Manufacture and Use of Printing Inks- Generic Scenario for Estimating Occupational Exposures and Environmental Releases

-Draft-

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) with support from Eastern Research Group, Inc. (ERG) has developed this draft scoping document for an Emission Scenario Document (ESD) on Manufacturing and Use of Printing Inks. The document is being distributed to the Organization for Economic Co-operation and Development (OECD) member countries to solicit input and data for the development of an ESD on these chemicals.

1.1 Purpose

OECD ESDs provide information on the sources, use patterns, and potential release pathways of chemicals used in a particular industry. The first step in preparing an ESD is clearly identifying the scope or industry/chemical sector that will be investigated to ensure a useful and manageable document is developed. This document presents a proposed scope for developing an ESD covering Manufacturing and Use of Printing Inks. To determine the scope, readily available data[1] are reviewed to clearly identify the different categories of operations and chemicals that may be utilized within an industry sector. Pre-manufacture Notice (PMN) submissions (EPA's new chemicals review program) are also reviewed to determine the specific types of chemicals commonly reviewed and the data typically unavailable for new chemicals substances. Based on these data, the specific processes, operations, and chemicals covered under the scope of an ESD may be identified.

1.2 Proposal Summary

Based on readily available information obtained on the manufacturing and use of printing inks, it appears that information currently available in the current generic scenario will need to be updated in order to reflect current release and exposure estimates and current market and technology trends in the printing industry. A search of recent PMN submissions indicates that most submissions provide sufficient information to complete a screening-level review of environmental releases and occupational exposures to new chemicals during the formulation of printing inks, but do not provide sufficient information to estimate environmental releases of and occupational exposures to these chemicals during the various use of the inks in printing processes. All submissions utilized the current 1994 generic scenario which contains outdated information and models to estimate releases and exposures. Therefore, it is recommended that the ESD focus on providing updated data and developing updated models to reflect current technologies.

The proposed ESD would track the use of chemicals used to formulate printing inks and the subsequent use of these inks in printing operations, and update releases and exposures to these chemicals. The following diagram demonstrates the applicability of this scenario.

[1] See Appendix A for a list of sources investigated.

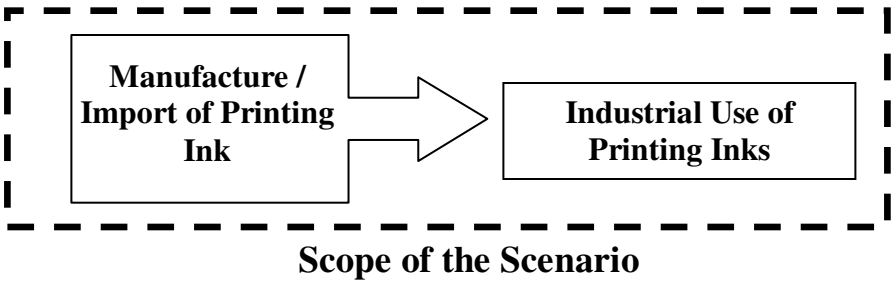


Figure 1-1: Proposed Scope of Emissions Scenario Document for Printing Inks

2.0 INDUSTRY BACKGROUND AND PROCESS SUMMARY

In 2007, the US Census Bureau reported 473 establishments under NAICS code 325910 for printing ink manufacturing, employing 7,432 production workers. The sales of all printing inks generated 4,990 millions of dollars in 2007, which presents a market growth of 18.3% domestically since 2002.

Printing inks are comprised of a colorant or variety of colorants dispersed in a vehicle to form a paste, liquid, or solid that is subsequently applied to a substrate surface and dried. Colorants used include numerous pigments, dyes, and toners. The vehicle, which is the majority of the printing ink composition, usually consists of several types of substances including solvents, binders, thinners, dispersing agents, and drying agents. The vehicle acts as a carrier of the colorant during the printing process and serves to bind the colorant to the substrate after drying.

Because printing inks come in either solid, liquid, or paste form, viscosities and physical and chemical properties vary depending on the type of printing process for which the ink will be used. Table 2-1 summarizes the viscosities and dried film thickness of various inks based on printing process use.

Table 2-1: Typical Physical Properties of Inks

Printing Process	Viscosity (Pa.s)	Dried Film Thickness (μm)
Off-set lithography	4 – 80	0.7 – 1.5
Flexography	$5 \times 10^7 – 5 \times 10^8$	1 – 3
Gravure	$4 \times 10^7 – 3 \times 10^8$	3 - 8
Letterpress	3 – 50	2 - 3
Screen	1 – 20	25 – 100
Intaglio	10 - 100	10 – 40
Ink jet	$1 \times 10^6 – 3 \times 10^6$	1 – 2

Source: Kirk-Othmer, "Inks", August 2004

It was estimated that approximately 97% of all industrial end use printing activities can be categorized within five different printing processes: lithography, flexography, gravure, letterpress and screen printing (OECA, 1995). In recent years, digital printing and quick printing, which primarily utilizes digital printing methods, has become an increasingly popular method of printing for many businesses. However, despite decreasing market share, the traditional industrial printing processes remain the dominant methods for printing magazines, newspapers, packaging, consumer paper product, etc. Table 2-2 summarizes the 2007 Economic Census data for these major commercial use industries for printing inks.

Table 2-2: 2007 Economic Census Data for Printing Ink Use Industries

NAICS Code	NAICS Description	No. of Establishments	No. of Production Workers	Annual Sales ($1,000)
323110	Commercial Lithographic Printing	13,197	225,207	53,451
323111	Commercial Gravure Printing	288	14,505	4,074
323112	Commercial Flexographic Printing	973	23,289	7,303
323113	Commercial Screen printing	4,730	48,728	8,628
323114	Quick Printing	6,157	21,064	3,246
323115	Digital Printing	2,477	25,865	6,437
323119	Other Commercial Printing[1]	1,916	13,136	2,484
Industry Averages		**4,221**	**64,973**	**15,188**

Source: Census, 2007 (data as of September, 2009)
[1]This category includes letterpress printing processes

While each printing process is unique, they all contain the same basic process sequence of imaging, pre-press, printing, and post-press operations. Imaging involves the production of a positive or negative image to be printed on the substrate. The image can be photographic or digital, which has become more common in recent years. In pre-press operations, the image carrier is produced to transfer ink to the desired imaging areas. The printing operation is where the ink is applied to an imaging plate, transferred, and dried onto a substrate. The final post-press operation involves any number of finishing operations (e.g. cutting, sizing, binding). Printing inks are not introduced to the process until the actual printing operation; therefore, this operation will be the focus of releases and exposures relating to printing inks.

2.1 Manufacturing of Printing Inks

The manufacturing of printing inks consists of two major processes: vehicle preparation and dispersion. Vehicle preparation consists of creating and mixing all other components of the ink except the dye or pigment. The process can consist of polymerization of resins, solvent mixing, and dissolving of other solid and liquid components. These processes are conducted in various types of autoclaves, reactors and high speed mixers. The dispersion stage is where dyes and pigments are added to the ink vehicle to form the final product. Dispersion is done in ball or media mills. The type of media used in the mills depends on the color, texture and final use of the ink product (Kirk-Othmer, 2004). Figure 2-1 shows the basic process flow for printing ink manufacturing.

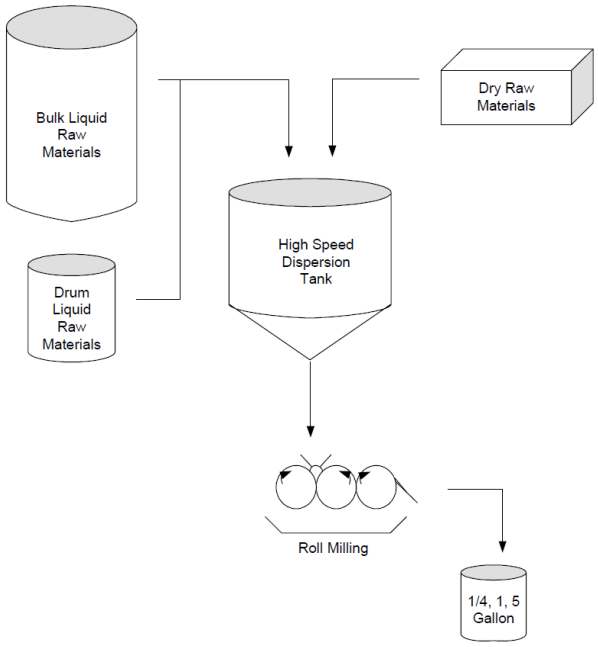


Figure 2-1: Basic Inks Manufacturing Process Flow Diagram (OECA, 2005)

The majority of liquid components used in ink manufacturing are volatile organic compounds (VOC) which typically make up the solvent portion of the ink. The dry components are typically pigment or dye powders. VOC and particulate emissions are expected from the unloading of raw materials into the dispersion tank. Additional VOC emissions are expected as a result of heat-up losses and surface evaporation during the dispersion and milling operations as well as during the loading of the final ink product into receiving containers. There are typically control measures in place to reduce the emissions generated by VOC and particulates during ink manufacturing. Table 2-3 provides a summary of several of these control methods.

Table 2-3: Summary of Control Technologies Used in Printing Ink Manufacturing

Control Type	Control Technology
Recovery Devices	Condensers
	Adsorption Devices
	Dust Collectors (e.g. bag house)
	Floating Roofs on Storage Tanks
Destructive Devices	Catalytic Incinerators
	Thermal Incinerators
	Venturi Scrubbers
	Enclosed Oxidizing Flares
Equipment/Process Modifications	Covered Mixing Tanks
	Enclosed Mills
	Use of Pigment Pastes (i.e. no particulates)
	Product Reformulation (e.g. convert to water-based or solid inks)

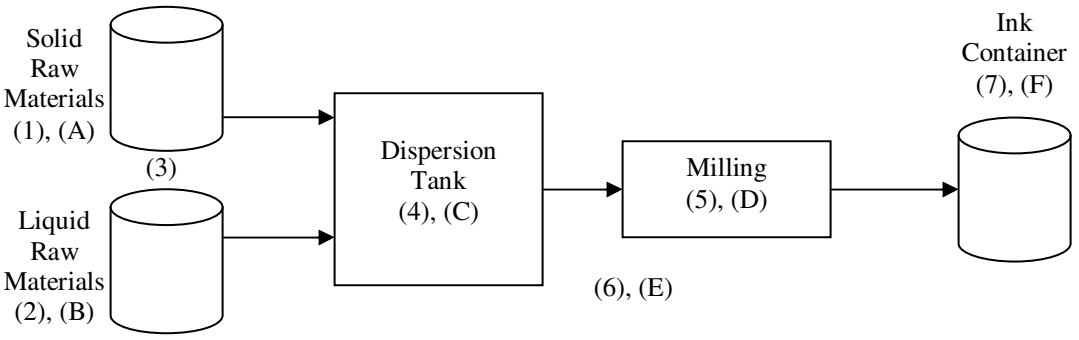
Additional environmental releases are expected from waste streams associated with container and equipment cleaning. Workers are likely to encounter both inhalation and dermal exposure during handling of raw materials and ink products as well as equipment cleaning. Data from the 2007 Toxics Release Inventory (TRI) was collected and analyzed to identify recent trends in environmental release media. Table 2-4 summarizes the results from this data search.

Table 2-4: 2007 TRI Data for Printing Ink Manufacturing

NAICS Code	NAICS Description	Number of Facilities Reporting	Air Releases (lb/yr)	Water Releases (lb/yr)		Land Releases (lb/yr)	Other Disposal (lb/yr)
				Surface Water	POTW/ Wastewater		
325910	Printing Ink Manufacturing	160	190,832	29	823	5,561	51,303

Source: 2007 TRI

The TRI data suggests air is the most prominent environmental release media during the formulation of printing inks with the remaining releases being contributed mainly to landfill and other disposal. Figure 2-2 gives a summary of the potential environmental releases and occupational exposures from a typical printing ink manufacturing process.



Environmental Releases:
1. Releases from solid particulate during unloading
2. Fugitive air releases from volatile liquids during unloading
3. Container Residue
4. Fugitive air releases from dispersion tank
5. Fugitive air releases from milling
6. Equipment cleaning residue
7. Fugitive air releases from volatile components during loading of ink

Occupational Exposure:
A. Dermal exposure solid raw materials and inhalation exposure to particulate
B. Dermal exposure to liquid raw materials and inhalation exposure to volatile materials
C. Inhalation exposure to fugitive air emissions from dispersion tank
D. Inhalation exposure to fugitive air emissions from milling
E. Dermal and inhalation exposure during equipment cleaning
F. Dermal exposure to ink during loading and inhalation exposure from volatile components

Figure 2-2: Typical Release and Exposure Points During Printing Ink Manufacturing

2.2 Use of Ink in Printing Processes

As previously discussed, most modern industrial printing processes can be categorized as lithographic, flexographic, gravure, letterpress, or screen printing with digital printing and other plateless printing technologies becoming more prominent. The following sections describe each of these printing methods and the typical environmental releases and occupation exposures expected in the printing industry.

2.2.1 Lithography

The lithography process is based on the immiscibility of oil and water. The image area on the printing plates is photochemically treated to absorb an oil-based ink in the image areas and to absorb only water in the non-image areas. At the printing facility, the ink paste is unloaded from a container into an ink tank on the printing machine. The machine is set in motion and ink is transferred first to the ink rollers, then to the printing cylinder, then to the intermediate blanket roll, and finally to the paper. Depending on the final printed product, additional roller units may be utilized to add various colors and dimension to the printed image. Lithography presses may be web-fed, sheet-fed, non-heat-set-fed, or heat-set-fed. The web-fed process is the most commonly used method in the lithographic printing industry and is used in the production of articles such as periodicals, newspapers, advertising, and books. Figure 2-3 shows a diagram of a simple lithographic printing process.

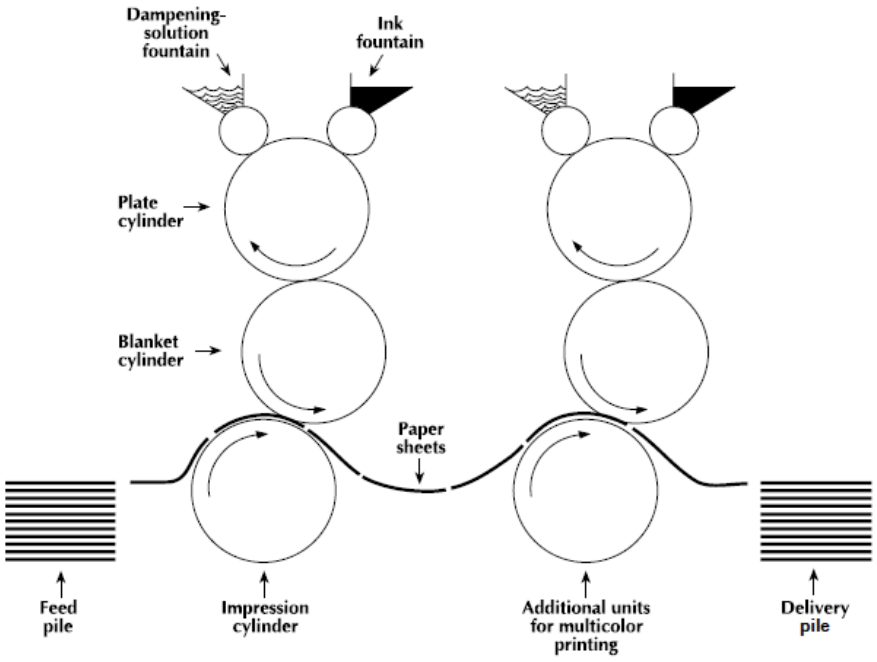


Figure 2-3: Simplified Lithographic Press Layout (OECA, 1995)

2.2.2 Gravure

Gravure printing utilizes an engraved cylinder to act as the ink carrier and separate the image areas from the non-image areas. The cylinder contains minute cells that make up the image. During the printing process, ink is applied to the engraved cylinder, then wiped from the surface by the doctor blade, leaving only ink on the engraved image area. The printing substrate is then brought into contact with the cylinder with enough pressure to collect the ink in the depressions of the cylinder. Low viscosity inks are required for gravure printing to allow proper dispersion into the tiny engraved cells. The substrate will then pass through a drying oven to drive off the ink solvents. Figure 2-4 shows the general layout of a rotogravure press.

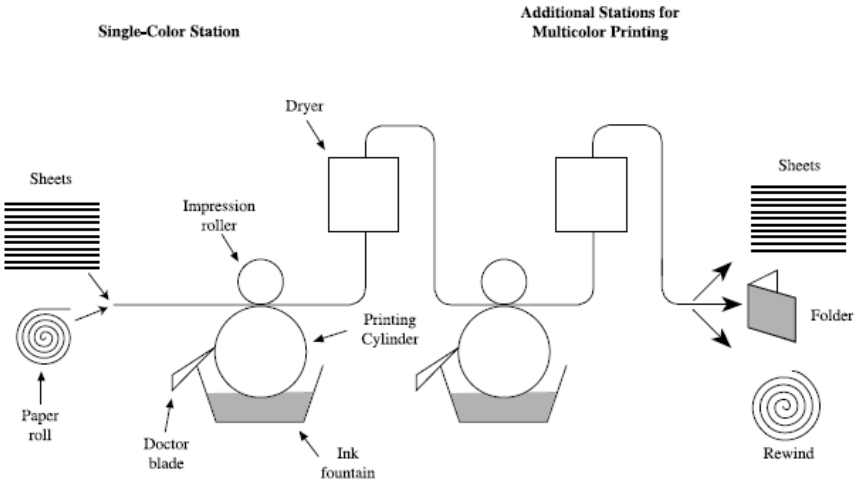


Figure 2-4: Rotogravure Press (OECA, 1995)

2.2.3 Flexography

Flexographic printing typically utilizes printing plates made of a flexible material like rubber or plastic. The image is raised relative to the non-image areas. The substrate is fed into the press, then travels through a series of roller stations where different colored inks are applied. Each roller station is equipped with an overhead dryer section to dry the ink before the substrate proceeds to the next station. After the substrate has passed through all printing stations, the substrate web will typically move through an overhead tunnel dryer to remove all residual solvents. The finished product is rewound onto a roll. As with gravure printing, low viscosity, fast drying inks are used for flexography. The ink tray used on larger flexographic presses is very long, allowing for significant evaporation of ink. Modern presses are now equipped with enclosed doctor blade systems which eliminate the fountain roller and fountain, thereby reducing evaporation losses. Printers with the more narrow presses generally use water based inks and UV coatings as using UV inks reduces the volatility of the ink. Figure 2-5 shows a diagram of a typical web-fed flexographic printing press.

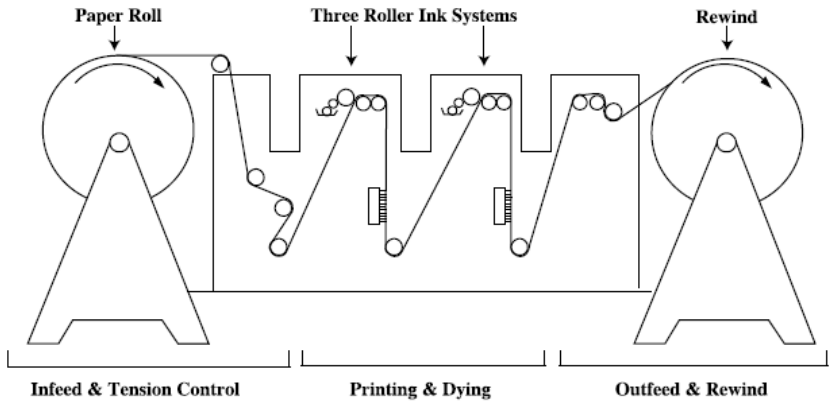


Figure 2-5: Web-fed Rotary Flexographic Press (OECA, 1995)

2.2.4 Letterpress

Letterpress is the oldest printing process and utilizes raised plates similar to flexographic printing. The use of letterpress printing has decreased substantially as it is being gradually replaced with other printing methods. Web-fed presses are the most popular method for letterpress printing. Similar to the previously described process, the substrate is fed through a series of rollers where the ink is applied and subsequently dried. Figure 2-6 shows a diagram of a typical rotary type letterpress printing press.

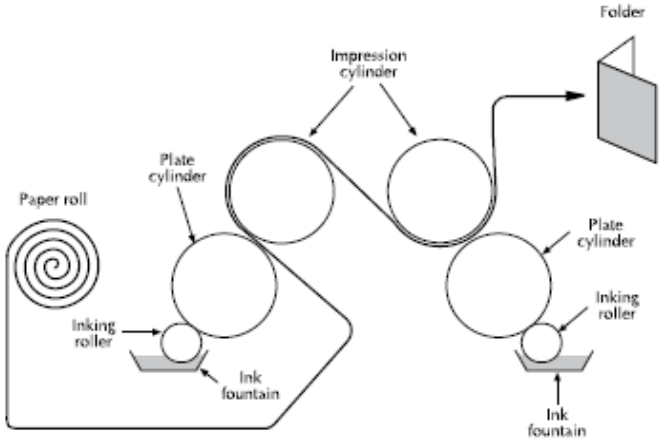


Figure 2-6: Rotary Letterpress Press (OECA, 1995)

2.2.5 Screen Printing

Unlike the other traditional printing methods previously described, screen printing does not utilize impervious plates to print images but rather a porous mesh. The mesh is stretched tightly over a frame and a stencil defining the image is applied to the mesh. Ink is applied to the mesh frame and a squeegee is used to apply pressure to the ink to force it through

the mesh and onto the substrate. In a rotary screen printing press, magnetic force is typically used to control the squeegee pressure. This type screen printing is represented in Figure 2-7.

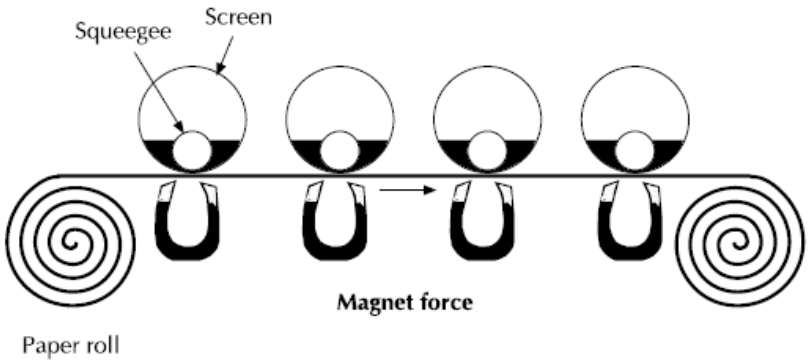


Figure 2-7: Rotary Screen Printing Press (OECA, 1995)

2.2.6 Digital Printing

Digital printing is growing as an alternative method to traditional printing methods. While the largest utilization exists as smaller operations using single sheet feeds and quick printing business models, advances in technology have allowed the development and use of continuous digital printing press operations. Pre-press operations involve the creation and manipulation of the image on digital media (i.e. computers). The digital image is then transferred onto the substrate using several methods including electrophotography and ink jet printing. Ink jet printing is the most common method utilized in digital printing. During ink jet printing, small drops of ink are propelled onto the substrate with direct contact between the nozzle and the substrate. The properties of the ink drops are controlled by several variables including the nozzle size, pumping pressure, and viscosity of the ink. Several types of inks can be used for digital printing. These include solid ink jet, wet/dry toner systems, and liquid ink jet.

2.2.7 Release and Exposure in the Printing Industry

A large portion of the releases from the printing industry are associated with VOC emissions. These come from the volatile components in the printing inks as well as from various solvents that are used for equipment cleaning. Air emissions are likely to result from unloading inks into the ink reservoirs on the printing press, the generation of ink mist during high speed printing operations, and fugitive emissions from various source points in the printing process (e.g. ink reservoirs, drying ovens). Additional environmental releases of chemicals contained in printing inks can result from residual ink wastes from container cleaning, and disposal of rags and solvents used to wipe down and clean printing equipment. Inhalation exposure among production workers is likely to occur as a result of potential emissions with major contributions coming from ink handling and ink mist generation from printing equipment. Dermal exposure to inks and cleaning solvents are expected during material unloading and cleaning of the printing equipment.

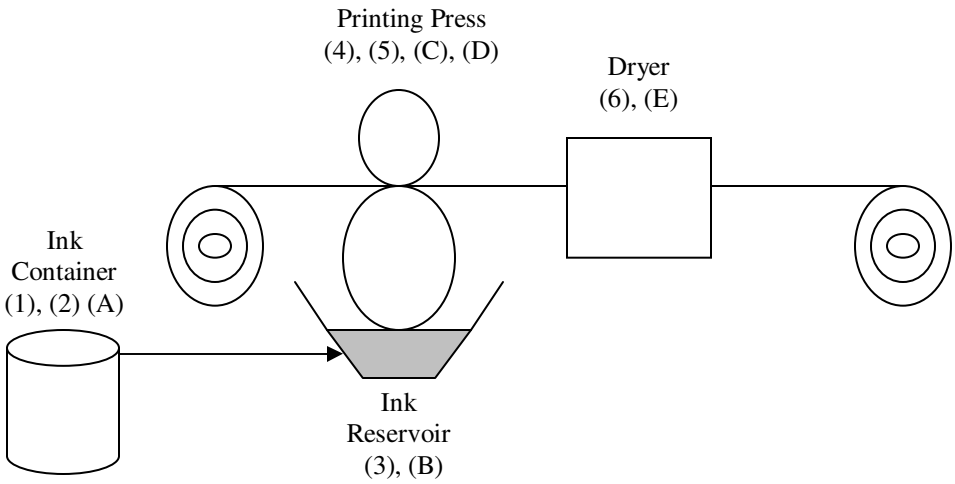
Data from the 2007 Toxics Release Inventory was also collected and analyzed to identify recent trends in environmental release media for each major type of printing process. Table 2-5 summarizes the results from this data search.

Table 2-5: 2007 TRI Data for Commercial Printing Industry

NAICS Code	NAICS Description	Number of Facilities Reporting	Air Releases (lb/yr)	Water Releases (lb/yr)		Land Releases (lb/yr)	Other Disposal (lb/yr)
				Surface Water	POTW/ Wastewater		
323110	Commercial Lithographic Printing	159	5,865,923	275	1,015	750	177,701
323111	Commercial Gravure Printing	156	11,197,402	275	3,200	603	210,010
323112	Commercial Flexographic Printing	32	272,772	0	0	18,619	22,418
323113	Commercial Screen Printing	23	19,069	2	48	2,696	41,215
323115	Digital Printing	8	72,823	0	1	11	1,767
323119	Other Commercial Printing	16	14,150	0	313	3,337	8,136

Source: 2007 TRI

The TRI data suggests that air is the most prominent environmental release media for all commercial printing operations with the remaining releases being contributed mainly to landfill and other disposal. Figure 2-8 gives a summary of the potential environmental releases and occupational exposures to printing ink during a generic printing process.



Environmental Releases:
1. Container residue
2. Fugitive air releases during unloading from volatile components
3. Fugitive air releases from volatile components in ink reservoir
4. Fugitive air releases from ink mist generated by printing press
5. Equipment cleaning residuals
6. Fugitive air releases of volatile components during drying

Occupational Exposure:
A. Dermal exposure to ink and inhalation exposure to volatile components during unloading
B. Inhalation exposure to fugitive air releases from ink reservoir
C. Inhalation exposure to ink mist generated from printing press
D. Dermal and inhalation exposure during equipment cleaning
E. Inhalation exposure to fugitive air releases from drying

Figure 2-8: Typical Release and Exposure Points During Printing Operations

3.0 PMN DATABASE SEARCH

EPA maintains a database of the functions and uses of chemicals reviewed under the Pre-manufacture Notice (PMN) program (EPA's new chemicals review program). Chemicals received from 2000 to December 2009 were reviewed to help identify and narrow the scope of the ESD. All submissions related to manufacturing and uses of printing inks were searched. The keyword "printing inks" was used for this search. A total of 105 submissions were identified. Fourty-one submissions were low volume exemption cases. The most recent 15 submissions were reviewed. Based on the process description in the reviewed submissions, all 15 chemicals utilize the same type of printing ink formulation process. Key findings from the review are presented as follows:

- All chemicals were non-volatile (VP < 0.001 torr);
- 6 chemicals were non-volatile liquids, 9 chemicals were non-volatile solids;
- Of the 9 solid chemicals, 5 assessed fugitive releases during unloading using the 2007 Dust Model and inhalation to particulates.

- 8 chemicals were manufactured or imported in 100% concentration; 7 chemicals were manufactured or imported in concentrations < 100%.
- 12 chemicals were either imported, or both imported and domestically manufactured; 3 chemical were only manufactured domestically.
- 6 chemicals were colorants; 9 chemicals were other additives.
- 8 of the 15 cases conservatively assessed releases from equipment and container cleaning during ink formulation; the remaining cases used submission specific information.
- None of the submissions specified the use of control technologies.
- All cases used the roll coating model to assess inhalation exposures to ink mists during use.
- All cases referenced the 1994 Generic Scenario: *Manufacturing and Use of Printing Inks* for release media for equipment cleaning and container residuals during use operations and for ink mist concentrations during printing to assess inhalation exposures. One case referenced the Generic Scenario on UV Curable Coatings.

4.0 PROPOSED SCOPE

This section presents a more detailed analysis of the proposed scope presented in Section 1.2. Conclusions made based on the industry sector or the PMN database search are presented below.

4.1 Scope Definition

Based on existing generic scenarios, literature reviewed, and a search of the PMN database, it is recommended that the ESD focus on both the manufacturing and use of printing inks. Results from the PMN database search revealed that all submissions reviewed were required to assess both manufacture (i.e., formulation) and use of printing inks.

The PMN database search also revealed the majority of chemicals used to formulate printing inks are imported and all chemicals were non-volatile. Most of the submissions provided specific information on release media for equipment and container cleaning and other specific activities during ink manufacturing. A few did not provide specific information and environmental releases were conservatively estimated. During ink use, the 1994 Generic Scenario: Manufacturing and Use of Printing Ink was referenced to assess exposures to ink mists and environmental releases from equipment and container cleaning due to lack of specific information provided in the submission.

The scope of the proposed ESD will cover the following process activities (to estimate releases and exposures):

- Disposal of container residue during printing ink manufacturing and use;
- Disposal of equipment residue during printing ink manufacturing and use;
- Exposures during ink manufacturing;
- Process specific environmental releases and occupational exposures during printing; and

- Use of control technologies used to mitigate environmental releases and occupational exposures.

4.2 Recommendation for Scenario Development

EPA recommends developing an updated ESD for chemicals used in the manufacturing and use of printing inks for the following reasons:

- All recent PMN submissions reviewed assess both manufacturing and use of printing inks.
- All submissions utilize the 1994 Generic Scenario: *Manufacturing and Use of Printing Ink* which provides outdated information on estimates for number of workers, number of facilities, estimated use rate for each printing process, and ink mist concentrations during printing.
- Current technology trends are not accurately reflected in the 1994 generic scenario. Digital printing is slowly becoming a more prominent printing process and needs to be further evaluated for environmental releases and occupational exposures.

Figure 4-1 illustrates the proposed ESD scope for the manufacturing and use of printing inks.

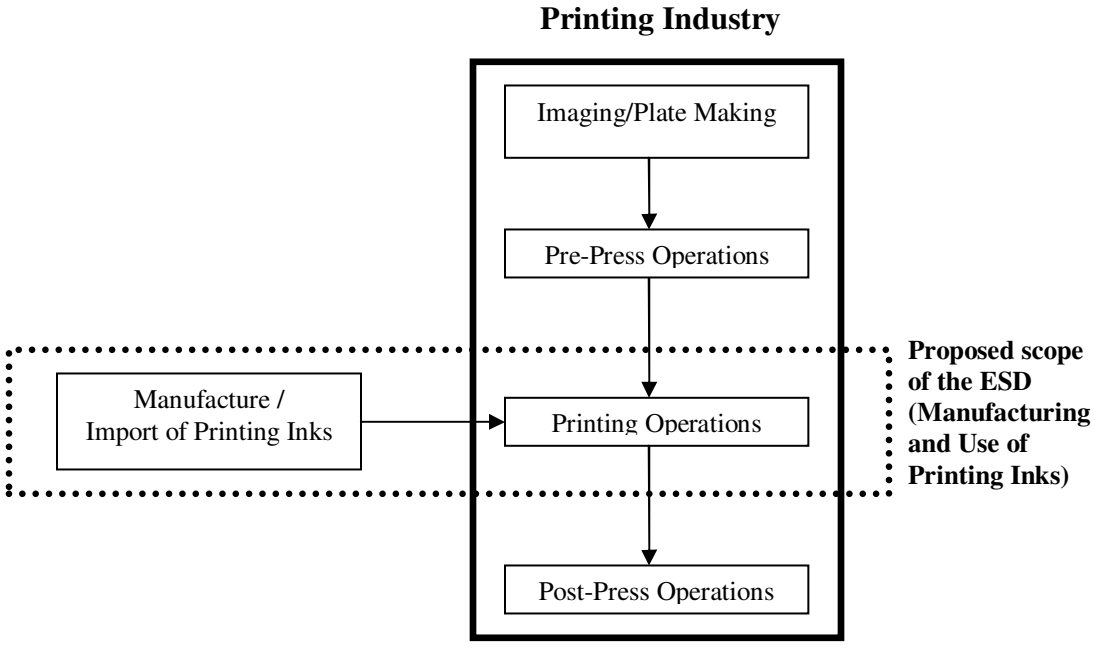


Figure 4-1: Proposed Scope of Emission Scenario Document

5.0 SOURCES INVESTIGATED AND NECESSARY RESEARCH

For the development of this document, readily-available sources were investigated. Phase 1 of the Literature Search in the *Generic Scenarios Development Process* (CEB, 2006) was completed. Appendix A presents the specific sources investigated. As the scenario is developed, scientific literature and other more specialized sources will be investigated as presented in Phase 2 of the Literature Search. A summary of the key sources identified is presented below. Note that the following list of resources does not go into great detail about the specific contents of each article as most of the information found during this search is presented in the previous sections.

5.1 Sources Investigated

Kirk-Othmer Encyclopedia of Chemical Technology, "Inks", "Printing Processes." "Inks" provides a detailed description on the different types of printing inks, the manufacturing processes, and typical chemicals used in printing inks. "Printing Processes" provides a detailed description on the various types of printing processes.

EPA Office of Compliance Sector Notebook Project, Profile of Printing and Publishing Industry. Sept 1995. EPA/310-R-95-014. This document provides process descriptions, release information, number of facilities, sales and industry trend for the overall printing industry.

U.S. EPA, Office of Air. *Methods for Estimating Air Emissions from Paint, Ink, and Other Coating Manufacturing Facilities*. Feb. 2005. This documents provides emission sources and control technologies relevant to the formulation of printing inks.

U.S. EPA. *Generic Scenario: Manufacturing and Use of Printing Inks*. 1994. This scenario provides general information on release and exposure.

U.S. Census Bureau, *2007 Economic Census, Printing Ink Manufacturing.* This report contains 2007 statistics on the number of establishments, sales and business patterns for the printing ink manufacturing industry.

U.S. Census Bureau, *2007 Economic Census, Printing.* This report contains 2007 statistics on the number of establishments, sales and business patterns for the printing industry.

U.S EPA, *2007 Toxics Release Inventory*. This dataset provides updated estimates on environmental releases printing ink manufacturing and use industries.

5.2 Necessary Research

In order to complete the proposed ESD, additional information is needed to fill certain data gaps. These data are critical to the estimation of conservative release and exposure values from the use of chemicals in the manufacturing and use of printing inks. The following are areas identified that require additional research:

- Disposal of container and equipment residuals
    - Literature reviewed indicates most waste streams associated with the manufacture and use of printing inks are disposed of off-site. However, the method of disposal for off-site wastes is unclear. Additional research will be needed to identify the most prominent release media for these wastes.

- Digital Printing Processes
    - Recent industry trends and literature reviews indicate digital printing processes are becoming a more dominant in the printing industry. Additional research will need to be conducted to evaluate releases and exposures specific to digital printing.

- Efficiency of control technologies
    - Literature reviewed indicates several types of control technologies are used in the formulation of printing inks. However, additional information on the efficiency of these control technologies is needed.

6.0 REFERENCES

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(U.S. Census Bureau, 2007) 2007 Economic Census, *Printing*.

APPENDIX A: LITERATURE SEARCH DOCUMENTATION

Generic Scenario Literature Search Documentation Table (January 20, 2005 version)

Phase 1: Standard Literature Search
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Phase 1 Completion Date: 1/13/10

Primary Keywords: printing inks, printing industry, printing process

Phase 1, Part 2: Search of Standard CEB Sources

Source	Search Description	Results
U.S. EPA CEB	Followed GS Literature Search SOP.	Located relevant resources for printing ink manufacturing and printing industry study
U.S. EPA TRI	Followed GS Literature Search SOP.	TRI Guidance document for Printing Publishing and Packaging. Chapter 3 lists several general chemicals used in the industry but does not contain information specific to thin film.
U.S. EPA Office of Water	Followed GS Literature Search SOP.	No industry specific information found.
U.S. EPA Office of Air	Followed GS Literature Search SOP.	EIIP Volume 2 guidance document for printing ink manufacturing, containing a process description, types of chemicals used, general potential release points (no loss fraction), and types of control technologies (no efficiency).
U.S. EPA OECA Sector Notebooks	Followed GS Literature Search SOP.	Profile on the Printing and Publishing Industry, containing 1995 data on number of facilities, sales, industry trend, process description, types of chemicals used, description of general wastes, recycling activity for overall printing industry, and TRI data for the printing industry.
U.S. EPA AP-42	Followed GS Literature Search SOP.	Emissions factors for printing ink manufacturing.
Other U.S. EPA (e.g., DfE)	Followed GS Literature Search SOP.	General information on the printing industry.
SRI	Followed GS Literature Search SOP.	Market profile, annual consumption of various printing ink types, and expected growth of printing industry.
OSHA	Followed GS Literature Search SOP.	Potential exposure to workers from several specific common chemicals currently used in printing inks.
NIOSH	Followed GS Literature Search SOP.	Monitoring data from health hazard evaluations of two printing shops.
OECD	Followed GS Literature Search SOP.	OECD ESD on Printing Industry is current a project in preparation. OECD ESD on Formulation of Radiation Curable Coatings, Inks and Adhesives was unavailable.

Phase 1, Part 2: Search of Standard CEB Sources

Source	Search Description	Results
Environment Canada	Followed GS Literature Search SOP.	No industry specific information found.
Canadian P2 Information Clearinghouse	Website is not available.	General information on releases from the printing industry.
U.S. Census Bureau	Followed GS Literature Search SOP.	NAICS 325910 (Printing Ink Manufacturing), 323110 (Lithography), 323111 (Gravure), 323112 (Flexography), 323113 (Screen), 323115 (Digital), 323114 (Quick Printing), and 323119 (Other). County business patterns, annual survey of manufacturers, current industrial reports and economic census for the printing ink manufacturing and printing industries.
NC Division of Pollution Prevention and Environmental Assistance	Followed GS Literature Search SOP.	Fact sheets, case studies on pollution prevention in printing industry.
Kirk-Othmer	Followed GS Literature Search SOP.	Technical information on the printing inks, ink manufacturing, and printing processes.
Other Sources: U.S. EPA, OPPT/CEB	Search for past Generic Scenarios	1994 Generic Scenario on Manufacturing and Use of Printing Ink includes general information on release and exposure.