Final Background Document
on the sector

Publication gravure

Prepared in the framework of EGTEI

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Summary

Sector : Publication gravure

SNAP : 06 04 03 03 or NFR 3 D OTHER including products containing HMs and POPs

Publication rotogravure is used for printing magazines, catalogues, and large amounts of sheets on various paper types. This printing technique produces solvent emissions during the drying of solvent based inks. [1]

ACTIVITY : consumption of ink non diluted (t / year)
POLLUTANT CONSIDERED : VOC (only toluene)

1 Data from the bibliography

Following data are just displayed for comparison reasons

1.1 Data currently used in the RAINS model [6], [7]

In the RAINS model, sub-sectors of the printing industry are treated separately (i.e : flexography and rotogravure in packaging, rotogravure in publication, screen printing and offset printing).

1.1.1 Control options

Three control options are considered in RAINS for "Rotogravure in Publication" :

- NoC : Reference case;
- LSI + ENC : low solvent inks and enclosure (applicability up to 80%; reduction efficiency : 50%).
- WBI : substitution with water-based inks (applicability 20%; efficiency : up to 90%). Applicability is rather small because the development of these inks is still under research due to the lower quality of the finish.
- ENC + ACA : enclosure and solvent recovery (applicability : up to 100%; efficiency : 75%). Enclosing the process, reducing the solvent content of inks and recovering solvents is assumed to be an integral part of new installations.

1.1.2 Abatement costs

Table 1.1.2.1 : General abatement costs taken into account in the RAINS model

Technology	Unit cost range [€$_{1990}$ / t VOC]
LSI + ENC	20-50
WBI	30-70/350-750 (new installations)
ENC + ACA	1 000-2 000

1.2 Situation in the UK [8]

This sector is treated in [8]. Four general measures are described for the printing industry in general (it is important to underline that for Publication gravure, only measures 01 and 04 are applicable):

- Measure 01 : waste minimization and improved cleaning techniques.
- Measure 02 : substitution with radiation curing inks, modified inks, water based system, cleaning fluids and non toxic inks.
- Measure 03 : abatement technique (incineration).
- Measure 04 : solvent recovery.

The average costs of compliance for the whole printing industry are expected to vary between 200 and 2 500 € / tonne of VOC reduced under the Directive (for medium (15-25 tonnes of solvent/y) and large (25+ tonnes of solvent/y) installations respectively).

2 Short technology description [1]

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 cells 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 cells.

The following distinctions can be made between publication and packaging gravure [3] :

Table 2.1 : Differences between publication and packaging gravure

Characteristics	Publication gravure	Packaging gravure
Substrate printed	Paper only	Paper, board, plastic and aluminium foil
Sides printed	Both sides of the substrate	Only one side of the substrate
Number of colors	Always 4 for each side, each press unit printing one side in one go	Often 8 sometimes even 10 for the one side. Each press unit printing one color
Number of dryers	One per unit; i.e. 8	One per unit plus an additional final dryer
Main solvent used	Only toluene	Ethylacetate or an ethylacetate/ethanol mixture
Press width	Anything between 0,9 and 4,32 meters	Mostly 1 meter, sometimes a bit wider
Particulars		On plastic and aluminium foil a 100% coverage white base ink needed as a base for printing, also in the final printing stage often 100% coverage with a varnish is added.

Therefore, the packaging gravure sector has to be studied in an other specific document.

3 EU regulation : Directive 1999/13/EC of 11 March 1999 [2]

Operators concerned can conform to the Directive in either of the following ways:

- by complying with the canalized and fugitive emission limit values.
- by introducing a reduction scheme to obtain an equivalent emission level, (in particular by replacing conventional products which are high in solvents with low-solvent or solvent-free products).

Directive applies to all installations. Installations with a solvent consumption below 25 t/y are extremely rare or non existent.

Emission limits for application of the Directive are presented in table 3.1.

Table 3.1 : Emission limit values

Solvent consumption threshold [t/y]	VOC emission limit value in residual gases [mg C / Nm^3]	Fugitive emissions [% of solvent input *]
> 25	75	New installations : 10 Existing installations : 15

* Solvent input : quantity of organic solvents used as input into the process in the time frame over which the mass balance is being calculated (purchased solvent) + quantity of organic solvents recovered and reused as solvent input into the process (recycled solvents are counted every time they are back into the printing cycle).

All obligations of the Directive are not described in this chapter.

Requirements can be different among the European countries. The German example is displayed in table 3.2. Installations have to comply with both emission limit values and total emission limit values.

Table 3.2 : Emission limit values in Germany

Solvent consumption threshold [t/y]	VOC emission limit value in residual gases [mg C / Nm^3]	Total emissions [% of solvent input]
> 25	50 for new installations 100 for existing installations *	New installations : 5 Existing installations : 10

* Applicable until 2007

4 Definition of Reference Installation

The most important distinction between publication gravure presses is their width and speed. In general the wider presses are also the faster and younger presses.
Reference installations refer to single printing presses. One plant will normally have more than one press, often even of two or three different widths. Five width groups have been distinguished [5].

Calculations of the average ink consumption per press have been provided by [5] based on an ERA database of information about all publication gravure presses in Europe : these consumptions are estimations and they could vary depending on work load.

The different types of presses are presented in table 4.1.

Table 4.1 : Different press's types

Presses	Description		
	Min width [mm]	Max. width [mm]	Ink consumption * [t /y]
1	900	1 999	430
2	2 000	2 449	640
3	2 450	2 749	920
4	2 750	3 179	1 130
5	3 180	4 320	1 330

* Inks non diluted (50 wt. % solvent content) as delivered to the printing plant by the ink manufacture.

Table 4.2 : European statistics [5]

Presses	Number of presses *	Average toluene input [t / y]
1	63	± 860
2	39	± 1 280
3	77	± 1 840
4	25	± 2 260
5	28	± 2 660

* Last updated data

However, only one medium press is defined as Reference Installation.

Table 4.3 : Reference Installation

Reference installation RIC	Description			
	Min width [mm]	Max. width [mm]	Ink consumption [t /y]	Average toluene input [t / y]
01	2 450	2 749	920	1 840

5 Emission abatement techniques and costs

5.1 Definitions of primary measures

Only toluene based inks are used [3]. Ink contains 50% toluene when leaving the ink factory. A dilution is made in the printing plant to obtain the proper concentration in toluene : machine ready ink contains up to 80% toluene [5]. This dilution is made with toluene recovered inside the plant.

Water based inks were used in publication gravure before the 40s. At that time, the web widths were very limited (<1 m) and the web speed were lower. Water based inks have been under development and have been tested on modern web presses : experiments have proved that these inks can not be used for technical and economical reasons. Furthermore, products produced with water based inks are not recyclable.

A successful development of publication gravure inks has led to a new generation of still toluene based inks. Their formulation has been modified so toluene evaporates more efficiently in the dryers leading to fugitive emissions reductions. These new inks are distributed by several manufactures (i.e. Reductol® inks, TR® inks…).

Table 5.1.1 : Primary measures

Primary Measure Code PMC	Description
00	Conventional solvent based ink

5.2 Definitions of secondary measures

All installations in Europe are equipped with an activated carbon adsorber [4], [9]. The best way to reduce emissions is then to lower fugitive emissions : this is done by routing the biggest part of VOC emissions to the abatement device. Reduction of canalized emission values are not considered hereafter.

Three different secondary measures are defined :

- Measure 00 corresponds to the standard situation : only dryer ventilation from running presses is sent to the abatement device.
- Measure 01 : when the press is idling the dryer air is also sent to the abatement device; all press room vents are also routed to the adsorber.
- Measure 02 : same as 01 + use of new inks evaporating more efficiently in the dryer leading to significant reduction of fugitive emissions. This is not applicable in all cases of existing installations.

Table 5.2.1 : Secondary measures

Secondary Measure Code SMC	Description
00	Activated carbon adsorption. Fugitive emission : 15% of solvent input
01	Activated carbon adsorption. Fugitive emission : 10% of solvent input
02	Activated carbon adsorption. Fugitive emission : 5% of solvent input

5.3 Emission factors and costs data for the different combinations

Table 5.3.1 : Emission factors, and abatement efficiencies for relevant combinations

RIC PMC SMC	NMVOC Emission Factor [kg / kg of ink non diluted]	Abatement efficiency [%]	Q	CI %
01 00 00	0,3	0	4	20
01 00 01	0,2	33	4	20
01 00 02	0,1	67	4	20

Q : Quality of data
CI : Coefficient of variation

Table 5.3.2 : Investments and operating costs

RIC PMC SMC	Investments [€] *	Q	CI %	Operating Costs * [€/y]	Q	CI %	Savings [€ / y]	Q	CI %
01 00 00	0	-	-	0	-	-	0	-	-
01 00 01	500 000	3	30	100 000	3	30	46 000	3	30
01 00 02	500 000	3	30	100 000	3	30	92 000	3	30

* Costs are estimations and could vary depending on the situation of the real installations [9]

6 Data to be provided by national experts for the completion of the database for their own country

The following tasks are required :

6.1 Validation work

For presenting costs in this sector, the national expert is invited to comment the methodology defined by the Secretariat.

- Validate investment costs provided or,
- Provide other costs for the same combination of techniques and justify them.

Comments have to be sent to the Secretariat in the two weeks after electronic publication of the document.

6.2 Provision of specific data

Tables to be filled in by national experts

- Determination of country and sector specific data to calculate variable costs.

Table 6.2.1 : Country and sector specific data

Parameter	Default cost [€/kg] *	Country specific cost [€/kg]
Toluene	0,5	

* the price is based on the exchange price in Rotterdam

- Total activity level (consumption of ink non diluted tonnes / y) in 2000, 2005, 2010, 2015, 2020. Some default values for the confidence interval are given. They can be used by the Party if no data are available.

The methodology used in Rains for estimating the future activity level will be described in the methodology. This methodology can be used or information can be obtained from the industry.

Table 6.2.2 : Total activity level (consumption of ink non diluted expressed in t of ink / y)

RIC	2000	CI%	2005	CI%	2010	CI%	2015	CI%	2020	CI%
01										
Default values proposed for CI		10		20		50		100		100

For explanations on the coefficient of variation, refer to the Methodology.

Total activity (t of ink non diluted / y) should evolve from 2000 to 2020.

- Respective percentage of combinations of reduction measures in 2000 as well as if possible, the percentage of use in 2005, 2010, 2015, 2020 due to the VOC Directive or national regulations and applicability according to the definition used in the RAINS model.

Table 6.2.3 : Application rate and Applicability for each combination of reduction measures

RIC PMC SMC	Application rate in 2000 [%]	Application rate in 2005 [%]	Appl. [%]	Application rate in 2010 [%]	Appl. [%]	Application rate in 2015 [%]	Appl. [%]	Application rate in 2020 [%]	Appl. [%]
01 00 00									
01 00 01									
01 00 02									
Total RIC 01	**100**	**100**		**100**		**100**		**100**	

Table 6.2.4 : Unabated emission factor [kg VOC / kg of ink non diluted]

Default data mean	CI %	User input mean	CI %
0,3	20		

The "default data mean" can be modified in a range of ± 10%.

7 Explanatory notes

7.1 Solvent emission factors (EF)

Emission factors are given in kg of VOC per kg of ink non diluted (50% of toluene) used. Total emissions vary according to fugitive emission levels.

- Average ink consumption : 920 t/y with 50% solvent content : 460 t of toluene / y.
- Average input of recovered toluene : 1 380 t/y for dilution.
- The total input of toluene is 460 + 1 380 = 1 840 t/y.

SMC 00 corresponds to fugitive emissions of 15% of solvent input giving 1 840 × 0,15 = 276 t VOC/y.
SMC 01 corresponds to fugitive emissions of 10% of solvent input giving 1 840 × 0,10 = 184 t VOC/y.
SMC 02 corresponds to fugitive emissions of 5% of solvent input giving 1 840 × 0,05 = 92 t VOC/y.

Table 7.1.1 : Emission factors (kg VOC / kg ink non diluted)

PMC SMC	Emission factor [kg VOC / kg ink non diluted]	Abatement efficiency [%]
00 00	276 / 920 = 0,3	0
00 01	184 / 920 = 0,2	33
00 02	92 / 920 = 0,1	67

7.2 Derivation of cost data

Primary measures

No cost is accounted because only one primary measure is defined.

Secondary Measures

It is assumed that all installations are already equipped with adsorbers. That is why, investments and operating costs for the end-of-pipe devices are not taken into account hereafter. Only over-costs between old and new updated presses are estimated. These costs are derived from [4].

- To comply with secondary measure 01 emission limit levels, investments are necessary. It is very expensive to transform a press but **in the case of a new press purchase**, additional investment is considered to be around 500 000 euros per press (for an average press) [4].
  Additional operating costs are assessed to be around 100 000 euros per press.
- For measure 02, investment is incurred for higher dryer capacity (no over cost is considered in this document). Special inks are about the same price as conventional ink. The only limit, is the technical applicability of the measure, which also applies to the reduction of the fugitive emissions.

This is considered that all toluene, which is not emitted, is recovered. This toluene will be either re-used in the plant or will be resold to the ink supplier. A price of 0,5 €/kg of toluene is used to estimate the savings [9]. However this cost is country specific and can be modify in the tool (see table 6.2.1).

Table 7.2.1 : Saving's calculations

RIC PMC SMC	Calculation
01 00 01	920 000 [kg ink/y]× (0,3–0,2) [kg toluene/kg ink]× 0,5 [€/kg toluene]= 46 000 [€/y]
01 00 02	920 000 × (0,3–0,1) = 92 000

Table 7.2.2 : Emission factors, investments, operating costs and technical lifetime for each secondary measure

RIC PMC SMC	NMVOC Emission Factor [kg / kg of ink non diluted]	Investment [€]*	Operating Costs [€/y]*	Savings [€/y]	Tech. Lifetime [y]
01 00 00	0,3	0	0	0	15
01 00 01	0,2	500 000	100 000	46 000	15
01 00 02	0,1	500 000	100 000	92 000	15

* Investments and operating costs are given for new presses as an incremental cost over traditional press situation.

8 References

[1] Task force on the assessment of abatement options and techniques for VOC from stationary sources. Draft background document – Prepared by IFARE for UN/ECE-May 1999.

[2] 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 installations.

[3] Mr Paul W. VERSPOOR Intergraf. Personal communication. October 2002.

[4] W. FLECK; Dr. J. ARNOLD; P. W. VERSPOOR MBA. Printing and the environment. Guidance on Best Available Techniques (BAT in Printing Industries. INTERGRAF/EGF. January 1999.

[5] Josef BERNARD. ERA. Personal communication. March 2003.

[6] Z. KLIMONT; M. AMANN; J. COFALA. Estimating costs for Controlling Emissions of Volatile Organic Compounds (VOC) from Stationary Sources in Europe. Interim Report IR-00-51. IIASA. August 1, 2000.
http://www.iiasa.ac.at/~rains/voc_review/voc_ir-00-51.pdf

[7] Review of data used in RAINS-VOC model.
http://www.iiasa.ac.at/~rains/voc_review/single.html

[8] Regulatory and Environmental Impact Assessment for the Implementation of the EC Solvent Emissions Directive. Final Report. Entec UK Limited. 20 December 1999.

[9] ERA. Common meeting. April 2003.