The industry is very diverse, which is reflected by the multitude of different products which bear some form of printing, e.g., books, daily newspapers, periodicals, packaging, cartons, carrier bags, drink containers, signs, forms, brochures, advertisements, wall paper, textiles, sheeting, metal foil etc.

Text, diagrams and pictures etc. are designed and composed, e.g., on a newspaper page. If pictures and/or text are to be printed in several colors, these must be separated. The pictures are also often screened, i.e., the picture consists of a large number of very small dots instead of a whole field. Photographic techniques are used for setting and working on pictures.

The page is then transferred to a printing form, a printing block (high-intensity, flexography), plate (offset), roller (rotogravure) or stencil (screen printing). This is done by means of exposure to a light-sensitive coating. In the case of offset, screen printing and usually book printing too, the printing form is developed by washing away part of the coating; the form may then in theory be used immediately. The offset plate is coated with rubber to protect it from oxidation. The screen sheet’s sides are masked using protective paint.

Other printing methods require further stages. The small grooves in the gravure roller are etched or, increasingly commonly, engraved and the surface is chromed for better durability. The rubber printing block for flexographic printing is cast or engraved by laser.

Printing is done on single sheets or paper web, using one or more printing units, depending on the number of colors required.

The dyeing agent is, in most cases, a solvent which evaporates from the paper. In some cases, it is necessary to hasten evaporation by feeding in warm air. Clear varnish is also sometimes added to the printed surface.

The printed matter is processed off-machine, where it is cut, jointed, folded, sewn, bound, packaged etc.

Printing may also be a step in another manufacturing process, for example laminating at package printing works, i.e., the joining of different layers of paper, plastic and metal foil.

Treatment of the surface of plastic to facilitate printing is achieved using electrical discharges from an electrode system, so-called “corona treatment”.

Waste Characteristics

Emissions into the air mainly consist of organic solvents and other organic compounds. Some substances may cause unpleasant odors or effects upon health and the environment.

Discharges to water bodies mainly consist of silver, copper, chromium, organic solvents and other toxic organic compounds.

Noise comes principally from fans, printing presses and transport.

Waste consists of environmentally hazardous waste such as photographic and residual chemicals, metal hydroxide sludge, dyestuff and solvent residues, wiping material containing dyes and solvents and oil spills. Other waste includes bulky waste such as paper.
Pollution Prevention and Control

The recommended pollution prevention measures are:
- Estimate and control quantities of volatile organic solvents used annually, including the amount used in dyes, inks, glues and damping water. Estimate and control the proportion that is made up of chlorinated organic solvents.
- Replace solvent-based dyes and glues with solvent-free or water based, where feasible. Water-based dyes are preferred for flexographic printing on paper and for screen printing, rotogravure, and flexographic printing on plastic.
- Give preference to the use of radiation setting dyes.
- Perform engraving instead of etching of gravure cylinders, producing smaller quantities of heavy metals.
- Enclose presses and ovens to avoid diffuse evaporation of organic substances entering the general ventilation system, where feasible. Use suction hoods to collect vapors and other fugitive emissions.
- Evacuate air from printing presses and drying oven in to a ventilation system.
- Where possible, replace chemicals used for form preparation and cleaning with more environmentally friendly alternatives. Maintain a record of chemicals and environmentally hazardous waste. Do not use halogenated solvents and degreasing agents in new plants. Replace them with nonhalogenated substances in existing facilities.
- Estimate the quantity of developing bath and fixing bath used per year and maintain these to acceptable levels.
- Minimize the rinsing water flow in the developing machines e.g., by use of “stand-by.”
- Collect fixing bath, developer, used film, photographic paper and blackened ends of photosetting paper and manage them properly.
- Use counter-current flow fixing processes.
- Aim for a closed washing system.
- Store chemicals and environmentally hazardous waste such as dyes, inks and solvents so that the risk of spillage into the wastewater system is minimized. Retaining dykes, or areas with no outlet, as a means of absorbing spillage are examples of items which should be checked.
- Minimize noise disturbance from fans and presses.
- Use equipment washdown waters as make-up solutions for subsequent batches. Use counter-current rinsing.
- Recover energy from combustion systems, when used.
- Return toxic materials packaging to the supplier for reuse.
- Recover plates by remelting.
- Label and store toxic and hazardous materials in secure bunded areas.

Treatment Technologies

Air Emissions

Emissions of gases from web offset with heat-setting are controlled by thermic or catalytic incineration. Toluene is recovered from rotogravure by absorption using active carbon. Adsorption of solvents using zeolites with recovery of organic solvents should be used. Treat organic solvents using trickling filters. Biological scrubbers should be used for treatment of discharges of water-soluble solvents. Chemical precipitation, sedimentation and filtration of water containing metals from the manufacture of gravure cylinders and printing blocks is an established method of treating effluents. Collect fixing baths for recovery or destruction. Evaporate solvents from regeneration of active carbon filters. Perform closed screen chase washing with recirculation of solvent and sludge separation. Developing machines should be fitted with counter-flow fixing and/or connected to an organic ion-exchanger. Collect film developing agents for destruction. Perform high-pressure water jet cleaning. Use ultra-filtration for the treatment of washing water.

Due to the relatively small volumes of solid wastes, it is difficult to find acceptable and affordable methods of disposal. Ideally, solid wastes should be sent for incineration where combustion conditions (such as 1,100°C and at least 0.5 second residence time) which ensure effective destruction of toxics are maintained.
Emissions Guidelines

Emission levels for the design and operation of each project must be established through the Environmental Assessment (EA) process, based on country legislation and the Pollution Prevention and Abatement Handbook as applied to local conditions. The emission levels selected must be justified in the EA and acceptable to MIGA.

The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance, including MIGA guarantees; any deviations from these levels must be described in the project documentation.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

The maximum value for emissions of volatile organic compounds (VOCs) should be below 20 milligrams per normal cubic meter (mg/Nm³) calculated as total carbon, and chlorine (chloride/chlorinated hydrocarbons) emissions should be below 10 mg/Nm³.

Liquid Effluents

The following effluent levels should be achieved:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum value (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5-10</td>
</tr>
<tr>
<td>BOD₅</td>
<td>30</td>
</tr>
<tr>
<td>COD</td>
<td>150</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>50</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>10</td>
</tr>
<tr>
<td>Cadmium and Hexavalent</td>
<td>0.1</td>
</tr>
<tr>
<td>chromium (each)</td>
<td></td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>0.5</td>
</tr>
<tr>
<td>Copper</td>
<td>0.5</td>
</tr>
<tr>
<td>Silver</td>
<td>0.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Effluent requirements are for direct discharge to surface waters.

Solid Wastes

Toxic solid wastes should be treated to destroy toxic organics to levels below 0.05 milligrams per kilograms (mg/kg). Wastes containing toxic metals should be stabilized to achieve levels in the leachate below those indicated in the effluent table above.

Ambient Noise

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Ambient Noise

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Daytime</th>
<th>Nighttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential; institutional; educational</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Industrial; commercial</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>
The emission requirements given here can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems.

Monitoring and Reporting

Frequent sampling may be required during start-up and upset conditions. Once a record of consistent performance has been established, sampling for the parameters listed above should be as detailed below:

- Continuously monitor air emissions exiting the air pollution control system where toxic organics are being emitted at rates greater than 0.1 kg/h.
- Analyze liquid effluents generated from the process at least monthly, and solid waste before sending it for disposal.

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. Records of monitoring results should be kept in an acceptable format. These should be reported to the responsible authorities and relevant parties, as required, and provided to MIGA if requested.

Key Issues

The following box summarizes the key production and control practices that will lead to compliance with emission guidelines:

- Good management practices, especially cleanliness and materials control, are essential and must be put in place.
- Spent fixing solution should be collected and reused or managed as hazardous waste.
- Recirculate liquid effluents.
- Do not use halogenated solvents.
- Use organic solvent free dyes and glues, where feasible.
- Minimize air emissions and toxic wastes (especially organics) generated.
- Incinerate all toxic organic wastes (except those containing toxic volatile metals).
- Collect solvent vapors (including toluene). Either recover solvents or incinerate in a combustion unit. Encapsulation and provision of hoods should be included.

- Manage spent photographic chemicals, plate developer, dye residues and other wastes containing toxic organics or metals as hazardous waste.

Further Information

The following are suggested as sources of additional information (these sources are provided for guidance and are not intended to be comprehensive):
