Inks in the study

The ink systems

The study examined the three main flexo ink systems: solvent-based, water-based, and UV-cured. To investigate whether any one ink system showed clear advantages in terms of health, safety, or environmental aspects, the study compared the three ink systems and looked at the chemicals and chemical categories in the individual inks.

The primary difference among the ink systems is the method used for drying or curing the ink. Solvent-based and water-based inks are dried by evaporation, whereas UV-cured inks are cured by chemical reactions. Flexo inks contain components that are responsible for several main functions, including solvents, colorants, resins, additives, and (for ultraviolet inks only) UV-curing compounds.

Solvent-based inks

Solvent-based inks are generally considered the industry standard for ease of use and quality of printing, and they are widely used in flexo. However, because these inks dry by evaporation, the solvents usually contain significant amounts of VOCs, which have notable health and safety concerns. VOCs are usually very flammable, and they contribute to the formation of ground-level ozone (a component of smog), which causes respiratory and other health problems. Solvent-based ink systems are equipped with oxidizers and other pollution-control devices to destroy VOCs.

Water-based inks

Although the primary solvent in water-based inks is water, these inks can and usually do contain VOCs, up to a maximum of 25% by volume. They may also contain one or more of the 188 hazardous air pollutants that were listed in the 1990 Clean Air Act. Depending on their HAP and VOC content, water-based inks may or may not have fewer health and environmental concerns than traditional solvent-based inks. (Note that in some locations and for some water-based inks, oxidizers must be used to destroy VOCs and most HAPs.) Also, again depending on their VOC content, water-based inks show a range of flammability. Some of them are not at all flammable, but others are as flammable as some solvent-based inks.

UV-cured inks

UV-cured inks are the newest ink system to make major progress in flexo. The use of UV inks has been steadily increasing, especially for narrow-web labels and tags. Chemicals in UV-cured inks form solids and bond to the substrate when they are exposed to ultraviolet light, whereas solvent-based and water-based inks dry by evaporation. Because of this difference, UV-cured inks do not contain traditional solvents, so they may have very low VOC content. However, they do contain many chemicals that have not been tested comprehensively for environmental, health, and safety impacts.

Functional components of flexo ink chemicals

Chemical components allow ink to adhere to a substrate. These components can be divided into five basic functional categories:

- Solvents
- Colorants
- Resins
- Additives
- UV-curing compounds

Some chemical categories are called "multi-functional." A category with this label contains multiple chemicals that serve different functions. Thus chemical A might be a solvent and chemical B an additive. Each chemical was assigned to only one functional category.

Solvents help deliver the ink to the substrate. The solvent allows the ink to flow through the printing mechanism, and then the solvent evaporates so that the ink forms a solid coating on the substrate. Typically, inks are manufactured and transported in a concentrated form, and the printer must add solvent to the ink to attain the desired viscosity (flow). A solvent must adequately disperse or dissolve the solid components of the ink, but it must not react with the ink or with any part of the press. It must dry quickly and thoroughly, and have little odor.

Colorants give inks their color. The two types of colorants used in printing are dyes and pigments. Dyes can be useful when transparency is desired, and the colors of dyes are often quite strong. However, dyes can be susceptible to attack by chemicals and water, and they can also be toxic. Pigments are small, insoluble particles. Some pigments can also be toxic. In general, pigment-containing inks are more resistant to chemicals and heat and are less prone to bleeding through the substrate than are dye-containing inks. The inks used in this study contained pigments, including those that are based on organic, inorganic, and organometallic structures.

Resins cause ink to stick to the substrate. They also disperse the pigment and give gloss to the finished coating. Resins can provide flexibility, scuff resistance, cohesive strength, block resistance, and compatibility with printing plates. Common categories of resins include nitrocellulose, polyamides, carboxylated acrylics, and polyketones.

Additives are used to improve the performance of inks. Plasticizers enhance the flexibility of resins. Waxes and other slip additives provide lubrication to the dried ink and resist damage from rubbing and scuffing. Wetting agents modify the surface tension to help inks stick to the substrate. Defoaming agents reduce bubble-forming tendencies of water-based inks. Buffers maintain the pH of the ink at a desired level. Inhibitors are used to prevent an unwanted chemical change.

UV curing compounds enable UV inks to chemically change to dry solids that bond with the substrate. Monomers are individual molecular units that can combine to form larger structures known as polymers. Acrylated polyols act as monomers, whereas acrylated polymers can be both monomers and polymers. Oligomers are small polymers that can be further combined to form larger polymers. Photoinitiators, such as aromatic ketones, aromatic esters, and organophosphorous compounds, use UV light to enable a chemical reaction to take place among monomers and oligomers.

Every function is associated with specific categories of chemicals, which are listed in Table 13.

TABLE 13 Chemical Categories by Ink Function

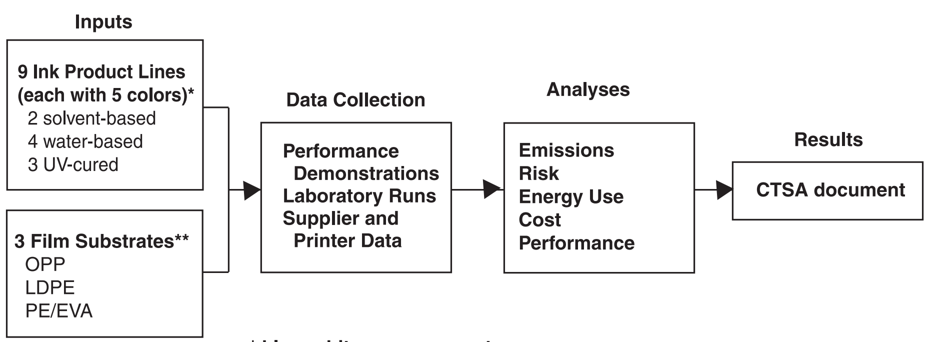
Solvents	Colorants	Resins	Additives	Curing Compounds	Multiple Functions
Solvent-based system					
Alcohols Alkyl acetates Propylene glycol ethers	Organic, inorganic, and organometallic pigments	Polyol derivatives Resins	High-molecular-weight hydrocarbons Organic acids or salts Olefin polymers (waxes) Organotitanium compounds (adhesion promoters) Siloxanes (defoamers and wetting agents)	None	Amides or nitrogenous compounds (slip additives, buffers, inhibitors) Inorganics Low-molecular-weight hydrocarbons
Water-based system					
Alcohols Ethylene glycol ethers Propylene glycol ethers	Organic, inorganic, and organometallic pigments	Resins	Acrylic acid polymers High-molecular-weight hydrocarbons Organic acids or salts Siloxanes (defoamers and wetting agents)	None	Amides or nitrogenous compounds (slip additives, buffers, inhibitors) Inorganics Low-molecular-weight hydrocarbons
UV-cured system					
Alcohols	Organic, inorganic, and organometallic pigments	Polyol derivatives Resins	Aromatic esters (plasticizers) Olefin polymers (waxes) Siloxanes (defoamers and wetting agents)	Acrylated polyols Acrylated polymers Aromatic esters Aromatic ketones Organophos-phorous compounds	Amides or nitrogenous compounds (slip additives, buffers, inhibitors)

Methodology of the flexo ink study

When the study was conducted, UV-cured inks were not being not used commercially to a significant extent to print film substrates on wide-web presses.

The study used a methodology called a Cleaner Technologies Substitutes Assessment (Figure 1). A CTSA systematically evaluates traditional and alternative technologies for the potential risks they pose to human health and the environment, as well as for performance and cost. The objective of this CTSA (the flexo ink study) was to develop a comprehensive and systematic picture of the three primary flexo ink technologies.

FIGURE 1 Study Methodology



* blue, white, cyan, magenta, green.
** OPP = oriented polypropylene. LDPE = low-density polyethylene.
PE/EVA = polyethylene/ethyl vinyl acetate co-extruded film.

The study printed samples using nine ink product lines, each containing five colors (blue, white, cyan, magenta, and green). Altogether, the 45 ink formulations contained more than 100 chemicals. Printing ink suppliers voluntarily provided the ink formulations, which represented the three primary flexo ink systems in use at the time: solvent-based, water-based, and UV-cured. The inks fell into the following categories:

- two solvent-based product lines,
- four water-based product lines, and
- three UV-cured product lines.

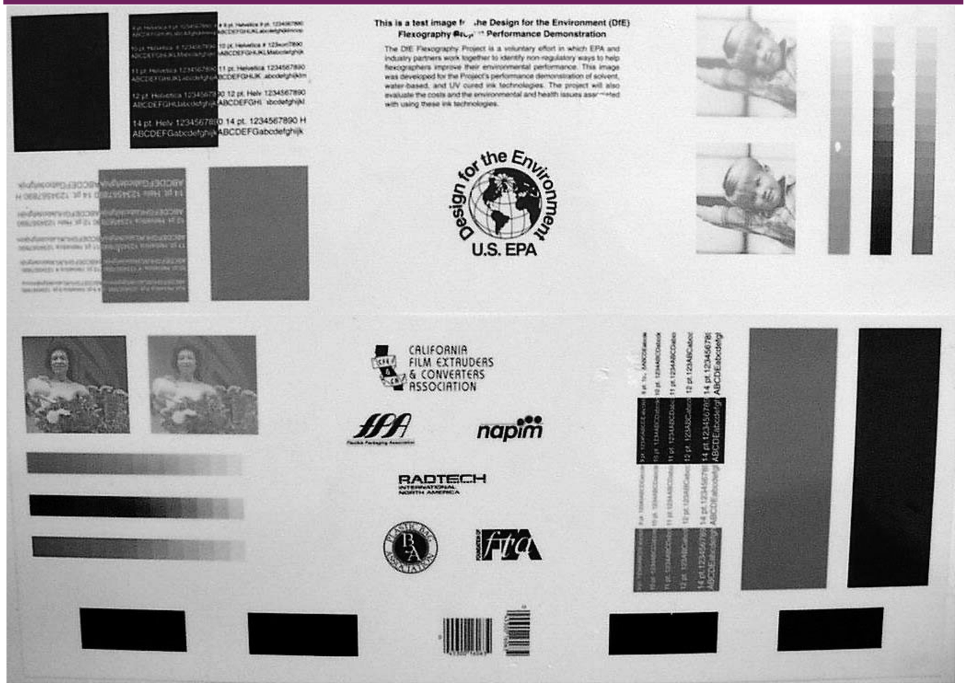
This study was not designed to cover every possible ink formulation, performance category, or substrate type. Rather, it gives a "snapshot" of flexo inks at a specific point in time. This is important, because although this booklet identifies issues to consider when thinking about the "best" inks for workers and the environment, each facility and job is unique, and these results should not be generalized. This booklet can help flexo professionals learn more about integrating risk, performance, and cost considerations to both improve operations and reduce environmental impacts.

Performance

The partners included in the study a series of performance demonstrations — brief printing runs of a representative 20” x 16” test image (Figure 2) printed using wide-web presses onto three types of film substrates. Through Flexo Project partners, eleven commercial wide-web printing facilities volunteered as sites for the performance demonstrations. Test samples were printed using a representative image that enabled analysis of 18 performance tests that were considered important to flexo printers. Some tests were conducted during the demonstrations runs, and afterwards the printed images were sent to Western Michigan University, where other performance tests were conducted.

The general CTSA methodology is described in the DfE document, Cleaner Technologies Substitutes Assessment: A Methodology and Resources Guide. The complete Flexographic Ink Options: A Cleaner Technologies Substitutes Assessment (CTSA) describes the methodology used for this study. You may download these documents from the DfE website (www.epa.gov/dfe).

FIGURE 2 Test Image Used in Demonstration Runs (original was run in 5 colors)

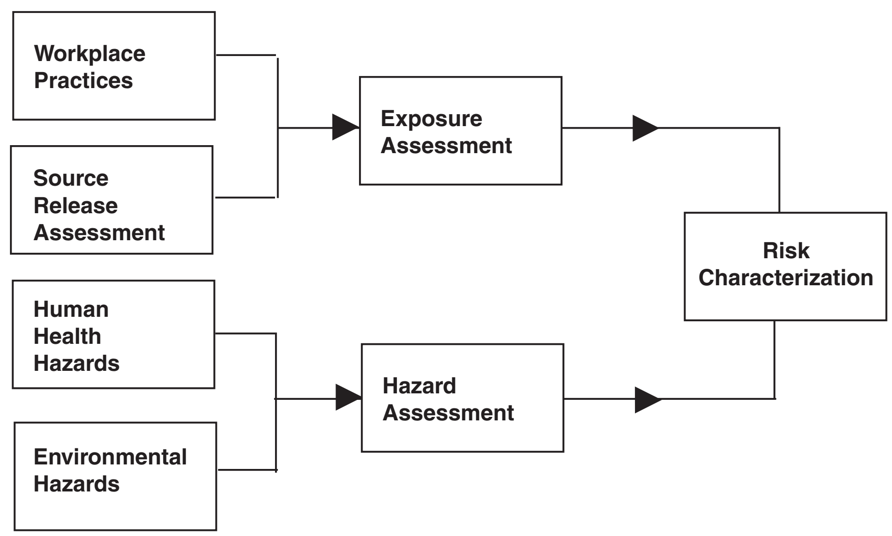


Hazards and risks

To analyze the hazards, exposures, and risk concerns of chemicals in the inks, the study used published toxicological data, EPA release and exposure models, and EPA structure-activity analyses. The *release and exposure models* helped to determine the rate at which flexo workers are exposed to ingredients in inks. The study analyzed two routes or pathways by which flexo workers could be exposed to ink chemicals: inhalation (breathing), and dermal (skin). The amount of exposure a worker receives can be affected by chemical components of the inks, methods of handling inks, and exposure route.

The *structure-activity analyses* provided hazard information for chemicals that had not been subjected to toxicological research. Because many ink chemicals have not undergone research about their health and environmental effects, SAT reports were used for many of the flexo chemicals in the study. Figure 3 shows graphically the process that the study used to develop the risk assessment for flexo ink chemicals.

FIGURE 3 The Risk Assessment Process Used in the Flexo Ink Study



Operating costs

The study looked at the costs of buying and using inks that were submitted voluntarily by printing ink suppliers. Sources of information about ink costs included members of the Flexo Partnership Technical and Steering Committees, contributors to the performance demonstrations, and U.S. Census data. Cost categories that were analyzed in the study include materials, labor, capital, and energy. The cost of substrates was not included in the analysis, because the amount of substrate used did not depend on the ink system.

Energy and natural resources

The study looked at the electricity and natural gas that were consumed in printing these inks. Sources of information about the consumption of ink products included

- Members of the Flexo Partnership Technical and Steering Committees
- Contributors to the performance demonstrations
- Energy equipment vendors
- U.S. Department of Energy data

The study also looked at the types and amount of emissions that might be generated by printing with each ink system.

Research assumptions

The study looked at many aspects of printing flexo inks, and thus was complex to plan and implement. In any study design, assumptions are made that will influence the results. For the flexo ink study, some of the important assumptions include the following.

- At each volunteer test site, the test image was run at a press speed of 300-500 feet per minute for roughly two hours. Press speed under many printing conditions is expected to be different (and in general, higher) than in this analysis.
- When the project methodology was developed, regulations did not require that air pollution control equipment be used with low-VOC inks. Therefore, the energy and cost calculations assumed that an oxidizer was used with solvent-based inks but not with water-based or UV-cured inks.
- Workers could be exposed to chemicals via dermal (skin) or inhalation (breathing) absorption, and the general population could be exposed via inhalation only. Neither population was subject to toxic effects via oral exposure (e.g., drinking or eating contaminated substances).

A "model facility" was designed to use when calculating the risk, cost, and energy consumption figures. A number of assumptions were made about a hypothetical "model facility" in developing the risk assessment. Thus, facilities with different operating characteristics would have different findings.

Thirty percent of VOCs released to air would be uncaptured emissions, and 70% would be stack emissions.

- Solvent-based ink systems would have a catalytic oxidizer with a 95% destruction efficiency.
- Pressroom and prep-room workers would work a 7.5 hour shift, 250 days/year.
- Pressroom and prep-room workers would have routine two-hand contact (no gloves) with ink unless a substance was corrosive.
- Press speed would be 500 feet per minute.

These parameters are important to keep in mind when considering how the results may apply to an actual printing facility.

Environmental resources

The resources listed here are divided into four sections: selected publications, flexo associations, technical assistance organizations, and chemical information sources. Many of these publications can be found on the DfE website (www.epa.gov/dfe), which may also serve as a source of information on other chemical substances. The DfE Program has reviewed many chemical substances in other cleaner technology evaluations, including previous partnerships focused on the activities of screen and lithographic printers.

DfE documents may also be obtained from:

National Service Center for Environmental Publications
P.O. Box 42419
Cincinnati, OH 45242-2419
Phone: 800-490-9198 or 513-489-8190
Fax: 513-489-8695
e-mail: nceipmal@one.net
Internet: www.epa.gov/ncepihom/ordering.htm

Selected publications

Flexographic Ink Options: A Cleaner Technologies Substitutes Assessment
(EPA 744-R-02-001A&B)
Vol. A — 400 pages; Vol. B (Appendices) — 430 pages; February 2002

The CTSA contains detailed information about the study. It includes chapters on risk analysis, 18 performance tests, cost analysis, energy consumption, a benefit-cost analysis, and environmental impacts.

Inside Flexo: A Cleaner Run for the Money (EPA/744-V-98-001)
19 minutes; April 1998

This video provides useful tips to flexo printers for working more efficiently and saving money, while improving the environment. Veteran printers share their success stories in the following areas: (1) managing inks efficiently, (2) printing successfully with alternative inks, (3) making the best use of press return inks, (4) using new cleaning methods that improve efficiency, and (5) improving the bottom line through sound environmental practices.

Flexography Project Case Study #1: Reducing VOCs in Flexography
(EPA/744-F-96-013)
4 pages; March 1997

Highlights the experiences of a flexography printer who successfully reduced VOC emissions and hazardous waste volumes. The case study focuses on the use of water-based ink and cleaning systems, which reduced costs along with environmental and worker-safety concerns. Tambien disponible en español.

Flexography Project Case Study #2: Learning from Three Companies that Reduced VOC Emissions (EPA/744-F-96-016)
4 pages; June 1997

Highlights how three flexo printing facilities went about reducing their VOC emissions. It presents the factors that went into management decisions, the results of switching to water-based inks and of installing an oxidizer, and how ink suppliers, trade associations, and consultants can help printers make decisions and solve problems. Tambien disponible en español.

High Performance Flexo: Printing with a Cleaner, Greener Image (Videoconference)
2.5 hours; 2000

This tape includes the entire videoconference, which discussed ways to improve environmental aspects of flexo printing. It is available through the Printers National Environmental Assistance Center (PNEAC) at www.pneac.org.

Printing Industry and Use Cluster Profile (EPA/744-R-94-003)
183 pages; June 1994

This resource provides an in-depth profile of the U.S. printing industry. Demographic information is given for the entire industry, as well as for the specific sectors: screen printing, lithography, gravure, flexography, and letterpress. The profile also presents detailed information about the processes and technological trends involved in each sector.

Integrated Environmental Management Systems Implementation Guide
(EPA 744-R-00-011)
290 pages, 48 worksheets; October 2000

The Guide was developed over three years and has been tested by several small businesses that used it to build an Integrated Environmental Management System (EMS) for their companies. An IEMS integrates worker safety and health concerns along with environmental concerns into a company's cost and performance analysis of products, processes and activities. An IEMS also includes the principles and technical methods of the EPA's Design for the Environment (DfE) Program, which emphasizes reducing risk to humans and the environment, along with preventing pollution and managing resources wisely. The Guide provides clear, step-by-step guidance on implementing an IEMS in a small company.

Integrated Environmental Management Systems Company Manual Template for Small Business (EPA 744-R-00-012)
60 pages; December 2000

The template was developed to help companies document their IEMS. Written as if it were the actual manual of a specific small business, the template helps companies understand how to adapt the procedures to implement an EMS and how to document their IEMS. It contains procedures that are normally documented as part of an ISO 14001-compliant EMS.

Flexographic associations

The following organizations are partners in the DfE Flexography Project:

California Film Extruders and Converters Association

www.cfeca.org

The California Film Extruders and Converters Association (CFECA) is a trade association of manufacturers and suppliers dedicated to representing the broad interests of the plastic film extruding and converting industry in California.

Film and Bag Federation

www.plasticbag.com

The Film and Bag Federation of The Society of the Plastics Industry is a consortium of 60 of the industry's leading manufacturers and suppliers, who work together on issues of interest and concern to the industry. Among its goals are to promote the industry's growth and to provide members with programs, services and the forum for addressing environmental, regulatory and other industry issues.

Flexible Packaging Association

www.flexpack.org

The Flexible Packaging Association (FPA) is the leading trade association for converters and suppliers of flexible materials and allied products for packaging, industrial, and related end-use markets. FPA represents their interests before government, promotes the value of their products, and provides information related to their industries.

Flexographic Technical Association

www.flexography.org

The Flexographic Technical Association is the leading technical society devoted exclusively to the flexo printing industry. Its members come from all aspects of the flexo industry, and include printers, suppliers, graphic trade shops, consumer product companies, designers, end-users, consultants, and educational institutions. Together they provide a wealth of products, services and shared knowledge to the flexographic printing industry.

National Association of Printing Ink Manufacturers

www.napim.org

The National Association of Printing Ink Manufacturers is a trade association that provides information and assistance to its members, to help them better manage their businesses, and that represents the printing ink industry in the United States.

RadTech International North America

www.radtech.org

RadTech International North America, a non-profit organization, is the association for the advancement of ultraviolet and electron beam (UV/EB) technology. RadTech serves as an industry forum, addressing the educational needs of the users and suppliers of UV and EB equipment and materials.

Environmental technical assistance organizations

Several non-profit and government sources of technical assistance and pollution prevention information are listed below.

EPA Small Business Ombudsman

www.epa.gov/sbo/

The Office of the Small Business Ombudsman (EPA SBO) serves as an effective conduit for small businesses to access EPA and facilitates communications between the small business community and the Agency. It also provides a list of state SBOs with expertise on local issues. The EPA SBO reviews and resolves disputes with EPA and works with EPA personnel to increase their understanding of small businesses in the development and enforcement of environmental regulations. The EPA SBO acts as a liaison for the small business community in the development of EPA regulations and standards.

EPA Regional Pollution Prevention Coordinators

http://www.epa.gov/opptintr/p2home/resources/regions.htm

Each region of the United States has a coordinator for pollution prevention (P2) activities. This website lists the contacts and provides a link to a webpage describing activities in each region.

National Pollution Prevention Roundtable

www.p2.org

The National Pollution Prevention Roundtable (NPPR) is the largest membership organization in the United States devoted solely to pollution prevention (P2). The mission of the Roundtable is to provide a national forum for promoting the development, implementation, and evaluation of efforts to avoid, eliminate, or reduce pollution at the source. NPPR holds national meetings; runs its publications program, which includes its quarterly newsletter and many other documents and reports; operates four topic-specific electronic listservs (NPPR [P2 Policy], P2 Tech, P2 Trainer, and P2 Energy); and coordinates roundtable workgroups.

Printers National Environmental Assistance Center (PNEAC)

www.pneac.org

EPA's Office of Enforcement and Compliance Assurance and Pollution Prevention Policy Staff have partnered with industry and environmental experts to develop this environmental assistance center for the printing industry, including compliance assistance and P2 information.

This is a communications-based center linking trade, governmental, and university service providers to efficiently provide the most current and complete compliance assistance and pollution prevention information to the printing industry. The project's staff are located within the partnering organizations. The Great Lakes Information Network is providing support for the two Internet listservs.

Small Business Assistance Program

www.epa.gov/ttn/sbap/

All states have a small business assistance program to help businesses comply with environmental regulations. The EPA Small Business Assistance Program (SBAP) is a forum for state assistance providers to share information, and it provides a list of state SBAPs with expertise on local issues. The SBAP has a website and several publications that provide information to small businesses, as well as contact information for individual state representatives.

Small Business Development Centers

www.sba.gov/sbdc/

The U.S Small Business Administration (SBA) administers the Small Business Development Center Program to provide management assistance to current and prospective small business owners. SBDCs offer one-stop assistance to small businesses by providing a wide variety of information and guidance in central and easily accessible branch locations. The lead organization coordinates program services offered to small businesses through a network of subcenters and satellite locations in each state.

The program is a cooperative effort of the private sector, the educational community, and federal, state, and local governments. The program is designed to deliver up-to-date counseling, training, and technical assistance in all aspects of small business management. SBDC services include, but are not limited to, assisting small businesses with financial, marketing, production, organization, engineering, and technical problems and feasibility studies. The website provides contact information for local representatives.

Manufacturing Extension Partnership (MEP)

www.mep.nist.gov

MEP is a nationwide network of not-for-profit centers in more than 400 locations nationwide, whose sole purpose is to help small and medium-sized manufacturers. The MEP centers, serving all 50 states, the District of Columbia and Puerto Rico, are linked through the Department of Commerce's National Institute of Standards and Technology. With specialists who have experience on manufacturing floors and plant operations, MEPs can perform assessments, provide technical and business solutions, help create successful partnerships, and provide seminars and training programs.

Chemical information

Following are some sources of chemical information to help you better build chemical profiles on flexographic ink ingredients and better understand the health and environmental impacts of flexo inks.

ASTDR (Agency for Toxic Substances and Disease Registry).

http://atsdr1.atsdr.cdc.gov

- ToxFAQs. A series of summaries about hazardous substances from the ATSDR Toxicological Profiles and Public Health Statements. Each fact sheet serves as a quick and easy-to-understand guide to the effects of hazardous substances on human health.

  http://www.atsdr.cdc.gov/toxfaq.html

- Toxicological Profiles. Toxicological profiles for hazardous substances found at National Priorities List sites. Profiles include minimum risk levels.

  http://www.atsdr.cdc.gov/toxpro2.html

ChemID. The National Library of Medicine's Chemical Dictionary. Contains over 339,000 compounds of biomedical and regulatory interest. Records include CAS Registry Numbers, molecular formulae, generic names, synonyms, and other references.

http://chem.sis.nlm.nih.gov/chemidplus

ChemFinder. Searchable database of chemical names, synonyms, CAS Registry Numbers, and molecular formulas.

http://chemfinder.camsoft.com

Chemical Right-to-Know (RTK) Initiative, U.S. EPA. Developed to rapidly test chemicals and make the data available to scientists, policy makers, industry, and the public.

http://www.epa.gov/chemrtk

ECOSAR (Ecotoxicity of Structure-Activity Relationships Database). Based on structure analysis, contains estimates of toxicity to fish, invertebrates, and aquatic plants.

http://www.epa.gov/oppt/newchems/21ecosar.htm

ECOTOX Database System. Chemical-specific ecological toxicity databases. Includes AQUIRE, for aquatic toxicity.

http://www.epa.gov/ecotox

International Agency for Research on Cancer (IARC). Overall evaluations of carcinogenicity to humans. List and searchable database of chemicals evaluated as IARC Monographs.

http://193.51.164.11

National Toxicology Program (NTP) Annual Report on Carcinogens. This contains lists of chemicals known or reasonably anticipated to be carcinogenic to humans.

http://ntp-server.niehs.nih.gov/NewHomeRoc/CurrentLists.html

Office of Pollution Prevention and Toxics (OPPT), U.S. Environmental Protection Agency. Databases and software produced by OPPT are valuable tools for obtaining chemical and regulatory information.

http://www.epa.gov/opptintr/opptdb.htm

- EPA's Exposure Assessment webpage includes exposure assessment methods, databases, and prediction models.

  http://www.epa.gov/opptintr/exposure

- Estimation Program Interface (EPI) Suite is a series of physical/chemical property and environmental fate estimation models.

  http://www.epa.gov/opptintr/exposure/docs/episuite.htm

  http://www.epa.gov/opptintr/exposure/docs/epiwin.htm

- Flexography Project website contains many documents to help flexo professionals develop market environmentally improved ink formulations.

  http://www.epa.gov/dfe

RTECs (Registry of Toxic Effects of Chemical Substances). Toxicity data for over 140,000 chemicals. Only available through commercial vendors; URL provides further vendors.

http://www.cdc.gov/niosh/rtecs.html

TOXNET. The National Library of Medicine's Toxicology Data Network. Contains databases on toxicology, hazardous chemicals, and related areas.

http://toxnet.nlm.nih.gov

Toxnet includes:

- CCRIS (Chemical Carcinogenisis Research Information System). Sponsored by the National Cancer Institute, a scientifically evaluated and fully referenced data bank containing some 8,000 chemical records with carcinogenicity, mutagenicity, tumor promotion, and tumor inhibition test results.
- GENE-TOX. Genetic toxicology (mutagenicity) test data, resulting from expert peer review of the open scientific literature for approximately 3,000 chemical substances.
- HSDB (Hazardous Substances Data Bank). Data file that focuses on the toxicology of over 4,500 potentially hazardous substances. Includes human exposure, industrial hygiene, emergency handling, and environmental fate. Scientifically peer-reviewed.
- IRIS (Integrated Risk Information System). An EPA database that contains health risk information on over 500 chemicals. This includes cancer weight-of-evidence classifications and cancer potency factors. These data have been reviewed by EPA and represent EPA consensus.

  http://www.epa.gov/iris

Pollution prevention tips for flexo professionals

Flexo decision-makers have many opportunities to encourage environmental improvements and cleaner, more sustainable operations, including pollution prevention. This involves reducing or eliminating environmental discharges at the source, before they are generated. Pollution prevention requires taking active steps to implement changes in workplace practices, technology, and materials, such as the type of ink used. By reducing the amount of waste produced in the first place, disposal and compliance issues are minimized.

The pollution prevention pyramid shows source reduction at the top. This means that reducing or eliminating environmental problems should be the first and most comprehensive approach to preventing pollution. If a chemical showing hazards or risk concerns cannot be eliminated, then it should be recycled. If it cannot be recycled as is, it should be treated, and only if none of these options exist should it be disposed to a landfill.

Each step in the printing process offers opportunities for pollution prevention. Possible benefits from following pollution prevention practices include cost savings, improved productivity, better product quality, reduced health risk concerns to workers, reduced pressures of regulatory compliance, and of course reduced environmental impacts.

The list that follows includes some obvious and some not-so-obvious suggestions for reducing environmental effects of printing operations. You can probably implement other good ideas that are specific to your facility's operations.

Pre-press

Use Computers for Proofs and Plates: Eliminating all proofs and plates enables printers to skip photographic development and eliminate the use of darkroom chemicals.

Switch from Rubber to Photopolymer Plates: Use of traditional nitric acid baths to etch designs into metal plates may generate wastewater that is low in pH and high in metal content, requiring regulation under the Clean Water Act. Photopolymer plates eliminate this waste stream as well as the metal engravings and wastes generated from the production of conventional molded rubber plates.

Printing and clean-up

Install Enclosed Doctor Blade Chambers: Enclosed doctor blade chambers reduce ink evaporation, which results in better control of ink usage, more consistent color, and improved performance of the inks on press. Making this change to an older press may greatly reduce ink evaporation, thus minimizing worker exposure to hazardous chemicals.

Cover Volatile Materials: By keeping all cans, drums, and open ink fountains covered, printers can reduce odors and worker health risk concerns by minimizing uncaptured VOC emissions.

Use Higher Linecount Anilox Rolls: This enables printers to apply smaller ink droplets closer together, to achieve much finer ink distribution, easier drying, and potentially faster press speeds.

Rework Press Return Ink: Reworking press return ink can increase efficiency, reduce ink purchases, and reduce hazardous waste if contamination issues can be addressed. Ink can be reworked by blending press return ink with virgin ink or other press return inks.

Use Computerized Ink Blending: Software and specialized equipment help printers blend ink, reduce surplus ink, and reuse press return ink.

Print with Four-Color Process: The limited number of inks in four-color process printing can minimize the amount of mixed colored inks used and eliminate residues of unusual colors at the end of each job. With chambered doctor blade systems, the increased use of process printing to produce a broad spectrum of colors has become more easily attainable.

Co-Extrude Colored Film: Films can be co-extruded to have panels of color in a clear field, which eliminates the need for heavy coverage with colored ink.

Run Light Colors First: By running lighter jobs before darker jobs, printers can reduce the number of clean-ups.

Standardize Repeat Print Jobs: Make-ready times and waste materials can be greatly reduced if the press operators knows the anilox roll linecount and cell volume, the sequence of colors applied, ink parameters such as pH and viscosity, and other set-up information.

Standardize Anilox Roll Inventory: This saves time during makeready and reduces waste.

Use Multi-Stage Cleaning: Solvent use can be reduced by using a multi-stage cleaning procedure for the printing decks. This procedure reduces solvent use by reusing solvents that are otherwise discarded. Pre-used solvent is used in the first stage to remove the majority of the ink. In the second stage, a cleaner but still pre-used solvent removes more ink. In the third stage, clean solvent removes any remaining ink.

Install Automatic On-Press Cleaning: When paired with solvent recovery, on-press cleaning systems use much less cleaning solution than hand cleaning, while also having a very short cycle time.

Clean Anilox Rolls Promptly: Prompt attention will prevent the inks from setting, thereby reducing the need for harsh chemicals. Clean rolls also produce more predictable ink densities, potentially reducing on-press waste and improving quality.

Use Alternative Methods to Clean Anilox Rolls: Printers can choose among many alternatives for cleaning anilox rolls to reduce or eliminate the need for traditional cleaning solvents. These alternatives use sonic cleaning, dry ice, lasers, polyethylene beads, and sodium bicarbonate.

Recirculate Warm Press Air: Both solvent-and water-based printers can significantly reduce their energy requirements by recirculating warm air from dryers.

Throughout the printing process

Use Safer Chemicals: Switching to inks, cleaning agents, and adhesives that contain a lower percentage of VOCs and fewer HAPs may reduce risk concerns to worker health and the environment.

Segregate Hazardous Waste: Segregating hazardous wastes allows disposal of pure instead of mixed wastes. Because pure wastes are much easier to treat than mixed ones, they are not only less expensive to dispose of, but also require less energy.

Return Containers: Using returnable containers prevents unnecessary waste generation and results in additional cost savings.

Track Inventory: Tracking chemical purchases and disposal can help to maintain a minimum inventory on the shelf, thus reducing the amount of materials wasted. For example, hazardous waste can be minimized by labeling inks with the date and having a "first-in, first-out" rule, i.e., rotating the inks so that the oldest inks are used first. This avoids disposing of expired ink as hazardous waste. Tracking systems using bar codes take inventory control to an even higher level.

Make a Management Commitment: Management should establish, communicate, and demonstrate its commitment to the concept of pollution prevention, to encourage company-wide source reduction in everyday practice. Management can assemble pollution prevention teams of employees, incorporate pollution prevention into job responsibilities, and provide incentives for employees to prevent pollution.

Train Employees: Pollution prevention training for company personnel may facilitate process changes by educating workers on the need for such change. Training also helps to encourage general source reduction and stimulate pollution prevention ideas by personnel.

Monitor Employee Practices: Periodic monitoring helps ensure that source reduction practices are followed.

Seek Out and Encourage Employee Initiatives: Supporting, encouraging, and actively acknowledging pollution prevention initiatives by company personnel can stimulate innovative ideas for source reduction. This may be especially beneficial because employees who are closest to the process are often in the best position to recommend change.

Develop an Environmental Management System (EMS): An EMS is a set of management tools and principles designed to guide a company to integrate environmental concerns into its daily business practices.

DfE has developed an Integrated Environmental Management System Implementation Guide, which provides technical methods, step-by-step guidance, and worksheets for facilities that want to implement an EMS. You may download it from the DfE website (www.epa.gov/dfe). For a printed copy, contact EPA's National Service Center for Environmental Publications:
Phone 800-490-9198 or
513-489-8190;
Fax:513-489-8695;
e-mail:ncepimal@one.net;
or Internet:
www.epa.gov/ncepihom/ordering.htm

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