4.9.2 Publication Gravure Printing

4.9.2.1 Process Description[1-2]

Publication gravure printing is the printing by the rotogravure process of a variety of paper products such as magazines, catalogs, newspaper supplements and preprinted inserts, and advertisements. Publication printing is the largest sector involved in gravure printing, representing over 37 percent of the total gravure product sales value in a 1976 study.

The rotogravure press is designed to operate as a continuous printing facility, and normal operation may be either continuous or nearly so. Normal press operation experiences numerous shutdowns caused by web breaks or mechanical problems. Each rotogravure press generally consists of 8 to 16 individual printing units, with an 8-unit press the most common. In publication printing, only 4 colors of ink are used: yellow, red, blue, and black. Each unit prints 1 ink color on 1 side of the web, and colors other than these 4 are produced by printing 1 color over another to yield the desired product.

In the rotogravure printing process, a web or substrate from a continuous roll is passed over the image surface of a revolving gravure cylinder. For publication printing, only paper webs are used. The printing images are formed by many tiny recesses or cells etched or engraved into the surface of the gravure cylinder. The cylinder is about one-fourth submerged in a fountain of low- viscosity mixed ink. Raw ink is solvent-diluted at the press and is sometimes mixed with related coatings, usually referred to as extenders or varnishes. The ink, as applied, is a mixture of pigments, binders, varnish, and solvent. The mixed ink is picked up by the cells on the revolving cylinder surface and is continuously applied to the paper web. After impression is made, the web travels through an enclosed heated air dryer to evaporate the volatile solvent. The web is then guided along a series of rollers to the next printing unit. Figure 4.9.2-1 illustrates this printing process by an end (or side) view of a single printing unit.

At present, only solventborne inks are used on a large scale for publication printing. Waterborne inks are still in research and development stages, but some are now being used in a few limited cases. Pigments, binders, and varnishes are the nonvolatile solid components of the mixed ink. For publication printing, only aliphatic and aromatic organic liquids are used as solvents. Presently, 2 basic types of solvents, toluene and a toluene-xylene-naphtha mixture, are used. The naphtha base solvent is the more common. Benzene is present in both solvent types as an impurity, in concentrations up to about 0.3 volume percent. Raw inks, as purchased, have 40 to 60 volume percent solvent, and the related coatings typically contain about 60 to 80 volume percent solvent. The applied mixed ink consists of 75 to 80 volume percent solvent, required to achieve the proper fluidity for rotogravure printing.

4.9.2.2 Emissions And Controls[1,3-4]

Volatile organic compound (VOC) vapors are the only significant air pollutant emissions from publication rotogravure printing. Emissions from the printing presses depend on the total amount of solvent used. The sources of these VOC emissions are the solvent components in the raw inks, related coatings used at the printing presses, and solvent added for dilution and press cleaning. These solvent organics are photochemically reactive. VOC emissions from both controlled and uncontrolled publication rotogravure facilities in 1977 were about 57,000 megagrams (Mg) (63,000 tons),

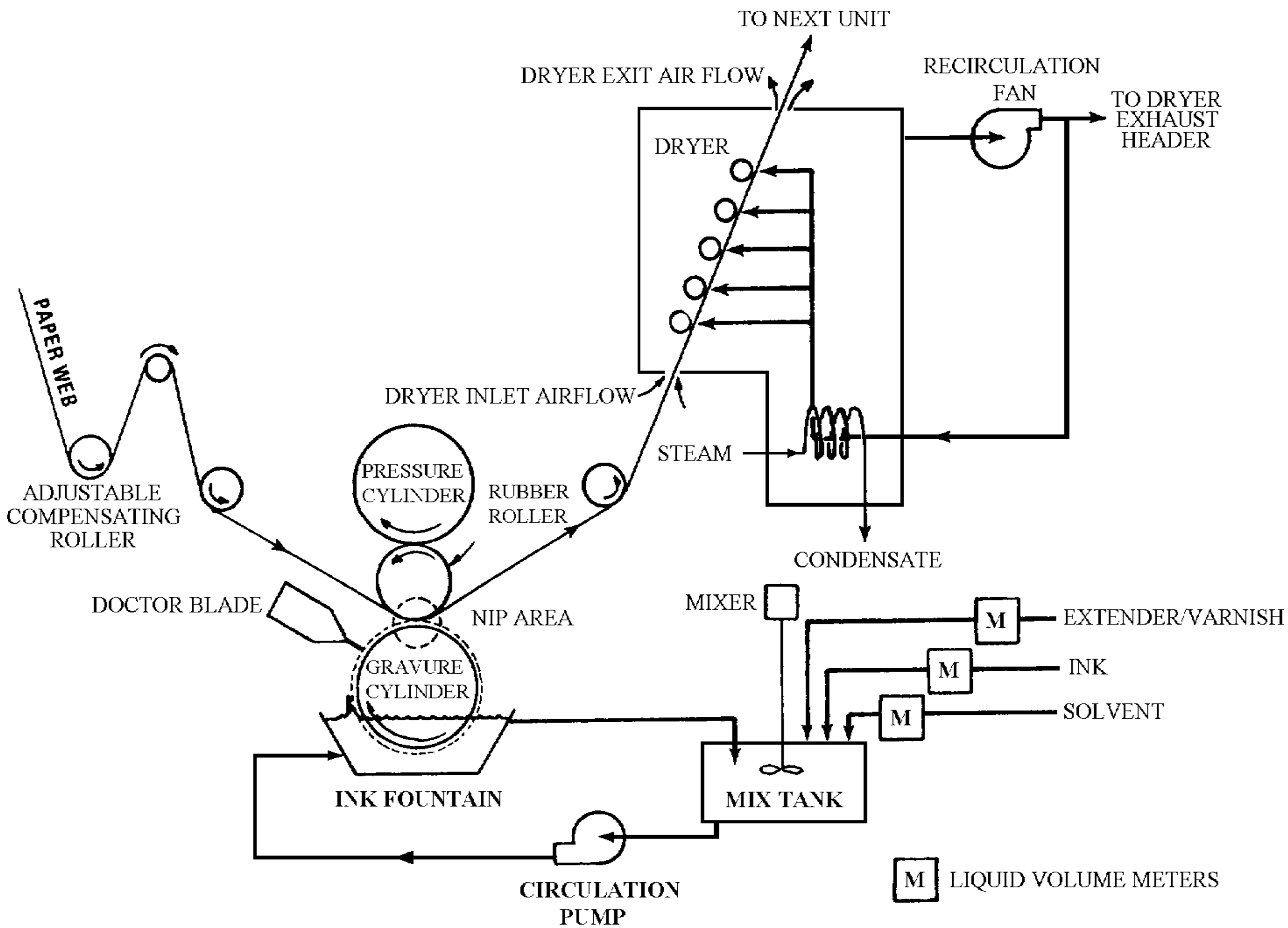

Figure 4.9.2-1. Diagram of a rotogravure printing unit.

15 percent of the total from the graphic arts industry. Emissions from ink and solvent storage and transfer facilities are not considered here.

Table 4.9.2-1 presents emission factors for publication printing on rotogravure presses with and without control equipment. The potential amount of VOC emissions from the press is equal to the total amount of solvent consumed in the printing process (see Footnote f). For uncontrolled presses, emissions occur from the dryer exhaust vents, printing fugitive vapors, and evaporation of solvent retained in the printed product. About 75 to 90 percent of the VOC emissions occur from the dryer exhausts, depending on press operating speed, press shutdown frequency, ink and solvent composition, product printed, and dryer designs and efficiencies. The amount of solvent retained by the various rotogravure printed products is 3 to 4 percent of the total solvent in the ink used. The retained solvent eventually evaporates after the printed product leaves the press.

There are numerous points around the printing press from which fugitive emissions occur. Most of the fugitive vapors result from solvent evaporation in the ink fountain, exposed parts of the gravure cylinder, the paper path at the dryer inlet, and from the paper web after exiting the dryers between printing units. The quantity of fugitive vapors depends on the solvent volatility, the temperature of the ink and solvent in the ink fountain, the amount of exposed area around the press, dryer designs and efficiencies, and the frequency of press shutdowns.

The complete air pollution control system for a modern publication rotogravure printing facility consists of 2 sections: the solvent vapor capture system and the emission control device. The capture system collects VOC vapors emitted from the presses and directs them to a control device where they are either recovered or destroyed. Low-VOC waterborne ink systems to replace a significant amount of solventborne inks have not been developed as an emission reduction alternative.

4.9.2.2.1 Capture Systems -

Presently, only the concentrated dryer exhausts are captured at most facilities. The dryer exhausts contain the majority of the VOC vapors emitted. The capture efficiency of dryers is limited by their operating temperatures and other factors that affect the release of the solvent vapors from the print and web to the dryer air. Excessively high temperatures impair product quality. The capture efficiency of older design dryer exhaust systems is about 84 percent, and modern dryer systems can achieve 85 to 89 percent capture. For a typical press, this type capture system consists of ductwork from each printing unit's dryer exhaust joined in a large header. One or more large fans are employed to pull the solvent-laden air from the dryers and to direct it to the control device.

A few facilities have increased capture efficiency by gathering fugitive solvent vapors along with the dryer exhausts. Fugitive vapors can be captured by a hood above the press, by a partial enclosure around the press, by a system of multiple spot pickup vents, by multiple floor sweep vents, by total pressroom ventilation capture, or by various combinations of these. The design of any fugitive vapor capture system needs to be versatile enough to allow safe and adequate access to the press in press shutdowns. The efficiencies of these combined dryer exhaust and fugitive capture systems can be as high as 93 to 97 percent at times, but the demonstrated achievable long term average when printing several types of products is only about 90 percent.

4.9.2.2.2 Control Devices -

Various control devices and techniques may be employed to control captured VOC vapors from rotogravure presses. All such controls are of 2 categories: solvent recovery and solvent destruction.

Table 4.9.2-1 (Metric And English Units). EMISSION FACTORS FOR PUBLICATION ROTOGRAVURE PRINTING PRESSES

EMISSION FACTOR RATING: C

Emission Points	VOC Emissions[a]								
	Uncontrolled			75% Control			85% Control		
	Total Solvent	Raw Ink		Total Solvent	Raw Ink		Total Solvent	Raw Ink	
	kg/kg (lb/lb)	kg/L	lb/gal	kg/kg (lb/lb)	kg/L	lb/gal	kg/kg (lb/lb)	kg/L	lb/gal
Dryer exhausts[b]	0.84	1.24	10.42	—	—	—	—	—	—
Fugitives[c]	0.13	0.19	1.61	0.13	0.19	1.61	0.07	0.10	0.87
Printed product[d]	0.03	0.05	0.37	0.03	0.05	0.37	0.03	0.05	0.37
Control device[e]	—	—	—	0.09	0.13	1.12	0.05	0.07	0.62
Total emissions[f]	1.0	1.48	12.40	0.25	0.37	3.10	0.15	0.22	1.86

[a] All nonmethane. Mass of VOC emitted per mass of total solvent used are more accurate factors. Solvent assumed to consist entirely of VOC. Total solvent used includes all solvent in raw ink and related coatings, all dilution solvent added and all cleaning solvent used. Mass of VOC emitted per volume of raw ink (and coatings) used are general factors, based on typical dilution solvent volume addition. Actual factors based on ink use can vary significantly, as follows:

- Typical total solvent volume/raw ink (and coatings) volume ratio - 2.0 (liter/liter) (L/L) (gal/gal); range, 1.6 - 2.4. See References 1,5-8.

- Solvent density (D_s) varies with composition and temperature. At 21°C (70°F), the density of the most common mixed solvent used is 0.742 kg/L (6.2 lb/gal); density of toluene solvent used is 0.863 kg/L (7.2 lb/gal). See Reference 1.

- Mass of VOC emitted/raw ink (and coating) volume ratio determined from the mass emission factor ratio, the solvent/ink volume ratio, and the solvent density.

$$\text{kg/L} = \text{kg/kg} \times \text{L/L} \times D_s$$
$$(\text{lb/gal} = \text{lb/lb} \times \text{gal/gal} \times D_s)$$

[b] Reference 3 and test data for presses with dryer exhaust control only (Reference 1). Dryer exhaust emissions depend on press operating speed, press shutdown frequency, ink and solvent composition, product printed, and dryer design and efficiencies. Emissions can range from 75 - 90% of total press emissions.

[c] Determined by difference between total emissions and other point emissions.

[d] Reference 1. Solvent temporarily retained in product after leaving press depends on dryer efficiency, type of paper, and type of ink used. Emissions have been reported to range from 1 - 7% of total press emissions.

[e] Based on capture and control device efficiencies (see Footnote f). Emissions are residual content in captured solvent-laden air vented after treatment.

[f] References 1,3. Uncontrolled presses eventually emit 100% of total solvent used. Controlled press emissions are based on overall reduction efficiency equal to capture efficiency x control device efficiency. For 75% control, the capture efficiency is 84% with a 90% efficient control device. For 85% control, the capture efficiency is 90% with a 95% control device.

Solvent recovery is the only present technique to control VOC emissions from publication presses. Fixed-bed carbon adsorption by multiple vessels operating in parallel configuration, regenerated by steaming, represents the most used control device. A new adsorption technique using a fluidized bed of carbon might be employed in the future. The recovered solvent can be directly recycled to the presses.

There are 3 types of solvent destruction devices used to control VOC emissions: (1) conventional thermal oxidation, (2) catalytic oxidation, and (3) regenerative thermal combustion. These control devices are employed for other rotogravure printing. At present, none are being used on publication rotogravure presses.

The efficiency of both solvent destruction and solvent recovery control devices can be as high as 99 percent. However, the achievable long-term average efficiency for publication printing is about 95 percent. Older carbon adsorber systems were designed to perform at about 90 percent efficiency. Control device emission factors presented in Table 4.9.2-1 represent the residual vapor content of the captured solvent-laden air vented after treatment.

4.9.2.2.3 Overall Control -

The overall emission reduction efficiency for VOC control systems is equal to the capture efficiency times the control device efficiency. Emission factors for 2 control levels are presented in Table 4.9.2-1. The 75 percent control level represents 84 percent capture with a 90 percent efficient control device. (This is the EPA control techniques guideline recommendation for State regulations on old existing presses.) The 85 percent control level represents 90 percent capture with a 95 percent efficient control device. This corresponds to application of best demonstrated control technology for new publication presses.

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