

# **Flexographic Ink Options: A Cleaner Technologies Substitutes Assessment**

VOLUME 1



**Design for the Environment Program  
Economics, Exposure, and Technology Division  
Office of Pollution Prevention and Toxics (7404)  
U.S. Environmental Protection Agency**

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*Developed in Partnership with the Following Associations:*



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Highland Supply Corporation	
Huron River Watershed Council	
International Paper	

\* These companies voluntarily supplied materials for the CTSA or participated in the performance demonstrations.



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# Abbreviations

<b>ADC</b>	Average Daily Concentration
<b>ADD</b>	Average Daily Dose
<b>BACT</b>	Best Available Control Technology
<b>BCM</b>	Billion Cubic Microns per Square Inch
<b>BOD</b>	Biological Oxygen Demand
<b>CAA</b>	Clean Air Act
<b>CAS</b>	Chemical Abstracts Service Registry Number
<b>CBI</b>	Confidential Business Information
<b>CERCLA</b>	Comprehensive Environmental Response, Compensation, and Liability Act
<b>CESQG</b>	Conditionally Exempt Small Quantity Generator
<b>CFR</b>	Code of Federal Regulations
<b>CTG</b>	Control Technology Guidelines
<b>CTSA</b>	Cleaner Technology Substitutes Assessment
<b>CWA</b>	Clean Water Act
<b>DfE</b>	Design for the Environment
<b>EPA</b>	Environmental Protection Agency
<b>EPCRA</b>	Emergency Planning and Community Right-to-Know Act
<b>FPA</b>	Flexible Packaging Association
<b>FTA</b>	Flexographic Technical Association
<b>FWPCA</b>	Federal Water Pollution Control Act
<b>HAP</b>	Hazardous Air Pollutant
<b>HQ</b>	Hazard Quotient
<b>HSWA</b>	Hazardous and Solid Waste Amendments
<b>IARC</b>	International Agency for Research on Cancer
<b>LDPE</b>	Low-Density Polyethylene
<b>LEPC</b>	Local Emergency Planning Commission
<b>LOAEL</b>	Lowest Observed Adverse Effect Level
<b>LQG</b>	Large Quantity Generator
<b>MACT</b>	Maximum Achievable Control Technology
<b>MEK</b>	Methyl Ethyl Ketone
<b>MIBK</b>	Methyl Isobutyl Ketone
<b>MOE</b>	Margin of Exposure
<b>MSDS</b>	Material Safety Data Sheet

<b>NAICS</b>	North American Industry Classification System
<b>NAPIM</b>	National Association of Printing Ink Manufacturers
<b>NCP</b>	National Oil and Hazardous Substances Pollution Contingency Plan
<b>NESHAP</b>	National Emissions Standards for Hazardous Air Pollutants
<b>NOAEL</b>	No Observed Adverse Effect Level
<b>NPDES</b>	National Pollution Discharge Elimination System
<b>OPP</b>	Oriented Polypropylene
<b>OPPT</b>	Office of Pollution Prevention and Toxics
<b>OSHA</b>	Occupational Safety and Health Administration
<b>PE/EVA</b>	Polyethylene/Ethylvinyl Acetate
<b>POTW</b>	Publicly Owned Treatment Works
<b>PTE</b>	Permanent Total Enclosure
<b>RACT</b>	Reasonably Achievable Control Technology
<b>RCRA</b>	Resource Conservation and Recovery Act
<b>RfC</b>	Reference Concentration
<b>RfD</b>	Reference Dose
<b>SARA</b>	Superfund Amendments and Reauthorization Act
<b>SDWA</b>	Safe Drinking Water Act
<b>SERC</b>	State Emergency Response Commission
<b>SIC</b>	Standard Industrial Classification
<b>SQG</b>	Small Quantity Generator
<b>TRI</b>	Toxics Release Inventory
<b>TSCA</b>	Toxic Substances Control Act
<b>TSD</b>	Treatment, Storage, and Disposal (facility)
<b>TSS</b>	Total Suspended Solids
<b>UST</b>	Underground Storage Tank
<b>VOC</b>	Volatile Organic Compound

# Glossary

<b>Acetate</b>	a family of solvents also known as esters of acetic acid
<b>Acrylate</b>	a chemical functional group commonly used in UV curing
<b>Acute exposure</b>	one dose or multiple dose exposures occurring over a short time (24 hours)
<b>Additive</b>	a substance used in small quantities to modify the properties of an ink
<b>Adhesion</b>	state in which two surfaces are held together by molecular forces; measure of the strength with which one material sticks to another
<b>Adhesive</b>	any material that is applied to one or more surfaces to form a bond between the two
<b>Adsorbent</b>	material (e.g., carbon) that adsorbs (concentrates) a substance on its surface
<b>Adsorption</b>	accumulation of a gaseous, liquid, or dissolved substance on the surface of a solid
<b>Ambient environment</b>	the existing conditions in the environment or immediate vicinity
<b>Amide</b>	a nitrogen-containing compound that usually is basic (alkaline)
<b>Anilox roll</b>	engraved steel and chrome-coated metering roll to control the amount of ink sent from the fountain roller to the printing plates
<b>Anilox volume</b>	the volume of cells on an anilox roll in a standardized area, expressed as billion cubic microns per square inch (BCM)
<b>Aquatic toxicity</b>	capability of a substance to cause adverse effects in aquatic organisms
<b>Benefit</b>	the value to society of a good or service. From a firm's perspective, the benefit of a good or service can be measured by the revenue the firm receives from its sales as compared to the costs incurred when producing its products. From the consumer's perspective, the benefit can be measured by what the consumer would be willing to pay for the good or service. Some goods and services, such as environmental amenities and health risk reductions, are not generally for sale in a market economy. However, these goods and services do provide benefits to society which should be recognized. Economists attempt to estimate the value of these goods and services through various nonmarket valuation methods.
<b>Best Available Control Technology (BACT)</b>	an emission limitation based on the maximum degree of emission reduction (considering energy, environmental, and economic impacts) achievable through application of production processes and available methods, systems, and techniques; (EPA) the most stringent technology available for controlling emissions; major sources are required to use BACT, unless it can be demonstrated that it is not feasible for energy, environmental, or economic reasons.
<b>Block resistance</b>	a type of performance test that measures the bond between ink and substrate when heat and pressure are applied
<b>Blocking</b>	undesired adhesion between layers of material that may cause damage to at least one surface upon their separation

<b>Caliper</b>	the thickness of a sheet or material measured under specific conditions, expressed in thousandths of an inch
<b>Carcinogen</b>	cancer-causing chemical
<b>Carcinogenic effect</b>	malignant tumor or other manifestation of abnormal cell growth caused by cancer
<b>Catalyst</b>	a substance that accelerates the rate of a reaction between two or more substances without being consumed in the process
<b>Catalytic oxidizer</b>	type of oxidizer that contains a catalyst
<b>Cationic ink</b>	a type of UV-cured ink in which photoinitiators start the reaction by causing an electron deficiency in the monomers and oligomers
<b>Central impression printing press</b>	printing press in which the material being printed is in continuous contact with a single-large diameter impression cylinder; the color stations are arranged around the circumference of the cylinder and imprint the image on the substrate
<b>Chill roller</b>	metal roll or drum with internal cooling, used to cool the printed web prior to rewinding
<b>Coating</b>	the outer covering of a film or web; the film may be coated on one or both sides
<b>Co-extruded polyethylene/ethyl vinyl acetate (PE/EVA)</b>	a type of film substrate used in flexographic printing
<b>Co-extrusion</b>	a process used to produce a product, such as a film substrate, by forcing more than one extruder through a common die
<b>Colorant</b>	a substance that provides the color associated with ink; it can be a pigment or a dye
<b>Control option</b>	add-on technological system or device that removes pollutants from a flexographic facility's waste stream and thereby keeps them out of air, water, and landfills; pollutants may be captured for reuse, recycling, or disposal
<b>Conventional pollutant</b>	a pollutant chemical in wastewater effluent regulated under the Clean Water Act (CWA); includes biological oxygen demand (BOD), total suspended solids (TSS), fecal coliform bacteria, fat/oil/greases (FOG), and pH
<b>Core</b>	a tube on which paper, film, or foil is wound for shipment; the metal body of a roller which is rubber covered
<b>Corona treater</b>	equipment that electrically charges the substrate to improve ink adhesion by raising the surface tension of the substrate
<b>Corrosivity</b>	capability of corroding
<b>Cross-linker</b>	a component of UV-cured inks, such as a monomer or oligomer, that is capable of reacting to form a solid coating
<b>Cure</b>	process of treating inks with ultraviolet light which creates a bond between the monomers and oligomers in the ink; the reaction (or "drying") causes the ink to solidify and bind with the substrate

<b>Curing agent</b>	a chemical that participates in the reaction that results in the curing of UV inks
<b>Dermal exposure</b>	exposure through the skin
<b>Developmental toxicity</b>	adverse effects caused to a developing organism from exposure to a substance prior to conception, during prenatal development, or postnatally up to the time of sexual maturation
<b>Die</b>	any of various sharp cutting forms, used to cut desired shapes from papers, paperboard, plastics or other stocks
<b>Diluent</b>	a liquid with no solvent action, used to dilute or thin an ink or lacquer; a type of extender
<b>Direct medical costs</b>	costs associated specifically with the identification and treatment of a disease or illness (e.g., costs of visits to the doctor, hospital costs, costs of drugs).
<b>Discounting</b>	Economic analysis procedure by which monetary valuations of benefits and/or costs occurring at different times are converted into present values which can be directly compared to one another.
<b>Dispersant</b>	material that enables a uniform distribution of solid particles
<b>Dispersion</b>	a uniform distribution of solid particles in a vehicle by mixing or milling
<b>Doctor blade</b>	a thin flexible blade that grazes the anilox roll at an angle to remove excess ink from the roll before the ink is applied to the printing plate
<b>Dose-response assessment</b>	in a risk assessment, the relationship between the dose of the chemical received and the incidence and severity of the adverse health effects in an exposed population
<b>Dot gain</b>	the undesired increase in size of a printed “dot” of ink
<b>Dye</b>	coloring material which is soluble in an ink vehicle, as opposed to pigments, which are not soluble and must be dispersed
<b>Electrolytic silver recovery</b>	method of silver recovery whereby a current is passed between two electrodes in silver-laden water, plating the silver on the cathode in a virtually pure form
<b>Exposed population</b>	the estimated number of people from the general public or a specific population group who are exposed to a chemical, process, and/or technology. The general public could be exposed to a chemical through wide dispersion of a chemical in the environment (e.g., DDT). A specific population group could be exposed to a chemical due to its physical proximity to a manufacturing facility (e.g., residents who live near a facility using a chemical), through the use of the chemical or a product containing a chemical, or through other means.
<b>Exposed worker population</b>	the estimated number of employees in an industry exposed to the chemical, process, and/or technology under consideration. This number may be based on market share data as well as estimations of the number of facilities and the number of employees in each facility associated with the chemical, process, and/or technology under consideration

<b>Exposure assessment</b>	in risk assessment, identification of the pathways of which toxicants may reach individuals, estimation of how much of a chemical an individual is likely to be exposed to, and estimation of the number of people likely to be exposed
<b>Epoxy resin</b>	plastic or resinous materials used for strong, fast-setting adhesives, as heat resistant coatings and binders
<b>Extender</b>	any material added to inks to reduce its color strength and/or viscosity
<b>External benefits</b>	a positive effect on a third party who is not part of a market transaction. For example, if an educational program (i.e., a smoking-cessation class) results in behavioral changes which reduce the exposure of a population group to a disease (i.e., lung cancer), then an external benefit is experienced by those members of the group who did not participate in the educational program (i.e., those inhaling second-hand smoke). External benefits also occur when environmental improvements enhance enjoyment of recreational activities (e.g., swimming, hiking, etc.).
<b>External costs</b>	a negative effect on a third party who is not part of a market transaction. For example, if a steel mill emits waste into a river which poisons the fish in a nearby fishery, the fishery experiences an external cost to restock as a consequence of the steel production. Other examples of external costs are the effects of second-hand smoke on nonsmokers, increasing the incidence of respiratory distress, and a smokestack which deposits soot on someone's laundry, thereby incurring costs of relaundering.
<b>Externality</b>	a cost or benefit that involves a third party who is not a part of a market transaction; "a direct effect on another's profit or welfare arising as an incidental by-product of some other person's or firm's legitimate activity" (Mishan, 1976). The term "externality" is a general term which can refer to either external benefits or external costs.
<b>Extrusion</b>	the production of a continuous product (e.g., a sheet of film) by forcing a material (e.g., thermoplastic) through a die or orifice
<b>Flammability</b>	the capability of burning
<b>Flexible packaging</b>	any package or part of packaging with a thickness of ten millimeters or less whose shape can be changed readily
<b>Flexographic printing plate</b>	a plate with a raised image that prints on the desired substrate
<b>Formulation</b>	a specific color (e.g., Reflex blue) within an ink product line used in the CTSA (e.g., solvent-based ink#1)
<b>Fountain</b>	a pan or trough on a press that serves as a reservoir for ink
<b>Fountain roll</b>	a press roll that picks up ink or coating material from the fountain and applies it to the transfer roll
<b>Four-color process</b>	printing with cyan, magenta, and yellow color inks plus black, and using combinations of these colors to create all other colors (see process printing)
<b>Free radical</b>	an unstable, reactive molecule that has a neutral charge (in comparison to an ion)

<b>Free radical curing</b>	a type of ultraviolet curing in which photoinitiators release reactive free radicals
<b>Fugitive emissions</b>	emissions that escape from the printing press and leave the facility through openings such as windows and doors
<b>Hazard</b>	potential for a chemical or other pollutant to cause human illness or injury; the inherent toxicity of a compound
<b>Hazard identification</b>	in a risk assessment, determining whether exposure to a chemical could cause adverse health effects in humans or in nature; an informed judgment based on verifiable toxicity data from animal models or human studies
<b>Hazard quotient</b>	the ratio of estimated site-specific exposure to a single chemical over a specified period to the estimated daily exposure level at which no adverse health effects are likely to occur
<b>Hazardous</b>	harmful to human health and the environment
<b>Hazardous Air Pollutant (HAP)</b>	air pollutants listed under the Clean Air Act (CAA) as being hazardous to human health and the environment
<b>Hazardous waste</b>	by-products of industrial activities that can pose a substantial or potential hazard to human health or the environment when improperly managed
<b>Hazardous waste generator</b>	a facility that produces hazardous waste
<b>Human health benefits</b>	reduced health risks to workers in an industry or business as well as to the general public as a result of switching to less toxic or less hazardous chemicals, processes, and/or technologies. An example would be switching to a less volatile chemical or a new method of storing or using a volatile, hazardous chemical, to reduce the amount of volatilization, thereby lessening worker inhalation exposures as well as decreasing the formation of photochemical smog in the ambient air.
<b>Human health costs</b>	the cost of adverse human health effects associated with production, consumption and disposal of a firm's product. An example is the cost to individuals and society of the respiratory effects caused by stack emissions, which can be quantified by analyzing the resulting costs of health care and the reduction in life expectancy, as well as the lost wages as a result of being unable to work.
<b>Ignitability</b>	capability of lighting on fire
<b>Illness costs</b>	a financial term referring to the liability and health care insurance costs a company must pay to protect itself against injury or disability to its workers or other affected individuals. These costs are known as illness benefits to the affected individual.
<b>Incineration</b>	the process of burning to ashes with the intent of reducing harmful substances to more benign ones
<b>Indirect medical costs</b>	costs associated with a disease or medical condition resulting from exposure to a chemical, product or technology, such as the costs of decreased productivity of patients suffering a disability or death, and the value of pain and suffering borne by the afflicted individual and/or family and friends.

<b>Individual risk</b>	an estimate of the probability of an exposed individual experiencing an adverse effect, such as "1 in 1,000" (or 10 <sup>-6</sup> ) risk of cancer.
<b>Inhalation exposure</b>	exposure through breathing
<b>Ink pan</b>	reservoir for ink
<b>Ink splitter</b>	a device that separates solids from fluids in waste ink and cleaning solutions, or removes pigments from water-based ink wastes using a porous cellulose material
<b>In-line printing press</b>	a multicolored press in which the color stations are mounted horizontally in a line; a press coupled to another operation such as bagmaking, sheeting, diecutting, creasing, etc.
<b>Ion exchange</b>	method of recovering silver from wash water or mixtures of wash waters, fixer and bleach fix, especially from dilute solutions
<b>Laminate</b>	to bond together two or more layers of material or materials
<b>Line color printing</b>	process of printing "line work" such as text, display type, and some types of graphics
<b>Liquid ink</b>	low-viscosity ink
<b>Low-density polyethylene (LDPE)</b>	type of film substrate used for printing on packaging such as frozen food bags
<b>Lowest Observed Adverse Effect Level (LOAEL)</b>	lowest exposure level at which adverse effects to human health and/or the environment have been shown to occur
<b>Major Source</b>	under Title V of the Clean Air Act, a facility that has the potential to emit 10 tons per year or more of any individual Hazardous Air Pollutant (HAP), 25 tons per year or more of any combination of HAPs, or 100 tons per year or more of any air pollutant. The 100 tons per year limit applies to facilities located in areas with relatively good air quality ("attainment areas"); the limit decreases in non-attainment areas.
<b>Makeready</b>	the preparation and correction of the printing plate before starting the print run, to insure uniformly clean impressions; all preparatory operations preceding production
<b>Margin of exposure (MOE)</b>	the ratio of the no-observed-adverse-effect-level (NOAEL) to the estimated exposure dose
<b>Material Safety Data Sheet (MSDS)</b>	a compilation of information required under the Occupational Safety and Health Administration (OSHA) Communication Standard on the identity of hazardous chemicals, health and physical hazards, exposure limits, and precautions of a product
<b>Maximum Achievable Control Technology (MACT)</b>	the emission standard for sources of air pollution requiring the maximum reduction of hazardous emissions, taking cost and feasibility into account
<b>Metallic replacement</b>	method of silver recovery whereby wastewater is passed through one or more steel wool filters in which silver in the wastewater is chemically replaced by iron from the filter
<b>Monomer</b>	an individual molecular unit that is capable of linking together to form polymers

<b>Narrow web press</b>	any printing press web that is less than 24 inches wide; narrow web presses are able to do multiple converting operations (e.g., diecutting) in the same pass with the printing
<b>National Emission Standards for Hazardous Air Pollutants (NESHAP)</b>	emissions standards set by EPA for air pollutants that may cause an increase in fatalities or in serious, irreversible, or incapacitating illness
<b>Net benefit</b>	the difference between the benefits and the costs. For a company this could be interpreted as revenue - costs, assuming that the revenue and the costs are fully determined.
<b>No Observed Adverse Effect Level (NOAEL)</b>	the highest exposure level that can occur without statistically or biologically significant adverse effects to human health and/or the environment
<b>Non-conventional pollutant</b>	any wastewater effluent pollutant regulated under the Clean Water Act (CWA) that is not identified as a conventional or priority pollutant
<b>Oligomer</b>	a low-weight polymer that is capable of further combination; the component of UV-cured inks that links together to form a solid coating
<b>Opportunity cost</b>	a hidden or implied cost incurred due to the use of limited resources such that they are not available for an alternative use. For example, the use of specific laborers in the production of one product precludes their use in the production of another product. The opportunity cost to the firm of producing the first product is the lost profit from not producing the second. Another example would be a case where in hiring legal representation to respond to a lawsuit, and due to limited financial resources, a firm must cancel a planned expansion. The opportunity cost of responding to the lawsuit is the lost gain from not expanding.
<b>Oral exposure</b>	exposure to contaminated substances through eating or drinking
<b>Oral toxicity</b>	ability of a chemical to cause injury when ingested
<b>Oriented polypropylene (OPP)</b>	a film substrate noted for clarity, stiffness, and ability to form a strong barrier
<b>Overprinting</b>	the printing of one impression over another
<b>Oxidation</b>	the reaction of a chemical (such as VOCs) with oxygen; the process of combining with oxygen
<b>Oxidizer</b>	equipment that burns contaminated air to break down harmful substances (e.g., VOCs) into water, carbon dioxide, and other gases
<b>Ozone</b>	a gas containing three oxygen molecules; at ground level it is a pollutant formed in part by the reaction of volatile organic compounds (VOCs) released by solvent-based inks; contributes to smog formation
<b>Paste ink</b>	high-viscosity ink
<b>Permanent total enclosure</b>	a structure that completely surrounds a source of air emissions, captures all VOC emissions, and sends them to a control device
<b>Photoinitiator</b>	the component of UV-cured inks that reacts with ultraviolet light to begin the curing process
<b>Photopolymer</b>	any mixture of materials that can change its own physical properties on exposure to ultraviolet or visible light

<b>Pigment</b>	insoluble substance used to give color to inks, paints and plastics
<b>Pinholing</b>	failure of a printed ink to form a complete continuous film; visible in the form of small holes in the printed area
<b>Plasticizer</b>	material (usually in liquid form) that is added to ink to improve the flexibility of dried ink
<b>Pollution prevention</b>	identification of substances, processes, and activities that create excessive waste products or pollutants, followed by reductions in pollution generation by altering or eliminating a process or materials
<b>Polyethylene</b>	a synthetic resin of high molecular weight resulting from the polymerization of ethylene gas under pressure.
<b>Polymer</b>	a compound formed by the linking together of simple molecules
<b>Polymerization</b>	a chemical reaction in which the molecules of a monomer are linked together to form large molecules
<b>Polypropylene</b>	a synthetic resin of high molecular weight resulting from the polymerization of propylene gas
<b>Population risk</b>	an aggregate measure of the projected frequency of effects among all exposed people, such as "four cancer cases per year."
<b>Present value</b>	the value in today's terms of a sum of money received in the future. Present Value is a concept which specifically recognizes the time value of money, i.e., the fact that \$1 received today is not the same as \$1 received in ten years time. Even if there is no inflation, \$1 received today can be invested at a positive interest rate (say 5 percent), and can yield \$1.63 in ten years; \$1 received today is the same as \$1.63 received ten years in the future.
<b>Press-side solvent or additive</b>	a product added to ink during a press run to improve the printing performance (e.g., to decrease viscosity)
<b>Primer</b>	a first coat intended to enhance subsequent printing
<b>Priority pollutant</b>	a toxic chemical found in wastewater effluent and regulated under the Clean Water Act (CWA)
<b>Private (internalized) benefits</b>	the direct gain received by industry or consumers from their actions in the marketplace. One example includes the revenue a firm obtains in the sale of a good or service.
<b>Private (internalized) costs</b>	the direct negative effects incurred by industry or consumers from their actions in the marketplace. Examples include a firm's cost of raw materials and labor, a firm's costs of complying with environmental regulations, or the cost to a consumer of purchasing a product.
<b>Process color printing</b>	halftone color printing created by the color separation process; a piece of copy is broken down to the primary colors to produce individual halftones, which are then recombined at the press to replicate the full range of colors
<b>Product line</b>	a group of proprietary inks that are made by one manufacturer, share certain printing characteristics, include multiple colors, and are intended for use with a specific ink system (e.g., solvent-based)
<b>Propylene</b>	gas used in polymerization to form polypropylene

<b>Publicly Owned Treatment Works (POTW)</b>	a municipal or regional water treatment plant
<b>Reactive diluent</b>	material used in ultraviolet curing that reduces viscosity of ink
<b>Reactivity</b>	property of being able to decompose or react with other chemicals
<b>Reasonably Available Control Technology (RACT)</b>	technology required under the Clean Air Act to control the emissions of volatile organic compounds
<b>Recycling</b>	the practice of reducing environmental wastes by recovering and reprocessing waste materials, thereby reducing the use of virgin materials
<b>Reducer</b>	material used to alter the body, viscosity, or color strength of ink
<b>Reference concentration</b>	<i>lowest continuous human inhalation exposure</i> that does not have an appreciable risk of deleterious, non-cancerous effects during a lifetime
<b>Reference dose</b>	<i>lowest daily human exposure</i> that does not have an appreciable risk of deleterious, non-cancerous effects during a lifetime
<b>Repeat length</b>	printing length of a plate cylinder, determined by one complete revolution of the plate cylinder gear
<b>Reportable quantity</b>	substance-specific amount of hazardous material reportable under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
<b>Reproductive toxicity</b>	biologically adverse effects on the female or male reproductive organs, the related endocrine system, or offspring
<b>Resin</b>	natural or synthetic complex organic substance with no distinct melting point, which in a solvent solution forms the binder portion of the flexographic ink
<b>Reverse printing</b>	printing on the underside of a transparent film; or a design in which an image or type is "dropped-out" and the background is printed
<b>Risk characterization</b>	in risk assessment, the process of using hazard, dose-response, and exposure information to develop quantitative and qualitative expressions of risk
<b>Scuffing</b>	action of rubbing something against a printed surface
<b>Silver recovery</b>	process by which silver is recovered from printing wastewater
<b>Smog-related emissions</b>	gases, such as volatile organic compounds (VOCs), carbon monoxide, and nitrogen oxides (NO <sub>x</sub> ), that are released during printing or energy production operations and contribute to the formation of smog when exposed to sunlight
<b>Social benefit</b>	the total benefit of an activity that society receives, i.e., the sum of the private benefits and the external benefits. For example, if a new product prevents pollution (e.g., reduced waste in production or consumption of the product), then the total benefit to society of the new product is the sum of the private benefit (value of the product that is reflected in the marketplace) and the external benefit (benefit society receives from reduced waste).

<b>Social cost</b>	the total cost of an activity that is imposed on society. Social costs are the sum of the private costs and the external costs. Therefore, in the example of the steel mill, social costs of steel production are the sum of all private costs (e.g., raw material and labor costs) and the sum of all external costs (e.g., the costs associated with replacing the poisoned fish).
<b>Solvent</b>	medium used to dissolve a substance
<b>Solvent-based ink</b>	an ink containing more than 25% VOCs and formulated to dry via evaporation
<b>Solvent recovery</b>	process of recovering purified solvents from VOC emissions
<b>Solvent resistance</b>	the ability of a cured ink coating to resist removal during exposure to a solvent such as methyl ethyl ketone (MEK)
<b>Stack emission</b>	emissions that are collected from the printing press and are released through a roof vent or stack to the outside air, sometimes undergoing treatment to reduce the emissions
<b>Stack printing press</b>	press where the printing stations are placed one above the other, each with its own impression cylinder
<b>Substrate</b>	material upon which an image is printed
<b>Systemic toxicity</b>	adverse effects on any organ system following absorption and distribution of a chemical throughout the body
<b>Thermal oxidizer</b>	oxidizer that requires high operating temperatures (see Oxidizer)
<b>Thinner</b>	liquid, solvent, and/or diluent added to ink for dilution or thinning; a type of extender
<b>Tone</b>	color quality or value; a tint or shade of color
<b>Toxic Chemical Release Inventory (TRI)</b>	requirement under the Emergency Planning and Community Right-to-Know Act (EPCRA) requiring certain facilities to report release of specified chemicals
<b>Toxicity</b>	property of being harmful or poisonous
<b>Trapping</b>	printing of one color over another
<b>Tropospheric Ozone</b>	see Ozone
<b>Turbidity</b>	a condition in which the clarity of water is reduced because of the presence of sediment, pigment, or other suspended material
<b>Ultraviolet light</b>	electromagnetic radiation of shorter wavelength than visible light
<b>UV-cured ink</b>	ink that is cured by ultraviolet light rather than evaporation
<b>Vehicle</b>	liquid component of a printing ink; carries the ink from the ink pan to the substrate
<b>Viscosity</b>	resistance to flow
<b>Volatile Organic Compound (VOC)</b>	any organic (carbon-containing) compound that participates in atmospheric photochemical reactions, except those designated by EPA as having negligible photochemical reactivity
<b>Volatilization</b>	the process of passing from liquid to gaseous state; subject to rapid evaporation; having high vapor pressure at room temperature

<b>Waste generator</b>	a facility that generates wastes and is responsible for determining whether the waste is hazardous and what classification may apply to a waste stream
<b>Water-based ink</b>	an ink containing less than 25% VOCs and formulated to dry via evaporation
<b>Wetting</b>	process by which a liquid wets the surface of a dissimilar material by reducing the surface tension of the liquid
<b>Wide-web press</b>	a printing press with a web that is greater than 24 inches wide, usually in the range of 50-60 inches
<b>Willingness-to-pay</b>	estimates used in benefits valuation intended to encompass the full value of avoiding a health or environmental effect, which are often not observable in the marketplace. For human health effects, the components of willingness-to-pay include the value of avoided pain and suffering, impacts on the quality of life, costs of medical treatment, loss of income, and, in the case of mortality, the value of a statistical life.

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