

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

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1 INTRODUCTION

Since 1996 a code of practice for solvent emissions from the flexographic/gravure printing industry has operated in Victoria. Significant progress was achieved by Victoria's printing industry under the 1996 code. This information bulletin replaces the 1996 code, *Code of Practice for VOC Emissions from the Flexographic/Gravure Printing Industry* (EPA Publication 487) as well as EPA Publication 779, *Minimising VOC Emissions from Victoria's Flexographic and Rotogravure Printing Industry*.

The principal environmental impact of the printing industry comes from the use and subsequent emission of solvents to the atmosphere. These emissions have the potential to cause adverse environmental and human health impacts. Emissions to air must be managed in accordance with the provisions of the State environment protection policy (Air Quality Management [SEPP(AQM)]). The SEPP (AQM) focuses on waste minimisation, application of best practice and continuous improvement of environmental management.

This information bulletin provides guidance on minimising volatile organic compounds (VOC) emissions from all Victoria's printing industry by promoting innovative and cleaner production activities and where necessary, application of emission control technology. Minimisation of solvent consumption can benefit businesses in a

range of ways, including cost savings and by reducing wastes, and will help companies interested in enhancing business sustainability and profitability.

For the purposes of this bulletin, the term volatile organic compounds (VOC) is taken to cover a wide range of chemical substances that contain carbon and vaporise readily at normal atmospheric temperatures and pressures. Liquid solvents used in many industrial processes, including printing, contain VOCs and the minimisation of their discharge to the air environment is an important environmental management objective.

Section 2 of this bulletin gives information about printing and coating processes.

Section 3 gives information about the environmental impact of VOC emissions from the printing industry.

Section 4 gives information about environmental management tools that can be applied to help reduce VOC emissions.

Section 5 gives information about Victorian regulatory requirements relevant to the printing industry.

2 THE PRINTING PROCESS

The printing and coating industry uses a wide range of processes and materials. Printing processes can be described by the nature of the substrates that are

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

printed as well as the type of printing processes used.

Printing may be performed on coated or uncoated paper and on other surfaces, such as metallic and plastic films. A wide range of printing processes have evolved to meet various product needs and a brief outline of these are presented here.

Printing inks vary widely in composition, but generally consist of three major components:

- pigments, which produce the desired colours and are composed of finely ground organic and inorganic materials;
- binders, the components that lock the pigments to the substrate and which are composed of organic resins and polymers or, in some inks, oils and resins; and
- organic solvents or water, which disperse the pigments and binders and act as carriers. The carriers are evaporated from the ink during the drying process, leaving the finished coating on the substrate. Organic solvents typically consist of a mixture of VOCs.

2.1 Rotogravure printing

Rotogravure (usually abbreviated as gravure) printing is a process in which an image is etched or engraved into the surface of a cylinder. On the gravure cylinder, the printing image consists of millions of minute cells. Gravure printing requires very fluid inks that flow smoothly from the cells to the substrate at high press speeds. Solvent-based or water-based ink systems can be used in gravure printing but these ink systems are not immediately interchangeable. Rotogravure printing is usually

performed on a continuous web (a roll of substrate such as paper or plastic film).

Rotogravure cylinder engraving is complex and expensive and therefore best suited to longer running, ongoing printing jobs. Packaging gravure inks include VOC-based inks. The main VOCs used are ethanol, ethyl acetate, propanol, and propyl acetate. For applications requiring specific properties, the following solvents are used: methyl ethyl ketone, methyl isobutyl ketone, toluene, xylene and acetone.

In gravure printing, the majority of presses are multi colour machines that allow many colours to be applied in one pass. Some of these printing presses are connected directly to adhesive laminators, which allow a second material to be applied to the printed web, before being rolled up. The substrate to be printed is usually a film of paper, polyester, polypropylene, polystyrene, aluminium foil, cellulose, metallised polyester, metallised polypropylene, or some combination of these.

Materials other than inks, including adhesives, primers, coatings and varnishes may also be applied with gravure cylinders. These materials dry by evaporation as the substrate passes through hot air dryers.

2.2 Flexographic printing

In flexographic printing, the impression is raised from the surface of a plate with a polymer image carrier. The process is usually web-fed and used for medium or long multicolour runs on a variety of substrates, including heavy paper, fibreboard, metal and plastic film. Almost all milk cartons and multi-

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

wall bags and around half of all flexible packaging in Australia is printed by this process.

VOC-based inks are used primarily in packaging and printing on plastic or metallic films. The VOC is usually an alcohol or acetate such as ethanol or ethyl acetate. The inks dry by absorption into the web or by evaporation, usually in high-velocity hot-air dryers, at temperatures below 120 degrees celcius. Water-based inks and UV curable inks are used for printing on heavy paper and fibreboard.

2.3 Offset lithographic printing

Unlike flexo-gravure printing, lithography is characterised by a 'planographic' image carrier, that is the image and non-image areas are on the same plane. The image area is ink-wettable and water-repellent, and the non-image area is chemically repellent to ink. The inks used in lithography are either heat set or non-heat set. Heat set inks require heat for the drying and curing process to be completed. UV curable inks and coatings are also becoming popular, although considerable energy use may be associated with such inks.

In offset printing, the graphic image is applied from an ink-covered printing plate to a rubber-covered 'blanket' cylinder and then transferred onto the substrate, hence the name 'offset' lithography. The substrate in offset lithography can be either a web or sheets. A web substrate can be used with either heatset or non heat set inks; sheets are used with non heat set inks only.

An aqueous solution of isopropyl alcohol, commonly used to dampen the non-image area on the plate, is called the 'fountain' or 'dampening' solution. The use of isopropyl alcohol based fountain solution in

offset lithographic printing is diminishing. Fountain solutions containing organic compounds of lower volatility are gaining acceptance in Australia.

Heat set lithographic printing uses a paper web that can be printed on both sides, one side at a time. Heat set inks are used, usually containing about 35 per cent by volume of solvent. The web is dried after each colour is applied.

2.4 Letterpress printing

Letterpress printing is the oldest form of movable type printing. Like flexography, letterpress printing uses a relief printing plate and viscous inks similar to lithographic inks. Various types of letterpress plates are available. These plates differ from flexographic plates in that they have a rigid backing - metal or plastic - and are therefore not flexible. Both sheet-fed and web presses are in use. Web letterpress equipment uses both heat set and non-heat set inks. Fountain solutions are not used in letterpress printing, and the cleaning solvents are similar to those used in lithography. In the past, letterpress printing dominated periodical and newspaper publishing. However, the majority of newspapers in Australia have now converted to non-heat set web offset printing.

Heat set letterpress ink is similar to heat-set lithographic ink. These inks contain resins dissolved in aliphatic hydrocarbons and are dried in hot-air ovens.

2.5 Screen printing

Screen printing involves forcing ink through a stencil in which the image areas are porous screens, generally made of silk, nylon, or metal mesh. Screen

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

printing is used for signs, wallpaper, greeting cards, ceramics, decals, banners, and textiles. Most screen printing work in Australia is conducted on textiles. Ink systems used include ultraviolet cure, water-based, solvent-based, and plastisol (polyvinyl chloride) which is mainly confined to textile printing. Solvent-based ink systems contain aliphatic, aromatic and oxygenated organic solvents.

2.6 Plateless printing

This technology is a relatively new process used primarily for short runs on paper substrates. Plateless printing processes include electronic (laser printing), electrostatic (photocopiers), magnetic, thermal (facsimile machines) and ink jet printing. Plateless printing processes account for only a small fraction of printing activity presently.

3 ENVIRONMENTAL IMPACTS

The emission of VOCs from industrial printing and coating processes has a range of environmental effects mainly affecting the air environment having:

- local impacts such as odour and toxicity;
- regional or metropolitan scale impacts such as the formation of photochemical pollution; and
- global impact due to VOCs acting directly or indirectly following dissociation and oxidation to carbon dioxide which then contributes to climate change as a greenhouse gas.

Best practice must be applied to all activities leading to emissions to air. For larger premises, with relatively large emissions, best practice includes end-of pipe treatment to minimise odour, visible emissions and regional impacts. Table 1 shows the level of VOC usage by various printing processes.

Printing / coating process	Substrate	Ink system	VOC usage
Rotogravure	Film	Solvent	High
Flexography	Paper	Solvent	High
	Paper	Water	Low
	Film	Water	Low
	Film	Solvent	High
	Film (non-food contact)	UV curing	Very low
Heat-set lithography	Paper	Solvent	High
Offset lithography	Paper	Oil paste	Very low
Letterpress	Paper	Water	Very low
Screen-printing	Textile	Oil paste	Medium

Table 1: Summary of relative VOC usage for various processes

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

Premises at which VOC usage exceeds 500 Tonnes per annum are categorised as 'very large'. Processes associated with VOC usage at this level include heat-set printing and flexo-gravure printing. An indicative scale of the range of VOC emissions typically occurring in Melbourne is shown below:

ANNUAL DISCHARGE	RELATIVE SIZE OF OPERATION
1000 tonnes/year	Extremely large
500 tonnes/year	Very large
100 tonnes/year	Large
35 tonnes/year	Medium
25 tonnes/year	Small
10 tonnes/year	Very small

Discharges of VOC to the atmosphere at the higher end of this scale are so large that local air quality may be compromised unless the discharge is treated by some form of pollution control device such as an afterburner or bio-filter.

Photochemical pollution is a result of atmospheric reactions which occur on a regional (metropolitan wide) scale. The total level of VOC (and NOx) emissions from all sources in an area and meteorological conditions are the main factors influencing how much photochemical oxidant (or 'smog') is eventually produced. The minimisation of all VOC emissions by all premises is required by SEPP(AQM); premises at the higher end of the scale are more significant contributors and therefore need to adopt tighter controls.

4 MANAGING VOC EMISSIONS

The preferred approach to dealing with VOC emissions is to avoid these emissions altogether by the use of non-VOC based processes. Apart from obvious environmental benefits, occupational exposure to VOC would be avoided and the costs associated with disposal of VOC wastes would be reduced.

If the use of VOC cannot be avoided, a strategy must be adopted to reduce the impacts of VOC emissions. This may involve substitution with less harmful VOCs and/or treatment of discharges using vapour recovery or destruction techniques. During the 1990s many products printed by the flexographic and gravure printing industry were converted from ink systems using more harmful VOCs such as MEK, MIBK, toluene and xylene to systems using less toxic solvents such as ethanol and propanol.

4.1 Integrated environmental management

The State environment protection policy (Air Quality Management) establishes a requirement for 'integrated environmental management'.

Integrated environmental management relies on various impacts being considered and balanced to achieve the most favourable overall environmental outcome. Due to the difficulty of comparing different environmental issues, this may not always be a clear-cut process.

Balancing the impacts of the major components of a VOC discharge necessarily involves a degree of judgment. The 'VOC impact matrix' approach involves identifying impacts and making a judgment as to whether this is a significant impact or not.

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

For example if VOC X has the following environmental impacts:

Local impact	Regional impact	Global impact
Medium	High	Low

and another VOC Y, which could be substituted for X, has the following environmental impacts:

Local impact	Regional impact	Global impact
Low	Medium	Low

it is clear that Y is preferable to X and a program of replacing VOC X with VOC Y should be implemented as soon as practical.

In the absence of other priorities, the reduction of local impacts should take precedence over reducing regional impacts that should in turn take precedence over reducing global impacts. When significant reductions in regional or global impacts can be made at the cost of a slight increase in the local impact, this option should be considered, provided that the beneficial uses at the local level are still protected.

4.2 Planning for improvement

All aspects of the operation that impact on the environment should be targeted for continuous improvement. However, the key environmental issue for flexographic / gravure printing facilities is solvent emissions to air. Setting targets for reductions in VOC emissions is therefore a priority.

Premises should prepare an environment improvement plan¹, setting out key operational requirements, strategies for improvement and

targets, particularly in relation to reducing VOC emissions.

Target setting in environment improvement plans involves benchmarking against best practice. When benchmarking the effect of organic compounds on smog formation it is useful to look at the aggregate total of the organic compounds, that is the total annual or daily amount of VOC discharged from a facility.

If very large VOC emissions cannot be eliminated, installation of emission control equipment may be necessary. Emission control devices may allow the use of VOCs that would otherwise have undesirable offsite impacts. Control equipment should be selected based on best practice and greenhouse and energy considerations, with preference for more energy efficient solutions.

4.3 Steps to reduce VOC emissions

The most desirable target for VOC emissions to air is zero. Achieving this involves avoiding the use of any solvents that produce VOC emissions. This is practicable for some printing applications, in particular where paper or cardboard substrates are being printed.

The preferred hierarchy for dealing with VOC in the printing industry is:

1. Avoid VOC emissions altogether by the use of non-VOC based ink systems.
2. Use low-VOC ink systems or otherwise substitute VOCs that are less photo-chemically

¹ Please see EPA Publication 739, *Guidelines for the Preparation of Environment Improvement Plans* for more information about environment improvement plans.

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

reactive², provided odour, occupational toxicity and other characteristics of the substitute(s) are acceptable.

3. The use of end-of-pipe treatment options should only be considered for very large VOC emissions which cannot be eliminated by other means.

If the use of VOC cannot be avoided, continuous improvement in the efficiency of VOC use is required.

4.4 Measuring the efficiency of VOC use

As explained above, the total amount of VOC emitted is an important factor influencing environmental impact of the discharge. In seeking to minimise the total VOC emitted it is important to maximise the efficiency of the printing process with respect to use of solvents.

The Council of the European Union has published a directive³ that provides limits for VOC used by various surface coating industries⁴. The directive encourages high solid low VOC formulations but

² State of California Code of Regulations, Article 3, Aerosol Coating Products, Sections 94521-94524 and 94526, *Reducing Volatile Organic Compound Emissions from Aerosol Coating Products* gives information that can be used to determine photo-chemical reactivity and consequent impact on smog formation potential. The regulation and other relevant information can be downloaded from:

<http://www.arb.ca.gov/regact/conspro/aerocoat/finreg.doc>

³ Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and industries. The regulation and other relevant information can be downloaded from:

<http://europa.eu.int/scadplus/printversion/en/lvb/l28029b.htm>

⁴ Industries covered in the EC Solvent Emissions Directive include: adhesive coating; surface coating; dry cleaning; manufacturing of coating preparations, varnishes, inks and adhesives; manufacturing of pharmaceutical products; printing; rubber conversion; vegetable oil and animal fat extraction; vehicle refinishing; wire coating; timber preservation; and wood and plastic lamination.

also provides total site emission limits. The directive introduces the concept of measuring the efficiency of VOC use by calculating the ratio of VOC emitted and solids deposited on substrates during the printing process.

The 1996 code (as well as EPA Publication 779), used ratios of solvent emission to production output as indicators of VOC usage efficiency. While the 1996 code demonstrated that the act of monitoring and actively minimising solvent consumption can benefit businesses in a range of ways, it also showed that ratios of solvent to production output may vary considerably and as such do not provide an absolute and infallible way of comparing performance at printing facilities. Notwithstanding the limitations of ratios of solvent emission and production output as absolute indicators of performance, they have a useful role as general indicators of performance efficiency.

The efficiency of VOC use can be measured by calculating the ratio of VOC used to solids deposited on the substrates for relevant coated products produced during the year.

$$R_e = \frac{\text{Solvent emitted [kg]}}{\text{Solids deposited [kg]}}$$
$$R_u = \frac{\text{Solvent used [kg]}}{\text{Solids deposited [kg]}}$$

Typically, where no significant action has been taken at a site to reduce solvent usage, the Solvents/Solids ratio is about 4.0. Progress can be measured year by year, the aim being to reduce the ratio as close as possible to zero.

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

The following table indicates the range of ratios typically occurring in Victorian printing companies

and some indicative levels of performance.

10 kg of VOC used per 1 kg of solids deposited	10:1		Very poor
5 kg of VOC used per 1 kg of solids deposited	5:1		Poor
3 kg of VOC used per 1 kg of solids deposited	3:1		Average
2 kg of VOC used per 1 kg of solids deposited	2:1		Reasonable
1.5 kg of VOC used per 1 kg of solids deposited	1.5:1		Good
1 kg of VOC used per 1 kg of solids deposited	1:1		Very good
0 kg of VOC used	0	Excellent	

5 LEGISLATIVE REQUIREMENTS FOR REDUCING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

The *Environment Protection Act 1970* ('the Act') is the primary legislation for the protection of Victoria's environment. State environment protection policies (SEPPs) are subordinate legislation made under the provisions of the Act to provide more detailed requirements and guidance.

The State environment protection policy (Air Quality Management) or SEPP(AQM) sets the framework for the management of emissions of wastes to air. Companies that generate emissions are responsible for their emissions and are required to avoid and minimise these emissions by the application of best practice to all activities.

The Environment Protection (Scheduled Premises and Exemptions) Regulations 1996 specify premises that require works approvals or licences to operate. Printing premises that use more than 100 kilograms per day of VOC are scheduled under category 10A of the regulations. The regulations require that these premises must apply for works approval for

construction or modification of processes and obtain a waste discharge licence specifying operating conditions, discharge limits, monitoring and reporting requirements.

Heat set printing plants are exempt from licensing, but works approval applications for these plants must meet the requirements of the *Protocol for Environmental Management – Minimum Control Requirements for Stationary Sources* (EPA Publication 829). The main requirement associated with this protocol is that the discharges from heat set printing presses must be treated by an afterburner which is interlocked so that if the afterburner stops, so do the presses.

Protocols for environmental management are incorporated documents under SEPPs and are therefore legislative requirements. Copies of these documents are available on EPA's website www.epa.vic.gov.au.

EPA will apply the following requirements through the licensing system to scheduled flexographic / rotogravure printing premises:

MINIMISING VOC EMISSIONS FROM VICTORIA'S PRINTING INDUSTRY

- From 30 June 2006, VOC emissions from the premises must not exceed 500 tonnes per annum*;
- From 30 June 2008, VOC emissions from the premises must not exceed 250 tonnes per annum;
- Ongoing monitoring and reporting to demonstrate how the emission caps will be met within the specified timeframes; and
- Ongoing monitoring and reporting of the ratios of VOC usage/emissions and solids deposited at the premises including measures to continuously reduce the ratio.

Progress toward compliance with the targets set out in this bulletin will be reviewed by 1 December 2005.

EPA licences and works approvals incorporate requirements for environmental management at premises. Premises which are the subject of justified complaints may be required to achieve earlier compliance programs and additional requirements on an individual basis, as specified in a pollution abatement notice, works approval or licence.

When considering applications for works approval, EPA will take into account the applicant's plans (or demonstrated progress) toward meeting premises emissions caps as well as improvement in the VOC used / solids deposited ratio at the premises.

If a company operates more than one premises, EPA may approve a trade-off in emissions so more emissions reduction is achieved at the larger scheduled premises in return for less reduction at smaller scheduled premises.

* This requirement applies from 30 June 2005 at premises where works approval is sought for works involving the installation of new printing presses.