Final Background Document
on the sector

Flexography and rotogravure in packaging

Prepared in the framework of EGTEI

Prepared by CITEPA, Paris

Summary

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General data currently used in RAINS are displayed in this paragraph. Country specific data are downloadable on http://www.iiasa.ac.at/~rains/voc_review/single.html

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4. Definition of Reference Installations (p.5)

Four reference installations are defined according to the annual product consumption (t of products ready to use/y).

5. Emission abatement techniques and costs (p.6)

Five primary and three secondary measures are defined.
Table 5.3.1 summarizes the emission factors with the corresponding abatement efficiencies for each combination measure.
Table 5.3.2 summarizes investments and operating costs.

If a measure is missing in the document, national experts have to contact the Secretariat to add it in the background documents.

6. Data to be provided by national experts for the completion of the database for their own country (p.8)

Tables to be filled in by national experts are displayed :
Table 6.2.1 : Country specific data (electricity, natural gas, steam, wages).
Table 6.2.2 : Country and sector specific data (price of solvent recovered).
Table 6.2.3 : Activity levels of Reference Installations. Consumptions of products ready to use (t/y) in each type of reference installation (RI) is required.

- Total activity (t products ready to use/y) has to be estimated from 2000 to 2020 and distributed according to the different installations.
- If no detailed information is available in 2000, total activity can be divided equally between all RI (i.e.: 25% for each one).
- If no prevision on the structure of this sector is available (for 2005 to 2020), the proportions used in 2000 can be used. But total activity (t of products ready for use/y) should evolve.

Table 6.2.4 : Application rate and applicability.

- If detailed information is available, table 6.2.4 can be filled in.
- If only sparse information is available, then table 6.2.4 can be filled in with the same "Application rates" for all RI (this corresponds to the filling of table 6.2.5).

Table 6.2.5 : Unabated emission factor

Default data means can be modified in a range of ± 10%.

7. Explanatory notes on emission factors and costs (p.12)

Explanations about the figures are given in this paragraph. Investments and operating costs of primary measures have been provided by industrial experts. For secondary measures, costs are calculated from the equations of the document "Methodology".

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Sector : Flexography and Rotogravure in the Packaging

SNAP : 06 04 03 01 or NFR 3 D OTHER including products containing HMs and POPs

By flexography and rotogravure processes, paper, cardboard, plastics and aluminium surfaces are printed. Emissions of NMVOC arise mainly from the evaporation of solvents during the ink drying stage [1].

ACTIVITY : consumption of products (ink, adhesives and varnishes) ready to use (t / year)
POLLUTANT CONSIDERED : VOC

1 Data from the bibliography

Following data are just displayed for comparison reasons

1.1 Data currently used in the RAINS model [6], [9]

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

Four control options are considered in RAINS for “Flexography and Rotogravure in packaging” :

- NoC : Reference case
- LSI+ENC : Low solvent inks and enclosure (applicability 95%; reduction efficiency : 65%).
- WBI : Substitution with water-based inks (applicability 30%; efficiency : 90%).
- ENC+ACA : Enclosure and solvent recovery (applicability : 20%; efficiency : 75%).
- ENC+INC : Enclosure and incineration (applicability : 20%; efficiency : 75%).

Combinations of these techniques are also considered in the RAINS model.

1.1.2 Abatement costs

Typical costs ranges are displayed in table 1.1.2.1. Combinations being very numerous, costs are not given for specific countries.

No comments are made on the figures displayed bellow because no further information is available. Data at a county level are downloadable on http://www.iiasa.ac.at/~rains/voc_review/single.html

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

Technology	Unit cost range [$€_{1990}$ / t VOC]
NoC	0
LSI+ENC	20-30
WBI	30-50/100-300 (new installations)
ENC+ACA	150-300
ENC+INC	1150-1650

1.2 Situation in the UK [7]

Four general measures are described for the printing industry :

- 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.

For flexography, gravure and screen, the following techniques are described :
This is assume that 1,6 kg of VOC is released for every 1 kg of ink in flexography and gravure.
Waste minimization consists in a reduction of solvents used (especially for cleaning solvents).
Non or low Solvent Inks and Cleaners : the use of water based inks tends to increase. Changing to water based or other non volatile system requires fundamental operational changes however and a largely unknown expenditure.
Pollution abatement : Either thermal or catalytic incineration is normally used. For plants using rotogravure process only, carbon adsorption is normally the best option.

Table 1.2.1 : Costs incurred for VOC reduction

Measure	Investment / installation [€]	Operating cost / installation [€ / y]
01	≈ 0	≈ 0
02	≈ 0	≈ 0
03	600 000	60 000

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].

1.3 Situation in Norway [8]

The report covers only the general increase in the use of products without solvent. No special costs are associated with this measure.

2 Short technology description [1]

2.1 Flexography

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. The process is usually web fed and is employed for medium or long multicolour runs on a variety of substrates, including heavy paper, fibreboard, and metal and plastic foil. The major categories of the flexography market are flexible packaging and laminates, multiwall bags, milk cartons, gift wrap, folding cartons, corrugated paperboard (which is sheet fed), paper cups and plates, labels, tapes, and envelopes. Almost all milk cartons and multiwall bags and half of all flexible packaging are printed by this process.
Water-based inks in flexography printing are in regular production use in some packaging applications such as paper bags and plastic carrier bags [3].

2.2 Rotogravure

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 (the process is identical as the one used in the publication industry except for difference in size, speed and solvents used : see table in introduction). Water-based inks in rotogravure printing are very rarely used [3]

In the larger installations, flexography and gravure may be found on the same site.

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 installations with a solvent consumption above 15 t per year.

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

Table 3.1 : Emission limits

Solvent consumption threshold [t/y]	VOC emission limit value in residual gases [mg C / Nm^3]	Fugitive emissions [% of solvent input*]
15-25	100	25
> 25	100	20

* 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 put back into process cycle).

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

4 Definition of Reference Installations

This sector is wide. Very small to very large installations exist and processes differ according to the size of installations.

A distinction is made between installations according to their size and the technique used. Emissions and abatement techniques will be different from one reference installation to another. Four different reference installations have been defined with [3].

1) Small flexography installation : uncomplicated printing on plastic or paper. No varnish or lamination is used. All emissions are fugitive because no dryer is employed. Activity : an input of 28 tonnes of products (press ready to use) are used representing around 25 tonnes of VOC emissions.
2) Large flexography installation : limited amount of varnishing and lamination are used. Substrates printed are either plastic, aluminium, paper or board. Activity : an input of 125 tonnes of products (press ready to use) are used representing around 100 tonnes of VOC emissions.
3) Small gravure plant installation : lots of varnishing and lamination. The largest proportion of solvents are found in varnishes and adhesives. Activity : an input of 313 tonnes of products (press ready to use) are used representing around 250 tonnes of VOC emissions.

4) Large gravure plant : lots of varnishing and lamination. The largest proportion of solvents are found in varnishes and adhesives. Activity : an input of 1250 tonnes of products (press ready to use) are used representing around 1000 tonnes of VOC emissions

Reference installations are presented in table 4.1.

Table 4.1 : Reference installations

Reference Installation Code RIC	Description
01	Small flexography : input of 28 t of products (inks, adhesives, varnishes : press ready) / year; production : paper or plastic
02	Large flexography : input of 125 t of products (inks, adhesives, varnishes : press ready) / year, production : plastic aluminum, paper, cardboard
03	Small rotogravure : input of 313 t of products (inks, adhesives, varnishes : press ready) /year; production : plastic aluminum, paper, cardboard
04	Large rotogravure : input of 1 250 t of products (inks, adhesives, varnishes : press ready)/year; production : plastic aluminum, paper, cardboard

5 Emission abatement techniques and costs

5.1 Definitions of primary measures

Solvent based inks can have different solvent contents when bought but ready to use inks contain about 90% of solvents for RIC 01 and about 80% for RIC 02 to 04 (these figures take into account cleaning agents).

As a matter of fact, the inks are more or less the same. In the machine they contain close to 80% of solvents. The problem is however that during printing, fugitive emissions from the smallest printing unit (RIC 01) are such that viscosity increases far too much and that solvents need to be added at a much larger scale than in other plants. This is due to the very unfavorable ratio between the size of the ink unit and the actual amount of ink necessary for the image to be printed (this gives a solid-solvent ratio of 1:8 or 9 instead of 1:4) [3].

Substitution can be implemented with water-based products, UV curing inks and 2-components adhesives. The use of these products is not always technically feasible : it depends on the complexity of the process as well as on the substrate to be printed.
In some cases, just a portion of the products can be replaced by substitution products.

Table 5.1.1 : Primary measures

Primary Measure Code PMC	Description
00	Conventional solvent products (content of 90 wt.-% of solvent for ready for use inks)
01	Conventional solvent products (content of 80 wt.-% of solvent for ready for use inks)
02	Water-based products (solvent content of 5 wt.-%)
03	UV curing inks (solvent content of 0 wt.-%)
04	60% of products used replaced by 2 components adhesives (solvent content of 0 wt.-%)

5.2 Definitions of secondary measures

- ✓ When substitution is not technically feasible or not sufficient to obtain the regulation limits, incineration can be used to reduce VOC emissions.
- ✓ For RIC 01, for which all VOC emissions are fugitive (no dryer used), a total encapsulation of the system with an incinerator would be necessary. According to [3], operators need to get to the machine quite often. This means that concentrations inside the encapsulation need to be below the Occupational Exposure Limit (OEL). For ethanol which is often used in flexography, the OEL is 500 mg/m^3. For other solvents, it is even lower. An average concentration of 250 mg/m^3 is taken into account in this report.
- ✓ For reference installations 03 and 04, adsorption might also be implemented because products with mono-solvent are sometimes used (like in Italy for example).

Table 5.2.1 : Secondary measures

Secondary Measure Code SMC	Description
00	No secondary measure
01	Incineration
02	Adsorption and solvent recovery

5.3 Emission factors and costs data for the different combinations

To simplify the tables, non appropriate combinations are not considered hereafter (see explanations in paragraphs 5.1 and 5.2)

Table 5.3.1 : Emission factors (EF) and abatement efficiencies for each relevant combination

Combination Code RIC PMC SMC	EF VOC [g / kg of ink ready to use]	Abatement efficiency [%]	Q	CI %
01 00 00	900	0	4	20
01 02 00	50	94,5	4	20
01 03 00	0	100	4	20
01 00 01	216	76	4	20
02 01 00	800	0	4	20
02 02 00	100	87,5	4	20
02 01 01	192	76	4	20
03 01 00	800	0	4	20
03 02 00	50	93,75	4	20
03 04 00	320	60	4	20
03 01 01	192	76	4	20
03 01 02	192	76	4	20
03 04 01	80	90	4	20
03 04 02	80	90	4	20
04 01 00	800	0	4	20
04 02 00	50	93,75	4	20
04 04 00	320	60	4	20
04 01 01	192	76	4	20
04 01 02	192	76	4	20
04 04 01	80	90	4	20
04 04 02	80	90	4	20

Table 5.3.2 : Investments and operating costs

RIC PMC SMC	Investment [k€]	Q	CI %	Variable OC [k€/y]	Q	CI %	Fixed OC [k€/y]	Q	CI %	Saved Costs [k€ / y]	Q	CI %
01 00 00	0.0	-	-	0	-	-	-	-	-	-	-	-
01 02 00	42,0	2	35	0	3	-	-	-	-	-	-	-
01 03 00	42,0	2	35	0	3	-	-	-	-	-	-	-
01 00 01	2 138,5	4	25	44,4	4	25	106,9	4	25	-	-	-
02 01 00	0.0	-	-	0	-	-	-	-	-	-	-	-
02 02 00	187,5	2	35	0	3	-	-	-	-	-	-	-
02 01 01	1 506,0	4	25	33,4	4	25	75,3	4	25	-	-	-
03 01 00	0.0	-	-	0	-	-	-	-	-	-	-	-
03 02 00	469,5	2	35	0	3	-	-	-	-	-		
03 04 00	0.0	-	-	0	4	-	-	-	-	-	-	-
03 01 01	1 506,0	4	25	23,6	4	25	75,3	4	25	-	-	-
03 01 02	1 031,0	4	25	48,5	4	25	51,6	4	25	28,5	4	5
03 04 01	1 332,0	4	25	19,3	4	25	66,6	4	25	-	-	-
03 04 02	710,0	4	25	22,2	4	25	35,5	4	25	11,3	4	5
04 01 00	0.0	-	-	0	-	-	-	-	-	-	-	-
04 02 00	1 875,0	3	35	0	3	-	-	-	-	-	-	-
04 04 00	0.0	-	-	0	4	-	-	-	-	-	-	-
04 01 01	2 325,0	4	25	91,6	4	25	116,3	4	25	-	-	-
04 01 02	1687,5	4	25	154,7	4	25	84,4	4	25	114,0	4	5
04 04 01	2 082,0	4	25	75,8	4	25	104,1	4	25	-	-	-
04 04 02	1 182,0	4	25	71,6	4	25	59,1	4	25	45,0	4	5

(-) : Not applicable

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

- Validate investments provided and,
- Validate the method of derivation of operating costs.

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 having received the document.

6.2 Provision of specific data

Tables to be filled in by national experts

- Determination of country specific data to calculate variable costs : (they are valid for all VOC sectors and only have to be entered in the tool once).

Table 6.2.1 : Country-specific data

Parameters	Default values	Country specific costs
Electricity [€/kWh] (net of taxes)	0,0686	
Natural gas [€/kWh] (net of taxes)	0,0192	
Steam [€/kg] (net of taxes)	0,016	
Wages [€/h]	25,9	

Table 6.2.2 : Country and sector specific data

Parameters	Default value	Costs
Price of recovered solvents [€/kg]	0,15	

- Respective shares (t products ready to use/y) of the total activity level carried out on each reference installation 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.

Table 6.2.3 : Activity levels on Reference Installations (t products ready to use / year)

RIC	2000	CI%	2005	CI%	2010	CI%	2015	CI%	2020	CI%
01										
02										
03										
04										
Default values for CI		10		20		50		100		100
Total	Calculated automatically by the tool									

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

- Total activity (t products ready to use/y) has to be estimated from 2000 to 2020 and distributed according to the different installations.
- If no detailed information is available in 2000, total activity can be divided equally between all RI (i.e.: 25% for each one).
- If no prevision on the structure of this sector is available (for 2005 to 2020), the proportions used in 2000 can be used. But total activity (t of products ready for use/y) should evolve.

- Respective percentage of combinations of reduction measures in 2000 for each reference installation 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 6.2.4 : Application rate and Applicability

RIC PMC SMC	Application rate in 2000 [%]	Application rate in 2005 [%]	Applicability [%]	Application rate in 2010 [%]	Applicability [%]	Application rate in 2015 [%]	Applicability [%]	Application rate in 2020 [%]	Applicability [%]
01 00 00									
01 00 01									
01 02 00									
01 03 00									
Total RIC 01	**100**	**100**		**100**		**100**		**100**	
02 01 00									
02 01 01									
02 02 00									
Total RIC 02	**100**	**100**		**100**		**100**		**100**	
03 01 00									
03 02 00									
03 04 00									
03 01 01									
03 01 02									
03 04 01									
03 04 02									
Total RIC 03	**100**	**100**		**100**		**100**		**100**	
04 01 00									
04 02 00									
04 04 00									
04 01 01									
04 01 02									
04 04 01									
04 04 02									
Total RIC 04	**100**	**100**		**100**		**100**		**100**	

If detailed information is available, table 6.2.4 can be filled in.
If only sparse information is available, then table 6.2.4 can be filled in with the same "Application rates" for all RI (this corresponds to the filing of table 6.2.5).

Table 6.2.5 : Aggregated table

RIC PMC SMC	Application rate in 2000 [%]	Application rate in 2005 [%]	Applicability [%]	Application rate in 2010 [%]	Applicability [%]	Application rate in 2015 [%]	Applicability [%]	Application rate in 2020 [%]	Applicability [%]
Aggreg. 00 00									
Aggreg. 01 00									
Aggreg. 02 00									
Aggreg. 03 00									
Aggreg. 04 00									
Aggreg. 00 01									
Aggreg. 01 01									
Aggreg. 01 02									
Aggreg. 04 01									
Aggreg. 04 02									
Total aggreg.	**100**	**100**		**100**		**100**		**100**	

Aggreg. : Aggregation

Table 6.2.6 : Unabated emission factor [g VOC / kg of product ready to use consumed]

PMC	Default data mean	CI %	User input mean	CI %
00	900	20		
01	800	20		

"Default data means" can be modified in a range of ± 10%.
If a measure is missing in the document, national experts have to contact the secretariat to add it in the background documents.

6.3 Additional explanations for completing tables 6.2.3 and 6.2.4

Usually, product consumptions are available as consumption of products non diluted (tonnes of products non diluted / year) in the statistics.
In this document, activity is defined as the consumption of products ready to use (after dilution). Preliminary data treatments are consequently required to fill in table 6.2.3 with the requested data.

6.3.1 Definition of the consumption of products non diluted (tonnes / year)

Consumption of non diluted products	X tonnes / year

This can be provided by national statistics.

6.3.2 Definition of the rate of use of the different primary measures for non diluted products

Table 6.3.2.1 : Rate of use of the primary measures for the non diluted products

Definition of the measures	% of application for each year considered
Use of water based products (PMC 02)	x
Use of UV curing inks (PMC 03)	y
Use of 60% of 2 components adhesives (PMC 04)	z
Use of conventional solvent products (PMC 00 + 01)	100 – x - y - z

6.3.3 Determination of the consumption of ready to use products (tonnes / year)

Consumption of ready to use products	Y tonnes / year *

* this figure corresponds to the total activity level as defined in this document

Multiplying factor of dilution	A (country specific)

1 kg of conventional solvent based products is diluted to obtain **A** kg of ready to use products.
(A is usually a mean value for PMC 00 and 01)

Consumption of water based products = X × x / 100 (these products are not diluted).
Consumption of UV curing inks = X × y / 100 (these products are not diluted).
Consumption of 2 components adhesives = X × z /100 × [0,6 + 0,4 × A] (according to the measure definition, only 40% of the products are diluted. The country specific factor A is used).
Consumption of ready to use conventional solvent products = X × [100 - x – y – z] / 100 × A (these products are diluted).

Total consumption of ready to use products :

$$Y = X \times [x + y + z \times (0,6 + 0,4 \times A) + (100 - x - y - z) \times A] / 100$$

6.3.4 Determination of the rate of use of the different primary measures for ready to use products

Table 6.3.4.1 : Rate of use of the primary measures for the ready to use products

Definition of the measures	% of application for each year considered
Use of water based products (PMC 02)	x ×X / Y
Use of UV curing inks (PMC 03)	y ×X / Y
Use of 60% of 2 components adhesives (PMC 04)	z × [0,6 + 0,4 × A] ×X / Y
Use of conventional solvent products (PMC 00 + 01)	[100 - x – y – z] × A ×X / Y

Parameter defined in table 6.3.4.1have to be compatible with data used in table 6.2.4 to define the application rates of the different measures at an installation level.

7 Explanatory notes

7.1 Solvent emission factors (EF)

- In installations without secondary measure, it is considered that all solvents consumed are evaporated (EF = 1g VOC/g solvent used).
- For PMC 04, we assumed that 60% of the products are replaced by 2 components adhesives.
- In installations with an abatement device, 80% of emissions are collected and treated with an efficiency of 95%.

Table 7.1.1 : Emission factors related to mass of product (g VOC / kg product ready to use)

RIC PMC SMC	VOC Emission Factor [g VOC / kg product ready-to-use]	Abatement efficiency [%]
01 00 00	900	0
01 02 00	50	94,5
01 03 00	0	100
01 00 01	900 × (0,8×0,05+0,20) =216	76
02 01 00	800	0
02 02 00	50	87,5
02 01 01	800 × (0,8×0,05+0,20) = 192	76
03 01 00	800	0
03 02 00	50	93,75
03 04 00	0,6 × 0 + 0,4 × 0,8 = 320	60
03 01 01	800 × (0,8×0,05+0,20) = 192	76
03 01 02	800 × (0,8×0,05+0,20) = 192	76
03 04 01	320 × (0,8×0,05+0,20) = 80	90
03 04 02	320 × (0,8×0,05+0,20) = 80	90
04 01 00	800	0
04 02 00	50	93,75
04 04 00	0,6 × 0 + 0,4 × 0,8 = 320	60
04 01 01	800 × (0,8×0,05+0,20) = 192	76
04 01 02	800 × (0,8×0,05+0,20) = 192	76
04 04 01	320 × (0,8×0,05+0,20) = 80	90
04 04 02	320 × (0,8×0,05+0,20) = 80	90

7.2 Derivation of cost data

Primary measures

Costs for substitution of products are derived from an example given by [3]. An industrial of category 3 or 4 has switched from solvent-based products to water-based products. An average investment of 25000 to 190 000 € per varnish or adhesive has been observed. An average of 75 000 €/product is used in the document. This investment accounts for :

- Research and development , product testing and permissions;
- Adaptations of the process equipment (dryers, cylinders…);
- Water treatment process.

For RIC 04, a switch of 25 products leads to a total investment of 1 875 000 €. As information is missing, investments for the other reference installations are calculated proportionally to the ink input.

✓ No over-cost is accounted for operating costs. Water-based products are supposed to cost about the same price as solvent products.

Table 7.2.1 : Emission factors, investments, operating costs and technical lifetime for each primary measures

RIC PMC SMC	NMVOC EF [g / kg of product ready-to-use]	Investment [€]	Operating Costs [€ / y]	Tech. Lifetime [y]
01 00 00	900	0	0	20
01 02 00	50	42 000	0	20
01 03 00	0	42 000	0	20
02 01 00	800	0	0	20
02 02 00	50	187 500	0	20
03 01 00	800	0	0	20
03 02 00	50	469 500	0	20
03 04 00	320	0	0	20
04 01 00	800	0	0	20
04 02 00	50	1 875 000	0	20
04 04 00	320	0	0	20

✓ Cots for the use of 2 components adhesives have not been accounted for VOC emission reduction. This measure do not allow the industrial to reach the emission limits. These adhesives are technical products used to enhance the production quality [3]. This measure is just studied to represent the baseline and because when coupled with a secondary measure, the use of 2 component adhesives make it possible to go further than the directive limits.

Secondary Measures

According to [5] and based on industrial cases, for installations with solvent input < 400 t, flow rates are relatively similar : an average flow rate of 50 000 m^3/h is observed.
For installations with a solvent input of 1 000 t of solvents, flow rates between 100 000 and 120 000 m^3/h are observed. An average value of 110 000 m^3/h has been used.

In theory, knowing the working time and gas flow rates, VOC-concentrations in the exhaust gas can be assessed and then, investments and operating costs.
Small flexo : working time : 1 600 h/y,
Large flexo and small gravure : working time : 3 200 h/y,
Large gravure : working time : 4 800 h/y

VOC concentrations are needed to calculate operating costs of secondary measures :

VOC concentration [g/m^3] = 0,8 × [(g COV / kg ink) × (kg ink/y)] / [(m^3/h) × (h/y)]

- *RIC 01* :

As noticed in paragraph 5.2, RIC 01 is an exception. VOC concentrations of 0,25 g / m^3 are assumed in the exhaust gas. The flow rate is assessed from this concentration :

Flow rate [m^3/h] = 0,8 × [(g COV / kg ink) × (kg ink/y)] / [(g VOC/m^3) × (h/y)]

For this type of installations, encapsulation costs have to be considered. According to [3], no example exist in Europe because of the high costs incurred by this measure. An investment of 250 000 € is taken into account knowing that uncertainty is very high on this parameter.

RIC 02, 03 and 04 :
Flow rates of 50 000 and 110 000 m^3/h are the design flow rates for incinerator. Investments must indeed be based upon this figure.

Real average flow rates however are quite a bit smaller because dryers do not always operate at the design flow rate, upon which the incinerator capacity was based. This is due to the fact that every dryer is capable of coping with 100% ink coverage and that in practice most colours are printed with a smaller ink coverage. Still there is also a minimum airflow to every dryer for safety reasons.

All in all, this means that the concentration attained are, on average, higher than the 2,0 g/m^3 calculated with the equation above. These plants attain on average, depending on the ratio between inks, varnishes and adhesives, between 3 and 5 g/m^3 (a mean value of 4 g/m^3 is used).
When 2 components adhesives are used (PMC 04), flow rates decrease a little (a ratio of 20% is considered hereafter). VOC concentrations in the stack are lowered. A VOC concentration of 2 g/m^3 is then considered.

Flow rates displayed in table 7.2.2 can only be attained if, before the incinerator is installed, the dryers are 'optimised'. This reduces the airflow to the levels given above. Before optimisation they may easily be twice as large. The cost of this optimisation process is quite large. It amounts to some 20% of the investment in incineration. These over-costs are included in the investments [3].

Costs for optimisation are considered to be equivalent for incineration and adsorption processes.

Table 7.2.2 : VOC concentration calculations

RIC PMC SMC	Production time [h / y]	Flow rate [m^3 / h]	VOC conc. [g / m^3]
01 00 01	1 600×0,8×0,6 = 768	0,8 × 28000 × 900 / 768 / 0,25 = 105000	0,25
02 01 01	3 200×0,8×0,6 = 1 536	50 000	1,0
03 01 01	3 200×0,8×0,6 = 1 536	50 000	4,0
03 01 02	3 200×0,8×0,6 = 1 536	50 000	4,0
03 04 01	3 200×0,8×0,6 = 1 536	40 000	2,0
03 04 02	3 200×0,8×0,6 = 1 536	40 000	2,0
04 01 01	4 800×0,8×0,75 = 2 880	110 000	4,0
04 01 02	4 800×0,8×0,75 = 2 880	110 000	4,0
04 04 01	4 800×0,8×0,75 = 2 880	90 000	2,0
04 04 02	4 800×0,8×0,75 = 2 880	90 000	2,0

Investment and operating costs are based on the equations displayed in the document "Methodology". Investments for optimizations are added.
Operating costs are country specific : figures in table 7.2.3 are displayed as examples).

Table 7.2.3 : Emission factors, investments, operating costs and technical lifetime for secondary measures

RIC PMC SMC	NMVOC EF [g / kg of product ready to use]	Investment [€]	Optimisation [€]	Variable operating costs [k€/y]	Fixed operating Costs [k€/y]	SC * [k€/y]	Tech. Life [y]
01 00 01	216	1 888 500	250 000	44,4	106,9	-	10
02 01 01	192	1 255 000	251 000	33,4	75,3	-	10
03 01 01	192	1 255 000	251 000	23,6	75,3	-	10
03 01 02	192	780 000	251 000	48,5	51,5	28,5	10
03 04 01	80	1 110 000	222 000	19,3	66,6	-	10
03 04 02	80	488 000	222 000	22,2	35,5	11,3	10
04 01 01	192	1 937 500	387 500	91,6	116,2	-	10
04 01 02	192	1 300 000	387 500	154,7	84,3	114,0	10
04 04 01	80	1 735 000	347 000	75,8	104,1	-	10
04 04 02	80	835 000	347 000	71,6	59,1	45,0	10

* SC : Saved costs (value of recovered products = 0,15€/kg [1]

8 References

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9. Modifications made to the draft document

No comment has been made on the draft document.

9.1 Modification of Chapter 5

Costs corresponding to the use of an adsorber (SMC 02) have been modified (these costs have been recalculated with parameters defined in table 7.2.2).

9.2 Modification of Chapter 6

In this document, activity is considered as the consumption of products (ink, adhesives and varnishes) ready to use (t / year), but national statistics are usually available in tonnes of products non diluted. Preliminary data treatments are consequently required.

Explanations have been added in chapter 6 (paragraph 6.3 : Additional explanations for completing tables 6.2.3 and 6.2.4) for the purpose of helping national experts to fill in the tables.