, coating, and gluing. The cartons are shipped flat, to be assembled and filled by the customer. In addition to gravure printing, flexography is used for folding cartons. Letterpress use has declined. Most of the gravure presses used for folding carton printing are web-fed. However, some folding carton presses are sheet-fed, with only one or two print stations.[6]

Flexible Packaging. Flexible packaging, by one definition, consists of "converted materials intended to package and display products weighing less than 25 pounds."[7] The word "converted" in this use is an industry-specific term that refers to the fact that flexible packaging materials start out as rolls of paper or foil, or beads of plastic resin, and are "converted" into a package or roll of packaging material. Flexible package manufacturers are sometimes referred to as "converters". The ratio of gravure printing to flexographic printing among converters is approximately 20:80,[8] it is, however, an important component of the gravure printing industry. Converters produce a wide range of non-rigid packages made of paper, plastic film, foil laminates, and combinations of these substrates.

One portion of the flexible packaging industry provides fully printed packaging materials (designated "preformed specialty bags") to contract packagers. Another portion provides combination or laminated materials (designed converted wrap) for printing and/or final packing by captive packaging operations. Applying coatings is a major capability of flexible packaging converters, so the same facilities may be used to manufacture non-packaging materials such as gift wraps and hot stamp foils.[9]

Labels and Wrappers. Labels and wrappers include roll and sheet labels applied to cans, unprinted cartons, composite cans, bottles and other containers, tags, and self-adhesive label products. Paper is the common substrate, but laminates and foil are also used. The industry makes a distinction between labels and wrappers, which are package components, from a product that becomes the entire package and should be called a flexible package. This is because of the distinction of SIC codes that apply (see above). However, it is suggested that product shipment reports are probably based more on the substrate (i.e., paper for labels and wrappers; plastic film for flexible packages) than on a precise definition of end use.[10]

One interesting manufacturing technique used in making labels is the use of combination gravure/flexo presses. The manufacturer uses a gravure cylinder for "halftone" material and for coating operations, and uses a flexographic cylinder for typographic material that might have frequent changes.[11]

Gift Wraps. About 90 percent of all gift wraps are printed. They are produced by greeting card companies and by label and flexible packaging firms. Because gravure printing is particularly suitable for producing the continuous patterns used on gift wrap, it accounts for 60 to 70 percent of the market.[12] Historically a significant portion of the gift wrap was made from laminated foil, as are many flexible packaging materials. Although foil gift wrap is no longer a significant product, it is the reason why flexible package manufacturers often print gift wrap.[13]

Wallcoverings. The wallcovering industry is a traditional user of gravure. The principal types of wallcoverings are prepasted paper, prepasted paper-backed vinyl, fabric-backed vinyl, and specialty items (e.g., metallics, grass cloth, rice paper). Gravure printing is typically used to print only the vinyl wallcoverings.[14]

The steps in manufacturing wallcoverings include printing the paper and laminating it to the backing sheet. A special effect that may be added in some cases is "registered embossing" to add texture. It is usually done in line with the laminator.[15]

Vinyl Printing. These products consist of auto upholstery, furniture upholstery, tablecloths, decorative trim, and shower curtains. Gravure dominates this product area because of the complex repeat patterns (e.g., woodgrain), and the requirement, in many cases, for overcoating that is readily applied using a gravure cylinder. Printing is performed on unsupported vinyl, supported vinyl (backed with fabric or paper), and paper substrate that is then coated with vinyl.[16]

The manufacturing steps typically consist of printing, coating, embossing, and other finishing. In some cases items that are screen printed or flexographically printed are still coated using a gravure process.[17]

Decorative Laminates. These products consist of solid, thermoset laminates used in furniture and construction, and other laminates, principally wood grain veneers, widely used in furniture. The dense sheets consist of many layers of polymer-saturated paper. The top sheet is a translucent sheet impregnated in melamine, laid over a printed or solid pigmented pattern sheet. Heat and pressure are both used to produce the final product.[18]

Floor Coverings. Gravure presses are used to decorate and apply texture and finish to sheet vinyl floor coverings. Rotary screen printing is sometimes used in combination with gravure. Gravure is also used to print transfer papers used to decorate vinyl tile, and some tile products are printed using "offset/gravure," a hybrid press type using a gravure cylinder offsetting to a rubber image carrier.[19]

Tissue Products. Some type of printing process is used to apply color patterns to paper towels, bathroom tissue, and napkins. The older paper mills producing tissue products were typically equipped with gravure presses. Today, that production accounts for less than 5 percent of the total production.[20]

Miscellaneous Specialty Products. Other miscellaneous and specialty products that require a printed patter are also produced using gravure printing. One such product is cigarette tipping paper, the paper with a cork-like or other pattern that is wrapped around cigarette filters.

2.2.2.1 Process Description. The rotogravure printing process is described in section 2.2.1.1. Product and packaging rotogravure differs from publication gravure with respect to the materials used, the applicable control devices, and the decreased importance of the actual printing process in an overall manufacturing process.

Packaging and product rotogravure printing uses a wide variety of different ink systems, including the aromatic HAP based ink systems common to publication gravure, solvent based non-HAP ink systems, and waterborne ink systems. Numerous specially mixed colors are applied at various times in this industry segment, in contrast to the publication segment which primarily applies four basic colors. In addition a wider range of materials are applied with gravure cylinders in this segment of the industry. A variety of coatings, adhesives and primers are applied at print stations on rotogravure presses.

Because of the variety of materials applied, the approach to HAP and VOC control in packaging and product gravure facilities varies. In addition to the activated carbon based solvent recovery systems used by the publication segment, packaging and product gravure facilities also use a variety of thermal and catalytic oxidizers. Many facilities operate without significant HAP use and do not have control devices.

Printing is only one stage (often minor) in manufacturing. In many cases, operations such as laminating, cutting, folding and calendering make up a greater proportion of the value of the product or package than the printing operation.

2.2.2.2 Profile of the Package/Product Rotogravure Segment

As of 1994, the Gravure Association of America (GAA) estimated that rotogravure printing operations were conducted at 400 locations within the U. S.[21] The EPA sent an information collection request (ICR) to approximately 80 parent companies thought to operate rotogravure printing equipment. Responses pertaining to rotogravure operations at more than 100 locations were received. In lieu of completing the ICR, nearly all of the companies chose to respond to a simplified question list developed by EPA with the assistance of GAA and the Flexible Packaging Association (FPA). A list of companies from which usable information was received is given in Table 2-2. These responses are included in the project docket. Specific descriptions of printed products and packaging are given for five substrate categories in Tables 2-3 through 2-7.

2.2.2.3 Hap Use and Emissions. In product and packaging gravure facilities, HAP is contained in both the printing inks and in other materials (adhesives, coatings) that are applied as part of a continuous manufacturing process. One survey showed that the weight of coatings and lacquers applied in gravure packaging plants was almost as much as the weight of the ink.[22] The predominant type of ink is based on nitrocellulose resin, with some polyamide inks. Solvent

Table 2-2. Packaging/Product Gravure Responses (See Codes Following Table).

Company Name	Location		Code
AMGRAPH Packaging, Inc.	Versailles	CT	M
Alcan Foil Products	Louisville	KY	F
Alford Packaging	Baltimore	MD	P
Allied Stamp Corporation	Sand Springs	OK	P
Alusuisse Flexible Packaging, Inc.	Shelbyville	KY	M
American Fuji Seal, Inc.	Anaheim	CA	F
American Fuji Seal, Inc.	Fairfield	NJ	F
American Greetings	Corbin	KY	P
Avery Dennison	Clinton	SC	M
Avery Dennison	Framingham	MA	P
Avery Dennison	Schereville	IN	V
Avery Dennison Corporation	Pasadena	CA	W
Butler Printing & Laminating, Inc.	Butler	NJ	V
CPS Corporation	Franklin	TN	M
Cello-Foil Products, Inc.	Battle Creek	MI	M
Chiyoda America Inc.	Morgantown	PA	P
Cleo, Inc.	Memphis	TN	P
Columbus Coated Fabrics	Columbus	OH	V
Congoleum Corporation	Marcus Hook	PA	V
Congoleum Corporation	Mercerville	NJ	V
Constant Services, Inc.	Fairfield	NJ	V
DRG Medical Packaging	Madison	WI	M
Decor Gravure Corporation	Bensenville	IL	V
Decorating Resources	Clifton	NJ	F
Decorative Specialties International, Inc.	Johnston	RI	P
Decorative Specialties International, Inc.	Reading	PA	M
Decorative Specialties International, Inc.	West Springfield	MA	V
Dinagraphics	Norwood	OH	W
Dittler Brothers	Atlanta	GA	W
Dittler Brothers	Oakwood	GA	W
Dopaco, Inc.	Downingtown	PA	P
Dopaco, Inc.	Saint Clarles	IL	P
Dopaco, Inc.	Stockton	CA	P
Eskimo Pie Corporation	Bloomfield	NJ	M
Federal Paper Board Co., Inc.	Durham	NC	P
Federal Paper Board Co., Inc.	Wilmington	NC	P
Fleming Packaging Corporation	Peoria	IL	M
Fres-Co System USA, Inc.	Telford	PA	F
GenCorp Inc.	Jeannette	PA	F
GenCorp Inc.	Salem	NH	V
GenCorp Polymer Products	Columbus	MS	V
Graphic Packaging Corporation	Franklin	OH	M
Graphic Packaging Corporation	Lawrenceburg	TN	P
Graphic Packaging Corporation	Paoli	PA	P
Gravure Carton & Label	Surgoinsville	TN	P
Gravure Packaging, Inc.	Richmond	VA	P
Hallmark Cards	Kansas City	MO	P
Hallmark Cards	Leavenworth	KS	P
Hargro Flexible Packaging	Edinburgh	IN	M
Hargro Packaging	Flemington	NJ	M
International Label Company	Clarksville	TN	P
International Playing Card & Label Company	Rogersville	TN	P
J. W. Fergusson and Sons, Inc.	Richmond	VA	M
JSC/CCA	Carol Stream	IL	P
JSC/CCA	Lockland	OH	P
JSC/CCA	North Wales	PA	P

Table 2-2. Packaging/Product Gravure Responses (concluded).

JSC/CCA	Santa Clara	CA	P
JSC/CCA	Stone Mountain	GA	P
James River Corporation	Hazelwood	MO	M
James River Paper Company	Darlington	SC	P
James River Paper Company	Fort Smith	AR	P
James River Paper Company	Lexington	KY	P
James River Paper Company	Portland	OR	M
James River Paper Corporation	Kalamazoo	MI	P
Jefferson Smurfit Corporation	Chicago	IL	P
Jefferson Smurfit Corporation	Jacksonville	FL	W
Johio, Inc.	Dayton	OH	M
Koch Label Company, Inc.	Evansville	IN	M
Lamotite, Inc.	Cleveland	OH	W
Lux Packaging Ltd.	Waco	TX	P
Mannington Mills, Inc.	Salem	NJ	V
Mundet-Hermetite Inc.	Buena Vista	VA	P
Newco Inc.	Newton	NJ	V
Orchard Decorative Products	Blythewood	SC	M
Orchard Decorative Products	St. Louis	MO	M
Package Service Company	Northmoor	MO	M
Paramount Packaging Corporation	Chalfont	PA	F
Paramount Packaging Corporation	Longview	TX	F
Paramount Packaging Corporation	Murfreesboro	TN	F
Quick Roll Leaf Manufacturing Company	Middletown	NY	F
Reynods Metals Company	Richmond	VA	F
Reynolds Metals Company	Downingtown	PA	M
Reynolds Metals Company	Richmond	VA	M
Riverwood International USA, Inc.	Bakersfield	CA	P
Riverwood International USA, Inc.	Cincinnati	OH	P
Riverwood International USA, Inc.	West Monroe	LA	P
Roslyn Converters Inc.	Colonial Heights	VA	P
Scientific Games, Inc.	Alpharetta	GA	W
Scientific Games, Inc.	Gilroy	CA	W
Screen Art	Fulton	NY	M
Screen Art	Moorestown	NJ	F
Shamrock Corporation	Greensboro	NC	M
Shamrock Corporation	Greensboro	NC	P
Smurfit Flexible Packaging	Schaumburg	IL	M
Smurfit Laminations	Elk Grove Village	IL	M
Somerville Packaging	Newport News	VA	P
Stone Container Corporation	Louisville	KY	P
Technographics Printworld	North Monroe	NC	W
The C. W. Zumbiel Company	Cincinnati	OH	P
Union Camp Corporation	Asheville	NC	M
Union Camp Corporation	Englewood	NJ	P
Union Camp Corporation	Spartanburg	SC	P
Vernon Plastics Company	Haverhill	MA	V
Vitex Packaging, Inc.	Suffolk	VA	M
Waldorf Corporation	Chicago	IL	P
Waldorf Corporation	Saint Paul	MN	P
Wrico Packaging	Chicago	IL	M

P=Paper/Cardboard only
F=Film/Foil only
V=Vinyl product
M=Paper/cardboard AND Foil/film
W=miscellaneous, NEC

Table 2-3. Rotogravure Facilities Printing on Paper and Cardboard.

Company Name	State	Product
Alford Packaging	MD	Paperboard
Allied Stamp Corporation	OK	Soft drink labels, trading stamps
American Greetings	KY	Gift wrap
Avery Dennison	MA	Paper packaging
Chiyoda America Inc.	PA	Paper packaging
Cleo, Inc.	TN	Gift wrapping paper
Decorative Specialties Int'l, Inc.	RI	Paper coating / printing for book covering/fancy packaging
Dopaco, Inc.	PA	Paperboard packing (cartons and cups)
Dopaco, Inc.	IL	Paperboard packaging (cartons and cups)
Dopaco, Inc.	CA	Paperboard packaging (cartons and cups)
Federal Paper Board Co., Inc.	NC	Paper packaging
Federal Paper Board Co., Inc.	NC	Consumer packaging/cartons
Graphic Packaging Corporation	TN	Paperboard packaging, folding cartons
Graphic Packaging Corporation	PA	Paper packaging
Gravure Carton & Label	TN	Paper
Gravure Packaging, Inc.	VA	Paperboard packaging
Hallmark Cards	MO	Paper products (98%); Vinyl products (2%)
Hallmark Cards	KS	Paper products
International Label Company	TN	Paper packaging
Int'l Playing Card & Label Co.	TN	Paper packaging
JSC/CCA	IL	Paper board packaging
JSC/CCA	OH	Paperboard packaging
JSC/CCA	PA	Paper packaging
JSC/CCA	CA	Paperboard packaging (folding cartons)
JSC/CCA	GA	Paper packaging
James River Paper Company	SC	Sanitary paper food containers, paper plates, bowls,cups
James River Paper Company	AR	Paper
James River Paper Company	KY	Side paper for 3 oz. paper cups.
James River Paper Corporation	MI	Paperboard packaging
Jefferson Smurfit Corporation	IL	Folding cartons
Lux Packaging Ltd.	TX	Paper packaging
Mundet-Hermetite Inc.	VA	Tipping paper for cigarettes
Riverwood International USA, Inc.	CA	Paperboard packaging
Riverwood International USA, Inc.	OH	Paperboard packaging
Riverwood International USA, Inc.	LA	Paperboard packaging
Roslyn Converters Inc.	VA	Tipping paper for cigarettes
Shamrock Corporation	NC	Cigarette tipping paper

Table 2-3. Rotogravure Facilities Printing on Paper and Cardboard (concluded).

Company Name	State	Product
Somerville Packaging	VA	Paperboard box
Stone Container Corporation	KY	Paper packaging products - small bags
The C. W. Zumbiel Company	OH	Paper folding cartons
Union Camp Corporation	NJ	Paperboard packaging (sheet fed gravure--not webs)
Union Camp Corporation	SC	multiwall paper bags
Waldorf Corporation	IL	Paperboard packaging
Waldorf Corporation	MN	Paperboard packaging

Table 2-4. Rotogravure Facilities Printing Exclusively on Foil and Film.

Company Name	State	Product
Alcan Foil Products	KY	Foil packaging
American Fuji Seal, Inc.	CA	Heat shrinkable film
American Fuji Seal, Inc.	NJ	Heat shrinkable film
Decorating Resources	NJ	Film - heat transfer labels
Fres-Co System USA, Inc.	PA	Film packaging
GenCorp Inc.	PA	Graphic arts/decorative films (facings for gypsum, metal, wood)
Paramount Packaging Corporation	PA	Film packaging
Paramount Packaging Corporation	TX	Film packaging
Paramount Packaging Corporation	TN	Film packaging
Quick Roll Leaf Manufacturing Co.	NY	Roll leaf stamping film
Reynolds Metals Company	VA	Foil packaging
Screen Art	NJ	Film packaging

Table 2-5. Rotogravure Facilities Printing Vinyl Products.

Company Name	State	Product
Avery Dennison	IN	Polyester and vinyl films
Butler Printing & Laminating, Inc.	NJ	Vinyl wallcovering and pool liner
Columbus Coated Fabrics	OH	Vinyl/paper wallcovering, Industrial films
Congoleum Corporation	PA	Vinyl floor covering
Congoleum Corporation	NJ	Vinyl floor covering
Constant Services, Inc.	NJ	vinyl
Decor Gravure Corporation	IL	Vinyl wall covering
Decorative Specialties Int'l, Inc.	MA	Vinyl coated saturated or unsaturated paper
GenCorp Inc.	NH	Vinyl wallcovering, upholstery, vinyl to wood/metal laminates
GenCorp Polymer Products	MS	Vinyl wallcovering, commercial vinyls
Mannington Mills, Inc.	NJ	Vinyl flooring
Newco Inc.	NJ	Vinyl wallcovering
Vernon Plastics Company	MA	Decorated vinyl film products

Table 2-6. Rotogravure Facilities Printing on Paper or Cardboard and Foil or Film.

Company Name	State	Product
Amgraph Packaging, Inc.	CT	Flexible packaging
Alusuisse Flexible Packaging, Inc.	KY	Paper, film and foil packaging
Avery Dennison	SC	Paper postage stamps, paper and film label products
CPS Corporation	TN	Paper and foil giftwrap
Cello-Foil Products, Inc.	MI	Flexible packaging
DRG Medical Packaging	WI	Paper & Film Packaging
Decorative Specialties Int'l, Inc.	PA	Paper and paper/foil laminated paper
Eskimo Pie Corporation	NJ	Paper/foil laminations
Fleming Packaging Corporation	IL	Paper & foil packaging items (labels, lids, bands)
Graphic Packaging Corporation	OH	Paper, film and foil packaging
Hargro Flexible Packaging	IN	Paper/polyethylene packaging; paper/foil packaging; film packaging
Hargro Packaging	NJ	Paper packaging, film packaging
J. W. Fergusson and Sons, Inc.	VA	Paper, film, foil, packaging
James River Corporation	MO	Paper packaging, film packaging
James River Paper Company	OR	Paper, film packaging
Johio, Inc.	OH	Paper packaging, film packaging, foil packaging
Koch Label Company, Inc.	IN	Paper, foil, metallized paper, film labels
Orchard Decorative Products	SC	Decorative papers and paper foils
Orchard Decorative Products	MO	Paper for wall paneling, furniture, RTA furniture, HP laminates, film
Package Service Company	MO	Foil, paper labels
Reynolds Metals Company	PA	Flexible packaging with foil, film, paper, and laminates
Reynolds Metals Company	VA	Film, paper, board, aluminum foil
Screen Art	NY	Paper packaging, film packaging, foil packaging, paper gift wrap
Shamrock Corporation	NC	Paper and foil packaging (giftwrap)
Smurfit Flexible Packaging	IL	Foil, paper, poly, PVC, PET, packaging
Smurfit Laminations	IL	Laminated films and foils, unlamninated paper and board stocks
Union Camp Corporation	NC	Paper and foil packaging
Vitex Packaging, Inc.	VA	Paper packaging, Film packaging
Wrico Packaging	IL	Paper, film and boxboard packaging

Table 2-7. Rotogravure Facilities Printing Miscellaneous Products.

Company Name	State	Product
Avery Dennison Corporation	CA	Self adhesive postage stamps
Dinagraphics	OH	Heat transfer labels on wax-coated paper
Dittler Brothers	GA	Product Gravure - Commercial Games
Dittler Brothers	GA	Product Gravure - Lottery tickets
Jefferson Smurfit Corporation	FL	Heat transfer labels on wax-coated paper, paper packaging
Lamotite, Inc.	OH	Reinforced laminations
Scientific Games, Inc.	GA	Scratch-off lottery tickets
Scientific Games, Inc.	CA	Scratch-off lottery tickets
Technographics Printworld	NC	Decorative papers for heat transfer to cloth and for laminated surfaces

systems include aromatic, aliphatic and oxygenated hydrocarbon solvent inks, and water-based inks.

Due to the wide variety of ink types and colors that are used in this segment of the printing industry, ink is typically received in drum (or smaller container sizes) and tote bins. Only rarely is bulk ink received and stored in tank farms.

About 60 percent of the coatings used are petroleum-based waxes and hot melts. About 35 percent of the coatings are extrusion coatings, typically low density polyethylene (LDPE). The remaining 5 percent are solution coatings, typically applied to flexible packaging. The 25 percent of theextrusion coatings that are not LDPE consist of polyvinyl chloride (PVC), polyvinyl acetate (PVA), ethylene vinyl acetate (EVA) copolymers, high density polyethylene, and polypropylene.[23]

Folding Cartons. About half of the ink used for folding cartons is nitrocellulose based. The remainder is alcohol solvent and water based. On a weight basis, coatings and lacquers are about equal to ink use.[24]

Flexible Packaging. Solvent-based, nitrocellulose resin ink is the predominant type. Coatings and lacquers are only a third of the ink use, by weight.[25] Some flexible packaging printers have switched from the traditional toluene solvent to non-HAP solvents such as iso- and normal-propyl acetate.[26] The use of water-based inks in this industry segment is growing. At one company, all HAP except for glycol ethers have been eliminated.[27]

Labels and Wrappers. Nitrocellulose resin inks account for about half the inks used in this industry segment, with a wide variety of ink types accounting for the rest. Coatings and lacquers amounted to about 1.5 times the weight of ink used.[28]

Vinyl Products. In response to the ICR, vinyl product manufacturers reported use of methyl ethyl ketone, and methyl isobutyl ketone as the major HAP present in materials applied with rotogravure presses. Significant quantities of toluene and xylene were also used.

2.2.2.4 Baseline Emissions

HAP emissions data are available for most of the facilities submitting data in response to the ICR. In some cases, responses were received, however, the HAP emissions data were not usable. This resulted from missing or ambiguous answers to questions relating to HAP usage and control efficiency. Specific data on control efficiency for HAP are not available. Data have been analyzed on the assumption that overall HAP control efficiency is equivalent to reported overall efficiency. These data are most often based on tests or vendor guarantees relating to VOC. In many cases, HAP makes up only a minor proportion of the VOC used on-press.

Baseline emissions calculated from the responses to the ICR are given in Table 2-8. Analogous information given in Table 2-9 pertains to major sources as determined on the basis of actual HAP emissions. When potential-to-emit is considered there are more major sources. An upper bound on baseline emissions can be estimated by assuming that there are 400 product and packaging gravure facilities and that the facilities providing usable data in response to the ICR are representative of the total population. In this case, baseline emissions from product and packaging gravure would be approximately 32,000,000 lb/yr. It is more likely that responses were obtained from larger facilities within the industry, and that baseline emissions are much lower.

2.2.3 Intaglio Plate Gravure

Intaglio plate gravure or engraving, uses a flat copper plate on a sheetfed press. This process is used for currency, postage stamps, securities and stationery[29]. It makes up a small proportion of the gravure printing segment.

Table 2-8. Baseline Emissions from Product and Packaging Rotogravure Responses.

Industry Segment	Number of Usable Responses	HAP Emissions (lb/yr)
Paper/Cardboard Only	40	2,004,000
Foil/Film Only	10	597,900
Paper/Cardboard/Foil/Film	27	2,598,000
Vinyl Product	10	896,500
Miscellaneous	9	1,465,000
Total	96	7,561,000

Table 2-9. Baseline Emissions from Major Sources in the Product and Packaging Rotogravure Industries.

Industry Segment	Number of Usable Responses	HAP Emissions (lb/yr)
Paper/Cardboard Only	16	1,811,000
Foil/Film Only	4	581,100
Paper/Cardboard/Foil/Film	9	1,257,000
Vinyl Product	3	822,500
Miscellaneous	4	1,418,000
Total	36	5,890,000

2.3 FLEXOGRAPHY

Flexographic printing is considered to be the application of words, designs and pictures to a substrate by means of a printing technique in which the pattern to be applied is raised above the printing plate and the image carrier is made of rubber or other elastomeric materials.[30] It has been estimated that there are 1,587 plants in the U. S. with flexographic presses.[31] The major applications of flexographic printing are flexible and rigid packaging; tags and labels; newspapers, magazines, and directories; and paper towels, tissues etc. Because of the ease of plate making and press set up, flexographic printing is more suited to shortproduction runs than gravure. It is estimated that 85 percent of package printing is done by flexography.[32]

Flexographic inks must be very fluid to print properly. Flexographic inks include both waterborne and solvent based systems. Solvents used must be compatible with the rubber or polymeric plates; thus, aromatic solvents are not used. Some of the components of solvent based flexographic ink include ethyl, n-propyl and i-propyl alcohols; glycol ethers, aliphatic hydrocarbons, acetates and esters.[33]

Flexographic printing can be divided between publication and packaging/product printing. An alternate approach, and the one chosen for this project, is to divide between wide web and narrow web equipment with an 18 inch web width being an arbitrary cutoff between the two categories. Additional distinctions can be made on the basis of web vs. sheetfed press equipment.

2.3.1. Wide Web (and Sheetfed) Flexographic Printing

Wide web flexographic presses are used to print flexible and rigid packaging; newspapers, magazines, and directories; and paper towels, tissues etc; and printed vinyl shower curtains and wallpaper. Corrugated cartons are one of the few substrates printed by sheetfed flexography.[34] Substrates include polyolefins, polystyrene, polyesters, glassine, tissue, sulfite, kraft and other paper stocks, aluminum foil, paperboard, corrugated, folding cartons, gift wraps, paper cups and containers.[35]

2.3.1.1 Process Description. Flexographic presses can be divided into three main types depending on the relative relationship of the print stations. Stack presses have individual print stations oriented vertically with the unwind and rewind sections on the same side of the print stations. Stack presses are easily accessible for rapid changeovers between pressruns. Common impression presses have the print stations around the circumference of a single large impression cylinder. The web is constantly supported between print stations, which is an advantage for printing on stretchable materials. In-line presses have the print stations in a horizontal row (the geometry is similar to rotogravure presses). These presses have an advantage when used with additional converting (such as cutting, gluing and laminating) equipment.[36]

2.3.1.2 Profile of Wide Web Flexographic Segment. Most wide web flexographic printing facilities produce various types of packaging. Flexible packaging producers often operate both flexographic and rotogravure presses at the same facilities; the selection of equipment for a particular job depends on length of run, quality requirements and substrate. The printing component makes up a relatively minor part of the value of some types of packaging. Facilities that produce corrugated cartons and paper bags may not consider themselves to be printers. Large paper companies often operate many small facilities at locations around the country to serve local markets.

Newspaper production makes up a small proportion of flexographic printing facilities. There are 35 flexographically printed newspapers in the U. S.[37] This number is expected to grow as newspapers replace aging letterpress equipment. Several large newspaper chains use flexographic presses at multiple locations.

The EPA sent an information collection request (ICR) to approximately 380 parent companies thought to operate flexographic printing equipment. Approximately 100 of these facilities were found to operate only narrow web presses; no information was collected from narrow web printers other than their names, addresses and numbers of employees. Responses pertaining to wide web flexographic printing operations at approximately 500 facilities were received. In lieu of completing the ICR, nearly all companies chose to respond to a simplified question list developed by EPA with the assistance of the Flexible Packaging Association (FPA). A list of the names and locations of facilities submitting information is given in Table 2-10. These responses, with the exception of confidential business information, are included in the project docket.

2.3.1.3 HAP Use and Emissions. HAP emissions result from components of ink (and other materials applied with flexographic plates, including varnishes, primers, and adhesives) and solvents used to clean presses and equipment. In the past, flexographic platemaking systems commonly used HAP; these systems are becoming rare as improved HAP free platemaking technologies have become available. Within the converting industry, printed substrates are formed or purchased then printed and converted to packaging such as bags or boxes. In many cases, the printing operation is a relatively small part of the processing which may include film blowing, laminating, coating, adhesive application, and cutting. Some or all of these processing operations are done at flexographic press stations or in-line with the presses. Converting operations done in conjunction with flexographic printing may result in additional HAP emissions.

Most flexographic printing (including all flexographic newspaper and corrugated carton printing) is done with

Table 2-10. Wide-Web Flexographic Printing Responses.

Name	Address
Abbott Box Co. Inc.	58 Teed Drive, Randolph, MA 02368
Action Packaging	667 Atkins Avenue, Brooklyn, NY 11208
Acorn Corrugated Box Co.	5133 W. 65th Street, Bedford Park, IL 60638
Advance Packaging Corporation	4450 36th Street, SE, P.O. Box 888311, Grand Rapids, MI 49588-8311
Advance Packaging Corp.	2400 E. High St., P.O. Box 730, Jackson, MI 49203
Akron Beacon Journal	44 East Exchange St., Akron, OH 44309
All-Pak, Inc.	5383 Truman Drive, Decatur, GA 30035
Alusuisse Flexible Packaging, Inc.	1403 Fourth Ave.,New Hyde Park, NY 11040
Alusuisse Flexible Packaging, Inc.	5303 St. Charles Road, Bellwood, IL 60104
Alusuisse Flexible Packaging, Inc.	6700 Midland Industrial Drive, Shelbyville, KY 40065
American Greetings Corp	P.O. Box 1570, Corbin, KY 40702-5851
American Greetings Corp.	Hwy. 11 E ByPass, Afton, TN 37616
American National Can/Food Plastics	1300 S. River St., Batavia, IL 60510
American National Can/Food Plastics	1500 E. Aurora Ave., Des Moines, IA 50313
American National Can/Food Plastics	271 River St., Menasha, WI 54952
American National Can/Food Plastics	150 26th Ave. SE, Minneapolis, MN 55414
American National Can/Food Plastics	201 W. Madison St., Mount Vernon, OH 43050
American National Can/Food Plastics	1815 Marathon Ave.,Neenah,WI 54956
American National Can/Food Plastics	6590 Central Ave., Newark, NJ 94560
American National Can/Food Plastics	3600 Alabama Ave.,St. Louis Park, MN 55416
American Packaging Corp.	2900 Grant Ave., Philadelphia, PA 19114
American Packaging Corp.	125 W. Broad St., Story City, IA 50248
American Packaging Corp.	200 Continental Dr., Columbus, WI 53925
American Packaging Corp.	777 Driving Park Ave., Rochester, NY 14613
Amko Plastics, Inc.	12025 Trilon Road, Cincinnati, OH 45246
Anagram International, Inc.	7700 Anagram Drive, Eden Prairie, MN 55344
Arcata Graphics\Kingsport	P.O. Box 711, Press and Roller Streets, Kingsport, TN 37662
Arcon Coating Mills, Inc.	3067 New Street, Oceanside, NY 11572
Arkansas Poly, Inc.	1248 So. 28th Street, Van Buren, AR 72956
Atlanta Film Converting Co, Inc.	1132 Pryor Rd., P.O. Box 6756, Atlanta, GA 30315

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Automated Packaging Systems, Inc.	13555 McCracken Road, Garfield Heights, OH 44125
Automated Label Systems Co.	8400 Darrow Road, twinsburg, OH 44087
Avery-Dennison, K & M Division	4100 Hwy 45 North, Meridian, MS 39305
Avery-Dennison	4350 Avery Drive, P.O. Box 547, Flowery Branch, GA 30542
Bagcraft Corporation of America	3900 West 43rd St., Chicago, IL 60632
Bancroft Bag, Inc	425 Bancroft Blvd, West Monroe, LA 71291
Banner Packaging, Inc.	3550 Moser Street, Oshkosh, WI 54901
Bell Packaging Corp	3102 S. Boots St., Marion, IN 46953
Bingo Paper Inc.	801 River Drive So., Great Falls, MT 59405
Bomarko, Inc	1955 North Oak Road, P. O. Box K, Plymouth, IN 46563
Bonar Packaging, Inc.	2410 N. Lyndon, Tyler, TX 75702
Bryce Corporation	450 S. Benton St., Searcy, AR 72143
BRC, A Division of Bryce Corporation	75 Isabelle Street, Buffalo, NY 14207-0007
Bryce Corporation	4505 Old Lamar and 3861 Delp Street, Memphis, Tennessee 38118
Johnson Bryce Corp.	4224 Premier Street, Memphis, TN 38118
Bryce Dixico	1300 South Polk St., Dallas, TX 75224
Tennessee Packaging	Hwy 11 Longmeadow Rd, Sweetwater, TN 37874
Koch Container	777 Old Dutch Road 14564
All-Size Corrugated Prods.	P.O. Box 4544, Lancaster, PA 17604
Buckeye Container	P.O. Box 16, 326 N. Hillcrest Drive, Woostor, OH 44691
Buckeye Packaging	12223 Marlboro Avenue, Alliance, OH 44601
Burrows Paper Corporation	101 Commerce Drive, Mt. Vernon, OH 43050
Burrows Paper Corporation	1722 53rd Street, Fort Madison, IA 52627
Cadillac Products, Inc.	840 Woodrow St., S.W., Atlanta, GA 30310-3431
Cadillac Products, Inc.	2005 S. Main St., Paris, IL 61944-2950
Cadillac Products, Inc.	7000 East 15 Mile Rd, Sterling Heights, MI 48311-8012
Cello-Wrap Printing Company, Inc.	110 N. Main, P.O. Box 32, Farmersville, TX 75442
Central States Diversified, Inc.	5221 Natural Bridge, St. Louis, MO 63115
Champion International Corp.	155 East Hanover Ave, Morristown, NJ 07960
Champion International Corp.	1500 South 14th Street, Clinton, IA 52732

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Champion International Corp.	7920 Mapleway Drive, Olmsted Falls, OH 44138
Champion International Corp.	1901 Windsor Place, Fort Worth, TX 76110
Champion International Corp.	600 Dairy Pak Road, Athens, GA 30607
Charleston Packaging Company, Inc.	4229 Domino Ave, North Charleston, SC 29405-7486
Clark Container, Inc.	P.O. Box 160, Bates Crossing Industrial Park, Lyles, TN 37098
Cleo, Inc.	3963 Vernal Pike, Bloomington, IN 47402
Compak, Inc.	8789 E. Lansing Road, Durand, MI 48429
Webcor Packaging Corp.	1220 N. Center Road, Burton, MI 48509
Crystal Tissue	1118 Progress Way, Maysville, KY 41056
Castle Rock Container Company	P.O. Box 530 - Grove Street, Adams, WI 53910
C. P. C. Packaging, Inc.	214 Brace Ave., Eluria, OH 44035
Cryovac Division	1301 West Magnolia Avenue, Iowa Park, TX 76367
Cryovac Division	1125 Wilson Avenue, S.W., Cedar Rapids, IA 52406
Cryovac Division	P.O. Box 338 (803 N. Maple St.), Simpsonville, SC 29681
Bemis Company, Inc.	1401 West 3rd Avenue, Crossett, AR 71635
Bemis Company, Inc.	1975 Latham St., Memphis, TN 38106
Bemis Company, Inc.	2705 University Ave., Minneapolis, MN 55418
Bemis Company, Inc.	3514 South 25th St., Omaha, NE 68105
Bemis Company, Inc.	Sloan St., Peoria, IL 61603
Bemis Company, Inc.	Chapel Place, Pepperell, MA 01463
Bemis Company, Inc.	55 South Atlantic St., Seattle, WA 98124
Bemis Company, Inc.	1401 West 4th Plain Blvd, Vancouver, WA 98660
Bemis Company, Inc.	1000 East 13th St., Wichita, KS 67214
Bemis Company Inc.	1350 North Fruitridge Ave., Terre Haute, IN 47808
Bemis Company, Inc.	Rt. 12 West, P.O. Box 475, Flemington, NJ 08822
Bemis Company, Inc.	Jaycee Drive, Hazleton, PA 18201
Bemis Specialty Films	2450 Badger Avenue, Oshkosh, WI 54904
Bemis Curwood	19th and Wall Sts., Murphysboro, IL 62966
Bemis Curwood	718 High St., New London, WI 54961
Bemis Milprint	590 Woodrow St., Denmark, WI 54902
Bemis Milprint	1309 HWY 61 North, Lancaster, WI 53813
Cello-Foil Products, Inc.	155 Brook Street, Battle Creek, MI 49017

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Custom Poly Bag, Inc.	9465 Edison Street, NE, Alliance, OH 44601
Dart Container Corporation	60 E. Main Street, Leola, PA 17540
Deco Paper Products, Inc.	1028 South Eighth Street, Louisville, KY 40203
Design Containers, Inc.	2913 West Side Blvd., Jacksonville, FL 32209
Dixico, Inc.	276 S. Parkway West, Memphis, TN 38109
Dynamic Packaging, Inc.	7875 School Road, Cincinnati, OH 45249
Eisenhart Wallcoverings Co.	400 Pine Street, P.O. Box 464, Hanover, PA 17331
Eskimo Pie Corporation	118 J.F. Kennedy Dr. North, Bloomfield, NJ 07003
Equitable Bag Co., Inc	7600 Empire Drive, Florence, KY 41042
Excelsior Transparent Bag MFG Corp.	159 Alexander Street, Yonkers, NY 10701
Fabricon Products	1721 W. Pleasant, River Rouge, MI 48218
Fabricon Products	4101 North American Street, Philadelphia, PA 19140
Spec-Fab	1818 Rowland Street, Riverton, NJ 08077
Fleetwood Container & Display	2721 E. 45th Street, Vernon, CA 90058
fp Webkote, Inc.	1016 S. W. Adams St., Peoria, IL 61602-1694
Spiralkote, Inc.	1200 Central Florida Parkway, Orlando, FL 32809
Flex-Pak, Inc.	555 Branch Drive, Alpharetta, GA 30201
Flexo Transparent, Inc.	28 Wasson St, Buffalo, NY 14210
Focus Packaging, Inc.	5207 Richland Ave., Kansas City, KS 66106
Fort Wayne Newspapers	600 W. Main St., Fort Wayne, IN 46801
Frank C. Meyer Company, Inc.	585 S. Union Street, Lawrence, MA 01843
Gateway Packaging	P.O. Box 29, Granite City, IL 62040
Gentry Poly Specialties, Inc.	P.O. Box 688, Route 2, Gentry, AR 72734
Georgia-Pacific Corp.	1500 Orchard Hill Drive, LaGrange, GA 30240
Georgia-Pacific Corp.	327 Margaret Street, Plattsburgh, NY 12901
Georgia-Pacific	P.O. Box 3333, Crossett, AR 71635
Georgia-Pacific Corp	17 Forester Ave, Warwick, NY 10990
Georgia-Pacific Corp	P.O. Box 919, Palatka, FL 32178-0919
Georgia-Pacific	RR6 Box 8, Riverside Lane, Brattleboro, VT

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Georgia-Pacific	300 W. Laurel Street, Bellingham, WA 98225
G-P Albany Plant	405 Maxwell Drive, Albany, GA 31701
G-P Asheboro Plant	200 McDowell Road, Asheboro, NC 27203
G-P Augusta Plant	Perkins & New Savannah Rd, Augusta, GA 30913
G-P Bradford Plant	One Owen's Way, Bradford, PA 16701
G-P Buena Park Plant	6300 Regio Avenue, Buena Park, CA 90620
G-P Canton Plant	2820 Winfield Way, Canton, OH 44705
G-P Chicago Plant	440 East 138th Street, Chicago, IL 60627
G-P Cincinnati Plant	220 West North Bend Road, Cincinnati, OH 45216
G-P Circleville Plant	2850 Owens Road, Circleville, OH 43113
G-P Cleveland Plant	4660 Brook Park Road, Cleveland, OH 44142
G-P Cleveland Plant	4200 Old Tasso Road, Cleveland, TN 37311
G-P Doraville Plant	4600 NE Expressway, Doraville, GA 30340
G-P Dubuque Plant	2150 Kerper Boulevard, Dubuque, IA 52004
G-P Franklin Plant	210 Grove Street, Franklin, MA 02038
G-P Huntsville Plant	3420 Stanwood Boulevard, Huntsville, AL 35811
G-P Kansas City Plant	8600 Northeast 38th Street, Kansas City, MO 64161
G-P Lake Placid Plant	400 S.R. 70 West, Lake Placid, FL 33852
G-P Madera Container Plant	24600 Avenue 13, Madera, CA 93637
G-P Martinsville Plant	US 200 and Route 970, Martinsville, VA 24112
G-P Memphis Plant	611 Winchester Road, Memphis, TN 38116
G-P Milan Plant	951 County Street, Milan, MI 48160
G-P Modesto Plant	2400 Lapham Drive, Modesto, CA 95354
G-P Monticello Plant	823 North Cedar Street, Monticello, IA 52310
G-P Mt. Olive Plant	Old Rt. 66 and 8th Street, Mt. Olive, IL 62029
G-P Mt. Wolf Plant	25 Walnut Street, Mt. Wolf, PA 17347
G-P Olympia Plant	1203 Fones Road, Olympia, WA 98501
G-P Ooltewah Plant	5201 Ooltewah-Ringwold Road, Ooltewah, TN 37363
G-P Oshkosh Plant	413 East Murdock Avenue, Oshkosh, WI 54902

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

G-P Owosso Plant	465 S. Delaney Road, Owosso, MI 48867
G-P Schenectady Plant	Building 801 Corporations Park, Schenectady, NY 12302
G-P Sheboygan Plant	1927 Erie Avenue, Sheboygan, WI 53082
G-P So. San Francisco Plant	249 East Grand Avenue, So. San Francisco, CA 94080
G-P Spartanburg Plant	3100 Southport Road, Spartanburg, SC 29304
G-P Valdosta Plant	Highway 31 South, Clyattville, GA 31601
G-P Warren County Plant	U.S. Highway 1, Manson, NC 27553
G-P West Monroe Plant	400 Central Street, West Monroe, LA 71292
G-P Waxahachie Plant	5800 Hwy 35 East, Waxahachie, TX 75165
Gilman Converted Products	3201 McRae Highway, Eastman, GA 21023
Glenroy, Inc.	W158 N9332 Nor-X-Way Ave., P.O. Box 534, Menomonee Falls, WI 53052-0534
Graphic Packaging Corporation	708 South Avenue, Franklin, OH 45005
Graphic Packaging Corp.	Mathews and Cedar Hollow Road, P.O. Box 500, Paoli, PA 19301
Greif Bros. Corp	2750 - 145th Street West, Rosemount, MN 55068-4998
Gulf Coast Plastics Div. Dairy-Mix, Inc.	9314 Princess Palm Ave., Tampa, FL 33619
Gulf States Paper Corp.	244 Warner Road, Maplesville, AL 36750
H. S. Crocker Co., Inc.	12100 Smith Drive, Huntley, IL 60142
Hallmark Cards	Select Drive, Leavenworth, Kansas
Hallmark Cards	Eisenhower Road, Leavenworth, Kansas
Hargo Flexible Packaging Corp	County Line Road, Boyertown, PA 19512
Hargo Flexible Packaging Corp	1501 North Seventh Street, Harrisburg, PA 17102
Hargro Flexible Packaging	U.S. 31 North, P.O. Box 188, Edinburgh, IN 46124
Hargro Health Care Packaging	3500 N. Kimball Avenue, Chicago, IL 60618-5508
Home Plastics, Inc.	5250 NE 17th St, DesMoines, IA 50313
Huntsman Packaging Products, Corp	8039 S. 192nd Street, Kent, Washington 98032-2162
Carolina Printing & Converting Interflex	Rt. 4 Box 4 Highway 268 West, Wilkesboro, NC 28697
International Paper	310 Airport Drive, Presque Isle, ME 04769
International Paper	Auburndale
International Paper	Carson
International Paper	Chicago
International Paper	Cincinnati
International Paper	Dallas

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

International Paper	Detroit
International Paper	Edinburg
International Paper	El Paso
International Paper	Fond du Lac
International Paper	Geneva
International Paper	Georgetown
International Paper	Minneapolis
International Paper	Mobile
International Paper	Modesto
International Paper	Mt. Carmel
International Paper	Nashville
International Paper	Putnam
International Paper	Russellvile
International Paper	San Jose
International Paper	Shreveport
International Paper	Spring Hill
International Paper	Statesville
International Paper	Stockton
International Paper	Tallman
International Paper	Wooster
International Paper-Bag Pack	Camden
International Paper-Bag Pack	Jackson
International Paper-Bag Pack	Mobile
International Paper-Bag Pack	Pittsburg
International Paper-Bag Pack	Wilmington
International Paper-folding Cartons	Hopkinsville
International Paper--Label Div	Peoria
International Paper-Specialty Div.	Menasha
International Paper-Specialty Div.	Lancaster
International Paper-Specialty Div.	Kaukauna
International Paper-Specialty Div.	Knoxville
Interstate Packaging Corp.	P.O. Box 271, Coldenham Road, Walden, NY 12586
James River Paper Company	Camas Mill; 4th and Adams; Camas, WA 98607
James River Paper Co	P.O. Box 500, 126 A Avenue, Darlington, SC 29532
James River Paper Co., Inc	James River Corporation, 605 Kuebler Rd., Easton, PA 18042
James River Paper Co	4411 Midland Blvd., Fort Smith, AR 72904
James River Paper Co., Inc.	1505 West Main Street, Greensburg, IN 47240
James River Corp. Location 571	310 McDonnell Blvd., Hazelwood, MO 63042
James River Paper Co	451 Harbison Rd., Lexington, KY 40511
James River Corporation, Creative Expressions	3500 North Arlington Ave., Indianapolis, IN 46218
James River Corp	Canal Plant, 258 River Street, Menasha, WI 54952
James River Corp	River Road and Grantham Lane, New Castle, DE 19720
James River Corp	400 Island Avenue, Parchment, MI 49004
James River Paper Co., Inc.	North Portland Plant, 3400 N. Marine Drive, Portland, OR 97217

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

James River	2424 SE Holgate, Portland, OR 97202
James River - Specialty Tabletop	18554 S. Susana Road, Rancho Dominguez, CA
James River Corp.	2101 Williams Street, San Leandro, CA 94577
James River Paper Co.	210 Kansas City Ave., Shreveport, LA 71107
James River Corp - Wausau Plant	200 West Bridge Street, P.O. Box 1047, Wausau, WI 54402-1047
Smurfit Flexible Packaging	1228 E Tower Road, Schaumburg, IL 60173-4386
Jefferson Smurfit Corp	170 Lisle Road, Lexington, KY 40511
Jefferson Smurfit/Container Corp. of America	601 Monster Road, SW, Renton, WA 98055
Smurfit Flexible Packaging	7074 W. Parkland Ct, Milwaukee, WI 53188
Jefferson Smurfit Corp	301 S Butterfield Road, Muncie, IN 47303
Jefferson Smurfit Corp	12005 N. Burgard Road, Portland, OR 97203
JSC/CCA	99 Harris Street, Fulton, NY 13069
JSC/CCA	8440 Tewantin, Houston, TX 77061
Jefferson Smurfit Corp./Container Corp. of America	Shawnee & Ridge Road, Muskogee, OK 74401
Jefferson Smurfit Corp	Sixth and Zschokke, Highland, IL 62249
Jefferson Smurfit Corp	122 Quentin Ave., New Brunswick, NJ 08901
Jefferson Smurfit Corp./Container Corp. of America	577 Goddard Ave., Chesterfield, MO 63005
Jefferson Smurfit/Container Corporation of America	265 W Trigg Avenue, Memphis, TN 38106
Jefferson Smurfit Corporation	3505 Tree Court Industrial Blvd., St. Louis, MO 63122
Jefferson Smurfit Corporation	201 S. Hillview Drive - Milpitas, CA 95035
Jefferson Smurfit Corp.	4600 Newlon Rd., Ft. Smith, AR 72914
Jefferson Smurfit Corp.	6701 South Freeway, Fort Worth, TX 76134
Jefferson Smurfit Corp.	3 N. Sherman Street, Anderson, IN 46016
Jefferson Smurfit	111 Folmar Parkway, Montgomery, AL 36105
Jefferson Smurfit Corp	75 Cascade Blvd, Milford, CT 06460
JSC/CCA	100 McDonald Boulevard, Aston, PA 19014
Jefferson Smurfit	41 Campion Road, New Hartford, NY 13413
Jefferson Smurfit Corporation	12200 Westport Rd., Louisville, KY 40245
Jefferson Smurfic Corp	8209 CR 131, Wildwood, FL 34785
Jefferson Smurfit Corporation	365 Audubon Road, Wakefield, MA 01880

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Jefferson Smurfit Corp	4512 Anderson Road, Knoxville, TN 37918
Jefferson Smurfit Corp	2200 Industrial Dr., P.O. Box 2277, Jonesboro, AR72402
Jefferson Smurfit/Container Corp. of America	2601 S. Malt Ave., Los Angeles, CA 90040
Container Corporation of America	6541 Eastern Avenue, Baltimore, MD 21224
Jefferson Smurfit/Container Corporation of America	185 N. Smith Street, Corona, CA 91720
Jefferson Smurfit Corp	301 E 144th Street, Dolton, IL 60419
Jefferson Smurfit Corp.	2743 South Pierce Street, Dallas, TX 60419
JSC/CCA	2525 S. Sunland Avenue, Fresno, CA 93725
Container Corporation of America	9960 Alliance Road, Cincinnati, OH 45242
JSC/CCA	975 North Freedom, Ravenna, OH
Jefferson Smurfit Corporation	1201 East Lincolnway, LaPorte, IN 46350
Jefferson Smurfit	N Pt. Blvd., Winston Salem, NC
Jefferson Smurfit Corportion	1720 Ninth Avenue, Humboldt, TN 38343
Jefferson Smurfit Corp	1601 Tri View Avenue, Sioux City, IA 51103
Jefferson Smurfit Corp	Pearl and Central, Lancaster, NY 14086
Jefferson Smurfit Corporation	775 South Linwood Road, P.O. Box 1268, Galesburg, IL 61402-1268
Jefferson Smurfit Corporation	JSC Preprint, 9960 Alliance Road, Cincinnati, OH 45242
Jefferson Smurfit Corp	1125 Haley Road, Murfreesboro, TN 37133-0638
Jefferson Smurfit Corp	460 N Belcrest, Springfield, MO 65808
Jefferson Smurfit Corp./CCA	662 Washburn Switch Rd., Shelby, NC 28150
Packaging Unlimited, Inc.	P.O. Box 5102, Pta de Tierra Station, San Juan, Puerto Rico 00906
Jefferson Smurfit Corporation	2101 Rossville Ave, Chattanooga, TN 37408
John H. Harland Company	293 Miller Rd, Decatur, GA 30035
Kookaburra USA LTD	1 Commerce Drive S, Harriman, NY 10926
Kleartone, Inc.	695 Summer Avenue, Westbury, NY 11590
Lin Pac, Inc.	4200 Cambridge Road, Fort Worth, TX 76155
Lin Pac	5725 Commerce, Morristown, TN 37814
Longhorn Packaging, Inc.	110 Pierce Ave., San Antonio, TX 78208
Macon Telegraph	120 Broadway, Macon. GA 31213
Mafcote Industries	4525 N. Euclid Ave., St. Louis, MO 63115

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Mafcote/SWACO	101 Ascher Street., Quitman, MS 38355
Mail-Well Envelope	4500 Tiedeman Road, Cleveland, OH 44144
Maine Poly, Inc.	P.O. Box 8, Route 202, Greene, ME
Malnove, Inc.	4115 University Blvd. Court West, Jacksonville, FL 32217
Marglo Packaging Corp.	1522 Old Country Road, Plainview, NY 11803
Massillon Container	49 Ohio Street, Navarre, OH 44662
McClatchy Newspapers, Inc., dba The Modesto Bee	1325 "H" Street, Modesto, CA 95354
McClatchy Newspapers, Inc. dba The Fresno Bee	1626 E Street, Fresno, CA 93786
Mead Packaging	1105 Herndon Street, NW, Atlanta, GA 30318
Menasha Corporation	Menasha Packaging - Neenah Plant, 1645 Bergstrom Rd., Neenah, WI 54957
Miami Herald Publishing Co.	One Herald Plaza, Miami, FL 33032
Mid-West Poly Pak, Inc.	P.O. Box 35, 89 Marion Street, Doylestown, OH 44230
Milwaukee Container	2800 W. Custer Avenue, Milwaukee, WI 53209
M.T.P. Industries, Inc. (Mason Transparent Pkg)	1180 Commerce Avenue, Bronx, NY 10462
Neenah Printing - Wide Web Flexo Plant	1257 Gillingham Road, Neenah, WI 54957-0425
Midwest Film Corp	4848 South Hoyne Avenue, Chicago, IL 60609
Mohawk Northern Plastics, Inc.	701 "A" Street NW / Box 583, Auburn, WA 98002
Moore, Business Forms and Systems	2275 Commerce Drive, Fremont, OH 43420
NCR Corp.	2901 45W Bypass, Humboldt, TN 38343
NCR - B.F.D.	1201 North Main Street, Viroqua, WI 54665
Nichols Paper Products Co., Inc.	38 Depot Street, Nichols, WI 54152
Owens-Illinois, Inc.	Operator-1051 Bloomfield Rd., Bardstown, KY 40004
Package Printing Co., Inc.	33 Myron Street, West Springfield, MA 01089
Package Products Flexible Corporation	2203 Hawkins St., Charlotte NC 28203
Packaging Corp of America	Akron, OH
Packaging Corp of America	Arlington, TX
Packaging Corp of America	Ashland, OH
Packaging Corp of America	Atlanta, GA
Packaging Corp of America	Buffalo, NY
Packaging Corp of America	Burlington, WI
Packaging Corp of America	Colby, WI
Packaging Corp of America	Denver, CO
Packaging Corp of America	Garland, TX
Packaging Corp of America	Gas City, IN
Packaging Corp of America	Goldsboro, NC
Packaging Corp of America	Grafton, WV

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Packaging Corp of America	Grandville, MI
Packaging Corp of America	Hanover, PA
Packaging Corp of America	Harrisonburg, VA
Packaging Corp of America	High Point, NC
Packaging Corp of America	Honea Path, SC
Packaging Corp of America	Jackson, TN
Packaging Corp of America	Jacksonville,
Packaging Corp of America	Knoxville, TN
Packaging Corp of America	Lancaster, PA
Packaging Corp of America	Los Angeles, CA
Packaging Corp of America	Marshalltown, IA
Packaging Corp of America	Miami, FL
Packaging Corp of America	Middletown, OH
Packaging Corp of America	Milwaukee, WI
Packaging Corp of America	Minneapolis, MN
Packaging Corp of America	Morganton, NC
Packaging Corp of America	Newark, OH
Packaging Corp of America	Newberry, SC
Packaging Corp of America	Northhampton, MA
Packaging Corp of America	Omaha, NE
Packaging Corp of America	Opelika, AL
Packaging Corp of America	Phoenix, AZ
Packaging Corp of America	Pittsburgh, PA
Packaging Corp of America	Plano, TX
Packaging Corp of America	Plymouth, MI
Packaging Corp of America	Richmond, VA
Packaging Corp of America	Salisbury, NC
Packaging Corp of America	Syracuse, NY
Packaging Corp of America	Trexlertown, PA
Packaging Corp of America	Vincennes, IN
Packaging Corp of America	Winter Haven, FL
Packaging Industries, Inc.	2450 Alvarado Street, San Leandro, CA 94577
Packaging Materials Incorporated	62805 Bennett Avenue, Cambridge, OH 43725
Packaging Products Corp.	1807 Parrish Drive, Rome, GA 30161
Packaging Products Corporation	999 Lee Street, Elk Grove Village, IL 60007
Packaging Products Corp.	6800 W. 61st St., Mission, KS 66202
Packaging Specialties, Inc.	P.O. Box 360, 1663 Armstrong Ave., Fayetteville, AR 72702-0360
Pacquet Oneida, Inc.	10 Clifton Blvd., Clifton, NJ 07015
Paramount Packaging Corp.	800 Jordan Vally Rosad, Longview, TX 76508
Paramount Packaging Corp.	202 Oak Ave. Chalfont, PA 18914
Paramount Packaging Corp.	720 Eagle Blvd. Shelbyville, TN 37160
Paramount Packaging Corp.	106 Samsonite Blvd, Murfreesboro, TN 37130
Percy Kent Bag Co., Inc.	5910 Winner Road, Kansas City, MO 64125
Phoenix Packaging	10949 91st Ave, N, Maple Grove, MN 55369
Phoenix Products Co., Inc.	6161 N. 64th Street, Milwaukee, WI 53218

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Pioneer Balloon Company	2400 Pioneer Drive, El Dorado, KS 67042
Viskase Corp.	24th and O'Neal Streets, P.O. Box 250, Centerville, IA 52544
Plastic Packaging Corp	750 South 65th Street, Kansas City, KS 64111
Plastic Packaging, Inc.	1246 Main Ave., S.E., P.O. Box 2029, Hickory, NC 28603
Plicon Corp.	6001 River Road, Suite 300, Columbus, GA 31904
Poly Plastic Packaging, Inc.	510 Industrial Avenue, P.O. Box 219, Boynton Beach, FL 33425
Poly Plastic Packaging, Inc.	36-36 36th Street, Long Island City, NY 11101
Polyflex Film & Converting, Inc.	1301 Hwy 51 N, Summit, MS 39666
Press Telegram	604 Pine Avenue, Long Beach, California 90844
Procter and Gamble Co.	512 Liberty Expressway, Albany, GA 31703
Procter and Gamble Co.	Mehoopany, PA 18629
Procter and Gamble Co.	501 Eastman Ave., Green Bay, WI 54302
Procter and Gamble Co.	800 North Rice Ave., Oxnard, CA 93010
Providence Journal Company	210 Kinsley Avenue, Providence, RI 02903
Rand -Whitney/Northeast Container	45 Industrial Way, Dover, NH 03820
Rand -Whitney/Southeast Container Corp.	455 Narragansett Park Dr.,Pawtucket, RI 02861
Rand -Whitney Container Corp.	Agrand St., Worcester, MA 01607
Rex-Rosenlew International, Inc.	1308 Blair Street, Thomasville, NC 27360
The Robinette Company	250 Blackley Road, Bristol, TN 37625
Rock-Tenn Company	329 Industrial Park Road, Harrison, AR 72601
Rock-Tenn Company	525 West 19th Street, Chattanooga, TN 37408
Rock-Tenn Company	4691 Lewis Road, Stone Mountain, GA 30086
Rock-Tenn Company	302 Hartman Drive, P.O. Box 997, Lebanon, TN 37087
Rock-Tenn Company	Forest Hills School Road, Marshville, NC 28103
Rock-Tenn Company	105 Tote - M Avenue, Eutaw, AL 35462
Rock-Tenn	198 Commerce, Conway, AR 72032
Rock-Tenn Company	6702 Hwy. 66W, Greenville, TX 75402
Rock-Tenn Company	302 Hartman Drive, P.O. Box 997, Lebanon, TN 37087
R. R. Donnelley & Sons Company	Lancaster West Plant, 1375 Harrisburg Pike, Lancaster, PA 17601
Sealright Packaging Company	814 South First Street, Fulton, NY 13069
Sealright Packaging Co.	2925 Fairfax Road, Kansas City, KS 66115

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Sealright Packaging Co.	4209 E. Noakes Street, Los Angeles, CA 90023
Venture Packaging	1600 Westinghouse Blvd., Charlotte, NC 28273
Jaite Packaging	1972 Akron-Peninsula Road, Akron, OH 44313
Packaging Industries, Inc.	2450 Alvarado Street, San Leandro, CA 94577
Selig Sealing Products, Inc.	342 E. Wabash, Forrest, IL 61741
Solar Press	1500 Shore Road, Naperville, IL 60563-1799
Solo Cup Company	1951 Highway 304, Belen, New Mexico 87002
Solo Cup Company	1501 E. 96th Street, Chicago, IL 60628
Southern Colortype Co., Inc.	2927 Sidco Drive, Nashville, TN 37204
Specialty Container Corporation	1608 Plantation Rd., Dallas, TX 75235
Standard Packaging & Printing Corp.	NC Hwy 73W, Mt. Gilead, NC 27306
The Standard Register Company	Industrial Avenue, Rocky Mount, VA 24151
Sunrise Packaging, Inc.	2025 W. South Branch Blvd., Oak Creek, WI 53154
Superpac, Inc.	1220 Industrial Boulevard, Southampton, PA 18966
Susan Crane, Inc.	8107 Chancellor Row, Dallas TX 75247
Teepak, Inc.	915 N. Michigan Avenue, Danville, IL 61832
Tennessee Press, Inc.	1400 Sixth Avenue, Knoxville, TN 37917
Toph	1120 Heritage Drive, Osage, IA 50461-0119
Toph	1001 Rialto Rd., Covington, TX 38019
Uniflex, Inc.	474 Grand Blvd., Westbury, NY 11590
Union Camp Corp. - Container Division	1975 Lakeside Parkway SW 314, Tucker, GA 30084
Union Camp Corp	W. Lathrop Ave., Savannah, GA 31402
Union Camp Corp	345 Cedar Springs Rd., P.O. Box 5497, Spartanburg, SC 29302
Union Camp Corp.	Hazleton Plant, Maplewood Drive, Hazleton, PA 18201
Union Camp Corporation	501 Williams Street, Tomah, WI 54660
Union Camp Corp.	901 Commerce Circle, Shelbyville, KY 40065
Union Camp Corp	10801 Iona Ave., Hanford, CA 93230
Union Camp Corp	3100 Jim Christal Rd., Denton, TX 76207
Union Camp Corp	2200 D. Avenue East, Freeman Field, Seymour, IN 47274

Table 2-10. Wide-Web Flexographic Printing Responses (continued).

Union Camp Corp	3055 Sweeten Creek Rd., Asheville, NC 28813
Union Camp Corp.	Cloverdale Rd., P.O. Box 278, Sibley, IA 51249
Union Camp, Inc.	1829 Hwy. 35S, Monticello, AR 71655
Union Camp Corp	Rt. 2, Box 433K, Tifton, GA 31794
Union Camp Corp., Richmond Retail Pkg.	2801 Cofer Road, Richmond, VA 23224
Union Camp Corp	1304 Arthur K. Bolton Parkway, Griffin, GA 30223
Viskase Corp.	24th & O'Neal Streets, P.O. Box 250, Centerville, IA 52544
Vitex Packaging, Inc.	1137 Progress Road, Suffolk, VA 23434
Waldan Paper Services, Inc.	167 W. 28th Avenue, Oshkosh, WI 54901
Ward/Kraft, Inc.	2401 Cooper Street, P.O. Box 938, Fort Scott, Kansas 66701
Western Publishing Co., Inc.	1220 Mound Avenue, Racine, WI 53404
Beach Products	2001 Fulford, Kalamazoo, MI 49001
Wabash Pioneer Container Corp.	N143 W6049 Pioneer Road, Cedarburg, WI 53012
Westvaco Envelope Division	Springfield Plant, 315 Industry Avenue, Springfield, MA 01104-3246
Westvaco Envelope Division	Williamsburg Plant, Route 866, P.O. Box C, Williamsburg, PA 16693
Westvaco Envelope Division	Atlanta Plant, 5625 New Peachtree Road, Chamblee, GA 30341
Westvaco Envelope Division	North Chicago Plant, 1001 South Sheridan, North Chicago, IL 60064
Westvaco Envelope Division	Indianapolis Plant, 6302 Churchman Bypass, Indianapolis, IN 46203
Westvaco Envelope Division	Dallas Plant, 10700 Harry Hines Blvd., Dallas, TX 75220
Westvaco Envelope Division	Los Angeles Plant,2828 East 12th Street, Los Angeles, CA 90023
Westvaco Envelope Division	San Francisco Plant, 5650 Hollis Street, Emeryville, CA 94608
Westvaco - Flexible Packaging	311 Industry Avenue, Springfield, MA 01101
Westvaco Container Division	3400 East Biddle Street, Baltimore, MD 21213
Westvaco Container Division	85 Dorothy Street, Buffalo, NY 14206
Westvaco Container Division	4400 West 45th Street, Chicago, IL 60632
Westvaco Container Division	2110 West 110th Street, Cleveland, OH 44102
Westvaco	Blue Springs Road, Cleveland, TN 37311
Westvaco Container Division	4847 Cargo Drive, Columbus, GA 31907
Westvaco Container Division	RR 2, Hwy 35, Eaton, OH 45320
Westvaco Container Division	601 North Modena Street, Gastonia, NC 28053
Westvaco Container Division	Empire Avenue, Meriden, CT 06453

Table 2-10. Wide-Web Flexographic Printing Responses (concluded).

Westvaco Container Division	2300 Jefferson Davis Hwy, Richmond, VA 23234
Westvaco Container Division	Flexpak Plant 2910, Cofer Road, Richmond, VA 23224
Westvaco, Liquid Packaging Division	2828 Cofer Road, Richmond, VA 23224
Weyerhaeuser Paper Company	100 Hawkes Street, Westbrook, ME 04092
Weyerhaeuser Paper Company	950 Shaver Road NE, Cedar Rapids, IA 52402
Weyerhaeuser Paper Company	6706 N. 23rd Street, Tampa, FL 33610
Weyerhaeuser Paper Company	261 Broadway, P.O. Box 509, Franklin, KY 42134
Weyerhaeuser Company/IMPAK	5099 North Royal Atlanta Drive, Tucker, GA 30084
Willamette Industries, Inc.	Beaverton, OR;P. O. Box G
Willamette Industries, Inc.	Buena Park, CA
Willamette Industries, Inc.	Dallas, TX
Willamette Industries, Inc.	Kansas City, MO
Willamette Industries, Inc.	Tacoma, WA
Willamette Industries, Inc.	Aurora, IL
Willamette Industries, Inc.	Beaverton, OR; P. O. Box 666
Willamette Industries, Inc.	Bellvue, Wa
Willamette Industries, Inc.	Bellmawr, NJ
Willamette Industries, Inc.	Bowling Green, KY
Willamette Industries, Inc.	Cerritos, CA
Willamette Industries, Inc.	Compton, CA
Willamette Industries, Inc.	Dallas, TX
Willamette Industries, Inc.	Delaware, OH
Willamette Industries, Inc.	Elk Grove, IL
Willamette Industries, Inc.	Fort Smith, AR
Willamette Industries, Inc.	Golden, CO
Willamette Industries, Inc.	Griffin, GA
Willamette Industries, Inc.	Indianapolis, IN
Willamette Industries, Inc.	Kansas City, KS
Willamette Industries, Inc.	Lincoln, IL
Willamette Industries, Inc.	Louisville, KY
Willamette Industries, Inc.	Lumberton, NC
Willamette Industries, Inc.	Matthews, NC
Willamette Industries, Inc.	Memphis, TN
Willamette Industries, Inc.	Moses Lake, WA
Willamette Industries, Inc.	Newton, NC
Willamette Industries, Inc.	Sacramento, CA
Willamette Industries, Inc.	San Leandro, CA
Willamette Industries, Inc.	Sanger, CA
Willamette Industries, Inc.	Sealy, TX
Willamette Industries, Inc.	St. Paul, MN
Willamette Industries, Inc.	West Memphis, AR
Willamette Industries, Inc.	Tigard, OR
Zim's Bagging Co., Inc.	4200 Big Sandy Rd., Prichard, WV 25555

waterborne inks. Waterborne inks are available for some applications which contain no HAP. Some waterborne inks contain relatively low proportions of HAP, principally ethylene glycol and glycol ethers. Most solvent based flexographic inks contain little or no HAP. Capture and control devices used with solvent based inks are usually designed, permitted and operated for VOC control.

2.3.1.4 Baseline Emissions from Wide Web Flexographic Segment. HAP emissions data are available for most of the facilities submitting data in response to the ICR. In some cases, responses were received, however the HAP emissions data were not usable. This resulted from missing or ambiguous answers to questions relating to HAP usage and control efficiency. Nospecific control efficiency relative to HAP was requested. Data have been analyzed on the assumption that overall HAP control efficiency is equivalent to reported overall efficiency. These data are most often based on tests or vendor guarantees relating to VOC. In many cases, HAP makes up only a minor proportion of the VOC used on press.

HAP emissions were calculated from wide-web flexographic press operations at 475 facilities. Most facilities reported data for calendar year 1992; in some cases data for more recent twelve month periods were reported. A total of 10 facilities were determined to be major sources on the basis of emissions of 25 tons of HAP per year, or 10 tons of any individual HAP per year. If major source status is determined by potential-to-emit, there will be a greater number of major sources. Baseline emissions are given in Table 2-11.

2.3.2 Narrow Web Flexographic Printing

Narrow web flexographic presses are used principally for printing and adhesive application on tags and labels. The presses can be used to print on paper, foil, film or other substrates. Ink systems for narrow web flexographic printing can be similar to those for wide web; in addition, ultraviolet cure inks are used with some narrow web presses.

Table 2-11. Baseline Emissions from Flexographic Printing.

	All Responses	Major Sources
Number of Facilities	485	10
Material Applied (lb/yr)	176,000,000	10,200,000
HAP Used (lb/yr)	2,350,000	827,000
HAP Emitted	1,680,000	706,000

Narrow web presses have the potential to emit relatively small quantities of HAP. These presses are sometimes operated with no capture or control systems.

2.4 LITHOGRAPHY

Lithography is a planographic method of printing (in contrast to gravure, in which the image is etched into the plate or flexography, in which the image is raised above the surface of the plate). The plate surface is divided between water repellent (ink receptive) and water receptive (ink repellent). In offset lithographic printing, ink is transferred from the plate to a rubber blanket cylinder. The blanket cylinder is used to print the substrate[38]. An extensive discussion of the processes, equipment, inks, and other substances with the potential to result in HAP emissions is given in the Control Techniques Guideline for Offset Lithographic Printing[39]. There are over 54,000 lithographic printing plants in the US, which supply about 50 percent of the market for printing. About 91 percent of printing facilities have lithographic presses[40].

The lithographic printing industry is divided on the basis of press equipment between sheet-fed, non-heatset web and heatset web printing. The CTG[41] makes a further distinction between newspaper non-heatset web and non-newspaper non-heatset web printing.

2.4.1 Sheet-fed Lithography

About 92 percent of the facilities with lithographic presses have sheetfed lithographic presses. Sheetfed presses are used to print on metal, paper, cardboard, foil and film. Commercial printing (e. g. advertising, brochures, annual reports, business forms, etc.) is usually done by sheetfed lithography[42].

Organic emissions can arise from inks, fountain solutions and cleaning chemicals, although potential HAP emissions come primarily from fountain solutions. Sheet-fed lithographic inks contain phenolic, maleic-modified or rosin-ester resins dissolved in vegetable drying oils (e. g. linseed and soya) and diluted with hydrocarbon solvents[43]. Most inks used in sheetfed printing contain less than 25 percent VOC[44], and no HAP.

Fountain solutions are used to dampen the printing plates to make the non-image areas repellent to ink. Traditionally, these solutions were primarily isopropanol and water with some added resins and buffering salts. These solutions contain no HAP. In an attempt to reduce VOC emissions, alcohol substitutes which often contain glycols and glycol ethers, which are HAP, are now in use. Generally, no attempt has been made to capture glycol ethers emitted from sheetfed lithographic printing. Refrigeration of the fountain solutions is a practical means to control emissions of VOC from this source, but lower VOC, HAP containing alternatives have been adopted in some cases as an alternative to refrigeration of higher VOC, no HAP solutions.

Solvents used for press clean-up are usually kerosene type high boiling point hydrocarbons, sometimes mixed with detergents[45]. These materials can contain up to 100 percent VOC but are generally free of HAP.

2.4.2 Non-Heatset Web Lithographic Printing

Non-heatset web lithography is used to print newspapers, journals, directories and forms. It is estimated that there are 4950 plants with non-heatset web lithographic presses[46]. The ink used is similar to that used in sheetfed lithography and generally contains less than 35 percent VOC[47]. Fountain solutions and clean-up solvents are similar to those used in sheet-fed lithography. The main source of HAP from this process is low VOC fountain solutions which contain glycols and glycol ethers. Typically no controls for HAP are used. Refrigeration of the fountain solutions is a practical means to control emissions of VOC from this source, but lower VOC HAP-containing alternatives have been adopted in some cases as an alternative to refrigeration of higher VOC, no HAP solutions.

2.4.3 Heatset Web Lithographic Printing

Heatset web lithography is used to print magazines, periodicals and catalogs. It is estimated that there are 1376 plants with heatset web lithographic presses[48]. The inks are about 40 percent VOC and contain high boiling petroleum distillates, resins and pigments. In general, there are no HAP in the ink. Fountain solutions and clean-up solvents are similar to those used in sheet-fed lithography. The main source of HAP from this process is low VOC fountain solutions which contain glycols and glycol ethers.

Capture systems for heatset lithographic presses are used to collect drier exhaust gases, which contain about 20 percent of the VOC in the ink. Control system options include thermal incinerators, catalytic incinerators, condenser filters with activated carbon and condenser filters without activated carbon. VOC control efficiencies are estimated at 98 percent for incinerators, 95 percent for condenser filters with activated carbon and 90 percent for condenser filters without activated carbon[49]. It should be noted that there are no performance test data relating to HAP control efficiencies.

Refrigeration of the fountain solution is a practical means to control emissions of VOC from this source, but lower VOC HAP-containing alternatives have been adopted in some cases as an alternative to refrigeration of higher VOC, no HAP solutions. Clean-up solvents which contain no HAP, or only very low levels of HAP are available.

2.5 LETTERPRESS

Letterpress printing uses a relief printing plate as does flexography and viscous inks similar to lithographic inks. Various types of letterpress plates are available. These plates differ from flexographic plates in that they have a metal backing. Both sheetfed and web presses are in use. Web letterpress equipment using heatset and non-heatset inks is in use. Newspapers were traditionally printed by web non-heatset letterpress, however these are gradually being replaced by flexographic and lithographic presses. Letterpress is used to print newspapers, magazines, books, stationery and advertising. It is estimated that there are about 21,000 plants with letterpress equipment of which about 19,000 have sheetfed letterpress equipment[50].

2.5.1 Non-heatset Letterpress

Non-heatset web letterpress ink is similar to non-heatset lithographic ink differing mainly in that it contains less low viscosity mineral oils and more vegetable oils and high viscosity mineral oils[51]. No fountain solutions are required. Cleaning solvents are similar to those used in lithography. This process can be almost entirely HAP free. Non-heatset letterpress equipment typically has no emissions control systems.

Non-heatset sheetfed letterpress ink varies depending upon factors including the substrate printed, the type of plate and press, and the press speed. In most applications, this process can be almost entirely HAP free and is typically conducted with no control system. No fountain solutions are required. Cleaning solvents are similar to those used in lithography. "Moisture set" inks used in some packaging applications contain triethylene glycol, which is a HAP. "Water washable" letterpress inks are sometimes used for printing kraft paper and corrugated boxes. These inks contain glycol based solvents which may contain HAP.

2.5.2 Heatset Letterpress

Heatset letterpress is used for publication printing on coated papers. Heatset letterpress ink is similar to heatset lithographic ink. These inks contain resins dissolved in aliphatic hydrocarbons. These inks are dried in hot air ovens; drier exhausts can be ducted to VOC control systems. The inks can be entirely HAP free. No fountain solutions are required. Cleaning solvents are similar to those used in lithography.

2.6 SCREEN PRINTING

Screen printing processes involve forcing ink through a stencil in which the image areas are porous. The screens are generally made of silk, nylon or metal mesh. Screen printing is used for signs, displays, electronics, wall paper, greeting cards, ceramics, decals, banners and textiles. It has been estimated that there are more than 40,000 screen printing plants in the U. S., nearly half of which print textiles[52].

Ink systems used in screen printing include ultraviolet cure, waterborne, solvent borne and plastisol with plastisol (polyvinyl chloride) being mainly used in textile printing. Solvent based ink systems contain aliphatic, aromatic and oxygenated organic solvents.

Both sheetfed and web presses are used. Depending on the substrate printed, the substrate can be dried after each station or, for absorbent substrates, after all colors are printed. Solvent and waterborne inks are dried in hot air or infrared drying ovens. Dryer gases are partially recycled and partially vented (either to the atmosphere or to a control system). Both thermal and catalytic oxidizers are in use on screen printing dryer exhausts for solvent borne ink systems. Overall control efficiencies of 70 to 80 percent are achievable[53].

2.7 OTHER PRINTING PROCESSES

Plateless printing technologies are relatively new processes used primarily for short runs on paper substrates. These processes include electronic (e.g., laser printers), electrostatic (e.g., xerographic copiers), magnetic, thermal (e.g., facsimile machines) and ink jet printing. In 1991, plateless printing processes accounted for 3 percent of the total value of printing[54]. Electrostatic toners and ink jet printer inks may contain HAP, however the quantities emitted at any location are small.

2.7 REFERENCES

1. U. S. Environmental Protection Agency. Use Cluster Analysis of the Printing Industry, Draft Final Report. Washington, DC. May 26, 1992. p. 8.

2. Documentation for Developing the Initial Source Category List. U. S. Environmental Protection Agency, Research Triangle Park, NC. EPA-450/3-91-030. December, 1991.

3. Publication Rotogravure Printing - Background Information for Proposed Standards. U. S. EPA. Research Triangle Park, NC. EPA-450/3-80-031a. October, 1980. pp2-1 to 4-40.

4. Edgerton, Stephen, Joanne Kempen and Thomas W. Lapp. The Measurement Solution: Using a Temporary Total Enclosure Method for Capture Efficiency Testing. EPA-450/4-91-020. August 1991.

5. Reference 3, p. 3-7.

6. Profile Survey of the U. S. Gravure Industry; A Market Study of Industries Using Gravure and a Profile of Equipment, Cylinders, Ink and Substrates. Gravure Association of America. 1989. p. PRESS-18.

7. Reference 6, p. SUM-10.

8. Memorandum from Green, D., RTI, to D. Salman, EPA/ESD. April 6, 1993. Summary of meeting with EPA, RTI, and representatives of the Flexible Packaging Association, Research Triangle Park, NC.

9. Reference 6, p. MAR-56.

10. Reference 6, p. MAR-67.

11. Reference 6, p. MAR-72.

12. Reference 6, p. SUM-12.

13. Reference 6, p. MAR-79.

14. Reference 6, p. MAR-86.

15. Reference 6, p. MAR-87.

16. Reference 6, p. SUM-14.

17. Reference 6, p. MAR-97.

18. Reference 6, p. SUM-16.

19. Reference 6, p. SUM-18.

20. Reference 6, p. SUM-21.

21. Memorandum from Green, D., RTI, to D. Salman, EPA/ESD. September 12, 1994. Summary of Meeting with Representatives of the Gravure Association of America.

22. Reference 6, p. INK-5.

23. Reference 6, p. INK-11.

24. Reference 6, p. INK-6.

25. Reference 6, p. INK-8.

26. Memorandum from Green, D., RTI, to Salman, D., EPA/CPB. July 30, 1993. Summary of meeting with Representatives of the Flexible Packaging Association.

27. Reference 26.

28. Reference 6, p. INK-9.

29. Reference 6, p. MAR-126.

30. Reference 2.

31. Reference 1, p. 15.

32. Mulvihill, Donna C. Flexography Primer, Graphic Arts Technical Foundation, Pittsburgh, PA. 1985. p. 57.

33. Printing Ink Handbook, Fifth edition. National Association of Printing Ink Manufacturers, Inc. Harrison, NY. 1988. p. 38.

34. Reference 32, p. 60.

35. Reference 32, p. 60-64.

36. Reference 32, p. 49-50.

37. Cunningham, Elizabeth. Flexo in Flux. American Ink Maker. June 1992. pp. 52.

38. U. S. Environmental Protection Agency. Control of Volatile Organic Compound Emissions from Offset Lithographic Printing -Draft. Research Triangle Park, NC. September, 1983. p. 2-1.

39. Reference 38, 235 pp.

40. Reference 1, p. 63.

41. Reference 38, p. 2-4

42. Reference 33, p. 34.

43. Kirk-Othmer Encyclopedia of Chemical Technology, Third Edition. "Inks". New York, NY. 1982. p. 374.

44. Reference 38, p. 2-8.

45. Reference 38, p.2-4.

46. Reference 1, p. 63.

47. Reference 38, p. 3-37.

48. Reference 1, p. B-28.

49. Reference 38, p.4-1 to 4-14.

50. Reference 1, p. 101.

51. Cunningham, H. W. Nonheatset Web Printing, in Bunicore, A. and W. T. Davis. Air Pollution Engineering Manual. New York, NY. 1992.

52. Kinter, Marcia. Screen Printing, in Bunicore, A. and W. T. Davis. Air Pollution Engineering Manual. New York. NY. 1992.

53. Reference 52.

54. Reference 1, p. 40.

3.0 CONTROL TECHNOLOGY AND PERFORMANCE OF CONTROLS

3.1 INTRODUCTION

There are two approaches to limitation of HAP in the printing and publishing industry. The first approach is to improve capture and control systems or to add control devices where none are in use. Capture and control can be addressed separately, although in many cases, improved capture is achieved through an increase in the amount of air handled. This can necessitate upgrades to existing control devices. The second approach, focusing on pollution prevention, is to substitute low HAP or HAP-free materials for materials (inks, coatings, varnishes, adhesives, primers, etc.) presently in use.

3.2 CAPTURE SYSTEMS

Capture systems are designed to collect solvent laden air and direct it to a control device. In heatset printing processes, solvent is removed from the printed substrate by evaporation in a dryer. The exhaust from the dryer can be ducted to a control device. Additional systems are often used to collect solvents which evaporate from other parts of the printing press, as well as those which escape from the dryer. In addition, pressroom ventilation air can be exhausted to a control device.

Differences in capture efficiency contribute much more to the variation in overall efficiencies than the choice of control device. Reported capture efficiencies ranged from estimates of less than 50 percent to the 100 percent capture which is assumed for systems meeting the requirements of permanent total enclosures. Test procedures have been established for determining capture efficiency[1] and for confirming the presence of permanent total enclosures.[2] Capture systems can be improved through collection of additional solvent laden air from the press area and through construction of additional hooding and press enclosures. In theory, capture can be improved to (nearly) 100 percent for any press or pressroom by retrofitting walls and increasing ventilation to meet the requirements of permanent total enclosures. In practice, it may be prohibitively expensive to retrofit some existing facilities.

3.2.1 Publication Rotogravure.

Within the publication rotogravure industry, all presses have dryer exhaust gases routed to the solvent recovery system. Based on responses to the voluntary question list developed by the EPA and the GAA, additional capture systems in place were described as dryer hood systems, partial upper deck enclosures, full upper deck enclosures, enclosed presses, permanent total enclosures, room enclosures, rooms operated under negative pressure and floor sweeps. It is not known whether the capture systems described as enclosed presses and room enclosures meet the EPA definition of permanent total enclosure[3]. Typically, solvent laden air captured from several presses is combined and treated with a common solvent recovery system. The individual presses may have different capture devices, and different capture efficiencies.

3.2.2 Product and Package Gravure.

In the product and package gravure industry, many facilities use low VOC (and low-HAP) inks and coatings. Dryer exhausts from these facilities may be captured and vented to the atmosphere without the use of a control device. Where solvent based inks are in use, more elaborate capture and control systems may be required. Capture systems in use at product and packaging gravure facilities include combinations of dryer exhausts, floor sweeps, collection ducting, hoods, press enclosures, total enclosures, room enclosures, negative pressure pressrooms, partial enclosures and ink pan covers. With the exception of total enclosures, none of these technologies has a precise definition with regard to capture efficiency. In many cases terms are used interchangeably. Where control devices are in use, solvent laden air from several presses may be combined and ducted to a common control device.

3.2.3 Wide-web Flexographic Printing.

Capture systems in use at flexographic printing facilities include combinations of dryer exhausts, floor sweeps, hoods, and total enclosures. Capture efficiencies of between 50 and 100 percent were reported, although many respondents did not report capture efficiencies.Many facilities, including most sheetfed corrugated box facilities have no capture systems and rely on pressroom exhaust to the atmosphere to dilute the small amount of HAP present in the ink.

3.3 CONTROL DEVICES

The control devices in use in rotogravure and flexographic printing processes include carbon adsorption, thermal incineration and catalytic incineration. The selection of a control device is influenced by the type of inks (and other materials) applied on the press, the volume of solvent laden air to be treated and the operating schedule of facility. Design procedures and limitations for these control devices are given in the EPA Control Technologies Handbook[4].

3.3.1 Carbon Adsorption.

Activated carbon is a material with a high surface area which adsorbs many organics from air streams. Typically, solvent laden air is passed through two or more fixed beds of granular activated carbon. Organic HAP in the air is adsorbed on active sites on the carbon, until, at some point the capacity of the carbon is exhausted, and the organics pass through unadsorbed. Adsorbers are operated in parallel so that when the capacity of one unit is exhausted, it can be removed from service and a second adsorber can be put into service. The exhausted carbon in the first adsorber is then regenerated[5].

In contrast to incineration techniques, carbon adsorption does not destroy the HAP in the treated air. Carbon adsorbers in the printing industry are regenerated by passing steam through the carbon beds. The HAP is removed from the carbon, and transferred to the steam. The steam-HAP mixture is then condensed, and the solvent separates from the water. The solvent can then be decanted for sale or reuse.

Carbon adsorption systems can achieve control device efficiencies of 95 to 99 percent for some organic HAP[6]. These systems are most suitable for solvent systems which are immiscible with water, such as toluene and xylene. They are not recommended for ketones such as methyl ethyl ketone and methyl isobutyl ketone.

3.3.2 <u>Thermal Incineration</u>

Thermal incinerators are control devices in which the solvent laden air is preheated and the organic HAP are ignited and combusted to carbon dioxide and water. Dilute gas streams require auxiliary fuel (generally natural gas) to sustain combustion. Various incinerator designs are used by different manufactures. The combustion chamber designs must provide high turbulence to mix the fuel and solvent laden air. The other requirements are a high enough temperature and a long enough residence time to insure essentially complete combustion. Thermal incinerators can be operated to achieve a wide range of control device efficiencies[7]. Efficiencies of 98 percent[8] to greater than 99 percent are possible[9].

Because the incinerator must be in operation at times when HAP emissions are very low (e. g. when presses are on standby between jobs) supplemental fuel requirements will vary. Incinerators are supplied with controls to start-up and bring the combustion chamber to the proper temperature. These controls can provide an interlock to prevent operation of the press until the incinerator temperature is adequate to insure destruction of HAP.

3.3.3 <u>Catalytic Incineration</u>

Catalytic incinerators are control devices in which the solvent laden air is preheated and the organic HAP are ignited and combusted to carbon dioxide and water. In the presence of a catalyst, this reaction will take place at lower temperatures than those required for thermal incineration. Temperatures between 350 and 500 degrees Celsius are common. The catalysts are metal oxides or precious metals where are supported on ceramic or metallic substrates. Catalytic incinerators can achieve control device efficiencies of 95 to 99 percent[10].

From an operational standpoint, the lower reaction temperature means that the requirement for supplemental fuel is reduced or eliminated during normal operation. The lower operating temperatures will also decease the formation of oxides of nitrogen.

The use of a catalyst is inconsistent with certain ink formulations. Chlorinated solvents and some silicone ink additives can poison or deactivate catalysts. Design of catalytic incinerators varies from manufacturer to manufacturer. The major differences involve the geometry of the combustion chamber, the type of catalyst and support material, and the type of contact between the gas and the catalyst.

3.4 PERFORMANCE OF CONTROLS

3.4.1 Publication Gravure

The 27 plants currently operating in the U. S. all use toluene based ink systems, and operate solvent recovery systems which include fixed bed activated carbon adsorption units which are regenerated with steam. Recovered solvent is added to the as-purchased ink to adjust the viscosity as necessary. Excess recovered solvent is sold back to the ink manufacturers. Press capture systems vary depending on the age of the press, however the majority of the solvent is captured through the dryer exhausts.

A total of 31 separate solvent recovery systems are in service at the 27 publication gravure plants. In addition, some plants have substituted non-HAP solvents for a portion of the toluene based solvent in publication gravure ink.

Catalytic and thermal oxidation systems are technically feasible for control of publication gravure emissions. These technologies offer little or no potential improvement in control and have economic disadvantages as they destroy rather than recover the solvent.

The control devices in use at all publication gravure facilities are similar in design and operation. Capture efficiencies of between 85 and 100 percent were reported, however this information was not available for the majority of the presses. Control device efficiencies of 95 to 99.9 percent were reported, however, these data were not reported for all control systems. The median control efficiency reported was 98 percent. One solvent recovery system manufacturer estimates control device efficiencies for publication gravure systems at 97 to 99 percent. This estimate excludes solvent retained in the web equal to between 1 and 5 percent of that applied[11]. This indicates a maximum expected overall efficiency of 98 percent (i.e. 99 percent control of the 99 percent of the HAP which is not retained).

Excluding that portion of the HAP which is retained in the web and emitted after it leaves the press, control device efficiencies can theoretically be improved with thicker carbon beds. Improvement in capture efficiency is expected to be more cost effective in many cases, as capture efficiencies of close to 100 percent have been achieved using total enclosures.

Overall efficiencies, based on liquid-liquid mass balances were reported for all control systems. Overall efficiency represents the product of capture efficiency and control device efficiency. These involve determinations of total VOC present in purchased ink and other VOC containing materials, inventories of solvent recovery and use through tank level measurements, and flow meters on ink distribution and recovered solvent purchases. These balances are conducted frequently by all facilities, and are typically reported as monthly averages.

Long term averages are highly accurate as noise from measurement errors is averaged out. The nature of the testing, i. e. material balance, eliminates much of the error associated with sampling and analysis of stack emissions. Analyses of VOC and HAP content of inks and other materials are, however, subject to chemical analysis errors.

On an annual basis, overall efficiencies were reported in the range of 83 to 109 percent. It should be noted that the system reporting 109 percent overall efficiency is able to achieve a solvent recovery of over 100% by drawing air from a pressroom controlled by a separate control system, containing presses with a lower capture efficiency. Thus, this control system actually recovers fugitive emissions from a separate source, in addition to the emissions from the presses that it controls.

All facilities reported overall efficiencies achieved in 1992, and provided the range of overall efficiencies achieved determined on a monthly basis for 1992. Since some facilities operate more than one control system, data from 33 control systems were reported by the 27 facilities. The range of overall control data reported for these control systems in the voluntary responses provided to EPA is given in Table 3-1.

Table 3-1. Overall Control Efficiencies Reported for Publication Gravure Plants.

Basis of Ranking	**Best Month**	**Annual Average**	**Worst Month**
Overall Control	%	%	%
Best System	115	109	96
Median System	94	91.8	88
Worst System	85	83	78

3.4.2 Product and Packaging Gravure

Product and packaging gravure facilities use a variety of ink systems. Inks in use include toluene based inks which are similar or identical to those used in publication gravure (See section 3.4.1), high VOC solvent based inks with very low or no HAP content, waterborne ink with low VOC and low HAP content and waterborne ink with low VOC and no HAP content.

The type of ink used is influenced by factors including the nature of the substrate printed, the type of product or package printed, the age of the press and existing air pollution regulations and permit requirements related to VOC emissions. Product and packaging rotogravure ink can contain HAP such as toluene, hexane, methyl ethyl ketone, methyl isobutyl ketone, methanol and glycol ethers as well as non-HAP VOC such as ethyl acetate propyl acetate and butyl acetate. The control technologies employed are influenced by the type of ink used.

Existing control technologies for product and packaging rotogravure are directed to control of VOC. In most cases, the HAP and non-HAP portion of the VOC present in the ink are equally difficult to control.

Based on data submitted in response to the ICR, control devices in use at product and packaging gravure facilities include carbon adsorption, catalytic incineration, fume incineration, fume/vapor incineration, (unspecified) incineration, fumes burned in boiler, periodic recuperative thermal oxidation, recuperative incineration, regenerative thermal oxidation and regenerative thermal incineration. These terms refer to devices which can be divided into three groups: carbon adsorption, thermal incineration and catalytic incineration.

Emissions data submitted in response to the ICR are based on emissions tests, equipment vendors guarantees and various types of engineering estimates. In all cases, emissions test data refer to VOC emissions. It is assumed that recovery or destruction of VOC is equivalent to that for HAP. Capture efficiencies of between 30 and 100 percent were reported, although many respondents did not report capture efficiencies. Control device efficiencies of between 89 and 100 percent were reported by respondents reporting non-zero control device efficiencies. Control device efficiencies were not reported by all facilities which operate control devices.

Data on overall efficiency were reported for 87 control systems. Some facilities responding to the ICR did not operate control systems. The 87 systems for which usable data were available claimed overall efficiencies of between 45 and 100 percent. The basis for the estimates vary. Where solvent recovery systems are in place the overall efficiencies are typically determined by liquid-liquid mass balances (as described in Section 3.4.2). If total enclosures are in place capture efficiency is assumed to be 100 percent; control device efficiency is calculated.

For catalytic and thermal incineration control devices test data is available for overall efficiency in some cases and for control device efficiency in others. Where test data is available for destruction across the control device, capture efficiencies are often estimated using engineering judgment. Overall efficiencies incorporate these judgments. In many cases, either the control device efficiency or the capture efficiency was based on vender guarantees and the overall efficiency was estimated. In general, when operated as designed, control devices will out-perform vender guarantees on an average basis.

It should be noted that the accuracy of the reported overall efficiencies varies. In addition to the (presumably biased low) data based on vendor guarantees, estimates made by operating personnel of capture efficiency may not be realistic. There is, however, less likelihood of a consistent bias (high or low) in these estimates.

Overall efficiency data were reported for 87 control systems. Other facilities had no control devices in place. These data are of variable reliability, as described above. In addition it should be recalled that reported efficiency data pertain to VOC control and that the applicability of these data to the HAP portion of the VOC has not been determined. The range of overall efficiencies for carbon adsorption, catalytic incineration and all other types of incineration are given in Table 3-2.

Table 3-2. Overall Efficiencies Reported for Product and Packaging Gravure Facilities with Control Systems.

Control Device	Number of Systems	Minimum Efficiency	Average Efficiency	Maximum Efficiency
Carbon Adsorption	22	45	79.8	100
Catalytic Incineration	24	65	85.4	99.2
Thermal Incineration	41	47.5	83.6	99.2

The range of control device efficiencies for the systems where these data are reported is given in Table 3-3. Overall efficiencies reported for three specific industry segments are given in Table 3-4. These data are also given for the major sources (as determined by actual HAP emissions) in the industry segments.

3.4.3 Wide-web Flexographic Printing

Flexographic printing facilities use a variety of ink systems. Solvent based inks are primarily formulated with non-HAP solvents which may contain small proportions of ethylene glycol, glycol ethers and methanol which are HAP. Solvent based inks are available for some applications which are completely HAP free. Capture and control systems used with these systems are designed and operated for control of VOC. In the absence of compound specific performance data it is assumed that individual HAP are controlled to the same extent as VOC.

The type of ink used is influenced by factors including the nature of the substrate printed, the type of product or package

Table 3-3. Control Device Efficiencies Reported for Packaging and Product Gravure Facilities with Control Systems.

Control Device	Minimum Efficiency (%)	Maximum Efficiency(%)
Carbon Adsorption	89	100
Catalytic Incineration	88.8	99.7
Thermal Incineration	88.8	99.3

Table 3-4. Overall Efficiencies by Industry Segment for Packaging and Product Gravure Facilities with Control Systems (Data for Major sources in Parentheses).

Industry Segment	Overall Efficiency (%)
Paper/Cardboard Only	45-98.6 (65-95.3)
Foil/Film Only	65-95 (65-95)
Vinyl Product	80-97.7 (80-93)

printed, the age of the press and existing air pollution regulations and permit requirements related to VOC emissions. Packaging ink is subject to additional requirements depending on the intended contents of the package.

Many wide web flexographic printing facilities use waterborne inks with either no HAP or low HAP content. The majority of these facilities have no control devices, and may have converted from solvent based to waterborne materials to avoid the need to install control devices to comply with VOC regulations. Existing control devices for flexography are directed to control of VOC. In most cases, the HAP and non-HAP portion of the VOC present in the ink are equally difficult to control.

Where control devices are in use, solvent laden air from several presses may be combined and ducted to a common control device. In addition, HAP from flexographic printing may be ducted to control devices designed and operated for control of HAP from other processes (such as rotogravure) operated at the same plant.

Based on data submitted in response to the ICR, control devices in use at flexographic facilities include carbon adsorption, catalytic incinerators, and thermal incinerators (including, but not limited to regenerative and recuperative). Usable ICR data are reported by industry segment and control device in Table 3-5.

Emissions data submitted in response to the ICR is based on emissions tests, equipment vendors guarantees and various types of engineering estimates. In all cases, emissions test data refer to VOC emissions. It is assumed that recovery or destruction of VOC is equivalent to that for HAP. Control device efficiencies of between 90 and 99 percent were reported by respondents reporting non-zero control device efficiencies.

A total of 53 facilities operated control devices. Those facilities which do not operate control devices were assumed to emit 100% of the HAP used. Not all of the facilities which

Table 3-5. Control Devices in Use by Flexographic Printers.

Segment	Control Device						
	None	Catalytic Incinerator	Thermal Incinerator			Solvent Recovery	Total
			Recuperative	Regenerative	Other		
Corrugated box	238	0	0	0	0	0	238
Flexible Packaging							
Film/foil	55	26	4	0	1	1	87
Paper/cardboard	40	1	0	0	0	0	41
Mixed/unknown	43	15	1	2	1	1	63
Total	138	42	5	2	2	2	191
Product							
Paper/plastic	9	0	0	0	0	0	9
Paper only	40	0	0	0	0	0	40
Total	49	0	0	0	0	0	49
Books/directories	3	0	0	0	0	0	3
Newspapers	8	0	0	0	0	0	8
Total	436	42	5	2	2	2	489

reported overall efficiencies provided separate data on capture and control efficiencies. The basis for the estimates vary. Solvent recovery systems are in place at two facilities; overall efficiency data for these control systems are typically determined by liquid-liquid mass balances (as described in Section 3.4.1).

For catalytic and thermal incineration control devices test data is available for overall efficiency in some cases and for control device efficiency in others. Where test data is available for destruction across the control device, capture efficiencies are often estimated using engineering judgment. Overall efficiencies incorporate these judgments. In many cases, either the control device efficiency or the capture efficiency was based on vender guarantees and the overall efficiency was estimated.

It should be noted that the accuracy of the reported overall efficiencies varies. In addition to the (presumably biased low) data based on vendor guarantees, estimates made by operating personnel of capture efficiency may not be realistic. There is, however, less likelihood of a consistent bias (high or low) in these estimates.

Based on approximately 500 usable responses to the ICR, 125 facilities reported using no HAP whatsoever for flexographic printing. Overall efficiency data was reported for 53 control systems. It should be noted that none of the facilities operating control devices had HAP emissions in excess of 25 tons per year of HAP of 10 tons per year of any specific HAP. Reported efficiency data pertain to VOC control and the applicability of these data to the HAP portion of the VOC has not been determined. The range of overall efficiencies for carbon adsorption, catalytic incineration and all other types of incineration are given in Table 3-6.

Most of the variation in overall efficiencies is due to variation in capture efficiencies. All of the reported control device efficiencies were greater than 91 percent, although not

Table 3-6. Overall Efficiencies Reported for Flexographic Facilities with Control Systems.

Control Device	Number of Systems	Minimum Efficiency	Average Efficiency	Maximum Efficiency
Carbon Adsorption	2	91	93	95
Catalytic Incineration	42	48	77	98
Thermal Incineration	9	48	76	95

all facilities reporting overall efficiencies provided data on control device efficiencies.

Control device capabilities applicable to flexographic printing are comparable to those for packaging and product rotogravure (see Section 3.4.2). Capture systems for in-line presses are comparable to those for gravure presses. Capture systems for dryer exhausts from common impression and stack presses may be less efficient than those for in-line presses. The technology and capabilities of total enclosures and press room ventilation described in Section 3.2 are applicable to flexographic printing.

3.5 LOW HAP AND HAP-FREE INKS (AND OTHER MATERIALS)

Most facilities have adopted air pollution control strategies directed towards elimination or control of VOC. Many low HAP inks contain high proportions of VOC. VOC control devices also control organic HAP. Some existing regulations have resulted in lower VOC emissions as sources converted from solvent based to waterborne inks. In some cases, conversion to waterborne inks, which could result in significant reduction in VOC use, will be inhibited if HAP standards are formulated in terms of percentage reduction.

The types of control devices used by facilities using solvent based inks, are not likely to adequately function as HAP control devices when waterborne inks are used, because the dryer exhaust streams will contain relatively large amounts of water and relatively low heat content. In cases where low HAP (as opposed to no HAP) inks are necessary for particular products or packaging, the feasibilty of conversion to waterborne inks may form the basis for segmentation of the industry for HAP regulation. Conversion from solvent based inks to waterborne inks may in some cases increase the amount of HAP in the press exhaust.

3.5.1 Publication Rotogravure

At present all publication gravure facilities use solvent systems based on HAP. The solvent in use is principally toluene; other aromatic HAP (xylenes and ethylbenzene) are sometimes present in the solvent blend. Eleven of the 33 control systems use solvents which are 100 percent HAP. Some facilities have been able to print with acceptable speed and quality using a solvent which contains a lower proportion of HAP. While the solvent in use is still 100 percent VOC, the substitution of non-HAP solvent represents a HAP pollution prevention opportunity of demonstrated feasibility.

As of yet, water-borne publication gravure inks have not been developed which offer the production speed and print quality of solvent based inks[12]. The development of acceptable waterborne inks may represent a future pollution prevention opportunity.

3.5.2 Product and Packaging Rotogravure

Pollution prevention, in terms of HAP elimination has been achieved by many facilities in the packaging and product rotogravure industry. Inks with zero HAP content are available and in use at some facilities in all industry segments. In addition, many facilities, particularly those printing on paper and cardboard packaging, use waterborne inks which contain only a very low percentage of HAP. These inks typically contain a small proportion of glycol ethers which function to reduce surface tension and improve flow characteristics. The adoption of these inks by additional existing sources is a likely consequence of increased regulation of HAP emissions. It should also be noted that some solvent based inks are completely HAP free.

Packaging and product rotogravure facilities produce a wide variety of products. Flexible packaging producers, in particular, print on many different substrates within the same facility. Low HAP inks may not be available to meet all of the performance requirements of these facilities. In addition, many facilities use hundreds of different inks to print various custom colors required by their packaging customers. Low HAP inks may not be available for all substrates in all of the colors required by some facilities. Existing facilities with well performing control systems may have little incentive to make additional investments to adapt to inks with no HAP.

Some sources currently use carbon adsorption steam regeneration solvent recovery systems. These systems have important pollution prevention benefits, in that they recover solvent for reuse as opposed to thermal or catalytic destruction. At present, solvent recovery systems work best with HAP solvents, particularly toluene. Conversion to no HAP or low HAP acetate based solvent systems would complicate or eliminate the utility of these systems and increase VOC use. In cases where existing solvent recovery systems are performing well, they may represent an overall pollution prevention benefit. One possibility would be to regulate product and packaging rotogravure facilities with solvent recovery systems under the same standards which are applied to publication rotogravure facilities.

3.5.3 Wide-web Flexographic Printing

Pollution prevention, in terms of HAP elimination has been achieved by many facilities in the flexographic printing industry. Inks with zero HAP content are available and in use at some facilities in all industry segments. In addition, many facilities use inks which contain only a very low percentage of

HAP. These inks typically contain a small proportion of glycol ethers which function to reduce surface tension and improve flow characteristics. The adoption of these inks by additional existing sources is a likely consequence of increased regulation of HAP emissions.

Flexographic printing facilities produce a wide variety of products. Flexible packaging producers, in particular, print on many different substrates within the same facility. Low HAP inks may not be available to meet all of the performance requirements of these facilities. In addition, many facilities use hundreds of different inks to print various custom colors required by their packaging customers. Low HAP inks may not be available for all substrates in all of the colors required by some facilities. Replacement of existing inks with inks containing less HAP (for those applications for which satisfactory replacements are available) is likely to occur.

Two specific examples where pollution prevention strategies are promising are corrugated box and newspaper production. In both cases facilities using zero HAP inks can produce nearly identical products to those using low HAP inks. Increased awareness of the options available will cause some flexographic printers to eliminate HAP.

Based on approximately 500 usable responses to the ICR, 125 facilities reported using no HAP whatsoever for flexographic printing. These facilities included 49 corrugated box manufacturers, 22 paper product manufacturers, 2 product manufacturers that made at least some plastic products, one book manufacturer, and 51 flexible packaging manufacturers. Of the flexible packaging manufacturers, 15 printed on paper substrates, 19 printed on foil or film substrates. The remaining 17 flexible packaging manufacturers either indicated that they printed on both paper and film or did not provide specific information about substrate. It should be noted that 9 of these facilities operated catalytic incinerators for VOC control. Some unknown fraction of the facilities which reported no HAP use on press may have been unaware of the HAP content. It is clear, however, that HAP free formulations are available for printing on both porous and non-porous substrates. Many other facilities applied materials on their flexographic presses which contained very low proportions of HAP on an average annual basis.

The types of control devices used by facilities applying solvent based materials are not likely to adequately function as HAP control devices when waterborne inks are used, because the dryer exhaust streams will contain relatively large amounts of water and relatively low heat content. In cases where low HAP (as opposed to no HAP) inks are necessary for particular products or packaging, the feasibility of conversion to waterborne inks may be a basis for segmentation of the industry for HAP regulation. Conversion from solvent based inks to waterborne inks may in some cases increase the amount of HAP in the dryer exhaust.

3.6 REFERENCES

1. Edgerton, Stephen, Joanne Kempen and Thomas W. Lapp. The Measurement Solution: Using a temporary Total Enclosure Method for Capture Efficiency Testing. EPA-450/4-91-020. August 1991. p.39-42.

2. Reference 1, p. B-1 through B-4.

3. Standards of Performance for Magnetic Tape Coating Facilities. 40 CFR 60, Subpart SS, July 1990. pp.438-444.

4. U. S. Environmental Protection Agency. Handbook: Control Technologies for Hazardous Air Pollutants. Publication No. EPA/625/6-91/014. Cincinnati, OH. June 1991. 168 pp.

5. U. S. Environmental Protection Agency. Internal Instruction Manual for ESD Regulation Development: Combustion Controls for Organic Emissions from Process Vents, Second Printing. Research Triangle Park, North Carolina. August 31, 1994. p. 3-39 through 3-43.

6. Reference 4, p.3-4.

7. Reference 6, p. 3-16 through 3-21.

8. Reference 6, p. 3-16.

9. Handbook: Control Technologies for Hazardous Air Pollutants. (Ref. 2) p.4-2.

10. Reference 4, p. 4-10.

11. Worrall, M. J. VOC Capture for High Speed Publication Rotogravure Printing. Paper 93-TA-33.02, presented at AWMA Meeting. June 1993.

12. Reference 11.

4.0 MODEL PLANTS, CONTROL OPTIONS, AND ENHANCED MONITORING

4.1 INTRODUCTION

This chapter describes model plants, control options and enhanced monitoring options for specific segments of the printing and publishing industry. Model plants were developed to evaluate the effects of various control options on the source category. Control options were selected based on the application of presently available control devices and varying levels of capture consistent with different levels of overall control. Enhanced monitoring options are specified to insure the consistent performance of control devices.

4.2 MODEL PLANTS

Model plants have been specified for three segments of the printing industry. Model plants have been selected to represent the range of capacity and overall control efficiency existing in these industry segments as determined by responses to the information collection requests.

4.2.1 Publication Rotogravure Model Plants

Model plants have been selected to represent a total industry population of 33 separate control systems at 27 publication rotogravure plants. Specifications for these plants are given in Table 4-1. Information on HAP usage and overall control efficiencies are available for the entire population. Four model plants are based on size (based on ink usage) and control efficiencies reported in voluntary responses to EPA question lists. The large plants (Model Plants 1 and 2) were specified based on the 80th percentile of ink usage. The small plants (Model Plants 3 and 4) were specified based on the 20th percentile of ink usage.

Table 4-1. Publication Rotogravure Model Plants.

Model Plant	1	2	3	4	5
Presses/Stations	8/10	8/10	4/8	4/8	5/8
Pressroom Length (ft)	240	240	120	120	150
Pressroom Width (ft)	150	150	120	120	120
Pressroom Height (ft)	30	30	30	30	30
HAP usage(lb/yr)	22,500,000	22,500,000	6,400,000	6,400,000	14,000,000
HAP usage (g/min)	19,435	19,435	5,528	5,528	12,093
Capture Efficiency (%)	98.1	90.7	98.1	90.7	80.4
Control Efficiency (%)	97.0	97.0	97.0	97.0	97.0
Overall Control (%)	95.2	88.0	95.2	88.0	78.0
HAP controlled (lb/yr)	21,420,000	19,800,000	6,092,800	5,632,000	10,920,000
HAP emitted (lb/yr)	1,080,000	2,700,000	307,200	768,000	3,080,000
HAP retained (lb/yr)	337,500	337,500	96,000	96,000	210,000
HAP to Pressroom(lb/yr)	90,000	1,755,000	25,600	499,200	2,534,000
Pressroom Volume (CF)	1,080,000	1,080,000	432,000	432,000	540,000

Assumed 1.5% of HAP used is retained in the web, and ultimately emitted outside the pressroom.

Plants with a high level of control (Model Plants 1 and 3) were selected based on the 80th percentile of overall control efficiencies. Plants with a low level of control (Model Plants 2 and 4) were specified based on the 20th percentile of overall control efficiency. One additional model plant (Model Plant 5) was selected based on the lowest reported monthly overall control efficiency. The size of this plant was specified based on the approximate size of the actual plant reporting this efficiency.

Presses under control at each model plant were specified based on the approximate equipment in use at plants with this level of ink usage. Pressroom dimensions were assumed based on equipment size. Actual facilities may have multiple pressrooms under control by common systems, or more widely spaced presses separated by other equipment. All plants in this segment of the industry have similar solvent recovery systems; most of the difference in overall control is due to variations in capture. All or nearly all of the HAP in use at the plants is accounted for by overall liquid-liquid mass balances. Unrecovered HAP may be due to fugitive emissions, stack emissions or residual solvent shipped out in the product (this is assumed to be emitted at some stage in the life cycle of the product).

4.2.2 Product and Packaging Gravure Model Plants

Data provided by packaging and product rotogravure facilities in response to the ICR were used to subcategorize this part of the printing industry on the basis of substrate and end use. The list of facilities for which usable information was received and the subcategories into which these facilities were placed is described in Chapter 2.

HAP usage varied widely among the facilities. In addition, HAP usage as a proportion of total material applied on rotogravure presses varied widely. At least twelve facilities reported zero HAP usage, including one facility which applied over 7 million pounds per year of inks and coatings. The availability of suitable low HAP or no HAP ink may be dependent upon the substrate and specific end product. In addition, existing control devices, which in most cases are designed and operated for VOC control, may not be compatible with low HAP formulations. Substitution of inks with lower HAP content may be an important pollution prevention option at some facilities. Other facilities, which are operating efficient VOC control systems may have little incentive to reduce the HAP content of their inks.

Facilities printing on paper and cardboard packaging only, film and foil packaging only and vinyl products have been listed in Tables 4-2 through 4-4. Based on data submitted in response to the ICR, total ink (including coatings, adhesives, varnishes and primers) use, HAP use associated with this ink use, estimated overall control and probable major source status have been listed in these tables. In some cases, data were incomplete or ambiguous. These tables exclude facilities which print on both paper or cardboard and foil or film, and other miscellaneous products. Lists of these facilities are given in Chapter 2.

Model plants were selected from the mid-range of the identifiable major sources within each subcategory. It should be noted that while this is representative of the sources which will be regulated, it is not necessarily representative of the subcategory as a whole. Because of the varying approaches to emissions control used by the major sources in the packaging subcategories (relatively high HAP use with extensive control versus relatively low-HAP use with no control), two model plants have been selected for paper/cardboard and foil/film packaging.

Model plant specifications are given in Table 4-5. Ink, HAP and VOC use, overall efficiency and numbers of presses and stations were based on actual responses from representative facilities in each sub-category.

4.2.3 Wide-web and Sheet Fed Flexography Model Plants

Data were provided by approximately 500 flexographic printing facilities in response to the ICR. The list of facilities for which usable information was received is included in Chapter 2. Responses were obtained from printers of flexible

Table 4-2. HAP Use by Rotogravure Facilities Printing on Paper and Cardboard.

Company Name	Ink Usage (lb/yr)	HAP usage (lb/yr)	Overall Control(%)	Major[a]	Emissions (lb/yr)
Alford Packaging	1,484,884	78,125	90	NO	7812
Allied Stamp Corporation	699,562	111,908	98	NO	2238
American Greetings	1,650,000	20,040	0	NO	20040
Avery Dennison	879,000	867,000	89	YES	95370
Cleo, Inc.	7,400,000	0	NA	NO	0
Decorative Specialties International, Inc.	374,000	19,185	0	NO	19185
Dopaco, Inc., Downington	2,288,742	939,235	80.6	YES	182211
Dopaco, Inc., Saint Charles	901,135	191	0	NO	191
Dopaco, Inc.	1,146,807	2,423	0	NO	2423
Federal Paper Board Co., Inc., Wilmington	4,144,000	440,084	70	YES	132025
Federal Paper Board Co., Inc., Durham	1,240,840	1,858	NA	NO	NA
Graphic Packaging Corporation, Lawrenceburg	8,978,632	796,552	95.3	YES	37437
Graphic Packaging Corporation, Paoli	534,468	4,823	71.78	NO	1361
Gravure Carton & Label	71,360	14,190	0	NO	14190
Gravure Packaging, Inc.	1,795,000	205,100	78.7	YES	43686
Hallmark Cards, Kansas City	58,000	6,777	30	NO	4743
Hallmark Cards, Leavenworth	2,629,406	21,880	45	NO	12034
International Label Company	1,089,824	316,891	86.83	YES	41734

Table 4-2. HAP Use by Rotogravure Facilities Printing on Paper and Cardboard.

Company Name	Ink Usage (lb/yr)	HAP usage (lb/yr)	Overall Control(%)	Major[a]	Emissions (lb/yr)
International Playing Card & Label Company	2,856,071	568,680	85	YES	85302
James River Paper Company, Darlington	1,915,572	575,988	0	YES	575988
James River Paper Company, Fort Smith	1,233,549	147,951	0	YES	147951
James River Paper Company, Lexington	131,794	0	0	NO	0
James River Paper Corporation, Kalamazoo	4,343,000	115,372	93	NO	8076
Jefferson Smurfit Corporation, Chicago	262,923	91,122	80	NO	18224
JSC/CCA, Carol Stream	1,060,412	93,178	75	YES	23294
JSC/CCA, Lockland	1,218,069	66,868	78.7	NO	14242
JSC/CCA, North Wales	819,965	307,574	90	YES	30757
JSC/CCA, Santa Clara	1,673,193	25,139	0	NO	25139
JSC/CCA, Stone Mountain	1,219,797	238,190	95.5	NO	10718
Lux Packaging Ltd.	845,985	46,442	88.9	NO	5155
Mundet-Hermetite Inc.,	1,149,193	101,856	NA	NA	NA
Riverwood International USA, Inc., Bakersfield	828,788	1,833	65	NO	641
Riverwood International USA, Inc., Cincinnati	789,562	275,294	71	YES	79835
Riverwood International USA, Inc., West Monroe	3,832,837	534,045	65	YES	186915

Table 4-2. HAP Use by Rotogravure Facilities Printing on Paper and Cardboard.

Company Name	Ink Usage (lb/yr)	HAP usage (lb/yr)	Overall Control(%)	Major[a]	Emissions (lb/yr)
Roslyn Converters Inc.	3,005,492	2,079	98.6	NO	29
Shamrock Corporation	773,564	0	0	NO	0
Somerville Packaging	NA	NA	84.7	NA	NA
Stone Container Corporation	648,444	44,564	62.4	NO	16756
The C. W. Zumbiel Company(Cleneay)	422,603	0	0	NO	0
The C. W. Zumbiel Company(Harris)	1,078,595	179,970	95	NO	8998
Union Camp Corporation, Englewood	265,650	160,200	84.7	YES	24510
Union Camp Corporation, Spartanburg	2,065,555	188,456	76	YES	45229
Waldorf Corporation, Chicago	600,551	378,408	79	YES	79465
Waldorf Corporation, Saint Paul	964,900	839,594	NA	YES	NA

NA=Not available, a=based on estimated emissions.

Table 4-3. HAP Use by Rotogravure Facilities Printing Exclusively on Foil and Film.

Company Name	Ink used (lb/yr)	HAP used (lb/yr)	Overall Control(%)	Major[a]	Emissions (lb/yr)
Alcan Foil Products	NA	NA	95	YES	NA
American Fuji Seal, Inc., Anaheim	104,700	3,152	95	NO	157
American Fuji Seal, Inc., Fairfield	384,706	77,845	89	NO	8562
Decorating Resources	81,473	65,212	97	NO	1956
Paramount Packaging Corporation, Chalfont	296,351	2,692	74.4	NO	689
Paramount Packaging Corporation, Longview	847,883	109,400	95	NO	5470
Screen Art	87,980	0	92	NO	0
Fres-Co System USA, Inc.	1,665,400	1,077,618	90	YES	107761
Paramount Packaging Corporation, Murfreesboro	289,395	67,083	0	YES	67083
Quick Roll Leaf Manufacturing Company	3,500,000	840,000	93	YES	58800
Reynolds Metals Company	5,315,422	992,744	65	YES	347460

NA=Not available, a=based on estimated emissions.

Table 4-4. HAP Use by Rotogravure Facilities Printing Vinyl Products.

Company Name	Ink	HAP usage	Efficiency	Major[a]	Emissions
	lbs/yr	lbs/yr	%		
Avery Dennison	2,037,375	885,684	93	Yes	61,998
Butler Printing & Laminating	915,500	803,400	85	YES	120,510
Columbus Coated Fabrics	2,355,116	1,346,742	NA	NA	NA
Congoleum Corporation, Marcus Hook	1,830,000	0	0	NO	0
Congoleum Corporation, Mercerville	210,000	173,000	93	NO	12,110
Constant Services, Inc.	222,622	206,898	87	NA	26,897
Decor Gravure Corporation	400,000	400,000	97.7	NO	9,200
Decorative Specialties Int'l	101,100	156,644	97	NO	4,699
GenCorp Inc., Salem	1,500	5,228	0	NO	5,228
GenCorp Polymer Products, Columbus	3,938,395	3,200,000	80	YES	640,000
GenCorp, Inc., Jeanette	182,000	166,000	NA	NA	NA
Mannington Mills, Inc.	1,242,127	190,674	91.7	NO	15,826
Newco Inc.	290,874	270,014	NA	NA	NA
Vernon Plastics Company	NA	549,455	NA	NA	NA

NA=Not available. a=based on estimated emissions.

Table 4-5. Model Plant Specifications for Product/Packaging Rotogravure.

Model Plant	1	2	3	4	5
Substrate	Vinyl Products	Paper/Cardboard Packaging		Foil/Film Packaging	
Ink Use, lb/year	1,000,000	1,800,000	2,000,000	3,000,000	300,000
VOC Use, lb/year	900,000	1,000,000	800,000	2,500,000	150,000
HAP Use, lb/year	900,000	200,000	600,000	1,000,000	65,000
Capture Efficiency, %	89	81	N/A	95	N/A
Control Device Efficiency, %	95	97	0	95	0
Overall Efficiency, %	85	79	0	90	0
Presses/Stations	8/4	4/8	1/6	2/8	4/6
Pressroom Dimensions, ft x ft x ft	240 x 100 x30	150 x 120 x 30	100 x 30 x30	60 x 150 x 30	120 x120 x30

packaging, products, corrugated cartons and newspapers. Flexible packaging and products involved both porous and non-porous substrates.

HAP usage varied widely among the facilities. In addition, HAP usage as a proportion of total material applied on flexographic presses varied widely. Over 100 facilities reported zero HAP usage; many more reported HAP usage well below one percent of the total material applied. The availability of suitable low HAP or no HAP ink is dependent upon the substrate and specific end product. In addition, existing control devices, which in most cases are designed and operated for VOC control, may not be compatible with low HAP formulations. Substitution of inks with lower HAP content may be an important pollution prevention option at some facilities. Other facilities, which are operating efficient VOC control systems may have little incentive to reduce the HAP content of their inks.

A list of facilities for which usable data are available is given in Table 4-6. Based on data submitted in response to the ICR, total ink (including coatings, adhesives, varnishes and primers) use, HAP use associated with this ink use, estimated emissions and type of substrate have been listed in this table. In some cases, data were incomplete or ambiguous.

Model plants have been selected to represent those sources which are likely to be regulated under the standard. It should be noted that while this is representative of the sources which will be regulated, it is not necessarily representative of the sub-category as a whole. Three model plants are specified in Table 4-7. Plants 1 and 2 and based on actual responses from uncontrolled major sources due to flexographic printing. Model plant 1 is a large plant using waterborne inks with a low HAP concentration and no control device. Model plant 2 is a medium sized plant using solvent based inks containing a significant amount of HAP and no control device.

A number of facilities operate flexographic printing operations as well as other more HAP intensive operations such as

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Abbott Box Co. Inc.	15,000	10	10	b
Acorn Corrugated Box Co.	161,000	0	0	b
Advance Packaging Corporation	122,100	1,591	1,591	b
Advance Packaging-Jackson	13,400	745	745	b
Tennessee Packaging	19,454	72	72	b
Koch Container	2,154	0	0	b
All-Size Corrugated Prods.	11,178	0	0	b
Compak, Inc.	10,295	193	193	b
Webcor Packaging Corp.	122,060	2,512	2,512	b
Castle Rock Container Company	231,768	10	10	b
Fleetwood Container & Display	78,660	Not major		b
Focus Packaging, Inc.	36,000	0	0	b
Frank C. Meyer Company, Inc.	333,045	0	0	b
GP-Albany Plant	361,893	3,619	3,619	b
GP-Asheboro Plant	165,206	1,652	1,652	b
GP-Augusta Plant	225,000	4,500	4,500	b
GP-Bradford Plant	212,664	2,127	2,127	b
GP-Buena Park Plant	1,235,300	12,353	12,353	b
GP-Canton Plant	70,627	706	706	b
GP-Chicago Plant	135,335	2,707	2,707	b
GP-Cincinnati	114,342	1,143	1,143	b
GP-Circleville Plant	224,653	2,247	2,247	b
GP-Cleveland Plant	134,926	1,349	1,349	b
GP-Cleveland Plant	131,708	13,171	13,171	b
GP-Doraville Plant	114,791	1,148	1,148	b
GP-Dubuque Plant	216,303	649	649	b
GP-Franklin Plant	180,000	12,600	12,600	b
GP-Huntsville Plant	187,152	0	0	b
GP-Kansas City Plant	219,516	0	0	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
GP-Lake Placid Plant	721,374	0	0	b
GP-Madera Container Plant	213,754	641	641	b
GP-'Martinsville Plant	250,000	0	0	b
GP-Memphis Plant	69,786	209	209	b
GP-Milan Plant	190,693	572	572	b
Modesto Plant	175,052	525	525	b
GP-Monticello Plant	26,779	7,498	7,498	b
GP-Mt. Olive Plant	212,188	664	664	b
GP-Mt. Wolf Plant	70,586	212	212	b
GP-Olympia Plant	133,080	1,198	1,198	b
GP-Ooltewah Plant	1,000	40	40	b
GP-Oshkosh Plant	27,077	542	542	b
GP-Owosso Plant	94,057	1,882	1,882	b
GP-Schenectady Plant	57,763	1,329	1,329	b
GP-Sheboygan Plant	122,629	2,453	2,453	b
GP-So. San Francisco Plant	932,691	2,798	2,798	b
GP-Spartanburg Plant	141,211	0	0	b
GP-Valdosta Plant	540,000	0	0	b
GP-Warren County Plant	120,173	361	361	b
GP-West Monroe Plant	140,969	5,639	5,639	b
GP-Waxahachie Plant	228,934	9,157	9,157	b
GP-Gulf States Paper Corp.	424,405	0	0	b
International Paper-Presque Isle	101,725	844	844	b
International Paper-Auburndale	223,525	1,182	1,182	b
International Paper-Carson	375,752	822	822	b
International Paper-Chicago	226,287	770	770	b
International Paper-Cincinnati	129,055	523	523	b
International Paper-Dallas	166,287	390	390	b
International Paper-Detroit	146,360	1,020	1,020	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
International PaperEdinburg	240,391	856	856	b
International Paper-El Paso	197,102	1,900	1,900	b
International Paper-Fond du Lac	230,990	683	683	b
International Paper-Geneva	98,250	136	136	b
International Paper-Georgetown	59,711	2,846	2,846	b
International Paper-Minneapolis	95,542	720	720	b
International Paper-Mobile	230,224	3,039	3,039	b
International Paper-Modesto	347,046	1,341	1,341	b
International Paper-Mt. Carmel	337,500	4,940	4,940	b
International Paper-Nashville	245,662	8,685	8,685	b
International Paper-Putnam	228,407	890	890	b
International Paper-Russellville	247,201	1,198	1,198	b
International Paper-San Jose	328,783	775	775	b
International Paper-Shreveport	417,513	0	0	b
International PaperSpring Hill	254,985	3,957	3,957	b
International Paper-Statesville	158,250	5,315	5,315	b
International PaperStockton	2,626	36	36	b
International Paper-Tallman	447,392	2,139	2,139	b
International Paper-Wooster	200,425	859	859	b
International Paper-Hopkinsville	308,312	2,312	2,312	b
James River-Portland	124,655	0	0	b
Jefferson Smurfit Corp-Lexington	6,000	113	113	b
Jefferson Smurfit-Renton	103,004	483	483	b
Jefferson Smurfit Corp-Muncie	13,100	0	0	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).

Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Jefferson Smurfit Corp-Portland	111,952	0	0	b
JSC/CCA-Fulton	42,672	0	0	b
JSC/CCA-Houston	150,200	2,148	2,148	b
Jefferson Smurfit Corp.-Muskogee	94,733	344	344	b
Jefferson Smurfit Corp-Highland	101,000	0	0	b
Jefferson Smurfit Corp-New Brunswick	156,597	815	815	b
Jefferson Smurfit Corp-Chesterfield	68,000	0	0	b
Jefferson Smurfit-Memphis	193,043	3,455	3,455	b
Jefferson Smurfit -St.Louis	39,000	0	0	b
Jefferson Smurfit Milpitas	210,000	0	0	b
Jefferson Smurfit-Ft. Smith	6,500	49	49	b
Jefferson Smurfit-Ft. Worth	186,000	0	0	b
Jefferson Smurfit -Anderson	102,625	1,840	1,840	b
Jefferson Smurfit-Montgomery	252,000	0	0	b
Jefferson Smurfit -Milford	63,990	422	422	b
JSC/CCA-Aston	312,136	1,853	1,853	b
Jefferson Smurfit-New hartford	121,488	728	728	b
Jefferson Smurfit-Louisville	98,300	1,760	1,760	b
Jefferson Smurfit-Wildwood	183,798	1,060	1,060	b
Jefferson Smurfit -Wakefield	100,300	496	496	b
Jefferson Smurfit-Knoxville	na	1,320	1,320	b
Jefferson Smurfit-Jonesboro	na	14	14	b
Jefferson Smurfit-Los Angeles	179,367	0	0	b
JSC/CCA-Baltimore	140,170	894	894	b
Jefferson Smurfit-Corona	129,419	0	0	b
Jefferson Smurfit-Dolton	151,682	550	550	b
Jefferson Smurfit-Dallas	40,300	22	22	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
JSC/CCA-Fresno	135,093	0	0	b
JSC/CCA-Cincinnati	178,484	3,195	3,195	b
JSC/CCA-Ravenna	75,753	1,356	1,356	b
Jefferson Smurfit -LaPorte	174,297	316	316	b
Jefferson Smurfit-Winston-Salem	240,000	0	0	b
Jefferson Smurfit -Humboldt	11,887	270	270	b
Jefferson Smurfit-Sioux City	160,536	92	92	b
Jefferson Smurfit -Lancaster	79,000	620	620	b
Jefferson Smurfit-Galesburg	46,149	0	0	b
JSC Preprint-Cincinnati	251,500	0	0	b
Jefferson Smurfit -Murfreeesboro	115,466	0	0	b
Jefferson Smurfit-Springfield	15,589	0	0	b
Jefferson Smurfit -Shelby	83,773	586	586	b
Packaging Unlimited, Inc.	121,382	6,386	6,386	b
Jefferson Smurfit -Chattanooga	120,000	0	0	b
Lin Pac, Inc.	52,289	3	3	b
Mafcote Industries	138,189	9,130	9,130	b
Mafcote/SWACO	96,674	0	0	b
Malnove, Inc.	27,606	0	0	b
Massillon Container	13,000	0	0	b
Menasha Corporation	197,095	282	282	b
Milwaukee Container	139,571	2,791	2,791	b
PCA/Akron	21,860	219	219	b
PCA/Arlington	198,800	1,998	1,998	b
PCA/Ashland	234,000	2,340	2,340	b
PCA/Atlanta	120,000	1,200	1,200	b
PCA/Buffalo	62,300	623	623	b
PCA/Burlington	305,000	3,050	3,050	b
PCA/Colby	116,000	1,160	1,160	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).

Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
PCA/Denver	119,900	1,199	1,199	b
PCA/Garland	145,800	1,458	1,458	b
PCA/Gas City	97,300	973	973	b
PCA/Goldsboro	11,400	114	114	b
PCA/Grafton	43,000	430	430	b
PCA/Grandville	110,600	1,106	1,106	b
PCA/Hanover	28,000	280	280	b
PCA/Harrisonburg	160,000	1,200	1,200	b
PCA/High Point	19,100	191	191	b
PCA/Honea Path	45,950	460	460	b
PCA/Jackson	137,000	1,370	1,370	b
PCA/Jacksonville	126,700	1,267	1,267	b
PCA/Knoxville	3,520	35	35	b
PCA/Lancaster	187,800	1,878	1,878	b
PCA/Los Angeles	294,000	1,470	1,470	b
PCA/Marshalltown	129,800	1,298	1,298	b
PCA/Miami	64,300	643	643	b
PCA/Middletown	75,022	750	750	b
PCA/Milwaukee	38,300	383	383	b
PCA/Minneapoolis	78,000	780	780	b
PCA/Morganton	60,800	1,250	1,250	b
PCA/Newark	76,300	763	763	b
PCA/Newberry	109,500	1,095	1,095	b
PCA/Northhampton	133,900	1,339	1,339	b
PCA/Omaha	90,000	900	900	b
PCA/Opelika	10,600	106	106	b
PCA/Phoenix	98,800	988	988	b
PCA/Pittsburgh	193,800	1,938	1,938	b
PCA/Plano	140,600	1,406	1,406	b
PCA/Plymouth	60,500	605	605	b
PCA/Richmond	49,400	494	494	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
PCA/Salisbury	97,000	970	970	b
PCA/Syracuse	141,800	1,418	1,418	b
PCA/Trexlertown	158,332	1,583	1,583	b
PCA/Vincennes	65,500	655	655	b
PCA/Winter Haven	238,800	2,388	2,388	b
Rand -Whitney/Northeast Container	18,087	158	158	b
Rand -Whitney/Southeast Container Corp.	17,426	5	5	b
Rand -Whitney Container Corp.	91,727	0	0	b
Rock-Tenn-Harrison	25,000	0	0	b
Rock-Tenn -Chattanooga	30,000	300	300	b
Rock-Tenn-Stone Mountain	117,624	1,340	1,340	b
Rock-Tenn-Lebanon	104,400	0	0	b
Rock-Tenn-Marshville	15,000	0	0	b
Rock-Tenn-Eutaw	200,000	500	500	b
Rock-Tenn-Conway	28,719	4	4	b
Rock-Tenn Greenville	125,000	0	0	b
Sealright Packaging Co.	326,000	0	0	b
Union Camp Corp. -Tucker	126,000	2,720	2,720	b
Wabash Pioneer Container Corp.	498,303	2,145	2,145	b
Westvaco-Baltimore	305,000	15,410	15,410	b
Westvaco-Buffalo	219,000	1,590	1,590	b
Westvaco Chicago	423,000	290	290	b
Westvaco-Cleveland OH	205,000	870	870	b
Westvaco-Cleveland TN	290,000	5,300	5,300	b
Westvaco-Columbus	249,000	1,900	1,900	b
Westvaco-Eaton	292,000	4,740	4,740	b
Westvaco-Gastonia	125,000	2,630	2,630	b
Westvaco-Meridian	214,400	1,400	1,400	b
Westvaco-Richmond	128,000	560	560	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Westvaco-Flexpak-Richmond	482,000	0	0	b
Weyerhaeuser -Westbrook	145,609	790	790	b
Weyerhaeuser-Cedar Rapids	151,270	1,971	1,971	b
Weyerhaeuser-Tampa	464,367	421	421	b
Weyerhaeuser -Franklin	540,817	3,366	3,366	b
Weyerhaeuser-Tucker	1,674,177	151	151	b
Willamette -Beaverton	435,581	0	0	b
Willamette -Buena Park	394,942	0	0	b
Willamette -Dallas	383,384	0	0	b
Willamette -Kansas City	140,814	0	0	b
Willamette -Tacoma	130,604	0	0	b
Willamette -Aurora	435,235	962	962	b
Willamette -Beaverton 2	237,772	311	311	b
Willamette -Ellvue	460,521	1,895	1,895	b
Willamette -Bellmawr	265,373	355	355	b
Willamette -Bowling Green	226,528	516	516	b
Willamette -Cerritos	268,859	515	515	b
Willamette -Compton	403,363	685	685	b
Willamette -Dallas 2	299,787	684	684	b
Willamette -Delaware	679,079	3,334	3,334	b
Willamette -Elk Grove	223,379	447	447	b
Willamette -Ft. Smith	231,814	440	440	b
Willamette -Golden	58,801	90	90	b
Willamette -Griffen	380,183	1,784	1,784	b
Willamette -Indianapolis	63,083	159	159	b
Willamette -Kansas City	168,945	338	338	b
Willamette-Lincoln	41,256	80	80	b
Willamette -Louisville	11,924	16	16	b
Willamette -Lumberton	41,488	191	191	b
Willamette -Matthews	90,770	203	203	b

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).

Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Willamette -Memphis	40,958	214	214	b
Willamette -Moses Lake	302,716	549	549	b
Willamette -Newton	65,621	475	475	b
Willamette -Sacramento	297,249	537	537	b
Willamette -San Leandro	423,133	590	590	b
Willamette -Sanger	227,039	496	496	b
Willamette -Sealy	133,688	289	289	b
Willamette -St. Paul	81,811	118	118	b
Willamette -West Memphis	157,355	177	177	b
American Greetings Corp	230,000	7,400	7,400	d
Avery-Dennison	15,954	0	0	d
Cadillac Products, Inc.Paris	250,633	27,334	27,334	d
Cadillac Products, Inc.	25,516	3,039	3,039	d
Cleo, Inc.	20,000	400	400	d
Crystal Tissue	125,333	170	170	d
Eisenhart Wallcoverings Co.	63,076	321	321	d
Pioneer Balloon Company	113,820	1,484	1,484	d
Waldan Paper Services, Inc.	550,000	0	0	d
American Greetings Corp.Aftan	4,187,556	0	0	e
Deco Paper Products, Inc.	571,308	4,055	4,055	e
Design Containers, Inc.	11,201	21	21	e
GP-LaGrange	36,941	843	843	e
GP-Plattsburgh	1,757,500	0	0	e
GP-Crosett	652,182	8,424	8,424	e
GP-Palatka	329,000	0	0	e
GP-Brattleboro	134,810	125	125	e
GP-Bellingham	76,650	0	0	e
Gilman Converted Products	913,367	5,460	5,460	e
Hallmark Cards	69,900	14	14	e

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
James River Darlington	234,017	5,277	5,277	e
James River-Easton	93,644	0	0	e
James River-Lexington	88,592	0	0	e
James River-Indianapolis	281,088	0	0	e
John H. Harland Company	121,650	0	0	e
Kookaburra USA LTD	55,329	0	0	e
Mail-Well Envelope	103,150	426	426	e
Moore, Business Forms and Systems	124	1,101	1,101	e
NCR Corp.	117,290	0	0	e
Procter and Gamble-Albany	636,886	0	0	e
Procter/Gamble-Mehoopany	949,300	0	0	e
Procter/Gamble-Green Bay	423,400	0	0	e
Procter/Gamble-Oxnard	113,450	0	0	e
Solo Cup Company-Belan	38,680	0	0	e
Solo Cup Company-Chicago	18,870	0	0	e
The Standard Register Company	209,305	1	1	e
Susan Crane, Inc.	136,840	0	0	e
Toph-Osage	60,000	0	0	e
Toph-Covington	203,963	0	0	e
Ward/Kraft, Inc.	37,783	5	5	e
Beach Products	260,000	1,660	1,660	e
Westvaco-Springfield	855,473	0	0	e
Westvaco-Williamsburg	929,945	7,284	7,284	e
Westvaco-Atlanta	840,289	0	0	e
Westvaco-North Chicago	546,821	7,277	7,277	e
Westvaco-Indianapolis	890,044	4,608	4,608	e
Westvaco-Dallas	721,007	5,662	5,662	e
Westvaco-Los Angeles	831,225	2,656	2,656	e
Westvaco-San Francisco	460,905	0	0	e
Arcata Graphics\Kingsport	57,117	0	0	g

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
R. R. Donnelley & Sons Company	367,200	100	100	g
Western Publishing Co., Inc.	57,200	5,475	5,475	g
Interstate Packaging Corp.	217,277	8,361	2,341	h
American Packaging-Storry City	892,160	7,660	7,660	h
American Packaging-Columbus	1,869,137	3,293	3,293	h
Avery-Dennison, K & M Division	28,500	19,950	19,950	h
Bagcraft Corporation of America	650,000	15,000	15,000	h
Bancroft Bag, Inc	1,522,877	350,870	350,870	h
Bingo Paper Inc.	38,701	0	0	h
Champion-Morristown	294,738	23,832	23,832	h
Champion-Clinton	167,415	18,728	18,728	h
Champion-Olmstead Falls	304,197	19,028	19,028	h
Chamption-Ft. Worth	192,319	14,790	14,790	h
Champion-Athens	285,554	22,213	22,213	h
Bemis Company-Crosett	530,107	0	0	h
Bemis Company-Memphis	323,542	2,070	2,070	h
Bemis Company-Minneapolis	16,000	0	0	h
Bemis Company-Omaha	665,336	1,728	1,728	h
Bemis Company-Peoria	318,364	3,021	3,021	h
Bemis Company-Pepperell	182,063	0	0	h
Bemis Company-Seattle	105,275	2,377	2,377	h
Bemis Company-Vancouver	437,010	0	0	h
Bemis Company-Wichita	7,138	0	0	h
Graphic Packaging Corp.	195,031	0	0	h
Hallmark Cards	72,286	846	846	h
International Paper-Camden	663,359	0	0	h
International Paper-Mobile	650,000	355	355	h

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
International Paper-Pittsburg	195,000	0	0	h
International Paper-Wilmington	396,000	57	57	h
James River -Ft. Smith	41,959	2,937	2,937	h
James River - Specialty Tabletop	12,500	0	0	h
James River Corp - Wausau Plant	425,873	291	291	h
Mead Packaging	2,267,734	564	564	h
Percy Kent Bag Co., Inc.	665,500	0	0	h
The Robinette Company	633,000	0	0	h
Sealright Packaging Co.	82,491	0	0	h
Union Camp-Savannah	320,362	4,416	4,416	h
Union Camp-Spartenburg	1,476,648	21,420	21,420	h
Union Camp-Hazleton	206,000	0	0	h
Union Camp-Hanford	155,864	1,045	1,045	h
Union Camp-Sibley	435,923	13,500	13,500	h
Westvaco, Liquid Packaging	135,900	8,524	8,524	h
Willamette Industries, Inc.	1,070,078	0	0	h
Alusuisse-Shelbyville	206,000	1,000	282	m
Equitable Bag Co., Inc	1,805,400	46,152	13,107	m
Alusuisse-New Hyde Park	2,030,000	76,000	15,124	m
Bryce Corporation	2,045,155	0	0	m
BRC, A Division of Bryce Corporation	294,587	34	14	m
Bemis -Terre Haute	5,114,960	27,267	7,089	m
Bemis -Oshkosh	2,619,780	108,864	14,261	m

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).

Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Bemis Milprint Denmark	1,268,300	2,118	593	m
Bemis Milprint Lancaster	3,644,494	1,628	133	m
Spec-Fab	34,088	681	102	m
Spiralkote, Inc.	844,943	19,360	6,970	m
Glenroy, Inc.	124,809	0	0	m
Smurfit Flexible Packaging	90,167	7,731	951	m
Kleartone, Inc.	118,953	2,271	227	m
Packaging Products Corp., Rome, GA Division	338,780	12,792	1,254	m
Pacquet Oneida, Inc.	712,400	1,735	226	m
Westvaco Envelope Springfield	453,238	36,470	6,565	m
Fabricon Products	287,616	4,172	1,168	m
Alusuisse-Bellwood	1,540,000	8,000	2,160	m
Union Camp-Asheville	224,842	5,193	2,700	m
Graphic Packaging Corporation	120,000	100,000	9,100	m
American Packaging Philadelphia	89,756	243	243	m
American Packaging Rochester	49,557	250	250	m
Bell Packaging Corp	27,832	453	453	m
Bomarko, Inc	499,260	0	0	m
Bryce Corporation	3,060,900	0	0	m
Burrows Paper Corporation - Ft. Madison Facility	344,426	6,180	6,180	m
Cello-Wrap Printing Company, Inc.	170,120	2,453	2,453	m
Charleston Packaging Company, Inc.	415,057	350	350	m
Bemis Curwood-Murphysboro	330,112	12,329	12,329	m
Bemis Curwood-New London	2,919,293	38,367	38,367	m
Dixico, Inc.	734,273	0	0	m

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Fabricon Products	104,364	1,158	1,158	m
fp Webkote, Inc.	111,606	19,800	19,800	m
Gateway Packaging	10,000	200	200	m
Greif Bros. Corp	279,494	0	0	m
H. S. Crocker Co., Inc.	91,823	0	0	m
Hargo-Harrisburg	349,576	0	0	m
Hargro-Edinburgh	200,942	7702	7,702	m
IP-Jackson	591,966	942	942	m
IP-Peoria	325,387	33,827	33,827	m
IP-Menasha	100,254	6,490	6,490	m
IP-Lancaster	24,124	1,477	1,477	m
IP-Kaukauna	525,606	3,189	3,189	m
IP-Knoxville	127,235	55	55	m
James River -Camas	68,000	0	0	m
James River-Hazelwood	991,726	923	923	m
James River-Menasha	64,025	28	28	m
James River-San Leandro	866,000	0	0	m
Longhorn Packaging, Inc.	29,894	?		m
Neenah Printing - Wide Web Flexo Plant	364,376	1,924	1,924	m
Midwest Film Corp	276,679	20	20	m
NCR - B.F.D.	33,342	0	0	m
Nichols Paper Products Co., Inc.	86,289	418	418	m
Phoenix Products Co., Inc.	61,040	16,656	16,656	m
Solar Press	131,324	0	0	m
Standard Packaging & Printing Corp.	305,000	0	0	m
Sunrise Packaging, Inc.	632,789	4,579	4,579	m
Superpac, Inc.	560,300	7,039	7,039	m
Teepak, Inc.	816,691	0	0	m
Union Camp-Monticello	368,000	12,232	12,232	m

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).

Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Union Camp-Tifton	469,967	0	0	m
Vitex Packaging, Inc.	502,402	5,819	5,819	m
Akron Beacon Journal	308,031	3,018	3,018	n
Fort Wayne Newspapers	381,022	0	0	n
Macon Telegraph	195,000	1,053	1,053	n
Modesto Bee	394,237	0	0	n
The Fresno Bee	699,367	0	0	n
Miami Herald Publishing Co.	981,662	22,743	22,743	n
Press Telegram	236,000	82	82	n
Providence Journal Company	930,300	2,902	2,902	n
Bonar Packaging, Inc.	334,260	13,401	3,886	p
Georgia-Pacific-Warwick	721,500	210	84	p
Paramount Packaging-Longview	169,577	109,200	5,460	p
Paramount Packaging-Chalfont	440,317	1,154	196	p
Action Packaging	120,370	602	138	p
All-Pak, Inc.	254,199	748	187	p
Atlanta Film Converting Co, Inc.	398,621	0	0	p
Automated Packaging Systems, Inc.	344,101	2,329	326	p
Automated Label Systems Co.	346,955	1,461	136	p
Banner Packaging, Inc.	1,718,688	46,311	12,967	p
Cryovac-Iowa Park	70,786	350	182	p
Cryovac-Cedar Rapids	248,500	8,100	1,944	p
Cryovac-Simpsonville	1,060,000	1,515	348	p
Bemis Company-Hazelton	7,622,511	59,472	13,381	p
Cello-Foil Products, Inc.	551,055	0	0	p
Excelsior Transparent Bag MFG Corp.	1,358,606	5,300	1,007	p
Flex-Pak, Inc.	400,694	0	0	p

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Hargo-Boyerstown	605,047	1,876	413	p
Huntsman Packaging Products, Corp	409,000	10,205	1,765	p
Smurfit Flexible Packaging	392,612	???		p
Marglo Packaging Corp.	13,506	333	130	p
Package Printing Co., Inc.	108,896	0		p
Package Products Flexible Corporation	2,360,000	0	0	p
Packaging Materials Incorporated	7686	0	0	p
Packaging Products Corp.	397,000	5,904	1,830	p
Plastic Packaging, Inc.	1,002,196	126	41	p
Plicon Corp.	216,717	11,740	3,992	p
Poly Plastic Packaging, Inc.	55,229	506	104	p
Union Camp-Tomah	305,483	117,815	16,494	p
Union Camp -Griffen	383,193	2,180	109	p
Central States Diversified, Inc.	200,288	1,973	322	p
Mohawk Northern Plastics, Inc.	101,214	3,684	280	p
Maine Poly, Inc.	312,000	4,996	999	p
Amko Plastics, Inc.	370,630	21,354	21,354	p
Anagram International, Inc.	254,542	3,436	3,436	p
Arcon Coating Mills, Inc.	261,812	787	787	p
Arkansas Poly, Inc.	145,796	2,134	2,134	p
Johnson Bryce Corp.	230,390	0	0	p
Bryce Dixico	505,943	52	52	p
Buckeye Container	37,775	0	0	p
Buckeye Packaging	115,737	0	0	p
Cadillac Products, Inc.	158,021	0	0	p
Clark Container, Inc.	81,660	5,216	5,216	p
C. P. C. Packaging, Inc.	9,725	1,945	1,945	p

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Bemis -Flemington	53,139	56	56	p
Custom Poly Bag, Inc.	71,417	0	0	p
Dart Container Corporation	26,149	0	0	p
Dynamic Packaging, Inc.	189,489	1,591	1,591	p
Eskimo Pie Corporation	41,767	0	0	p
Flexo Transparent, Inc.	107,033	11,094	11,094	p
Gentry Poly Specialties, Inc.	38,192	0	0	p
Gulf Coast Plastics Div. Dairy-Mix, Inc.	9,702	0	0	p
Hargro Health Care Packaging	24,335	0	0	p
Home Plastics, Inc.	35,000	700	700	p
Carolina Printing & Converting A Division of Interflex	162,739	10,694	10,694	p
James River-Greensburg	4,756,127	0	0	p
James River-New Castle	874,312	31	31	p
James River-Parchment	150,000	0	0	p
James River-Portland	407,858	292	292	p
James River-Shreveport	2,088,304	0	0	p
Lin Pac	317,468	298	298	p
Mid-West Poly Pak, Inc.	25,015	112	112	p
M.T.P. Industries, Inc. (Mason Transparent Pkg)	125855	0	0	p
Owens-Illinois, Inc.	1,438,000	42,086	42,086	p
Packaging Industries, Inc.	836,972	12,117	12,117	p
Packaging Products Corporation	188,780	7,693	7,693	p
Packaging Specialties, Inc.	598,431	14,425	14,425	p
Paramount Packaging-Shelbyville	320,770	1,169	1,169	p
Paramount Packaging -Murfreesboro	566,370	96,821	96,821	p

Table 4-6. HAP Use on Flexographic Presses (See Notes Following Table).				
Name	INK ETC. APPLIED (lb/yr)	HAP USED ON PRESS (lb/yr)	HAP Emissions (lb/yr)	PROD.
Phoenix Packaging	8,170,551	19,784	19,784	p
Viskase Corp.	103,718	5,924	5,924	p
Plastic Packaging Corp	65,560	0	0	p
Poly Plastic Packaging, Inc.	26,800	226	226	p
Polyflex Film & Converting, Inc.	566,106	0	0	p
Rex-Rosenlew International, Inc.	494,445	1	1	p
Sealright Packaging Company	429,758	12,729	12,729	p
Packaging Industries, Inc.	836,972	12,117	12,117	p
Selig Sealing Products, Inc.	16,950	26	26	p
Southern Colortype Co., Inc.	65,176	332	332	p
Specialty Container Corporation	60,819	45,790	45,790	p
Tennessee Press, Inc.	1,546,762	0	0	p
Uniflex, Inc.	208617	208,617	50,068	p
Union Camp-Shelbyville	256,216	0	0	p
Union Camp-Denton	269,994	13,499	13,499	p
Union Camp-Freeman Field	332,087	558	558	p
Union Camp Corp., Richmond	217,253	0	0	p
Viskase Corp.	103,718	5,924	5,924	p
Zim's Bagging Co., Inc.	1,400	25	25	p

Notes: b=corrugated box, d=paper/plastic products, e=paper products, g=books, h=paper packaging, m=mixed packaging, n=newspapers, p=plastic packaging

Table 4-7. Model Plant Specifications for Flexography.

Model Plant		1	2	3
Substrate		Multi-wall bags	Film Packaging	Paper/Film Pkg
Ink Use	lb/year	1,500,000	800,000	1,500,000
VOC Use	lb/year	25,000	550,000	1,100,000
HAP Use	lb/year	21,000	100,000	8,000
Capture Efficiency	%	0	0	78
Control Device Efficiency	%	0	0	94
Overall Efficiency	%	0	0	73
Presses/Stations		12/4	6/6	6/6
Pressroom Dimensions	ft x ft x ft	150 x 90 x 30	150 x 90 x 30	150 x 90 x 30

rotogravure. Model plant 3 represents a flexographic printing operation which is not a major source when considered alone. Some flexographic operations of this nature will come under the NESHAP regulations because of other HAP emitting operations at the facility. It is possible that more flexographic facilities will be regulated because of non-flexographic printing emissions than because of the HAP which results from flexographic operations by themselves.

4.3 CONTROL OPTIONS

4.3.1 Control Options for Publication Rotogravure

All publication rotogravure plants in the United States presently use solvent recovery systems incorporating activated carbon adsorption and steam regeneration. Control device efficiencies of 95 percent to greater than 99 percent were reported. The recovered solvent is blended with purchased ink to maintain the proper viscosity for printing. Excess solvent is resold to the ink manufacturers.

Most of the variation in overall efficiencies reported by publication gravure facilities is due to variations in capture systems. In all cases, dryer exhausts, containing relatively concentrated solvent laden air, are ducted to the solvent recovery system. Additional solvent losses during the printing process result from evaporation from ink fountains, escape of solvent laden air from driers (e. g. carried out with web between stages) and residual solvent left in substrate after the final press station. Non-production solvent losses occur from uncontrolled proof presses, off-press cylinder cleaning, and the storage, mixing, shipping and receiving of ink and solvent.

Control options include varying degrees of improvement in capture and reduction in HAP content of ink. Improved capture involves containment of additional solvent laden air. Capture technologies, beyond collection and ducting of dryer exhausts, presently in use include floor sweeps, partial and full upper deck hooding of the presses, and total enclosures. Total enclosures are used in conjunction with collection and treatment of all pressroom ventilation air. Control options involving air handling can be specified in terms of varying degrees of air collection, up to and including construction of (or conversion of existing pressrooms to) permanent total enclosures. Improvements to press capture systems, including "close-in" hooding, will result in less HAP escaping to the pressroom. Reduced flows of HAP to the pressroom will decrease the overall air treatment requirements (with or without a total enclosure) if pressroom ventilation air must be treated to improve overall efficiency.

All improved capture and control options, costed in Chapter 6, require the handling and treatment of additional volumes of air. The incremental solvent captured will be present at lower concentrations than the solvent laden air presently ducted to the solvent recovery systems. In the case of total enclosure systems, the HAP concentration in the additional air will approximate that of the pressroom. Pressroom concentrations of toluene, the HAP present in highest concentration in the ink (and the pressroom air), are limited by occupational health considerations to 100 ppmv.

It may be economically advantageous to pretreat the additional air resulting from improvements in capture efficiency using solvent concentrator systems. It should be noted that systems of this type are not presently in use in the publication gravure industry segment; they are, however, in use in related applications including control of paint spray booth emissions. Concentrator systems are designed to adsorb solvents from dilute air streams. The sorbent (activated carbon or zeolite) is regenerated with hot air. The regeneration air requirement is only about ten percent of the volume of air treated. Thus the dilute solvent laden air stream is converted to a concentrated regeneration air stream which is exhausted to another control device. In this case, the exhaust from the concentrator system may be ducted to the existing solvent recovery system. Some increase in capacity of the existing solvent recovery systems may be required.

The substitution of non-HAP solvents for a portion of the HAP solvents in the ink is a control option which may be used to decrease HAP emissions without increasing either the capture efficiency or the control device efficiency. This control option may not be available to all facilities. No information is available on the cost and effects on output quality resulting from substitution of non-HAP solvents for HAP such as toluene. It should be noted that while substitution of non-HAP solvents for HAP could be encouraged as a pollution prevention option, it does not significantly affect VOC emissions.

All demonstrated control options include the use of solvent recovery systems as the control device. The systems of demonstrated effectiveness are composed of fixed bed activated carbon adsorption units which are cyclically regenerated with steam. These systems include regeneration gas condensers and solvent/water decanters.

The distinction among the control options is the capture system employed. The specification of ventilation, hooding and ducting for incremental improvements to existing systems is site specific. There are an infinite number of gradations between existing capture systems and permanent total enclosures. Table 4-8 lists control options which represent discrete levels of capture.

In all cases pollution prevention could be encouraged by allowing credit for elimination of HAP emissions through substitution of non-HAP solvent for HAP. A reduction in HAP emissions through substitution, combined with some degree of improvement in capture can achieve the same reduction in HAP emissions as that of the specified control option.

4.3.2 Control Options for Product and Packaging Rotogravure

Packaging and product rotogravure plants in the United States use a variety of control technologies. Control strategies are influenced by the composition of inks and other materials applied on the press, and regulatory requirements. In most cases, regulations presently in effect limit emissions of VOC.

Table 4-8 Control Options for Publication Rotogravure Plants.

Option	Control Device	Capture System
A	Solvent recovery system with carbon adsorption and steam regeneration.	Draw 50% of required pressroom ventilation air through concentrator to existing solvent recovery system.
B		Draw 100% of required pressroom ventilation air through concentrator to existing solvent recovery system.
C		Construct permanent total enclosure and draw 100% of required pressroom ventilation air through concentrator to existing solvent recovery system.

Control devices presently in operation were, for the most part, specified and operated to meet VOC emissions requirements. Where ink systems are primarily based on non-HAP solvents, no data have been collected to demonstrate the effectiveness of existing control devices with respect to individual HAP. Where HAP (e. g. toluene) based inks are used, control device efficiencies are directly relevant to HAP control.

The selection of ink is influenced by the substrate printed and the performance requirements of the packaging or product. Air pollution regulations in force at the time of construction of the facility or specification of the control device also influence the type of ink system.

Control technologies presently in use among major sources include activated carbon solvent recovery systems, catalytic incinerators and oxidizers, and thermal incinerators and oxidizers. These devices are capable of controlling greater than 95 percent of most volatile organic compounds when properly designed and operated. Much of the variation in overall control efficiencies achieved with any of these control devices is due to variation in capture efficiency. Where presses are located within permanent total enclosures capture efficiencies are assumed to be 100 percent. In other cases, capture efficiencies depend on the type of capture devices and pressroom ventilation systems in use.

Some plants have adopted waterborne ink technologies to reduce VOC emissions. In many cases, low VOC ink formulations are used with no control devices. Capture systems at these facilities serve to collect dryer exhausts and vent them to the atmosphere. Some formulations are HAP free; many low VOC waterborne ink systems do contain small percentages of HAP (typically glycols, glycol ethers or alcohols).

Control options for packaging and product rotogravure plants are given in Table 4-9. In options A and B, a control device is used with different levels of capture efficiency. The control device can be selected based on the ink system in use, or if more

Table 4-9. Control Options for Packaging and Product Rotogravure Plants.

Option	Control Device	Capture System
A	Solvent recovery system, or catalytic incinerator or thermal incinerator depending on ink system in use.	Treat dryer exhaust plus 50 percent of required pressroom air with control device.
B		Permanent Total Enclosure
C	Use of ink containing less than 1.5 percent HAP.	None

than one type of device is potentially suitable, on the basis of cost. As described above, all control devices presently in use in this segment of the industry can achieve efficiencies of more than 95 percent. Option C provides for the use of low HAP ink with no control, provided that emissions do not exceed those of plants using solvent based inks with a high HAP content using an efficient capture and control system.

4.3.3 Control Options for Wide-web and Sheet Fed Flexography

Most flexographic printing facilities, and all flexographic printing facilities outside of the flexible packaging industry, operate without control devices. Control strategies are influenced by the composition of inks and other materials applied on the press, and regulatory requirements. Control devices presently in operation were, for the most part, designed and operated to meet VOC emissions requirements. Where ink systems are primarily based on non-HAP solvents, no data have been collected to demonstrate the effectiveness of existing control devices with respect to individual HAP.

The selection of ink (and other materials such as adhesives, primers and varnishes) is influenced by the substrate printed and the performance requirements of the packaging or product. Air pollution regulations in force at the time of construction of the facility or specification of the control device also influence the type of ink system.

Some plants have adopted waterborne ink technologies to reduce VOC emissions. In many cases, low VOC ink formulations are used with no control devices. Capture systems at these facilities serve to collect dryer exhausts and vent them to the atmosphere. Some formulations are HAP free; many low VOC waterborne ink systems contain small percentages of HAP (typically glycols, glycol ethers or alcohols). Many flexographic printers use solvent based formulations which are completely HAP free. In some cases, solvent based inks contain small percentages of the same HAP used in waterborne materials. Some of these facilities operate VOC control devices. In the absence of compound specific data on HAP control, HAP removal efficiencies are estimated on the basis of VOC removal efficiencies.

Control technologies presently in use include activated carbon solvent recovery systems, catalytic incinerators and oxidizers, and thermal incinerators and oxidizers. These devices are capable of controlling greater than 95 percent of most volatile organic compounds when properly designed and operated. Much of the variation in overall control efficiencies achieved with any of these control devices is due to variation in capture efficiency. Where presses are located within permanent total enclosures capture efficiencies are assumed to be 100 percent. In other cases, capture efficiencies depend on the type of capture devices and pressroom ventilation systems in use. None of the flexographic facilities using control devices for materials applied on flexographic presses are major sources on the basis of reported HAP emissions.

Control options for flexographic printing facilities are given in Table 4-10. In options A and B, a control device is used with different levels of capture efficiency. The control device can be selected based on the ink system in use, or if more than one type of device is potentially suitable, on the basis of cost. As described above, all control devices presently in use in this segment of the industry can achieve efficiencies of more than 95 percent, at high concentrations of HAP in the solvent laden air. (It may be difficult to reach this level of control device efficiency at lower HAP concentrations.) Option C provides for the use of low HAP ink with no control, provided that emissions do not exceed those of plants using solvent based inks with a high HAP content using an efficient capture and control system.

4.4 ENHANCED MONITORING

4.4.1 Enhanced Monitoring for Publication Gravure

All existing publication rotogravure facilities monitor control system performance using liquid-liquid mass balances.

Table 4-10. Control Options for Flexographic Printing Plants.

Option	Control Device	Capture System
A	Solvent recovery system, or catalytic incinerator or thermal incinerator depending on ink system in use.	Treat dryer exhaust plus 50 percent of required pressroom air with control device.
B	Solvent recovery system, or catalytic incinerator or thermal incinerator depending on ink system in use.	Permanent Total Enclosure
C	Use of ink containing less than 1 percent HAP.	None

These mass balances provide average recovery data averaged over the reporting period. Because the HAP emissions are recovered, rather than destroyed, any intermittent system failures, decreases in control device efficiency or increases in fugitive emissions will be reflected in the overall mass balance. This method provides an average of continuous overall efficiency (rather than an average of discrete measurements of control device efficiency).

4.4.2 Enhanced Monitoring for Product and Packaging Rotogravure

Facilities operating solvent recovery systems monitor control system performance using liquid-liquid mass balances. These mass balances provide recovery data averaged over the reporting period. Because the HAP emissions are recovered, rather than destroyed, any intermittent system failures, decreases in control device efficiency or increases in fugitive emissions will be reflected in the overall mass balance. Since this method provides an average of continuous overall efficiency (rather than an average of discrete measurements of control device efficiency) enhanced monitoring is not recommended for this industry segment.

Facilities operating thermal incinerators or catalytic incinerators must monitor control device performance. Continuous emission monitoring may not be reliable for emission streams in which the HAP present makes up a small percentage of the VOC present, as is the case in many emission streams from packaging and product rotogravure printing. The output of continuous emissions monitors may not reflect the HAP concentration of the emissions stream due to differences in response among the HAP, non-HAP VOC, and products of incomplete combustion.

Continuous control device measurement should be required for facilities operating thermal incinerators or catalytic incinerators. Variations in combustion temperature affect the performance of these devices. The operators of thermal and catalytic incinerators should install, calibrate, maintain, and operate a temperature monitoring device in accordance with the manufacturer's specifications. The temperature should be maintained at a temperature equal to or higher than the temperature at which compliance was demonstrated.

4.4.3 Enhanced Monitoring for Wide-web and Sheet Fed Flexography

Based on responses to the ICR, none of the flexographic printing facilities operating control devices had HAP emissions in excess of 25 tons per year of HAP or 10 tons per year of any specific HAP. Facilities affected by a MACT standard regulating HAP emissions which operate control devices should be subject to the same enhanced monitoring requirements as product and packaging gravure facilities (see Section 4.4.2).

Facilities controlling HAP emissions through the use of low HAP ink formulations should maintain documentation confirming the HAP content of the materials applied on flexographic presses. In the event that specifications provided by ink suppliers are inadequate to establish the HAP content, additional compositional analyses should be conducted by the facility.

5.0 ENVIRONMENTAL AND ENERGY IMPACTS OF CONTROL OPTIONS

5.1 ENERGY IMPACT

5.1.1 Publication Rotogravure

Energy requirements for implementation of the control options for publication gravure plants include electricity to collect and treat additional ventilation air, natural gas to heat air for desorption of HAP recovered by the concentrators, and additional steam required for regeneration of the incremental activated carbon and recovery of the incremental HAP. The control options will recover incremental amounts of toluene, which has a heating value but is not used as a fuel. Energy use has been estimated for each of the 27 publication rotogravure facilities. The sum of the increased energy requirements is given in Table 5-1. Control options B and C have equal energy requirements.

Energy impact calculations were based on the assumption of 1.5 percent solvent retention in the substrate. Uncontrolled and unretained HAP is assumed to be available in pressroom air at 50 ppmv. Ventilation requirements are estimated based on the volume of air necessary to dilute the uncontrolled and unretained HAP to this level. Fan power requirements are based on moving 50 percent (Control option A) or 100% (Control options B and C) of the pressroom ventilation requirement through concentrator systems plus the desorption gas. The desorption gas flow rate is 10 percent of the gas treated. The concentrator is assumed to be 93 percent efficient (this assumption is subject to change, should test data become available); the incremental adsorption capacity devoted to the concentrated stream is assumed to be 98 percent efficient.

Table 5-1. Energy Impact of Control Options for Publication Rotogravure Plants.

Energy Impact	Control Option A	Control Options B & C
Fan Power (kwhr/yr)	26,100,000	52,100,000
Natural Gas (SCF/yr)	553,000,000	1,100,000,000

The concentrator is assumed to be desorbed with 300 degree F air heated with natural gas at 90 percent efficiency. Incremental carbon capacity is desorbed with 2 pounds steam per pound of HAP, based on model plant calculations. Table 5-1 gives the energy impact of the control options, assuming natural gas fired boilers are used to generate incremental carbon regeneration steam.

5.1.2 Product and Packaging Rotogravure

Energy requirements for implementation of the control options A and B for package and product gravure plants include electricity to collect and treat additional ventilation air and natural gas for auxiliary fuel required for HAP destruction. Energy use has been estimated for 36 package and product rotogravure facilities with large enough emissions to be covered under the MACT standard. The sum of the increased energy requirements for control options A and B have been estimated in Table 5-2. These estimates are based on improvements to capture (with incineration of the recovered fugitive emissions) at 28 facilities, and installation of capture systems and control devices at 6 presently uncontrolled facilities. Two facilities which apply materials which are less than 4 percent HAP, and have no control devices, are excluded from the estimate.

Electricity and natural gas requirements have been based on the model plant calculations. Model plants with control devices had average electricity and gas requirements of 16 kwhr and 9000 SCF per pound of incrementally controlled HAP. Model plants

Table 5-2. Energy Impact of Control Options for Product and Packaging Gravure Plants.

Energy Impact	Control Option A	Control Option B
Fan Power (kwhr/yr)	47,000,000	70,000,000
Natural Gas (SCF/yr)	1.8 E 10	3.0 E 10

without control devices had average electricity and gas requirements of 11 kwhr and 2000 SCF per pound of incrementally controlled HAP. Control option B provides overall control equivalent to 96.5 percent of HAP usage. This is consistent with a 98 percent efficient control device, allowing for 1.5 percent HAP retention in the printed substrate. Control option A provides for varying overall efficiencies depending on the capture efficiency of the existing system. HAP retention may vary, but this will have only a small effect on energy requirements.

Control option C could represent a decrease in energy requirements if facilities which presently operate incinerators converted to ink formulations with lower HAP content. Under some circumstances, operation of existing incinerators would no longer be required. This would result in the elimination of all auxiliary fuel requirements. These energy savings would not be realized by facilities presently operating control devices for VOC control unless waterborne (low HAP, low VOC), formulations were used. The energy impact of this control option has not been estimated because it is impossible to predict what formulations would be used to comply.

5.1.3 Wide-web and Sheet Fed Flexography

Energy requirements for implementation of the control options A and B for wide web flexography plants include electricity to collect and treat additional ventilation air and natural gas for auxiliary fuel required for HAP destruction. It is estimated that 50 facilities may have emissions large enough to be covered by the standard based on estimated "potential to emit". This includes all facilities providing responses to the ICR with HAP usage of at least 10,000 pounds in 1992. Some of these facilities may have permit restrictions or other limitations which would keep their potential to emit below 25 tons HAP per year (or ten tons of any single HAP). Of these facilities, 15 presently operate control devices. The following discussion assumes that the 35 flexographic printing facilities not presently operating control devices will comply with the standard by reducing their HAP usage and the remaining facilities will improve capture and control.

The sum of the increased energy requirements for control options A and B have been estimated in Table 5-3. These estimates are based on improvements to capture (with incineration of the recovered fugitive emissions) at 15 facilities. Energy requirements will increase if facilities which presently have no control devices install them to meet the standard. Energy requirements may decrease somewhat if some of the facilities considered on the basis of HAP usage are not major sources by reason of limitations of their potential to emit.

Electricity and natural gas requirements have been based on the model plant calculations. Model plants with control devices had average electricity and gas requirements of 30 kwhr and 5400 SCF per pound of incrementally controlled HAP. Control option B provides overall control equivalent to 93.5 percent of HAP usage. This is consistent with a 95 percent efficient control device, allowing for 1.5 percent HAP retention in the printed substrate. Control option A provides for varying overall efficiencies depending on the capture efficiency of the existing system. HAP retention may vary, but this will have only a small effect on energy requirements.

Table 5-3. Energy Impact of Control Options for Wide-web and Sheet Fed Flexography.

Energy Impact	Control Option A	Control Option B
Fan Power (kwhr/yr)	1,770,000	3,540,000
Natural Gas (SCF/yr)	318,000,000	637,000,000

Control option C could represent a decrease in energy requirements if facilities which presently operate incinerators converted to ink formulations with lower HAP content. Under somecircumstances, operation of existing incinerators would no longer be required. This would result in the elimination of all auxiliary fuel requirements. These energy savings would not be realized by facilities presently operating control devices for VOC control unless waterborne (low HAP, low VOC), formulations were used. The energy impact of this control option has not been estimated because it is impossible to predict what formulations would be used to comply.

5.2 AIR IMPACTS

5.2.1 Publication Rotogravure

The major air impact of implementing the control options is reduced emissions of HAP to the atmosphere. Minor impacts are associated with the production and use of electricity and fuel required for fans, desorption gas heaters, and boilers generating steam for incremental carbon regeneration requirements. Table 5-4 lists air impacts for the control options. Impacts associated with electric utility generation are assumed to be 3.6 grams sulfur dioxide and 560 grams carbon dioxide per kwhr.

5.2.2 Product and Packaging Gravure

The major air impact of implementing the control options is reduced emissions of HAP to the atmosphere. Minor impacts are associated with the production and use of electricity required

Table 5-4. Air Impact of Control Options for Publication Rotogravure Plants.

Air Impact	Control Option A	Control Options B & C
HAP Eliminated (Ton/yr)	7,000	14,000
Sulfur Dioxide Emitted (Ton/yr)	103	206
Carbon Dioxide Emitted (Ton/yr)	50,000	100,000

for fans and auxiliary fuel for incinerators. Table 5-5 lists air impacts for the control options. Estimates for options A and B are based on upgrades to 28 facilities presently operatingcontrol devices and installation of capture and control systems at 6 facilities. Estimates for option C are based on the 34 facilities considered for options A and B plus two additional facilities presently applying formulations containing less than 4 percent HAP. Impacts associated with electric utility generation are assumed to be 3.6 grams sulfur dioxide and 560 grams carbon dioxide per kwhr.

5.2.3 Wide-web and Sheet Fed Flexography

The major air impact of implementing the control options is reduced emissions of HAP to the atmosphere. Minor impacts are associated with the production and use of electricity required for fans and auxiliary fuel for incinerators. Table 5-6 lists air impacts for the control options. Estimates for options A and B are based on upgrades to 15 facilities presently operating control devices. Estimates for option C are based on a total of 50 facilities (an additional 35 facilities not presently considered for options A and B are included). Impacts associated with electric utility generation are assumed to be 3.6 grams sulfur dioxide and 560 grams carbon dioxide per kwhr.

Table 5-5. Air Impact of Control Options for Product and Packaging Rotogravure Plants.

Air Impact	Option A	Option B	Option C
HAP Eliminated (Ton/yr)	1800	2600	2400
Sulfur Dioxide Emitted (Ton/yr)	1900	2800	NA
Carbon Dioxide Emitted (Ton/yr)	31000	47000	NA

NA=Not available.

Table 5-6. Air Impact of Control Options for Wide-web and Sheet Fed Flexography.

Air Impact	Option A	Option B	Option C
HAP Eliminated (Ton/yr)	29	59	830
Sulfur Dioxide Emitted (Ton/yr)	7.0	14	NA
Carbon Dioxide Emitted (Ton/yr)	20,000	39,000	NA

NA=Not available.

5.3 WATER IMPACTS

5.3.1 Publication Rotogravure

Water impacts resulting from implementation of the control options are insignificant. Small increases in boiler blowdown may be associated with the incremental increase in steam required for recovery of incremental HAP. This water will be of relatively high quality.

5.3.2 Product and Packaging Rotogravure and Wide-web and Sheet Fed Flexography

Water impacts resulting from implementation of the control options are insignificant. Control option C does not assume conversion to waterborne inks. If waterborne inks are adopted, pressroom cleaning will be done with water which may generate an additional low volume wastewater stream.

5.4. SOLID WASTE IMPACT

5.4.1 Publication Rotogravure

The impact of the control options on solid waste will be negligible. The incremental carbon will require replacement every five to ten years. It is expected that most of this material will be sold for reprocessing into other products and will not become solid waste. The concentrators are expected to last 15 years or longer.

5.4.2 Product and Packaging Rotogravure and Wide-web Flexography

The impact of the control options on solid waste will be negligible. If catalytic incinerators are used, catalyst replacement may be necessary every ten years. Spent catalyst may require disposal as hazardous waste.

6.0 MODEL PLANT CONTROL OPTION COST

6.1 INTRODUCTION

Model plants, and the criteria used to choose them have been described in Chapter 4. Control options applicable to specific segments of the printing and publishing industry have also been described in Chapter 4. This chapter describes the estimated costs of applying the control options to the model plants.

6.2 PUBLICATION ROTOGRAVURE

Model plant specifications are given in Table 6-1. These are based on several assumptions. HAP retention in the web is assumed to be 1.5 percent of that used. This material is not emitted in the pressroom or dryer. Pressroom ventilation rates have been proposed based on the volume of air necessary to dilute the fugitive emissions to acceptable levels for the health and safety of the operators. This ventilation may be presently supplied by doors, windows and leaks to the atmosphere. Pressroom volumes have been assumed based on the number and size of the presses in the model plants. Corresponding air exchange rates are listed, however, only the assumed ventilation rate affects the amount of air to be treated. The pressroom volume and air exchange rates can vary to provide the assumed ventilation rate. The pressroom and control systems are assumed to operate 120 hours per week.

The control options apply to incremental capture and control of fugitive emissions. The control options involve collecting and treating pressroom air containing fugitive HAP which escapes

Table 6-1. Publication Rotogravure Model Plant Specifications Used for Control Option Costing.

Model Plant	1	2	3	4	5
Presses/Stations	8/10	8/10	4/8	4/8	5/8
Pressroom Length (ft)	240	240	120	120	150
Pressroom Width (ft)	150	150	120	120	120
Pressroom Height (ft)	30	30	30	30	30
Hap usage(lb/yr)	22,500,000	22,500,000	6,400,000	6,400,000	14,000,000
HAP usage (g/min)	19,435	19,435	5,528	5,528	12,093
Capture Efficiency (%)	98.1	90.7	98.1	90.7	80.4
Control Efficiency (%)	97.0	97.0	97.0	97.0	97.0
Overall Control (%)	95.2	88.0	95.2	88.0	78.0
HAP controlled (lb/Yr)	21,420,000	19,800,000	6,092,800	5,632,000	10,920,000
HAP emitted (lb/Yr)	1,080,000	2,700,000	307,200	768,000	3,080,000
HAP retained (lb/Yr)	337,500	337,500	96,000	96,000	210,000
HAP to Pressroom(lb/Yr)	90,000	1,755,000	25,600	499,200	2,534,000
Pressroom Volume (CF)	1,080,000	1,080,000	432,000	432,000	540,000
Air Change Rate(/hr)	2	30	2	30	60
Vent. Rate (SCFM)	36,000	540,000	14,400	216,000	540,000
Pressroom Conc.(lb/acf)	6.66e-06	8.66e-06	4.74e-06	6.16e-06	1.25e-05
Pressroom Conc.(ppm)	28.3	36.8	20.1	26.2	53.2

Assumed pressroom volume based on new installation information. Assumed 1.5% of HAP used is retained in the web, and ultimately emitted outside the pressroom. Operating time based on 1980 NSPS. Assumed plant (and concentrator) operation 5 days/wk; 24 hr/day.

the existing capture system. Since the pressroom air is at relatively low concentration, cost calculations are based on use of a concentrator system. The assumed concentrator specifications are given in Table 6-2. Control option A has not been applied to model plants 1 and 3, as incremental HAP reduction would be negligible for these cases. The concentrator systems are assumed to be 93 percent efficient (this assumption is subject to revision if test data become available) and exhaust a stream of 10 percent of the volume of the treated pressroom air. This concentrated exhaust stream is assumed to be added to the carbon adsorption/steam regeneration solvent recovery system. The capital costs of these systems for the three control options are given in Tables 6-3 through 6-5. Concentrator system costs were based on telephone quotes from three vendors. An upgrade to the existing solvent recovery system to account for the increased capacity required to treat the concentrator exhaust is included in Tables 6-3 through 6-5. These costs are detailed in Tables 6-6 and 6-7. The inclusion of solvent recovery system upgrade costs is conservative as existing solvent recovery systems may be adequate to treat the incremental concentrator exhaust flows. In this case, increased regeneration frequencies could be required. Control option C includes retrofit construction of a permanent total enclosure. These costs are estimated in Table 6-8 and included in Table 6-5. Total enclosure costs are based on the construction of two new walls and the presence of two existing walls. Depending on the existing structure, total enclosure costs could be higher or lower than those estimated.

Total annual costs have been estimated for the three control options in Tables 6-9 through 6-11. These estimates include recovery of capital costs based on a 7 percent interest rate and a 15 year equipment life. Operating costs include utilities, labor, materials, tax, insurance and administration. Additional notes to the cost calculation tables are given in Table 6-12.

Cost effectiveness of the control options applied to the model plants is given in Table 6-13. Cost effectiveness varies between

Table 6-2. Publication Rotogravure Control Device Specifications used for Control Option Costing.

Concentrator System-Control Option A

Model Plant		2	4	5	
Flow to Concentrator (scfm)		300,000	100,000	300,000	
Flow from Concentrator (scfm)		30,000	10,000	30,000	
HAP to Concentrator (lb/yr)		975,000	231,111	1,407,778	
Incremental Control (lb/yr)		879,548	208,485	1,269,956	
Incremental Control Efficiency (%)		3.91	3.26	9.07	
New overall Control (%)		91.9	91.3	87.1	

Concentrator System-Control Options B & C

Model Plant	1	2	3	4	5
Flow to Concentrator (scfm)	36,000	540,000	14,400	216,000	540,000
Flow from Concentrator (scfm)	3,600	54,000	1,440	21,600	54,000
HAP to Concentrator (lb/yr)	90,000	1,755,000	25,600	499,200	2,534,000
Incremental Control (lb/yr)	81,189	1,583,186	23,094	450,328	2,285,921
Incremental Control Efficiency (%)	0.36	7.04	0.36	7.04	16.33
New overall Control (%)	95.6	95.0	95.6	95.0	94.3

Assumed 93% concentrator efficiency.

Table 6-3. Capital Costs of Concentrator/Solvent Recovery Systems for Control Option A at Model Publication Rotogravure Plants.

Model Plant	2	4	5
Intake Rate (SCFM)	300,000	100,000	300,000
Intake rate (ACFM)	327,473	109,158	327,473
Exhaust rate (SCFM)	30,000	10,000	30,000
Installed Cost--Note 1	$3,600,000	$1,200,000	$3,600,000
Site Preparation-Note 2	360,000	120,000	360,000
Duct Length (ft)--Note 12	180	60	180
Duct Diameter (in)	60	60	60
Duct Cost @$126/ft	22,680	7,560	22,680
Solvent Recovery System upgrade	19,040	7,955	24,536
Cost including duct and site Prep.	4,001,720	1,335,515	4,007,216
Engineering, supervision, construction, field expenses, fee, start-up, performance test and contingencies-Note 3	1,240,533	414,010	1,242,237
Total Capital Cost-Concentrator System	5,242,253	1,749,524	5,249,453
Capital Recovery factor-Note 4	0.1098	0.1098	0.1098
Annualized Capital Cost	$575,571	$192,088	$576,362
Solvent recovery system upgrade costs are detailed in Table 6-6. See notes to cost calculations in Table 6-12.			

Table 6-4. Capital Costs of Concentrator/Solvent Recovery Systems for Control Option B at Model Publication Rotogravure Plants.

Model Plant	1	2	3	4	5
Intake Rate (SCFM)	36,000	540,000	14,400	216,000	540,000
Intake rate (ACFM)	39,297	589,451	15,719	235,780	589,451
Exhaust rate (SCFM)	3,600	54,000	1,440	21,600	54,000
Installed Cost--Note 1	$432,000	$6,480,000	$172,800	$2,592,000	$6,480,000
Site Preparation-Note 2	$43,200	$648,000	$17,280	$259,200	$648,000
Duct Length (ft)--Note 12	30	330	30	150	330
Duct Diameter (in)	60	60	60	60	60
Duct Cost @$126/ft	$3,780	$41,580	$3,780	$18,900	$41,580
Solvent Recovery System upgrade	$5,000	$26,725	$5,000	$14,140	$34,542
Cost including duct and site Preparation	$483,980	$7,196,305	$198,860	$2,884,240	$7,204,122
Engineering, supervision, construction field expenses, fee, start-up, performance test and contingencies-Note 3	$150,034	$2,230,855	$61,647	$894,114	$2,233,278
Total Capital Cost- Concentrator System	$634,014	$9,427,159	$260,507	$3,778,355	$9,437,400
Capital Recovery factor-Note 4	0.1098	0.1098	0.1098	0.1098	0.1098
Annualized Capital Cost	$69,611	$1,035,051	$28,602	$414,843	$1,036,176

Solvent recovery system upgrade costs are detailed in Table 6-7.
See notes to cost calculations in Table 6-12.

Table 6-5. Capital Costs of Concentrator/Solvent Recovery Systems for Control Option C at Model Publication Rotogravure Plants.

Model Plant	1	2	3	4	5
Intake Rate (SCFM)	36,000	540,000	14,400	216,000	540,000
Intake rate (ACFM)	39,297	589,451	15,719	235,780	589,451
Exhaust rate (SCFM)	3,600	54,000	1,440	21,600	54,000
Installed Cost--Note 1	$432,000	$6,480,000	$172,800	$2,592,000	$6,480,000
Site Preparation-Note 2	$43,200	$648,000	$17,280	$259,200	$648,000
Duct Length (ft)--Note 12	30	330	30	150	330
Duct Diameter (in)	60	60	60	60	60
Duct Cost @$126/ft	$3,780	$41,580	$3,780	$18,900	$41,580
Solvent Recovery System upgrade	$5,000	$26,725	$5,000	$14,140	$34,542
Cost including duct and site Prep.	$483,980	$7,196,305	$198,860	$2,884,240	$7,204,122
Engineering, supervision, construction, field expenses, fee, start-up, performance test and contingencies-Note 3	$150,034	$2,230,855	$61,647	$894,114	$2,233,278
Total Capital Cost- Concentrator System	$634,014	$9,427,159	$260,507	$3,778,355	$9,437,400
Permanent Total Enclosure Construction Cost	$44,704	$44,704	$28,284	$28,284	$31,568
Total Capital Cost	$678,718	$9,471,864	$288,790	$3,806,638	$9,468,968
Capital Recovery factor-Note 4	0.1098	0.1098	0.1098	0.1098	0.1098
Annualized Capital Cost	$74,520	$1,039,960	$31,708	$417,948	$1,039,642

Permanent total enclosure costs are detailed in Table 6-8. Solvent recovery system upgrade costs are detailed in Table 6-7. See notes to cost calculations in Table 6-12.

Table 6-6. Capital Costs of Required Solvent Recovery System Upgrades for Control Option A at Model Publication Rotogravure Plants.

Model Plant	2	4	5
Incremental Flow Rate (SCFM)	30,000	10,000	30,000
Pressroom Concentration (ppm)	36.8	26.2	53.2
Concentrator Exhaust Conc. (ppm)	342	244	495
Incremental HAP Loading (lb/hr)	140.6	33.3	203.0
Adsorption Time (hr)	2	2	2
Equilibrium Adsorptivity (lb toluene/lb carbon)	0.31	0.30	0.32
Working Capacity (lb HAP/lb carbon)	0.154	0.148	0.160
Carbon Required (lb)	1827	449	2532
Adsorber Volume Required (CF)	109.59	26.97	151.95
Adsorber Length (ft)	16	9	22
Adsorber Diameter (ft)	3	2	3
Adsorber Surface (sf)	164.934	62.832	221.4828
Adsorber Cost ($1989)	$14,389	$6,791	$18,099
Adsorber Cost ($1993)	$14,474	$6,831	$18,205
Carbon Cost @$2.50/lb	$4,566	$1,124	$6,331
Adsorber Cost including carbon	$19,040	$7,955	$24,536
Note: Costs escalated to 1993$ using Marshall and Swift cost index factor of (394.4/392.1).			

Table 6-7. Capital Costs of Required Solvent Recovery Upgrades for Control Options B and C at Model Publication Rotogravure Plants.

Model Plant	1	2	3	4	5
Incremental Flow Rate (SCFM)	3,600	54,000	1,440	21,600	54,000
Pressroom Concentration (ppm)	28.3	36.8	20.1	26.2	53.2
Concentrator Exhaust Conc. (ppm)	263	342	187	244	495
Incremental HAP Loading (lb/hr)	13.0	253.0	3.7	72.0	365.3
Adsorption Time (hr)	2	2	2	2	2
Equilibrium Adsorptivity (lb toluene/lb carbon)	0.30	0.31	0.29	0.30	0.32
Working Capacity (lb HAP/lb carbon)	0.15	0.15	0.14	0.15	0.16
Carbon Required (lb)	174	3288	51	971	4558
Adsorber Volume Required (CF)	10.41	197.26	3.08	58.25	273.51
Adsorber Length (ft)	NOTE 13	16	NOTE 13	19	22
Adsorber Diameter (ft)	NOTE 13	4	NOTE 13	2	4
Adsorber Surface (sf)	NOTE 13	226.1952	NOTE 13	125.656	301.5744
Adsorber Cost ($1989)	NOTE 13	$18,397	NOTE 13	$11,645	$23,011
Adsorber Cost ($1993)	NOTE 13	$18,505	NOTE 13	$11,713	$23,146
Carbon Cost@$2.50/lb	NOTE 13	$8,220	NOTE 13	$2,427	$11,396
Adsorber Cost including carbon	$5,000	$26,725	$5,000	$14,140	$34,542

Note: Costs escalated to 1993$ using Marshall and Swift cost index factor of (394.4/392.1). See notes to cost calculations in Table 6-12.

Table 6-8. Capital Costs of Permanent Total Enclosure for Control Option C at Model Publication Rotogravure Plants.

Wall Dimensions (ft)	240 x 30	240 x 30	120 x 30	120 x 30	150 x 30
Wall Dimensions (ft)	150 x 30	150 x 30	120 x 30	120 x 30	120 x 30
Total Area-Two Walls (SF)	11700	11700	7200	7200	8100
Large Door Dimensions (ft)	6 x 10	6 x 10	6 x 10	6 x 10	6 x 10
Small Door Dimensions (ft)	8 x 4	8 x 4	8 x 4	8 x 4	8 x 4
Wall Cost	$42,694	$42,694	$26,274	$26,274	$29,558
Large Door Cost	1850	1850	1850	1850	1850
Small Door Cost	160	160	160	160	160
Total Cost	$44,704	$44,704	$28,284	$28,284	$31,568

Assumptions: Two existing walls, two walls to be constructed, one large door and one small door to be added. 8" concrete (sand aggregate) block, 3/8" mortar joint, tooled one side. Large door-Aluminum door and frame including hardware and closer. Small door-16 gauge steel, 5" deep.

Costs from Waier, Phillip R. et al.,Means Building Construction Cost Data, 51st Annual Edition, R. S. Means Company, 1992.

Table 6-9. Total Annual Costs for Control Option A at Model Publication Rotogravure Plants.

Control Option/Model Plant	A-2	A-4	A-5
Annualized Capital Cost	$575,571	$192,088	$576,362
Operating Costs			
Electricity-Concentrator-Note 5	146,867	48,956	146,867
Gas-Concentrator-Note 6	44,973	14,991	44,973
Steam-Recovery System Upgrade-Note 14	10,286	2,531	14,261
Operating labor-Note 7	58,662	19,554	58,656
Supervisory Labor-Note 8	8,799	2,933	8,798
Maintenance Labor-Note 9	64,528	21,509	64,522
Materials-Note 10	64,528	21,509	64,522
Property tax, Insurance and Administrative-Note 11.	209,690	69,981	209,978
Total Annual Costs	$1,183,905	$394,053	$1,188,939
Solvent Recovery Credit-Note 15	$131,932	$31,273	$190,493
Net Annual Costs	$1,051,972	$362,780	$998,445
See notes to cost calculations in Table 6-12.			

Table 6-10. Total Annual Costs for Control Option B at Model Publication Rotogravure Plants.

Control Option/Model Plant	B-1	B-2	B-3	B-4	B-5
Annualized Capital Cost	$69,611	$1,035,051	$28,602	$414,843	$1,036,176
Operating Costs					
Electricity-Concentrator-Note 5	17,624	264,361	7,050	105,744	264,361
Gas-Concentrator-Note 6	26,909	403,638	10,764	161,455	403,638
Steam-Recovery System Upgrade-Note 14	977	18,515	289	5,467	25,671
Operating labor-Note 7	9,777	107,547	29,331	48,885	107,547
Supervisory Labor-Note 8	1,467	16,132	4,400	7,333	16,132
Maintenance Labor-Note 9	10,755	118,302	32,264	53,774	118,302
Materials-Note 10	10,755	118,302	32,264	53,774	118,302
Property tax, Insurance and Administrative-Note 11.	25,361	377,086	10,420	151,134	377,496
Total Annual Costs	$173,235	$2,458,934	$155,383	$1,002,409	$2,467,624
Solvent Recovery Credit-Note 15	$12,178	$237,478	$3,464	$67,549	$342,888
Net Annual Costs	$161,057	$2,221,456	$151,919	$934,859	$2,124,736
See notes to cost calculations in Table 6-12.					

Table 6-11. Total Annual Costs for Control Option C at Model Publication Rotogravure Plants.

Control Option/Model Plant	C-1	C-2	C-3	C-4	C-5
Annualized Capital Cost	$74,520	$1,039,960	$31,708	$417,948	$1,039,642
Operating Costs					
Electricity-Concentrator-Note 5	17,624	264,361	7,050	105,744	264,361
Gas-Concentrator-Note 6	26,909	403,638	10,764	161,455	403,638
Steam-Recovery System Upgrade-Note 14	977	18,515	289	5,467	25,671
Operating labor-Note 7	9,777	107,547	29,331	48,885	107,547
Supervisory Labor-Note 8	1,467	16,132	4,400	7,333	16,132
Maintenance Labor-Note 9	10,755	118,302	32,264	53,774	118,302
Materials-Note 10	10,755	118,302	32,264	53,774	118,302
Property tax, Insurance and Administrative-Note 11.	27,149	378,875	11,552	152,266	378,759
Total Annual Costs	$179,932	$2,465,631	$159,620	$1,006,645	$2,472,353
Solvent Recovery Credit-Note 15	$12,178	$237,478	$3,464	$67,549	$342,888
Net Annual Costs	$167,754	$2,228,153	$156,156	$939,096	$2,129,465
See notes to cost calculations in Table 6-12.					

Table 6-12. Notes to Control Cost Calculations for Model Publication Rotogravure Plants.

Note 1.	From telephone quotes; $12/SCFM installed price--modular: no economies of scale
Note 2.	Arbitrarily assumed 10% of installed cost.
Note 3.	31% of installed cost, per EPA Handbook (EPA/625/6-91/014)
Note 4.	15 years at 7%
Note 5.	Volume is 110% of intake rate, pressure drop =6 in. water, fan efficiency is 65%, electricity at 0.06/kwhr
Note 6.	Desorption air at 300 degrees F. Desorption gas flow rate =10% intake flow rate. Gas at $5/MM Btu.
Note 7.	0.5 hr/shift per concentrator, $25/hr including overhead.
Note 8.	15% of operating labor
Note 9.	110% of operating labor
Note 10.	Assumed equal to maintenance labor.
Note 11.	4% of total capital cost
Note 12.	30 ft length of 5 ft diameter duct in parallel.
Note 13.	The existing adsorbers can be operated to handle the small additional loading. A nominal upgrade cost is given as a upper bound estimate.
Note 14.	0.3 lb steam/lb carbon. Steam at $6/1000 lb.
Note 15.	Recovered toluene valued at $0.15/lb.

Table 6-13. Cost Effectiveness of Concentrator Systems for Incremental Control of Publication Rotogravure Model Plants.

Control Option A					
Model Plant		2		4	5
HAP Reduction (lb/yr)		879,548		208,485	1,269,956
Annual Cost		$1,051,972		$362,780	$998,445
Cost Effectiveness ($/Ton)		2,392		3,480	1,572
Control Option B					
Model Plant	1	2	3	4	5
HAP Reduction (lb/yr)	81,189	1,583,186	23,094	450,328	2,285,921
Annual Cost	$161,057	$2,221,456	$151,919	$934,859	$2,124,736
Cost Effectiveness ($/Ton)	3,967	2,806	13,157	4,152	1,859
Control Option C					
Model Plant	1	2	3	4	5
HAP Reduction (lb/yr)	81,189	1,583,186	23,094	450,328	2,285,921
Annual Cost	$167,754	$2,228,153	$156,156	$939,096	$2,129,465
Cost Effectiveness ($/Ton)	4,132	2,815	13,524	4,171	1,863

$1500 and $14,000 per ton of HAP reduction. The cost per incremental ton of HAP reduction is highest at the model plants with high levels of baseline HAP control, as these plants have less fugitive emissions available for capture and treatment. The annual costs for these plants are lower than the annual costs for the model plants with low levels of baseline control as less additional air must be handled at the well controlled plants.

6.3 PRODUCT AND PACKAGING ROTOGRAVURE

Model plant specifications are given in Table 6-14. These are based on several assumptions. HAP retention in the web is assumed to be 1.5 percent of that used. This material is not emitted in the pressroom or dryer. Pressroom ventilation rates have been proposed based on the volume of air necessary to dilute the fugitive emissions to 50 ppmv VOC. The concentration of HAP in the pressroom varies depending on the composition of the materials applied. Ventilation air to dilute fugitive emissions may be presently supplied by doors, windows, and leaks to the atmosphere. Pressroom volumes have been assumed based on the number and size of the presses in the model plants. The pressroom and control systems are assumed to operate 80 hours per week.

Control options A and B, as described in chapter 4, apply to incremental capture and control of fugitive emissions from existing capture systems at the model plants. Control options A and B involve collecting and treating pressroom air containing fugitive HAP which escapes the existing capture system. Costs have been estimated on the basis of thermal incineration of this pressroom air stream. Specifications for thermal incinerators applicable to the model plants are given in Table 6-15. In many cases, catalytic incineration would be appropriate for the solvents in use. Catalytic incineration systems would have lower operating costs and might have total annualized costs than the estimates for thermal incineration systems. In some cases, concentrator systems (see Section 6.2) might be used to reduce the size and capital and operating costs of the incinerator.

Table 6-14. Model Plant Specifications for Product and Packaging Rotogravure.

Model Plant		1	2	3	4	5
Substrate		Vinyl Products	Paper/Cardboard Packaging		Foil/Film Packaging	
Presses/Stations		8/4	4/8	1/6	2/8	4/6
Pressroom Dimensions	ft x ft x ft	240 x 100 x30	150 x 120 x 30	100 x 30 x30	60 x 150 x 30	120 x 120 x30
Ink Use	lb/year	1,000,000	1,800,000	2,000,000	3,000,000	300,000
VOC Use	lb/year	900,000	1,000,000	800,000	2,500,000	150,000
HAP Use	lb/year	900,000	200,000	600,000	1,000,000	65,000
Capture Efficiency	%	89	81	N/A	95	N/A
Control Device Efficiency	%	95	97	0	95	0
Overall Efficiency	%	85	79	0	90	0
HAP Controlled	lb/year	765,000	158,000	0	900,000	0
HAP Retained	lb/year	13,500	3,000	9,000	15,000	975
HAP to Pressroom	lb/year	121,500	39,000	591,000	85,000	64,025
VOC Controlled	lb/year	765,000	790,000	0	2,250,000	0
VOC Retained	lb/year	13,500	15,000	12,000	37,500	2,250
VOC to Pressroom	lb/year	121,500	195,000	788,000	212,500	147,750
Pressroom VOC Conc.	ppm	50	50	50	50	50
Pressroom HAP Conc.	ppm	50.0	10.0	37.5	20.0	21.7

N/A=Not applicable.

Table 6-15. Incinerator Specifications for Product and Packaging Rotogravure Control Options.

Thermal Incinerator--Control Option A						
Model Plant		1	2	3	4	5
VOC Molecular Weight		92.1	88.9	91.1	89.7	89.8
Ventilation Rate	SCFM	37,845	62,925	248,140	67,960	47,182
Incinerator Intake	SCFM	18,922	31,462	124,070	33,980	23,591
VOC to Incinerator	lb/yr	60,750	97,500	394,000	106,250	73,875
HAP to Incinerator	lb/yr	60,750	19,500	295,500	42,500	32,013
Incremental HAP Control	lb/yr	57,713	18,525	280,725	40,375	30,412
Incremental Control Effic.	%	6.4	9.3	46.8	4.0	46.8
New Overall Control	%	91	88	47	94	47

Thermal Incinerator--Control Option B						
Model Plant		1	2	3	4	5
VOC Molecular Weight		92.1	88.9	91.1	89.7	89.8
Ventilation Rate	SCFM	37,845	62,925	248,140	67,960	47,182
Incinerator Intake	SCFM	37,845	62,925	248,140	67,960	47,182
VOC to Incinerator	lb/yr	121,500	195,000	788,000	212,500	147,750
HAP to Incinerator	lb/yr	121,500	39,000	591,000	85,000	64,025
Incremental HAP Control	lb/yr	115,425	37,050	561,450	80,750	60,824
Incremental Control Effic.	%	12.8	18.5	93.6	8.1	93.6
New Overall Control	%	98	98	94	98	94

Assume: HAP is toluene (MW=92.1), Non-HAP VOC is ethyl acetate (MW=88.1)
Pressroom ventilation incinerator efficiency=95%.

The capital costs of these systems for control options A and B are given in Tables 6-16 and 6-17. These costs are based on the OAQPS Control Cost Manual[1]. The capital cost for control option B includes retrofit construction of a permanent total enclosure. The basis of this cost estimate is given in Table 6-18, and included in Table 6-17. Total enclosure costs are based on the construction of two new walls and the presence of two existing walls. Depending on the existing structure, total enclosure costs could be higher or lower than those estimated.

Total annual costs have been estimated for control options A and B in Tables 6-19 and 6-20. These estimates include recovery of capital costs based on a 7 percent interest rate and a 15 year equipment life. Operating costs include utilities, labor, materials, tax, insurance and administration.

Cost effectiveness of the control options applied to the model plants is given in Table 6-21. Cost effectiveness varies between $10,000 and $48,000 per ton of HAP reduction. The cost per incremental ton of HAP reduction is highest at the model plants with high levels of baseline HAP control, as these plants have less fugitive emissions available for capture and treatment. The annual costs for these plants are lower than the annual costs for the model plants with low levels of baseline control as less additional air must be handled at the well controlled plants.

Control option C involves the use of low HAP ink. The adoption of this control option could, in some cases, represent a net savings over baseline levels of control. The applicability of this option depends to a large extent on the type of printing and the performance requirements of the product or package. Some facilities, printing on both porous and non-porous substrates report either zero or very low HAP use as a proportion of total materials applied on rotogravure presses. Where feasible, conversion to low HAP inks could result in substantial reductions in operating costs. Cost reductions from conversion to low HAP inks have not been calculated, because low HAP inks may still

Table 6-16. Capital Costs for Thermal Incinerators at Model Product and Packaging Rotogravure Plants - Control Option A.

Model Plant		1	2	3	4	5
Incinerator Intake	SCFM	18,922	31,462	124,070	33,980	23,591
VOC to Incinerator	lb/yr	60,750	97,500	394,000	106,250	73,875
HAP to Incinerator	lb/yr	60,750	19,500	295,500	42,500	32,013
Control Efficiency	%	95	95	95	95	95
Heat Recovery	%	70	70	70	70	70
Costs (1988$)						
Incinerator, auxiliary equipment instrumentation, sales tax, and freight		302,738	343,780	484,445	350,460	319,903
Direct Installation Cost		90,822	103,134	145,334	105,138	95,971
Indirect Installation Cost		93,849	106,572	150,178	108,643	99,170
Site Preparation		30,274	34,378	48,445	35,046	31,990
Total Costs (1988$)		517,683	587,864	828,402	599,287	547,034
Total Costs (1993$)		587,497	667,143	940,119	680,106	620,806
Capital Recovery Factor		0.1098	0.1098	0.1098	0.1098	0.1098
Annualized capital cost		$64,507	$73,252	$103,225	$74,676	$68,164

Direct Installation includes foundation, supports, handling, erection, electrical, piping, insulation for ductwork, and painting. Indirect installation cost includes engineering, construction and field expenses, contractor fees, start-up, performance test, and contingencies. Costs based on OAQPS Control Cost Manual (EPA 450/3-90-006, January 1990). Costs escalated to 1993$ using Marshall and Swift Cost Index (Factor=966.9/852.0).

Table 6-17. Capital Costs for Thermal Incinerators at Model Product and Packaging Rotogravure Plants - Control Option B.

Model Plant		1	2	3	4	5
Incinerator Intake	SCFM	37,845	62,925	248,140	67,960	47,182
VOC to Incinerator	lb/yr	121,500	195,000	788,000	212,500	147,750
HAP to Incinerator	lb/yr	121,500	39,000	591,000	85,000	64,025
Control Efficiency	%	95	95	95	95	95
Heat Recovery	%	70	70	70	70	70
Costs (1988$)						
Incinerator, auxiliary equipment instrumentation, sales tax and freight		360,020	408,828	576,107	416,769	380,431
Direct Installation Cost		108,006	122,648	172,832	125,031	114,129
Indirect Installation Cost		111,606	126,737	178,593	129,198	117,934
Site Preparation		36,002	40,883	57,611	41,677	38,043
Total Equipment Costs (1988$)		615,634	699,096	985,143	712,675	650,537
Total Equipment Costs (1993$)		698,659	793,374	1,117,998	808,786	738,268
Permanent Total Enclosure (1993$)		39,231	31,568	16,241	24,999	28,284
Cost including PTE (1993$)		737,890	824,942	1,134,239	833,785	766,552
Capital Recovery Factor		0.1098	0.1098	0.1098	0.1098	0.1098
Annualized capital cost		$81,020	$90,579	$124,539	$91,550	$84,167

Direct Installation includes foundation, supports, handling, erection, electrical, piping, insulation for ductwork, and painting. Indirect installation cost includes engineering, construction and field expenses, contractor fees, start-up, performance test, and contingencies. Permanent total enclosure costs based on assumptions in following table. Costs based on OAQPS Control Cost Manual (EPA 450/3-90-006, January 1990).Costs escalated to 1993$ using Marshall and Swift Cost Index (Factor=966.9/852.0).

Table 6-18. Total Enclosure Construction Costs for Product and Packaging Rotogravure - Control Option B.

Model Plant	1	2	3	4	5
Wall Dimensions (ft)	240 x 30	150 x 30	100 x 30	150 x 30	120 x 30
Wall Dimensions (ft)	100 x 30	120 x 30	30 x 30	60 x 30	120 x 30
Total Area- Two Walls (SF)	10200	8100	3900	6300	7200
Large Door Dimensions (ft x ft)	6 x 10	6 x 10	6 x 10	6 x 10	6 x 10
Small Door Dimensions (ft x ft)	8 x 4	8 x 4	8 x 4	8 x 4	8 x 4
Wall Cost	$37,221	$29,558	$14,231	$22,989	$26,274
Large Door Cost	1850	1850	1850	1850	1850
Small Door Cost	160	160	160	160	160
Total Cost	$39,231	$31,568	$16,241	$24,999	$28,284

Assumptions: Two existing walls, two walls to be constructed, one large door and one small door to be added. 8" concrete (sand aggregate) block, 3/8" mortar joint, tooled one side. Large door-Aluminum door and frame including hardware and closer. Small door-16 gauge steel, 5" deep.

Costs from Waier, Phillip R. et al., Means Building Construction Cost Data, 51st Annual Edition, R. S. Means Company, 1992.

Table 6-19. Total Annual Costs for Thermal Incinerators at Model Product and Packaging Rotogravure Plants - Control Option A.

Model Plant		1	2	3	4	5
Electricity Required	kW	77.37	128.66	507.34	138.95	96.47
Natural Gas Required	SCFM	231	386	1516	417	289
Electricity Cost-Note 1	$/yr	19,365	32,202	126,980	34,778	24,145
Gas Cost-Note 2.	$/yr	173,217	290,146	1,138,602	312,811	217,107
Operating Labor-Note 3.	$/yr	3,886	3,886	3,886	3,886	3,886
Maintenance Labor-Note 4	$/yr	3,718	3,718	3,718	3,718	3,718
Maintenance Mat'l-Note 5	$/yr	3,718	3,718	3,718	3,718	3,718
Overhead-Note 6	$/yr	6,793	6,793	6,793	6,793	6,793
Other costs-Note 7	$/yr	23,500	26,686	37,604	27,204	24,832
Capital Recovery	$/yr	64,507	73,252	103,225	74,676	68,164
Total Annual Cost		298,704	440,401	1,424,526	467,584	352,363

Note 1. Fan power based on 4 inch pressure drop through incinerator and 15 inch pressure drop through 70% efficient heat exchanger. Fan/motor efficiency = 60%. Operation 4171 hours per year. Electricity cost = 0.06/kWhr.

Note 2. Operation at 1400 degrees F, 4171 hours per year. Gas at $0.003/SCF.

Note 3. Operator labor 0.5 hr/shift at $12.96/hr. Supervisory labor = 15% of operating labor.

Note 4. Maintenance labor 0.5 hr/shift at $14.26/hr.

Note 5. Maintenance material assumed equal to maintenance labor.

Note 6. Overhead assumed 60% of labor plus maintenance materials.

Note 7. Administrative charges, property taxes and insurance assumed to be 4% of total capital cost.

Table 6-20. Total Annual Costs for Thermal Incinerators at Model Product and Packaging Rotogravure Plants - Control Option B.

Model Plant		1	2	3	4	5
Electricity Required	kW	154.74	257.32	1014.68	277.9	192.94
Natural Gas Required	SCFM	462	772	3032	834	578
Electricity Cost-Note 1	$/yr	38,730	64,404	253,960	69,556	48,290
Gas Cost - Note 2.	$/yr	346,434	580,292	2,277,204	625,622	434,214
Operating Labor -Note 3.	$/yr	3,886	3,886	3,886	3,886	3,886
Maintenance Labor-Note 4	$/yr	3,718	3,718	3,718	3,718	3,718
Maintenance Mat'l-Note 5	$/yr	3,718	3,718	3,718	3,718	3,718
Overhead-Note 6	$/yr	6,793	6,793	6,793	6,793	6,793
Other costs- Note 7	$/yr	27,946	31,735	44,720	32,352	29,530
Capital Recovery	$/yr	81,020	90,579	124,539	91,550	84,167
Total Annual Cost		512,245	785,125	2,718,538	837,195	614,316

Note 1. Fan power based on 4 inch pressure drop through incinerator and 15 inch pressure drop through 70% efficient heat exchanger. Fan/motor efficiency = 60%. Operation 4171 hours per year. Electricity cost = 0.06/kWhr.

Note 2. Operation at 1400 degrees F, 4171 hours per year. Gas at $0.003/SCF.

Note 3. Operator labor 0.5 hr/shift at $12.96/hr. Supervisory labor = 15% of operating labor.

Note 4. Maintenance labor 0.5 hr/shift at $14.26/hr.

Note 5. Maintenance material assumed equal to maintenance labor.

Note 6. Overhead assumed 60% of labor plus maintenance materials.

Note 7. Administrative charges, property taxes and insurance assumed to be 4% of total capital cost.

Table 6-21. Cost Effectiveness of Control Options A and B for Incremental Control at Model Product and Packaging Rotogravure Plants.

Model Plant	1	2	3	4	5
Control Option A					
HAP Reduction (lb/yr)	57,713	18,525	280,725	40,375	30,412
Annual Cost	$298,704	$440,401	$1,424,526	$467,584	$352,363
Cost Effectiveness ($/Ton)	10,351	47,547	10,149	23,162	23,173
Control Option B					
HAP Reduction (lb/yr)	115,426	37,050	561,450	80,750	60,824
Annual Cost	$512,245	$785,125	$2,718,538	$837,195	$614,316
Cost Effectiveness ($/Ton)	8,876	42,382	9,684	20,735	20,200

require operation of a control device to meet VOC emissions standards established by other regulations.

6.4 WIDE-WEB AND SHEET FED FLEXOGRAPHY

Model plant specifications are given in Table 6-22. These are based on several assumptions. HAP retention in the web is assumed to be 1.5 percent of that used. This material is not emitted in the pressroom or dryer. Pressroom ventilation rates have been proposed based on the volume of air necessary to dilute the fugitive emissions to 50 ppmv VOC. The concentration of HAP in the pressroom varies depending on the composition of the materials applied. Ventilation air to dilute fugitive emissions may be presently supplied by doors, windows, and leaks to the atmosphere and by exhaust fans discharging directly to the atmosphere. Pressroom volumes have been assumed based on the number and size of the presses in the model plants. The pressroom and control systems are assumed to operate 80 hours per week.

Control options A and B apply to incremental capture and control of uncontrolled emissions and fugitive emissions at the model plants. Control options A and B involve collecting and treating pressroom air containing uncontrolled HAP (model plants 1 and 2) or fugitive HAP which escapes the existing capture system (model plant 3). Costs have been estimated on the basis of thermal incineration of this pressroom air stream. Specifications for thermal incinerators applicable to the model plants are given in Table 6-23. In many cases, catalytic incineration would be appropriate for the solvents in use. Catalytic incineration systems would have lower operating costs and might have lower total annualized costs than the estimates for thermal incineration systems. In some cases, concentrator systems (see Section 6.2) might be used to reduce the size and capital and operating costs of the incinerator.

The capital costs of these systems for control options A and B are given in Tables 6-24 and 6-25. These costs are based on

Table 6-22. Model Plant Specifications for Flexography.

Model Plant		1	2	3
Substrate		Multiwall Bags	Film Packaging	Paper/Film Pkg
Presses/Stations		12/4	6/6	6/6
Pressroom Dimensions	ft x ft x ft	150 x 90 x30	150 x 90 x30	150 x 90 x 30
Ink Use	lb/year	1,500,000	800,000	1,500,000
VOC Use	lb/year	25,000	550,000	1,100,000
HAP Use	lb/year	21,000	100,000	8,000
Capture Efficiency	%	0	0	78
Control Device Efficiency	%	0	0	94
Overall Efficiency	%	0	0	73
HAP Controlled	lb/year	0	0	5840
HAP Retained	lb/year	315	1,500	120
HAP to Pressroom	lb/year	20,685	98,500	2,040
VOC Controlled	lb/year	0	0	803,000
VOC Retained	lb/year	375	8,250	16,500
VOC to Pressroom	lb/year	24,625	541,750	280,500
Pressroom VOC Concentration	ppm	50	50	50
Pressroom HAP Concentration	ppm	46.9	19	1

Assumed HAP is methanol (MW=32), Non-HAP VOC is ethyl acetate (MW=88.1). Assumed 1.5% of HAP and VOC used is retained in the substrate and ultimately emitted outside the pressroom. Assumed plant (and control system) operates 16 hr/day, 5 day/week.

Table 6-23. Incinerator Specifications for Flexography Control Options.

Thermal Incinerator--Control Option A				
Model Plant		1	2	3
VOC Molecular Weight		35.5	66.8	87
Ventilation Rate	SCFM	19,899	232,654	92,492
Incinerator Intake	SCFM	9,950	116,327	46,246
VOC to Incinerator	lb/yr	12,313	270,875	140,250
HAP to Incinerator	lb/yr	10,343	49,250	1,020
Incremental HAP Control	lb/yr	9,825	46,788	969
Incremental Control Efficiency	%	46.8	46.8	12.1
New Overall Control	%	46.8	46.8	85.1
Thermal Incinerator--Control Option B				
Model Plant		1	2	3
VOC Molecular Weight		35.5	66.8	87
Ventilation Rate	SCFM	19,899	232,654	92,492
Incinerator Intake	SCFM	19,899	232,654	92,492
VOC to Incinerator	lb/yr	24,625	541,750	280,500
HAP to Incinerator	lb/yr	20,685	98,500	2,040
Incremental HAP Control	lb/yr	19,651	93,575	1,938
Incremental Control Efficiency	%	93.6	93.6	24.2
New Overall Control	%	93.6	93.6	97.2
Assume: HAP is methanol (MW=32), Non-HAP VOC is ethyl acetate (MW=88.1) Pressroom ventilation incinerator efficiency = 95%.				

Table 6-24. Capital Costs for Thermal Incinerators at Model Flexographic plants - Control Option A.

Model Plant		1	2	3
Incinerator Intake	SCFM	9,950	116,327	46,246
VOC to Incinerator	lb/yr	12,313	270,875	140,250
HAP to Incinerator	lb/yr	10,343	49,250	1,020
Control Efficiency	%	95	95	95
Heat Recovery	%	70	70	70
Costs (1988$)				
Incinerator, auxiliary equipment instrumentation, sales tax, and freight		257,811	476,716	378,535
Direct Installation Cost		77,343	143,015	113,560
Indirect Installation Cost		79,921	147,782	117,346
Site Preparation		25,781	47,672	37,853
Total Costs (1988$)		440,856	815,185	647,294
Total Costs (1993$)		500,311	925,120	734,588
Capital Recovery Factor		0.1098	0.1098	0.1098
Annualized capital cost		$54,934	$101,578	$80,658
Direct Installation includes foundation, supports, handling, erection, electrical, piping, insulation for ductwork, and painting. Indirect installation cost includes engineering, construction and field expenses, contractor fees, start-up, performance test, and contingencies. Costs based on OAQPS Control Cost Manual (EPA 450/3-90-006, January 1990). Costs escalated to 1993$ using Marshall and Swift Cost Index (Factor=966.9/852.0).				

Table 6-25. Capital Costs for Thermal Incinerators at Model Flexographic plants - Control Option B.

Model Plant		1	2	3
Incinerator Intake	SCFM	19,899	232,654	92,492
VOC to Incinerator	lb/yr	24,625	541,750	280,500
HAP to Incinerator	lb/yr	20,685	98,500	2,040
Control Efficiency	%	95	95	95
Heat Recovery	%	70	70	70
Costs (1988$)				
Incinerator, auxiliary equipment, instrumentation, sales tax and freight		306,588	566,916	450,156
Direct Installation Cost		91,976	170,075	135,047
Indirect Installation Cost		95,042	175,744	139,548
Site Preparation		30,659	56,692	45,016
Total Equipment Costs (1988$)		524,265	969,427	769,767
Total Equipment Costs (1993$)		594,967	1,100,162	873,577
Permanent Total Enclosure (1993$)		28,284	28,284	28,284
Cost including PTE (1993$)		623,251	1,128,446	901,861
Capital Recovery Factor		0.1098	0.1098	0.1098
Annualized capital cost		$68,433	$123,903	$99,024
Direct Installation includes foundation, supports, handling, erection, electrical, piping, insulation for ductwork, and painting. Indirect installation cost includes engineering, construction and field expenses, contractor fees, start-up, performance test, and contingencies. Permanent total enclosure costs based on assumptions in following table. Costs based on OAQPS Control Cost Manual (EPA 450/3-90-006, January 1990). Costs escalated to 1993$ using Marshall and Swift Cost Index (Factor=966.9/852.0).				

the OAQPS Control Cost Manual[2]. The capital cost for control option B includes retrofit construction of a permanent total enclosure. The basis of this cost estimate is given in Table 6-26, and included in Table 6-25. Total enclosure costs are based on the construction of two new walls and the presence of two existing walls. Depending on the existing structure, total enclosure costs could be higher or lower than those estimated. Total annual costs have been estimated for control options A and B in Tables 6-27 and 6-28. These estimates include recovery of capital costs based on a 7 percent interest rate and a 15 year equipment life. Operating costs include utilities, labor, materials, tax, insurance and administration.

Cost effectiveness of the control options applied to the model plants is given in Table 6-29. Cost effectiveness varies between $30,000 and $60,000 per ton of HAP reduction for model plants 1 and 2. For model plant 2, a large part of the cost may be justified on the basis of non-HAP VOC control. Costs per ton of HAP reduction at model plant 3 are extremely high because of the dilute nature of the fugitive HAP. This type of plant would be expected to meet the standard by reducing the HAP content of its ink, or limiting its potential to emit in some other way.

Control option C involves the use of low HAP ink. The adoption of this control option could, in some cases, represent a net savings over baseline levels of control. The applicability of this option depends to a large extent on the type of printing and the performance requirements of the product or package. Some facilities, printing on both porous and non-porous substrates report either zero or very low HAP use as a proportion of total materials applied on flexographic presses. Where feasible, conversion to low HAP inks could result in substantial reductions in operating costs. Cost reductions from conversion to low HAP inks have not been calculated, because low HAP inks may still require operation of a control device to meet VOC emissions standards established by other regulations.

Table 6-26. Total enclosure Construction Costs for Flexographic Plants - Control Option B.

Wall Dimensions (ft)	150 x 30
Wall Dimensions (ft)	90 x 30
Total Area- Two Walls (SF)	7200
Large Door Dimensions (ft x ft)	6 x 10
Small Door Dimensions (ft x ft)	8 x 4
Wall Cost	26274
Large Door Cost	1850
Small Door Cost	160
Total Cost	$28,284
Assumptions: Two existing walls, two walls to be constructed, one large door and one small door to be added. 8" concrete (sand aggregate) block, 3/8" mortar joint, tooled one side. Large door-Aluminum door and frame including hardware and closer. Small door-16 gauge steel, 5" deep.	
Costs from Waier, Phillip R. et al., Means Building Construction Cost Data, 51st Annual Edition, R. S. Means Company, 1992.	

Table 6-27. Total Annual Costs for Thermal Incinerators at Model Flexographic Plants - Control Option A.

Model Plant		1	2	3
Electricity Required	kW	40.7	475.7	189.1
Natural Gas Required	SCFM	123	1436	569
Electricity Cost-Note 1	$/yr	10,185	119,069	47,334
Gas Cost - Note 2	$/yr	92,660	1,078,176	427,316
Operating Labor-Note 3.	$/yr	3,886	3,886	3,886
Maintenance Labor-Note 4	$/yr	3,718	3,718	3,718
Maintenance Mat'l-Note 5	$/yr	3,718	3,718	3,718
Overhead-Note 6	$/yr	6,793	6,793	6,793
Other costs-Note 7	$/yr	20,012	37,005	29,384
Capital Recovery	$/yr	54,934	101,578	80,658
Total Annual Cost		195,906	1,353,943	602,807

Note 1. Fan power based on 4 inch pressure drop through incinerator and 15 inch pressure drop through 70% efficient heat exchanger. Fan/motor efficiency = 60%. Operation 4171 hours per year. Electricity cost = 0.06/kWhr.

Note 2. Operation at 1400 degrees F, 4171 hours per year. Gas at $0.003/SCF.

Note 3. Operator labor 0.5 hr/shift at $12.96/hr. Supervisory labor = 15% of operating labor.

Note 4. Maintenance labor 0.5 hr/shift at $14.26/hr.

Note 5. Maintenance material assumed equal to maintenance labor.

Note 6. Overhead assumed 60% of labor plus maintenance materials.

Note 7. Administrative charges, property taxes and insurance assumed to be 4% of total capital cost.

Table 6-28. Total Annual Costs for Thermal Incinerators at Model Flexographic Plants - Control Option B.

Model Plant		1	2	3
Electricity Required	kW	81.4	951.5	378.2
Natural Gas Required	SCFM	247	2872	1138
Electricity Cost-Note 1	$/yr	20,369	238,138	94,669
Gas Cost-Note 2.	$/yr	185,311	2,156,352	854,631
Operating Labor-Note 3.	$/yr	3,886	3,886	3,886
Maintenance Labor-Note 4	$/yr	3,718	3,718	3,718
Maintenance Mat'l-Note 5	$/yr	3,718	3,718	3,718
Overhead-Note 6	$/yr	6,793	6,793	6,793
Other costs-Note 7	$/yr	24,930	45,138	36,074
Capital Recovery	$/yr	68,433	123,903	99,024
Total Annual Cost		317,158	2,581,646	1,102,513

Note 1. Fan power based on 4 inch pressure drop through incinerator and 15 inch pressure drop through 70% efficient heat exchanger. Fan/motor efficiency = 60%. Operation 4171 hours per year. Electricity cost = 0.06/kWhr.

Note 2. Operation at 1400 degrees F, 4171 hours per year. Gas at $0.003/SCF.

Note 3. Operator labor 0.5 hr/shift at $12.96/hr. Supervisory labor = 15% of operating labor.

Note 4. Maintenance labor 0.5 hr/shift at $14.26/hr.

Note 5. Maintenance material assumed equal to maintenance labor.

Note 6. Overhead assumed 60% of labor plus maintenance materials.

Note 7. Administrative charges, property taxes and insurance assumed to be 4% of total capital cost.

Table 6-29. Cost Effectiveness of Control Options A and B for Control of Model Flexographic Printing Plants.

Model Plant	1	2	3
Control Option A			
HAP Reduction (lb/yr)	9,825	46,788	969
Annual Cost	$195,906	$1,353,943	$602,807
Cost Effectiveness ($/Ton)	39,879	57,876	1,244,184
Control Option B			
HAP Reduction (lb/yr)	19,651	93,575	1,938
Annual Cost	$317,158	$2,581,646	$1,102,513
Cost Effectiveness ($/Ton)	32,279	55,178	1,137,784

6.5 REFERENCES

1. U. S. Environmental Protection Agency. OAQPS Control Cost Manual, Fourth Edition. EPA-450/3-90-006, January, 1990. p. 3-42 to 3-58.

2. U. S. Environmental Protection Agency. OAQPS Control Cost Manual, Fourth Edition. EPA-450/3-90-006, January, 1990. p. 3-42 to 3-58.

TECHNICAL REPORT DATA

(Please read Instructions on reverse before completing)

1. REPORT NO EPA-453/R-95-002a	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE National Emission Standards for Hazardous Air Pollutants: Printing and Publishing Industry Background Information for Proposed Standards		5. REPORT DATE February 1995 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Emission Standards Division (MD-13) Office of Air Quality Planning and Standards Research Triangle Park, NC 27711		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO
12. SPONSORING AGENCY NAME AND ADDRESS Director Office of Air Quality Planning and Standards Office of Air and Radiation U.S. Environmental Protection Agency Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Final 14. SPONSORING AGENCY CODE EPA/200/04
15. SUPPLEMENTARY NOTES		

16. ABSTRACT National emission standards for the control of hazardous air pollutants from the printing and publishing industry are being proosed under the authority of Section 112 of the Clean Air Act. This document contains background information and environmental and cost impact assessments of the regulatory alternatives considered in developing the proposed standards.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Printing Publishing Rotogravure Flexography Hazardous Air Pollutants	Air Pollution control	
18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS *(Report)* Unclassified	21. NO. OF PAGES 176
	20. SECURITY CLASS *(Page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE