Environmental, Health, and Safety Guidelines for Printing

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

The EHS Guidelines for Printing include information relevant to printing facilities and the main printing technologies including lithography / offset, gravure / rotogravure, flexography, screen, and letterpress printing. This document does not provide information applicable to plateless printing such as digital color printing machines for short runs up to DINA3 size, or electrostatic, magnetic, and thermal devices. Annex A contains a full description of industry activities for this sector. This document is organized according to the following sections:

Section 1.0 — Industry-Specific Impacts and Management
Section 2.0 — Performance Indicators and Monitoring
Section 3.0 — References
Annex A — General Description of Industry Activities

[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with printing, which occur during the operational phase, along with recommendations for their management. Recommendations for the management of EHS issues common to most large industrial facilities during the construction and decommissioning phases are provided in the **General EHS Guidelines**.

1.1 Environment

Environmental issues in printing facilities primarily include the following:

- Emissions to air
- Wastewater
- Hazardous materials management
- Waste

Emissions

Volatile Organic Compounds (VOC)

VOC emissions to air constitute approximately 98 to 99 percent of all toxic releases in the printing industry. The most significant sources of VOCs emissions in printing activities result from evaporation of the fountain (e.g. isopropyl alcohol and ethanol) and cleaning (e.g. organic solvents) solutions that are used in pressrooms.[2] Significant VOC emissions may be generated from lacquering with solvent-based lacquers and from laminating with solvent-based adhesives. Other sources of VOCs include binding, laminating, coating, and drying operations, as well as cleaning, ink storage and mixing, and press proofing. VOCs (alcohols) may be emitted during platemaking in offset and letterpress processes, from the use of perchloroethylene to wash photopolymer plates in flexography, from the screen-cleaning operation in screen printing, and from the developing and drying operation during cylinder-etching in gravure.

Although no significant VOC emissions are generated from the prepress / imaging process, developers and fixers may generate emissions of sulfur compounds, acetic acid, and ammonia from blueprint, as well as odors, particularly in older processes. Annex B presents a list of potential toxic substances, including VOCs, that are relevant to the printing industry.

Recommended strategies for prevention and control of VOC emissions include the following:

- Selection of materials or processes with no or low demand for VOC-containing products, for example:
  - Use of water-based degreasing solvents instead of chlorinated solvents for silkscreen stencil
  - Reduction in the use of solvents containing benzene, toluene, and other aromatic hydrocarbons, as well as acetic acid
  - Use of water-based inks and vegetable oil–based inks (e.g. soy, linseed, canola) and ultraviolet (UV)-curable inks
  - Use of fountain solutions / cleaning solutions with low-volatility components (e.g. with benzene content less than 0.1 percent, toluene and xylene less than 1 percent) or vegetable oil based cleaning agents as substitutes for organic solvents, reducing or replacing isopropyl alcohol
  - Use of cleaning agents based on soap or detergent solutions and vegetable oils esterified with alcohol for solvent-free cleaning operations, wherever possible. These cleaning agents have a minimum flash point of 100°C for fire safety

[2] Toluene, methyl ethyl ketone (MEK), xylenes, and 1,1,1-trichloroethane typically represent the most common high-volatility toxic chemicals employed in this sector. Large rotogravure printing facilities may consume more than 200 tons of solvent per year.

- Use of press-cleaning solvents with minimum flash points of 55°C (e.g. low volatility hydrocarbon mixtures, non-VOC citrus, vegetable oils and their esters)
- Use of computer-to-plate (CTP) technology in imaging / platemaking steps
- Replacement of dichloromethane (methylene chloride) for the removal of dried ink
- Use of water-based and UV-curing lacquers
- Substitution of solvent-based adhesives with adhesives with a lower solvent content, UV-drying systems, or water-based adhesives or thermofoiling;
- Implementation of waterless offset printing
- Reduction of the etching depth of the plate in rotogravure (e.g. thermal laser direct imaging, instead of diamond stylus or chemically etching with ferric chloride), when items can be printed with soy / vegetable based ink. Thermal gravure system coupled with electrolytic copper removal technology that automatically controls the cell-depth allows the use of water-based ink
- Use of dry ice blasting processes for cleaning

- Avoiding or minimizing VOC losses through process modifications and solvent vapor recovery, including:
  - Adoption of automatic wash-up systems and automatic blanket wash systems
  - Use of pumped transfer systems to refill ink ducts on large flexographic presses
  - Use of refrigerated circulators to control isopropyl alcohol emissions from the fountain solution in lithography
  - Use of enclosed doctor blade systems or VOC recovery by activated carbons in flexography
  - Implementation of solvent recovery and recycling systems, including in-line filters for fountain solutions and distillation units for solvents
  - Use of enclosed storage for all solvent and cleaning fluids, as well as for the disposal of contaminated rags and cloths
  - Quality control of storage containers and drums containing volatile materials (e.g. inks, paints and solvent-laden cleaning rags), ensuring that they are kept closed and segregated in a ventilated room or area
- Implementing secondary controls, as necessary, to address residual emissions, including:
  - Activated carbon adsorbers (not suitable for ketone-based inks in rotogravure or for rotogravure / flexography facilities using a variety of inks with different solvent mixtures)
  - Use of heatset afterburners / recuperative / regenerative thermal oxidizers (compatible with most inks for rotogravure and flexography, but energy intensive)
  - Use of catalytic / regenerative catalytic oxidizers (suitable for facilities dedicated to long-term production for specific items, but not suitable for certain inks with chlorinated solvent additives)
  - Incineration of exhaust gases if using solvent-based lacquers
- Developing and implementing a solvent management plan that includes procedures for reduction in the use of solvents through:
  - Verification of compliance with emission limits, providing a quantification of the solvent emissions from all sources (including solid wastes, wastewater, air emissions)
  - Identification of future reduction options, including implementation schedule
  - Record keeping on annual solvent consumption and solvent emissions

Additional guidance applicable to process handling and storage of hazardous materials is provided in the **General EHS Guidelines.**

Other Toxic Compounds

Galvanic, chromium-plating, and dechroming baths in gravure printing cylinder-making may be sources of emission of some toxic compounds including hexavalent chromium, hydrochloric acid, and isocyanates. Recommended prevention and control strategies for these types of emissions include:

- Installation of baffle separators with aerosol screens to limit emissions of hexavalent chromium (Cr VI) from chromium-plating baths;
- Maintaining hydrochloric acid concentrations at 10 percent by volume in dechroming baths and plugging the ends of the cylinders to avoid the interior exposure to hydrochloric acid (HCl), thus minimizing HCl emissions;
- Avoiding or minimizing emissions of isocyanates generated during the handling, loading, and mixing processes involving coatings containing isocyanate; the handling and storage of isocyanate-contaminated wastes; and printing / coating and drying processes involving coatings that contain isocyanate, Prevention and control techniques include:
  - Use of automatic pumps to transfer liquid isocyanates from drums / storage containers to process containers
  - Selection and use of isocyanates containing fewer free, and less volatile, isocyanates
  - Use of enclosed mixing and storage containers

Particulate Matter

Paper slitting, folding, and cutting operations generate particulate matter (paper dust). Paper dust emissions to the atmosphere or exposure to workers should be avoided or minimized through the implementation of applicable prevention and control techniques, including:

- Reduction or removal of dust emissions at the source through:
  - Removal of dust from precut paper board using vacuum systems at the press infeeds
  - Installation of built-in dust collectors for dust-generating equipment (e.g. large folding / cutting units or over print stations)
  - Use of humidity-level stabilizers
- Collection of fugitive dust from process areas through:
  - Maintenance of negative pressure in selected locations (e.g. the cutting areas and the press areas)
  - Installation of floor sealers and doors to help seal off cutting areas from printing areas
  - Installation of filter-fan units
  - Removal of dust from collection and extraction systems through use of cyclones and, if necessary, High Efficiency Particulate Air (HEPA) filters to capture fine particles

Combustion By-Products

Printing facilities may have boilers and / or thermal fluid heaters to produce heat for certain processes, such as in flexography. Guidance for the management of small combustion source emissions with a heat input capacity of up to 50 megawatt hours thermal (MWth), including air emission standards for exhaust emissions, is provided in the **General EHS Guidelines**.

Wastewater

Industrial Process Wastewater

Wastewater sources in the printing industry are typically associated with photo and plate processing activities. Prepress / imaging operations with photographic films, now largely out of use, involve light-sensitive salts, alkaline or acid baths, and

other chemicals used in black and white printing (e.g. n-hexane, sodium thiosulfate, ammonia, hydroquinone, diethanolamine, and zinc compounds). Wastewaters from the industrial process may contain metal compounds (e.g. silver and mercury) and cleaning solutions may contain pigments, acids, and solvents (e.g. toluene).

Acid plate-etching chemicals used in gravure may contain nitric acid, perchloroethylene, and butanol. In addition, copper and chromium compounds, as well as ethylene glycol, glycol ethers, and methanol, may be found in these operations.

Prepress / imaging liquid wastes consist of spent developers, used rinse / wash water, and spent fixers, resulting from treatments to recover chemicals such as silver. The rinsing water from developing stencils in screen printing contains reactive acrylates, is toxic to aquatic organisms, and may cause nitrification effects. Rinsing water used during cylinder-making in gravure printing may contain copper, chromium, and nickel, and is acidic. Rinsing water generated during the development of the light-sensitive plate coating may contain limited quantities of decoating agents, with a chemical oxygen demand (COD) of approximately 300 mg/l.

Recommended wastewater prevention strategies should consist of the substitution of potentially hazardous compounds and the reduction in volume of wastewater requiring treatment. Techniques to minimize the generation of wastewater include:

- Reducing the amount of chemicals in chemical baths using nonsilver photographic films and washless processing systems;
- Use of water-developed films and water-developed plates;
- Use of countercurrent rather than parallel rinse processes to reduce the amount of clean water used;
- Reducing the use of chromium, lead, and barium in the pigments and use alternative coatings (e.g. electrostatic / powder coatings, toxic-free alternative paints). If chromium application is required, use dragout recovery and reduction or evaporation, or reverse osmosis technologies;
- Using water-based lacquer coating for overprint processes;
- Using water-soluble adhesives in binding operations or low VOC glue, as necessary. Adoption of CTP technology for platemaking;
- Maximizing opportunities to recycle treated effluent.

Process Wastewater Treatment

Since the printing industry has a range of products that uses a diverse range of raw materials, chemicals and processes, wastewater treatment may require the use of unit operations specific to the manufacturing process in use and the specific contaminant. Techniques for treating industrial process wastewater in this sector include (i) source segregation and pretreatment of wastewater streams containing high concentrations of non-biodegradable compounds using phase separation such as solvent recovery, air stripping, chemical oxidation, adsorption processes, etc., (ii) reduction in heavy metals using chemical precipitation, coagulation and flocculation, electrochemical recovery, ion exchange, etc., and (iii) disposal of residuals in designated hazardous waste landfills. Additional engineering controls may be required for (i) advanced metals removal using membrane filtration or other physical/chemical treatment technologies, (ii) removal of recalcitrant organics and halogenated organics using activated carbon or advanced chemical oxidation, (iii) reduction in effluent toxicity using appropriate technology (such as reverse osmosis, ion exchange, activated carbon, etc.), (iv) residual color removal using adsorption or chemical oxidation and (v) containment and treatment of volatile organics stripped from various unit operations in the wastewater treatment system.

Management of industrial wastewater and examples of treatment approaches are discussed in the **General EHS Guidelines**. Through use of these technologies and good practice techniques for wastewater management, facilities should meet the Guideline Values for wastewater discharge as indicated in the relevant table of Section 2 of this industry sector document.

Other Wastewater Streams & Water Consumption

Guidance on the management of non-contaminated wastewater from utility operations, non-contaminated stormwater, and sanitary sewage is provided in the **General EHS Guidelines**. Contaminated streams should be routed to the treatment system for industrial process wastewater. Recommendations to reduce water consumption, especially where it may be a limited natural resource, are provided in the **General EHS Guidelines**.

Hazardous materials management

The printing industry uses a variety of hazardous materials, including solvents and other chemicals. Guidance on the management of hazardous materials, including handling, storage, and transport, is provided in the **General EHS Guidelines**.

Waste

Liquid waste from the press may include ink residues (containing zinc, chromium, barium, lead, manganese, benzene, dibutyl / ethyl acetates); waste from fountain and cleaning solutions (e.g. spent organic solvents, including trichloroethane, methylene chloride, carbon tetrachloride, acetone, methanol); and other solvents and container residues (e.g. toluene, xylene, glycol ethers, Methyl ethyl ketone, and ethanol). Water-based inks may contain biocides and photo initiators. Postpress wastes may include zinc, barium, and cadmium from waste paper, and n-hexane, methanol, and 1,1,1-trichloroethane from container residues. Solid wastes may include waste paper and other substrates, exhausted printing plates, cylinder-etching operation waste, rags, containers, and packaging.[3]

Guidance on the storage, handling, and disposal of hazardous and non-hazardous waste is provided in the **General EHS Guidelines.** Additional recommended waste management strategies specific to this sector include:

- Reduction in the generation of hazardous and non-hazardous waste through:
  - Use of computer-controlled ink-feed systems and digital set-up machines to reduce the number of make-ready sheets
  - Recover plates by remelting and prioritize use new generation polymeric plates
  - Use of high-volume printing plates
  - Use of engraving rather than etching for gravure cylinders
  - Re-blend waste inks
  - Use of spent inks and solvents as supplementary fuel

1.2 Occupational Health and Safety

Occupational health and safety hazards during the construction and decommissioning of printing facilities are common to those of most industrial facilities, and their prevention and control is discussed in the **General EHS Guidelines**. Occupational health and safety hazards during the operational phase and specific to the printing industry primarily include the following:

- Chemical hazards
- Physical hazards
- Noise

[3] The average paper loss from printing facilities using paper as substrate is approximately 6 percent.

Chemical Hazards

The most common occupational chemical hazards in printing are associated with potential exposures to solvents and their associated VOCs, in addition to dust. Guidance on the prevention and control of chemical hazards is provided in the occupational health and safety section of the **General EHS Guidelines**. The following additional information is specific to printing facilities.

Inhalation Hazards

Inhalation of potentially hazardous chemicals may occur at any stage of the printing process where alcohols or solvents evaporate into the work environment or more specifically through the generation of ozone produced by UV lamps or from corona treatment of plastic film surfaces. An additional source of inhalation exposure is the different types of dust generated at some stages of the printing process. Recommended prevention and control for VOC and ozone inhalation exposures include the following:[4]

- Select less hazardous process materials, such as cleaning solutions with no hazardous constituents. Other alternatives include low volatility cleaners / coating materials (e.g. VOC composite vapor pressure less than 10mm Hg at 20°C), and water- and vegetable oil–based inks;
- Prevent VOC dispersion into the work area through installation of local exhaust extraction systems that are externally vented, particularly at the main emissions points, including:
  - Pressrooms
  - Locations where socyanate-based inks are used
  - Ink mixing activity areas / processes
  - Drying rack and oven drying processes / areas;
  - Gravure processes
- Reduce, contain and exhaust ozone associated with UV units through the techniques:
  - control ozone generation during installation and commissioning of UV units in lithographic printing
  - Use water-cooled UV units (they may generate less ozone than air-cooled units)
  - Screen UV exposure units in screen printing with UV-cured inks and coatings with fixed or interlocked covers
  - Screen UV units behind shutters, blinds or wraparound curtains when producing photopolymer plates
  - Install local exhaust ventilation for the enclosed area surrounding a conventional air-cooled UV lamp
- Maintain the oven used to cure inks below atmospheric pressure when in use;
- Restrict access to the pressroom and to areas where toxics may be released.

Dermal Contact Hazards

The use of hazardous materials in printing may generate exposure hazard for workers through direct skin contact with liquid or solid hazardous / corrosive substances (e.g. vapors and / or sprays). Exposure may occur in the prepress phase (e.g. acid baths for film developing and hand correction of lithoplate). Other potential sources of exposures include isopropyl alcohol in fountain solution and press-cleaning solvents, nonwater-based inks, and UV-cured inks during the press and postpress phases. Recommended prevention and control measures for dermal contact exposure include:

- Adoption of adequate personal protection equipment (PPE), including correctly specified gloves, coveralls, face

[4] Guidance on prevention and control of dust exposures are provided together with the recommendations for management of dust-induced fires and explosions.

or eye shields / eye protection, suitable for chemical protection;

- Immediate change of protective clothing if contaminated with uncured ink;
- Monitoring for incidence of dermatitis or other indicators of potential exposure to chemical through dermal contact.

Fire Hazards (Powder, Dust, and Other Materials)

Anti-offset powder, used mainly in sheet-fed offset presses, is a very fine, nontoxic powder that is emitted from the final roller.[5] This powder contains maize starch, calcium carbonate, and tripolite. It may settle on exposed surfaces in the pressroom, and is classified as a nuisance dust with a potential for explosion. In addition, it constitutes a potential health hazard.

Prevention and control techniques for anti-offset powder include the following:

- Maintain / modify spraying units to reduce the amount of powder used;
- Use of local exhaust ventilation, followed by control with bag filters.

Dislodgment and explosion of accumulated dust represents a significant safety hazard in the printing industry. Small clouds of dust from paper may ignite and cause accumulated dust to dislodge and explode.[6] In large folding and cutting units, dust may accumulate on horizontal surfaces, which is particularly dangerous in the event of fire. Prevention and control measures for dust related explosion hazards include the following:

- Conduct monitoring of dust deposition on horizontal surfaces and remove it through vacuum and cleaning techniques that avoid the use of compressed air and blowing systems;
- Improve ventilation and limit dispersion of VOCs or dust throughout facility areas;
- Install dust filters.
- Install dust and explosion proof equipment, wiring and fixtures in areas where explosion hazard is high.

Substances such as inks, chemicals, paper, boards, plastics, and other printable substrates may be dangerous (e.g. due to generation of toxic fumes and potential explosions) in the event of fire. The main causes of fire in pressrooms are heat from friction, static electricity, and sparks. Recommended prevention and control measures include the following:

- Install anti-static cleaning equipment;
- Ground all presses to avoid static electricity between the web and the press rollers;
- Provide fire-resistant containers for contaminated cleaning rags;
- Maintain minimum quantities of flammable substances in the pressroom and provide fire-resistant bins to store ink and solvents;
- Install fire protection measures in the pressroom including fire extinguishing systems (e.g. detection and sprinkler systems, in addition to fire suppression systems;
- Avoid storage of large stocks of flammable materials, and if necessary, provide a fire-proof storeroom outside the main facility building;
- Use fire walls to separate production lines with large quantities of solvents (e.g. rotogravure);
- Use a dedicated fire-resistant room (e.g. 30 minute fire separation rating) for the mixing or diluting of inks, and equip with appropriate fire extinguisher systems.

[5] The UV-drying printing ink technique in offset printing does not require the use of anti-offset powder.

[6] Typical lower explosion limits (LEL) for dust are approximately 50-100 g/m^3 and upper explosion limits (UEL) are 2-3 kg/m^3.

Physical Hazards

Physical hazards in this sector are typically associated with the potential for serious hand and arm injuries, including amputations, during the use of folding, cutting (e.g. guillotines, paper knives, wire cutters), and binding machinery and during operation and maintenance of printing presses. More frequent, but typically less serious hazards, include cuts to extremities and strains from lifting or handling of printed materials, in addition to slips and fall due to slippery surfaces.

In addition to the measures to prevent and control physical hazards discussed in the **General EHS Guidelines**, including machine safety recommendations, industry-specific prevention and control of physical hazards should include the following:

- Installation of binding, folding, and cutting equipment with complete safety devices (e.g. interlocking, photoelectric, guillotines requiring two-handed operation) or retrofitting of existing equipment to provide adequate safeguards;
- Installation of modern machinery or retrofitting with 'inch-stop-lock-clean', 'inch-stop-clean', 'hold-to-run / slow crawl', and prestart audible warning devices; emergency stop buttons; and lockout switches;
- Installation of automatic wash-up systems;
- Implementation of written procedures to prevent opportunities for the insertion of hands into the moving parts of printing presses or other equipment during operation.

Noise

Printing industry machinery, including ventilation systems, may result in continuous or intermittent sources of noise. In addition to the noise prevention and control strategies provided in the **General EHS Guidelines**, noise management strategies in printing operations include:

- Installation of overlapping PVC strip curtains (which can obtain noise reduction of 10 dB[A]) and / or automatic door-closers;
- Enclosure of parts of process machinery using acoustic enclosures in pressrooms;
- Use of sound absorbent materials for walls and ceilings.

1.3 Community Health and Safety

Community health and safety impacts during the construction, operation, and decommissioning phases of printing industry facilities are common to those of most industrial facilities and are discussed in the **General EHS Guidelines.**

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

Tables 1 and 2 present effluent and emissions guidelines for this sector. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. These guidelines are achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document.

Emissions guidelines are applicable to process emissions. Combustion source emissions guidelines associated with heat- and power-generation activities from sources with a heat input capacity equal to or lower than 50 MWth are addressed in the **General EHS Guidelines** with larger power source emissions addressed in the **EHS Guidelines for Thermal Power**. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines**.

Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guidelines**. These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels in consideration of specific, local project conditions should be justified in the environmental assessment.

Table 1. Air Emission Levels for Printing Industry

Pollutants	Units	Guideline Value
VOCs	mg/Nm^3	100[a,b]
		20[a,c]
		75[a,d]
		100[a,e]
Particulates	mg/Nm^3	50[f]
NOx	mg/Nm^3	100 - 500[g]
Isocyanates	mg/Nm^3	0.1[h]

NOTES:
[a] Calculated as total carbon
[b] Heatset web offset printing with 15-25 tonnes / year solvent consumption
[c] Heatset web offset printing with >25 tonnes / year solvent consumption
[d] Publication rotogravure with >25 tonnes / year solvent consumption
[e] Other rotogravure, flexography, rotary screen printing, laminating, or varnishing units (> 15 tonnes / year solvent consumption) rotary, screen printing on textile/card-board (> 30 tonnes / year solvent consumption)
[f] As 30 minute mean for contained sources. From all processes / activities.
[g] As 30 minute mean for contained sources. From turbines, reciprocating engines or boilers used as VOC abatement equipment.
[h] As 30 minute mean for contained sources, excluding particulates, and expressed as NCO. From all processes / activities using isocyanates.

Table 2. Effluent Levels for Printing Industry

Pollutants	Units	Guideline Value
pH	--	6-9
COD	mg/L	150
BOD_5	mg/L	30
Total Phosphorus	mg/L	2
Total Suspended Solids	mg/L	50
Oil and Grease	mg/L	10
Aluminum	mg/L	3
Cadmium	mg/L	0.1
Chromium Hexavalent Total	mg/L	 0.1 0.5
Copper	mg/L	0.5
Iron	mg/L	3
Lead	mg/L	1
Silver	mg/L	0.5
Zinc	mg/L	0.5
Cyanide	mg/L	0.2
Adsorbable Organically-bonded Halogens (AOX)	mg/L	1
Toxicity	To be determined on a case specific basis	
Temperature increase	°C	<3[a]

[a] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Resource Use and Waste

Table 3 provides examples of indicators for energy, water and raw material consumption and waste generation. Industry benchmark values are provided for comparative purposes only and individual projects should target continual improvement in these areas.

Table 3. Resource Use and Waste[a]

Inputs per unit of product	Unit	Industry Benchmark
Energy Energy consumption	MWh/ton	0.52-0.77[b]
Water Water consumption per paper used	m^3/ton	0.62-2.09[c]
Materials Total consumption of printing carriers Non-renewable materials (films, plates, mineral-based oil in printing ink, UV-ink and plastics) Hazardous materials	 kg/ton kg/ton kg/ton	 1,110-1,370 0.50-11 0-1.2
Outputs per unit of product	**Unit**	**Industry Benchmark**
Emissions VOC-emissions	kg/ton	0.17-0.69

Notes:
[a] Data from 1998-2000 for Swedish commercial printing industry, except where otherwise noted. Source: Enroth (2001)
[b] Includes statistics for Finland, 130 printing firms, in year 2000. Source: O.Ö. Energiesparverband (2003)
[c] Data from year 2000 for 130 printing firms in finland. Lower value for heatset and higher value for sheet-fed printers. Coldset printers have intermediate values. Source: O.Ö. Energiesparverband (2003)

Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and

reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),[7] the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),[8] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[9] Indicative Occupational Exposure Limit Values published by European Union member states,[10] or other similar sources.

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)[11].

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals[12] as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

[7] Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/
[8] Available at: http://www.cdc.gov/niosh/npg/
[9] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992
[10] Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/
[11] Available at: http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm
[12] Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

3.0 References and Additional Sources

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Annex A: General Description of Industry Sector Activities

The majority of printing companies are small (fewer than 5 people) or medium-size (fewer than 20 people) facilities, serving a local or regional market. They are often located in urban settings, business centers, or in industrial estates. Medium-size printing facilities are typically located close to binding and postpress facilities, and couriers to reduce transportation costs. Large printing facilities usually have flexographic or gravure-type production and supply national or international markets.

The main raw materials used by the printing industry include coated and uncoated paper and board, as well as other printable substrates (e.g. plastics, metals, glass, wood, among others), chemicals, plates, inks, toner cartridges, lacquers, glues, adhesives, stitches, ring-bounds, wires, and other bookbinding items. Use of photographic films, previously one of the most important materials in prepress / imaging processes, is rapidly declining.

Prepress / Imaging

Prepress / imaging is the process used to produce an image, typically through electronic devices and software, of the subject to be printed. Modern imaging workflows consist of color proof checks; transmission of image files to automatic plate processing; final data transmission to automatic laser platemaker; and plates, and auto-inking control files, to press.

Traditional plate processing uses photographic films (now largely disused), which are developed, fixed, and rinsed. Wet-proofs are made before plating, and plates are produced before pressing. Raw materials used in prepress and imaging processes include zinc, aluminum, plastic, paper, copper-plate cylinder, flexible rubber or plastic mold, porous polyester mesh, and films (nonhazardous materials), in addition to acids, solvents, and fixers (hazardous materials).

Press

According to the type of plate used, press technology may be divided into the following categories (i) Lithography / offset printing; (ii) Gravure / rotogravure; (iii) Flexography; (iv) Screen printing; and (v) Letterpress. Computer-to-plate (CTP) technologies have partially replaced traditional platemaking in all sectors. Raw materials used in the press process include various printable surfaces (e.g. paper, textiles, plastics, and metals, in addition to inks, cleaning solvents, and water-based or solvent-based solutions.

Lithography / Offset Printing

Offset printing uses planographic plates and oil-based lithographic inks. A rubber blanket transfers the image from the plate to the substrate, and image / nonimage areas are on the same plane. The plate (commonly made of zinc, aluminum, plastic, or paper) is coated with a light-sensitive chemical that becomes ink-receptive when exposed to light. The negative is exposed to light, chemically altering the exposed areas and making the image area ink-wettable (and water repellent), while the non-image areas become water-wettable (and chemically repellent to ink). An aqueous solution of isopropyl alcohol (generally 15 percent alcohol, but potentially up to 30 percent), called fountain or dampening solution, is used to dampen the nonimage area on the plate. Fountain solutions containing less volatile organic compounds (VOCs) or alcohol substitutes are being used more often, especially in the newspaper industry. Offset printing requires cleaning solutions to clean the press and other parts. Traditionally, these are solvent-based solutions, but lower solvent or nonsolvent cleaning solutions have been developed recently and are available. In general, the main lithography products include books, brochures, artwork, and magazine printing, as well as packaging applications. The lithographic process includes the following options:

- Sheet-fed offset, in which the substrate is fed one sheet at a time, and is mainly used for printing books, brochures, artworks, magazines, and catalogues. It is suitable for higher-quality runs from 1,000 to 100,000 copies with a mechanical velocity up to 15,000 revolutions / hour.
- Web-offset coldset, in which paper is printed from a roll, is used mainly for printing newspapers and business forms.
- Web-offset heatset, which typically is used for printing quality magazines and catalogues. Both web-offset coldset and heatset are suitable for medium- to high-quality runs from 20,000 to 1 million copies with a mechanical velocity up to 100,000 revolutions / hour.

Gravure / Rotogravure Printing

The gravure / rotogravure is a printing process in which an image is etched or (more commonly) electromechanically engraved into a cylinder surface. It is generally operated with web-fed presses and uses cylinders plated with copper. Either solvent-based or water-based inks are used. Inks usually are fluid and applied to the cylinder, and the excess is scraped using a doctor blade. Hot-air dryers are used to dry inks and solvents. This technology is typically used for medium-quality printing jobs (e.g. large distribution catalogs and magazines, newspaper supplements, packaging items, and wallpapers). The gravure / rotogravure process is suitable for runs from 300,000 to 5 million copies with a velocity of 55,000 copies / hour.

Flexography Printing

Flexography printing is sheet fed or, more frequently, web fed, and uses exposed flexible plates that are processed in an acid bath with raised images coming in contact with the substrate during printing. The plates can be used directly for letterpress or to mold a flexible rubber / plastic master. Alcohol-based inks are generally used. Flexography is used for medium or long multicolor runs on a variety of substrates (e.g. heavy paper, fiberboard, and metal and plastic foil). The substrate is fed into the press from a roll and travels through a series of steps, each one printing a single color. Overhead dryers dry the inks and a final overhead tunnel, close to the rewind station, removes the solvents. The use of specific inks allow for applications on impervious nonabsorbent substrates (e.g. plastics, films, and metallic surfaces) and on absorbent compressible substrates (e.g. paper and cardboard). Flexography is used to print flexible packaging, cardboard packaging, multiwall bags, food cartons, paper cups, plates, and gift wraps. It is suitable for runs from 10,000 to 150,000 copies with a machine velocity of 100 meters / minute.

Screen Printing

Screen-printing technology uses a porous polyester mesh with a stencil that defines the image to be printed. The inks used depend on the substrate to be printed (e.g. textiles, plastics, metals, or paper). Inks can be solvent-based, water-based, and UV-cured. CTP technology can be used in medium- or large-size facilities.

Letterpress Printing

Letterpress printing is an older technology and it is now often replaced by lithographic or flexographic technologies. Similar to flexography, it uses metal or plastic raised plates (relief printing plates). Letterpress uses solvent-based (about 40 percent by volume), viscous, heatset inks, similar to lithographic printing. It is primarily used for short runs to print books, business cards, and stationery.

Postpress / Finishing

Coating

Coating is used for products that need special brightness or protection. The printed substrates are varnished through overprint runs applying varnish and overprint runs under

dedicated roller coaters. Ultraviolet-cured, water-based, and solvent-based lacquers may be used.

Laminating

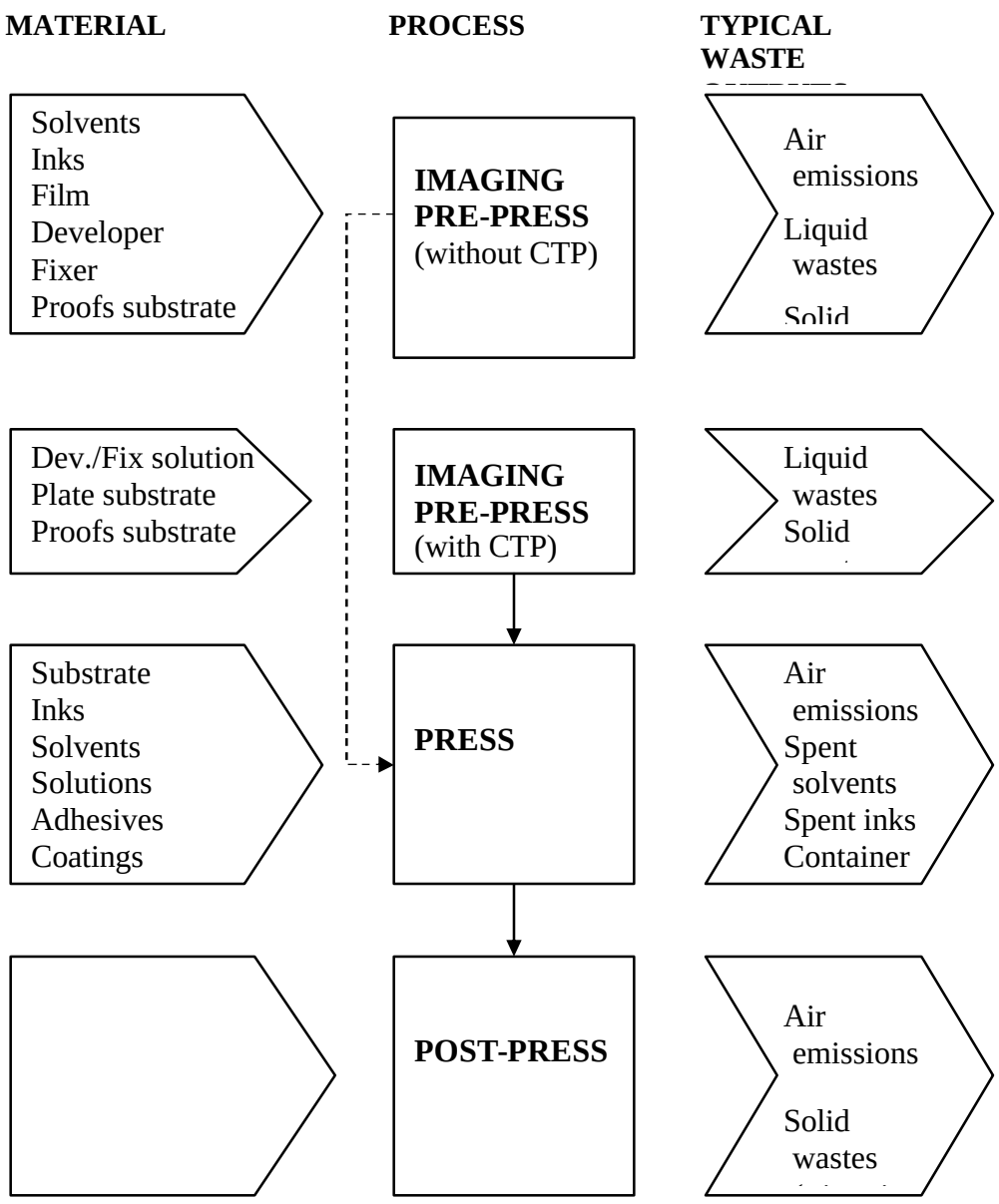
Printing products, usually for packaging applications, typically may be laminated by the following methods:

- Solvent-based systems, where a thin, plastic-coated film coupled to the printed item passes through an oven before being pressed on.
- Water-based system, wherea nip coater applies a polymer emulsion to the film which is then driven through an infrared device.
- Thermofoil (pressed on the printed product at high temperature).
- Urethane mixture (reacting to create a laminating film).
- Cutting, folding, and perforating steps usually complete the production.

Binding

Depending on the product thickness and type, binding may employ a variety of adhesives (e.g. hot-melt, water-based, and polyurethane) as well as several types of plastic or metal bookbinding items (e.g. metal stitches, metal or plastic ring-bounds, and wires)

Figure A.1: Material Inputs and Typical Waste Outputs in the Printing Industry



Source: Modified from US Environmental Protection Agency (2000)

Annex B. Chemicals Possibly Present in Printing Industry Activities

Water-based inks and coatings:

Ammonia, Zinc

Water- Solvent-based inks:
Ethyl-benzene, Ethylene-glycol, Glycol-ethers, Toluene diisocyanates

Solvent-based inks and coatings:
Hexane, Methyl-ethyl-ketone (MEK), Methanol, Propylene Oxide, Xylenes, Methyl-isobutyl-ketone (MIBK), Isopropyl Alcohol, Ethyl Acetate, Ethanol, Propyl Acetate, Butanol, 2-Butoxyethanol, Acetone

Pigments:
Barium, Cadmium, Chromium, Copper, Lead Chromate, Manganese, Zinc

Ink solvents:
n-Butyl alcohol, Isophorone

Ink catalysts or retardants for drying:
Manganese, Methyl Chloroform-1,1,1, Trichloroethane, Xylenes

Component in cleaning solvents:
Benzene, Cumene, Cyclohexane, Ethyl-benzene, Hexane, Methyl Chloroform-1,1,1, Trichloroethane, Methyl-ethyl-ketone, Methylene Chloride, Naphthalene, Toluene, Xylenes, 1,2,4 Trimethylbenzene, Isopropyl Alcohol

Component in cleaning solvents fountain solution additive:
Diethylene-glycols, Ethylene-glycols, Glycol Ethers, Phosphoric acid

Component in copper plating solution:
Ethylene-glycols, Methylene Chloride

Adhesives/Spray adhesives:
Cyclohexane, Hexane, Methyl Chloroform-1,1,1, Trichloroethane, Vinyl Acetate, Isopropyl Alcohol

Plasticizer in inks and coating:
Dibutyl Phthalate

Film developing:
Diethanolamine, Formaldehyde, Hydroquinone, Phenol

Plate developer:
Perchloroethylene, Phenol

Film cleaner:
Hexane, Methylene Chloride

Cleaners / Etching:
Nitric acid, Phosphoric acid, Perchloroethylene

Blanket/Roller Wash:

Cumene, Ethylbenzene, Naphthalene, Methanol, Methyl Chloroform-1,1,1-Trichloroethane, Methylene Chloride, Toluene, Xylenes,

SOURCE:
Environment Australia 1998
UK Secretary of State, Welsh Assembly Government, and Scottish Ministers. 2004. Secretary of State's Guidance for Printing. Process Guidance Note 6/16(04)
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