SNAP CODE: **060403**

SOURCE ACTIVITY TITLE: **OTHER USE OF SOLVENTS & RELATED ACTIVITY**
Printing Industry

NOSE CODE: **107.04.03**

NFR CODE: **3 D**

1 ACTIVITIES INCLUDED

Five main printing techniques have been identified:

- Offset
  - Cold set web offset
  - Heat set web offset
  - Sheet fed offset
- Rotogravure
- Flexography
- Letterpress
- Screen Printing

Only the printing processes listed above and the related coating and laminating processes are considered in this section.

Note: printing processes may involve the use of lacquers, adhesives and solvents for cleaning. There may therefore be overlapping with the SNAP categories 060108, 060201, 060405. It is important to ensure that 'double counting' does not occur.

The types of industries and the main techniques used may be classified as follows :

Press - Printing of daily newspapers.
- Cold set web offset is the main technique
- Letterpress is used in some rural areas.

Edition/Publication - Printing of books, magazines, catalogues, advertisements.
- Cold set web offset
- Heat set web offset
- Sheet fed offset
- Rotogravure
- Screen printing

Packaging - printing of products for packaging, e.g. cardboard, corrugated cardboard, paper, flexible plastic, aluminium foils and cellulose films.

- Sheet fed offset
- Rotogravure
- Flexography
- Screen printing

Rigid Metallic Packaging - printing of food cans, aerosol cans, caps and closures.

- Sheet fed offset. (Note that subsequent varnishing is also used which results in higher VOC emissions).

Decoration - manufacture of wall coverings, floor coverings etc on paper and plastic.

- Rotogravure
- Flexography
- Screen printing

2 CONTRIBUTION TO TOTAL EMISSIONS

Table 1: Contribution to total emissions of the CORINAIR90 inventory (*28 countries*)

Source-activity	**SNAP-code**	**Contribution to total emissions [%]**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Printing Industry	060403	-	-	1.3	-	-	-	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported

In addition, most of this emission, perhaps 87%, is thought to come from the packaging and decoration sectors (Allemand 1990). Swedish data (1990) on emissions by technique is given below:

Technique	**% contribution to total emissions from printing**
Offset	29
Flexography and rotogravure	78
Screen Printing	3

This activity is not believed to be a significant source of $PM_{2.5}$ (as of December 2006).

3 GENERAL

3.1 Description

Printing involves the use of inks which may contain a proportion of organic solvents. These inks may then be subsequently diluted before use. Different inks have different proportions of

organic solvents and require dilution to different extents. Printing can also require the use of cleaning solvents and organic dampeners. Ink solvents, diluents, cleaners and dampeners may all make a significant contribution to emissions from industrial printing involves the application of inks using presses. The largest plants may have as many as ten presses.

3.2 Definitions

Flexography means a printing process using an image carrier of rubber or elastic photopolymers on which the printing areas are above the non printing areas, using liquid inks, that dry through the evaporation of organic solvents.

Offset means a printing process, using an image carrier in which the printing and non-printing area are of the same plane. The non-printing area is treated to attract water and thus reject ink. The printing area is treated to receive and transmit ink to the surface to be printed.

Rotogravure means a printing process using a cylindrical image carrier in which the printing area is below the non printing area, using liquid inks, that dry through evaporation. The recesses are filled with ink and the surplus is cleaned off the non-printing area before the surface to be printed contacts the cylinder and lifts the ink from the recesses.

Screen means a printing process in which the ink is passed onto the surface to be printed by forcing it through a porous image carrier, in which the printing area is open and the non-printing area is sealed off, using liquid inks, that dry through the evaporation of organic solvents.

Sheet-fed means that the material to be printed is fed to the machine as separate sheets.

Web-fed means that the material to be printed is fed to the machine from a reel as distinct from separate sheets.

Heat set means a printing process where evaporation takes place in an oven where hot air is used to heat the printed material.

3.3 Techniques

The different printing process use characteristic inks with different proportions of organic solvents. Inks may be described as high solvent, low solvent or water based inks.

The solvent content of these types of inks have the following ranges when applied:

Ink type	Solvent content on application
High solvent	30 to 90%
Low solvent	5 to 30%
Water based	<5 to 20%

The solvent part of the ink may be evaporated at ambient temperatures or through heating in an oven. Certain specialist inks, containing very little solvent, may be cured using ultra violet or infra red radiation.

Solvents driven off through evaporation may be discharged untreated, recovered through carbon adsorption or destroyed via incineration.

Cleaning techniques range from wiping over equipment with a solvent cloth to the use of enclosed cleaning unit designed to recycle solvents.

3.4 Emissions/Controls

Emissions to air arise primarily from the organic solvents used in inks and for the dilution inks. This is especially true for rotogravure, flexography and screen printing. Solvents used in cleaning, the storage and handling of solvents and the use of organic solvents as dampeners (commonly isopropanol especially in offset printing) are also important sources of emissions of organic compounds. The use of glues and adhesives, particularly in publication etc., is also a potential source of emissions.

Control options may be categorised as replace, reduce, recover or destroy.

3.4.1 Replacement

In some types of flexography and screen printing, water based inks may be used instead of organic solvent based inks. Water based solvents will contain organic compounds such as alcohols and amines. The proportion of organic compounds varies widely from less than 5% to as much as 20%.

The composition of ink can also be changed allowing ultra-violet, infra-red or electron radiation for curing the ink. Many of these curing methods use inks with almost no organic solvent content.

Less volatile cleaning agents may also be used.

3.4.2 Reduction

Possibilities for solvent reduction may be identified through solvent management plans. Changes in work practises, particularly during the storage, and handling of solvents and the cleaning of equipment, can lead to reduced fugitive losses. Technical changes including reduced etching depth in rotogravure can also reduce consumption.

3.4.3 Recovery

If a single solvent is used, e.g. toluene in rotogravure printing of newspapers and magazines, the solvent may be economically recovered for reuse, by means of activated carbon or other adsorption medium. Mixtures of solvents may also be recovered in this way, however, their immediate reuse is often not practical, and the recovered solvents are generally sent away for reprocessing or destruction.

3.4.4 Destruction

Destruction of solvent emissions may be achieved through oxidation to carbon dioxide and water. The various techniques may be categorised as follows:

Incineration
- Thermal
- Catalytic (also thermal but generally requires less additional fuel)

Biological
- Biofilters
- Bioscrubbers

In practice, thermal incineration is the most widely used method for destroying organic compounds emitted from printing processes. Destruction techniques are often better than 90% efficient, however, this may not necessarily mean a 90% reduction in emissions as solvents are also lost from storage, transportation, cleaning etc.

4 SIMPLER METHODOLOGY

The simpler methodology involves either the use of solvent consumption data or combining ink consumption with emission factors for the industry. Note, if solvent consumption data is used, then all solvents must be considered, including cleaning solvents, diluents and dampeners, as well as solvents present in the ink bought.

It should be possible to categorise the use of solvents/inks by each type of printing process. The following categories are recommended:

- Offset
- Rotogravure
- Flexography
- Letterpress
- Screen Printing

In the simpler methodology, unless solvent consumption data is used, no account is taken of the use of water based or low solvent inks, and no account is taken of the extent of controls such as incineration. The simpler methodology should therefore not underestimate the emission.

5 DETAILED METHODOLOGY

The detailed methodology requires an estimate to be made of the extent of control of emissions from printing processes and a reappraisal of the default emission factors used in the simpler methodology.

The extent of control and the reappraisal of emission factors is achieved through an audit of a representative range of printing processes. At least three types of printing processes should be included in the audit: rotogravure, flexography and offset. The audit should determine the total consumption of solvent at each plant, the control methods used, if any, and the estimated efficiency of the technique. Emissions data from the audit are compared with the default data used in the simpler methodology and a more accurate emission estimate is derived.
The greater the number of printing plants to be audited, the more accurate the final emission estimate. It is recommended that enough plants are audited to account for half of the total solvent consumption. Data from CITEPA (Allemand, 1990), suggests that for a country such as France, approximately 40 printing plants consume the majority of solvent used in the printing industry. These plants use rotogravure or flexography and are in the Edition/Publication, Packaging and Decoration sectors.

6 RELEVANT ACTIVITY STATISTICS

Relevant activity statistics include: solvent consumption per sector as listed in section 5; ink consumption per sector as listed in section 5.

7 POINT SOURCE CRITERIA

The distribution of solvent consumption amongst flexible packaging has been established for four European countries (Allemand 1990). The plants responsible for at least 50% of the emission typically consume 1kt or more of solvents each year.

This is therefore the recommended plants which consume 1000 tonne or more of solvent each year are identified for consideration as point sources, and that plants which emit 1000 tonne or more per year are reported as point sources criteria for consideration as point sources.

Note: consuming 1000 tonne or more of solvent does not necessarily mean emitting 1000 tonne or more of solvent if the solvent is destroyed by incineration for example.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler Methodology

In the absence of better data, the following default emission factors may be used. The emission factors relate to the consumption of ink.

Sector	Technique	Emission Factor (kg/t ink consumed)	Qual.	Ref.
Press	cold set web offset	54	C	1
Edition/Publication	heat set web offset	182	C	1
	rotogravure	425	C	1
Packaging	sheet fed offset	437	C	1
	rotogravure	1296	C	1
	flexography	800	C	1
Rigid Metallic Packaging	sheet fed offset	437	C	1
	rotogravure	1296	C	1
	flexography	800	C	1
Decoration	rotogravure	1296	C	1
	flexography	800	C	1
	screen printing	935	C	1
Others	varnish	363*	C	1
	cleaning solvent	140	D	2

1 - Passant 1993
2 - Giddings 1991
* - per tonne of varnish

8.2 Detailed Methodology

Emission factors derived from an audit are compared with the default emission factors listed in 8.1. In particular, lower emission factors can be expected where low solvent or water based inks are used, or where recovery or destruction techniques are used to control emissions.

9 SPECIES PROFILES

The most common classes of solvents used in the printing industry as a whole are (SEPA 1990, Passant 1993):

- white spirit and paraffins
- aromatics
- alcohols
- esters
- ketones
- glycol ethers

Individual compounds identified include (USEPA 1988, SEPA 1990, Passant 1993)

- cyclohexane
- toluene
- xylene
- ethyl benzene
- diethyl benzene
- methanol
- ethanol
- isopropanol
- isobutanol
- cyclohexanol
- ethyl acetate
- acetone
- methyl ethyl ketone
- methyl isobutyl ketone

It has been found that the solvents used in different printing processes are a strong characteristic of the country or region. Unless better information is available, the following default species profile, with a quality code of D is suggested for the printing industry as a whole:

Alkanes (e.g. decane)	50%
Alcohols (e.g. isopropanol, ethanol)	35%
Aromatics (e.g. toluene)	15%
Ketones (e.g. methyl ethyl ketone)	10%

10 UNCERTAINTY ESTIMATES

10.1 Simpler methodology

An emission estimate based on emission factors, without taking into account control measures may have an uncertainty as high as 100%. An emission estimate based on solvent consumption, without taking into account control measures may have an uncertainty of 50%.

10.2 Detailed Methodology

An emission estimate based on an audit, taking into account control measures may have an uncertainty of 20%.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

11.1 Simpler Methodology

The weakest aspects of the approach recommended above is the need to use quite detailed information activity statistics, namely the ink supplied to different types of printing processes in different market sectors. Such information may not be directly available and may have to be estimated.

In addition, the approach takes little account of the use of abatement systems, particularly destruction processes such as incineration. The impact of these systems would reduce the emission estimate.

Finally, information on cleaning and damping solvents is particularly poor.

11.2 Detailed Methodology

This requires audits of the major plants, perhaps 40 for a country like France. Such audits are time consuming, and may not be possible if solvent audits are not a requirement of process authorisation.

Priority areas for improvement is a detailed review of the rotogravure and flexographic techniques to improve the current emission factors to at quality Code B and a methodology for assessing the extent of abatement and its effectiveness.

Note, in the EU the countries with the largest rotogravure and flexographic industries are thought to be Italy, Germany, UK and France (Allemand 1990).

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

In the simpler methodology, no point sources are defined. Spatial disaggregation should therefore be done on a population basis, or if possible, using the distribution of engineering workers.

In the detailed methodology, large printing processes are identified. The residual may be disaggregated according to population, or if possible, distribution of engineering workers.

13 TEMPORAL DISAGGREGATION CRITERIA

Large print works may work 24 hour shifts continually emitting VOCs. Smaller print works may only work single shifts of 8 hours during the day.

In the absence of other data, it may be assumed that emissions are relatively consistent over the course of a year.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

Godomski et al., An Evaluation of Emissions and Control Technologies for the Metal Decorating Process. JAPCA, Volume 24, No 6, June 1974.

Hutchinson G.H., Developments in the Technology and Applications of Offset Lithographic Printing Inks. Chemistry and Industry, 17 November, 1986.

Verspoor W. Paul. Reduction of Volatile Organic Compounds Use in the Production of Flexible Packaging. UNEP Industry and Environment October - November 1991.

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16 VERIFICATION PROCEDURES

Verification of emission estimates will be primarily through inter-comparison between countries, since some countries can be expected to carry out the detailed methodology.

Significant difference in emissions of organic compounds per tonne of ink used, or per capita may indicate poor quality data.

In addition, measurements carried out at individual printworks could be used to establish the actual efficiency of abatement equipment.

17 REFERENCES

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18 BIBLIOGRAPHY

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20 POINT OF ENQUIRY

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